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FOR THE SAFETY OF AIR NAVIGATION

EUROCONTROL

Enclosure 1

EUROCONTROL Specification for Aeronautical Information Exchange

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Abstract

This document is the EUROCONTROL Specification, developed under the EUROCONTROL Regulatory and Advisory Framework (ERAF), for Aeronautical Information Exchange (AIX). It enables the standardised encoding and the distribution in digital format of the aeronautical information/data that is in the scope of Aeronautical Data Quality (ADQ) Regulation (EU) 73/2010, developed in accordance with the interoperability Regulation in the framework of the Single European Sky (SES). The Specification also sets out the use of the Aeronautical Information Exchange Model (AIXM) complying with requirements listed in the document.

Keywords

AIXM	Specification	Interoperability	AIX
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Contact person(s)	Tel.	Unit
Manfred UNTERREINER	+32 2 729 3038	DSS/REG/SES

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AUTHORITY		NAME AND SIGNATURE	DATE
DSS/REG/SES	Editor	Mr Eduard Porosnicu Mr Vincent Treve	
Activity Manager		Mr Manfred UNTERREINER	
Director Single Sky		Mr Luc TYTGAT	
On behalf of the Director General by special delegation Principal Director ATM		Mr. Bo REDEBORN	

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Publications
EUROCONTROL Headquarters
96 Rue de la Fusée
B-1130 BRUSSELS

Tel: +32 (0)2 729 4715
Fax: +32 (0)2 729 5149
E-mail: publications@eurocontrol.int

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EXECUTIVE SUMMARY

This document is the EUROCONTROL Specification, developed under the EUROCONTROL Regulatory and Advisory Framework (ERAF), for Aeronautical Information Exchange (AIX). The specification is designed to enable interoperability between the different actors of the aeronautical data chain, through the standardised encoding and the distribution in digital format of the aeronautical information/data. The scope is the data that has to be provided by the national Aeronautical Information Services (AIS) in accordance with the International Civil Aviation Organisation (ICAO) Convention.

The objective is to define a specification that can be used for compliance with the interoperability implementing rule on the quality of aeronautical data and aeronautical information (ADQ Regulation (EU) 73/2010) developed in accordance with the interoperability Regulation in the framework of the Single European Sky (SES).

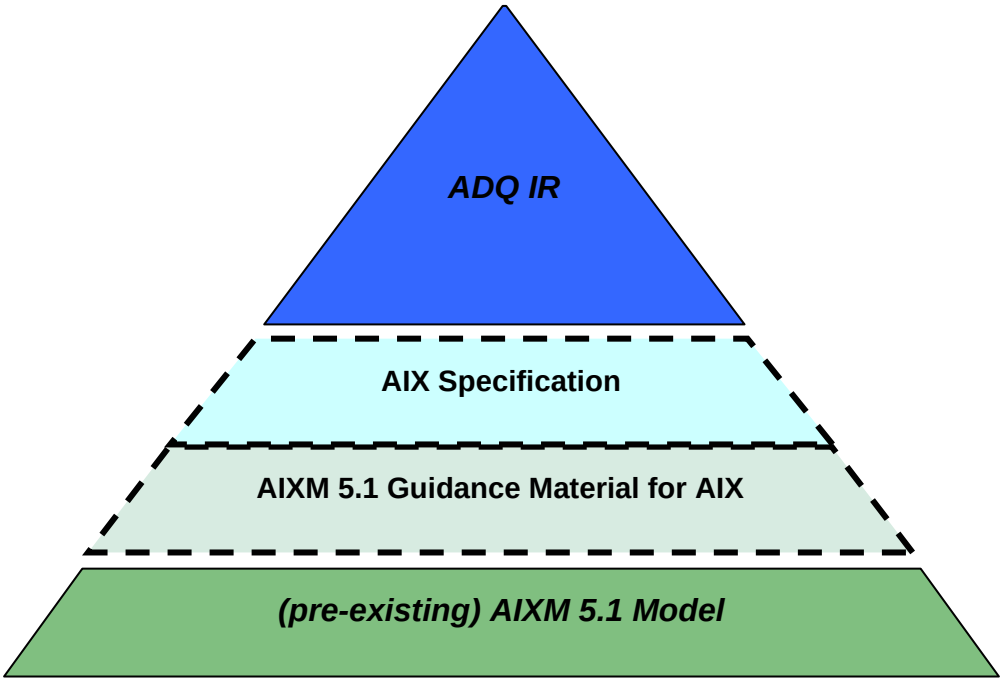
This version of the Specification includes compliancy statements concerning the use of the Aeronautical Information Exchange Model (AIXM) version 5.1 for complying with all the requirements listed in this AIX Specification. In addition, it is indicated when the use of the earlier AIXM version 4.5 also enables compliance, but only with specific requirements. However, the Specification does not exclude the use of other compliant data set specifications and/or data exchange formats for compliance with the ADQ Regulation.

1. Introduction

1.1 Purpose of the document

The Specification on Aeronautical Information Exchange (AIX) has been developed by the European Organisation for the Safety of Air Navigation (EUROCONTROL) in order to provide means of compliance with Articles 4 and 5 of the interoperability implementing rule on the quality of aeronautical data and aeronautical information for the Single European Sky (SES)[1] (hereinafter the ADQ IR). The document specifically addresses Integrated Aeronautical Information Package (IAIP), aerodrome mapping and electronic obstacle data set specification[2] and data exchange format requirements[3] as referred to in Article 4 and Article 5 respectively of the ADQ IR. Note that the provisions for electronic terrain data sets are excluded from the scope of this Specification.

A layered approach was followed in the development of the Specification, placing the AIX Specification and the supporting Guidelines in between the ADQ IR and the pre-existing Aeronautical Information Exchange Model (AIXM), as indicated in the diagram below:



The ***AIX Specification*** provides requirements defined in response to regulatory provision that are contained in Articles 4 and 5 of the ADQ IR.

The use of the Aeronautical Information Exchange Model (AIXM) V5.1 is proposed in order to comply with the data set specification and data exchange format requirements of this Specification. The ***EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification*** provides evidences of compliance of AIXM 5.1 with the requirements of the AIX Specification. The Specification provides statements of compliance for AIXM v5.1 in relation with these requirements. However, this Specification does not exclude the use of other models (e.g. AIXM version 4.5) which could be demonstrated as being compliant with part or all of the AIX Specification requirements and with ADQ IR Articles 4 and 5.

[1] Commission Regulation (EU) No. 73/2010, of 26 January 2010, laying down requirements on the quality of aeronautical data and aeronautical information for the single European sky OJ L 23/6 (27.1.2010)

[2] Annex 1, part A of the ADQ IR

[3] Article 5(2) – Annex II, Part A of the ADQ IR

A regulated party could consider one of the following approaches:

- use this AIX Specification and AIXM 5.1 to demonstrate compliance with Articles 4 and 5 of the ADQ IR;
- use the AIX Specification as a means of compliance with Articles 4 and 5 of the ADQ IR, but use another compliant model, not AIXM 5.1;
- develop other means of compliance with Articles 4 and 5 of the ADQ IR.

Whatever the approach chosen by the regulated parties, the provisions of the ADQ IR shall be respected. In particular, the interoperability objectives shall be achieved when applying digital data exchange with originators and/or next intended users.

1.2 Scope

The following articles of the ADQ IR are **within the scope** of this Specification:

- Article 4 – Annex I – Part A ("*IAIP, aerodrome mapping and electronic obstacle data*") and C ("*Metadata*");
- Article 5(2) – Article 5(2) – Annex II – Part A ("*IAIP, aerodrome mapping and electronic obstacle data*");
- Article 5(3) – Digital NOTAM.

The following articles of the ADQ IR are **outside the scope** of this Specification:

- Article 4 – Annex I – Part B ("*Electronic terrain data sets*");
- Article 5(2) – Annex II – Part B ("*Electronic terrain data*").

1.3 About AIXM

The objective of the Aeronautical Information Exchange Model (AIXM) is to provide a globally applicable logical model for aeronautical information and an exchange format that can be used to facilitate interoperability between both internal Aeronautical Information Services (AIS) systems as well as with external systems.

The model is needed because of the increasing dependence of aviation on timely, consistent, high-quality aeronautical information, which can only be ensured through automation. AIS offices are moving from product-centric operations to data-centric operations. In a product-centric operation, each aeronautical product is maintained separately, which means that a change in aeronautical information must be manually propagated through every product. In a data-centric environment aeronautical products are created from a single logical data source, so that aeronautical data changes automatically propagate through all products.

AIXM satisfies the requirements for a common conceptual model and common data exchange format stated by ICAO in the AIS to AIM Transition Roadmap and which are progressively being translated into ICAO Standards and Recommended Practices. The model provides:

- a common language for expressing aeronautical information for computer interpretation which is also readable by humans for development and validation/verification purpose;
- cost savings through software reuse and data model reuse;
- increased safety through improved data integrity and timeliness;
- cost reduction through improvements in data quality checking and integration.

In addition, a common model for aeronautical information enables new products that will lead to improvements in aviation efficiency, capacity and safety.

In 1997 EUROCONTROL began the development of AIXM as a data exchange specification for establishing a centralized pan-European reference database of quality-assured aeronautical information for AIS: the European AIS Database (EAD). AIXM has gradually grown and was adopted as a de-facto aeronautical information exchange specification for new AIS systems world-wide. The model accommodates:

- ICAO standards and recommended practices (especially Annex 4 and 15);
- ICAO guidance material, e.g. DOC 8126;
- industry requirements such as ARINC 424 and EUROCAE ED-99/RTCA DO-272;
- civilian and military aeronautical data.

The most recent increment, AIXM 5.1, was released in March 2010 (www.aixm.aero). It is the result of a common effort by EUROCONTROL and the United States Federal Aviation Administration (FAA), supported by the international AIS community. This version was designed to fulfil the following objectives:

- Alignment with ISO 19100 series standards for geospatial information, including the use of the Geography Markup Language (GML).
- Inclusion of a temporality model, including support for distribution of information of a temporary nature and of short duration contained in NOTAM.
- Support for the latest industry and ICAO requirements for aeronautical data, including obstacles, terminal procedures and airport mapping databases.
- Modularity and extensibility to support current and future aeronautical information messaging requirements.

The AIXM model has two main components. One component describes the concepts of the aeronautical information domain as a collection of features, properties and relationships. This component is referred to as the AIXM logical information model and it is defined using the Unified Modelling Language (UML). It can be used as the basis for the design of an AIS database and more generally as a common data set specification.

The second component derives from the AIXM logical information model and describes how to encode aeronautical data in a format that can be transmitted electronically between computer systems. The second component uses XML (Extensible Markup Language) as a language for system-to-system exchange. This component is also referred to as the XML Schema of AIXM.

More information about AIXM is available on the www.aixm.aero website.

1.4 Conventions

The conventions used in this document for denoting requirements, recommendations and optional elements are as follows:

'Shall' – indicates that they must be implemented to provide conformity with this specification;

'Should' - indicates that they are recommended to achieve the best possible implementation of this specification;

'May' – indicates an optional element or an alternative that can be followed in order to ensure conformity with the specification.

1.5 Abbreviations

Term	Definition
ADQ	Aeronautical Data Quality
ADQ IR	Commission Regulation (EU) No. 73/2010, of 26 January 2010, laying down requirements on the quality of aeronautical data and aeronautical information for the single European sky OJ L 23/6 (27.1.2010)
AIM	Aeronautical Information Management
AIP	Aeronautical Information Publication
AIRAC	Aeronautical Information Regulation And Control
AIS	Aeronautical Information Service
AIX	Aeronautical Information Exchange
AIXM	Aeronautical Information eXchange Model
AMDB	Aerodrome Mapping Database
ANSP	Air Navigation Service Provider
ARINC	Aeronautical Radio, Incorporated
ATM	Air Traffic Management
BR	Business Rules
(REQ-)CHG	REQuirement related to the exchange of baseline information as a result of permanent changes
(REQ-)DAT	REQuirement related to the definition of each attribute DAta Type
(REQ-)DF	REQuirement related to Data Format
DO	(RTCA) DOcument

(REQ-)DS	REQuirement related to the common Data Set specification in use
DSS	Single Sky Directorate (in EUROCONTROL)
EAD	European AIS Database
EC	European Commission
ECTL	EUROCONTROL
ED	EUROCAE Document (EUROCAE)
ERAF	EUROCONTROL Regulatory and Advisory Framework (Cadre réglementaire et consultatif d'EUROCONTROL)
EU	European Union
(REQ-)FC	REQuirement related to the documentation the common data set using a Feature Catalogue
(REQ-)GM	REQuirement related to the use of the Geographic Information - Spatial Schema
GML	Geographical Markup Language
IAIP	Integrated Aeronautical Information Package
ICAO	International Civil Aviation Organization
IEC	International Electrotechnical Committee
IR	Implementing Rule (SES)
ISBN	International Standard Book Number
ISO	International Standards Organization
(REQ-)MD	REQuirement related to Metadata
(REQ-)NAM	REQuirement related to naming convention for features, attributes and associations
NOTAM	Notice to Airmen
OCL	(UML's) Object Constraint Language
OGC	Open Geospatial Consortium
OJ	Official Journal
OMG	Object Management Group
PDF	Portable Document Format

REG	Regulatory division (in EUROCONTROL Single Sky Directorate)
REQ	REQuirement
RTCA	Radio Technical Commission for Aeronautics
SARPS	Standards And Recommended Practices
SBVR	Semantics of Business Vocabulary and Business Rules
SES	Single European Sky
SPEC	SPECification
(REQ-)TEM	REQuirement related to inclusion of a temporal model
UML	Unified Modelling Language
(REQ-)UML	REQuirement related to common data set if UML is used
UTC	Coordinated Universal Time
VOR	Very High Frequency Omnidirectional Radio Range
(REQ-)XFE	REQuirement related to exchange of data for both individual features and feature collections
XML	EXtensible Markup Language

1.6 Definitions

Term	Definition
aeronautical data	means a representation of aeronautical facts, concepts or instructions in a formalised manner suitable for communication, interpretation or processing
aeronautical information	means information resulting from the assembly, analysis and formatting of aeronautical data
aeronautical feature	means the abstract representation (in a model) of a real world phenomenon which falls within the scope of the aeronautical information domain
data quality	means a degree or level of confidence that the data provided meets the requirements of the data user in terms of accuracy, resolution and integrity
accuracy	means a degree of conformance between the estimated or measured value and the true value
resolution	means a number of units or digits to which a measured

	or calculated value is expressed and used
integrity	means a degree of assurance that a data item and its value have not been lost or altered since the data origination or authorised amendment
obstacle data	means data concerning all fixed (whether temporary or permanent) and mobile objects, or parts thereof, that are located on an area intended for the surface movement of aircraft or that extend above a defined surface intended to protect aircraft in flight
aeronautical information service provider	means the organisation responsible for the provision of an aeronautical information service, certified in accordance with Commission Regulation (EC) No 2096/2005
next intended user	means the entity that receives the aeronautical information from the aeronautical information service provider
direct electronic connection	means a digital connection between computer systems such that data may be transferred between them without manual interaction
data item	means a single attribute of a complete data set, which is allocated a value that defines its current status
NOTAM	means a notice distributed by means of telecommunication containing information concerning the establishment, condition or change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations
digital NOTAM	means a data set that contains the information included in a NOTAM in a structured format which can be fully interpreted by an automated computer system without human intervention
data originator	means an entity responsible for data origination
data origination	means the creation of a new data item with its associated value, the modification of the value of an existing data item or the deletion of an existing data item
data validation	means the process of ensuring that data meets the requirements for the specified application or intended use
data verification	means the evaluation of the output of an aeronautical data process to ensure correctness and consistency with respect to the inputs and applicable data standards, rules and conventions used in that process

1.7 Document structure

This specification is split in two parts.

- Section 2 specifies the requirements for complying with Article 4 of the ADQ IR regarding the data set specifications described in Annex I to the ADQ IR;
- Section 3 specifies the requirements for complying with Article 5 of the ADQ IR regarding the data set specifications described in Article 5(2) – Annex II to the ADQ IR.

2. Specification of enabling compliance with Article 4 of COMMISSION REGULATION (EU) NO 73/2010

2.1 Introduction

This Specification is developed to complement the Single European Sky (SES) interoperability implementing rule on the quality of aeronautical data and information (hereinafter called the Aeronautical Data Quality Implementing Rule (ADQ IR)) [1][4].

This Specification is a means of compliance with Articles 4 of the ADQ IR [1], identified in the following section.

2.2 Relevant extract from Regulation

2.2.1 Interoperability and Performance Requirements - Article 4 Data set

*Article 4, **Data set***

"*The parties referred to in Article 2(2) shall provide aeronautical data and aeronautical information in accordance with the data set specifications described in Annex I.*"

2.3 Specification

2.3.1 Identify the common data set specification in use

Annex 1 – Part A – 1(a)

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be provided according to a common data set specification"

2.3.1.1 Background

Interoperability between systems can only be achieved through the use of common specifications. However, a common data set specification does not mean that existing or future systems have to use it for their internal data structures. It only means that the data input/output by the system needs to be organised according to the common data set specification, which is achievable through mapping and data conversions. Obviously, if the internal model of a new system is derived from the common data set specification, then the mapping/conversion effort will be significantly reduced.

2.3.1.2 Requirements

In order to comply with Article 4 of the ADQ IR [1] and with the consequent requirement stated in Annex 1, Part A.1:

[REQ-DS-01] The regulated party shall ***declare the common data set specification that they use*** for the activities that fall within the scope of the ADQ IR [1].

[4] References given in square brackets in this document refer to the list of documents in Chapter 5.

[REQ-DS-02] The declaration of the common data set specification referred to in [REQ-DS-01] shall contain, as a minimum:

- the name (including the version, if applicable) by which the common data set specification is officially identified by its publishing authority;
- the necessary reference information (contact details, website, etc.) enabling the regulator to obtain a copy of the common data set specification documentation.

[REQ-DS-03] The regulated party shall provide evidence that the declared data set specification is used as a common data set specification by relevant organisations within the Aeronautical Information domain.

[REQ-DS-04] The evidence referred to in [REQ-DS-03] shall be in the form of one (or more) of the following possibilities:

- agreements signed with a significant number of relevant next intended users for the provision of aeronautical data according to the declared data set specification, or
- agreements signed by similar organisations in the same or in other European States for the provision of aeronautical data to their next intended users according to the declared data set, or
- agreements signed with a significant number of relevant data originators for the reception of aeronautical data according to the declared data set specification, or
- agreements signed by similar organisations in the same or in other European States for the reception of aeronautical data according to the declared data set, or
- an agreement signed with the European AIS Database (EAD) for the provision of the data to EAD according to the declared data set specification, if applicable.

2.3.1.3 Use of AIXM as a common data specification

The use of AIXM version 4.5 or 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 2.3.1.2, as detailed for version 5.1 in the "EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification" [3].

2.3.2 Document the common data set as UML or Feature Catalogue

Annex 1 – Part A – 1(a)

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be provided according to a common data set specification which shall

(a) be documented either:

- by using the Unified Modelling Language (UML), specified in the document referred to in point 13 of Article 5(2) – Annex III[5]*, in the form of class diagrams and associated definitions for classes, attributes, associations and lists of values, or*

- by using a feature catalogue specified in accordance with the ISO standard referred to in 25 of Article 5(2) – Annex III[6]*;"*

[5] Object Management Group Unified Modelling Language (UML) Specification Version 2.1.1

[6] International Organisation for Standardisation, ISO 19110:2005 — Geographic information — Methodology for feature cataloguing (Edition 1)

2.3.2.1 Background

The ADQ Regulation allows for a choice between the use of UML and the use of a feature cataloguing methodology for the definition of the common data set. The two are not mutually exclusive. An UML model may be used for generating a feature catalogue and vice-versa, on condition that certain specific rules are observed.

2.3.2.1.1 Unified Modelling Language (UML)

The Unified Modelling Language (UML) is an industry standard with a very broad scope, which covers a large and diverse set of application domains. It was particularly developed to support object-oriented software engineering.

The Object Management Group published the Unified Modelling Language (UML) Specification Version 2.1.1 in August 2007. The complete documentation is available from the OMG Website[7].

In the area of data modelling, UML provides a very rich set of graphical notations for creating "class diagrams". This is a category of structural UML diagrams that describes the structure of a system by showing system classes, their attributes, data types, operations and the relationships between classes. UML also prescribes the provision of definitions and names to these model elements.

2.3.2.1.2 Feature Catalogue

The methodology for feature catalogues is provided by the ISO 19110:2005. This International Standard specifies how the classification of feature types is organized into a feature catalogue and presented to the users of a set of geographic data. The Standard applies to the cataloguing of feature types that are represented in digital form. Its principles can be extended to the cataloguing of other forms of geographic data.

A feature catalogue must be available in electronic format and shall document the feature types that can occur in a data set containing geographical data. The ISO 19110:2005 International Standard provides a series of detailed conformance statements that shall be observed when creating a feature catalogue for an aeronautical data set.

A particular constraint of a Feature Catalogue as compared to a general UML model is that names and definitions of feature attributes, feature associations and association roles must be unique within the whole feature catalogue. This constraint is not applicable in the case of a general UML model, where such names and definitions have to be unique in the context of the individual features, not of the complete model.

2.3.2.2 Requirements

In order to comply with Article 4 of the ADQ IR [1] and with the consequent requirement stated in Annex 1, Part A.1 (a):

2.3.2.2.1 Using UML

[REQ-UML-01] If UML is used for documenting the data set specification, then the regulated party shall provide a document indicating, with reference to the OMG UML Specification version 2.1.1, which UML metamodel elements are actually used in the common data set specification referred to in [REQ-DS-01].

[REQ-UML-02] As a minimum, the list of UML metamodel elements referred to in [REQ-UML-01] shall include Class, DataType and Association.

[REQ-UML-03] The document referred to in [REQ-UML-01] shall include examples (real or fictitious) that demonstrate the use of the selected UML metamodel elements for documenting the data set.

[7] http://www.omg.org/spec/UML/2.1.1/

2.3.2.2.2 Using a Feature Catalogue

[REQ-FC-01] If a Feature Catalogue is used for documenting the data set specification, then the regulated party shall provide a document indicating, with reference to the ISO 19110:2005 International Standard, which elements of a feature type are actually used in the common data set specification referred to in [REQ-DS-01].

[REQ-FC-02] As a minimum, the list of feature type elements referred to in [REQ-FC-01] shall include Attributes and Associations.

[REQ-FC-03] The document referred to in [REQ-FC-01] shall include examples (real or fictitious) that demonstrate the use of the selected feature type elements for documenting the data set.

2.3.2.3 Use of AIXM as common data set specification

The use of AIXM 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 2.3.2.2, as detailed in the "EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification" [3].

2.3.3 Define each aeronautical feature requested to be published in the AIP

Annex 1 – Part A – 1(b)

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be provided according to a common data set specification which shall:

(b) define, as individual data elements, each aeronautical feature for which the information is requested to be published in accordance with the ICAO standards referred to in point 10 of Article 5(2) – Annex III[8] and the EUROCAE document referred to in point 24 of Article 5(2) – Annex III[9];"

ARTICLE 5(2) – ANNEX III, Point 10

"Appendix 1 (Contents of Aeronautical Information Publication (AIP)) of Annex 15 to the Chicago Convention — Aeronautical Information Services (Twelfth Edition — July 2004, incorporating Amendment No 34)"

ARTICLE 5(2) – ANNEX III, Point 24

"*Eurocae ED-99A, User Requirements for Aerodrome Mapping Information (October 2005).*"

2.3.3.1 Background

2.3.3.1.1 Aeronautical Information Publication (AIP)

Annex 15 to the Chicago Convention defines standards and recommended practices for Aeronautical Information Services and the information packages that are provided by AIS internationally. Appendix 1 to ICAO Annex 15 defines the structure and content of the Aeronautical Information Publication (AIP), which is the central component of the AIS information package. The AIP contains, in three parts, sections and subsections with information about the baseline capabilities and the organisation of the ground aeronautical infrastructure, airspace, route network, rules and procedures, etc.

[8] Appendix 1 (Contents of Aeronautical Information Publication (AIP)) of Annex 15 to the Chicago Convention — Aeronautical Information Services (Twelfth Edition — July 2004, incorporating Amendment No 34)

[9] Eurocae ED-99A, User Requirements for Aerodrome Mapping Information (October 2005)

In order to support the electronic exchange of the information contained in AIP, both as a whole and as individual updates, the data set specification must define the atomic components of the AIP data. These correspond either to real-world physical objects, such as runways, antennas, obstacles, etc. or to intangible concepts, such as routes, procedures, etc.

Note that this requirement might seem extremely demanding in the case of certain data originators (e.g. surveyors), which provide only small subsets of the information described by the AIP. The requirement must be interpreted correctly, as it does not mean that each party has to provide evidence that they are able to cover the complete AIP content. The relevant subpart of a commonly agreed data model has to be used. This is meant to prevent the proliferation of local data models and exchange formats, which could harm the interoperability objective of the Regulation.

2.3.3.1.2 Airport Mapping Database (AMDB)

The EUROCAE ED-99A document contains industry requirements for airport mapping data. It defines elementary components of the airport movement and non-movement area, which contain sufficient information to provide a graphical representation of the airport, for various applications such as navigational awareness, synthetic display, etc.

Many of the individual data elements described in the AMDB requirements are also covered by the AIP content requirements, for example runway, taxiway, etc. However, the ED-99A document contains unique requirements for elements such as Runway Element, etc. It also contains specific data encoding rules, such as non-overlapping, etc. Therefore, the AMDB requirements need to be dealt with specifically.

2.3.3.2 Requirements

In order to comply with Article 4 of the ADQ IR [1] and with the consequent requirement stated in Annex 1, Part A.1 (b):

[REQ-AIP-01] The regulated party shall provide formal evidence (e.g. in the form of a mapping table) that the common data set specification referred to in [REQ-DS-01] covers the scope of an Aeronautical Information Publication, as defined in ICAO Annex 15, Appendix 1.

[REQ-AIP-02] If an AIP data item is identified as “not covered” in the mapping table described in the [REQ-AIP-01], a justification shall be provided explaining why this occurs and what workaround is available.

[REQ-AMDB-01] The regulated party shall provide formal evidence (e.g. in the form of a mapping table) that documentation of the common data set specification referred to in [REQ-DS-01] covers the full scope of the User Requirements for Aerodrome Mapping Information, as defined in EUROCAE document ED-99A.

[REQ-AMDB-02] If an AIP data item is identified as “not covered” in the mapping table described in the [REQ-AMDB-01], a justification shall be provided explaining why this occurs and what workaround is available.

2.3.3.3 Use of AIXM as a common data specification

The use of AIXM 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 2.3.3.2, as detailed in the “EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification” [3].

2.3.4 Provide for each attribute the definition of its data type

Annex 1 – Part A – 1(c)

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be provided according to a common data set specification which shall:

(c) provide for each attribute the definition of its allowable values in the form of a data type, a range of values or an enumerated list;"

2.3.4.1 Background

The data type is an important aspect when defining the attributes of the classes that make up a data set specification. This is further detailed by eventual constraints that apply to the allowable values of the attribute and which may take the form of a range of values or of an enumeration of each discrete allowable value. Common agreement on data types, lists of enumerated values or ranges of values ensures a minimum of protection for a recipient system from being confronted with "out of range" data values, which could lead to unpredictable results and generate safety hazards.

2.3.4.2 Requirements

In order to comply with Article 4 of the ADQ IR [1] and with the consequent requirement stated in Annex 1, Part A.1 (c):

[REQ-DAT-01] The regulated party shall provide formal evidence that the common data set specification referred to in [REQ-DS-01] specifies a data type (e.g. character string, integer, decimal, etc.) for each class attribute (if UML is used) or feature attribute (if a Feature Catalogue is used).

[REQ-DAT-02] The data types mentioned in [REQ-DAT-01] may be further constrained through the provision of specified ranges of allowable values, between a minimum and a maximum value.

[REQ-DAT-03] The data types mentioned in [REQ-DAT-01] may be further constrained through the provision of exhaustive lists of allowable values.

2.3.4.3 Use of AIXM as a common data specification

The use of the AIXM version 4.5 or 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 2.3.4.2, as detailed for version 5.1 in the "EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification" [3].

2.3.5 Include a temporal model

Annex 1 – Part A – 1(d)

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be provided according to a common data set specification which shall:

(d) include the definition of a temporal model, UTC based, which can express the complete lifecycle of an aeronautical feature:

— from the creation date and time to the date and time of permanent withdrawal,

— including the permanent changes that create new baselines for that feature;"

2.3.5.1 Background

Time is an essential aspect on the aeronautical information world, where change notifications are usually made well in advance of their effective dates. Aeronautical information systems are usually requested to store and to provide both the current situation and the future changes. The expired information needs to be archived for legal investigation purposes.

There are two levels at which aeronautical feature instances are affected by time:

- Every feature has a start of life and an end of life;
- The properties of a feature can change within the lifetime of the feature; this includes the possibility for a property to be undefined over a time period.

For operational reasons, a distinction is usually made between:

- permanent changes (the effect of which will last until the next permanent change or until the end of the life of the feature) and
- temporary status (changes of a limited duration that are considered to be overlaid on the permanent state of the feature).

Therefore, a data set definition for aeronautical information has to include a “temporality concept” that enables modelling the evolution of a feature and its properties during the feature lifetime.

2.3.5.2 Requirements

In order to comply with Article 4 of the ADQ IR [1] and with the consequent requirement stated in Annex 1, Part A.1 (d):

[REQ-TEM-01] The regulated party shall provide formal evidence that the common data set specification referred to in [REQ-DS-01] includes a temporal concept.

[REQ-TEM-02] The temporality concept referred in [REQ-TEM-01] shall enable time positions and time durations to be expressed with reference to the Coordinated Universal Time (UTC) standard.

[REQ-TEM-03] The temporality concept referred in [REQ-TEM-01] shall enable identifying the start of life (commissioning) and the end of life (decommissioning or withdrawal) of an aeronautical feature instance.

[REQ-TEM-04] The temporality concept referred in [REQ-TEM-01] shall enable identifying the time position when a permanent change in the properties of an aeronautical feature instance occurs.

[REQ-TEM-05] The temporality concept referred in [REQ-TEM-01] shall enable identifying the exact feature properties that have been modified at the time of the permanent change.

[REQ-TEM-06] The temporality concept referred in [REQ-TEM-01] shall include examples (real or fictitious) that demonstrate its use for encoding of the complete feature lifecycle: start of life, one or more permanent changes, end of life.

2.3.5.3 Use of AIXM as common data set specification

The use of AIXM 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 2.3.5.2, as detailed in the “EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification” [3].

2.3.6 Define business rules

Annex 1 – Part A – 1(e)

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be provided according to a common data set specification which shall:

(e) include the definition of the rules that may constrain the possible values of the feature properties or the temporal variation of these values. This shall include, as a minimum:

— constraints that impose accuracy, resolution and integrity for positional (horizontal and vertical) data,

— constraints that impose the timeliness of the data;"

2.3.6.1 Background

In addition to data types, lists of allowable values and data ranges (as detailed in 0), there may exist other, more complex rules that constrain the possible values of the properties of an aeronautical features. Primary sources of such "business rules" are the ICAO Standards and Recommended Practices (SARPS), in particular as contained in Annex 10 (for navigation aids and communication), in Annex 11 (for airspace and routes), in Annex 14 (for airports) and in Annex 15 (for general data quality requirements).

Most of these rules are "static", meaning that a snapshot data set, containing aeronautical data valid at a moment in time, could be verified against such rules. For example, a rule that requires a certain accuracy of a positional value can be checked by looking only at the values as they are contained in that snapshot data set. There also exist "dynamic" rules, which imply verifying the variation in time of feature properties values. For example, the accuracy of a positional value should not decrease after a permanent change. Verifying the compliance with dynamic rules requires comparing the data values before and after the change.

Another important aspect is that many such business rules are not mandatory for all systems using the common data set specification. They can be enforced to various degrees, depending on the actual data needs of that system and also on the position of that system in the data chain. For example, a "minimum data rule" may require a frequency value to be provided for any VOR navaid. Obviously, such a rule cannot be enforced for a surveyor, who is only concerned with providing positional data. Such a rule does not need to be enforced either on a flight planning system, for which the VOR is only a significant point on a route and the VOR frequency value is of no use.

Business rules are generally expressed by operational staff in natural language. However, the problem with plain English text for business rules is that the text cannot be machine processed; semantic errors might be difficult to detect. Therefore, to enable the unambiguous encoding of business rules for machine processing, they need to be expressed in some formal representation. Examples are the Unified Modelling Language's Object Constraint Language (UML OCL) or Semantics of Business Vocabulary and Business Rules (SBVR).

The Object Constraint Language (OCL) is a declarative language for describing rules that apply to Unified Modelling Language (UML) models. It is a precise text language that provides constraint and object query expressions on any UML model or meta-model that cannot otherwise be expressed by diagrammatic notation.

The Semantics of Business Vocabulary and Business Rules specification provides a means for describing the structure of the meaning of rules expressed in the natural language that business people and operational staff use. A SBVR rule can easily be machine processed to perform object rule modelling, perform rule consistency analysis, or generate formal representations such as OCL constraints, databases, business rules repositories, business blueprints, business object models, software components, etc.

The latest version of SBVR is available on the OMG Website[10]

2.3.6.2 Requirements

In order to comply with Article 4 of the ADQ IR [1] and with the consequent requirement stated in Annex 1, Part A.1 (e):

[REQ-BR-01] The regulated party shall provide formal evidence that the common data set specification referred to in [REQ-DS-01] includes the description of business rules.

[REQ-BR-02] The business rules referred to in [REQ-BR-01] shall define constraints on data values that reflect ICAO Standards and Recommended Practices, European or national operational rules and practices.

[REQ-BR-03] The business rules referred to in [REQ-BR-01] shall include the specification of data accuracy constraints, based on the requirements contained in ICAO Annex 11, Appendix 5 and Annex 14, Volume I, Appendix 5;

[REQ-BR-04] The business rules referred to in [REQ-BR-01] shall include the specification of data resolution constraints, based on the requirements contained in ICAO Annex 15, Appendix 7;

[REQ-BR-05] The business rules referred to in [REQ-BR-01] shall include the specification of publication date and advanced notification constraints, based on the AIRAC cycle requirements contained in ICAO Annex 15, Chapter 6;

[REQ-BR-06] The business rules referred to in [REQ-BR-01] may be formally defined using the specification for Semantics of Business Vocabulary and Business Rules, as provided on OMG Website[10].

2.3.6.3 Use of AIXM as common data set specification

The use of AIXM version 4.5 or 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 2.3.6.2, as detailed for version 5.1 in the "EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification" [3].

2.3.7 Naming convention for features, attributes and associations

Annex 1 – Part A – 1(f)

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be provided according to a common data set specification which shall:

(f) apply a naming convention for features, attributes and associations, which avoids the use of abbreviations;"

2.3.7.1 Background

Establishing and consistently applying a naming convention in the definition of a data set is important for the comprehensibility of the feature catalogue or of the UML model. Feature cataloguing standards usually impose certain naming conventions. UML modelling techniques have also led to the establishment of good naming practices, which are de-facto standards. These include principles such as:

- names of model elements not using special characters, such as spaces, ampersand, umlauts, plus signs, etc.

[10] http://www.omg.org/spec/SBVR/1.0

- the name of an entity expressed using the "*UpperCamelCase*" principle;
- the name of a property expressed using the "*lowerCamelCase*" principle;
- Etc.

2.3.7.2 Requirements

In order to comply with Article 4 of the ADQ IR [1] and with the consequent requirement stated in Annex 1, Part A.1 (f):

[REQ-NAM-01] The regulated party shall provide formal evidence that the documentation of the common data set specification referred to in [REQ-DS-01] defines and consistently applies a naming convention for features, attributes and associations.

[REQ-NAM-02] If the use of abbreviations is permitted by the naming convention referred to in [REQ-NAM-01], such abbreviations should occur in less than 10% of the names of the model artefacts and shall be documented in a glossary.

2.3.7.3 Use of AIXM 5.1 as common data set specification

The use of AIXM 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 2.3.7.2, as detailed in the "EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification" [3].

2.3.8 Use of the "Geographic Information - Spatial Schema" (ISO-19107:2003)

Annex 1 – Part A – 1(g)

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be provided according to a common data set specification which shall:

(g) base the description of geometrical elements (point, curve, surface) on the ISO standard referred to in point 14 of Article 5(2) – Annex III[11];"

2.3.8.1 Background

This ISO 19107:2003 International Standard specifies conceptual schemas for describing the spatial characteristics of geographic features, and a set of spatial operations consistent with these schemas. It is part of a whole range of standards (the ISO 19100 series) which also define standard spatial operations for use in access, query, management, processing, and data exchange of geographic information for spatial (geometric and topological) objects.

This Standard, as most of the standards from the ISO 19100 series, was developed and continues to be maintained through the work of the Open Geospatial Consortium (OGC). This is a broad industry organisation, composed of commercial companies, research organisations, universities and governmental bodies that are active in the geospatial data domain. The main driver is the common interest of these organisations for interoperability between applications that process and share geographical data.

The use of the ISO 19107:2003 standard for the definition of the geometries and locations of aeronautical features (point, line, surface) ensures not only a better interoperability within the aeronautical domain but it also facilitates data exchange with other data domains and has the potential to lower the cost of the implementations through the use of commercial off-the-shelf software.

[11] International Organisation for Standardisation, ISO 19107:2003 — Geographic information — Spatial schema (Edition 1 — 8.5.2003)

2.3.8.2 Requirements

In order to comply with Article 4 of the ADQ IR [1] and with the consequent requirement stated in Annex 1, Part A.1 (g):

[REQ-GM-01] The regulated party shall provide formal evidence that the common data set specification referred to in [REQ-DS-01] reuses the GM_Point (documented in ISO 19107:2003) for the definition of the location of aeronautical features that have point type geometry.

[REQ-GM-02] The regulated party shall provide formal evidence that the common data set specification referred to in [REQ-DS-01] reuses the GM_Curve (documented in ISO 19107:2003) for the definition of the horizontal extent of aeronautical features that have line/curve type geometry.

[REQ-GM-03] The regulated party shall provide formal evidence that the common data set specification referred to in [REQ-DS-01] reuses the GM_Surface (documented in ISO 19107:2003) for the definition of the horizontal limits of aeronautical features that have surface type geometry.

2.3.8.3 Use of AIXM 5.1 as common data set specification

The use of AIXM 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 2.3.8.2, as detailed in the "EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification" [3].

2.3.9 Metadata

Annex 1 – Part A – 1(h) and 1(i), Part C

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be provided according to a common data set specification which shall :

(h) base the description of the metadata information on the ISO standard referred to in point 15 of Annex III;

(i) include the metadata items listed in Annex I, Part C."

2.3.9.1 Background

Metadata is data about data. It enables, for example, the provision of information about the origin of the data, point of contact, quality levels, etc. The use of ISO 19115:2003 — Geographic information — metadata as a basis for the description of the metadata information facilitates interoperability both within the aeronautical domain and with other data domains.

ISO 19115 is applicable to:

- the cataloguing of datasets, clearinghouse activities, and the full description of datasets;
- geographic datasets, dataset series, and individual geographic features and feature properties.

It defines:

- mandatory and conditional metadata sections, metadata entities, and metadata elements;
- the minimum set of metadata required to serve the full range of metadata applications (data discovery, determining data fitness for use, data access, data transfer, and use of digital data);
- optional metadata elements – to allow for a more extensive standard description of geographic data, if required;
- a method for extending metadata to fit specialized needs.

The metadata elements referred to in Annex I, Part C include information about the originator of the data, amendments made to the data, details of any validation and verification of the data that has been performed, for geospatial data the earth reference model used, etc.

2.3.9.2 Requirements

In order to comply with Article 4 of the ADQ IR [1] and with the consequent requirement stated in Annex 1, Part A.1 (h) and (i):

[REQ-MD-01] The regulated party shall provide formal evidence that the documentation of the common data set specification referred to in [REQ-DS-01] includes metadata elements.

[REQ-MD-02] The metadata elements referred to in [REQ-MD-01] shall be drawn from the 19115:2003 — Geographic information — Metadata Standard.

[REQ-MD-03] The metadata elements referred to in [REQ-MD-01] shall include constructs that capture information about the originator of the data.

[REQ-MD-04] The metadata elements referred to in [REQ-MD-01] shall include constructs that capture information about amendments made to the data.

[REQ-MD-05] The metadata elements referred to in [REQ-MD-01] shall include constructs that capture information about the persons or organisations that have interacted with the data and when.

[REQ-MD-06] The metadata elements referred to in [REQ-MD-01] shall include constructs that capture information about any validation and verification of the data that has been performed.

[REQ-MD-07] The metadata elements referred to in [REQ-MD-01] shall include constructs that capture information about the effective start date and time of the data.

[REQ-MD-08] The metadata elements referred to in [REQ-MD-01] shall include constructs which, for geospatial data, capture information about the Earth reference model used.

[REQ-MD-09] The metadata elements referred to in [REQ-MD-01] shall include constructs which, for geospatial data, capture information about the coordinate system used.

[REQ-MD-10] The metadata elements referred to in [REQ-MD-01] shall include constructs which, for numerical data, capture information about the statistical accuracy of the measurement or calculation technique used.

[REQ-MD-11] The metadata elements referred to in [REQ-MD-01] shall include constructs which, for numerical data, capture information about the data resolution.

[REQ-MD-12] The metadata elements referred to in [REQ-MD-01] shall include constructs which, for numerical data, capture information about the confidence level.

[REQ-MD-13] The metadata elements referred to in [REQ-MD-01] shall include constructs that capture information about any functions applied if data has been subject to conversion/transformation.

[REQ-MD-14] The metadata elements referred to in [REQ-MD-01] shall include constructs that capture information about any limitations on the use of the data.

2.3.9.3 Use of AIXM as a common data specification

The use of AIXM 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 2.3.9.2, as detailed in the “EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification” [3].

3. SPECIFICATION ALLOWING COMPLIANCE WITH ARTICLE 5 OF COMMISSION REGULATION (EU) NO 73/2010

3.1 Introduction

This Specification is developed to complement the Single European Sky (SES) interoperability implementing rule on the quality of aeronautical data and information (hereinafter called the Aeronautical Data Quality Implementing Rule (ADQ IR)) [1] .

This Specification is a means of compliance with Articles 5.2, 5.3, 5.4.c of the ADQ IR [1], identified in the following section.

3.2 Relevant extract from Regulation

3.2.1 Interoperability and performance requirements - Article 5 Data exchange

Article 5

Data exchange

1. *[…]*
2. *Air navigation service providers shall ensure that the aeronautical data and aeronautical information referred to in the second subparagraph of Article 2(1) are transferred between themselves in accordance with the data exchange format requirements laid down in Article 5(2) – Annex II.*
3. *Member States may exclude digital NOTAM from the data exchange format referred to in paragraph 2.*
4. *[…]*

3.3 Specification

3.3.1 Identify the common data format specification in use

Article 5(2) – Annex II – Part A – 1

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be formatted in accordance with a common specification"

3.3.1.1 Background

Global interoperability between systems can only be achieved through the use of common data format specifications. Otherwise, there is a risk that each pair of systems that need to exchange data will have to develop dedicated formats and specifications.

The common data format specification does not mean that existing or future systems have to use it for their internal data structures. It only means that the data input/output by the system needs to conform with that common data format. An interface component might be needed to provide an encoding/decoding functionality and allow interoperability.

3.3.1.2 Requirements

In order to comply with Article 5 of the ADQ IR [1] and with the consequent requirement stated in Article 5(2) – Annex II, Part A.1 - Paragraph 1:

[REQ-DF-01] The regulated party shall declare the common data format specification that they use for the activities that fall within the scope of the ADQ IR [1].

[REQ-DF-02] The declaration of the common data format specification referred to in [REQ-DF-01] shall contain, as a minimum:

- the name (including the version, if applicable) by which the common data format specification is officially identified by its publishing authority;
- the necessary reference information (contact details, website, etc.) enabling the regulator to obtain a copy of the common data format specification documentation.

[REQ-DF-03] The regulated party shall provide evidence that the declared data format specification is indeed commonly used in the Aeronautical Information domain.

[REQ-DF-04] The evidence referred to in [REQ-DF-03] shall be in the form of:

- agreements signed with a significant number of relevant next intended users for the provision of aeronautical data according to the declared data format specification;
- agreements signed by similar organisations in the same or in other European States for the provision of aeronautical data to their next intended users according to the declared data format;
- agreements signed with a significant number of relevant data originators for the receipt of aeronautical data according to the declared data format specification;
- agreements signed by similar organisations in the same or in other European States for the receipt of aeronautical data according to the declared data format;
- an agreement signed with the European AIS Database (EAD) for the provision of the data to EAD according to the declared data format specification, if applicable.

3.3.1.3 Use of AIXM as a common data format specification

The use of AIXM version 4.5 or 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 3.3.1.2, as detailed for version 5.1 in the "EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification" [3].

3.3.2 Use of Extensible Markup Language (XML) for data encoding

Article 5(2) – Annex II – Part A – 1 – Paragraph 1

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be formatted in accordance with a common specification, which shall

- *use the extensible mark-up language (XML) specification as defined in the ISO standard referred to in Article 5(2) – Annex III point 17[12] for data encoding"*

[12] International Organisation for Standardisation, ISO 19118:2005 — Geographic information — Encoding (Edition 1 — 17.3.2006 ISO/CD 19118 Edition 2 — 9.7.2007 [At committee stage]).

3.3.2.1 Background

XML is a subset of ISO/IEC 8879 and has been chosen because it is independent of the computing platform and interoperable with the World Wide Web. It is also widely used by industry at present, in particular for data encoding formats that need to be, to a certain extent, readable by humans. In the aviation domain, there is a tradition of using messages that are both readable by humans and to a certain extent interpretable by computers (Flight Plan, NOTAM, METAR, etc.). XML is therefore a natural choice.

XML also matches well with the use of the ISO 19100 standards that are specified in other parts of the ADQ Regulation. The purpose of the ISO 19100 series and most particularly ISO standard 19118:2005 is to provide information about how to enable interoperability between heterogeneous internal information systems using extensive mark-up language (XML).

The reference to ISO standard 19118:2005 mentioned in Article 5(2) – Annex II – Part A – 1 – Paragraph 1 is only used for referring to the Normative Reference section 3 of this ISO document. In this section the XML specification is defined as Extensible Markup Language (XML) 1.0 (Second Edition), W3C Recommendation 6 October 2000. This specification is available on the W3C website[13]. The term "Well-formed XML" is used to designate an XML file that complies with the XML specification.

3.3.2.2 Requirements

In order to comply with Article 5 of the ADQ IR [1] and with the consequent requirement stated in Article 5(2) – Annex II, Part A.1 - Paragraph 1:

[REQ-XML-01] The regulated party shall provide evidence that the common data format specification referred to in [REQ-DF-01] is based on the Extensible Markup Language (XML) specification, as defined on the W3C website[13].

[REQ-XML-02] The evidence referred to in [REQ-XML-01] may be in the form of the results of parsing a sample data file with an XML parser (such as Xerces[14]), which verifies whether the XML file is well-formed.

3.3.2.3 Use of AIXM as a common data format specification

The use of AIXM version 4.5 or 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 3.3.2.2, as detailed for version 5.1 in the "EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification" [3].

3.3.3 Use of XML Schema

Article 5(2) – Annex II – Part A – 1 – Paragraph 2

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be formatted in accordance with a common specification, which shall

- *be expressed in the form of an XML schema; in addition, a schematron as defined in the ISO standard referred to in point 19 of Article 5(2) – Annex III[15] may be used for expressing business rules,"*

[13] http://www.w3.org/TR/xmlschema-1/

[14] http://xerces.apache.org/xerces-c/

[15] International Organisation for Standardisation, ISO/IEC 19757-3:2006 — Information technology — Document Schema Definition Languages (DSDL) — Part 3: Rule-based validation — Schematron (Edition 1 — 24.5.2006)

3.3.3.1 Background

3.3.3.1.1 XML Schema

As mentioned in Section 3.3.2.1, one of the critical elements for data interchange is the application schema used for actual data encoding. This has to define the possible content and structure of the transferred data.

The first step for data transfer is to translate its internal data (configured according to a local structure) into a data structure that conforms to a common application schema. Conversely, the application schema allows the transposition of external data received in a local structure.

Both a sender and a receiver of data must have access to the common application schema used in order to prepare their own systems by implementing mappings of their own data structures according to the application schema.

In 3.3.2, the Extensible Markup Language (XML) was imposed as the data encoding format. Therefore, the XML Schema W3C Recommendation comes naturally into place as the way to express the syntax of the data set. The "*XML Schema: Structure*" as described on the W3C website[16], aims to "*define the nature of XML schemas and their component parts, provide an inventory of XML markup constructs with which to represent schemas, and define the application of schemas to XML documents*" and to "*define and describe a class of XML documents by using schema components to constrain and document the meaning, usage and relationships of their constituent parts: datatypes, elements and their content and attributes and their values. Schemas may also provide for the specification of additional document information, such as normalization and defaulting of attribute and element values. Schemas have facilities for self-documentation. Thus, XML Schema: Structures can be used to define, describe and catalogue XML vocabularies for classes of XML documents*."

The reference to ISO standard 19118:2005 mentioned in Article 5(2) – Annex II – Part A – 1 – Paragraph 2 is only used for referring to the Normative Reference section 3 of this ISO document. In this section the XML Schema specification is defined as the XML Schema Part 1: Structures, W3C Recommendation 2 May 2001 plus the XML Schema Part 2: Data types, W3C Recommendation 2 May 2001. These specifications are available on the W3C website[16]. The term "valid XML" is used to designate an XML file that complies with the constraints expressed in a specific XML Schema.

3.3.3.1.2 Schematron

Background information on business rules is provided in Section 2.3.6.1. The use of Schematron encodings for expressing business rules in a computer format is not mandatory for complying with ADQ IR [1] Article (5), but it naturally matches the use of XML as data encoding format.

Schematron defines a structurally based validation language for XML documents. It combines powerful validation capabilities with a simple syntax and implementation (XML notation) that can be used in an autonomous way or as a supplement to the XML Schema. Schematron allows more complex dependencies between the values of different data items to be checked, as compared with the XML Schema which only allows for syntactical validation and certain data range checks to be performed.

Schematron is defined in the ISO/IEC 19757-3:2006 "Information technology - Document, Schema Definition Languages (DSDL) - Part 3: Rule-based validation - Schematron" International Standard.

3.3.3.2 Requirements

In order to comply with Article 5 of the ADQ IR [1] and with the consequent requirement stated in Article 5(2) – Annex II, Part A.1 - Paragraph 2:

[16] http://www.w3.org/TR/xmlschema-1/

[REQ-XSD-01] The regulated party shall provide evidence that the common data format specification referred to in [REQ-DF-01] is compliant with the "XML Schema Part 1: Structures[17]" and "XML Schema Part 2: Data Types[18]", as defined on the W3C website.

[REQ-XSD-02] The evidence referred to in [REQ-XSD-01] may be in the form of the results of parsing a sample data file with a schema-validating XML parser (such as Xerces[19]), which verifies whether the XML file is valid against the XML Schema.

[REQ-SCH-01] If computer code is provided for supporting the verification of the business rules referred to in [REQ-BR-01], then the regulated party may provide evidence that this is in the form of Schematron code.

[REQ-SCH-02] The evidence referred to in [REQ-SCH-01] may be in the form of the result of verifying a sample data file with Schematron validating software referenced on the Schematron Website[20].

3.3.3.3 Use of AIXM as a common data format specification

The use of AIXM version 4.5 or 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 3.3.3.2, as detailed for version 5.1 in the "EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification" [3].

3.3.4 Exchange of data for both individual features and feature collections

Article 5(2) – Annex II – Part A – 1 – Paragraph 3

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be formatted in accordance with a common specification, which shall

- *enable the exchange of data for both individual features and feature collections,"*

3.3.4.1 Background

This requirement is designed to ensure not only that a whole and complete data set can be exchanged but also that a particular feature can be exchanged individually. This is particularly important for data providers and data originators providing only a limited subset of the whole data set or even just the value of one property, such as the position, elevation, frequency, identifier, etc. Also customers only interested in particular information only have to be able to access a limited sub-set of data.

This requirement is also designed to facilitate the use of the data encoding schema in standard Web service implementations (such as Web Feature Service – WFS), where the payload is typically at feature level. This will serve the interoperability objective through re-use of information industry standards and will avoid the development of domain-specific service interfaces.

3.3.4.2 Requirements

In order to comply with Article 5 of the ADQ IR [1] and with the consequent requirement stated in Article 5(2) – Annex II, Part A.1 - Paragraph 3:

[REQ-XFE-01] The regulated party shall provide evidence that the XML Schema referred to in [REQ-XSD-01] enables the creation of data files that contain a single feature.

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[17] http://www.w3.org/TR/xmlschema-1/

[18] http://www.w3.org/TR/xmlschema-2/

[19] http://xerces.apache.org/xerces-c/

[20] http://www.schematron.com/validators.html

[REQ-XFE-02] The evidence referred to in [REQ-XFE-01] may be in the form of a sample data file that contains data about a single aeronautical feature (such as an airport, a waypoint, etc.) and which passes the validation test described in [REQ-XSD-02].

[REQ-XFE-03] The regulated party shall provide evidence that the XML Schema referred to in [REQ-XSD-01] enables the creation of data files that contain more than one feature.

[REQ-XFE-04] The evidence referred to in [REQ-XFE-03] may be in the form of a sample data file that contains data about several aeronautical features (such as an airport and all runways, taxiways, aprons, etc.) and which passes the validation test described in [REQ-XSD-02].

3.3.4.3 Use of AIXM as a common data format specification

The use of AIXM version 4.5 or 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 3.3.4.2, as detailed for version 5.1 in the "EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification" [3].

3.3.5 Exchange of baseline information as a result of permanent changes

Article 5(2) – Annex II – Part A – 1 – Paragraph 4

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be formatted in accordance with a common specification, which shall

- *enable the exchange of baseline information as a result of permanent changes,"*

3.3.5.1 Background

Being able to encode and communicate changes to aeronautical information is important in the aviation domain. Data changes may trigger updates to operating procedures, charts, manuals, etc. The operationally significant changes in the aeronautical information domain are regulated by the AIRAC cycle[21].

It is not sufficient to provide just a complete new data set. That would put the burden on the client to identify what has changed, while this information is already known by the data provider. On the other hand, communicating just a property change might also be insufficient. That would require the recipient to be able to re-compose the feature data, merging the existing data with the changed values. Therefore, the data encoding format needs to support communicating both individual property changes and the complete feature data, as result of that change.

Usually, when a permanent change is communicated, it is not known when the next permanent change will take place. Therefore, the new feature status is considered a baseline with an unknown end of validity, which will cover the period until the next permanent change. Implicitly, when the next change occurs, the previous baseline is assigned an end of validity and needs to be updated / corrected.

3.3.5.2 Requirements

In order to comply with Article 5 of the ADQ IR [1] and with the consequent requirement stated in Article 5(2) – Annex II, Part A.1 - Paragraph 4:

[REQ-CHG-01] The regulated party shall provide evidence that the XML Schema referred to in [REQ-XSD-01] enables the explicit identification of the feature properties that have changed their values permanently.

[21] AIRAC stands for Aeronautical Information Regulation And Control and stems from ICAO Annex 15 - Aeronautical Information Services (AIS) document and defines a series of common dates and an associated standard aeronautical information publication procedure for States.

[REQ-CHG-02] The evidence referred to in [REQ-CHG-01] may be in the form of a data sample file that contains only the values of the properties that have changed for a given feature (such as an airport, runway, etc.) and which passes the validation test described in [REQ-XSD-02].

[REQ-CHG-03] The evidence referred to in [REQ-CHG-01] may be in the form of a data sample file that contains the data for a complete feature but in which the values of the properties that have changed for a feature (such as an airport, runway, etc.) are clearly marked and which passes the validation test described in [REQ-XSD-02].

[REQ-CHG-04] The regulated party shall provide evidence that the XML Schema referred to in [REQ-XSD-01] makes it possible to encode and communicate the complete list of property values of a feature after a permanent change of a one or more of these properties.

[REQ-CHG-05] The evidence referred to in [REQ-CHG-04] may be in the form of a data sample file that contains both the changed properties clearly marked (as requested in [REQ-CHG-02] or in [REQ-CHG-03]) and the complete feature data which results from the change and which passes the validation test described in [REQ-XSD-02].

3.3.5.3 Use of AIXM as a common data format specification

The use of AIXM version 4.5 or 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 3.3.5.2, as detailed for version 5.1 in the "EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification" [3].

3.3.6 Structure the format

Article 5(2) – Annex II – Part A – 1 – Paragraph 5

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be formatted in accordance with a common specification, which shall

- *be structured in accordance with the features, attributes and associations of the data set definition described in Annex I, Part A; the mapping rules shall be documented,"*

3.3.6.1 Background

The data format specification is requested to support the encoding of the full scope of the data set described in section 2.3.3. No feature should be described by the data set specification without having the possibility to encode and provide the data for that feature using the data format specification. Conversely, no feature should appear directly in the data format specification without being captured first in the data set description. In order to ensure this coherence between the data set specification and the data encoding format, the latter needs to be structured following the same separation lines as used in the data set: feature, attributes, associations, lists of values, etc.

Typically the XML schema that controls the data encoding format is generated automatically from the UML model or the feature catalogue that defines the data set. This ensures the quality of the XML Schema, by avoiding typing errors that could be introduced if it were created manually. It also facilitates the maintenance of the schema when the data set definition is updated and requires an update of the data encoding specification as well. The automatic generation of the schema is based on rules. These rules need to be documented in order to be able to demonstrate the correct mapping between the data set specification and the data encoding format specification.

3.3.6.2 Requirements

In order to comply with Article 5 of the ADQ IR [1] and with the consequent requirement stated in Article 5(2) – Annex II, Part A.1 - Paragraph 5:

3.3.6.2.1 If UML is used for data set

[REQ-STU-01] If UML is used for the data set specification, then the regulated party shall provide evidence that each element of the UML metamodel referred to in [REQ-UML-01] maps to a specific construct in the XML Schema referred to in [REQ-XSD-01].

[REQ-STU-02] The evidence requested in [REQ-STU-01] shall be in the form of a document that describes, as a minimum, how the classes, attributes and association elements of the UML metamodel referred to in [REQ-UML-01] are mapped into elements of the XML Schema referred to in [REQ-XSD-01].

[REQ-STU-03] The document referred to in [REQ-STU-02] should include examples (real or fictitious) that illustrate, for one or more selected classes of the UML model, how these are translated into XML Schema constructs.

3.3.6.2.2 If a Feature Catalogue is used for data set

[REQ-STF-01] If a Feature Catalogue is used for the data set specification, then the regulated party shall provide evidence that each element of the feature catalogue referred to in [REQ-FC-01] maps to a specific construct in the XML Schema referred to in [REQ-XSD-01].

[REQ-STF-02] The evidence referred to in [REQ-STF-01] shall describe, as a minimum, how feature type, their attributes and associations as referred to in [REQ-FC-02] are mapped into elements of the XML Schema referred to in [REQ-XSD-01].

[REQ-STF-03] The evidence referred to in [REQ-STF-01] shall include examples (real or fictitious) that illustrate, for one of more features from the feature catalogue, how these are translated into XML Schema constructs.

3.3.6.3 Use of AIXM as common data set specification

The use of AIXM 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 3.3.6.2, as detailed in the “EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification” [3].

3.3.7 Enumerated lists of values and range of values for each attribute

Article 5(2) – Annex II – Part A – 1 – Paragraph 6

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be formatted in accordance with a common specification, which shall

- *implement strictly the enumerated lists of values and range of values defined for each attribute in the data set,"*

3.3.7.1 Background

The data format specification is requested to support the encoding of the full scope of the data set described in section 2.3.3. The data set specification includes requirements (see 2.3.4) for lists of values and value ranges which constrain certain feature properties (for example, frequencies, lengths, angles, etc.).

An XML Schema provides constructs that make it possible to limit the values of a simple content element to a certain data type, range of values and/or pattern. The list of values and range of value limitations included in the data set can be relatively directly mapped into XML Schema data type restrictions. This ensures that a file that is valid against the XML Schema does not contain 'out of range' values, which could otherwise cause processing problems to recipient systems. This is the minimum level of 'business rules' validation that can be performed on a data set before running the more complex checks foreseen in 3.3.3.1.2.

3.3.7.2 Requirements

In order to comply with Article 5 of the ADQ IR [1] and with the consequent requirement stated in Article 5(2) – Annex II, Part A.1 - Paragraph 5:

[REQ-XDT-01]The regulated party shall provide evidence that each data type specified in [REQ-DAT-01] maps into a specific XML data type in the XML Schema referred to in [REQ-XSD-01].

[REQ-XDT-02] The regulated party shall provide evidence that each range of values specified in [REQ-DAT-02] maps into a specific XML data type constrain in the XML Schema referred to in [REQ-XSD-01].

[REQ-XDT-03] The regulated party shall provide evidence that each enumerated list of values specified in [REQ-DAT-03] maps into a specific XML data type constrain in the XML Schema referred to in [REQ-XSD-01].

[REQ-XDT-04] The evidence requested in [REQ-XDT-01], [REQ-XDT-02] and [REQ-XDT-03] shall be in the form of a document that describes how the data types, value ranges and enumerated lists of values are mapped into elements of the XML Schema referred to in [REQ-XSD-01].

[REQ-XDT-05] The document referred to in [REQ-XDT-04] should include examples (real or fictitious) that illustrate, for one or more selected attribute data types of the UML model, how these are translated into XML Schema constructs.

3.3.7.3 Use of AIXM as a common data format specification

The use of AIXM version 4.5 or 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 3.3.5.2, as detailed for version 5.1 in the "EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification" [3].

3.3.8 Comply with the geography mark-up language (GML)

Article 5(2) – Annex II – Part A – 1 – Paragraph 7

"The aeronautical data and aeronautical information referred to in points (a), (b) and (d) of the second subparagraph of Article 2(1) shall be formatted in accordance with a common specification, which shall

- *comply with the geography mark-up language (GML) specification, as defined in the reference referred to in point 18 of Article 5(2) – Annex III[22], for the encoding of geographical information."*

3.3.8.1 Background

The Geographical Markup Language (GML) is an XML grammar, formally defined by an XML Schema, for expressing geographical features. This allows users and developers to describe generic geographic data sets that contain points, lines and polygons. The key concepts used by GML to model the world are drawn from the ISO 19100 series of International Standards and the OpenGIS Abstract Specification, in particular:

- ISO/TS 19103 – Conceptual Schema Language (units of measure, basic types);
- ISO 19107 – Spatial schema (geometry and topology objects), which is referred to by the requirements of section 2.3.8;
- ISO 19108 – Temporal schema (temporal geometry and topology objects, temporal reference systems);
- ISO 19109 – Rules for application schemas (features);
- ISO 19111 – Spatial referencing by coordinates (coordinate reference systems);
- etc.

The fact that the GML Schema is an XML Schema, compliance with the requirements of this section implicitly ensures compliance with the requirements stated in sections 3.3.2 and 3.3.3.

3.3.8.2 Requirements

In order to comply with Article 5 of the ADQ IR [1] and with the consequent requirement stated in Article 5(2) – Annex II, Part A.1 - Paragraph 4:

[REQ-GML-01] The regulated party shall provide evidence that the XML Schema referred to in [REQ-XSD-01] complies with the Conformance rules stated in Chapter 2 "Conformance" of the ISO 19136:2007 — Geographic information — Geography Mark-up Language (GML) International Standard, Edition 1 — 23.8.2007.

3.3.8.3 Use of AIXM as common data format specification

The use of AIXM 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 3.3.8.2, as detailed in the "EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification" [3].

[22] International Organisation for Standardisation, ISO 19136:2007 — Geographic information — Geography Markup Language (GML) (Edition 1 — 23.8.2007)

3.3.9 Support Digital NOTAM

Article 5(3)

"Member States may exclude digital NOTAM from the data exchange format referred to in paragraph 2"

3.3.9.1 Background

The current NOTAM is a text note, which can be distributed by basic teletype networks such as AFTN. The NOTAM is intended to be read by pilots, controllers and other operational personnel involved in flight operations.

By contrast, a Digital NOTAM is a small data set, made available through more advanced communication networks (such as AMHS, TypeX, etc.). It is intended to be read and processed by automated systems, which in turn will convert it into text and graphical formats for presentation to humans. Digital NOTAM can be used for example in order to present an updated airport chart to the pilot or to the air traffic controller, containing graphical depictions of the work in progress areas, closed taxiways or runways, temporary obstacles, etc. A Digital NOTAM might also trigger automated actions, such as determine procedures impacted by the unavailability of a navaid.

The Digital NOTAM Event Specification[23] defines the rules for harmonised encoding as AIXM data sets (version 5.1 or later) of the information currently published through NOTAM messages. The main goal of the document is to enable the interoperability of the different systems that produce, transform, transmit and consume Digital NOTAM data, as part of the digital aeronautical information is general. The application of common rules is also expected to reduce the cost of the implementations because it minimises the need for mapping and adaptation of the data coming from different sources.

The rules specified for different events (scenarios) describe the minimum information necessary to be provided at short notice. In certain situations, this might be supplemented later with more detailed information in order to provide all the detail necessary to record a permanent change of the aeronautical feature concerned and which is not available for the initial notification.

The exception stated in Article 5(3) was necessary when the ADQ IR [1] was drafted because the Digital NOTAM concept was still in development. In the meantime, the concept has been validated by trials and pilot implementations and an initial operational capability is foreseen in Europe by 2012. Therefore, an optional capability of the data format specification should be to enable the encoding of Digital NOTAM and thus support the Member States that choose not to apply the exception stated in Article 5(3) of the ADQ IR [1].

3.3.9.2 Requirements

In order to comply with Article 5 of the ADQ IR [1] and with the consequent requirement stated in Article 5(3):

[REQ-XNT-01] The regulated party should provide formal evidence that the common data set specification referred to in [REQ-DS-01] supports the digital encoding of the information contained in NOTAM/SNOWTAM.

[REQ-XNT-02] The evidence requested in [REQ-XNT-01] may be in the form of a document that indicates how frequently issued NOTAM types can be encoded applying the data format specification referred to in [REQ-DS-01].

[REQ-XNT-03] The document referred to in [REQ-XNT-02] should include examples of real or fictitious NOTAM encodings.

[23] http://www.aixm.aero/public/standard_page/digital_notam_specifications.html, version 1.0, published in June 2010 by Eurocontrol.

3.3.9.3 Use of AIXM as common data format specification

The use of AIXM 5.1 is an acceptable technical means, inter alia, of enabling compliance with the requirement of Section 3.3.9.2, as detailed in the “EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification” [3].

4. Traceability to regulatory provisions

Commission Regulation (EU) No 73/2010	EUROCONTROL Specification for Aeronautical Information Exchange		Requirements
Article 4 Annex 1			
Part A	Section 2.3.1	Identify the common data set specification in use	[REQ-DS-01] [REQ-DS-02] [REQ-DS-03] [REQ-DS-04]
1(a) – Paragraph 1 1(a) – Paragraph 2	Section 2.3.2	Document the common data set as UML or Feature Catalogue	[REQ-UML-01] [REQ-UML-02] [REQ-UML-03] [REQ-FC-01] [REQ-FC-02] [REQ-FC-03]
1(b)	Section 2.3.3	Define each aeronautical feature requested to be published in the AIP	[REQ-AIP-01] [REQ-AIP-02] [REQ-AMDB-01] [REQ-AMDB-02]
1(c)	Section 2.3.4	Provide for each attribute the definition of its data type	[REQ-DAT-01] [REQ-DAT-02] [REQ-DAT-03]
1(d)	Section 2.3.5	Include a temporal model	[REQ-TEM-01] [REQ-TEM-02] [REQ-TEM-03] [REQ-TEM-04] [REQ-TEM-05] [REQ-TEM-06]
1(e)	Section 2.3.6	Define business rules	[REQ-BR-01] [REQ-BR-02] [REQ-BR-03] [REQ-BR-04] [REQ-BR-05] [REQ-BR-06]
1(f)	Section 2.3.7	Naming convention for features, attributes and	[REQ-NAM-01] [REQ-NAM-02]

		associations	
1(g)	Section 2.3.8	Use of the “Geographic Information - Spatial Schema” (ISO-19107:2003)	[REQ-GM-01] [REQ-GM-02] [REQ-GM-03]
1(h) and 1(i) and Part C	Section 2.3.9	Metadata	[REQ-MD-01] [REQ-MD-02] [REQ-MD-03] [REQ-MD-04] [REQ-MD-05] [REQ-MD-06] [REQ-MD-07] [REQ-MD-08] [REQ-MD-09] [REQ-MD-10] [REQ-MD-11] [REQ-MD-12] [REQ-MD-13] [REQ-MD-14]
Article 5 Article 5(2) – Annex II			
Part A-1	Section 3.3.1	Identify the common data format specification in use	[REQ-DF-01] [REQ-DF-02] [REQ-DF-03] [REQ-DF-04]
Paragraph 1	Section 3.3.2	Use of the extensive mark-up language (XML) for data encoding	[REQ-XML-01] [REQ-XML-02]
Paragraph 2	Section 3.3.3	Use of XML schema	[REQ-XSD-01] [REQ-XSD-02] [REQ-SCH-01] [REQ-SCH-02]
Paragraph 3	Section 3.3.4	Exchange of data for both individual features and feature collections	[REQ-XFE-01] [REQ-XFE-02] [REQ-XFE-03] [REQ-XFE-04]
Paragraph 4	Section 3.3.5	Exchange of baseline information as a result	[REQ-CHG-01]

		of permanent changes	[REQ-CHG-02] [REQ-CHG-03] [REQ-CHG-04] [REQ-CHG-05]
Paragraph 5	Section 3.3.6	Structure the format	[REQ-STU-01] [REQ-STU-02] [REQ-STU-03] [REQ-STF-01] [REQ-STF-02] [REQ-STF-03]
Paragraph 6	Section 3.3.7	Enumerated lists of values and range of values for each attribute	[REQ-XDT-01] [REQ-XDT-02] [REQ-XDT-03] [REQ-XDT-04] [REQ-XDT-05]
Paragraph 7	Section 3.3.8	Comply with the geography mark-up language (GML)	[REQ-GML-01]
Article 5 Article 5(3)			
	Section 3.3.9	Support Digital NOTAM	[REQ-XNT-01] [REQ-XNT-02] [REQ-XNT-03]

5. LIST OF REFERENCES

[1] Single European Sky (SES) interoperability implementing rule on the quality of aeronautical data and information, COMMISSION REGULATION (EU) NO 73/2010

[2] Internal guidelines for the development of EUROCONTROL specifications and EUROCONTROL guidelines. Edition 1.0 dated 16 October 2007. Ref. ECTL_SPEC_GUID_1.0 191007

[3] EUROCONTROL Guidelines – Use of AIXM 5.1 in relation to the AIX Specification. Draft Issue 0.3 dated 06 MAR 2012

[End of Document]