



ICAO

Doc 10003

Manual on the ICAO Meteorological Information Exchange Model

Second Edition, 2019



Approved by and published under the authority of the Secretary General

INTERNATIONAL CIVIL AVIATION ORGANIZATION



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FOREWORD

The first edition of the *Manual on the Digital Exchange of Aeronautical Meteorological Information* was published in response to the introduction of the exchange of aeronautical meteorological information in a digital form as part of Amendment 76 to Annex 3 — *Meteorological Service for International Air Navigation*, applicable 14 November 2013. As of that date, it was permissible to exchange aerodrome routine and special meteorological reports (METAR and SPECI, including trend forecasts (TREND)), aerodrome forecasts (TAF) and SIGMET information, in a digital form by States in a position to do so.

Amendment No. 1 was issued to reflect Amendment 77 to Annex 3, applicable 10 November 2016, which recommended the issuance of volcanic ash advisory and tropical cyclone advisory information, METAR and SPECI (including TREND), TAF, and SIGMET and AIRMET information in a digital form, in addition to their issuance in abbreviated plain language.

This second edition was issued in accordance with the mandatory exchange of the above information from November 2020, in addition to space weather advisory in the ICAO meteorological information exchange model (IWXXM) form, as specified in Amendment 78 to Annex 3, applicable from 8 November 2018. The title of this manual was changed from the *Manual on the Digital Exchange of Aeronautical Meteorological Information* to the *Manual on the ICAO Meteorological Information Exchange Model*.

Where States exchange space weather advisory, volcanic ash advisory and tropical cyclone advisory information, METAR and SPECI, TAF, and SIGMET and AIRMET information in a digital form, Annex 3 requires that the information:

- a) be formatted in accordance with a globally interoperable information exchange model;
- b) use extensible markup language (XML)/geography markup language (GML); and
- c) be accompanied by the appropriate metadata.

This manual is intended to assist States in each of these three respects and to clarify that States need to implement version 3 of IWXXM to meet the requirements of Amendment 79 to Annex 3.

The availability of aeronautical meteorological information in a globally interoperable digital format is seen as a key enabler for future global air traffic management within a system-wide information management (SWIM) environment. Consequently, the enabling of digital exchange is an important part of the transition of all required aeronautical meteorological information to a digital form and its integration into a SWIM environment. Future amendments to Annex 3 are therefore expected to enhance and expand the digital exchange provisions. This manual will, consequently, be subject to periodic review and amendment to ensure necessary alignment with the evolving Annex 3 provisions in this regard.

The content of the manual was developed primarily by the ICAO Meteorological Aeronautical Requirements and Information Exchange Project Team (MARIE-PT) and subsequently by the Meteorology Panel (METP) Working Group on Meteorological Information Exchange (WG-MIE). Expertise from airline and pilot representative organizations and regional programmes for air transport modernization, and the World Meteorological Organization, was used.

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LIST OF ABBREVIATIONS AND ACRONYMS

AFS*	Aeronautical fixed service
AIRMET*	Information concerning en-route weather phenomena which may affect the safety of low-level aircraft operations
AIXM	Aeronautical information eXchange model
ATM*	Air traffic management
CDM	Collaborative decision-making
FIXM	Flight information exchange model
GML	Geography markup language
ISO	International Organization for Standardization
IWXXM	ICAO meteorological information exchange model
METAR*	Aerodrome routine meteorological report (in meteorological code)
METCE	Modèle pour l'Échange des Informations sur le Temps, le Climat et l'Eau (of the World Meteorological Organization, WMO)
NOP	Network operational planning
OGC	Open Geospatial Consortium
OPM	Observable property model
SIGMET*	Information concerning en-route weather and other phenomena in the atmosphere that may affect the safety of aircraft operations
SPECI*	Aerodrome special meteorological report (in meteorological code)
SWIM	System-wide information management
TAC	Traditional alphanumeric codes
TAF*	Aerodrome forecast (in meteorological code)
TREND*	Trend forecast
UML	Unified modelling language
W3C	World Wide Web Consortium
WMO	World Meteorological Organization
XML	Extensible markup language
XSD	XML schema definitions

* Abbreviations included in the *Procedures for Air Navigation Services — ICAO Abbreviations and Codes* (PANS-ABC, Doc 8400)

Chapter 1

BACKGROUND

1.1 THE EVOLVING GLOBAL AIR TRANSPORT SYSTEM

1.1.1 The *Global Air Traffic Management Operational Concept* (Doc 9854) describes the manner in which the air traffic management (ATM) system will deliver services and benefits to airspace users by 2025-2030 and is in line with the recommendations of the Twelfth Air Navigation Conference (Montréal, 19–30 November 2012). It also details how ATM will act directly on the flight trajectory of a manned or an unmanned vehicle during all phases of flight, and the interaction of that flight trajectory with any hazard. Its scope describes the services that will be required to operate the global ATM system up to and beyond 2028.

1.1.2 This operational concept and the *Global Air Navigation Plan* (Doc 9750) address what is needed to increase user flexibility and maximize operating efficiencies in order to increase system capacity and improve safety levels in the future ATM system.

1.1.3 The guiding principle is that the ATM system is based on the provision of services. The service-based framework described in the operational concept considers all resources (including airspace, aerodromes, aircraft and humans) to be part of the ATM system. The primary functions of the ATM system will enable flight from an aerodrome into airspace and the subsequent landing, safely separated from hazards, within capacity limits, making optimum use of all system resources. The description of the operational concept components is based on realistic expectations of human capabilities and the ATM infrastructure at any particular time in the evolution of the ATM system described by this operational concept. It is independent of reference to any specific technology.

1.1.4 It is evident that the future ATM system will be founded on knowledge-based collaborative decision-making (CDM). Effective CDM requires the intelligent use of the characteristics of uncertainty that are associated with the meteorological information provided. This form of risk management will enable decision makers to make executive choices according to their own objectively determined thresholds for action.

1.1.5 The system will be a network-based operation formed of four main components:

- a) a robustly networked ATM system which improves information sharing;
- b) a sharing of quality information which enhances situational awareness;
- c) collaboration and self-synchronization enabled by shared situational awareness; and
- d) enhanced sustainability and speed of decision-making.

Collectively these will dramatically increase the efficiency of the ATM system.

1.2 NET-CENTRIC OPERATIONS

1.2.1 The concept of common (collaborative) information sharing has long been under development. It was borne from a clear recognition that future ATM will be managed on a “network-centric” (net-centric) basis, with each

aerodrome and each aircraft being considered as a node interlinked with all others within the system. Considerable investment is being made to develop the means to implement CDM at aerodromes and from a flow-management perspective, as first steps towards system-wide efficiency. Substantial progress has been made with the individual stakeholders at an aerodrome identified and the information needs and flows mapped. Site-specific trials are yielding positive results and CDM is being progressively rolled out on a global basis.

1.2.2 Nevertheless, it is clearly recognized that individual (national) airspaces and aerodromes cannot continue to be regarded as singular and isolated components of ATM. A transition to a service-centric approach within a global business framework is clearly required. ATM must be managed on a net-centric basis, and aerodrome and network CDM and the transition to a “time-ordered” system will be practical representations of this concept.

1.3 CONSEQUENCES FOR METEOROLOGICAL SERVICES

1.3.1 The global ATM system will continue to be subject to the same vagaries of weather phenomena that affect air transport today. The additional and significant volume of air traffic predicted for the coming years will render the system considerably more sensitive to disruption and the consequential increased costs associated with it. Historically, aeronautical meteorological services have mainly addressed safety issues. Now, within the context of the evolving ATM system, and while continuing to operate safely, the significant impact of weather on capacity and efficiency and the potential to mitigate some of the environmental impacts of aviation must be given greater consideration.

1.3.2 The importance of timely, accurate and easily available meteorological information for decision support is emphasized in Doc 9854. As such it is recognized that the success of the ATM system will be reliant on effective planning and management to deliver to the airspace user the (near as possible) optimum business trajectory while ensuring flexibility. Flow and capacity management enabled by high-precision time-based metering (e.g. consistently achieving the required time of arrival, four-dimensional (4D) trajectory management and short/medium-term conflict detection and resolution) will be significant means of ensuring flight punctuality, efficiency and maintaining system throughput. This will be a key component in the effective management of congested airspace and aerodromes.

1.3.3 Furthermore, based on forecast traffic volumes and their orientations, and weather forecasts, air traffic flow management will originate and control the daily plan (e.g. network operational planning (NOP), story book) and will apply any refinements to accommodate real-time events. The need to adapt the original plan may also result from forecast significant weather phenomena that are monitored on a continuous basis.

1.3.4 A key change needed is the evolution of the interfaces between the airlines, flight crews and ATM network in determining the optimum profiles for a flight. The airline operations centres will examine the requirements for a flight and the current and predicted environment in which to operate (e.g. as meteorological conditions, airspace structure, en-route capacity, aerodrome capacity and environmental considerations) so as to select the optimum flight trajectory. Meteorological information will be collated and analysed in order to assess, in conjunction with aircraft performance data and user charges, the cost benefit of modified flight profiles or alternative routes, and aircraft routing may be replanned while in flight.

1.3.5 The development of air- and ground-based automated systems, in association with new procedures and working arrangements in ATM (e.g. 4D trajectory management¹), are required to support future operations. It is expected that these will permit the dynamic management of airspace, allowing the tactical routing of aircraft to provide significant operational benefits (safety, economy, flexibility, improved regularity and environmental-impact mitigation) to users.

1. 4D trajectory management is the process that captures the overall traffic situation in the NOP and controls the development of the business or mission trajectories in four dimensions (latitude, longitude, flight level and time). Specifically, 4D trajectory management is the process by which the business trajectory of the aircraft is established, agreed, updated and revised. This is achieved through collaborative decision-making processes between the operator, ATM, and other stakeholders where applicable, except in time-critical situations when only the flight crew and controller are involved.

1.3.6 Certain meteorological conditions (e.g. low visibility, strong winds, thunderstorms) and weather-induced runway contamination (e.g. snow, volcanic ash) can and do restrict aerodrome and airspace capacity. Each aerodrome, and to some extent, each sector of airspace, is affected by local meteorological conditions which impact on their individual actual capacity at any moment in time. New equipment to support aircraft operations during hazardous meteorological conditions (e.g. advanced surface movement guidance and control systems, synthetic vision), are becoming increasingly available. Nevertheless, the key to mitigation and minimization of disruption will rely primarily on the intelligent use of increasingly accurate forecasting of meteorological conditions. This will be especially important for large, congested hub aerodromes and their associated airspace.

1.3.7 Improvements are also foreseen in terminal area short-term forecasting (e.g. departure and approach wind profiles) to maximize runway throughput. This will be achieved by the incorporation of such data into algorithms to provide tools for use by controllers to improve aerodrome throughput by delivering time-based separation rather than the inefficient distance-based separation of today, and a reduction of wake-vortex separation when conditions so exist. Furthermore, terminal area short-term forecasting will support continuous descent operations in general.

1.3.8 Figure 1-1 provides a graphical representation of the different stages in the 4D trajectory evolution linked to the various stages of planning and where the integration of meteorological information could be envisaged.

1.3.9 The key to efficient operation of the ATM system is interoperability within the ATM environment. This will be enabled by advanced communications systems, standard interfaces and by standard information exchange models that support the required seamless, transparent and open digital exchange of meteorological information.

1.3.10 An important consideration in this respect is to ensure global interoperability, not only from a meteorological information perspective, but also on interlinks with other identified relevant data domains. ATM systems, such as controller decision support tools, will not only use meteorological information but will fuse this information with other relevant information, such as aeronautical information and flight information, to support knowledge-based decision-making. Figure 1-2 provides a graphical representation of the different identified data domains and user communities.

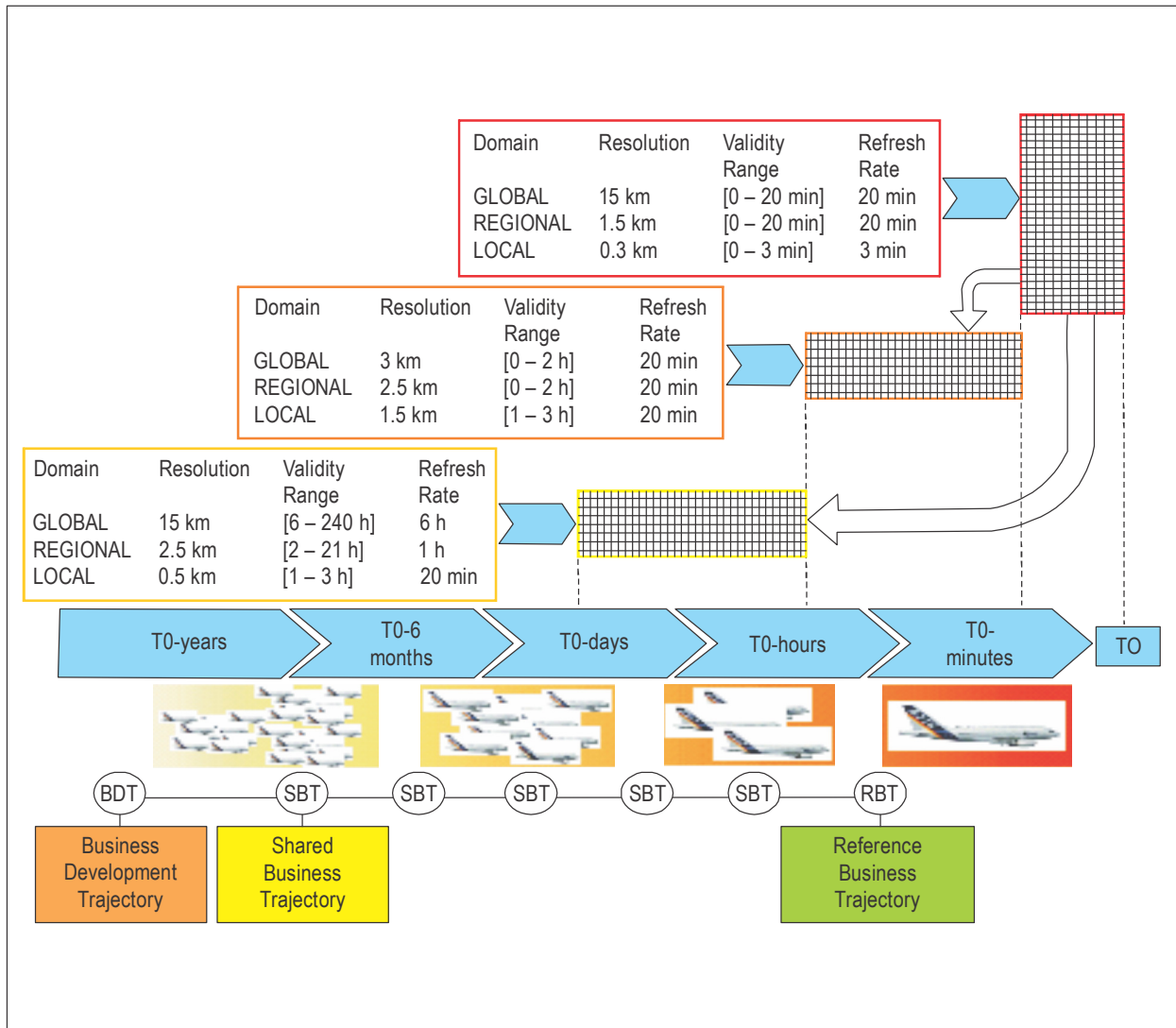


Figure 1-1. MET-ATM perspective

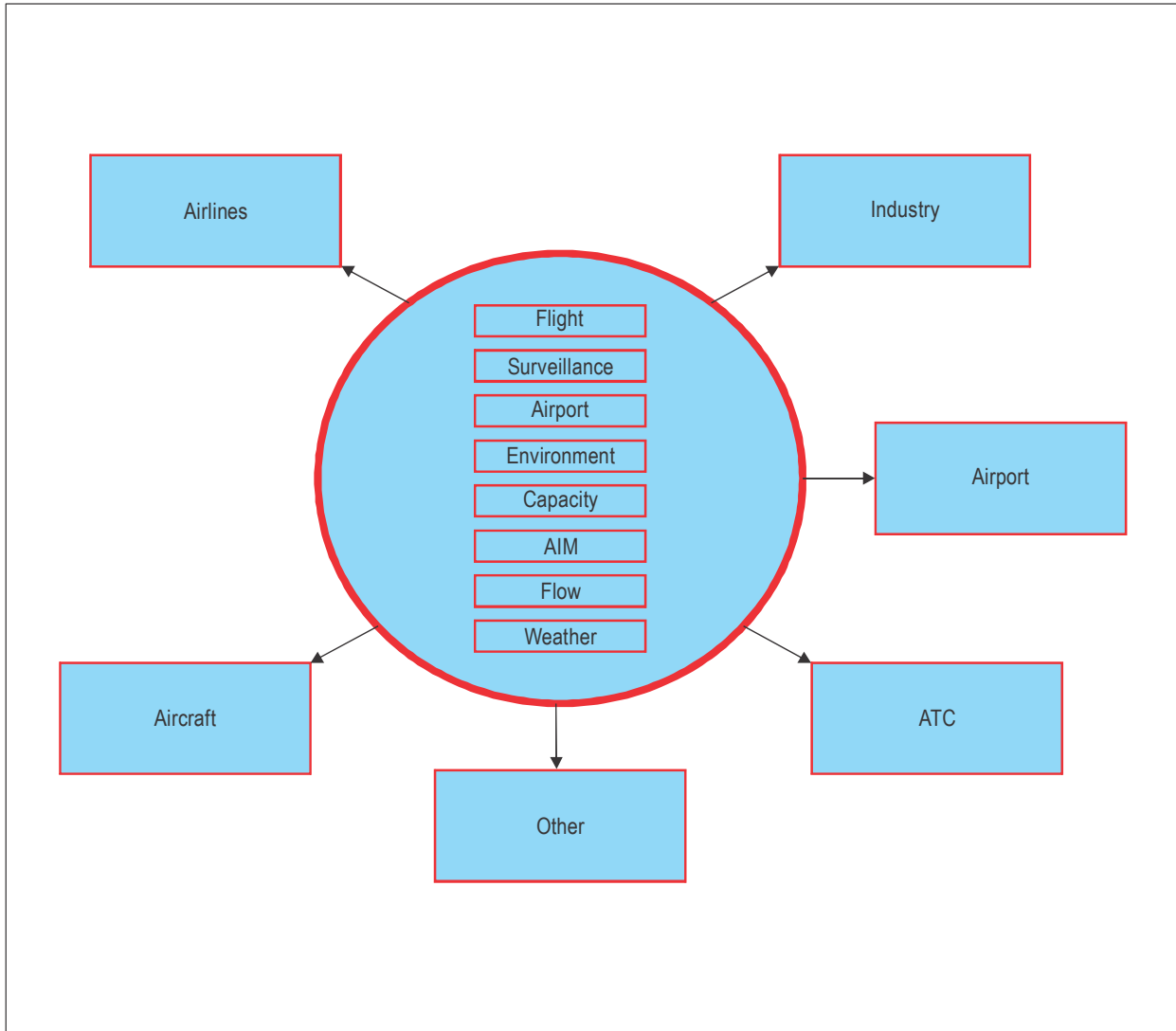


Figure 1-2. ATM information

Chapter 2

DIGITAL INFORMATION EXCHANGE PRINCIPLES

2.1 GLOBAL INTEROPERABILITY

2.1.1 To achieve global interoperability within the ATM system (see 1.3), it is crucial that the exchanged data share the same meaning at both its origin and its destination. This enables systems to combine and process received data from different identified domains and from (multiple) sources. This so-called global semantic interoperability is vital for international air navigation. It is a true strategic air transport industry asset and resource.

2.1.2 A simplified, non-exhaustive overview of the aggregation of the different information components that one could identify only in the wider context of aeronautical meteorological information exchange includes the following:

- a) ICAO global aeronautical meteorological constructs (the globally-defined aeronautical meteorological information constructs that are uniquely required by the provisions of Annex 3 and to be globally shared);
- b) ICAO regional aeronautical meteorological constructs (the regional aeronautical meteorological information constructs that are uniquely required by the provisions of ICAO regional air navigation plans as determined by regional air navigation agreement); and
- c) user-, State- or multi-State-specific aeronautical meteorological constructs (the aeronautical meteorological information constructs that are not specifically required by the provisions of Annex 3, or are additions to Annex 3 but identified as important to be shared in a specific user context with a specific user benefit).

2.1.3 These three identified components are a high-level decomposition of aeronautical meteorological information exchange, recognizing that this could be decomposed further. From a meteorological information provision perspective, each component includes elements that are not unique to aeronautical meteorology but are common to meteorology in general; or elements could be identified that are not unique to aeronautical meteorology but are common to aviation.

2.1.4 When establishing true global semantic interoperability, the efforts to standardize or specify meteorological information exchange should not be limited to the high-level perspective on aeronautical meteorological information only, but should include establishing the same meaning at both the origin and the destination of common meteorological and common aeronautical information elements. For example, the notion “runway” in a meteorological information exchange environment cannot have a different meaning from a “runway” used in aeronautical information exchange. Alternatively the meaning of “temperature” could not be modified in an aeronautical context and still be called “temperature”.

2.1.5 The decomposition of the broad domain of aeronautical meteorological information exchange in distinct elements such as the global aeronautical meteorological component, generic meteorological element and generic aeronautical element is the prerequisite for a truly data-centric environment to support international air navigation. By this decomposition, information is unbundled to potentially be rebundled and integrated in an information service that contributes to overall air transport safety and performance targets.

2.1.6 Meteorological information exchange then becomes an integral component of the system-wide information management concept, where information management solutions will be defined at the overall system level, rather than individually at each major subsystem (programme/project/process/function) and interface level, as has happened in the past (Doc 9854 refers).

2.2 SYSTEM-WIDE INFORMATION MANAGEMENT

2.2.1 The scope of global system-wide information management (SWIM) includes all the information exchanged globally between applications and the infrastructure that makes it possible by using a common methodology for information elements of interest and by the use of appropriate technology and standards. Conceptually, the following five loosely coupled, bidirectional layers are identified (see Figure 2-1):

- a) applications of global service providers and service consumers that publish and/or use information;
- b) services for information exchange, defined for each ATM information domain following governance specifications, and agreed by SWIM stakeholders;
- c) standards for information exchange that provide the subject-specific standards for sharing information for the above information exchange services;
- d) SWIM messaging infrastructure that provides the infrastructure and governance for sharing information and is sometimes referred to as the “SWIM Infrastructure”; and
- e) global information technology infrastructures, providing consolidated telecommunications services, including hardware.

2.2.2 The required provisions and guidance for the digital exchange of aeronautical meteorological information especially operate at levels b) and c) of this layered SWIM approach. The messaging infrastructure and information technology standards (levels d) and e)) are prerequisites for the Annex 3 provisions on digital information exchange and the scope of this guidance. The applications level (level a) is considered stakeholder-specific, so is the concern of the actual provider and consumer and, as such, is not included in Annex 3 provisions or in the associated guidance.

2.3 DATA, INFORMATION AND SERVICE MODELLING

2.3.1 One technique to structure the complex and interlinked aspects of global interoperability and the supporting information management framework is by modelling the data, information and services that are required from a systems perspective.

2.3.2 Data and information models are used to represent concepts, relationships, constraints, rules and operations to specify data semantics for a chosen domain of discourse, in this case ATM and its related domain aeronautical meteorology. These data models provide a shareable, stable, and organized structure of information requirements in a domain context and as such provide a key component of the required global (semantic) interoperability. Service models provide a description of (information) services needed to directly support an operational domain and as such build on the data/information captured in these respective models to define the information content of a service.

2.3.3 Different approaches exist in what the required level of abstraction and composition for data, information and services models should be for describing the required level of interoperable information exchange. For the purpose of digital aeronautical meteorological information exchange in support of Annex 3, it is sufficient to specify a so-called foundation and to represent the required models at the logical and physical level only.

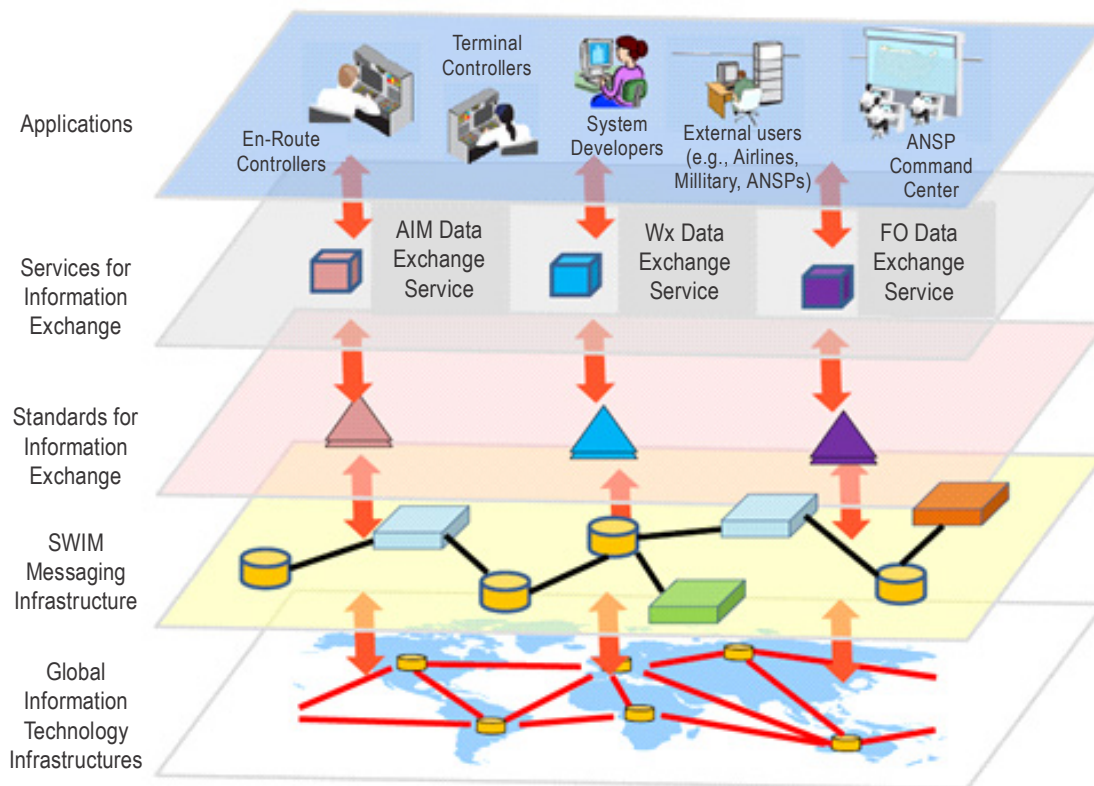


Figure 2-1. SWIM layers

2.3.4 Following iterations of the models to support the digital exchange of aeronautical meteorological information could require a separate conceptual view. This view usually provides a high-level description of the meteorological data concepts and the relationships between those concepts which are currently interwoven with the logical models, since a specific exchange solution was in mind.

2.3.5 The conceptual view should, in the medium to long term, not be described at the level of the data domain but on the level of all global air transport information exchanges required. When required, specific logical and physical representations of the meteorological exchange required could be derived from that. The recommendations of the AN-Conf/12 on a) globally interoperable system-wide information management and b) developing a logical architecture to address the global interoperability issues will drive this approach to derive logical and physical information exchange models from one reference. This will have an impact on the digital exchange of aeronautical meteorological information and the supporting models for iterations to come.

Foundation

2.3.6 Certain elementary steps need to be performed to create data models and the desired (semantic) interoperability to ensure that data exchanged from system component to system component share the same meaning at both their origin and their destination. In this elementary phase of modelling data, choices are made on the fit for use and fit for purpose of existing generic principles and standards with respect to information exchange. This so-called “foundation” of generic standards applicable for aeronautical meteorological information is primarily based on the notion

that it is a type of geospatial and time referenced information. Furthermore, when discussing the physical exchange of the information in more detail, this should be based on available generic web technology. Moreover, all should fit in the overall context of ATM information exchange also referred to in the draft ICAO SWIM Concept (in preparation).

2.3.7 The foundation applied to model aeronautical meteorological information is based on the following, mainly International Organization for Standardization (ISO), standards and specifications:

- ISO 19103 — *Geographic information — Conceptual schema language*
- ISO 19107 — *Geographic information — Spatial schema*
- ISO 19108 — *Geographic information — Temporal schema*
- ISO 19115 — *Geographic information — Metadata*
- ISO 19123 — *Geographic information — Schema for coverage geometry and functions*
- ISO 19136 — *Geographic information — Geography Markup Language (GML)*
- ISO/TS 19139 — *Geographic information — Metadata - XML schema implementation*
- ISO 639-2 — *Codes for the representation of names of languages (Part 2) Alpha-3 code*
- World Wide Web Consortium (W3C) — *XML Schema Specification*.

Logical data model

2.3.8 The level of abstraction required for a model that represents the aeronautical meteorological data exchange needs varies from system environment to system environment and is strongly related to the level of restrictions imposed by the choice of foundation.

2.3.9 To describe aeronautical meteorological information constructs with the given foundation, the level of abstraction reflected in the ICAO provisions is the logical data model. This model allows analysis of data definition aspect without consideration of implementation-specific or product-specific issues. Furthermore, the details of an often complex physical exchange of data are hidden in order to facilitate the communication of it to those who are not familiar with the techniques involved.

2.3.10 A commonly used language to provide the semantics and abstract structure of all the information that needs to be made available by meteorological service providers as prescribed by the existing provisions is the unified modelling language (UML)¹. Such a description in UML includes the intrinsic data requirements and structural business process rules and is a so-called technology independent description not concerned with code form specifications. More detail on UML is provided in Appendix A.

2.3.11 The ICAO meteorological information exchange model (IWXXM) provides such a logical data model for aeronautical meteorological information in support of international air navigation.

1. Defined by the object management group. The UML is a graphical language designed to visualize, specify, construct and document the artefacts of a software-intensive system. The UML offers a standard way to write a system's blueprints, including conceptual aspects such as business processes and system functions as well as concrete considerations such as programming language statements, database schemas and reusable software components.

Physical data model

2.3.12 From a system's architectural perspective, a guiding logical data model for aeronautical meteorological information is sufficient. This is the only prerequisite required to develop physical implementations of systems that exchange meteorological information in the ATM domain.

2.3.13 However, for the purpose of international information exchange and to establish true interoperability, it is beneficial to provide an additional level of structure. Currently, such a structure is provided by Annex 3 and other supporting documents, e.g. World Meteorological Organization Publication No. 306 — *Manual on Codes*.

2.3.14 This structure in the context of the digital exchange of aeronautical meteorological information is provided by a physical data model. Such a model for the physical implementation of aeronautical meteorological information exchange is, for instance, based on generic standards for the exchange of geospatial and time-referenced information.

Extensibility

2.3.15 As described in previous paragraphs, key to an interoperable data-centric environment satisfying user needs is the application of the common foundation of standards, specifications and modelling practices for all components of ATM information. This includes the possibility of developing an easy and cost-effective extension to the global baseline. Without the possibility of developing an extension, regional and State practices based on Annex 3 and user-specific requirements will require the development and maintenance of specific solutions for the information of their concern.

2.3.16 The extensibility of the IWXXM is fundamental to successful and affordable digital meteorological information exchange.

2.4 IDENTIFIED COMPONENTS TO SUPPORT THE DIGITAL EXCHANGE OF AERONAUTICAL METEOROLOGICAL INFORMATION

2.4.1 Based on the notions and principles described in 2.1, 2.2 and 2.3, the following structure of (model) components has been chosen to support the digital exchange of aeronautical meteorological information:

- a) *IWXXM logical model*. The exchange model for aeronautical meteorological information in UML, in the form of an ISO 19109 application schema, which, in its version 3, describes the exchange of space weather advisory, volcanic ash advisory and tropical cyclone advisory information, METAR and SPECI (including TREND), TAF, and SIGMET and AIRMET only²;
- b) *IWXXM XML schema*. A GML-based³ implementation of the IWXXM logical model derived programmatically following proven industry standards and best practices; and
- c) *WMO packages*⁴ which are either foundation elements (2.3.6 and 2.3.7 refer) from an IWXXM perspective or a construct for packaging a collection of IWXXM messages expressed as logical models in the form of UML class diagrams and as GML-based implementations (schema):

2. By some architectural frameworks, the current iteration of the IWXXM logical model would not qualify as a data model but as an information service model due to its specific nature of describing the exchange of legacy reports.

3. GML is the XML grammar defined by the OGC to express geographical features. GML serves as a modelling language and an open interchange format for geographic information transactions. The ability to integrate all forms of geographic information is key to the utility of GML.

4. The manual includes guidance on the IWXXM logical model and IWXXM XML schema only. For the WMO components refer to the appropriate WMO guidance material.

- 1) Modèle pour l'Échange des Informations sur le Temps, le Climat et l'Eau (WMO METCE) provides conceptual definitions of meteorological phenomena, entities and concepts in order to underpin semantic interoperability in the weather, climate and water domain in the form of an application schema⁵;
- 2) Observable Property Model (OPM) provides a framework for qualifying or constraining physical properties based on a draft best practice developed by the Open Geospatial Consortium (OGC) Sensor Working Group⁶; and
- 3) WMO Feature Collection Model (COLLECT) is used to represent a collection of one or more IWXXM messages⁷ of the same type. The intent is to allow IWXXM encoded meteorological information to be packaged in a way that emulates the existing data distribution practices used within the aeronautical fixed service (AFS).

2.4.2 Figure 2-2 provides an overview of the described structure in the form of a UML package diagram.

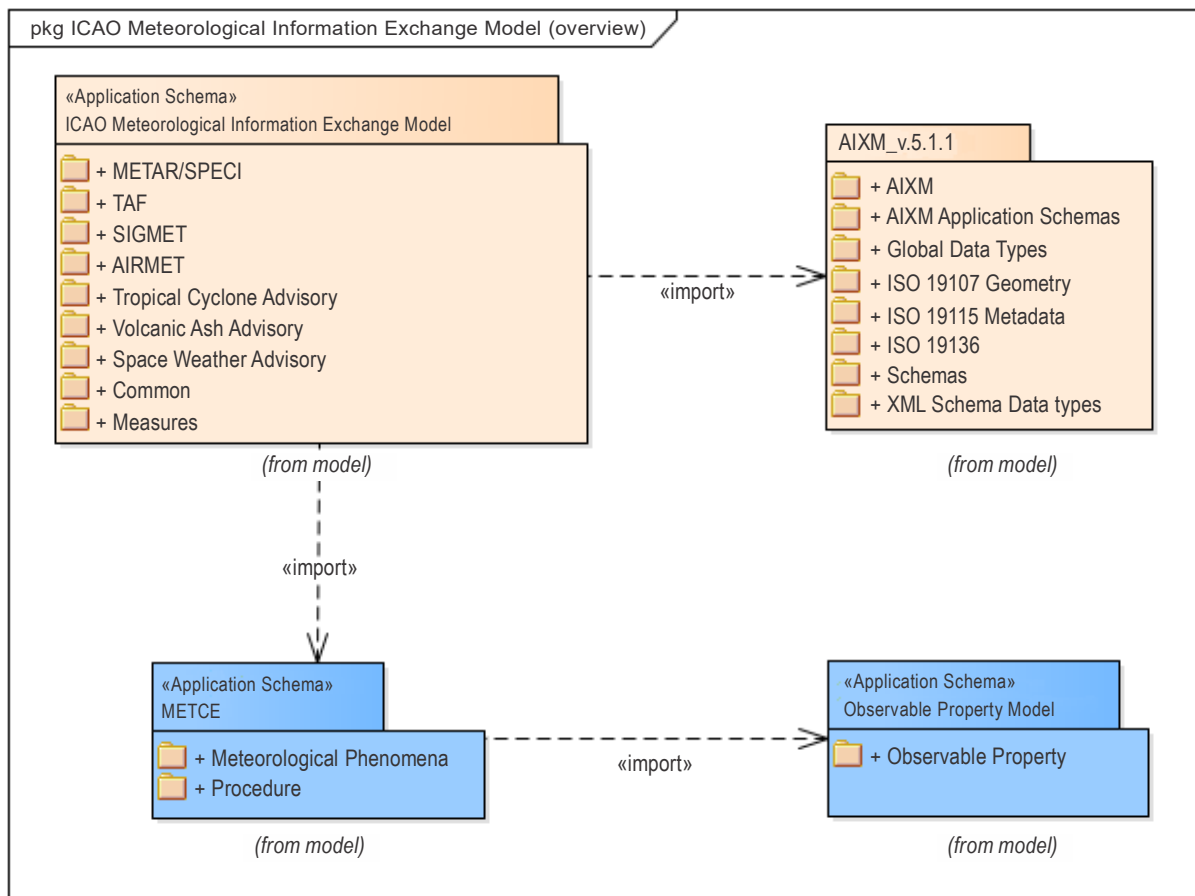


Figure 2-2. UML package diagram

5. The relevant schema, in the form of xsd-files, are available at <http://schemas.wmo.int/metce/>.

6. The relevant schema, in the form of xsd-files, are available at <http://schemas.wmo.int/opm/>.

7. A collection of meteorological information is often referred to as a bulletin.

Chapter 3

IWXXM LOGICAL MODEL

3.1 SCOPE

3.1.1 It is important to consider that the scope of the IWXXM logical model will evolve as aeronautical meteorological information requirements and the digital exchange of this required information will change over time. Additionally, not only evolving meteorological requirements but also emerging developments in other ICAO data domains will have an impact on the scope of the IWXXM.

3.1.2 This requires a modular approach for the logical data model which is provided by a strict adherence of next iterations of the logical data model to the declared foundation (inclusive of the WMO packages). The foundation provides the common ground for this modular approach and thus a flexible IWXXM.

3.1.3 Figure 3-1 provides a graphical representation of the foundation elements of the IWXXM. The IWXXM will, over time, evolve into the single global baseline for aeronautical meteorological information exchange, capturing all the global information exchange requirements with the possibility of creating IWXXM extensions to satisfy user specific needs.

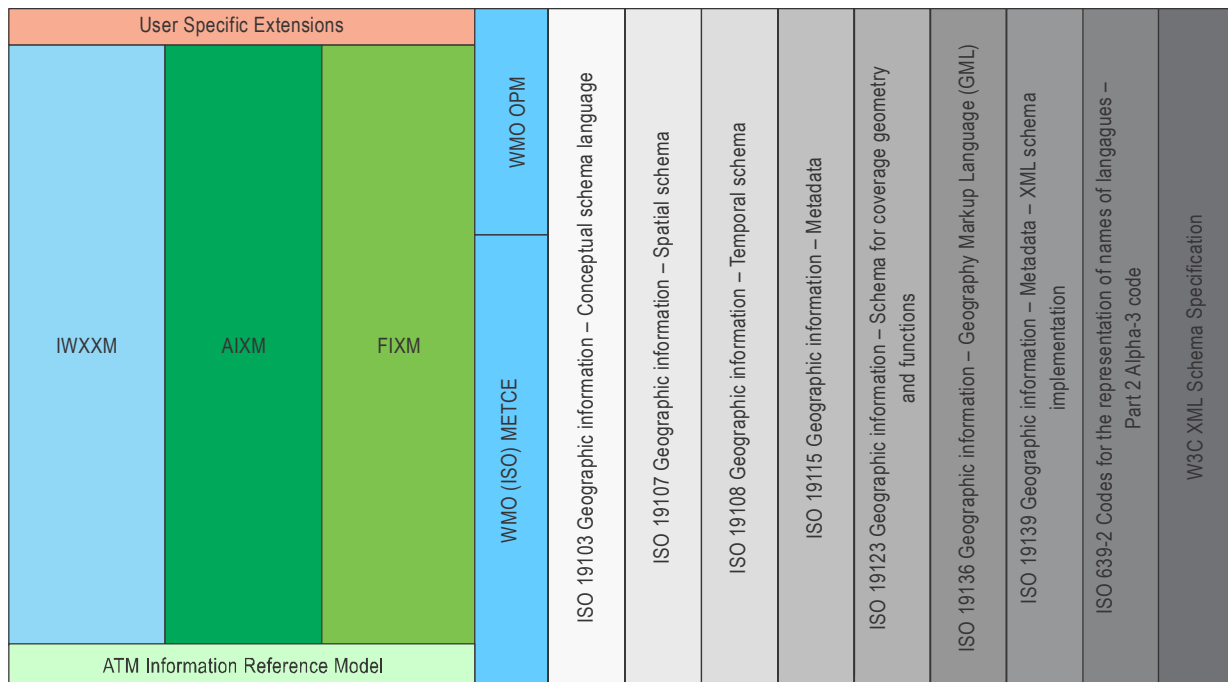


Figure 3-1. IWXXM and its foundation elements

3.2 BASELINE VERSION

The baseline for the IWXXM includes all information involved in the exchange of meteorological information described in Annex 3 which includes:

- a) METAR (including TREND);
- b) SPECI (including TREND);
- c) TAF;
- d) SIGMET;
- e) AIRMET
- f) tropical cyclone advisory;
- g) volcanic ash advisory; and
- h) space weather advisory.

3.3 SPECIFICATION

3.3.1 The IWXXM logical model describing the exchange of METAR and SPECI (including TREND), TAF, SIGMET, AIRMET, tropical cyclone advisory, volcanic ash advisory and space weather advisory information is specified by a number of interdependent context (class) diagrams written in UML. The context (class) diagrams describe the interrelationships between identified features, types and allowed enumerations.

3.3.2 The following context (class) diagrams specify the IWXXM at the logical level:

- a) METAR/SPECI:
 - 1) METAR/SPECI;
 - 2) METAR/SPECI observation;
 - 3) METAR/SPECI trend forecast;
 - 4) METAR/SPECI weather;
 - 5) METAR/SPECI runway state;
- b) TAF:
 - 1) TAF
 - 2) TAF forecast
- c) SIGMET:
 - 1) SIGMET;

- 2) SIGMET analysis;
- 3) SIGMET forecast position;
- d) AIRMET:
 - 1) AIRMET;
 - 2) AIRMET evolving condition analysis;
- e) tropical cyclone advisory:
 - 1) tropical cyclone advisory;
 - 2) tropical cyclone observed conditions;
 - 3) tropical cyclone forecast conditions;
- f) volcanic ash advisory:
 - 1) volcanic ash advisory;
 - 2) volcanic ash conditions;
- g) space weather advisory:
 - 1) space weather advisory;
 - 2) space weather conditions;
- h) common:
 - 1) cloud;
 - 2) surface wind;
 - 3) weather;
 - 4) relational operator; and
- i) measures:
 - 1) measure.

3.3.3 Figure 3-2 provides an example of a context diagram for meteorological aerodrome observation.

3.3.4 All the IWXXM context (class) diagrams with identified features, types and allowed enumerations are published in World Meteorological Organization Publication No. 306 — *Manual on Codes*, Volume I.3, Part D — *Representations derived from data models*, which is available online at <http://www.wmo.int/pages/prog/www/WMOCodes.html>.

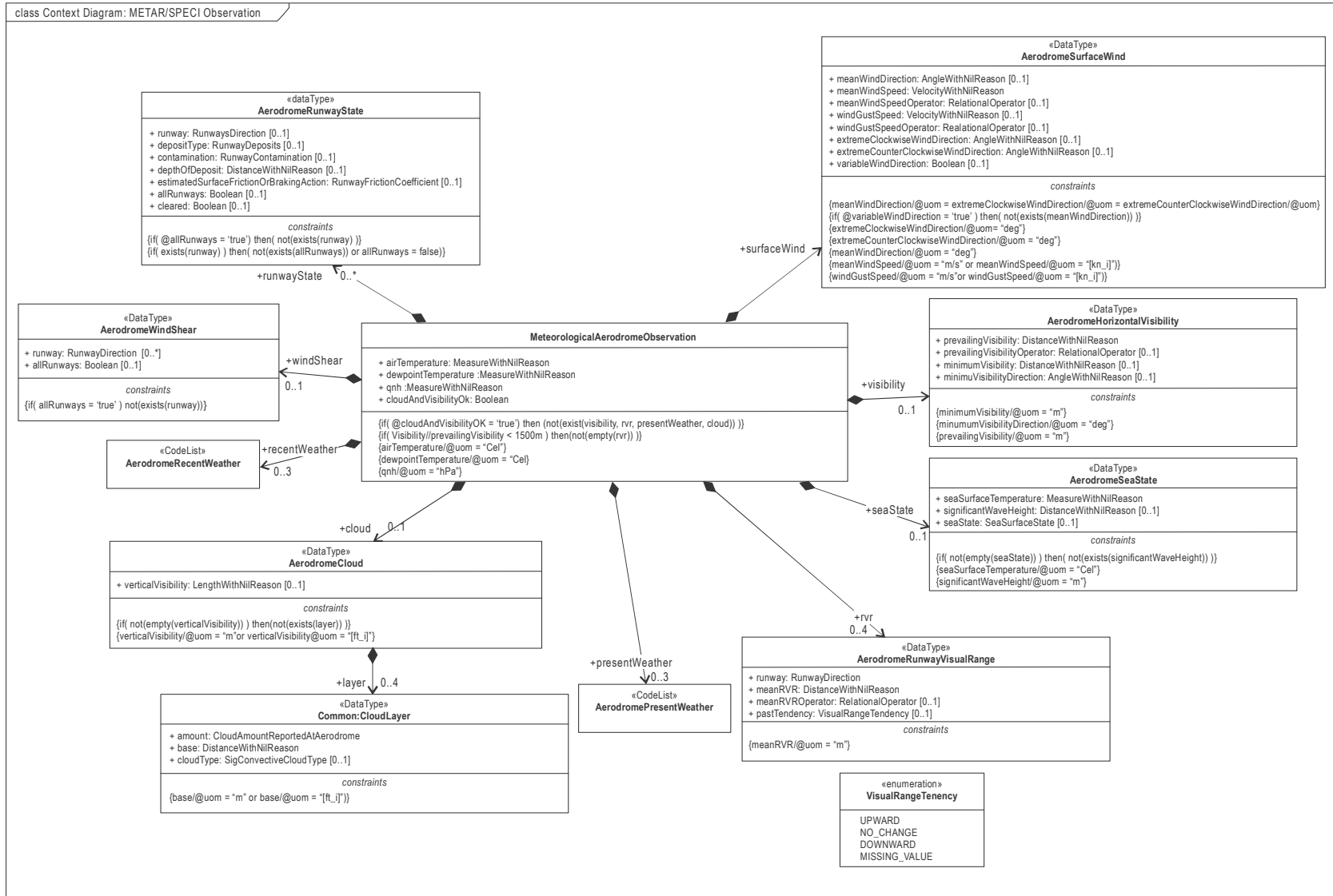


Figure 3-2. Example of a context diagram METAR/SPECI Observation

Chapter 4

IWXXM XML SCHEMA

4.1 INTRODUCTION

4.1.1 The IWXXM XML schema is a physical data model for aeronautical meteorological information in support of the meteorological service for international air navigation. It is a GML-based application of the logical data model. It uses pre-defined XML/GML elements and is based on industry standards and the available WMO packages: the physical model elements of the so-called foundation.

4.1.2 A physical exchange form based on XML was identified as the most suitable for the digital exchange of aeronautical meteorological information. Moreover, this general consensus extends to the need to migrate towards a specific XML grammar to express geographical features. The specific XML grammar selected to describe meteorological information in function of time, place, coverage, etc. is GML. More detail on XML/GML is provided in Appendix B.

4.1.3 Note that not every existing or emerging code format to exchange aeronautical meteorological information should necessarily be replaced by a GML-based code format in IWXXM. For example, gridded data can be exchanged in other, more efficient manners. Optionally, GML could still be used as the so-called “wrapper” of the information when found necessary.

4.1.4 However, independent of the exchange format, it is essential that all the information constructs, including for the gridded data, are captured at the technology- and format-independent layer of the IWXXM logical data model.

4.2 SPECIFICATION

XML/GML schema for aeronautical meteorological information exchange

4.2.1 The IWXXM XML/GML schema describing the physical exchange of METAR and SPECI (including TREND), TAF, SIGMET, tropical cyclone advisory, volcanic ash advisory, space weather advisory and AIRMET in the form of XML is specified by a number of XML schema definitions (XSD). IWXXM version 3 was introduced to meet the requirements of Amendment 79 to Annex 3 and only version 3 of IWXXM (or later) shall be exchanged on operational networks from 5 November 2020.

4.2.2 The following XSD specify the IWXXM at the physical exchange level:

- a) iwxxm.xsd;
- b) metarSpeci.xsd;
- c) taf.xsd;
- d) sigmet.xsd;

- e) airmet.xsd;
- f) tropicalCycloneAdvisory.xsd;
- g) volcanicAshAdvisory.xsd;
- h) spaceWeatherAdvisory.xsd;
- i) common.xsd; and
- j) measure.xsd.

4.2.3 Table 4-1 provides an example, adapted from <http://schemas.wmo.int/iwxxm/3.0.0RC3/metarSpeci.xsd>, of a fragment of metarSpeci.xsd from the IWXXM.

4.2.4 All the IWXXM XSD are published at <http://schemas.wmo.int/iwxxm>.

Table 4-1. A fragment of metarSpeci.xsd

```
<?xml version="1.0" encoding="UTF-8"?>
<schema elementFormDefault="qualified" targetNamespace="http://icao.int/iwxxm/3.0" version="3.0.0RC1"
xmlns:iwxxm="http://icao.int/iwxxm/3.0" xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns="http://www.w3.org/2001/XMLSchema">

  <include schemaLocation="measures.xsd"></include>
  <include schemaLocation="common.xsd"></include>
  <import namespace="http://www.opengis.net/gml/3.2"
schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"></import>
  <annotation>
    <documentation>METAR and SPECI reporting constructs as defined in ICAO Annex 3 / WMO No. 49-2.

    METAR and SPECI reports include identical information but are issued for different purposes.

    METAR reports are routine observations made at an aerodrome throughout the day. METAR observations are
    made (and distributed) at intervals of one hour or, if so determined by regional air navigation agreement, at
    intervals of one half-hour.

    SPECI reports are special (i.e. non-routine) observation made at an aerodrome as needed. SPECI observations
    are made (and distributed) in accordance with criteria established by the meteorological authority, in consultation
    with the appropriate ATS authority, operators and others concerned.

    References to WMO and ICAO Technical Regulations within this XML schema shall have no formal status and
    are for information purposes only. Where there are differences between the Technical Regulations and the
    schema, the Technical Regulations shall take precedence. Technical Regulations may impose requirements that
    are not described in this schema. </documentation>
  </annotation>
  <simpleType name="TrendForecastTimeIndicatorType">
    <annotation>
      <documentation>Time indicators for trend forecast conditions. These are equivalent to the traditional FM, TL, and AT
      codes</documentation>
    </annotation>
    <restriction base="string">
      <enumeration value="AT">
        <annotation>
          <documentation>This trend forecast specifies a time instant at which time conditions occur (AT)</documentation>
        </annotation>
      </enumeration>
      <enumeration value="UNTIL">
        <annotation>
          <documentation>This trend forecast specifies a time period which commences at the beginning of the trend forecast
          period and is completed by a specified time (TL)</documentation>
        </annotation>
      </enumeration>
    </restriction>
  </simpleType>
```

```

    <enumeration value="FROM">
    <annotation>
      <documentation>This trend forecast specifies a time period which commences at a specified time and is completed
    by the end of the trend forecast period (FM)</documentation>
    </annotation>
    </enumeration>
    <enumeration value="FROM_UNTIL">
    <annotation>
      <documentation>This trend forecast specifies a time period which commences at a specified time and is completed
    by another specified time (FM and TL)</documentation>
    </annotation>
    </enumeration>
  </restriction>
</simpleType>

<element name="MeteorologicalAerodromeObservationReport"
type="iwxxm:MeteorologicalAerodromeObservationReportType" substitutionGroup="iwxxm:Report" abstract="true">
  <annotation>
    <documentation>A report of observed and trend forecast weather phenomenon from the
    surface near an aerodrome. This is a shared superclass for METAR and SPECI reports, which have identical reported
    information.</documentation>
  </annotation>
</element>
<complexType name="MeteorologicalAerodromeObservationReportType" abstract="true">
  <complexContent>
    <extension base="iwxxm:ReportType">
      <sequence>
        <element name="aerodrome" type="iwxxm:AirportHeliportPropertyType">
          <annotation>
            <documentation>The aerodrome location for this report</documentation>
          </annotation>
        </element>
        <element name="issueTime" type="gml:TimeInstantPropertyType">
          <annotation>
            <documentation>The time at which this report was issued</documentation>
          </annotation>
        </element>
        <element name="observationTime" type="gml:TimeInstantPropertyType">
          <annotation>
            <documentation>The time at which phenomena were observed. This may differ from the times reported for
    forecast conditions</documentation>
          </annotation>
        </element>
        <element nillable="true" name="observation" type="iwxxm:MeteorologicalAerodromeObservationPropertyType">
          <annotation>
            <documentation>The observation which resulted in the current meteorological conditions at an
    aerodrome</documentation>
          </annotation>
        </element>
        <element nillable="true" name="trendForecast" minOccurs="0" maxOccurs="3">
          <annotation>
            <documentation>The process that results in a trend forecast. When no change is expected to occur during a forecast period
    ("NOSIG") this is indicated by a single missing trend forecast with a nil reason of noSignificantChange</documentation>
          </annotation>
        </element>
      </sequence>
    </extension>
  </complexContent>
</complexType>
</element>
</sequence>
...

```

Referencing meteorological vocabulary in IWXXM

4.2.5 In IWXXM, meteorological vocabulary has been moved out of the model so that changes to the vocabulary do not require a corresponding change in the data model. A uniform resource identifier (URI) is used in IWXXM messages to describe a meteorological concept or phenomena. For example, drizzle, as described in Table 4678 of World Meteorological Organization Publication No. 306°— *Manual on Codes*, is written as URI <http://codes.wmo.int/306/4678/DZ> in an XML document. See Table 4-2 for a fragment of a METAR XML message, adapted from <http://schemas.wmo.int/iwxxm/3.0.0RC3/examples/metar-A3-1.xml>, with drizzle in its present weather.

4.2.6 WMO has published authoritative meteorological terms on the WMO Codes Register (Appendix C refers) at <http://codes.wmo.int> to facilitate referencing of meteorological vocabulary in IWXXM. Through a browser, one can view not only whether a registry reference is valid, but also the authentic and detailed description of the entry. A local copy of the registry can also be used to validate the content of an IWXXM instance.

Table 4-2. A fragment of an XML METAR message

```
<?xml version="1.0" encoding="UTF-8"?>
<!--
  An example of a METAR.  Original METAR from ICAO Annex 3 Example A3-1:

  METAR YUDO 221630Z 24004MPS 0600 R12/1000U DZ FG SCT010 OVC020 17/16 Q1018
  BECMG TL1700 0800 FG BECMG AT1800 9999 NSW
-->
<iwxxm:METAR xmlns:iwxxm="http://icao.int/iwxxm/3.0" xmlns:xlink="http://www.w3.org/1999/xlink"
  xmlns:gml="http://www.opengis.net/gml/3.2"
  xmlns:aixm="http://www.aixm.aero/schema/5.1.1"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://icao.int/iwxxm/3.0 http://schemas.wmo.int/iwxxm/3.0.0RC1/iwxxm.xsd"
  gml:id="uuid.510df5de-feb-4406-bafd-faab35333ec0"
  permissibleUsage="OPERATIONAL"
  status="NORMAL"
  automatedStation="false">

  <!-- The aerodrome at which this observation took place -->
  <iwxxm:aerodrome>
    <aixm:AirportHeliport gml:id="uuid.143d63d9-15f5-442e-9bdc-1f3db93fb619">
      <aixm:timeSlice>
        <aixm:AirportHeliportTimeSlice gml:id="uuid.75c3340c-3679-4e31-8aec-efdabe375d49">
          <gml:validTime/>
          <aixm:interpretation>SNAPSHOT</aixm:interpretation>
          <aixm:designator>YUDO</aixm:designator>
          <aixm:name>DONLON/INTERNATIONAL</aixm:name>
          <aixm:locationIndicatorICAO>YUDO</aixm:locationIndicatorICAO>
          <aixm:ARP>
            <aixm:ElevatedPoint gml:id="uuid.dd2c810b-edaa-4ad9-bb65-9ab774d1522e" srsDimension="2"
              srsName="http://www.opengis.net/def/crs/EPSSG/0/4326">
              <gml:pos>12.34 -12.34</gml:pos>
            </aixm:ElevatedPoint>
          </aixm:ARP>
        </aixm:AirportHeliportTimeSlice>
      </aixm:timeSlice>
    </aixm:AirportHeliport>
  </iwxxm:aerodrome>

  <!-- the same as observationTime except for corrections/re-issuances -->
  <iwxxm:issueTime>
    <gml:TimeInstant gml:id="uuid.e5460ae4-98a4-48fa-bbfc-21799896f1f2">
      <gml:timePosition>2012-08-22T16:30:00Z</gml:timePosition>
    </gml:TimeInstant>
  </iwxxm:issueTime>

  <!-- time at which the METAR phenomena were observed -->
```

```

<iwxxm:observationTime>
  <gml:TimeInstant gml:id="uuid.85802aab-b4e5-4c4b-9303-10a02064e243">
    <gml:timePosition>2012-08-22T16:30:00Z</gml:timePosition>
  </gml:TimeInstant>
</iwxxm:observationTime>

<iwxxm:observation>
  <iwxxm:MeteorologicalAerodromeObservation gml:id="uuid.dc262f4d-1dc8-428b-91d8-74e10ed3cf69"
  cloudAndVisibilityOK="false">
    <iwxxm:airTemperature uom="Cel">17.0</iwxxm:airTemperature>
    <iwxxm:dewpointTemperature uom="Cel">16.0</iwxxm:dewpointTemperature>
    <iwxxm:qnh uom="hPa">1018</iwxxm:qnh>
    <iwxxm:surfaceWind>
      <iwxxm:AerodromeSurfaceWind variableWindDirection="false">
        <iwxxm:meanWindDirection uom="deg">240</iwxxm:meanWindDirection>
        <iwxxm:meanWindSpeed uom="m/s">4.0</iwxxm:meanWindSpeed>
      </iwxxm:AerodromeSurfaceWind>
    </iwxxm:surfaceWind>
    <iwxxm:visibility>
      <iwxxm:AerodromeHorizontalVisibility>
        <iwxxm:prevailingVisibility uom="m">600</iwxxm:prevailingVisibility>
      </iwxxm:AerodromeHorizontalVisibility>
    </iwxxm:visibility>
    <iwxxm:rvr>
      <iwxxm:AerodromeRunwayVisualRange pastTendency="UPWARD">
        <iwxxm:runway>
          <aixm:RunwayDirection gml:id="uuid.f920a641-0eba-4fa3-9411-5c50444a0aa3">
            <aixm:timeSlice>
              <aixm:RunwayDirectionTimeSlice gml:id="uuid.23b637cb-c450-4a24-83dd-ec6b965fe71d">
                <gml:validTime/>
                <aixm:interpretation>SNAPSHOT</aixm:interpretation>
                <aixm:designator>12</aixm:designator>
              </aixm:RunwayDirectionTimeSlice>
            </aixm:timeSlice>
          </aixm:RunwayDirection>
        </iwxxm:runway>
        <iwxxm:meanRVR uom="m">1000</iwxxm:meanRVR>
      </iwxxm:AerodromeRunwayVisualRange>
    </iwxxm:rvr>
    <iwxxm:presentWeather xlink:href="http://codes.wmo.int/306/4678/DZ"/>
    <iwxxm:presentWeather xlink:href="http://codes.wmo.int/306/4678/FG"/>
    <iwxxm:cloud>
      <iwxxm:AerodromeCloud>
        <iwxxm:layer>
          <iwxxm:CloudLayer>
            <iwxxm:amount xlink:href="http://codes.wmo.int/bufr4/codeflag/0-20-008/2"/>
            <iwxxm:base uom="[ft_ij]">1000</iwxxm:base>
          </iwxxm:CloudLayer>
        </iwxxm:layer>
        <iwxxm:layer>
          <iwxxm:CloudLayer>
            <iwxxm:amount xlink:href="http://codes.wmo.int/bufr4/codeflag/0-20-008/4"/>
            <iwxxm:base uom="[ft_ij]">2000</iwxxm:base>
          </iwxxm:CloudLayer>
        </iwxxm:layer>
      </iwxxm:AerodromeCloud>
    </iwxxm:cloud>
  </iwxxm:MeteorologicalAerodromeObservation>
</iwxxm:observation>
...

```

Extended content in IWXXM

4.2.7 Version 1.1 (2015) of the IWXXM schemas was a strict implementation of Annex 3 technical specifications for products and did not allow for additional content to appear in the resulting XML documents. However, given the built-in ability of XML to allow the complex types of a schema to be extended, this was not a significant limitation. States not only extended IWXXM 1.1 complex types to support requirements of the Annex 3 products, they also modified their unique specifications at the same time. After reviewing the technique used to extend IWXXM 1.1 schemas, there were concerns that the approach was too burdensome for States to implement, therefore the use of the XML extensible feature was not applied consistently, despite using XML built-in capabilities.

4.2.8 To facilitate consistency in how additional content appears in IWXXM, starting from version 2.1 (2017), the IWXXM schemas have an additional element, named "extension", in many of its complex type definitions. This solution allows unique and customized content in the resulting XML documents. The optional <extension> elements are of type <anyType>. As such, any simple or complex type defined in IWXXM or other published schemas like AIXM and FIXM or by the State in a separate schema file can be used. Typically, a State would create and define their own complex types specific to their needs in a schema file and make the file widely available. An IWXXM XML product with extended content would also refer to the State's schema file so that XML validation tools could find the definitions and verify correct usage.

4.2.9 To illustrate, suppose a State wishes to include wind shear information, as measured by radar profilers situated at the country's major airports, into their METAR and SPECI report. Table 4-3 shows a fragment of the schema file created containing an XML complex type to encode the profiler information. An IWXXM METAR message with additional wind shear information so encoded may look like the XML document in Table 4-4.

Table 4-3. A fragment of a national extension schema for encoding additional wind shear information

```
<schema elementFormDefault="qualified" targetNamespace="http://weather.gov/ss/iwxxm-ss/1.0" version="1.0"
  xmlns="http://www.w3.org/2001/XMLSchema" xmlns:gml="http://www.opengis.net/gml/3.2"
  xmlns:iwxxm-ss="http://weather.gov/ss/iwxxm-ss/1.0">
  <import namespace="http://www.opengis.net/gml/3.2" schemaLocation="http://schemas.opengis.net/gml/3.2.1/gml.xsd"/>
  <!--
    This schema file is meant to illustrate the use of IWXXM <extension> elements and how externally defined
    complex types would appear IWXXM XML documents
  -->
  <annotation>
  <documentation>
    Low-level wind shear is one of the major hazards to flight safety. Sudden changes in lift near the ground
    give pilots little time to recover. With the deployment of radar profilers at the major, high traffic airports that
    are able to detect low-level wind shears below 500 meters, it is vitally important that information regarding
    the base height and magnitude of the wind shear layer be communicated to airport traffic controllers and
    pilots. The complex type defined below will allow profiler data at the time of the METAR or SPECI measurement
    period be included in the IWXXM XML document.
  </documentation>
  </annotation>
  <element name="windShearAlert" type="iwxxm-ss:WindShearAlertType"/>
  <complexType name="WindShearAlertType">
    <annotation>
    <documentation>
      Complex type to convey wind shear information to air-traffic control and pilots. Wind shears usually occur near
      the boundary of the PBL and the free atmosphere. Shear is given in units of 'per time'.
    </documentation>
    </annotation>
    <sequence>
      <element name="windShearBaseHeight" type="gml:MeasureType"/>
      <element name="windShearValue" type="gml:MeasureType"/>
      <element name="windShearMagnitude" type="iwxxm-ss:WindShearSeverityTypes"/>
      <element name="windSpeedAtBase" type="gml:SpeedType"/>
    </sequence>
  </complexType>
</schema>
```

```

    <element name='windDirectionAtBase' type='gml:AngleType'/>
  </sequence>
</complexType>
<simpleType name="WindShearSeverityTypes">
  <annotation>
    <documentation>
      Simple table to describe the wind shear values (WS) in qualitative terms:
      "Moderate" 0.06 < WS <= 0.12 per second
      "Severe" 0.12 < WS <= 0.17 per second
      "Extreme" WS > 0.17 per second

      For large commercial aircraft, these categories represent loss/gain of relative wind speed over the wing of 10-15, 15-
      20, and 20 knots and greater.
    </documentation>
  </annotation>
  <restriction base="string">
    <enumeration value="Moderate"/>
    <enumeration value="Severe"/>
    <enumeration value="Extreme"/>
  </restriction>
</simpleType>
</schema>

```

Table 4-4. An XML METAR message with extension

```

<METAR xmlns="http://icao.int/iwxxm/3.0" status="NORMAL" permissibleUsage="OPERATIONAL" gml:id="...">
  <observation>
    <iwxxm:aerodrome/>
    <iwxxm:issueTime/>
    <iwxxm:observationTime/>
    <iwxxm:observation>
      <iwxxm:MeteorologicalAerodromeObservation/>
      <iwxxm:airTemperature/>
      <iwxxm:dewpointTemperature/>
      <iwxxm:qnh/>
      <iwxxm:surfaceWind/>
      <iwxxm:visibility/>
      <iwxxm:rvr/>
      <iwxxm:presentWeather/>
      <iwxxm:cloud/>
      <windShear>
        <AerodromeWindShear allRunways='true'>
          <extension>
            <windShearAlert xmlns="http://weather.gov.ss/iwxxm-ss/1.0"
              xsi:schemaLocation="http://weather.gov.ss/iwxxm-ss/1.0 http://weather.gov.ss/iwxxm-ss/1.0/IWXXM-SS.xsd">
              <windShearBaseHeight uom="[ft_i]">780</windShearBaseHeight>
              <windShearValue uom="1/s">0.084</windShearValue>
              <windShearMagnitude>Moderate</windShearMagnitude>
              <windSpeedAtBase uom="[kn_i]">32</windSpeedAtBase>
              <windDirectionAtBase uom="deg">145</windDirectionAtBase>
            </windShearAlert>
          </extension>
        </AerodromeWindShear>
      </windShear>
    </MeteorologicalAerodromeObservation>
  </observation>
</METAR>

```


Chapter 5

METADATA FOR AERONAUTICAL METEOROLOGICAL INFORMATION EXCHANGE

5.1 INTRODUCTION

5.1.1 The traditional requirement is for meteorological bulletins to be compact and concise due to constraints including communication bandwidths. Because of this, only a minimal amount of information is contained therein. Previously, when data or exercises were distributed over operational networks, the content of the traditional alphanumeric code (TAC) messages involved were modified (and hence deviated from the standard template in Annex 3) to differentiate them from other operational messages and avoid misuse. While the human-readable modified TAC messages could be recognized by users, the changes may not be picked up by the machines decoding the messages, especially as the associated modifications are likely to be different in different cases. The situation will be even more complex for non-human-readable IWXXM messages, as the schemas involved are rigid, making it possible to create a modified message that could pass XML validation and be interpreted by downstream machines for display in a human-readable form.

5.1.2 Starting from Version 2.1 of IWXXM, well-known indicators and information have been included as metadata in IWXXM messages to facilitate interpretation of the messages.

5.2 METADATA AS INDICATORS

Operational and non-operational status indicators

5.2.1 In certain circumstances, it has been, and will continue to be, necessary to issue IWXXM messages under test or exercise conditions. In particular, VAA, TCA and SIGMET messages are issued from time to time for test or exercise purposes. Operational and non-operational status indicators have been introduced in IWXXM to let the machines differentiate test or exercise messages from real messages so they can be properly handled; operational and non-operational messages are filtered on a display.

5.2.2 An operational message is intended as the basis for operational decision-making. As such, the content of the message may result in decisions that may affect any or all phases of flight by any authorized and competent stakeholder (i.e. air navigation service providers, airport authorities, pilots, flight dispatchers, etc.). Recipients of such messages (either automatic or human) would therefore expect that the information is sourced from a competent entity, that the originating equipment (sensors, etc.) is serviceable, and that any human involvement is carried out by qualified, competent personnel.

5.2.3 A non-operational message is not intended to be used for operational decision-making, even though it may contain realistic data (particularly during an exercise). Recipients of such messages shall ignore the content of the message with regard to operational decision-making. Non-operational messages may be further classified as either being related to tests or exercises.

5.2.4 Guidelines on the use of operational and non-operational indicators in IWXXM can be found on the WMO website at <https://wiswiki.wmo.int/tiki-index.php?page=TT-AvXML&structure=WIS+up>.

Translation Centre Information

5.2.5 While it is anticipated that IWXXM messages will eventually be prepared at the source, it is inevitable that during the early stage of IWXXM implementation, some States may not be able to provide IWXXM messages and may require a national OPMET centre (NOC), a regional OPMET centre (ROC) or a regional OPMET databank (RODB) to carry out the translation of TAC to IWXXM on behalf of the States. To identify these messages from those generated at the source and to enable translated message traceability, translation centre information has been introduced as metadata in IWXXM.

5.2.6 Further information on the inclusion of translation centre information in IWXXM can be found on the WMO website at <https://wiswiki.wmo.int/tiki-index.php?page=TT-AvXML&structure=WIS+up>.

Chapter 6

ENSURING INFORMATION QUALITY THROUGH XML VALIDATION

6.1 INTRODUCTION

6.1.1 Creating correctly-formatted aeronautical meteorological messages is an essential part of ensuring the quality of information being exchanged. Traditional alphanumeric code (TAC) information (e.g. METAR, SPECI, TAF, SIGMET, etc.) is currently distributed with many errors in the data streams. These errors come in many different forms: transposed characters due to human error; extra, non-standard content; the number '0' instead of the letter 'O'; incorrect ordering of information elements; missing required information markers; alternative formatting for location information; and many others. As a free text format, TAC data is particularly vulnerable to a variety of data issues. Data quality checks on TAC data have previously been performed by using TAC decoder software to try to read the TAC messages, but this can produce results that are specific to a particular implementation of the software. Additionally, decoder software is often complex and may not be widely available.

6.1.2 The IWXXM XML schema formally describes the expected structure and content of XML messages. Using software in a process known as XML validation, a specific IWXXM message (e.g. an IWXXM METAR) can be checked against the IWXXM XML schema to ensure it is properly formatted. An XML message is said to have passed validation if it is correctly structured and meets all the requirements specified in the XML schema.

6.2 VALIDATION OF IWXXM MESSAGES

Scope of validation

6.2.1 IWXXM currently includes several validation capabilities. This includes the location and number of information elements; the expected structure and order of the information; the verification that the units of measure used are among those allowed in ICAO Annex 3; and more. More validation capabilities would be added in future versions of IWXXM as necessary. Each of these capabilities is intended to allow both producers and consumers of XML information to detect errors, and thereby improve the overall quality of data in the system.

6.2.2 Validation can be used in two ways: as an informative tool or as a method of enforcing compliance. The roles and responsibilities of stakeholders in the creation, distribution and utilization of IWXXM messages are out of scope of this document and reference should be made to other ICAO documents as required.

The validation process

6.2.3 The correct formatting of IWXXM messages comprises two parts: validation against the IWXXM XML schemas and validation against rules written in ISO Schematron. Schematron is a rule-based validation language for making assertions about the presence or absence of patterns in an XML document. It is capable of expressing constraints in ways that other XML schema languages, like XML Schema, cannot. The IWXXM XML schema and Schematron rules jointly describe how IWXXM messages should be formatted. XML schema and Schematron are standardized technologies, and therefore a number of open-source and closed-source software packages can be used for validation.

6.2.4 A command line tool, CRUX (Command-line Refuter of Unshapely XML), is provided by the WMO for authoritative validation purposes. CRUX is a cross-platform Java tool which supports validating IWXXM XML schemas and Schematron rules, and is available at <https://github.com/NCAR/crux/releases>. For offline and/or local validation purposes, CRUX can be used with an XML catalogue file to utilize local copies of XML schema and Schematron rules. For convenience, a schema bundle is distributed for use with CRUX or other XML validation tools.

6.2.5 To facilitate the implementation of IWXXM, an authoritative validation website for WMO and ICAO data models is available at <http://wmo-icao-validator.rap.ucar.edu>. Based on CRUX, schemas which are hosted from <http://schemas.wmo.int> can be validated there, including IWXXM, METCE, COLLECT, and others. The site uses local copies of XML schema and Schematron files. XML files with WMO, ICAO, ISO, and OGC namespaces should validate quickly without any outgoing network connections.

Chapter 7

EXCHANGING IWXXM MESSAGES

7.1 INTRODUCTION

7.1.1 A meteorological bulletin in traditional alphanumeric code (TAC) format is composed of meteorological information preceded by an appropriate heading that typically identifies its type, point of origin and issue time. The meteorological information involved may be a single TAC message or a collection of TAC messages of the same type. The meteorological bulletin is usually distributed by the aeronautical fixed telecommunication network (AFTN) or air traffic services (ATS) aeronautical message handling system (AMHS) among local, regional and global stakeholders.

7.1.2 To emulate the existing information distribution practices, WMO developed the COLLECT-XML construct to represent a collection of GML feature instances of the same type of meteorological information in the same way as a meteorological bulletin in TAC format. In addition to the XML schema, Schematron rules are also in place to validate conformity of aggregated IWXXM messages to COLLECT-XML requirements. The resulting meteorological bulletin in IWXXM format can either be sent directly, or as a compressed file, as an attachment via AMHS with file transfer body part enabled, often as part of AMHS extended services. Table 7-1 is an example of a bulletin of IWXXM METAR messages aggregated with COLLECT-XML, and Table 7-2 shows its corresponding TAC bulletin.

Table 7-1. An example of a bulletin of IWXXM METAR messages aggregated with COLLECT-XML

```
<?xml version="1.0" encoding="UTF-8"?>
<collect:MeteorologicalBulletin gml:id="LAHK31VHHH-201511020800">
  <collect:meteorologicalInformation>
    <iwxxm:METAR gml:id="metar-VHHH-201511020800">
      ...
    </iwxxm:METAR>
  </collect:meteorologicalInformation>
</collect:meteorologicalInformation>
  <iwxxm:METAR gml:id="metar-RCTP-201511020800">
    ...
  </iwxxm:METAR>
</collect:meteorologicalInformation>
</collect:meteorologicalInformation>
  <iwxxm:METAR gml:id="metar-RCHK-201511020800">
    ...
  </iwxxm:METAR>
</collect:meteorologicalInformation>
</collect:meteorologicalInformation>
  <iwxxm:METAR gml:id="metar-RCSS-201511020800">
    ...
  </iwxxm:METAR>
</collect:meteorologicalInformation>
...
<collect:bulletinIdentifier>
  A_LAHK31VHHH020800_C_VHHH_201511020800--.xml
</collect:bulletinIdentifier>
</collect:MeteorologicalBulletin>
```

**Table 7-2. TAC bulletin corresponding
to the IWXXM bulletin in Table 7-1**

SAHK31 VHHH 020800
METAR VHHH 020800Z 34011KT CAVOK 24/14 Q1018 NOSIG=
METAR RCTP 020800Z 05017KT 5000 BR FEW010 SCT016 BKN025 19/16Q1021 NOSIG RMK A3015=
METAR RCKH 020800Z 34006KT 310V020 9999 FEW016 BKN045 BKN060 27/22Q1016 NOSIG RMK A3001=
METAR RCSS 020800Z 12009KT 4500 BR FEW008 BKN018 OVC035 20/17Q1021 NOSIG RMK A3015=
METAR RCMQ 020800Z 02017G28KT 9999 FEW012 BKN150 20/16 Q1017 NOSIGRMK A3004=
METAR RCNN 020800Z 33010KT 9999 FEW012 SCT025 BKN080 26/20 Q1016NOSIG RMK A3001=
METAR VMMC 020800Z 36014KT 9999 FEW045 23/15 Q1018 NOSIG=
METAR RPLL 020800Z 12008KT 040V170 9999 VCSH FEW023CB SCT025 SCT090BKN300 30/23 Q1010
NOSIG RMK A2983 CB NW PCPN DSTN W-N=
METAR RPVM 020800Z 04005KT 9999 FEW020 BKN100 29/24 Q1010 A2984 CBDSPTD=
METAR RPMD 020800Z NIL=
METAR RPLB 020800Z 06005KT 9999 FEW020 BKN080 29/22 Q1010 A2983NOSIG=
METAR RPLI 020800Z 34002KT 9999 FEW019 32/23 Q1009 NOSIG RMK A2980=
METAR RPMZ 020800Z NIL=
NNNN

Appendix A

UML

1. UML is a widely-used modelling methodology, developed primarily for “object-oriented” software engineering. In the context of this manual, only UML “class diagrams” are considered with the following elements:

UML class. The abstraction of a concept in the application domain. A class is shown in a class diagram as a rectangle giving its name (e.g. aircraft).

Properties. Properties represent structural features of a class. Properties are a single concept but they appear in two quite distinct notations: attributes and associations. Although they look quite different on a diagram, they are really the same thing.

Note.— Attributes are represented as a line of text in the second compartment of the class symbol.

2. Figure A-1 shows an example of a UML class (of data type) representing the trend forecast of wind at an aerodrome with the following attributes:

- a) meanWindDirection (data of angle type);
- b) meanWindSpeed (attribute of velocity type); and
- c) windGustSpeed (attribute of velocity type).

3. From a modelling perspective, it may be concluded from the example provided in Figure A-1 that the forecast of wind will be provided with the mean direction, the speed of wind, and the speed of gusts. For information, each attribute may define its type (in this case, angle or velocity, but could also be, for example, CharacterString, Real or DateTime).

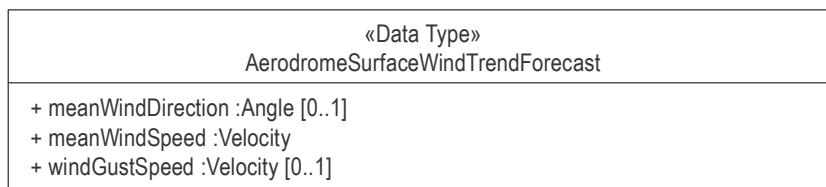


Figure A-1. Example of UML class

4. Associations express the relationship between classes. UML represents an association between two classes by drawing a line between their symbols. The role on the association end describes how the related class is used. Figure A-2 provides an example of an association and can be explained as follows:

- a) the “runway” has the property of being associated with an AirportHeliport. This is the role of “aerodrome” in the association; and
- b) such a diagram could also explicitly indicate that an aerodrome has (at least) one runway.

5. It is sometimes necessary to have unidirectional navigability. This is indicated by adding an arrow at the destination end of the association. This means that the association is easily navigated in the direction indicated by the arrow. This does not mean that the associations cannot be navigated in the other direction but the directionality is an indication that implementations should make the navigation in the primary direction convenient and efficient. One entity knows about the existence of the other in the direction of the arrow but the reverse is not necessarily true.

6. The multiplicity of a property is an indication of how many values are allowed for that property. Multiplicity of [0..1] means that the attribute is optional (i.e. it can appear once or not at all); for example, a runway is associated to maximum one aerodrome.

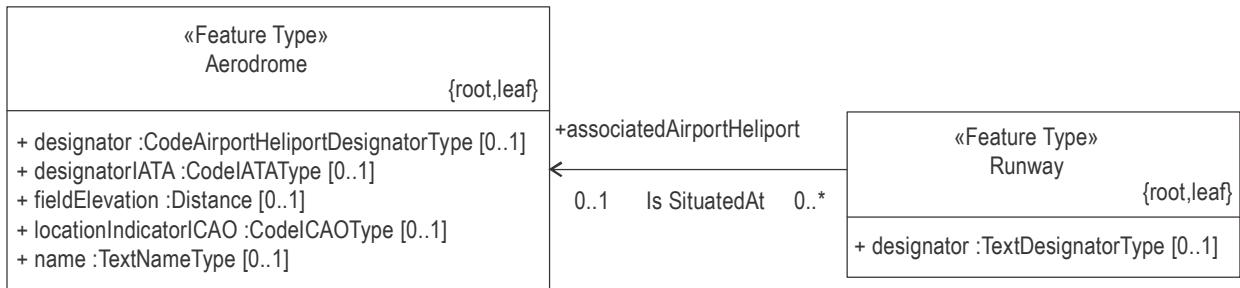


Figure A-2. Example of UML association

Appendix B

XML/GML

1. The geography markup language (GML) is an XML encoding in compliance with ISO 19118 for the transport and storage of geographic information modelled according to the conceptual modelling framework used in the ISO 19100—series and including both the spatial and non-spatial properties of geographic features. This specification defines the XML Schema syntax, mechanisms, and conventions that:

- a) provide an open, vendor-neutral framework for the definition of geospatial application schemas and objects;
- b) allow profiles that support proper subsets of GML framework descriptive capabilities;
- c) support the description of geospatial application schemas for specialized domains and information communities;
- d) enable the creation and maintenance of linked geographic application schemas and datasets;
- e) support the storage and transport of application schemas and data sets; and
- f) increase the ability of organizations to share geographic application schemas and the information they describe.

2. GML serves in daily life as a modelling language for systems as well as an open interchange format for geographic transactions on the Internet. The concept of feature in GML is a very general one and includes not only conventional "vector" or discrete objects, but also coverage. The ability to integrate all forms of geographic information is key to the utility of GML.

3. GML contains a rich set of primitives which are used to build application specific schemas or application languages. These primitives include:

- a) feature;
- b) geometry;
- c) coordinate reference system;
- d) topology;
- e) time;
- f) dynamic feature;
- g) coverage (including geographic images);
- h) unit of measure;

- i) directions; and
 - j) observations.
4. Application schemas such as IWXXM are XML vocabularies defined using GML and which reside in an application-defined target namespace. In the case of IWXXM, the application schema resides in the <http://icao.int/iwxxm/> namespace. Application schemas themselves can be built on the full GML schema set or use specific GML profiles.
5. GML profiles are logical restrictions to GML, and may be expressed by a document, an XML schema, or both. These profiles are intended to simplify adoption of GML, to facilitate rapid adoption of the standard. In contrast with application schema, GML profiles are part of the GML namespaces (open GIS GML).
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Appendix C

WMO CODES REGISTRY

1. The WMO Codes Registry is the mechanism through which the authoritative terms required in IWXXM messages are published as web-accessible resources, enabling the controlled vocabulary for IWXXM to be managed outside the data model. The definitive source of terms is World Meteorological Organization Publication No. 306 — *Manual on Codes* and other WMO Technical Regulations. Current coverage of WMO No. 306 is sparse, but it will be expanded with further development of digital exchange formats.
2. Overview of registry concepts:
 - a) *Register*. A single controlled collection (e.g. a list) maintained on behalf of some owner organization which provides the authority and governance regime for the collection.
 - b) *Entity*. A member of the controlled collection, the entity type is completely open but may be constrained by the register's governance policy.
 - c) *Sub-register*. A register may contain other registers, enabling creation of arbitrarily complex sub-register hierarchies.
 - d) *Register item*. A metadata record describing the relationship of an entity to a given register. The register item includes a graph of information properties that describe the entity as determined by the register manager enabling a local description of the entity to be maintained within the registry.
 - e) *Data model of the registry*. Derived from ISO 19135 — *Geographic information — Procedures for item registration*.
3. The WMO Codes Registry can be accessed at <http://codes.wmo.int>. Following with an entity identifier, it will be displayed on a web browser into a web page showing details of its definition. Figure C-1 shows the web page returned when referencing the entity “drizzle” described in Table 4678 of WMO No. 306 (<http://codes.wmo.int/306/4678/DZ>).
4. It is, however, anticipated that operational services will not have a direct dependency on the entry deployed at <http://codes.wmo.int>; local read-only copies of the registry content should be used to support validation of exchanged data products instead.



Figure C-1. Example of a web page shown when referencing <http://codes.wmo.int/306/4678/DZ> on a browser

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