Agenda Item 5: Digital representation of meteorological information
5.3: Manual on the Digital Exchange of Aeronautical Meteorological Information (Doc 10003)

DRAFT MANUAL ON THE DIGITAL EXCHANGE OF AERONAUTICAL METEOROLOGICAL INFORMATION (DOC 10003)

(Presented by the Secretary)

1. A draft of the Manual on the Digital Exchange of Aeronautical Meteorological Information (Doc 10003) is provided in the appendix for consideration by the group as prepared by Dennis. The group may wish to note that reference to this manual is included in Amendment 76 to Annex 3 — Meteorological Service for International Air Navigation which will become applicable on 14 November 2013. As a result, it is necessary that this manual be completed by mid-May 2013 at the latest in order to accommodate the ICAO editorial process.

2. The group is invited to consider what information is required to complete this manual, including technical information, and to develop a work plan to allow this completion by mid-May 2013.
Manual on the Digital Exchange of Aeronautical Meteorological Information

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Foreword
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1 Introduction

1.1 Purpose of the document

The first edition of the Manual on the Digital Exchange of Aeronautical Meteorological Information is intended as a guide for use by State authorities, providers of meteorological services and other aeronautical personnel on procedures, codes and the use of communications for the digital exchange of aeronautical meteorological information.

It provides an overview on how emerging international air navigation requirements for meteorological services can be supported by digital information exchange. It includes the relevant background information on data modelling practices required to ‘describe’ digital information exchange and includes considerations on implementing such models in systems and associated development activities.

1.2 Acronyms and Terminology

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<tr>
<td>ACARS</td>
<td>Aircraft Communications Addressing and Reporting System</td>
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<td>ADS-B</td>
<td>Automatic Dependent Surveillance - Broadcast</td>
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<td>AMAN</td>
<td>Arrival Manager</td>
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<td>AMDAR</td>
<td>Aircraft Meteorological Data Relay</td>
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<td>AMHS</td>
<td>Advanced Message Handling System</td>
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<td>AOC</td>
<td>Airline Operations Centre</td>
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<td>ASMGCS</td>
<td>Advanced Surface Movement Guidance and Control System</td>
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<td>ATC</td>
<td>Air Traffic Control</td>
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<td>ATFM</td>
<td>Air Traffic Flow Management</td>
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<td>ATM</td>
<td>Air Traffic Management</td>
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<td>CARATS</td>
<td>Collaborative Action for Renovation of Air Traffic Systems (Japan)</td>
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<td>CDM</td>
<td>Collaborative Decision Making</td>
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<td>CDO</td>
<td>Continuous Descent Operations</td>
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<td>COTS</td>
<td>Commercial Off-The-Shelf products</td>
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<tr>
<td>DMAN</td>
<td>Departure Manager</td>
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<td>GRIB</td>
<td>Gridded Binary Data</td>
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<td>IOC</td>
<td>Initial Operating Capability</td>
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<td>IP</td>
<td>Internet Protocol</td>
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<td>ISO</td>
<td>International Organization for Standardization</td>
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<td>MET</td>
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<td>METEOSAT</td>
<td>System of Observing satellites for Meteorology</td>
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<td>NEXTGEN</td>
<td>Next Generation Air Transport System (USA)</td>
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<td>NOP</td>
<td>Network Operations Plan</td>
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<td>OGC</td>
<td>Open Geospatial Consortium</td>
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<td>PBN</td>
<td>Performance-based Navigation</td>
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<td>RTA</td>
<td>Required Time of Arrival</td>
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<td>RTCA</td>
<td>Radio Technical Commission for Aeronautics</td>
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<td>SESAR</td>
<td>Single European Sky ATM Research Programme</td>
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<td>SOA</td>
<td>Service Oriented Architecture</td>
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2 Background

2.1 The evolving Global Air Transport System

The ICAO 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 fully in line with the recommendations provided by the 12th Air Navigation Conference. It also details how ATM will act directly on the flight trajectory of a manned or 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.

This operational concept and the Global Air Navigation Plan (GANP) addresses what is needed to increase user flexibility and maximise operating efficiencies in order to increase system capacity and improve safety levels in the future ATM system.

The guiding principle is that the ATM system is based on the provision of services. The service-based framework described in the concept considers all resources such as inter alia, 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 its subsequent landing, safely separated from hazards, within capacity limits, making optimum use of all system resources. The description of the 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.

It is clearly 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 is associated with the meteorological (MET) information provided. This form of risk management will enable decision-makers to make executive choices according to their own objectively determined thresholds for action.

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

1. A robustly networked ATM System which improves information sharing;
2. An information sharing which will enhance the quality of information and provide shared situational awareness;
3. Collaboration and self-synchronisation enabled by shared situational awareness; and
4. Enhanced sustainability and speed of decision making.

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

2.2 Network Centric Operations

The concept of common (collaborative) information sharing has been under development for a decade or more. It was born 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 actors 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.

Nevertheless it is clearly recognised that individual (national) airspaces and aerodromes cannot continue to be regarded as singular and isolated components of ATM. Each will serve as a node interlinked with all others within the system. 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 instantiations of this concept.
2.3 Consequences for Meteorological Services

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 significantly more sensitive to disruption and the consequent increased costs associated with it. Historically, aviation weather services have mainly addressed safety issues. Now within the context of the evolving ATM system, the considerable impact of weather on capacity and efficiency and the potential to mitigate some of the environment impacts of aviation must be given greater consideration whilst maintaining to operate safely.

The importance of timely, accurate and easily available MET information for decision support is emphasised in Doc.9854. As such it is recognised 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 whilst ensuring flexibility. Flow and capacity management enabled by high precision time-based metering such as consistently achieving the required Time of Arrival (RTA), 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.

Furthermore, based on forecast traffic volumes, their orientations and on weather forecasts, ATFM will originate and control the daily plan (e.g. Network Operation Plan, 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.

A key change needed is the evolution of the interfaces between the airlines, flight-crews and the ATM network in determining the optimum profiles for a flight. The Airline Operations Centres (AOC) will examine the requirements for a flight and the current and predicted environment to operate in, such as weather, airspace structure, en-route capacity, aerodrome capacity and environmental considerations so as to select the optimum flight trajectory. The collected weather information will be collated and analysed to assess in conjunction with aircraft performance data and user charges the cost-benefit of modified flight profiles or alternative routes and aircraft may be re-planned whilst in flight.

The development of air and ground-based automated systems, in association with new procedures and working arrangements in ATM such as 4D trajectory management is 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.

It is recognised that certain weather conditions (e.g. low visibility, strong winds, thunderstorms) and weather induced runway contamination can and do restrict aerodrome and airspace capacity. Each aerodrome and to some extent each sector of airspace is affected by local weather conditions, which impact on their individual actual capacity at any moment in time. New equipment to support aircraft operations during some adverse weather conditions such as advanced surface movement guidance systems (ASMGCS) and synthetic vision are becoming increasingly available. Nevertheless, the key to mitigation and minimisation of disruption will remain mainly in the intelligent use of increasingly accurate forecasting of weather events. This will be especially important for large, congested hub aerodromes and their associated airspace.

Improvements are also foreseen in the terminal area short-term forecasting. (e.g. departure and approach wind profiles) to maximise 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 (CDO) in general.

Figure 2.3-1 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 MET information could be envisaged.

1 4-D Trajectory Management is the process that captures the overall traffic situation in the Network Operations Plan (NOP) and controls the development of the business or mission trajectories in 4 dimensions (latitude, longitude, flight-level and time). Specifically, 4-D 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 aircraft operator, ATM and other stakeholders where applicable, except in time-critical situations when only Flight Crew and Controller are involved.
The key to efficient operations 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 MET Information.

An important consideration in this respect is to ensure global interoperability not only from a MET information perspective but also clearly focused on interlinks with other identified relevant data domains. ATM systems, such as controller decision support tools, will not only use MET information but will fuse this information with other relevant information such as Aeronautical Information (AIS/AIM) and Flight Information, to support knowledge based decision-making. Figure 2.3-2 provides a graphical representation of the different identified data domains and user communities.
3 Digital Information Exchange Principles

3.1 Global Interoperability

To achieve global interoperability within the ATM system (§2.3), it is crucial that the exchanged data shares the same meaning at both their origin and their 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.

A simplified non-exhaustive overview of the conglomeration of the different information components one could identify in the wider context of aeronautical MET information exchange only is the following:

1. ICAO Global aeronautical MET constructs; the globally defined aeronautical MET information constructs that are uniquely required by the provisions of ICAO Annex 3 and to be globally shared;
2. ICAO Regional aeronautical MET constructs; the regional aeronautical MET information constructs that are uniquely required by the provisions of Regional Air Navigation Plans based on ICAO Annex 3 and to be regionally shared; and
3. User, State or Multi-State specific aeronautical MET constructs; the aeronautical MET information constructs that are not specifically required by the provisions of ICAO Annex 3, or are additions to ICAO Annex 3, but identified as important to be shared in a specific user context with a specific user benefit.

These three identified categories are a high level decomposition of aeronautical MET information exchange recognising that this could be decomposed further. From a MET information provision perspective each components include 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.

When establishing true global semantic interoperability, the efforts to standardise or specify MET information exchange should not be limited to the high level perspective on aeronautical MET information only but should be inclusive of establishing the same meaning at both their origin and their destination of these common MET and common aviation information elements. E.g. the notion ‘runway’ in a MET information exchange environment can not have a different meaning than a ‘runway’ used in aeronautical information exchange. Or the meaning of ‘temperature’ could not be modified in an aeronautical context and still be called ‘temperature’.

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

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 (ref. Doc. 9854).

3.2 System Wide Information Management

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 (Figure 3.2-1):

1. Applications of global Service Providers and Service Consumers that publish and/or use information;
2. **Services for Information Exchange**, defined for each ATM Information Domain following governance specifications, and agreed upon by SWIM stakeholders;

3. **Standards for Information Exchange**, which provide the subject-specific standards for sharing information for the above Information Exchange services;

4. **SWIM Messaging Infrastructure** provides the infrastructure and governance for sharing information and sometimes referred to as the “SWIM Infrastructure”; and

5. **Global Information Technology Infrastructures**, providing consolidated telecommunications services, including hardware.

The required provisions and guidance for the digital exchange of aeronautical MET information especially operate at level 2 and 3 of this layered SWIM approach. The messaging infrastructure and information technology standards (level 4 and 5) are prerequisites for the Annex 3 provisions on digital information exchange and the scope of this guidance. The applications level (level 1) is considered stakeholder specific, therefore the concern of the actual provider and consumer and as such not included in the Annex 3 provision or in the guidance.

### 3.3 Data-, information- and service-modelling

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

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 subdomain aeronautical meteorology. These data models provide a sharable, stable, and organized structure of information requirements in a domain context and as such providing 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.
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 Amendment 76 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.

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 is currently interwoven with the logical models since a specific exchange solution was in mind.

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 MET exchange required could be derived from that. The recommendations of the 12th Air Navigation Conference on a) globally interoperable system-wide information management and b) to develop 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.

### 3.3.1 Foundation

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

The foundation applied to model aeronautical MET information is based on the following mainly ISO standards and specifications:

- ISO/TC 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 – GML
- ISO/TS 19139 Geographic information – Metadata – XML schema implementation
- ISO 19156 Geographic information – Observations and measurements
- ISO 639-2 Codes for the representation of names of languages – Part 2
- W3C XML Schema Specification

### 3.3.2 Logical Data Model

The level of abstraction required for a model that represents the aeronautical MET 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.

To describe aeronautical MET 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.

A commonly used language to provide the semantics and abstract structure of all the information that needs to be made available by MET service providers as prescribed by the existing provisions is the Unified Modelling Language (UML)\(^2\). 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.

The ICAO Meteorological Information Exchange Model (IWXXM) provides such a logical data model for aeronautical MET information in support of international air navigation.

### 3.3.3 Physical Data Model

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

However, for the purpose of international information exchange and to establish true interoperability, it is considered to be beneficial to provide an additional level of structure. Currently, such a structure is provided for METAR, SPECI and TAF by the supporting WMO Manual on Codes (No.306).

Models for the physical implementation of aeronautical MET information exchange, a physical data model, provide this structure. These models are for instance based on generic standards for the exchange of geospatial and time referenced information.

### 3.3.4 Extensibility

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 to develop easily and cost effective extension to the global baseline. Without the possibility to develop 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.

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

### 3.4 Identified components to support the digital exchange of aeronautical meteorological information

Based on the notions and principles described in §3.1 to §3.3 the following structure of (model) components has been chosen to support the digital exchange of aeronautical meteorological information:

- The IWXXM Logical Model; the exchange model of aeronautical meteorological information in UML in the from of a ISO 19109 Application schema which is restricted to describe the exchange of METAR, SPECI, TAF and SIGMET only\(^3\);
- The IWXXM XML Schema; a GML-based implementation of the IWXXM Logical Model derived programmatically from the IWXXM Logical Model following proven industry standards, industry best practices and the following components:
  - SAF; Simplified Aviation Features, that allow items such as airports, or runways to be described to the level of detail required for reporting aeronautical meteorological information. For the first iteration of the IWXXM, the SAF is the instantiation of the decomposed common aviation information

\(^2\) Defined by the Object Management Group (OMG); the UML is a graphical language designed to visualise, 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.

\(^3\) 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.
constructs used in the digital exchange of METAR, SPECI, TAF and SIGMET. Since no ICAO common aviation information model exists today, the SAF was developed and maintained as part of the IWXXM. In future releases of the IWXXM, the SAF should be a commonly developed, maintained and shared model in ICAO in line with the SWIM principles that should be inherited by the IWXXM.

- WMO packages⁴, which are from an IWXXM perspective foundation elements (see §3.3.1):
  - METCE; the Modèle pour l’Échange des informations sur le Temps, le Climat et l’Eau 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 schema.
  - Meteorological Basic Types (WMO MBT); provides a set of classes and XML types as a complement to ISO 19103 (Basic types) required to describe the physical quantities of interest for WMO
  - Observable Property Model (WMO OPM); provides a framework for qualifying or constraining physical properties based on a draft best practice developed by the OGC Sensor Working Group.

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⁴ The manual includes guidance on the IWXXM Logical model, IWXXM XML Schema and SAF only. For the WMO components please refer the appropriate WMO guidance material.
4 IWXXM Logical Model

4.1 Scope

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

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 thus a flexible IWXXM.

Error! Reference source not found. and Error! Reference source not found. provide a graphical representation of the potential evolution of the IWXXM. The IWXXM will over time evolve into the single global baseline for aeronautical MET information exchange capturing all the global information exchange requirements with the possibility to create IWXXM extensions to satisfy user specific needs.

The stakeholder requirement to have other aeronautical meteorological information exchange models like WXXM available to bridge the gap between the current scope of IWXXM and what is desired will then potentially become obsolete from a global information exchange perspective.
4.2 Baseline version

The baseline for the IWXXM includes all information constructs relevant to replace the Traditional Alphanumeric Codes (TAC). The TAC code formats involved are:

1. METAR (including TREND-type forecast);
2. SPECI (including TREND-type forecast);
3. TAF, and;
4. SIGMET

4.3 Specification

<TBD; the paragraph is the placeholder for a reference to an ‘outside’ specification of the IWXXM or the inclusion of the specification as integral part of the manual. This specification should be in the form of UML class-diagrams. A specification similar to how ISO publishes their standards>
5 IWXXM XML Schema

The IWXXM XML Schema is a physical data model for aeronautical MET information in support of the MET Service for International Air Navigation. It is an 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.

5.1 Introduction

A physical exchange form based on XML\(^5\) was identified as the best suitable for the digital exchange of aeronautical MET information. Moreover, this general consensus extends to the need to migrate towards a specific XML grammar to express geographical features. This specific XML grammar selected to describe MET information in function of time, place, coverage, etc. is GML\(^6\). More detail on XML/GML is provided in Appendix B.

Not necessarily every existing or emerging code format to exchange MET information should be replaced by a GML based code format. Especially gridded data can be exchanged in other more efficient manners. However, GML could still be used as the so-called ‘wrapper’ of the information when found necessary. Essential to it all is the fact that the information constructs, also for the gridded data, are captured at the technology and format independent layer of the WXXM ICAO CC logical data model.

For future IWXXM other fit for purpose exchange formats could be adopted as part of the physical implementation of the IWXXM Logical Model. However, GML could still be used as the so-called ‘wrapper’ of the information when found necessary. Essential to it all is the fact that the information constructs are captured at the technology and format independent layer of the IWXXM Logical Model.

5.2 Specification

5.2.1 XML/GML Schema for Aeronautical Meteorological Information Exchange

<TBD: the paragraph is the placeholder for a reference to an ‘outside’ specification of the IWXXM XML Schema>

5.2.2 Other Aeronautical Meteorological Information Exchange

<placeholder for iterations of IWXXM after 2013>

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\(^5\) XML: Extensible Markup Language.
\(^6\) GML: Geography Markup Language. GML is the XML grammar defined by the Open Geospatial Consortium (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.
6 Metadata for Aeronautical Meteorological Information Exchange

<?? A decisions needs to be taken on the metadata issues associated with IWXXM. Is it required to include guidance on metadata requirements for this version of the IWXXM ??>

6.1 Introduction
	<tbd>

6.2 Specification
7 Implementation Considerations

7.1 XML/gml conversion

7.2 ‘Portrayal’ rules (METAR, SPECI, TAF, SIGMET)

7.3 Fulfilling metadata requirements
Appendix A UML

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

- A **UML class** is 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** 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, and;
- **Attributes** are represented as a line of text in the second compartment of the class symbol.

In *Error! Reference source not found.*, an example is provided on an Aircraft class with the following attributes:

- stallSpeed
- mass
- type

<table>
<thead>
<tr>
<th>Aircraft</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ stallSpeed: Real</td>
</tr>
<tr>
<td>+ mass: Real</td>
</tr>
<tr>
<td>+ type: CodeAircraftType</td>
</tr>
</tbody>
</table>

From a modelling perspective you can conclude from the example provided in *Error! Reference source not found.* that an Aircraft has a stallSpeed, has mass and has a type. For information, each attribute may define its **type** (for example, CharacterString, Real or DateTime).

**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. *Error! Reference source not found.* provides an example of an association and can be explained as follows:

- The Aircraft has a property ‘manufacturer’. This is the role of AircraftManufacturer in the association, and;
- You can also say that an AircraftManufacturer ‘manufactures’ Aircraft.

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 a hint that implementations should make the navigation in the primary direction convenient and efficient. One class knows about the existence of the other in the direction of navigation but the reverse is not necessarily true.

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.
Aircraft

+ stallSpeed: Real
+ mass: Real
+ type: CodeAircraftType

UML: association

AircraftManufacturer

+ name: CharacterString

UML: association 0..1

Manufactures
Appendix B XML/GML