



Plan for Aeronautical Meteorological (MET) Information in System-Wide Information Management (SWIM)

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FOREWORD

The *Plan for Aeronautical Meteorological (MET) Information in System-Wide Information Management (SWIM)* is published to complement the introduction of ICAO Doc 10039, *Manual on System-Wide Information Management (SWIM) Concept*. This plan describes the role of meteorological information in a SWIM environment, and the relationship of MET-SWIM to other components of the overall system.

As of November 2020, according to ICAO Annex 3, *Meteorological Service for International Air Navigation*, States are required use the ICAO Meteorological Information Exchange Model (IWXXM) format as a standard for the international exchange of aeronautical meteorological information. This exchange will initially take place outside of a SWIM environment, but as SWIM implementation proceeds, these exchanges will be transitioned to a SWIM environment.

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LIST OF ABBREVIATIONS AND ACRONYMS

2-D	Two-dimensional
3-D	Three-dimensional
4-D	Four-dimensional
AIM	Aeronautical information management
AIP	Aeronautical information publication
AIRM	Aeronautical Information Reference Model
AIXM	Aeronautical Information Exchange Model
AMQP	Advanced message queuing protocol
ANSP	Air navigation service provider
ASBU	Aviation system block upgrade
ASP	ATM service provider
ATM	Air traffic management
CRS	Coordinate reference system
Doc	Document
ESM	Enterprise service management
FF-ICE	Flight and Flow Information for a Collaborative Environment
FIR	Flight information region
FIXM	Flight Information Exchange Model
FL	Flight level
GANP	Global Air Navigation Plan (ICAO Doc 9750)
GeoTIFF	Geostationary earth orbit tagged image file format
GIS	Geographical information system
GML	Geography markup language
GRIB	Gridded binary format
HTTP	Hypertext transfer protocol
ICAO	International Civil Aviation Organization
IP	Internet protocol
IWXXM	ICAO meteorological information exchange model
JPEG	Joint Photographs Expert Group format
JSON	JavaScript object notation
MET	Aeronautical meteorological
METP	ICAO Meteorology Panel
MET-SWIM	Aeronautical meteorological information in SWIM
MET-SWIM Plan	Plan for Aeronautical Meteorological Information in System-Wide Information Management
MET-SWIM Roadmap	Roadmap for Aeronautical Meteorological Information in System-Wide Information Management
NetCDF	Network common data form
NWP	Numerical weather prediction
OGC	Open Geospatial Consortium
PNG	Portable network graphics format
REST	Representational State transfer
SOA	Service oriented architecture
SOAP	Simple object access protocol
SVG	Scalable vector graphics
SWIM	System-Wide Information Management
TAC	Traditional Alphanumeric Code
TCP	Transmission control protocol
URL	Uniform resource locator
WCS	Web Coverage Service
WFS	Web Feature Service
WG-MIE	ICAO METP Working Group on Meteorological Information Exchange
WGS-84	World Geodetic System
WMO	World Meteorological Organization
WMS	Web Map Service
WSDL	Web services description language
XML	Extensible markup language

GLOSSARY OF TERMS

When the subsequent terms are used in this manual, they have the following meanings:

Authorization. Permission to engage in a specific activity. A SWIM-enabled application is authorized if it has permission to engage in a specific activity, such as subscribing to a publication service.

Consumer. See *Information consumer*.

Core Services. Functional capabilities of the SWIM Infrastructure such as interface management, request-reply and publish-subscribe messaging, service security and enterprise service management.

Discoverable. An information service that may be discovered by a potential user is discoverable.

Discovery. See *Service Discovery*.

Information Dissemination. The act of distributing information to one or more recipients.

Domain. A set of business activities that: (a) have a common mission or purpose; (b) share common operational and functional requirements and capabilities; and (c) needs to be considered separately from other activities, while maintaining the relevant relationships with them. For example, the MET and Aeronautical Information Management (AIM) information domains.

Enterprise. See *SWIM Enterprise*.

Enterprise Service Management (ESM). The SWIM core service addressing the management of SWIM-enabled services, including performance and availability. ESM provides the ability to monitor, manage and scale services within the enterprise to ensure the capability offerings are available, responsive and scalable to the operational environment supported.

Expose. To make a service interface discoverable. In SWIM, information services are exposed via one or more SWIM Service Registries.

Information Consumer. The person, application or system consuming an information service. Also called *consumer*.

Information Domain. Focused on identifying, defining and satisfying the information needs of the set of business activities associated with a specific domain.

Information Exchange Model. An Information Exchange Model is designed to enable the management and distribution of information services data in digital format. Normally this is defined for a specific domain such as aeronautical information.

Information Model. An information model is a representation of concepts and the relationships, constraints, rules and operations to specify data semantics for a chosen domain.

Information Producer. The person, application or system producing an information service. Also called *producer*.

Information Provider. Information service provider. Also called *provider*.

Information Service. An information service is a web service which provides information consumers access to one or more applications or systems by means of the SWIM core services. It encapsulates a distinct set of operations logic within a well-defined functional boundary.

Infrastructure. The logical and physical (i.e., hardware and software) elements that together provide (SWIM) functionality.

Message. A structured information exchange package consisting of a header and payload.

Messaging. The SWIM core service that provides delivery of data and notifications between applications and systems.

Notification. An indication presented to a user regarding the status of a system or an element in a system. In a publish-subscribe system, a publication may consist of notifications about data rather than the data itself.

Operational Pattern. An operational pattern describes the essential flow of a SWIM-enabled service. It is based on the term pattern, which describes the essential features of a common solution to a common problem in software development.

Publication. An information service based on the publish-subscribe operational pattern.

Publisher. An information service provider utilizing the publish-subscribe operational pattern.

Publish-subscribe. A one-to-many operational pattern in which an information provider called a *publisher* makes its services available (i.e. publishes) on a subscription basis. An information consumer in this paradigm called a *subscriber* requests access to the publication service via a subscription request. Based on the nature of their subscriptions, subscribers will continue to receive updates from the publisher until they request the termination of their subscription.

Reliable Delivery. A characteristic of information transfer in which the transfer is either successful or the sender of the information is notified of the failure of the transfer.

Request/Reply. The operational pattern distinguished by a two-way interaction between a requesting entity and a responding entity. This pattern is also called request/response.

REST. A REpresentational State Transfer (REST) architecture is a simpler way to implement web services using HTTP and other application protocols (rather than SOAP and WSDL).

Security. The SWIM core service responsible for the protection of information, operation, assets and participants from unauthorized access or attack.

Service. Attention is drawn to the dual meaning of “service” in an ICAO context. In the context of SWIM and this document, “service” refers to a web service (also see *Information Service*) rather than an ICAO service which is provided by States or other ICAO entities.

Service Consumer. An entity which seeks to satisfy a particular need through the use capabilities offered by means of a service.

Service Discovery. The act of locating and accessing the metadata (such as a web address) for a specific information service. Also referred to as *discovery*.

Service-Oriented Architecture (SOA). An approach to integrate applications running on heterogeneous platforms using industry-wide acceptable standards. Each application is exposed as one or more web services where each information service provides a particular function. Information services (applications) communicate with each other in a coordinated sequence that is defined by a business process.

Service Overview. A set of information service metadata intended to promote service discovery and an initial evaluation of the information service characteristics.

Service Provider. An entity (person or organization) providing a service. Refers (in this document) to ASPs or vendors that provide network or other value-added services; distinct from an information provider.

Service Registration. The act of creating an entry in the SWIM Service Registry.

Service Registry. SWIM web service registry.

SOAP. A SOAP architecture is an XML based web service protocol, alternative to REST for implementing web services over HTTP.

State. An ICAO Member State.

Subscriber. A consumer of a publication service.

Subscription. The process of becoming a subscriber to a publication service. Subscription consists of subscription administration and subscription activation.

Subscription Administration. The act of administering a subscription, including authorization, access list and other database updates, etc.

System-Wide Information Management (SWIM). SWIM consists of standards, infrastructure and governance enabling the management of ATM related information and its exchange between qualified parties via interoperable services.

SWIM Access Point. A SWIM access point is a logical entity which bundles a number of technical capabilities (e.g. messaging, security, logging, interface management, etc.).

SWIM core services. The fundamental SWIM mechanisms that enable information sharing: Interface Management, Messaging, Enterprise Service Management (ESM) and Security. These services are solution-agnostic (not limited to a single process or solution environment) and have a high degree of autonomy so that they support reuse. Also referred to as “core services”.

SWIM core services infrastructure. Hardware and software elements that provide the SWIM core services. Also referred to as “core services infrastructure”.

SWIM-enabled application. A SWIM enabled application consumes or provides SWIM information services using SWIM standards. Also referred to as “application”.

SWIM-enabled service. An information service that may be accessed via SWIM.

SWIM Enterprise. A SWIM enterprise can be an ATM service provider (ASP), a group of ASPs, or an Airspace User, or an ATM support industry that has full control of the implementation planning and execution within the enterprise.

SWIM Region. A collection of SWIM enterprises that have agreed upon common regional governance and internal standards. A region will be delineated by the area of influence of a given governance structure that defines the standards, policies, etc. that are applicable to all the participants within the region.

SWIM Registry. A registry or directory containing entries with the information necessary to discover and access services. The Registry utilizes a formal registration process to store, catalog and manage metadata relevant to the services, thereby enabling the search, identification and understanding of resources. Also referred to as “Service Registry” or “Registry”.

SWIM User. Depending on context, a person, organization or application authorized to provide and/or consume services via SWIM.

Web Service. A software system which provides request/reply support to consumers for querying data or generating results. Web services commonly communicate using HTTP and often work with and return XML, JSON and binary data.

Chapter 1 – INTRODUCTION

1.1 BACKGROUND

1.1.1 ICAO Doc 10039, *Manual on System-Wide Information Management (SWIM) Concept*, describes general SWIM concepts and characteristics. This document provides further detail on the role of aeronautical meteorology in SWIM, such as the relationship between meteorology and other SWIM domains (such as aeronautical information management (AIM)) in the system.

1.2 SCOPE

1.2.1 The scope of the plan is limited to the following:

- a) Identifying required infrastructure (Internet Protocol (IP) network, security capabilities, etc.);
- b) Identifying interfaces and relationships with the other SWIM Air Traffic Management (ATM) information domains, such as AIM;
- c) Identifying technologies and required high-level capabilities (e.g., web services, Extensible Markup Language (XML) and messaging) required for MET information service providers and consumers necessary to support SWIM services;
- d) Describing information flows and high-level data types; and
- e) Describing the roles and responsibilities of aeronautical meteorological system stakeholders, such as regional centers and Member States.

1.2.2 The scope of the plan excludes the detailed description of specific information services. It is anticipated that information services will be able to be modified over time without substantial changes to the concepts and infrastructure described in this plan.

1.2.3 The representation of MET information and its encoding falls under the responsibility of the World Meteorological Organization (WMO) and is therefore beyond the scope of this document.

1.3 PURPOSE / OBJECTIVE

1.3.1 This document, the *Plan for Aeronautical Meteorological Information in System-Wide Information Management* (hereafter referred to as the *MET-SWIM Plan*), describes the role of MET information in SWIM. In particular, approaches and concepts for the exchange of MET information (such as web services), high-level concepts regarding MET information exchange models and XML/Geography Markup Language (GML) are discussed. This document supplements the broader SWIM concept described in ICAO Doc 10039, with approaches and technologies specifically relevant to the exchange of meteorological information in SWIM.

1.4 TARGET AUDIENCE

1.4.1 This plan has been developed for ICAO Member States and other interested parties seeking information on integrating their MET-SWIM information management within a global SWIM construct. The plan does not specifically address any individual MET information service consumer.

1.5 ORGANIZATION OF THE PLAN

1.5.1 The MET-SWIM Plan is organized as follows:

- a) Chapter 1 provides the background, purpose and scope of the document;
- b) Chapter 2 considers the MET-SWIM global interoperability framework and its details, including interoperability of information exchange services, information exchange models and SWIM infrastructure. The functions and representative standards are provided;
- c) Chapter 3 considers the transition to MET-SWIM and operations in a mixed environment; and,
- d) The Appendix provides supporting material.

1.6 RELATIONSHIP TO OTHER DOCUMENTS

1.6.1 ICAO Doc 9854, *Global Air Traffic Management (ATM) Operational Concept*, describes a future concept in which information is managed system wide. Based upon this concept, ICAO Doc 9882, *Manual on Air Traffic Management System Requirements*, explicitly identifies the implementation of SWIM as a requirement for the future ATM system.

1.6.2 ICAO Doc 9965, *Manual on Flight and Flow Information for a Collaborative Environment (FF-ICE)*, provides a vision specifically for flight information that relies on SWIM as a mechanism for exchange of flight information, while managing the consistency and timeliness of the information. ICAO Doc 9971, *Manual on Collaborative Air Traffic Flow Management*, describes the importance of information exchange in establishing a collaborative environment.

1.6.3 The aviation system block upgrade (ASBU) elements within ICAO Doc 9750, *Global Air Navigation Plan (GANP¹)*, that focus on SWIM development are outlined in Table 1.

Table 1. ASBU Elements related to MET-SWIM.

ASBU Element	ASBU Element Title	ASBU Element Description	ASBU	Timeline
AMET-B1/4	Dissemination of MET Information	Represents the dissemination of meteorological products using a variety of formats	1	2019 – 2024
AMET-B2/4	MET Information Service in SWIM	Establishes standards for global exchange of the MET information within the SWIM environment	2	2025 – 2030
AMET-B3/4			3	2031 – 2036
AMET-B4/4			4	2037 – 2042
SWIM-B2/1	Information Service Provision	Defines the requirements for an information service provider to make aviation-related information available as an information service	2	2025 – 2030
SWIM-B2/2	Information Service Consumption	Defines the requirements for an information service consumer to discover and access aviation-related information provided via information services	2	2025 – 2030
SWIM-B2/3	SWIM Registry	Implements a SWIM registry as a means for the information service producer to publicize and for an information service consumer to	2	2025 – 2030

¹ ICAO GANP Portal found at: <https://www4.icao.int/ganpportal/>

		discover information services within a SWIM environment		
SWIM-B2/4	Air/Ground SWIM for Non-Safety Critical Information	Enables airspace users, specifically flight crew, to make information available to the air navigation service provider (ANSP), including reroute preferences and air reports / airspace conditions	2	2025 – 2030
SWIM-B2/5	Global SWIM Processes	Establishes global access to aviation-related information by connecting information service providers and consumers within a global interoperability framework	2	2025 – 2030
SWIM-B3/1	Air/Ground SWIM for Safety Critical Information	Extends Air/Ground SWIM to enable the exchange of safety critical information	3	2031 – 2036

1.6.4 ICAO Doc 10039 describes the overall SWIM concept along with key goals and characteristics of the system. This plan provides further detail on this general concept, and how aeronautical meteorological information is exchanged and used within the broader system.

1.6.5 ICAO Doc 10003, *Manual on ICAO Meteorological Information Exchange Model*, provides implementation guidance on aeronautical meteorological information exchange models and XML/GML. This plan addresses the long-term concept of the MET-SWIM system beyond implementation of the information exchange models and beyond initial implementation of XML/GML and digital exchange.

Chapter 2 – THE MET-SWIM CONCEPT

2.1 MET-SWIM CONCEPTS

2.1.1 MET information exchange takes place in SWIM using the core concepts described in ICAO Doc 10039. MET-SWIM exchanges are enabled by the following specialized concepts:

Information: The MET information contents being utilized and exchanged in SWIM. Information is exchanged using a data exchange format, of which one type is an Information Exchange Model. Further detail on the full range of MET information is provided in Section 2.3. Data exchange formats are typically returned from information exchange services (request/reply) or sent as a portion of publish/subscribe messages. In the latter case, the payload must be small or a reference (e.g., uniform resource locator (URL)). The primary information exchange model in MET-SWIM is IWXXM.

Information Service: A web service which provides information consumers access to one or more applications or systems by means of the SWIM core services. It encapsulates a distinct set of operations logic within a well-defined functional boundary.

MET Information Services: An information service which is used to exchange MET information. An information exchange service enables interoperability by following well-defined standards and governance specifications agreed upon by stakeholders and implemented via commonly agreed means. In the MET-SWIM system, information exchange services are used to distribute, filter and transform MET information for use in SWIM.

Information Service Overview: the information service metadata intended to promote service discovery and an initial evaluation of an information service. It is the responsibility of service providers (e.g., MET service providers, ANSPs, etc.) to ensure that Service Overview information is available to describe the SWIM information services.

Information Service Definition: An agreement that documents the similarities of provided services when information service providers decide to align their services. A Service Definition is intended to be a template for certain service categories addressing general descriptive elements of one service that can be reused, as well as a template for same services that address features and technical aspects that should be equally applied.

2.2 SWIM INTERFACES

2.2.1 MET-SWIM is a subset of the larger SWIM system and will interface with other SWIM components. There are two primary relationships: a MET-SWIM utilization and reliance upon SWIM infrastructure (such as reliable messaging); and MET-SWIM use of AIM in SWIM information services and data. MET-SWIM utilizes the common SWIM infrastructure for Transmission Control Protocol (TCP) / IP network communications, publish/subscribe messaging, request/reply communications, security, registry and metadata, and other facilities.

2.2.2 MET-SWIM may interface with AIM in SWIM, such as:

- a) Meteorological observing station metadata at aerodromes (such as location);
- b) Aerodrome reference points;
- c) Aerodrome runways;
- d) Flight information region (FIR) data and locations; and,
- e) Links to further metadata regarding aeronautical service providers as described in ICAO Annex 3.

2.3 INFORMATION AND DATA EXCHANGES

2.3.1 There are two main types of MET information:

- **Gridded data:** Also known as visual raster data, gridded data is two- or three-dimensional spatial (2-D or 3-D) data that represents a specific parameter. Examples include satellite data, radar data and output from numerical weather prediction (NWP) models.
- **Objects:** Known also as vector data, data objects comprise geometries (e.g., points, lines and polygons rather than a grid) and attributes. Examples include non-gridded information in IWXXM format.

2.3.2 Gridded Data

2.3.2.1 MET-SWIM information service consumers will need access to gridded data. Gridded data is often, but not always, a regularly spaced set of values, such as a set of temperature values over a large geographic area. While gridded data values may also be represented in exchange models in XML format, gridded data is general too voluminous to be transported efficiently in XML.

2.3.2.2 A graphic showing gridded data with nearby map location information (e.g., highways) is shown in Figure 1. The individual grid cells are visible, as is the regular spacing of each data value. Gridded data should be geo-located on a coordinate reference system (CRS), such as the world geodetic system (WGS-84) geographic CRS (latitude/longitude).

2.3.2.3 Gridded data is an efficient representation of raw data values representing values from data types such as satellite, radar and NWP models, including fields such as wind speed and air temperature.

2.3.2.4 In aeronautical meteorology, gridded data is often exchanged in either Gridded Binary (GRIB) or Network Common Data Form (netCDF) file formats. While other formats are used, few of these are as broadly utilized. Gridded data in the meteorological domain is usually updated over time and is comprised of either two or three spatial dimensions (2-D or 3-D) depending upon whether there is a vertical component.

2.3.2.5 It is important to note that some products disseminated via MET-SWIM information services may be in the form of rendered, geo-located images. Examples of image data formats include JPEG, PNG, SVG and geoTIFF files, such as those seen embedded in web mapping tools and other web sites. Image data may be useful in cases where data consumers need an authoritative and/or globally consistent visualization of raw data.

2.3.2.6 Image data (or imagery) can be used to visualize both gridded data and objects. An example of both types of data can be seen in Figure 1, which shows non-gridded road and political boundaries overlaid with gridded radar data. Due to the simple representation of images, it can easily be combined with other images (layered) with little effort or much knowledge of the details of the data being represented.

2.3.2.7 While image data is usually created with geo-referencing in mind, most of the commonly used image data formats do not have the necessary metadata to describe the geo-references. Some popular Geographical Information Systems (GIS) are using auxiliary files in simple or XML format to carry geo-referencing information for the image data files in which standardization in MET-SWIM may be required.

2.3.3 Objects

2.3.3.1 Many additional types of MET information are categorized as objects. Historically, meteorological information exchanges have mainly relied on simple textual data formats. However, the exchange of MET information is transitioning away from simple text and static imagery in favour of using XML data exchanges in IWXXM format, thus starting to enable MET-SWIM information service provision for aeronautical meteorological information. At the same time, other data formats will also be used and exchanged in the most efficient ways for the respective data types.

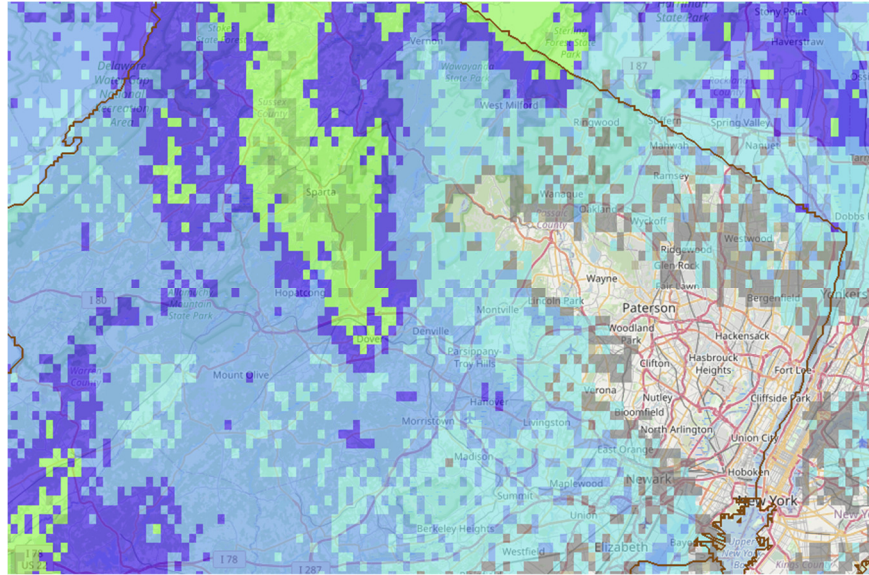


Figure 1. Rendered geographic map with gridded data cells overlaying non-gridded road and political boundaries.

2.3.3.2 MET-SWIM will utilize IWXXM, which is one of several existing exchange models intended for use in the aeronautical domain for meteorological information exchanges. As MET-SWIM implementation proceeds, current data products in IWXXM will migrate away from the restrictions of Traditional Alphanumeric Code (TAC) towards the exchange of observations, forecasts and warnings with broader utility. One example of such a change could be the introduction of multiple fidelity or even least processed data. These types of improvements allow for multiple uses through MET-SWIM information services based on the specific needs of end users, infrastructure and facility capability and performance, including different visualizations, ingestion into meteorological forecast models and potentially higher-level decision support web services.

2.3.3.3 As previously stated, image data can be used to visualize both gridded data and objects, as shown in Figure 1.

2.4 REGISTRIES AND METADATA

2.4.1 ICAO Doc 10039 describes the need for a registry for use in SWIM. The fundamental purpose of the SWIM registry (also known as a catalogue) is to provide a repository of information about who are the available information service providers, and what services and information each provides. A MET-SWIM information service consumer will utilize many of the resources identified for the SWIM registry, including:

- a) Web service instances (list of services available in SWIM from the various SWIM information service providers);
- b) Web service description documents;
- c) Reference models (common models for the implementation of services and information structures, i.e., the Aeronautical Information Reference Model (AIRM));
- d) Information exchange standards (e.g., Aeronautical Information Exchange Model (AIXM), IWXXM, Flight Information Exchange Model (FIXM));
- e) Policies (constraints to be respected in SWIM for security or other purposes);
- f) Compliance (describe levels of conformity e.g., SWIM compliance); and
- g) Participants (e.g., information service providers).

2.4.2 In addition, a MET-SWIM provider may publish aeronautical meteorology-specific metadata in the SWIM registry, such as:

- a) MET information services characteristics (e.g., update rate, data quality characteristics, data lineage, detailed data structure descriptions, list of included data fields);
- b) Static publish/subscribe messaging topics and/or queues available from the provider; and
- c) Semantic metadata relating to web services and data products available in the MET-SWIM system.

2.4.3 MET-SWIM providers shall make necessary arrangements with State authorities responsible for the publication of the Aeronautical Information Publication (AIP) to refer to the location of the SWIM registry in the State AIP. The reference will only include the web address to be minimal and non-repetitive.

2.5 INFORMATION EXCHANGE SERVICES (WEB SERVICES)

2.5.1 There are two main mechanisms by which information is exchanged between producers and consumers: information which may be requested through web services as needed, and on-going real-time feeds of messages (notifications or actual data). The former describes the request/reply message exchange pattern described in this section, and the latter describes the publish/subscribe or messaging exchange pattern discussed in the next section. Both mechanisms will be utilized by MET-SWIM information service providers.

2.5.2 MET-SWIM information exchange services will be utilized to exchange and filter data. MET-SWIM information exchanges can be quite voluminous, and information exchange services can be utilized to reduce the volume of the exchanged data to the exact needs of consumers. Due to the different nature of data being exchanged (gridded and objects) a specialized information exchange service is required for each. MET-SWIM information services will utilize the Open Geospatial Consortium (OGC) Web Coverage Service (WCS) for gridded data, the OGC Web Feature Service (WFS) for objects, and the OGC Web Map Service (WMS) for both gridded data and objects.

2.5.3 For all information exchange web services (gridded and objects) the following capabilities are supported:

- Requesting the set of data product(s) offered by the web service;
- Requesting the high-level capabilities of the web service;
- Requesting the detailed structure and content of the offered data products, such as geographic region of the data and the structure of offered data (such as the XML schema that describes offered non-gridded data);
- Requesting metadata regarding the data provider, such as contact information and organization name; and,
- Requesting metadata regarding the operational status of the web service and/or data product, such as metadata indicating experimental products.

2.5.4 For information exchange using the Web Feature Service, the following capabilities are supported in addition to the common capabilities identified in 2.5.3 above:

- Requesting data filtered by a geographic bounding box;
- Requesting data within a time range or at a time instant;
- Requesting data within a fixed distance from a route of flight (i.e., returning a vertical cross section, 4-D corridor, or horizontal slice); and,
- Requesting data that matches free-form queries, such as all aircraft observations where altitude is greater than FL400 and where the aircraft type is 'Boeing 747'.

2.5.5 For information exchange using the Web Coverage Service, the following capabilities are supported in addition to the common capabilities identified in 2.5.3 above:

- Requesting data filtered by a geographic bounding box;
- Requesting data within a time range or at a time instant;
- Requesting data which was generated at a specific forecast run time (for forecast model run data);
- Requesting data within a fixed distance from a route of flight (i.e., returning a vertical cross section,

- 4-D corridor, or horizontal slice); and,
- Requesting data that is re-sampled to a new grid spacing.

2.5.6 For information using the Web Map Service, the following capabilities are supported in addition to the common capabilities identified in 2.5.3 above:

- Requesting data filtered by a geographic bounding box;
- Requesting data within a time range or at a time instant;
- Requesting data which was generated at a specific forecast run time (for gridded forecast model run data);
- Requesting imagery that is at a different image resolution than the original data;
- Requesting data with custom rendering options such as colour ranges, transparency and symbology; and,
- Requesting data in different image formats, such as SVG, JPEG and PNG.

2.5.7 While the information exchange services as described above address the basic needs for the data exchange requirements of MET-SWIM, other more specialized web services are also possible in a MET-SWIM environment. These web services can be built to utilize data from the information exchange web services to address more specialized requirements. Because these web services are built on the top of the data made available from the information exchange services, information exchange web services may be considered the first tier (Tier 1) and a necessary building block for a second tier (Tier 2) of specialized web services.

2.5.8 An example of one such “Tier 2” web service is a warning service which would enable customized warnings to be pushed (over publish/subscribe communications) to consumers. The warning web service would allow consumers to receive crucial information for decision-making without needing access to large amounts of raw aeronautical meteorology information. As MET-SWIM information is updated, thresholds and geographic areas would be checked, and warnings pushed to consumers as appropriate. Consumers could submit the following to the warning web service:

- Any number of data variable names (such as composite reflectivity or observed wind speed);
- Geographic area(s) of interest (bounding box, flight path and distance, or polygon area);
- Time period(s) of interest; and,
- Rules describing when warnings are issued, such as the relationships between data variables, upper and lower data variable thresholds, geographic areas and time periods.

2.5.9 Tier 2 web services can be used to address global needs for complex decision-making, authoritative and consistent decisions and/or a synthesis of multiple sources of SWIM data including data from outside the MET domain, such as the AIM domain. Due to their dependence upon Tier 1 information exchange services for basic data access, implementation of Tier 2 web services in the MET-SWIM system will follow the deployment of Tier 1 web services. Given the unique and aviation-specific nature of these web services, they may not fit well into existing standardized web service protocols such as WCS, WFS and WMS, but will be implemented using web services and fit into the general SWIM architecture.

2.5.10 Web services that conform to the Representational State Transfer (REST) architecture style, called RESTful Web services, make information available to users in the form of Web resources through protocols like hypertext transfer protocol (HTTP). Similar to Simple Object Access Protocol (SOAP), a RESTful Web service typically accepts requests from a client, carries out necessary processing on the server, and returns the result back to the client in a transaction. Examples include the extraction of en-route aerodrome observations and forecasts, or gridded wind and temperature data, by providing a flight path in the request. Service description of SOAP or RESTful Web services should be described in machine readable form in Web Services Description Language (WSDL) in accordance with the Specifications for SWIM Service Description².

² Specifications for SWIM Service Description can be found [here](#).

2.6 MESSAGING AND PUBLISH / SUBSCRIBE

2.6.1 While information services provide advanced capabilities for accessing MET data, they are insufficient to address all MET-SWIM scenarios of real-time information exchange. ICAO Doc 10039 describes common messaging capabilities (the publish/subscribe messaging pattern) to be used throughout SWIM and MET-SWIM information service providers will utilize this capability to reliably distribute data, notifications and status updates. Messaging is particularly useful with data that is issued at an unpredictable or non-routine rate, data that must be delivered as quickly as possible, or data that represents a series of frequent and small updates. Publish/subscribe messaging technology is generally not well suited to distributing large data files/messages directly, and as such will be utilized by MET-SWIM information service providers for:

- Notifying information service consumers that data is available for access through a web service such as when a new gridded forecast is available for retrieval;
- Pushing relatively small data files directly to information service consumers as they are made available by the information service provider, such as non-gridded data like aerodrome observations; and,
- Mission-critical service updates to information service consumers, such as notifications of a web service outage, data outage, service/maintenance windows, notification by surveillance, or degraded provider capabilities.

2.6.2 While information exchange capabilities are considered a cross-cutting SWIM capability, information service consumers will communicate directly with information service providers. Information service brokers may be utilized and, similarly to other SWIM components, will be built upon standards that support heterogeneous information exchanges between multiple broker and/or client implementations. MET-SWIM information service providers could utilize the Advanced Messaging Queuing Protocol (AMQP), for example, directly to information service consumers, which allows consumers to choose their information service broker and client systems as appropriate for their requirements while allowing for broad system-wide interoperability.

2.6.3 Publish/subscribe messaging can be utilized to publish information in either a static or dynamic fashion. Static publish/subscribe configurations may be considered a design-time configuration regarding what information is published to predefined topics and/or queues. In the case of static configurations, information service providers publish to a fixed set of topics and/or queues which do not change while the system is running. With a dynamic publish/subscribe configuration, the set of published data and the destination topics and/or queues can be modified as the information service is running. For example, a filtered meteorological observation within a specific geographic area could be delivered to a small group of interested SWIM service consumers as needed. Dynamic configuration requires an additional request/reply web service on each information service provider to allow modifications to published information at runtime such as described in the OGC Publish/Subscribe Interface standards. The publish/subscribe system requires either a defined static subscription for generic information or dynamic subscriptions (e.g., for monitoring).

2.7 TESTING AND VALIDATION

2.7.1 As advanced capabilities (and particularly web services) are implemented in SWIM, they introduce the possibility of new types of interoperability problems when implemented incompletely or incorrectly. Therefore, as MET-SWIM capabilities are implemented, testing software will be available for evaluating the correct functioning of both web services and data products.

2.7.2 Testing and validation will occur on all components of the system, including web services, messaging capabilities, real-time data flow and data products. The specific techniques to evaluate the correct functioning of MET-SWIM information services are beyond the scope of this document but will be developed and described in a subsequent document.

Chapter 3 – TRANSITION TO MET-SWIM

3.1 A transition plan for the implementation of MET in SWIM has been defined by the ASBU schedule within the GANP and is detailed in the *Roadmap for Aeronautical Meteorological Information in System-Wide Information Management* (MET-SWIM Roadmap).

APPENDIX – MET-SWIM STANDARDS

This appendix describes the MET-SWIM standards that support the provision of aeronautical meteorological information services according to SWIM principles.

Table 2. Standards.

Capability	Standard
Request/reply network connectivity	Transmission Control Protocol version 4 (IETF RFC 793) Internet Protocol version 6 (IETF RFC 2460) and Internet Protocol version 4 (IETF RFC 791) Hypertext Transfer Protocol -- HTTP/1.1 (IETF RFC 2616)
Publish/subscribe network connectivity	Advanced Message Queuing Protocol (AMQP) 1.0
Gridded information exchange	OGC Web Coverage Service Interface Standard – Core v2.0.1 OGC Web Coverage Service Interface Standard – Range Subsetting Extension v1.0.0 OGC Web Coverage Service Interface Standard – Scaling Extension v1.0.0 OGC Web Coverage Service Interface Standard – CRS Extension v1.0.0 OGC Web Coverage Service Interface Standard – Interpolation Extension v1.0.0 OGC Web Coverage Service Interface Standard – XML/SOAP Protocol Binding Extension v1.0.0 OGC Web Coverage Service Interface Standard – Key Value Pair (KVP) Protocol Binding Extension v1.0.1
Non-gridded information exchange	OGC Web Feature Service Interface Standard v2.0.0 (also ISO 19142) OGC Filter on Coding v2.0
Imagery information exchange	OGC Web Map Service Implementation Specification v1.3.0 OGC Styled Layer Descriptor (SLD) Profile of the Web Map Service Specification v1.1.0 OGC Symbology Encoding Implementation Specification v1.1.0

— END —