Cuestión 4 del Orden del Día: **Revisión del Proyecto H4 - Intercambio OPMET**

Plan MET SWIM y Hoja de Ruta

(Presentada por la Secretaría)

RESUMEN

Esta nota presenta la Hoja de Ruta y el Plan MET para el SWIM.

Referencias:

- Doc 9750 – Plan Global de Navegación Aérea. Quinta Edición
- Informe de la Segundo Reunión de Proyectos MET, Lima 18 al 22 de septiembre del 2017
- Informe de la Cuarta Reunión del Panel MET de la OACI

Objetivos estratégicos de la OACI:	*A - Seguridad operacional* *B - Capacidad y eficiencia de la navegación aérea* *E - Protección del medio ambiente*

1. Introducción

1.1 El Plan Global de Navegación Aérea de la OACI (GANP) introdujo la metodología de los ASBUs.

1.2 La Reunión MP/2 había analizado la necesidad de preparar el intercambio de mensajes OPMET para trabajarlos en un entorno SWIM.

1.3 La Cuarta Reunión del Panel MET de la OACI preparó un Hoja de Ruta y un Plan MET para la parte MET del SWIM.

2. Análisis

2.1 El GANP, desde la Cuarta Edición introdujo la metodología de los ASBUs. La metodología está dividida en cuatro áreas de mejoras de performance y 4 bloques. Inicialmente, el módulo SWIM era parte del Área 2 (Interoperabilidad Global de datos y sistemas) y del Bloque 1 (2019-2025).

2.2 Las revisiones constantes al GANP y del estatus de las implantaciones a nivel global, además de los estatus de los habilitadores, han concluido en la necesidad de mover el SWIM al bloque 2.

2.3 La Reunión MP/2 había observado que, en el entorno actual de tecnología y una aviación en expansión, la gestión de la información es fundamental para la seguridad operacional y en la misma se debe cuidar todos los aspectos relacionadas con la calidad y seguridad de los datos, así como las fuentes de

información. La Reunión recordó que, dentro del Plan Global de Navegación Aérea, la gestión segura de la información es fundamental para alcanzar el logro de una mejora de todo el sistema de aviación.

2.4 Al considerar la implantación del SWIM, la Reunión MP/2 había considerado la necesidad de la interoperabilidad. Igualmente recordó que la comunidad ATM dependerá en gran medida del suministro de información oportuna, pertinente, precisa, acreditada y con garantía de calidad para colaborar y adoptar decisiones sobre la base de esa información. El intercambio de información a través de todo el sistema, permitirá a la comunidad ATM realizar sus actividades y operaciones de manera segura y eficiente.

2.5 Por las razones expuestas, la Reunión del MP/2 había instado a los Estados a articular procedimientos para que los proveedores de servicios meteorológicos aeronáuticos puedan preparar planes de implementación de Modelos de Intercambio de mensajes meteorológicos, así como la implementación de los mensajes XML/GML para introducir los mensajes meteorológicos en el ambiente SWIM.

2.6 La Cuarta Reunión del Panel MET (METP/4) de la OACI había analizado el desarrollo MET para el SWIM. El Working Group WG-MIE había presentado el Plan y hoja de ruta MET-SWIM. El documento presenta los conceptos, tecnologías y relaciones de MET-SWIM con otros componentes de SWIM y una hoja de ruta para la implementación de la meteorología (MET) en SWIM. Con relación al punto, la Reunión del Panel MET observó que el concepto SWIM y el Manual Doc 10003 sobre el intercambio digital de información meteorológica aeronáutica, proporcionan una guía de implementación sobre modelos de intercambio de datos meteorológicos aeronáuticos y XML/GML. El Plan MET-SWIM y la Hoja de ruta MET-SWIM complementan estos manuales con más detalles sobre el intercambio de información de meteorología aeronáutica en SWIM. El Plan MET-SWIM y la Hoja de ruta MET-SWIM tienen como objetivo ayudar a los Grupos Regionales de Planificación e Implementación (PIRG) de la OACI y al plan de los Estados para la implementación de la SWIM.

2.7 El METP/4 señaló que, en el último borrador del Doc 10039, las opciones arquitectónicas se habían eliminado, por lo que se consideró que esto también debería hacerse en el Plan MET-SWIM. El Plan MET-SWIM y la Hoja de ruta MET-SWIM son documentos "vivos" y se requiere consulta con IMP y el Panel de Comunicaciones (CP). Bajo estas consideraciones, el METP/4 había emitido la siguiente recomendación:

Recomendación 5/5: Plan MET-SWIM y hoja de ruta

Que el Panel:

a) apruebe la versión del Plan MET-SWIM y la Hoja de ruta MET-SWIM, como se indica en el Apéndice C al informe del METP/4;
b) invite a la Secretaría a cargar el Plan MET-SWIM y la Hoja de ruta MET-SWIM en el sitio web de la OACI METP (tanto público como seguro) y distribuirlo a los Grupos Regionales de Planificación e Implementación (PIRG); y
c) busque alinear mejor el plan MET-SWIM y la hoja de ruta MET-SWIM con los conceptos en el Doc 10039 Manual sobre la gestión de la información en todo el sistema.

2.8 El Plan MET-SWIM y Hoja de ruta se encuentran como **Apéndice A** a esta nota de estudio (disponible solo en inglés). Los Estados deberían revisarlo y estudiar los procedimientos de implantación con las áreas involucradas.

3. **Acción requerida**

3.1. Se invita a la Reunión a:

a) tomar nota de la información suministrada en esta nota de estudio;

b) revisar la información proveída en los Apéndices A; y

c) considerar acciones relacionadas a los ítems 2.8

APPENDIX A

MET-SWIM Plan and Roadmap

Plan for Meteorology in System Wide Information Management (SWIM)

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First Edition — October 2018

International Civil Aviation Organization

RECORD OF REVISIONS

REVISIONS		
No.	Date	Description

FOREWORD

This first edition of the *Plan for Meteorology in System Wide Information Management (SWIM)* is published to complement the introduction of the *Manual on System Wide Information Management* (Doc 10039). 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 2016, many aeronautical meteorology products from ICAO Annex 3 – *Meteorological Service for International Air Navigation* are recommended for exchange in ICAO Meteorological Information Exchange Model (IWXXM) form by States. This exchange will initially take place outside of a SWIM environment of Service Oriented Architecture (SOA) and web services, but as SWIM implementation takes place these exchanges will be transitioned to a SWIM environment.

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LIST OF ABBREVIATIONS AND ACRONYMS

AIM	Aeronautical information management
AIXM	Aeronautical information exchange model
AMQP	Advanced message queuing protocol
Annex 3	Annex 3 – *Meteorological Service for International Air Navigation*
ASBU	Aviation system block upgrade
ASP	ATM service provider
ATM	Air traffic management
CRS	Coordinate reference system
FIXM	Flight information exchange model
FL	Flight Level
GANP	ICAO Doc 9750 – *Global Air Navigation Plan*
GML	Geography markup language
GRIB	Gridded binary format
HTTP	Hypertext transfer protocol
ICAO	International Civil Aviation Organization
ISO	International Organization for Standardization
IWXXM	ICAO meteorological information exchange model
MET	Meteorology or Meteorological
METAR	Aerodrome routine meteorological report (in meteorological code)
NetCDF	Network common data form
OGC	Open Geospatial Consortium
OPMET	Operational meteorology, usually operationally-used aeronautical meteorology data products
SOA	Service-oriented architecture
SOAP	Simple object access protocol
SWIM	System-wide information management
TAC	Traditional alphanumeric codes
TCP/IP	Transmission control protocol / internet protocol
WCS	Web coverage service
WFS	Web feature service
WMS	Web map service
XML	Extensible markup language

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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 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 an alternative to SOAP for implementing web services over HTTP.
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 organizations.
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 Provider. An organization or entity 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 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 (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 (web services, XML, and messaging) required for MET SWIM information exchange;
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 products. It is anticipated that data products will be able to be modified over time without substantial changes to the concepts and infrastructure described in this plan.

1.3 PURPOSE/OBJECTIVE

1.3.1 This document, the *Plan for Meteorology in System Wide Information Management (SWIM)*, describes the role of aeronautical meteorology (MET) in SWIM. In particular, approaches and concepts for the exchange of meteorological information (such as web services), high-level concepts regarding aeronautical meteorological information exchange models and XML/GML are discussed. This document supplements the broader SWIM concept described in the *Manual on System Wide Information Management (SWIM) Concept* (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 States seeking information on integrating their MET SWIM information management within a global SWIM construct. The plan does not specifically address any individual member of the ATM community with interested parties to be found in all of the following communities:

a) ICAO;
b) regulatory authorities; and
c) States.

1.5 ORGANIZATION OF THE PLAN

1.5.1 The plan is organized as follows:

a) Chapter 1 gives the background and the purpose and scope of the document;
b) Chapter 2 considers the MET SWIM global interoperability framework and its details, including interoperability and governance at the information exchange services, the information exchange models and at the SWIM infrastructure level. 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 appendices provide supporting material.

1.6 RELATIONSHIP TO OTHER DOCUMENTS

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

1.6.2 The *Manual on Flight and Flow Information for a Collaborative Environment* (FF-ICE) (Doc 9965) 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. The *Manual on Collaborative Air Traffic Flow Management* (Doc 9971) describes the importance of information exchange in establishing a collaborative environment.

1.6.3 There are two aviation system block upgrade (ASBU) modules within the *Global Air Navigation Plan* (GANP) (Doc 9750) that focus on SWIM development: B1-SWIM and B2-SWIM. The ASBU module B1-SWIM is termed ‘Performance Improvement through the application of SWIM’ and applies to the “implementation of SWIM services (applications and infrastructure) creating the aviation intranet based on standard data models, and internet-based protocols to maximize interoperability”. The ASBU module B2-SWIM is termed ‘Enabling Airborne Participation in collaborative ATM through SWIM’ and applies to the “connection of the aircraft as an information node in SWIM enabling participation in collaborative ATM processes with access to rich voluminous dynamic data including meteorology”.

1.6.4 The *Manual on System Wide Information Management (SWIM) Concept* (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 The *Manual on the Digital Exchange of Aeronautical Meteorological Information* (Doc 10003) 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 Meteorological information exchange takes place in SWIM utilizing the core concepts described in Doc 10039. MET SWIM exchanges are enabled by the following more specialized concepts:

Information: The aeronautical meteorology contents being utilized and exchanged in SWIM. In the MET SWIM system there are three types of information: gridded data, non-gridded data, and imagery data. 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. The primary information exchange model in MET SWIM is the IWXXM.

Information Exchange 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.

2.2 SWIM INTERFACES

2.2.1 MET SWIM is a portion 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 SWIM information services and data. MET SWIM utilizes the common SWIM infrastructure for 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 SWIM for the following:

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 such as: meteorological watch offices, air traffic service units, world area forecast centres volcanic ash advisory centres and tropical cyclone advisory centres.

2.3 INFORMATION AND DATA EXCHANGES

2.3.1 Traditional OPMET exchanges have relied on textual data formats, also known as Traditional Alphanumeric Codes (TAC). TAC data exchanges are being replaced by IWXXM XML exchanges in MET SWIM, and new data forms will be exchanged.

2.3.2 INFORMATION EXCHANGE MODELS (NON-GRIDDED DATA)

2.3.2.1 MET SWIM will utilize IWXXM for information exchanges, one of several existing XML/GML exchange models intended for use in the aeronautical domain. 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 is the reporting of the raw observed meteorological values coming from the sensor instead of "binned" data values, such as is reported today with METAR ceiling values. These types of improvements allow for multiple uses of MET SWIM data products, including different visualizations, ready ingest into weather forecast models and direct utilization by both information exchange web services and potentially higher-level decision support web services.

2.3.3 GRIDDED DATA

2.3.3.1 While many data products are adequately specified with non-gridded exchange models, MET SWIM stakeholders will also need to exchange gridded data. Gridded data (also known as raster data) is often, but not always, a regularly spaced set of values such as a satellite image or 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 generally too voluminous to be transported efficiently in XML.

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

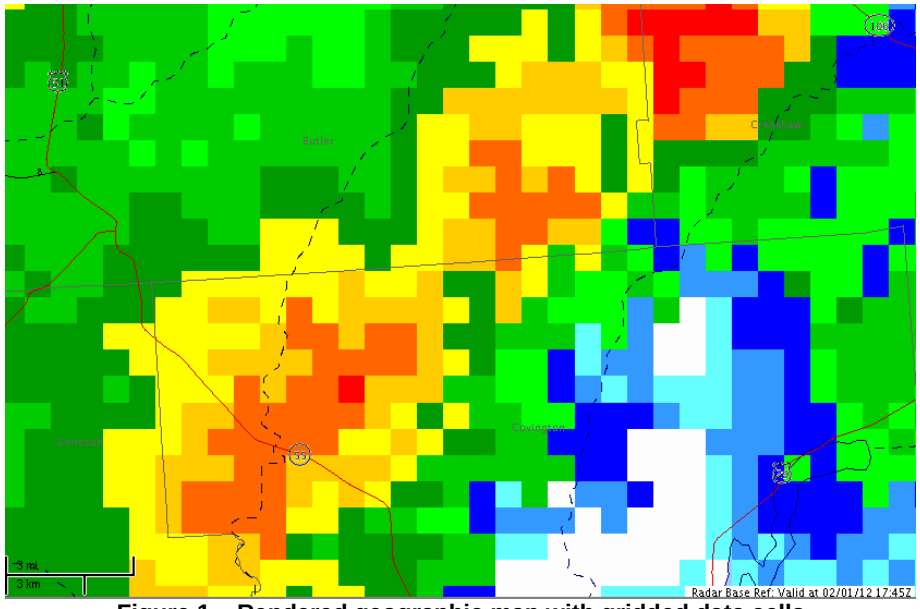

Figure 1 – Rendered geographic map with gridded data cells

2.3.3.3 Gridded data is an efficient representation of raw data values (i.e., not rendered values such as the colored pixels seen in imagery) representing data values from data types such as satellite, radar and numerical weather models, including fields such as wind speed and air temperature.

2.3.3.4 In aeronautical meteorology, gridded data is often exchanged in either the GRIB or 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.

2.3.4 IMAGE DATA

2.3.4.1 While most of the MET SWIM requirements are met with the raw data values exchanged within gridded and non-gridded data, some MET SWIM products may be disseminated as rendered, geo-located images. Examples of image data formats include JPEG, PNG, and SVG 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.

2.3.4.2 Image data can be used to visualize both gridded and non-gridded data. An example of both types of data can be seen in Figure 1, which shows the rendered gridded radar values overlain with non-gridded road and political boundaries. 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.

2.4 REGISTRIES AND METADATA

2.4.1 Doc 10039 describes the need for a registry for use in SWIM. The fundamental purpose of the SWIM registry (also known as a catalog) is to provide a repository of information about who are the available data service providers, what data services they each provide and what data sets they each provide. MET SWIM 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., AIXM, IWXXM, 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, MET SWIM will store and access aeronautical meteorology-specific metadata in the SWIM registry for the following:

a) meteorological data products (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 providers;
c) sensor metadata (e.g., location, quality characteristics); and
d) semantic metadata relating to web services and data products available in the MET SWIM system.

2.5 INFORMATION EXCHANGE SERVICES (WEB SERVICES)

2.5.1 There are two main mechanisms by which data will flow from producers to consumers: data 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 the publish/subscribe or messaging exchange pattern discussed in the next section. Both mechanisms will be utilized in MET SWIM.

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 trim down exchanged data to the exact needs of consumers. Due to the different nature of data being exchanged (gridded, imagery, and non-gridded) a specialized information exchange service is required for each. MET SWIM will utilize the OGC Web Feature Service (WFS) for non-gridded data, the OGC Web Coverage Service (WCS) for gridded data, and the OGC Web Map Service (WMS) for image data.

2.5.3 For all information exchange web services (gridded, non-gridded, and imagery web services) 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 non-gridded information exchange using the Web Feature Service, the following capabilities are supported in addition to the common capabilities identified 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; 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 gridded information exchange using the Web Coverage Service, the following capabilities are supported in addition to the common capabilities identified 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 imagery information exchange using the Web Map Service, the following capabilities are supported in addition to the common capabilities identified 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 color 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 atop 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 Another example of a "Tier 2" web service would enable authoritative conversion from XML to TAC for transition purposes and human display. This would remove potential ambiguities in the conversion process, and assist with a smooth transition away from TAC having the role of an data exchange format towards TAC having the role of a display format (potentially among many).

2.5.10 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 AIM. 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.

2.6 MESSAGING AND PUBLISH/SUBSCRIBE

2.6.1 While information exchange services provide advanced capabilities for accessing MET data, they are insufficient to address all MET SWIM scenarios of real-time information exchange. The *Manual on System Wide Information Management* (Doc 10039) describes common messaging capabilities (the publish/subscribe messaging pattern) to be used throughout SWIM and MET SWIM will utilize this capability to reliably distribute data, notifications, and status updates. Messaging is particularly useful with

data that is issued at an unpredictable 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 in MET SWIM for:

- notifying data 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 consumers as they become available on the provider, such as non-gridded data like aerodrome observations; and
- mission-critical service updates to data consumers, such as notifications of a web service outage, data outage, service/maintenance windows, or degraded provider capabilities.

2.6.2 There are many messaging broker implementations, such as ActiveMQ and RabbitMQ, but relatively few open and standard messaging protocols. As a programming application program interface (API), the Java Message Service (JMS) does not provide network level interoperability between implementations, merely a convenient way for software written in the Java programming language to be written to operate against different messaging broker implementations.

2.6.3 While messaging capabilities are considered a cross-cutting SWIM capability, States and other SWIM participants will communicate directly with other participants. No central messaging brokers will 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. Of the messaging protocol standards, the Advanced Message Queueing Protocol (AMQP) is the most general-purpose and well suited to support MET SWIM requirements, and is supported by many existing messaging broker implementations. MET SWIM publish/subscribe messaging will utilize AMQP directly between SWIM participants, which allows stakeholders to choose their message broker and client software as appropriate for their requirements but allow for broad system-wide interoperability.

2.6.4 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, SWIM 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 SWIM system is running. For example, a filtered meteorological observation within a specific geographic area could be delivered to a small group of interested Consumers as needed. Dynamic configuration requires an additional request/reply web service on each SWIM Provider to allow modifications to published information at runtime such as described in the OASIS WS-Notification and OGC Publish/Subscribe Interface standards. There are currently no identified requirements for dynamic subscription capabilities, and as such all publish/subscribe messaging will be published in a static, pre-defined manner.

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 States and Regional OPMET Centres (ROCs) implement MET SWIM capabilities 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 services are beyond the scope of this document, but will be developed and described in a subsequent document.

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Appendix A

MET SWIM Standards

This appendix describes the MET SWIM standards which should be implemented by MET States and Regions.

A.1 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 – Interpoation 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)
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 —

Appendix C

MET-SWIM Plan and Roadmap (continuation)

Roadmap for Meteorology in System Wide Information Management (SWIM)

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2 October 2018

Version 1.3

International Civil Aviation Organization

RECORD OF REVISIONS

Revisions		
No.	Date	Description
1.0	6 September 2016	Initial version developed by the ICAO Meteorological Information Exchange (MIE) Working Group
1.1	6 April 2018	WG-MIE updated based on GANP changes and discussions with the Communications and Information Management Panels
1.2	19 June 2018	Updated based on the outcomes of WG-MIE/4. Additional detail added on timelines and implementation plans
1.3	2 October	Updated based on METP/4 feedback

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LIST OF ABBREVIATIONS AND ACRONYMS

AFTN	Aeronautical Fixed Telecommunication Network
AMHS	Aeronautical Message Handling System
AMQP	Advanced message queuing protocol
ASBU	Aviation system block upgrade
FTBP	File Transfer Body Part
GANP	Global Air Navigation Plan (Doc 9750)
HTTP	Hypertext transfer protocol
IP	Internet protocol
IROG	International Regional OPMET Gateway
IWXXM	ICAO meteorological information exchange model
MET	Meteorology or Meteorological
MWO	Meteorological Watch Office
NOC	National OPMET Centre
RHWAC	Regional Hazardous Weather Advisory Centre
ROC	Regional OPMET Centre
RODB	Regional OPMET Data Bank
RQM	Request/reply query for meteorological databank data in TAC format
SWXC	Space Weather Centre
SWIM	System-wide Information Management
TAC	Traditional Alphanumeric Code
TCAC	Tropical Cyclone Advisory Centre
VAAC	Volcanic Ash Advisory Centre
WAFC	World Area Forecast Centre
WCS	Web Coverage Service
WFS	Web Feature Service
WMS	Web Map Service

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Chapter 1 – MET SWIM Roadmap

1.1 INTRODUCTION

1.1.1 The System Wide Information Management (SWIM) will complement human-to-human communications with machine-to-machine communications and improve data distribution and accessibility. However, the flexibility inherent in human communication is not intrinsically included in Information Technology (IT) systems and must be specified and included in the system design. To enable the desired flexibility, IT systems will increasingly need to "ask for / discover" operationally relevant facts, depending on the circumstances, rather than remain "being informed" by pre- agreed messages. Increased machine-to-machine capabilities will enable many new software applications while continuing to support existing human usages.

1.1.2 ICAO Doc 10039 - *Manual on System Wide Information Management (SWIM),* describes general SWIM concepts and characteristics. The MET SWIM Plan – *Plan for Meteorology in System Wide Information Management (SWIM)* - 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, along with design concepts.

1.1.3 This document, the MET SWIM Roadmap, describes the transition plan and associated timelines for implementing MET in SWIM, including the necessary timelines and strategies for implementing necessary non-MET components such as IP networking and HTTP support.

1.1.4 Transition to MET SWIM can be summarized as the following phases:

a) Provision of meteorological products in ICAO Meteorological Exchange Model (IWXXM) format;
b) Provision of meteorological via MET SWIM information exchange services, including Web Feature Service (WFS), Web Coverage Service (WCS), and Web Map Service (WMS), over HTTP;
c) Additional data types beyond IWXXM (non-gridded), including gridded data and imagery;
d) Replacement of AFTN and AMHS "message push" communications with AMQP; and
e) Additional data products beyond those currently distributed in IWXXM.

1.2 TRANSITION PLAN

1.2.1 MET SWIM implementation and transition will proceed based upon the Global Air Navigation Plan (GANP) Block upgrade schedule. IWXXM messages will also become a standard practice in 2020.

1.2.2 There are several components of the MET SWIM transition: physical network connectivity, communications protocols (AFTN, AMHS, AMQP, HTTP), information exchange services (WCS, WFS, WMS), and data types exchanged (gridded, non-gridded, and imagery). The following table summarizes the MET SWIM implementation timeline, this is expanded upon in sections below.

Table 1 - MET SWIM Timeline

	Block 0	Block 1	Block 2	Block 3
Communication protocols (AFTN, AMHS, AMQP)	AFTN (legacy) AMHS FTBP (transitional) AMQP/HTTP (optional)	AFTN (legacy) AMHS FTBP (transitional) AMQP/HTTP (optional)	AFTN (legacy) AMHS (legacy) AMQP/HTTP	AMQP/HTTP
Request/Reply at Regional OPMET Data Banks (RODBs)	AFTN/AMHS request/reply	AFTN request/reply (legacy) WFS, WCS, WMS (optional) AMHS request/reply	AMHS request/reply (legacy) WFS, WCS, WMS	WFS, WCS, WMS
Data Types	Non-gridded	Non-gridded Gridded (optional) Imagery (optional)	Non-gridded Gridded Imagery	Non-gridded Gridded Imagery
Data Addressing	NOC, ROC, RODB, IROG	NOC, ROC, RODB, IROG	IP and SWIM Registry	IP and SWIM Registry

1.2.3 In addition to the technology changes, a transition to MET SWIM will also result in modifications to the organizational roles involved in aeronautical meteorological exchanges. The most significant changes are:

a) IP communications and the SWIM Registry will greatly reduce the need for data aggregation; and
b) More organizations (especially States) will offer web services and data directly to data consumers.

Table 2 - MET SWIM Roles

Function/Role	Block 0	Block 1	Block 2
Data Producer	MWO, VAAC, TCAC, WAFC	MWO, VAAC, TCAC, WAFC, SWXC, RHWAC	MWO, VAAC, TCAC, WAFC, SWXC, RHWAC
Data Aggregator and Validator	NOC, ROC, RODB, IROG	NOC, ROC, RODB, IROG	NOC, ROC, RODB
Data Repository	WAFC, RODB	WAFC, RODB	WAFC, RODB, and State/NOC

Block 0: Current System

1.2.4 The current, mixed system of AFTN and AMHS communications will continue through the end of Block 0. States, ROCs, RODBs, and IROGs in a position to implement AMQP communications in addition to AMHS File Transfer Body Part (FTBP) may do so for IWXXM dissemination. AMHS is considered a transitional communications technique and AMQP implementation plans should be prioritized.

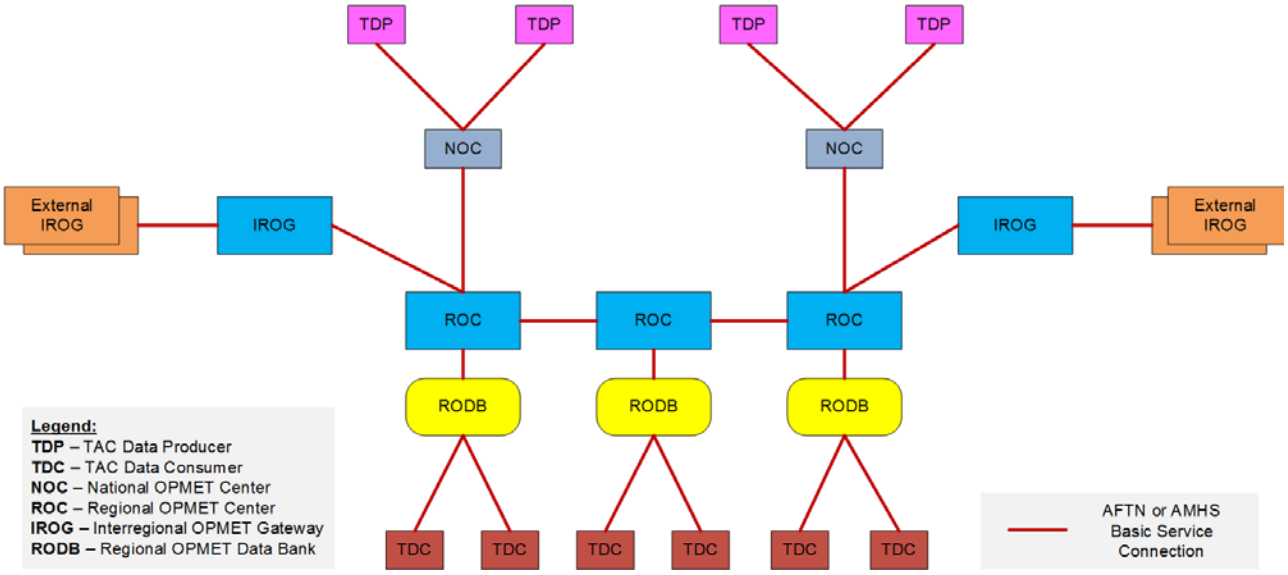

Figure 1 - MET SWIM Block 0

1.2.5 RODBs will utilize the existing RQM method for providing request/reply access to data, and States/RODBs may also offer information exchange services. Most States should be exchanging non-gridded IWXXM and TAC messages and some States may have commenced gridded and imagery information services.

Block 1 and 2: Transition to MET SWIM

1.2.6 States, ROCs, RODBs, and others may commence SWIM technology adoption in Block 1. As a transition Block, both legacy and SWIM communications technologies, data formats, and technology will co-exist for the duration. States, ROCs, RODBs, and others should commence and complete SWIM technology adoption in Block 2. Due to the transition being undertaken in both of these Blocks, the technology will be a mixture of traditional and SWIM-based approaches throughout both Blocks.

1.2.7 States shall implement IWXXM message production as of 2020, but TAC message production will continue throughout Block 1. States, ROCs, and RODBs in a position to do so will introduce gridded and imagery product dissemination on a regional basis.

1.2.8 For those RODBs and States in a position to do so, adoption of AMQP and HTTP (SWIM) communications should be adopted with a preference over AMHS-related communications for publish/subscribe messages and request/reply communications in Block 1. Specifically, ROCs and IROGs should prioritize the adoption of AMQP communications to facilitate State SWIM progress, RODBs should utilize Web Feature Services for request/reply access as an alternative to the AFTN and AMHS FTBP request response interface, and IWWXM data consumers should use the Web Feature Service to consume messages from RODBs and implement AMQP message consumption.

1.2.9 By the end of Block 2, adoption of AMQP and HTTP (SWIM) communications will be complete. ROC and IROG adoption of AMQP communications will be complete, RODBs will utilize Web Feature Services for request/reply access, and IWWXM data consumers will use the Web Feature Service to consume messages from RODBs and implement AMQP message consumption.

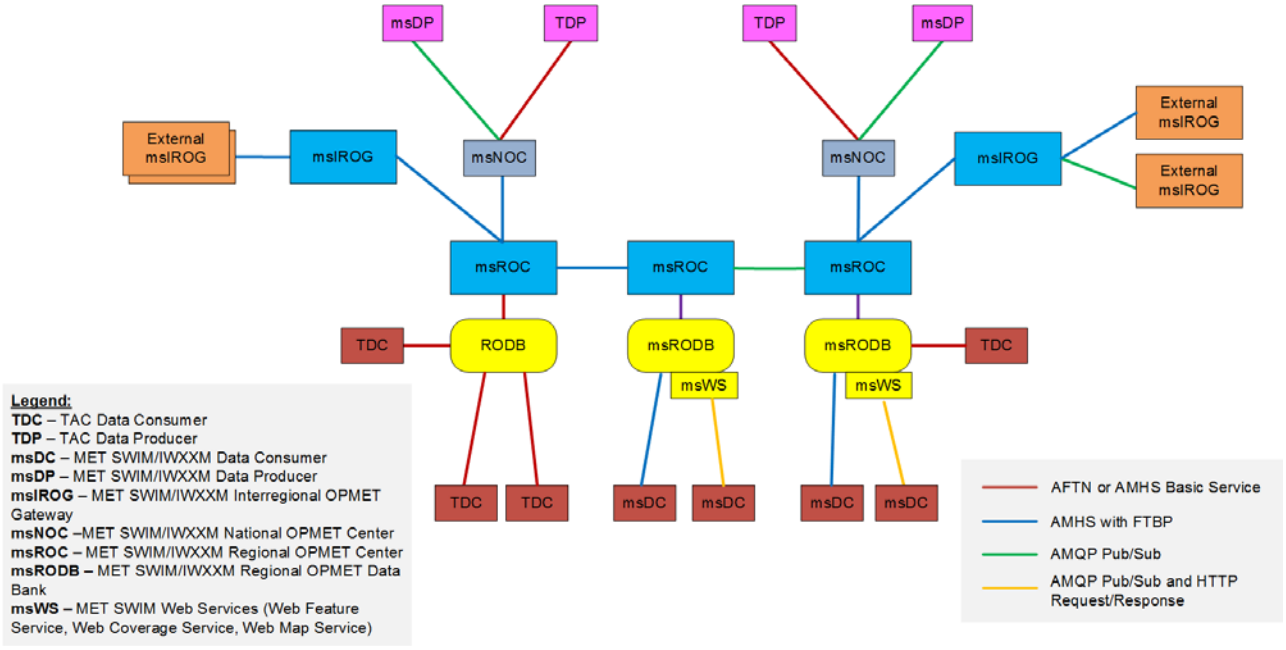

Figure 2 - MET SWIM Block 1 and 2

Block 3: MET SWIM Implementation

1.2.10 In Block 2 the protocol and data exchange transitions are completed and both IWXXM messages and gridded/image data notifications are distributed with AMQP. Gridded and image data consumers retrieve data using HTTP request/response to MET SWIM information exchange services.

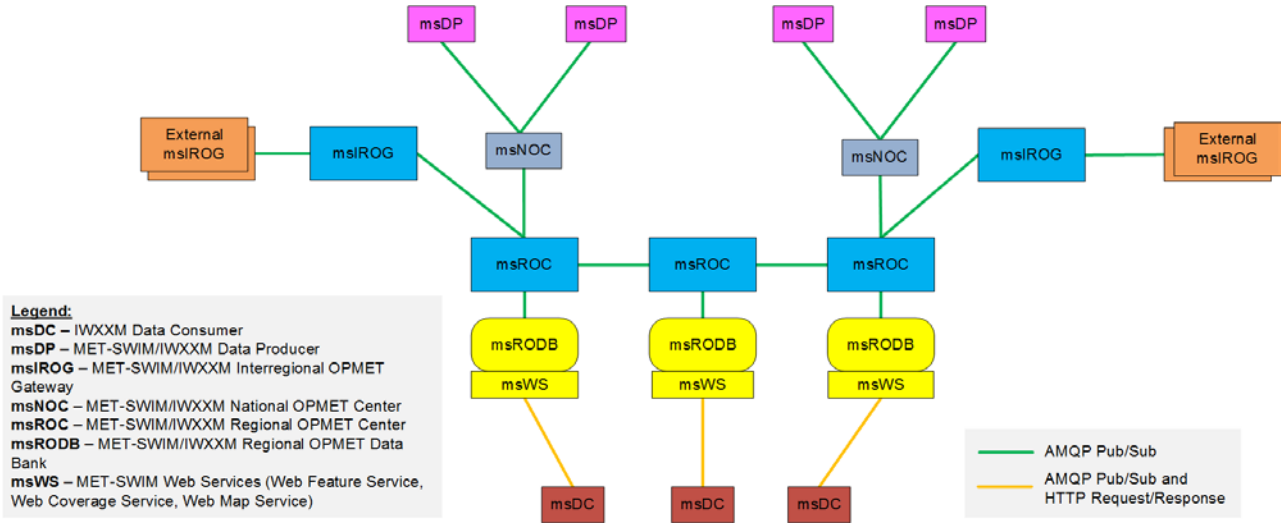

Figure 3 - MET SWIM Block 3

1.3 TIMELINES

1.3.1 As part of the SWIM activity and as part of the Global Air Navigation Plan, MET SWIM implementation will proceed in accordance with the GANP and ASBU schedule. The current ASBU timelines are as follows:

ASBU Block 0 – 2013 to 2018
ASBU Block 1 – 2019 to 2024: B1-SWIM and B1-AMET
ASBU Block 2 – 2025 to 2030: B2-SWIM and B2-AMET
ASBU Block 3 – 2031 and beyond

1.3.2 All MET SWIM pre-requisite interfaces are included in ASBU Module B1-SWIM and therefore MET SWIM Phase 1 can proceed concurrently with ASBU Module B1-SWIM.

Table 3 - MET SWIM Implementation Timelines

	ASBU Module	Implementation Start	Implementation End
SWIM Registry	**B1-SWIM**	2019	2024
Service security	**B1-SWIM**	2019	2024
MET SWIM Block 1 (Early Adoption/Transition)	**B1-AMET**	2019	2024
MET SWIM Block 2 (Transition)	**B2-AMET**	2025	2030
MET SWIM Phase 3 (Operation)	**B3-AMET**	2031	-

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