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MANUAL ON SYSTEM WIDE INFORMATION MANAGEMENT (SWIM) CONCEPT

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International Civil Aviation Organization

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FOREWORD

Today's air traffic management (ATM) system comprises a wide variety of applications developed over time for specific purposes. It is characterized by many custom communication protocols, each with their own self-contained information systems: on board the aircraft, in the air traffic service unit, etc. Each of these interfaces is custom designed, developed, managed, and maintained individually and locally at a significant cost. Moreover, the ways in which ATM information is defined, structured, provided and used are specific to most of the ATM systems.

With the expected growth in aviation demand, economic pressures and attention to environmental impact, the ATM system will be increasingly reliant on accurate and timely information. Such information must be organized and provided by solutions that support system-wide interoperability and secured seamless information access and exchange.

Global improvements in information management are needed in order to integrate the ATM network for a performance-enhancing operational scenario. These improvements are envisioned to be applied on a System Wide Information Management (SWIM) basis. The development of SWIM infrastructure and services should proceed in alignment with a globally-accepted operational concept that articulates the expected SWIM implementation in terms of the benefits, enablers, features, and principles for development and transition.

A global SWIM concept, presented in this manual, describes how stakeholders will participate in SWIM, how it will be managed based on the agreed SWIM governance, and how it will be operated at the various levels starting with the business and institutional down to the technical and implementation levels. As such it provides the foundation for further developments.

Comments concerning the manual should be addressed to:

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ABBREVIATIONS AND ACRONYMS

AAtS	Aircraft Access to SWIM
AFTN	Aeronautical Fixed Telecommunication Network
AI	Aeronautical Information
AIDC	ATS Inter-facility Data Communications
AIRM	ATM Information Reference Model
AIS	Aeronautical Information Services
AIXM	Aeronautical Information Exchange Model
AMHS	Aeronautical Message Handling System
ANS	Air Navigation Services
ANSP	Air Navigation Service Provider
AOC	Airline Operations Center
API	Application Program Interface
ASBU	Aviation System Block Upgrades
ASP	ATM Service Provider
ASTERIX	All Purpose Structured Eurocontrol Surveillance Information Exchange
ATC	Air Traffic Control
ATM	Air Traffic Management
ATMRPP	Air Traffic Management Requirements and Performance Panel
ATN	Aeronautical Telecommunications Network
ATS	Air Traffic Services
AU	Airspace User
BP	Boundary Protection
BPEL	Business Process Execution Language
B2B	Business to Business
CARATS	Collaborative Action for Renovation of Air Traffic Systems
CDM	Collaborative Decision Making
CIDIN	Common ICAO Data Interchange Network
CNAS	China New Generation ATM System
COI	Community of Interest
COTS	Commercial off-the-Shelf
DATM	Digital ATM Information Management

DDS	Data Distribution Service
DNS	Domain Name System (or Service)
eAIP	Electronic Aeronautical Information Publication
EBP	External Boundary Protection
EMB	Enterprise Messaging Bus
ESB	Enterprise Service Bus
ESM	Enterprise Service Management
EUROCAE	European Organization for Civil Aviation Equipment
FAA	Federal Aviation Administration
FIXM	Flight Information Exchange Model
FO	Flight Object
FOC	Flight Operations Center
GANP	Global Air Navigation Plan
GATMOC	Global ATM Operational Concept
GML	Geography Markup Language
GUFI	Globally Unique Flight Identifier
HTML	Hypertext markup language
HTTP	Hypertext Transfer Protocol
HTTPS	HTTP Secure
I&A	Identification and Authentication
IAIDQ	International Association of Information and Data Quality
ICAO	International Civil Aviation Organization
IETF	Internet Engineering Task Force
IM	Information Management
IP	Internet Protocol
IPS	Internet Protocol Suite
ISRM	Information Service Reference Model
IT	Information Technology
iWXXM	ICAO WXXM (model)
Java EE	Java Platform, Enterprise Edition
Java SE	Java Platform, Standard Edition
JMS	Java Messaging Service
JMX	Java Management eXtension
KPA	Key Performance Areas
MAC	Message Authentication Code

MEP	Message Exchange Pattern
MET	Meteorology
MOM	Message-Oriented Middleware
MQ	Message Queue
MTOM	Message Transmission Optimization Mechanism
NAS	National Airspace System (U.S.A)
NextGen	Next Generation Air Transportation System
NOTAM	Notice to Airmen
OASIS	Organization for the Advancement of Structured Information Standards
OGC	Open Geospatial Consortium
OLDI	On-line Data Interchange
OMG	Object Management Group
OWL	Web Ontology Language
PEP	Policy Enforcement Point
PKI	Public Key Infrastructure
QoS	Quality of Service
REST	REpresentational State Transfer
ROI	Return on Investment
SAML	Security Authorization Markup Language
SAS	SWIM Application Services
SASL	Simple Authentication and Security Layer
SDM	Service Delivery Management
SESAR	Single European Sky ATM Research
SLA	Service Level Agreement
SNMP	Simple Network Management Protocol
SOA	Service-Oriented Architecture
SSL	Secure Sockets Layer
SWIM	System Wide Information Management
TBD	To be determined
TCP	Transmission Control Protocol
TFM	Traffic Flow Management
TLS	Transport Layer Security
TMI	Traffic Management Initiative
UDDI	Universal Description, Discovery, and Integration
URL	Uniform Resource Locator

VoIP	Voice Over Internet Protocol
VPN	Virtual Private Network
W3C	World Wide Web Consortium
WAN	Wide Area Network
WCS	Web Coverage Service
WFS	Web Feature Service
WMS	Web Map Service
WS	Web Services
WSDL	Web Services Description Language
WSDM	Web Services Distributed Management
WSF	Web Services Framework
WS-RM	WS-Reliable Messaging
WS-RT	WS-Resource Transfer
WXXM	Weather Information Exchange Model
XML	eXtensible Markup Language
XPath	XML Path Language
XQuery	XML Query Language
XSD	XML Schema Definition
XSLT	eXtensible Stylesheet Language Transformations

GLOSSARY OF TERMS

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

Accessible. An information service that may be consumed by means of either the request/response or publish-subscribe operational pattern is accessible.

Application**.** See *SWIM-enabled application*.

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.

Build-time. The lifecycle stage in which an information provider or consumer is under development, e.g., pre-operational. Also called *design-time*.

Community of interest (COI). A collaborative group of users who must exchange information in pursuit of shared goals, interests, missions or business processes. COIs are established in a variety of ways and may be composed of members from one or more functions and organizations as needed for a shared mission.

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.

Design-time**.** The lifecycle stage in which an information provider or consumer is under development, e.g., pre-operational. Also called *build-time*.

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.

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.

Extensibility. A characteristic of an interface (or service) that continues to support previously conformant users after it has been modified (i.e. extended) for new users.

Filtering rules. Filtering rules define constraints on an information provider with respect to the data to be provided to a consumer.

Governance. SWIM governance is characterized by the people, policies, and processes required for leading, communicating, guiding, and enforcing the stakeholder organizational behaviours needed for global interoperability.

***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 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.

Interface Management. The SWIM core service providing a standard interoperable means for description, access, invocation and manipulation of resources to enable compatible communications between ATM information providers and consumers.

***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.

Middleware. Middleware is software that serves to "glue together" or mediate between two separate and often already existing messaging standards. Typically considered as being at the messaging layer and the transport layer.

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

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).

Runtime. The lifecycle stage in which an information provider or consumer is operational.

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

Selection Criteria. Selection criteria provide the means by which a consumer identifies the data of interest to an information provider.

Service. See *Information Service*.

Service Deregistration. The act of deleting an entry from the SWIM Service Registry.

Service Discovery. The act of locating and accessing the schema for a specific information service. Also referred to as *discovery*.

***Service-oriented*.** Pertaining to a service-oriented architecture.

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 services where each information service provides a particular functionality. 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 service registry.

SOAP. XML based web service protocol.

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 Activation**.** The act of initiating dissemination of publication data and notifications to a subscriber. Subscription can occur during either design-time or runtime.

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 static 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.

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Chapter 1

INTRODUCTION TO THE MANUAL

1.1 Background

1.1.1 The System Wide Information Management (SWIM) will complement human-to-human with machine-to-machine communication, and improve data distribution and accessibility in terms of quality of the data exchanged. However, the flexibility whereby human intelligence and oral communication, by their very nature, can adapt to situational nuances of communication and operations has to be engineered into Information Technology (IT) systems. Hence, 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.

1.1.2 Implementation of the SWIM Concept, outlined in this document, must address the challenge of creating an "interoperability environment" which allows the SWIM IT systems to cope with the full complexity of operational information exchanges. The SWIM Concept introduces a significant change in the business practices of managing information during the entire life cycle of an ATM process. The implementation of SWIM seeks to provide quality information to the right people with the right systems at the right time. The SWIM environment shifts the ATM information architecture paradigm from point-to-point data exchanges to system-wide interoperability.

1.1.3 According to the *Convention on International Civil Aviation* (Doc 7300) and its Annexes, the International Civil Aviation Organization (ICAO) is entrusted, among others, with the role of establishing communication and information standards. For example, the *Procedures for Air Navigation Services — Air Traffic Management* (Doc 4444) standardizes both the phraseology used by pilots and controllers, and the data exchanged to communicate flight intent and flight reports. Similarly, Annex 15 — *Aeronautical Information Services* standardizes aeronautical information services and products. These documents provide a template for the provision of aeronautical information with detailed requirements for aeronautical data, implemented using technology that is becoming increasingly outdated.

1.1.4 The *Global Air Traffic Management (ATM) Operational Concept* (Doc 9854) envisages the application of SWIM to promote information-based ATM integration, stated as follows:

> "The ATM operational concept envisages the application of a system-wide information management concept, where information management solutions will be defined at the overall system level, rather than individually at each major subsystem (programme/ project/ process/ function) and interface level, as has happened in the past."

1.1.5 The application of SWIM in support of the global ATM operational concept was further reinforced in the *Manual on Air Traffic Management System Requirements* (Doc 9882).

1.1.6 SWIM is an integral part of the *Global Air Navigation Plan* (GANP) (Doc 9750), fourth edition, and is covered in a number of the aviation system block upgrades (ASBU) modules. Additional information on the way SWIM is currently integrated in the GANP/ASBUs is provided in Section 5.1.

1.1.7 Over the course of the past years, research into SWIM concepts and solutions has taken place, and is already at various stages of development in a non-harmonized way in different ICAO Member States. Modernization programmes such as the Collaborative Action for Renovation of Air Traffic Systems (CARATS) in Japan, the China New Generation ATM System (CNAS), the Next Generation Air Transportation System (NextGen) in the United States and the Single European Sky ATM Research (SESAR) in Europe, all consider the implementation of SWIM as a fundamental requirement for future ATM systems.

1.2 SCOPE OF THE MANUAL

The scope of the manual is limited to articulating the concept for SWIM necessary to achieve global interoperability. The manual further defines terms and describes a common framework to facilitate discussions and promote interoperability.

1.3 PURPOSE/OBJECTIVE OF THE MANUAL

1.3.1 The purpose of the manual is to provide a vision for interoperable global information management and addresses the transition to a mixed operational environment. Its objectives are two-fold: 1) to assist in the creation of a common lexicon to ease communication when States/groups desire to coordinate on related topics; and 2) to provide a background framework for assisting States/Regions which have not yet undertaken the development and implementation of SWIM instantiations.

1.3.2 This manual establishes guidelines for providing information services via a Service-Oriented Architecture (SOA) approach that enables ATM service providers (ASPs) to deliver global interoperability. While standards will permit interoperability, the SWIM Concept does not prescribe, or expect, a single global implementation of SWIM.

1.3.3 This manual further elaborates the information management concept articulated in the *Global ATM Operational Concept* (Doc 9854). The manual addresses the following:

a) definition of terms of relevance to information management to enable international discourse on system-wide information interoperability;

b) a layered description of SWIM enabling the reader to understand representative standards that are applicable to different information management elements;

c) the layered model further enables an understanding of the separation of the information management from the information being managed and the consumers of that information;

d) a description, through operational scenarios including the actors, of the expected roles and responsibilities of the actors in the scenarios, and the information exchange through the various SWIM layers; and

e) a description of how SWIM will operate in a transitional environment with some legacy ASPs.

1.4 TARGET AUDIENCE

This manual has been developed for members of the ATM community seeking information on integrating their information management within a global SWIM construct. The manual does not specifically address any individual member of the ATM community with interested parties to be found in all of the following communities:

a) ATM service providers;

b) airspace providers;

c) airspace users;

d) aerodrome;

e) meteorological (MET) information providers;

f) ATM support industry;

g) ICAO;

h) regulatory authorities;

i) States; and

j) any direct consumer of information from the ATM system[1].

1.5 ORGANIZATION OF THE MANUAL

1.5.1 The manual is organized as follows:

a) Chapter 1 gives the background and the purpose and scope of the document;

b) Chapter 2 provides the need for a SWIM concept, the definition and the benefits of SWIM, and explains the SWIM concept;

c) Chapter 3 considers the SWIM global interoperability framework and its details. These consider interoperability and governance at the information exchange services, information exchange models, and at the SWIM infrastructure level. The functions and representative standards are provided;

d) Chapter 4 considers the transition to SWIM and operations in a mixed environment;

e) Chapter 5 considers some future developments; and

f) A number of appendices provide supporting material.

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[1] It is recognized that information from the ATM system that is publicly available may be re-packaged for broader consumption outside of the scope of this document.

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 GANP (Doc 9750) ASBU modules 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 Closely related to the management of information, are the standards that define the information content, format and rules for exchange. Some of these are described on websites articulating information exchange standards applicable to aeronautical information (AIXM – Aeronautical Information Exchange Model, 2013), flight information (FIXM – Flight Information Exchange Model, 2012), meteorological information (WXXM – Weather Information Exchange Model, 2011), (IWXXM – ICAO Meteorological Information Exchange Model, 2013), and aviation information (AIDX – Aviation Information Data Exchange, 2012).

1.6.5 Other existing standards are expected to be applied at all levels of the SWIM framework which include the World Wide Web Consortium (W3C) (2013) specifications, Unified Modelling Language (UML), and the standards for network layer exchange.

1.6.6 It is expected that international information technology standards will eventually be adopted for SWIM implementations. However, associated technologies and technical standards necessary for implementation of SWIM are presently evolving at a rapid pace. This manual, therefore, provides representative examples in Appendix B of the types of standards and technologies necessary for international harmonization but does not specify the standards at this point.

Chapter 2

THE SWIM CONCEPT

2.1 THE NEED FOR SWIM

2.1.1 The present-day model for information exchange acts as a constraint on the forward-looking implementation of future performance-enhancing operational improvements. Chief limitations are:

a) systems have not been designed and implemented to be globally interoperable within globally-agreed parameters;

b) many interfaces, which were designed to support point-to-point or application-to-application exchanges, have limited flexibility to accommodate new users, additional systems, new content or changed formats;

c) message-size limitations and a non-scalable approach to information exchange with the present infrastructure;

d) the current infrastructure can make it difficult and costly for one stakeholder to access, on a timely basis, information originated by another stakeholder;

e) the current variety of systems and exchange models makes it challenging to devise security frameworks across systems and stakeholders so as to support the increasing need for open and timely data exchange whilst at the same time respecting the legitimate security concerns of all stakeholders; and

f) currently, most organizations manage their ATM information in partial isolation leading to duplication and inconsistencies.

2.1.2 The *Global Air Traffic Management Operational Concept* (Doc 9854) acknowledges that the shortcomings of the current provision and management of ATM related information will be addressed, in part, by improvements in information management (IM). The global improvements in information management are intended to integrate the ATM network in the information sense, not just in the system sense, and are envisioned to be applied as a SWIM concept.

2.2 SWIM BENEFITS

2.2.1 SWIM contributes to achieving the following benefits:

a) improved decision making by all stakeholders during all strategic and tactical phases of flight (pre-flight, in-flight and post-flight) through:

(i) improved shared situational awareness; and

(ii) improved availability of quality data and information from authoritative sources;

b) increased system performance;

c) more flexible and cost-effective communications by the application of common standards for information exchange;

d) loose coupling which minimizes the impact of changes between information producers and consumers; and

e) support of ATM Service Delivery Management (SDM)[2].

2.3 SWIM DEFINITION

2.3.1 SWIM consists of standards, infrastructure and governance enabling the management of the ATM-related information and its exchange between qualified parties via interoperable services.

2.3.2 The scope of SWIM is illustrated in Figure 1. It includes information exchange standards and the infrastructure required to exchange information between SWIM-enabled applications. SWIM-enabled applications consume or provide SWIM information services using SWIM standards. The term 'application' as used in this manual designates an ATM SWIM-enabled application, unless stated otherwise.

2.3.4 SWIM is not meant to be a stand-alone concept. The justification for its development and deployment lies in the needs of its client applications which, although not part of SWIM, are the primary users thereof (a curved arrow is used to indicate this association). SWIM conveys the requirements of the operational ATM services through applications that define the scope and quality of the information. This manual will therefore reference this application layer in order to facilitate the presentation of the SWIM concept. A detailed global interoperability framework is introduced in Chapter 3.

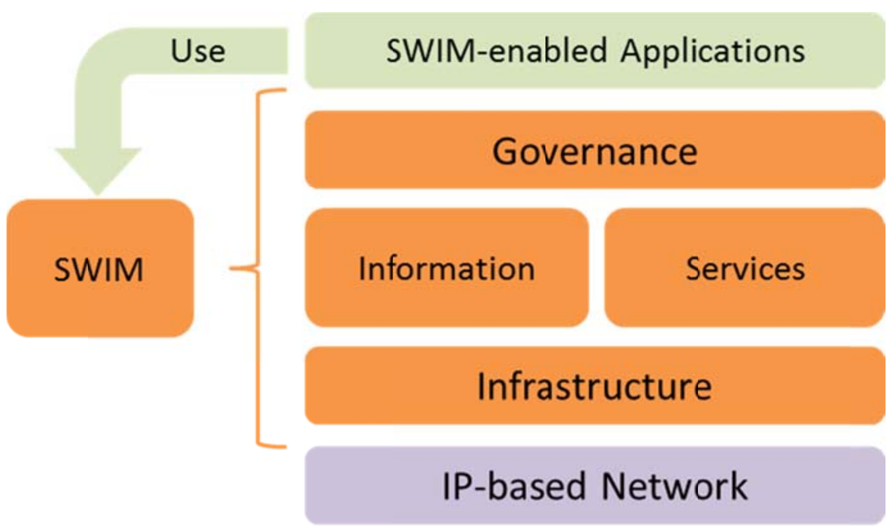

Figure 1. The Scope of SWIM

2 SDM is discussed later in Section 2.5

2.3.5 Interoperability is achieved on a global scale through the use of common information exchange models for information elements of interest, the use of common services for information exchange, and the use of appropriate technology and standards.

2.3.6 These models for ATM information have been defined in harmonized conceptual and logical data models. The models describe the data used in different information domains such as aeronautical, flight, meteorology, and surveillance domains. They also describe logical format and structure of the data elements that make up these domains.

2.3.7 Similarly, a definition of information services is necessary to indicate what types of services are provided, their behaviour, their performance levels and ways they can be accessed.

2.3.8 SWIM operates over an interoperable (runtime) infrastructure (ground/ground and air/ground) through which the data and information will be distributed. Its implementation may, depending on the specific needs profile, differ from one stakeholder to another, both in terms of scope and method of implementation. It will offer technical services based as much as possible on mainstream information technologies (IT). It will preferably be based on commercial off-the-shelf (COTS) products and services, but it is possible that in some cases specific software may need to be developed. Typically dedicated and secured IP networks and the Internet will provide the underlying basic ground/ground connectivity.

2.3.9 Achieving interoperability across all areas illustrated in Figure 1 requires that SWIM adheres to agreed-upon governance. Governance is further described in Section 3.8.

2.4 SWIM USE OF SERVICE-ORIENTED ARCHITECTURE (SOA)

2.4.1 Service-Oriented Architecture (SOA) is a general concept or paradigm for "organizing and utilizing distributed capabilities that may be under the control of different owners" (OASIS SOA Reference Model TC). While there is no formally-agreed definition of SOA, it is generally considered that partitioning of functionality into unassociated, self-contained and, therefore, reusable services that can be discovered by potential users is a key feature that discriminates SOA from more traditional architectural paradigms. The SOA paradigm has been used successfully in many industries including manufacturing, banking, health care, and merchandise retailing.

2.4.2 A service orientation is assumed for information exchanges between SWIM stakeholders, i.e. an information provider publishes and exposes its services for the use of information consumers; this is done via interconnected registries which list the services and the specific details for their use. One of the benefits of SOA is the promotion of "loose coupling". Loose coupling means that an information provider has a reduced impact on the information consumer. Dependencies are minimized allowing components and services to operate with as little knowledge as possible of other components or services (i.e. a consumer should need to understand only what is absolutely required to invoke a service and no more).

2.4.3 While service orientation is necessary for global SWIM-enabled services, implementation of SOA within individual stakeholders has to be balanced with any cost-benefit that it might endow.

2.4.4 SOA is being pursued internally by ASPs that have a large number of ATM systems which need to cooperate in order to provide ATM functions. ASPs and other stakeholders with few systems may opt to retain their current architectures as long as the SWIM information services that they wish to provide/consume are exposed externally in a standardized SWIM manner. (See Section 3.4 on information exchange services).

2.4.5 When empowered by SOA, SWIM will enable stakeholders to capitalize on opportunities, new services and capabilities by drawing upon industry best practices which have been proven to provide these benefits:

a) *More agile service delivery*: SOA enables organizations to respond quickly to new business imperatives, develop distinctive new capabilities and leverage existing services for true responsiveness by delivering information based services to the aviation industry;

b) *Cost reductions:* SOA promotes the reuse of existing assets, increasing efficiency and reducing application development costs and by sharing the most readily available code bases and services between ASPs. An integrated SWIM implementation improves coordination across all components of the modern ATM system reducing costly and time-consuming data conversion;

c) *Return on Investment (ROI):* SWIM and SOA do not necessarily only provide a financial benefit on their own. SWIM and SOA also provide a foundation for the high performance and future value to be found in the projects that they enable. Thus, even if they don't have a positive ROI on their own terms, SWIM/SOA projects must support a positive, combined ROI with the projects they enable – and may also boost it;

d) *Meet IT goals:* The technological value of SWIM includes:

   1) *Simpler systems:* SOA is based on industry standards and can reduce complexity when compared with integrating systems on a solution-by-solution basis. It also enables future applications to mesh seamlessly with existing standards-based services;

   2) *Lowering maintenance costs*: Simplicity and ease-of-maintenance signify that support costs are reduced;

   3) *Enhancing architectural flexibility:* SOA supports the building of next-generation performance-driven composite solutions that consolidate numerous business processes from multiple systems; and

   4) *Lowering integration costs:* SOA makes it possible for organizations to develop, implement and re-use processes that are technically enabled and integrated through the use of open technology standards. In addition, connectivity, data exchange and process integration efforts are simplified, reducing integration-related development and support costs.

2.5 ATM SERVICE DELIVERY MANAGEMENT (SDM)

2.5.1 One of the components of the *Global ATM Operational Concept* (Doc 9854) is the ATM service delivery management (ATM SDM). The ATM SDM concept component is described in Circular 335. The ATM SDM will operate seamlessly from gate to gate for all phases of flight and across all service providers. It will address the balance and consolidation of the decisions of the various other processes/services, as well as the time horizon at which, and the conditions under which, these decisions are made. Key conceptual changes include:

a) services to be delivered by the ATM SDM component will be established on an as-required basis subject to ATM system design. Once established, service provision will be done through on-request or event-driven basis;

b) ATM system design will be determined through a collaborative decision-making (CDM) process and by taking into account requirements of system-wide safety and performance cases;

c) services delivered by the ATM SDM component will, through CDM, balance and optimize user-requested trajectories to achieve the ATM community's expectations; and

d) management by trajectory will involve the development of an agreement that extends through all the physical phases of flight.

2.5.2 Carrying out ATM SDM entails analyzing and deciding what assets need to be deployed in order to deliver the required services and obtain the expected performance, while considering the following:

a) across and within global concept components — airspace organization, aerodrome operations, user operations, etc.;

b) across and within time horizons — from long-term planning through to tactical decisions; and

c) end-to-end — whether seen as gate-to-gate, or en route-to-en route.

2.5.3 Planning and conducting of SWIM will take place through ATM SDM. The ATM SDM defines the rules and means for safe and secure information sharing between all the participants. It acts as a focal point for coordination between the different service providers (i.e. through Letter of Agreement, Service Level Agreement, information sharing, delegation of service provision).

2.5.4 Doing ATM SDM requires that accredited, quality-assured, timely information be shared by decision makers on a system-wide basis to ensure the cohesion and linkage between concept components and to build an integrated picture. Therefore, the needs established through ATM SDM set the overall requirements for SWIM. Taking these needs into account, the SWIM concept provides consolidated guidance, addressing topics such as SWIM scope (e.g. models, infrastructure, applications), principles (e.g. open standards, service-oriented architecture), and governance (e.g. approval and evolution of standards, allocation of functions/infrastructure to stakeholders, definition of roles and responsibilities).

2.6 LIFE-CYCLE MANAGEMENT

2.6.1 The important role in SWIM of the overall governance of the service approach is described in Section 3.8. The SWIM registry is an important enabler for managing an information service. The service lifecycle will need to be managed as a transparent process for the stakeholders.

2.6.2 The *SOA Governance Framework* (The Open Group, 2009) enables organizations to define and deploy their own focused and customized SOA governance model. The framework uses the concept of a solution portfolio (designed to meet business needs) and a service portfolio that results from the solution portfolio. It then proposes a way to manage both the solutions and the services portfolios and their lifecycles through the planning and through the design and operational phases.

2.6.3 Some SWIM pioneers have developed their customized SWIM Governance Models. As an example, one SWIM pioneer ANSP identifies the following stages and specifies the processes in the service lifecycle for a producer.

a) identification of the business need;

b) proposal as a SWIM information service (and approval);

c) definition of the information service;

d) development of the information service;.

e) verification of the information service;

f) production and deployment of the information service;

g) deprecation of the information service (after decision to retire); and

h) retirement of the information service.

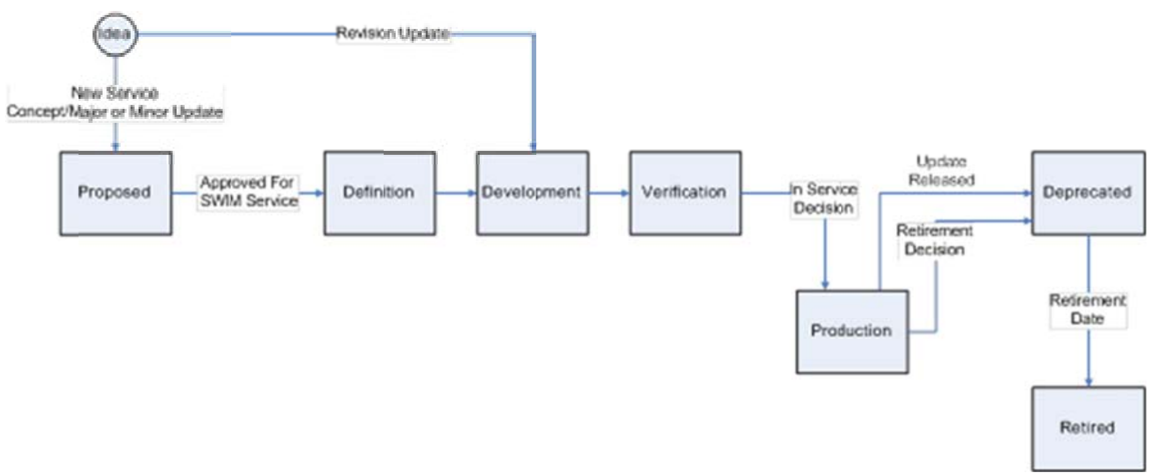

Figure 1. Example of a Service Lifecycle for Service Producer, Service Operator, and Service Provider (Including Brokers)

2.6.4 Changing requirements, during the life of an information service, can produce major or minor updates. Updates which require a change to the Service Level Agreement (SLA) and also require changes by consumers (i.e. not backward-compatible) are considered to be major. Updates which require a change to the SLA but not by any known consumers (i.e. are backward-compatible) are considered to be minor. There may also be revision updates (i.e. bug fixes) where no changes are needed to the SLA.

2.6.5 While the initial information service design and deployment is relatively straightforward, managing changes to a service is more complicated once the information service has been deployed and its use widespread. Producers will have to balance the need to "improve" the functionality of the information service, while consumers are looking for "stability" of the existing services. This is further complicated because some producers may not be aware of all the consumers. The deprecation cycle might have to be prolonged and different versions of the service might have to be supported at a given time. Each enterprise will need to coordinate with major stakeholders and within its region, as applicable. Similarly, regions will need to coordinate with other regions.

2.7 SWIM CONCEPT EXPLAINED

2.7.1 SWIM Principles

2.7.1.1 SWIM should utilize the best practices from different information communities to meet the needs of global ATM. The aim of SWIM is to provide information to users with access to relevant and mutually understood information in an interoperable manner. Interoperability is the ability of diverse systems belonging to different organizations to exchange information. This includes the ability, not only to communicate and exchange data, but also to interpret the information exchanged in a meaningful manner. Information should be of the right quality, provided at the right time and delivered to the right place, hence enabling net-centric ATM operations. In order to achieve this objective efficiently the following SWIM principles should be adhered to:

a) separation of information provision and information consumption to the extent possible. In the ATM network, almost every participant is a producer and a consumer of information. It is not always appropriate to decide in advance who will need what type of information and from whom it would be obtained and when. The key issue is to decouple producers of information from the possible consumers in such a way that the number and the nature of the consumers can evolve through time;

b) loose system coupling. Where each of its components has, or makes use of, as little knowledge as possible of the definitions of other distinct components. By doing this the barriers between systems and applications are minimized, and interfaces are compatible;

c) use of open standards. An open standard is one that is publicly available and has various rights of use associated with it. It may also have various properties describing its design phase (e.g. open process); and

d) use of interoperable services. After an analysis of the processes and needs of business domains, the required functionality is developed, packaged and implemented as a suite of interoperable services that can be used in a flexible way within multiple separate systems.

2.7.1.2 In order to achieve global interoperability, the above SWIM principles should be applied. Although this does not mandate the internal implementation of loose coupling and open standards (SOA), a particular stakeholder, within its own system, may choose to do so or not. Some ASPs may implement SOA internally for some of their systems to promote agile evolution, while other ASPs may choose not to, or plan evolutions at a later stage. As a consequence the connectivity between SOA and non-SOA needs to be ensured by means of Gateways. These Gateways may be shared by systems within a member state, provided as a shared resource for the use of multiple member states, or provided by a new participant such as a third-party provider. See Section 4 for descriptions of mixed SWIM and non-SWIM environments and some transition scenarios.

2.7.2 SWIM Stakeholders

2.7.2.1 The *Global ATM Operational Concept* (Doc 9854) lists and describes the various members comprising the ATM community, as follows:

a) aerodrome community;

b) airspace providers;

c) airspace users;

d) ATM service providers;

e) ATM support industry;

f) International Civil Aviation Organization (ICAO);

g) regulatory authorities; and

h) States.

2.7.2.3 Some of these members (e.g. ICAO, States and regulatory authorities) will be mainly responsible for SWIM governance.

2.7.2.4 One of the main changes brought about by SWIM is that any of these members can act both as information provider and as information consumer. Therefore, while the ASPs will continue to be at the core of the ATM processes, SWIM will allow other information providers to play a bigger role, e.g. an ASP may consume an information service from an airspace user to get a detailed trajectory profile for a given flight.

2.8 PERFORMANCE IMPROVEMENT VIA SWIM

2.8.1 Given the international nature of SWIM, it is not likely that one solution, and certainly not one single technology, will fit all. Individual ASPs are expected to implement suitable procedures in accordance with target performance levels as described in the *Manual on Global Performance of the Air Navigation System* (Doc 9883). Nevertheless, it is recognized that global interoperability and standardization are essential for efficient and safe international aviation and SWIM will likely be an important driver for new and updated standards.

2.8.2 The *Global ATM Operational Concept* (Doc 9854) equates Information Management (IM) with SWIM, and this document uses the latter term to avoid any confusion. As discussed above, the ASBU module B1-SWIM entitled “Performance Improvement through the application of SWIM” 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.

2.8.4 As described in *Circular 335 — Air Traffic Management Service Delivery Management* (*ATM SDM) Description*, the planning and conduct of SWIM will take place through the ATM SDM component of the Global ATM Operational Concept, which acts as a focal point for coordination; while the needs established through ATM SDM will set the overall requirements for SWIM.

2.8.5 In the above context, performance-based SWIM signifies that performance requirements for information management systems are not established from a technical perspective in isolation, but through a top-down/bottom-up trade-off process. The process links such requirements clearly and strongly to the Performance Case of the corresponding Operational Improvement which argues the benefits/disbenefits across the eleven Key Performance Areas (KPAs) of the Global ATM Operational Concept.

2.8.6 For example, a particular characteristic would be (or may be deemed to be) ‘required’ for a type of information transaction, not simply because it is technically feasible, or desirable, or because it would enable a potentially quicker operational response time by an aircraft or group of aircraft. Rather, it would be ‘required’ only after establishing that the potentially quicker operational response time can be realized during operations, and can also be taken full advantage of, to the extent that it will deliver tangible, justifiable benefits overall. In other words, information management systems are just one link in the chain, and their requirements must be in balance: (a) with those for the rest of the chain; and (b) with the overall benefits that the chain can realize in practice.

2.8.7 Although one size may not fit all the needs of all stakeholders, it is of the utmost importance, for the consistency of the global air transportation system, to achieve some level of interoperability between the different solutions developed. The SWIM infrastructure and services should be developed in alignment with a globally-accepted operational concept that articulates the expected SWIM implementation in terms of benefits, enablers, features, and principles for development and transition.

2.8.8 The *Global ATM Operational Concept* (Doc 9854) states that “Key to the philosophy adopted within the operational concept is the notion of global information utilization, management and interchange. This philosophy is supported in large part by evolution to a holistic, cooperative and collaborative decision-making environment ...”. As such, it will require an increase in information exchanges, both in terms of the number of exchanges performed and the number of participants involved. Security will become a critical factor, therefore the global SWIM concept encompasses aspects such as authentication, authorization, encryption, intrusion detection, security policies, etc.

2.8.9 Information required to perform an organization/company 'business' is one of the most important assets of any organization/company that allows it to deliver valuable services (to aviation, in this case).

Chapter 3

THE SWIM GLOBAL INTEROPERABILITY FRAMEWORK

3.1 SWIM LAYERS

3.1.1 This section presents a five-layered SWIM Global Interoperability Framework to describe the sharing of information via SWIM. The framework is based on several complementary descriptions of SWIM that have been created by stakeholders. The layers explain the functions, the combination of representative standards and the mechanisms for interoperability. This current description of the SWIM Global Interoperability Framework focusses on the technical elements of the ground-ground SWIM segment and is consistent with airborne segment solutions that are being developed.

3.1.2 The Global Interoperability Framework (see Figure 2) comprises the following layers:

a) **SWIM-enabled Applications** of information providers and information consumers around the globe. Individuals and organizations, such as air traffic managers and airspace users, will interact using applications that interoperate through SWIM;

b) **Information Exchange Services** defined for each ATM information domain and for cross domain purposes, where opportune, following governance specifications and agreed upon by SWIM stakeholders. SWIM-enabled applications will use information exchange services for interaction;

c) **Information Exchange Models** using subject-specific standards for sharing information for the above Information Exchange Services. The information exchange models define the syntax and semantics of the data exchanged by applications;

d) **SWIM Infrastructure** for sharing information. It provides the core services such as interface management, request-reply and publish-subscribe messaging, service security, and enterprise service management; and

e) **Network Connectivity** provides consolidated telecommunications services, including hardware. This infrastructure is a collection of the interconnected network infrastructures of the different stakeholders. These will be private/public Internet Protocol (IP) networks.

3.1.3 The scope of SWIM is limited to the three middle layers (i.e. Information Exchange Services, Information Exchange Models, and SWIM Infrastructure) and to the governance of these layers.

3.1.4 The currently identified Information exchange services of global interest pertain to aeronautical information, meteorological information, surveillance information, and flight information. Additional domain services and cross-domain composite services will likely be defined in the future. The most important task for SWIM implementing stakeholders is to agree upon a set of services for information exchange and the range of options that will be appropriate within each of these services (for member States with different levels of ATM sophistication) and the standards for information exchange.

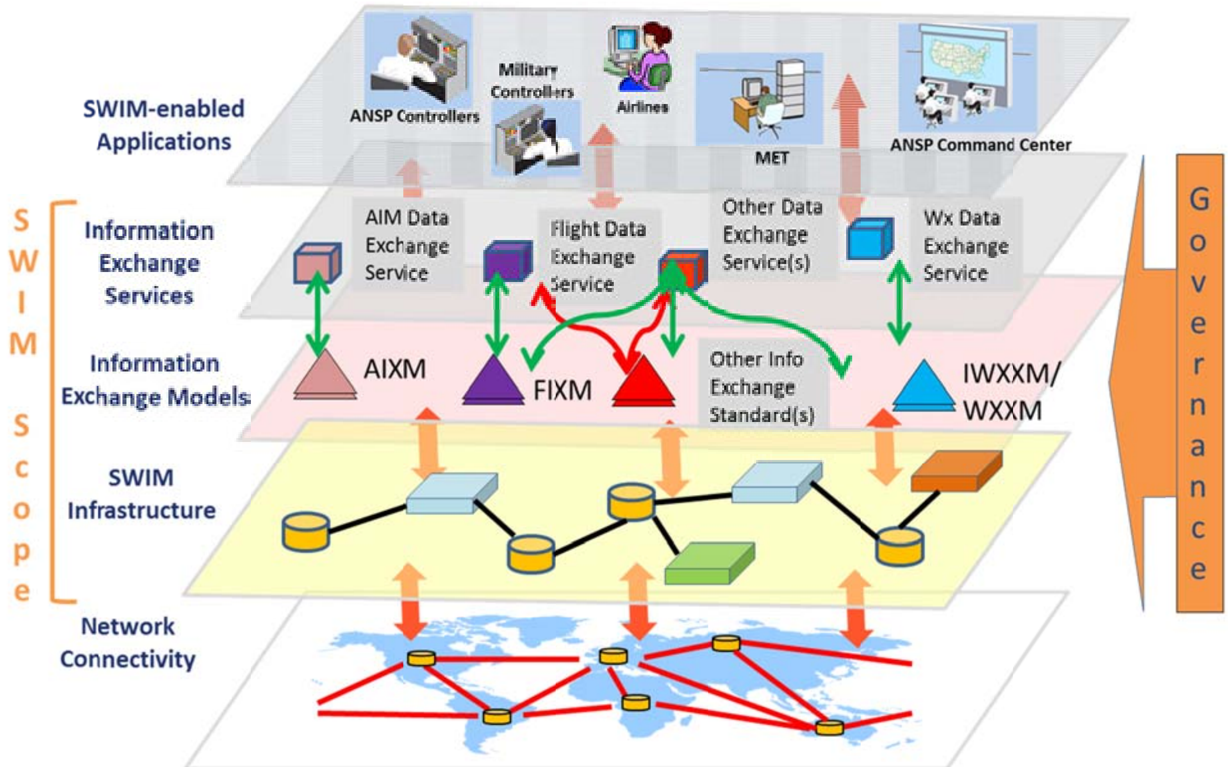

Figure 2. SWIM Global Interoperability Framework

3.1.5 There can be a many-to-many relationship between exchange services and exchange standards. In other words, an exchange service may use one or more exchange standards, and an exchange standard may be used by one or more exchange services.

3.1.6 The SWIM infrastructure and network connectivity layers are likely to be built upon a set of well-defined standards and are not expected to constitute the major technical barrier to the realization of SWIM. These infrastructures will also be gradually implemented and interconnected by stakeholders, such as an ASP. The specific type of SWIM implementations will be left to that stakeholder's organization as long as it is based on the SWIM Concept objectives and interoperability with other stakeholders is made possible.

3.2 INTEROPERABILITY AT DIFFERENT LAYERS

The SWIM global interoperability framework describes a layered framework enabling further discussion on how interoperability between SWIM-enabled applications will be achieved in practice. The following paragraph describes how information from one SWIM-enabled application is exchanged with another.

3.2.1 A Flight Data Exchange example

3.2.1.1 As an example, consider two SWIM-enabled applications that must share flight information of relevance to a flight being planned. These SWIM-enabled applications may be used by a variety of ATM service participants such as ATM service providers (ASPs), airspace users (AUs) or emergency service providers. In a global SWIM environment, the two interacting SWIM-enabled applications may be physically located anywhere in the world, and may be operated by different organizations which do not need to be of the same type (e.g. an ASP and an AU). The interaction proceeds as described in Figure 3.

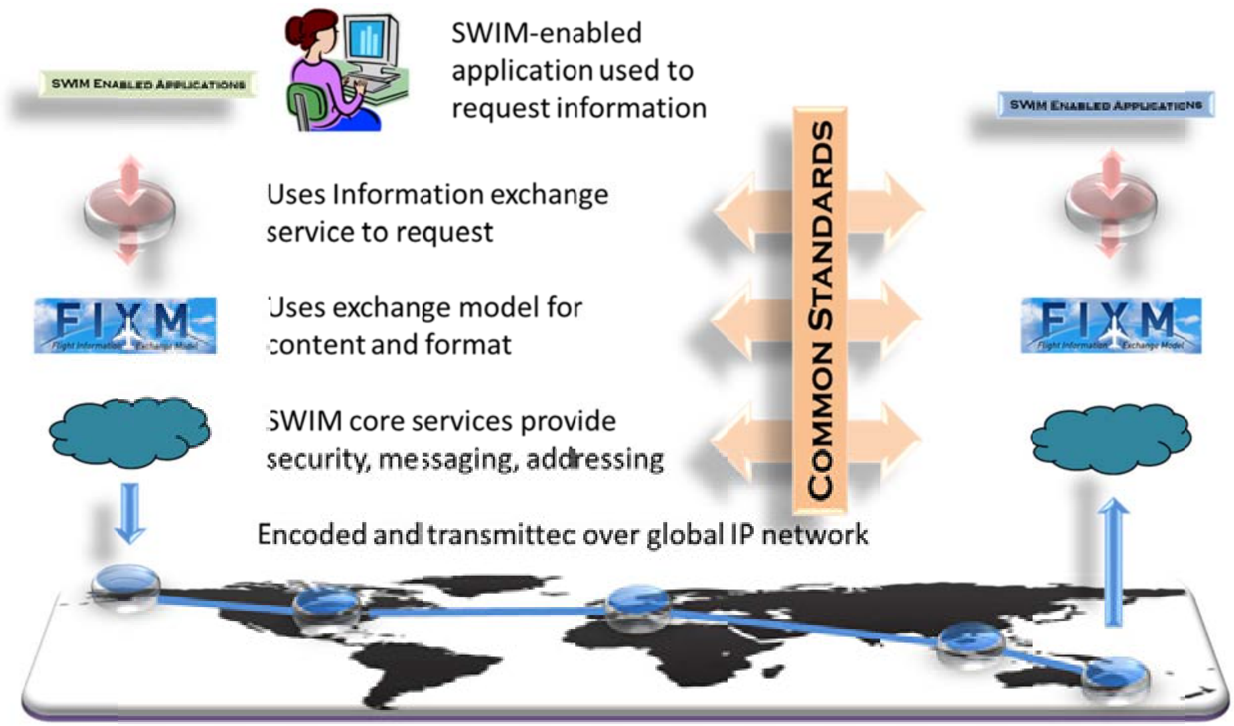

Figure 3. Example of flight information exchange between SWIM-enabled applications

3.2.1.2 The purpose of each layer in the SWIM global interoperability framework is described as follows:

a) at the highest layer, a SWIM-enabled application is used to request an information service. Semantic interoperability based on a common understanding of the information used is required. A SWIM-enabled application is capable of interacting with the layers below it through implementation of standards that enable interoperability;

b) at the Information Exchange Services layer, the characteristics of the requested information service are described in a technology-neutral manner. For example, a flight route provision service may give a flight's route upon request with the flight's GUFI (Globally Unique Flight Identifier). At this layer, the response characteristics including application-level error conditions (e.g. GUFI unknown) and normal response (e.g. provide the route) are described;

c) at the information exchange models layer, the characteristics of the data being used by the information exchange services are described to include information content, structure and format. Continuing with the previous example, the GUFI and flight route would be described via flight information exchange model (FIXM) compliant data elements. The combined information exchange services and the information exchange models layers define individual application-level messages that can be exchanged to deliver the requested service;

d) the SWIM Infrastructure layer provides core SWIM services such as interface management, messaging, service security, and enterprise service management. At this layer, application-level messages required to deliver the requested information service are implemented in accordance with a defined protocol for interoperability with the service deliverer through interface management functions that also manage performance requirements. Messaging core services provide such functions as addressing and message assurance. Security services such as authentication and authorization are also provided; and

e) the message is then transported over a global network, where it is delivered to a specified recipient responsible for providing the application-level message to the recipient SWIM-enabled application.

3.2.1.3 The process described above is somewhat analogous to a set of nesting dolls in which different layers take the payload from the layer above (see Figure 4). Upon receipt of the lowest layer, the process is reversed and each layer is unwrapped.

3.2.1.4 In order for the receiving party to successfully unwrap the messages received at each layer, each of these layers must understand the protocol used when the message was constructed. Outside of the scope of SWIM, at the network connectivity layer, interoperability is straightforward. At the SWIM Core services layer, many standards exist (see 0) that allow an information service, aware of the encoding standard, to recover the information. Information services do not need to operate with the same standards internally, but may require a translation function for interoperability.

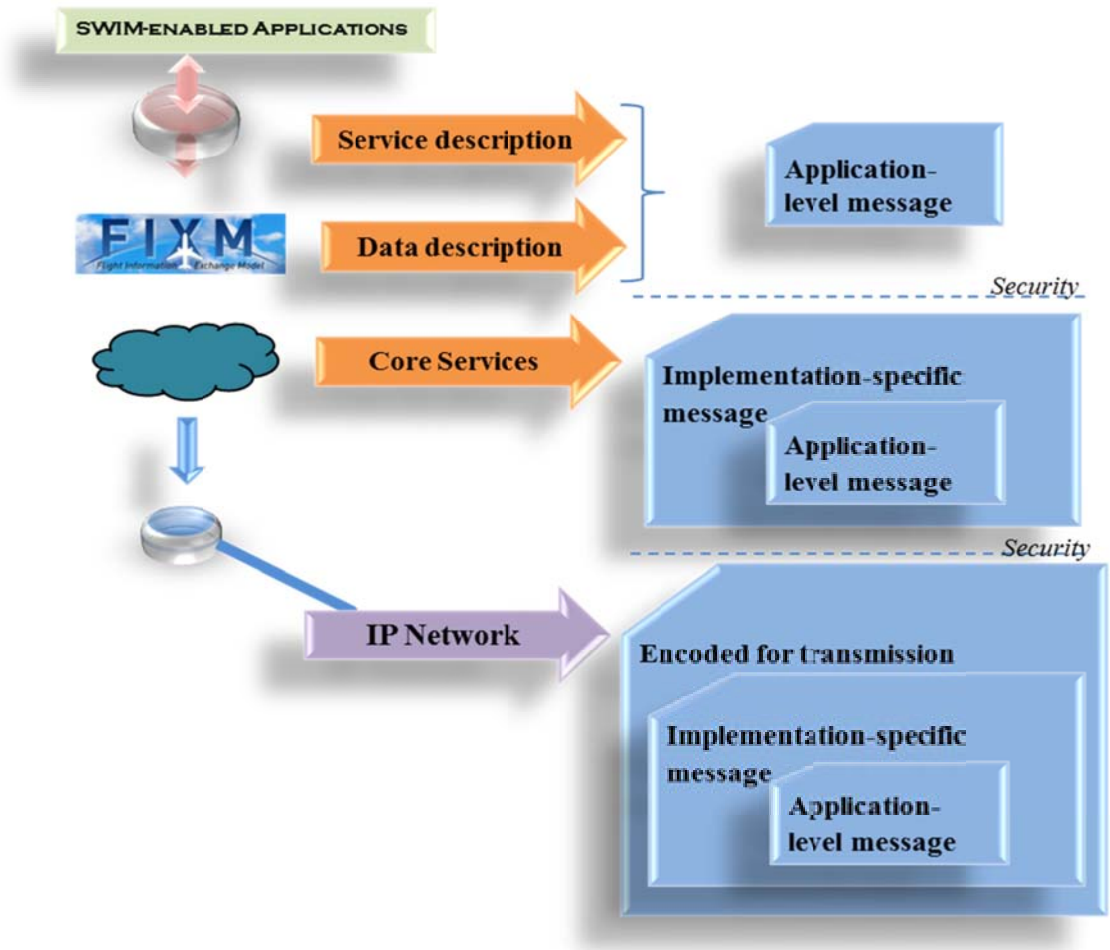

Figure 4. Layers encapsulate messages from prior layers

3.2.2 SWIM Enterprises and regions

3.2.2.1 It is clear that "one size fits all" may not be the most desirable solution at a global level as different stakeholders will be driven by differing performance expectations and circumstances. As a result, a global SWIM will be achieved through the inter-operation of potentially a variety of implementations. SWIM standards defined at a global level shall focus on the exchanges between SWIM enterprises and not on the exchanges within SWIM enterprises. In this context, a SWIM enterprise can be an ASP, a group of ASPs, an AU, or an ATM support industry that has full control of the implementation planning and execution within the enterprise.

3.2.2.2 The concept of a SWIM Region has previously been articulated in the *Manual on Flight and Flow – Information for a Collaborative Environment (FF-ICE)*, (Doc 9965). A SWIM region will be delimited by the area of influence of a given governance structure (i.e. the governance structure which defines the standards, the policies, etc. that are applicable to all the enterprises within the region). Within a SWIM Region, a collection of enterprises, for example ASPs or AUs, may choose to interoperate using standards established for that particular SWIM region. In turn, each enterprise may organize itself with whatever standards it deems appropriate to apply internally, provided they can interoperate with the SWIM region standards. Furthermore, a much richer set of services would likely be available within an enterprise.

Provider/consumer systems belonging to an enterprise will connect to SWIM via SWIM access points, which are logical entities that provide SWIM core services such as messaging, interface management, security, etc. SWIM access points are described later in Section 3.7, SWIM infrastructure.

3.2.2.3 Figure 4 provides an example of relationships between enterprises and SWIM regions. Three enterprises are shown – an ASP, and two AUs (AU-1 and AU-2). The applications in these enterprises are in systems that connect to their respective SWIM access points via service interfaces. The ASP, AU-1 and AU-2 belong to SWIM Region A which shares a common set of standards. The AU-2 enterprise also chooses to belong to a second SWIM Region B. Thus there is potential connectivity between all applications; however, security services may limit the exposure of services to selected authorized users.

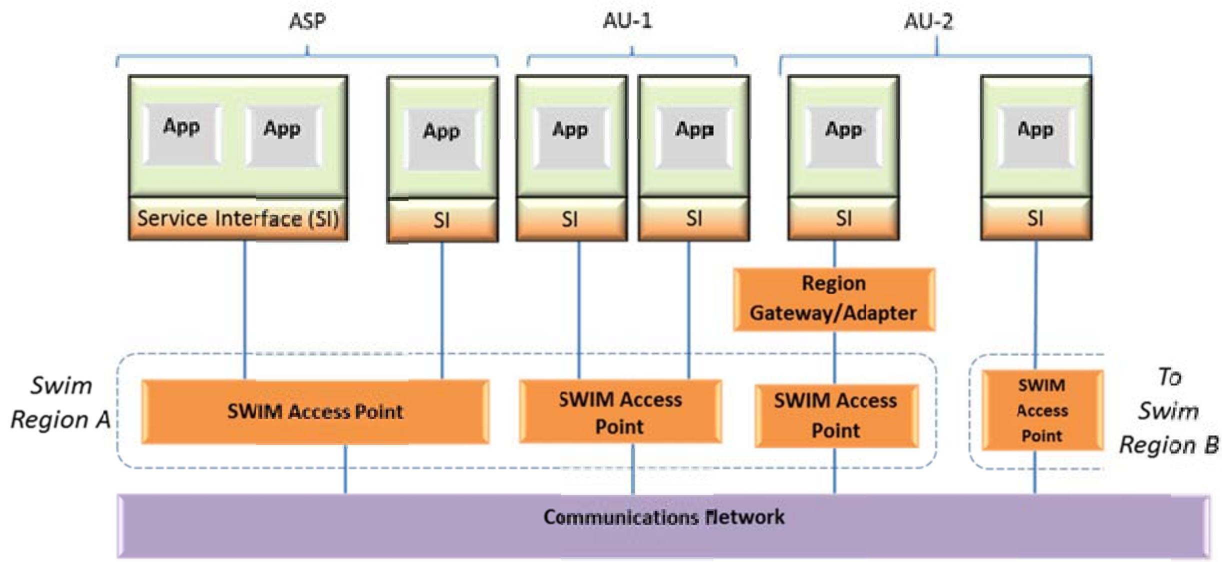

Figure 4. Illustration of Enterprises and SWIM Region

3.2.2.4 Where circumstances are such that full harmonization cannot be achieved across SWIM regions, then interoperability will be achieved via gateways/adapters. However, the organization responsible for implementing these gateways is not prescribed. As a result, several options exist for implementing these gateways or adapters, for example:

a) one enterprise may implement the gateway/adapters and expose services in other SWIM Regions to its SWIM Region;

b) each enterprise could be responsible for implementing gateways and adapters for their own enterprise (illustrated in Figure 5 for AU-2);

c) a new organization may appear exposing services of other SWIM Regions in accordance with one SWIM Region native standards; and

d) combination of the above.

3.2.2.5 Through the use of the gateways and adapters, participants within a SWIM region may then interoperate with SWIM-enabled applications in other regions by meeting global standards for interoperability. The impact of the above implies that a service consumer may potentially obtain services from global SWIM-enabled applications through a variety of paths. However, different service level agreements (SLAs), governance and security policies, and relative service costs may limit these paths.

3.3 OVERVIEW OF FUNCTIONS AND STANDARDS BY LAYER

Table 1 provides an overview of the functions and standards associated with the different layers of the Global Interoperability Framework. The table includes an initial set of candidate standards; additional standards may be added as needed. Sections 3.4 through 3.7 provide details on the three layers associated with SWIM. Governance will apply to all these layers and is considered in Section 3.8. The SWIM standards listed are examples. A brief description of these is provided in Appendix B.

Table 1. Global Interoperability Framework - Overview of Functions and Standards

Layer of Framework	Functions or Sub layers	Candidate Standards, models, implementations
SWIM-enabled Applications		ATS, ATFM, Airline Ops
Information Exchange Services	Service Interoperability	No global standards as yet
	Interface Definition	OGC CS-W, WSDL, WADL, WFS, WMS, WCS
Information Exchange Models and Schemas	For aeronautical, MET, and flight information	AIXM, WXXM, IWXXM, FIXM, FIXS, AIXS, WXXS
	Semantic Interoperability	Domain Specific: AIRM General: RDF/RDFS, OWL, SKOS
SWIM Infrastructure	Enterprise Service Management	DDS, JMX, SNMP
	Policy	WS-Policy standards
	Reliability	WS-RM & WS-RM Policy
	Security	WS-Security & SSL
	Interface Management (Service Registration)	OASIS/ebXML
	Data Representation	XML, XSD, GML
	Messaging	SOAP, JMS, DDS
	Transport	HTTP, JMS, MQ
	Boundary Protection	No global standards as yet
	Service Registry	UDDI, work on-going
Network Connectivity	Secure Network Connectivity	IPv4, IPv6
	Naming and Addressing	DNS
	Identity Management	No global standards as yet
	Incident Detection and Response	No global standards as yet

3.4 INFORMATION EXCHANGE SERVICES

3.4.1 As mentioned before, information is a key enabler, shared through SWIM services, for ATM innovation and performance improvements. SWIM is designed to improve information sharing by making the right information available to the right stakeholders at the right time. However, the challenge is to do this in an organized manner. More specifically it requires defining the information exchanges, based on agreements between stakeholders, and commonly agreed means. Within the concept of SWIM the solution to the above-mentioned challenge is based on the use of a SOA-based approach whereby application functionality is exposed through services.

3.4.2 Within the SWIM Global Interoperability Framework, the Information Exchange layer is instantiated by 'information services' as is further explained. Information services ensure interoperability between ATM applications which consume and provide interoperable information services. Consequently, the concept of information service is a fundamental building block of SWIM which enables interoperability through well-defined information exchanges.

3.4.3 Furthermore, applications make use of information as they consume or provide standardized information services based on the standards defined by SWIM. The definition of a standardized information service indicates: (1) what a service provides; (2) the service message (the structure of the message at the logical level); (3) the behaviour; (4) the performance levels; and (5) how the service can be accessed.

Note:— It is necessary to provide the complete definition through a Service Description Document.

3.4.5 Service message interoperability is achieved at the implementation level through the use of commonly agreed information exchange models, appropriate technology and standards within the scope of each service and related community of interest. The service definitions and implementation specifications are made available as open standards. The service definitions also contain the non-functional requirements and connect to one or more SWIM technical policies, hence providing well defined interfaces for implementation purposes.

3.4.6 Service consumers can, in principle, combine services together. The role of the common semantic reference is performed by the ATM Information Reference Model (AIRM) to which the service message complies for service definition purposes. Service message syntax specifications are treated as a separate concern based on constraints, opportunities and cost considerations at the implementation level.

3.5 SWIM REGISTRY

3.5.1 Design-time registries[3] help developers locate assets, make decisions about which ones are best to use among many that might be similarly appropriate or adequate, and understand the various costs involved in their consumption. Runtime registries help systems make automated, policy-based decisions about service selection.

3.5.2 An important aspect of SWIM is the overall governance of the service approach. A key component of the SWIM Concept is the service lifecycle, from the identification of the business needs through the design until the development of the services. The service lifecycle will need to be managed with a transparent process for the stakeholders. More information on a typical service life cycle process is provided in Section 2.6.

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[3] Registries, as used in this document, include any necessary repository functionality to store registry artifacts. A functional SWIM can exist without a service repository; it helps, but it is not required.

3.5.3 Achieving interoperability across all ATM areas requires governance. The registry is the key element which brings SWIM-related interoperability artifacts together and enables policy enforcement where required. It allows information providers to publish services and information consumers to find appropriate services based on the information exposed by the registry. Furthermore, the registry brings together qualified parties as trusted partners. Finally, the registry enables collaborative lifecycle management enabling participants to progressively plan and engage.

3.5.4 As a consequence the information services and their lifecycles must be stored in a catalogue and managed. Information service providers maintain and expose these services with their implemented instances through a SWIM registry.

3.5.5 Although the term “SWIM registry” is used in the singular, there will likely be multiple SWIM registries in different enterprises or regions; these will be linked together with the aim of functioning as a single global logical registry for authorized users. The various means of achieving this goal continues to be a topic of study.

3.5.6 Furthermore, the SWIM registry supports the governance of SWIM and provides *the* inventory of reference for service related resources in SWIM. It improves the accessibility to information facilitating a common understanding of SWIM. Figure 5 illustrates how a SWIM Registry is used by information providers and consumers.

3.5.7 Given the importance of the registry in the overall SWIM concept, the resources contained therein are further detailed. These are:

a) service instances (list of services available in SWIM from the various SWIM information service providers);

b) service description documents;

c) reference models (common models for the implementation of services and information structures i.e. AIRM);

d) information exchange standards (e.g. AIXM, WXXM, 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).

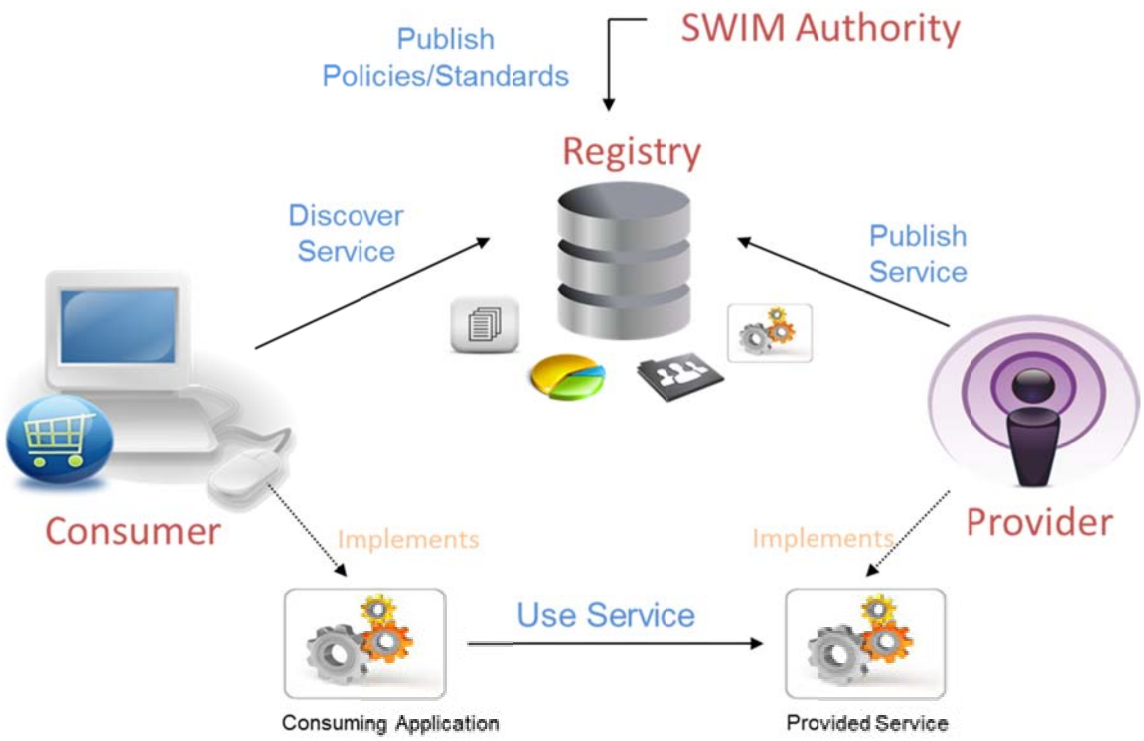

Figure 5. Concept of a SWIM Registry

3.5.8 The registry may have the following elements of functionality:

a) publication. Enabling the registration of new information;

b) discovery. Facilitating the discovery of information with search and browse capabilities;

c) change management. Enabling the controlled and collaborative change of information and the service lifecycle;

d) notification. Notifying stakeholders about changes in service metadata and lifecycle status; and

e) dependency management. Facilitating the impact analysis and identification of dependencies.

3.6 INFORMATION EXCHANGE MODELS

3.6.1 Information exchange models are desirable when information is provided by a large number of different participants and made available to a wide range of ATM information consumers. To permit interoperability, the information needs to be clearly and unambiguously defined and well understood. In other words, there is a need for semantic interoperability. This requires a detailed definition of the information both at the conceptual level and at the level of the data that is exchanged between systems.

3.6.2 Information exchange model constructs can be used, for example:

a) to define the information that is exchanged between providers and consumers (e.g. in process models);

b) to define and manage domain models; and

c) to act as the reference for the definition of the payload of a shared ATM Service.

3.6.3 The concept of information domains can be used to manage the definition of exchange models as smaller and more manageable units. The initial information domains were identified informally based on the major service exchanges that were already in use (pre-SWIM). Figure 7 shows several ICAO identified information domains. Individual States or organizations may choose to define other domains for their own region, as necessary[4]. Appendix A provides more information on the criteria for the creation of a new information domain; it also considers the major activities in managing an information domain.

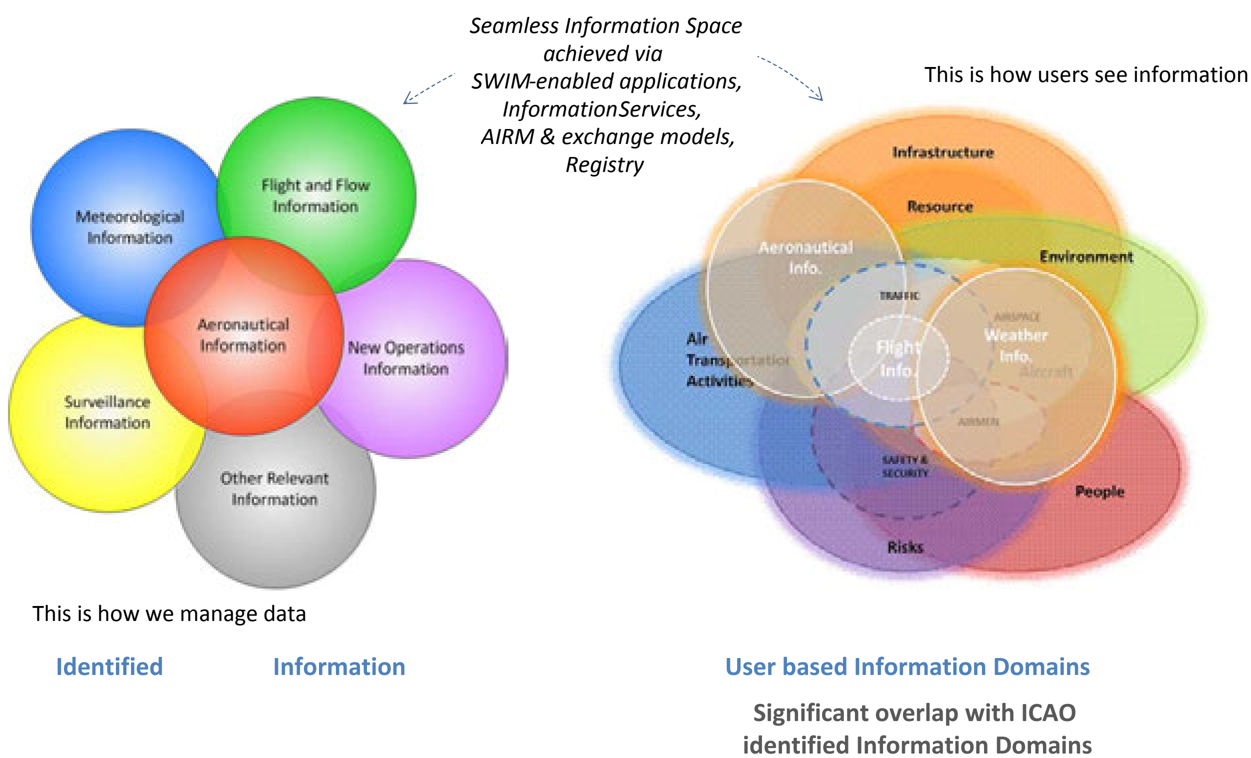

Figure 6. Potential Information Domains

[4] For example, the FAA initially defined a domain for NAS Infrastructure Management.

3.6.4 Current information domains are related to the current subdivision of identified activities. Users however see the information in a more interrelated way than it is in its current information domain state. Hence, within each solution space there is a tendency for users to expect seamless and interoperable information which can be fused. The concept of progressively achieving a seamless information space, supported by exchange models related to information domains within each user context, is realized by SWIM-enabled applications. This means that applications which consume and provide information services may relate to one or more domains, to one or more stakeholders, and to one or more points on the strategic-tactical time axis.

3.6.5 The *Global ATM Operational Concept* (Doc 9854) provides guidelines for Information Management. In particular, it requires that "*information management will use globally harmonized information attributes (2.9.11)*". In the GANP (Doc 9750), fourth edition, the B1-DATM (Service Improvement through Integration of all Digital ATM Information) module is described as: "Implement the ATM information reference model, integrating all ATM information, using common formats (UML/XML and WXXM) for meteorological information, FIXM for flight and flow information and internet protocols". Convergence to an ATM information reference model may be achieved in practice through a variety of methods.

3.6.6 The ATM information reference model (AIRM) is defined as a complement to the current exchange models and used as the semantic reference for SWIM information services. Existing exchange models will be consistent with the AIRM and may be used to define services for SWIM.

3.6.7 Consequently, at the global level, the AIRM is envisioned to provide support across the various individual exchange models (AIXM, FIXM, WXXM, AIDX, etc.). Specific examples of the types of support include alignment in terms of the levels of abstractions, i.e. details provided, as well as in terms of horizontal scope, i.e. content. The characteristics of the AIRM at this level would:

a) provide consistency with ICAO provisions;

b) complement and support the exchange models in a consistent manner;

c) foster convergence at the semantic level;

d) enable a model-driven approach;

e) provide an integrated reference across ICAO documents (annexes, manuals, etc.);

f) support global interoperability planning; and

g) support SWIM compliance criteria.

3.7 SWIM INFRASTRUCTURE

In a global environment, and considering that the service provision will not be restricted to the air navigation service provider (ANSP), as has traditionally been the case, the SWIM infrastructure might differ in the different SWIM implementations, be they local (e.g. ATM support industry), national or regional.

Therefore, the SWIM infrastructure might have different architectures (functional, physical) in different SWIM implementations. An agreed architectural concept that shall be generic enough to accommodate the differences in the implementations is needed at a global level. This architectural concept is the '***SWIM Access Point***'.

A SWIM access point is a logical entity that bundles a number of technical capabilities (e.g. messaging, security, logging, interface management, etc.). The SWIM infrastructure is the collection of the SWIM access points. SWIM access points will be implemented by information providers as well as by information consumers. The functions of a SWIM access point may be implemented external to or internal to (either partially or completely) provider and/or consumer systems. Some SWIM access points may also be shared by multiple systems. These options are shown in Figure 8. An enterprise SWIM implementation may include one or more of these options. Subject to authorization, consumers connected to a SWIM access point can potentially communicate with any providers that are connected to other SWIM access points.

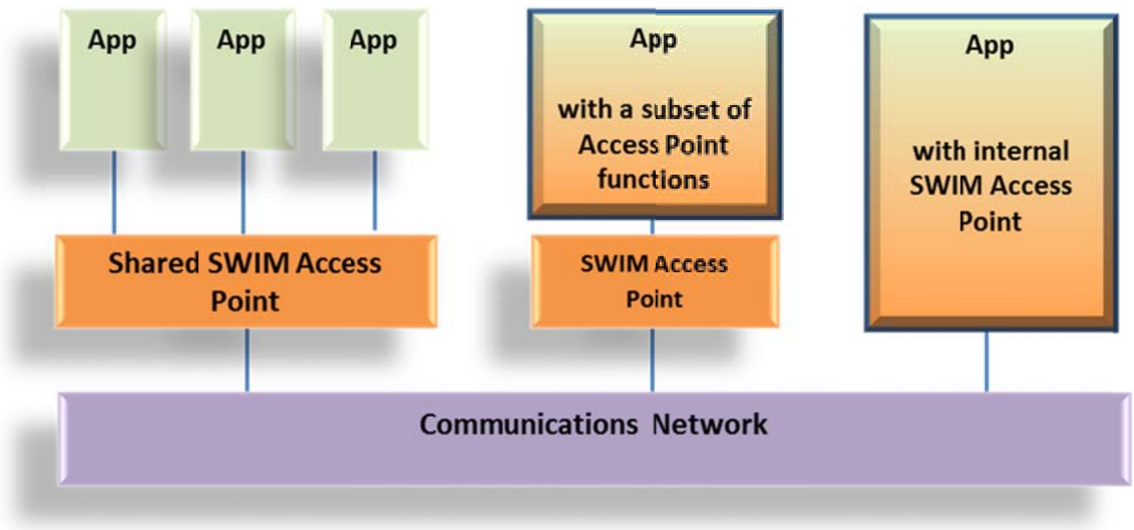

Figure 7. SWIM Access Point Implementation Options

As indicated previously, the detailed architecture of the SWIM infrastructure (and the associated SWIM access points) may be different in the different SWIM implementations. As an example, a specific SWIM enterprise may define for its SWIM implementation the functional architecture shown in Figure 8.

Global interoperability does not require the same functional architecture of the SWIM access points in all the SWIM implementations. Therefore, each SWIM enterprise implementation may develop different architectures. It is anticipated that some architectures will be implemented on the basis of Regional Air Navigation Agreements, following appropriate coordination with affected SWIM stakeholders.

The interoperability between the different SWIM implementations will be ensured either through common exchange standards or through gateways at the appropriate levels.

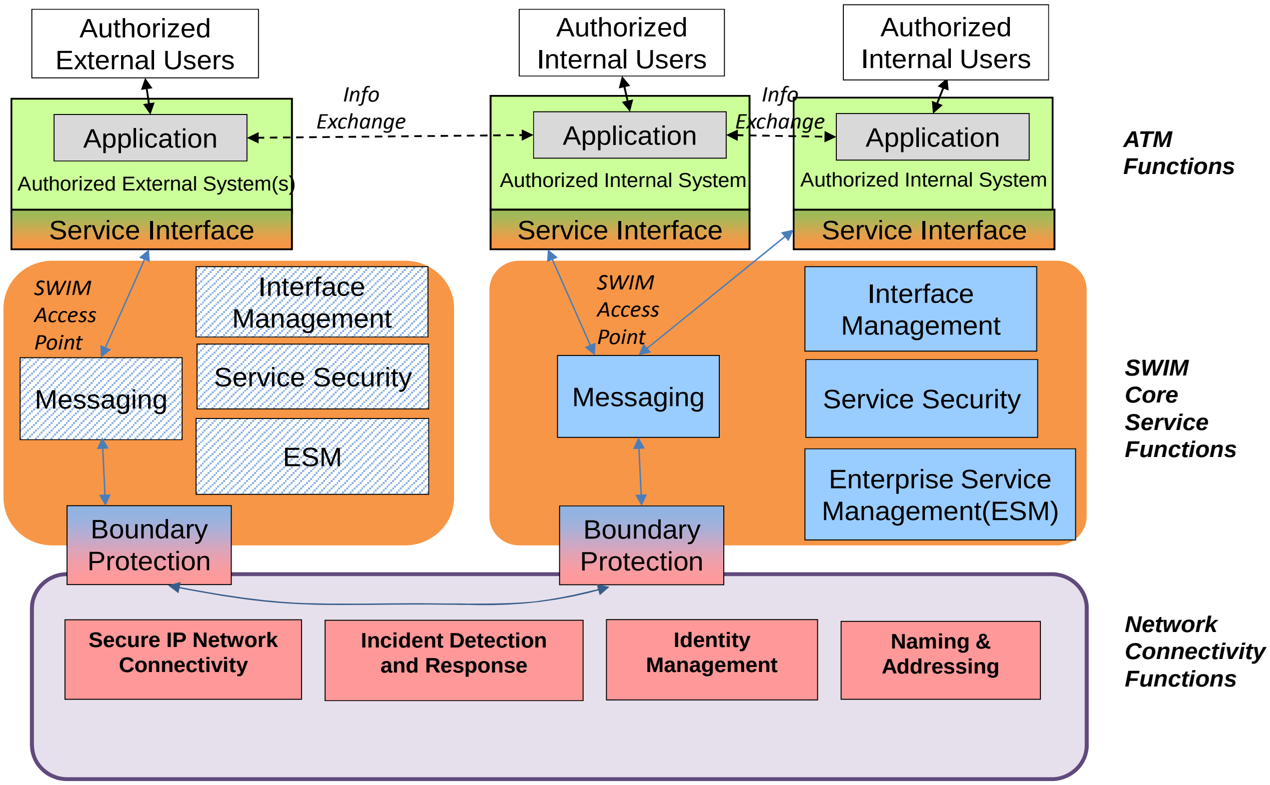

Figure 8. Functions of a SWIM Access Point - Example Only

3.7.1 SWIM Functional architecture example

3.7.1.1 One example of a functional architecture of a SWIM access point is described assuming the architecture in Figure 8. For convenience, the one on the right is considered as the primary one with systems applications that it considers internal to the enterprise. The functions are logically divided into three groups. At the top of the figure are the ATM functions which utilize the SWIM core service functions, shown in the middle of the figure, to interoperate. At the bottom are the network connectivity functions such as networking and security functions which are essential for the operation of higher level functions. The boundary protection functions are split across the SWIM service and network connectivity levels. However, for convenience, these are described under the SWIM core services.

3.7.1.2 The ATM functions provide specific functionality such as that provided by air traffic control automation systems, flow management systems, and meteorological information systems. The dashed line in Figure 8 shows the logical interaction between SWIM-enabled applications. Each application performs a Service Interface function that makes a set of information services available; these information services may be invoked by other applications via the SWIM core service functions in the SWIM access points.

3.7.1.3 SWIM distinguishes between SWIM application services (SAS) and SWIM core services. SAS are available – i.e. visible, discoverable, usable – to authorized systems. The service application interface of a system is the functional component that makes SAS services available to other authorized systems in a manner that conforms to the technical standards identified by SWIM. Similarly, external applications outside the enterprise interoperate with systems within the enterprise by accessing services and/or by providing services across the boundary (using their own SWIM access point). ATM information exchanges between internal and external applications via SWIM are mediated by boundary protection mechanisms which include security controls at all layers (for both enterprises).

3.7.1.4 On the other hand, the SWIM core services are not visible to other systems but are fundamental mechanisms that enable consumption of services and information sharing. These core 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. The core services are:

a) interface management which provides a standard interoperable means for description, access, invocation, and manipulation of resources to enable compatible communications between ATM information providers and consumers. To assure interoperability in the SWIM environment, interface management will maintain a set of standards for interface definition, description and discovery. (This function is also termed registry management in some SWIM documents);

b) messaging includes functions supporting message exchanges with a variety of relationships between message end-points including one-to-one and one-to-many. It enables message routing and the distribution of content, as well as functions for efficiently and reliably delivering that content across SWIM in a secure fashion. It includes functions to support synchronous and asynchronous information exchange;

c) service security provides functions that are used by systems and core services to ensure that SWIM services are provided in accordance with established security policies. Service security functions are used to enforce security policies at the core SWIM services level. These functions include authentication, authorization, confidentiality, integrity, and access control functions; and

d) enterprise service management (ESM) supports the management of the information services associated with providers and consumers, as well as the management of supporting SWIM core services themselves. ESM includes the monitoring and control of faults, configuration, accounting, performance, and security.

3.7.1.5 A brief description of the SWIM service functions associated with the core services is in Table 2.

Table 2. Summary of SWIM Core Service Functions

SWIM Core Service	Core Service Functions	Function Description
Interface Management	Service Exposure	Provides the capability to expose service information entities by using a registry.
	Service Discovery	Provides the capability for service consumers to be able to easily find information on services sought including alerts and registry content organization.
	Metadata Management	Provides the capability for managing the information in the registry, including managing information about multiple versions of a given service, as well as managing information about service level agreements (SLAs).

SWIM Core Service	Core Service Functions	Function Description
Messaging	Publish/Subscribe	Provides support for publish/subscribe message exchange pattern. (See Glossary for an expanded description.)
	Request/Response	Provides support for request/response message exchange pattern. (See Glossary for an expanded description.)
	Reliable Messaging	Provides support for various types of guarantees for message delivery.
	Message Routing	Provides support for message routing between information providers and information consumers.
	Mediation	Provides the capability for various types of mediation, such as data format transformation, between message senders and receivers.
	Message Transport	Provides multiple application level transports to any endpoint.
Security Services	Message Confidentiality	Provides mechanisms to ensure that only intended parties in a message exchange can view messages.
	Message Integrity	Provides mechanisms to ensure that messages are not unintentionally altered, and provides assurances that system data can be trusted to be accurate.
	Transport-level protections	Provide protections at the transport and session layers to ensure confidentiality and integrity for system communications.
	Identity Management	Provides mechanisms for managing the identity and organizational role of service consumers and service providers.
	Data Access Management	Provides management of access to data resources that are based on the requesting entity's identity, organizational role, or other considerations such as transaction state or application.
	Security Policy Management	Provides management of the rules that allow and limit access privileges to SWIM data resources.
	Security Policy Enforcement	Provides mechanisms to enforce security policies.
	Security Monitoring	Provides monitoring of SWIM services for any systems events that may indicate security breach or fraudulent use of system resources.
	Security Auditing	Includes the review of security controls to ensure that they are efficient and effective in controlling unauthorized access to systems.
Enterprise Service Management	Asset Management	Manages SWIM hardware, software, and network assets.

SWIM Core Service	Core Service Functions	Function Description
	Configuration Management	Manages in-development and operational baselines.
	Event and Performance Management	Monitors and controls faults, service quality including reliability, availability, performance, diagnostics, and policy.
	Service Desk Support	Supports personnel in the use of SWIM services and resolution of reported problems.
	Policy Management	Storing, categorizing, updating, and distributing policies.
Boundary Protection	Enterprise Boundary Protection	Prevents malicious content or attacks from being passed between applications internal to an enterprise and external applications. Allocation of appropriate security controls to this function will be a result of a properly conducted risk analysis by each enterprise. The boundary protection mechanism may best serve to limit protocols and communication destination addresses, and to provide early detection of denial of service attacks before their effects can be propagated to the enterprise's internal network and systems.

3.7.1.6 Sample network connectivity functions include the networking and security support functions described below in Table 3. This group of functions represents capabilities and services that are not specific to SWIM but that SWIM needs to use in support of higher level SWIM services.

Table 3. Network Connectivity Functions

Network Connectivity Function	Function Description
Secure IP Network Connectivity	Allows the components of the SWIM architecture to communicate with one another using the Internet Protocol (IP). It may include network layer security services, e.g. tunnels, encryption, network layer access control, etc. as needed. Both IPv4 and IPv6 will be used within the global SWIM.
Incident Detection and Response	Monitors the systems and networks of the SWIM architecture for indications of information system security intrusions or incidents, and supports corrective action when such intrusions or incidents are detected.
Naming and Addressing	Provides a domain name system (DNS) that translates from fully qualified domain names identifying systems to IP network addresses. It also includes the administrative functions that provide for allocation and management of IP address space.
Identity & Credential Management	Provides management of, and access to, identity information and credentials as needed to support authentication, authorization, and access control decisions that are made within the SWIM service security function.

3.7.1.7 Each enterprise is expected to implement its own IP infrastructure. Some enterprises may use the facilities provided by regional partners or commercial service providers to access SWIM. There is no implicit requirement that a dedicated IP network be set up solely for SWIM.

3.7.2 SWIM technical architecture

3.7.2.1 The SWIM technical architecture provides a view of the standards used in supporting the SWIM functions. Standards in the SOA environment are evolving rapidly, and should be expected to change, in the future. Compatibility among standards will be maintained via the use of conversion gateways.

3.7.2.2 SWIM emphasizes the use of web services standards, because these are, for the time being, promising and widely used standards for implementing SOA in a way that improves interoperability and flexibility. However, web services are not suitable for all applications. The intent of the SWIM architecture is to allow other standards to be used when necessary while retaining general SOA principles. To accomplish this, SWIM components should be capable of including information on services that are provided using a variety of different technologies and standards. Similarly, SWIM enterprise service management and service security components should be engineered, to the extent practical, to allow a variety of different technologies and standards to be managed and secured.

3.7.2.3 Since the standards are evolving and need to accommodate a variety of applications being considered by member states, an initial classification framework for SWIM technical standards (Figure 9) is proposed for discussion. The top two layers deal with the exchange of information via SWIM while the others are involved with the SWIM Infrastructure. The framework is extensible and additional layers may be inserted or existing layers consolidated over time. As mentioned earlier, governance covers multiple areas and will rely on the technical standards defined for ESM, interface management, security, policy, etc.

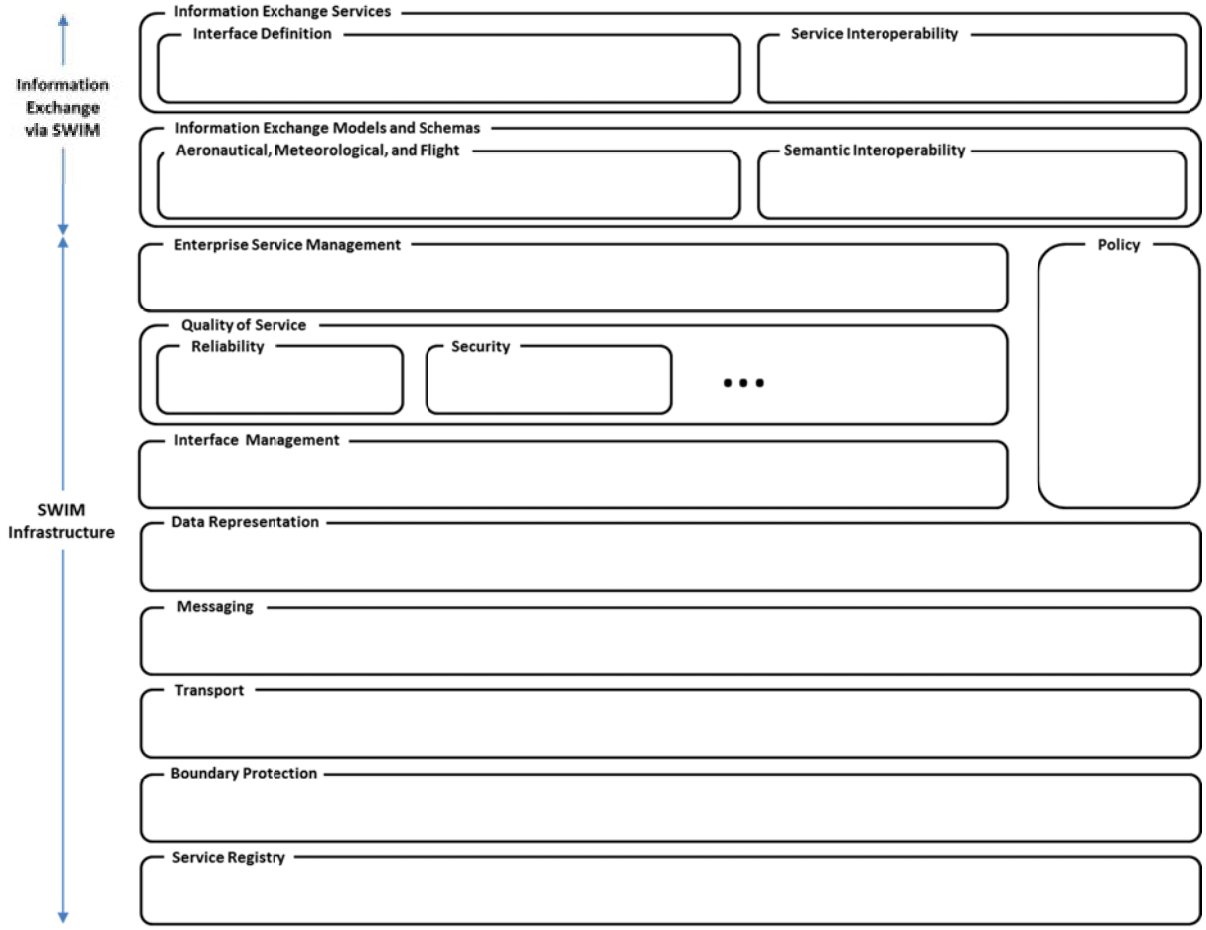

Figure 9. Initial Classification Framework for SWIM Technical Standards

3.7.2.4 Examples of some SWIM standards are shown in Figure 10; other standards may also be used. Some of the standards are supported by multiple commercial vendors of SOA products and are considered ready for implementation. Other standards are under evaluation and may be considered for implementation once they are widely supported commercially. Information Exchange Services are still under definition; initial efforts are focusing on service definitions for exchange of AIM data, Flight Information data, and meteorological data.

3.7.2.5 A short example of potential SWIM standards is provided in Appendix C. It has to be stressed that standards appearing in Figure 10 may actually not be selected as SWIM standards and that standards not present in the figure may be selected as SWIM standards. The process to select, as well as the selection of the precise standards that will be part of SWIM is one of the tasks to be done as part of the detailed definition of SWIM Governance.

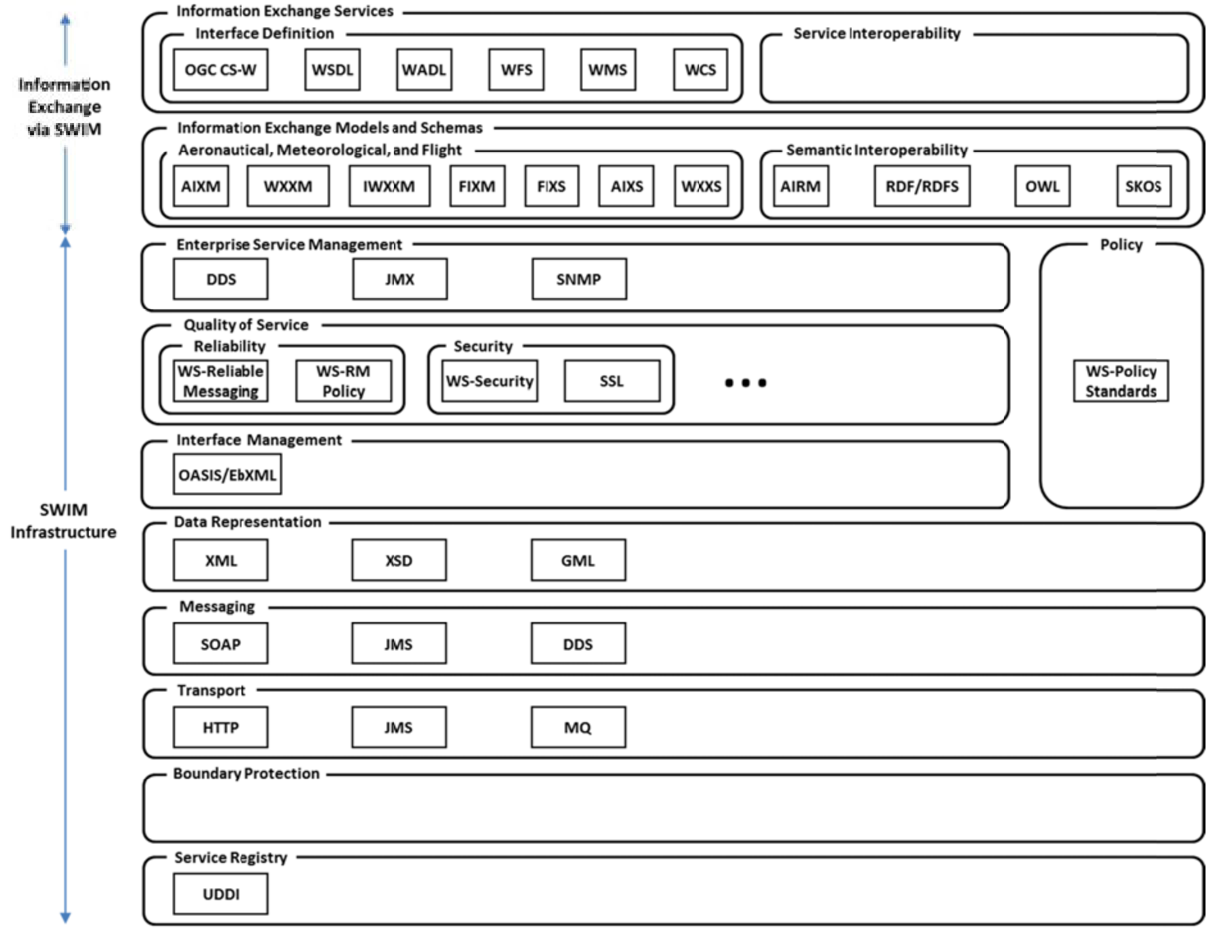

Figure 10. Examples of SWIM Technical Standards

3.8 SWIM GOVERNANCE

In a loosely coupled environment such as SWIM where services are provided and consumed by a number of entities, governance is essential. Governance establishes the processes to assure that appropriate rules, policies, and standards are followed. Governance defines the chains of responsibility, authority, and communication as well as the measurement and control mechanisms to enable participants to carry out their roles and responsibilities. As mentioned earlier, in Section 3.5, the SWIM registry will be an important enabler for SWIM governance.

The infrastructure, standards and management of information all need to be governed. Examples of this governance include the need to:

a) define who is involved in the approval and in the evolution of standards;

b) define the processes to be followed;

c) define the SWIM infrastructure to be provided by member States (or their network providers);

d) define the need and the nature of a national or regional SWIM Collaborative Authority and, if so, which components could be provided or managed by that authority;

e) define which information access management functions[5] will be executed by each information provider/consumer;

f) establish a common set of regulatory policies and standards;

g) promote semantic and structural interoperability among stakeholders by developing a common set of semantic and structural artifacts (e.g. taxonomies, ontologies, controlled vocabularies);

h) define the way costs will be shared by the parties participating in SWIM and the possible cost-recovery mechanisms to be used; and

i) define and establish governance structures at global, regional and local levels.

3.8.1 Governance of information definition

3.8.1.1 SWIM requires governance for the collaborative specification and definition of information within existing domains, across domains and within potential new domains.

3.8.1.2 Since not all solutions are equally fit-for-purpose for all, it is recognized that local and regional differences will continue to be required for information items. What truly matters in this context is that the information must be in a state which can be qualified as “known and managed”. This implies that governance at the level of a Global Interoperability Framework should be applied to the local and regional levels to allow for flexibility and take into account some differences necessary due to specific operational requirements.

3.8.1.3 Appendix A provides additional information on the processes involved in managing an information domain.

3.8.2 Governance of information services

3.8.2.1 An important aspect of SWIM is the overall governance of the service approach. A key component of the SWIM concept is the service lifecycle, from the initial identification of the business need for a possible information service through the following stages — proposal, definition, development, verification, deployment, deprecation and decommissioning. During the life of an information service, one should also expect that an information service will need to be changed for various reasons and updates will be necessary. Managing the change of an information service once it is in widespread use is much more challenging than creating the initial service; this is because of the countervailing pressures of stability versus improvement. The Open Group’s *SOA Governance Framework* provides a good framework that can be adapted by enterprises (and regions) for their SWIM information services. Section 2.6 provides additional information on the service life cycle and its management. Thus, service governance addresses concerns such as:

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5 It is assumed here that some information providers within a SWIM region may have additional access requirements, i.e. some information services may be available to certain consumers only.

a) service registration;

b) service versioning;

c) service ownership;

d) service funding;

e) service modeling;

f) service discovery and access;

g) deployment of services and composite applications;

h) security for services;

i) processes and procedures to support service publishing and service validation;

j) documenting the approach to support service lifecycle management and service reuse;

k) verify that the running services are the approved versions;

l) define mechanism to manage Service Level Agreements (SLAs) for services; and

m) provide a mechanism to enable runtime service look-up.

3.8.2.2 In a global context, the ICAO-level governance should stop at the information exchange services layer. At lower layers, it is expected that global technical standards would be used outside the remit of ICAO.

Chapter 4

TRANSITION AND MIXED ENVIRONMENT

This section describes ground SWIM operation during transition and in a mixed (SWIM, non-SWIM) environment. It is recognized that transition to SWIM may involve additional complexities beyond a mixed environment.

4.1 PARTICIPANTS

4.1.1 Figure 11 shows a gradual introduction of SWIM with a few digital services and an eventual merging into full SWIM functionality.

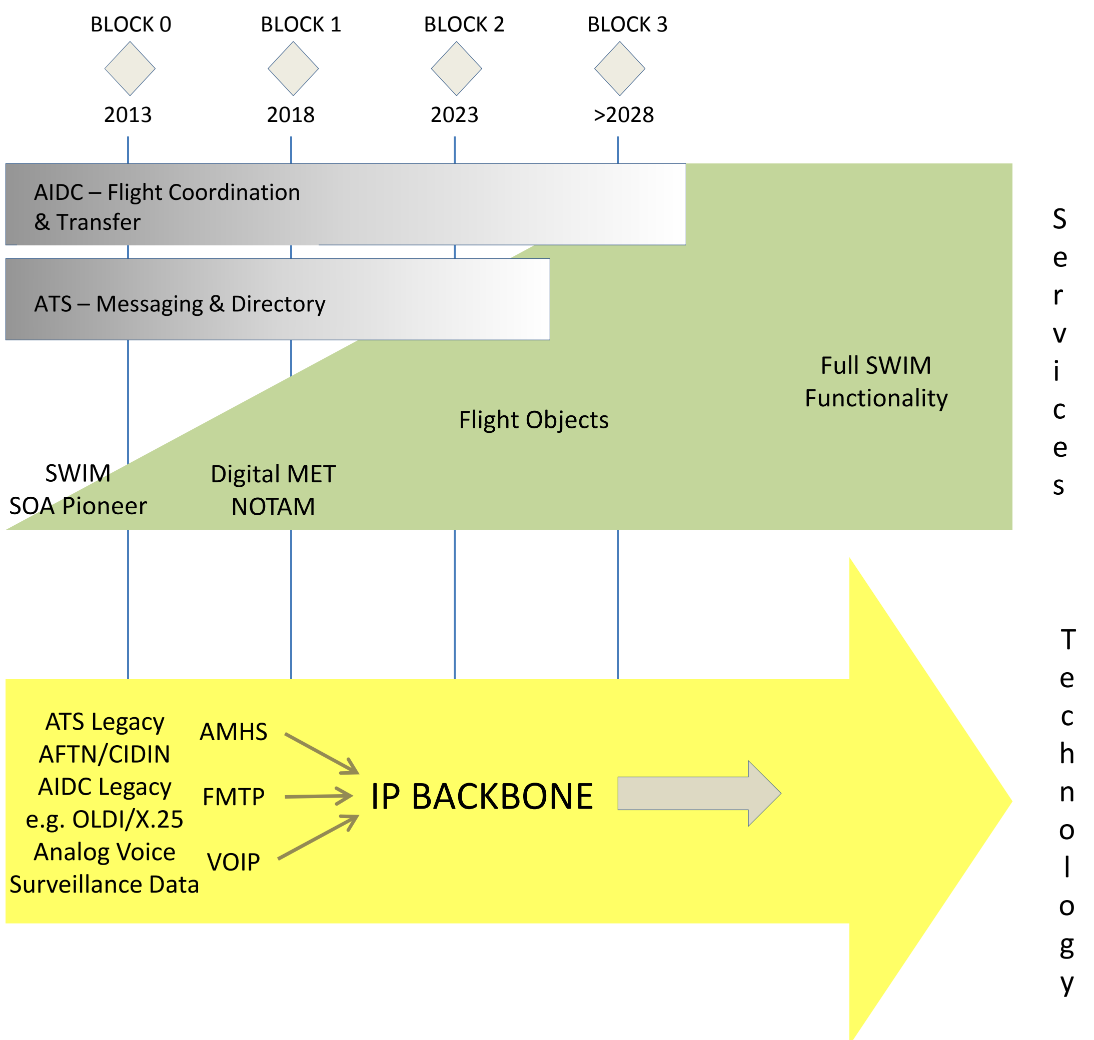

Figure 11. Air ground communications roadmap

4.1.2 ATN applications such as ATS inter-facility data communications (AIDC) and ATS messaging will move to SWIM as and when their performance requirements can be met. Existing legacy aeronautical fixed telecommunication network (AFTN) and AIDC networks will be modernized and their communications infrastructure move to IP networks which will permit multiple applications to share the same network.

4.1.3 Given the large number of member States having different levels of needs and sophistication, different technologies and ATM services are expected. A few States or regions may use SWIM extensively in the near future. Others will continue to use legacy systems. Interoperability is needed, whether using existing legacy systems or planning a transition for the long term. This is made possible via specialized gateways for messaging and a staged transition.

4.2 ROLES AND RESPONSIBILITIES

It is assumed that each member State or a number of States in a specific geographical region will develop their migration plans based on respective needs and timetables for their current ATM networks and services. States with legacy systems will have interoperability with other States but will not be able to provide or consume more complex services unless their systems are upgraded.

4.3 KEY INTERACTIONS

4.3.1 This section illustrates how a phased transition from AFTN/aeronautical message handling system (AMHS) to SWIM can be accomplished. The description is done in a context of ASP exchanges because ASPs are the main stakeholders using AFTN/AMHS protocols, but it can be extrapolated to other stakeholders. At the time of publication of this document, no formal selection of SWIM standards had been made, and no SWIM information services had been defined. As such the following description is just for illustration purposes. The actual applicability of this description will depend on a number of factors that cannot be determined yet.

4.3.2 The legacy AFTN/AMHS is used by many States, primarily to exchange flight plans, notices essential to personnel concerned with flight operations (NOTAM), and meteorological information. AFTN is character-oriented, limits character set, limits message length and its switches are interconnected using low speed lines. The AMHS was specified in *Manual on detailed Technical Specifications for the ATN using ISO/OSI protocols - ATS Message Handling Service* (Doc 9880), Part IIB, as a replacement for the outdated AFTN/common ICAO data interchange network (CIDIN). AMHS is based on ITU-T X.400 messaging standards. As such, AMHS 'removes' the restrictions and limitations imposed by AFTN. ICAO specified AMHS/AFTN gateways have been implemented and can be used to accommodate a mix of AMHS and AFTN exchanges (the AFTN limitations would still apply in this case). This mixed environment is shown in Figure 12. Although the IP connections represented in the figure seem to be point-to-point lines, they will very likely be implemented through IP networks.

4.3.4 ASPs will start implementing SWIM-enabled systems to take advantage of the benefits provided by the SWIM services. Full benefits will only be achieved when interaction with other ASPs with SWIM-enabled systems occurs.

4.3.4 ASPs without SWIM will continue to interoperate but will be limited to the applications they can support.

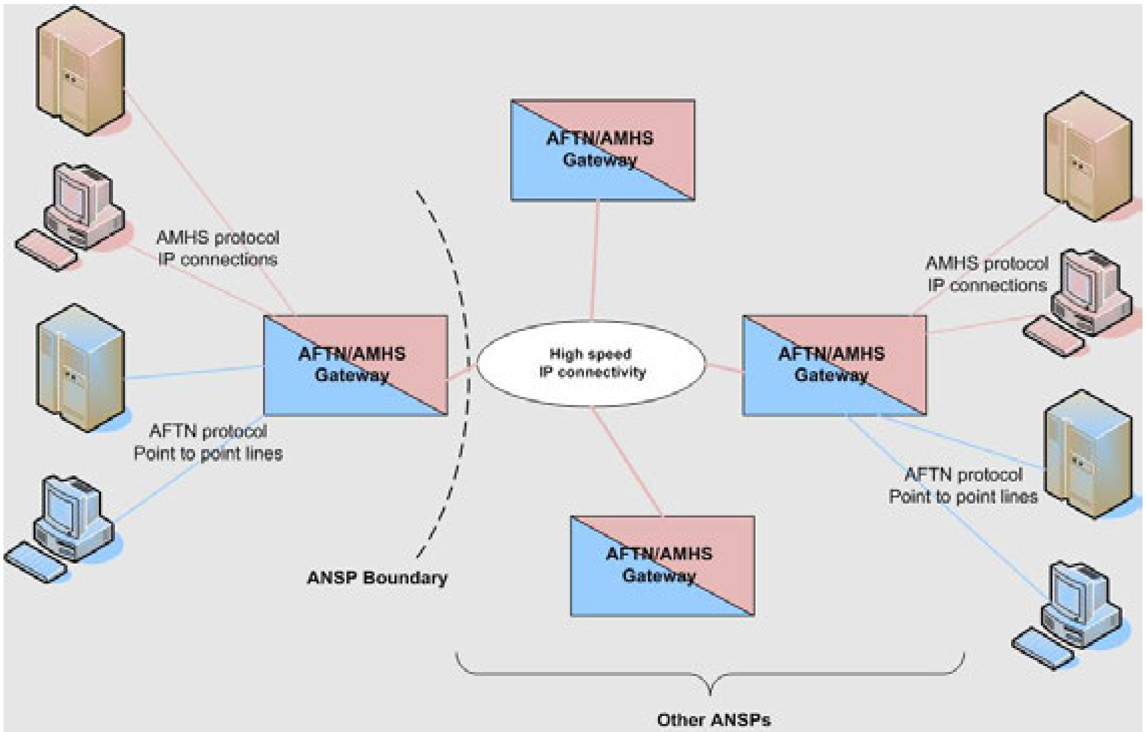

Figure 12. Current AFTN / AMHS environment

4.3.5 Due to the current early stage of the SWIM definition at a global level, different possibilities can be contemplated for the transition period regarding interoperability. Actually, each (to be) defined SWIM service may have different possibilities; therefore, the transition period and interoperability arrangements can be different for the different services that will be implemented. A brief description of a number of such possibilities is provided.

4.3.6 There can be SWIM services for which the interoperability with 'legacy' systems will have to be ensured by the SWIM-enabled system, i.e. it might be up to the SWIM-enabled system to implement the service in the "SWIM form" and to also support it in the legacy format. Therefore, the SWIM-enabled system should support both ways of providing such services during a transition period to allow a SWIM migration path. This case is represented in Figure 13. Again, while the IP connections represented in the figure are shown as point-to-point lines, they will very likely be implemented through IP networks.

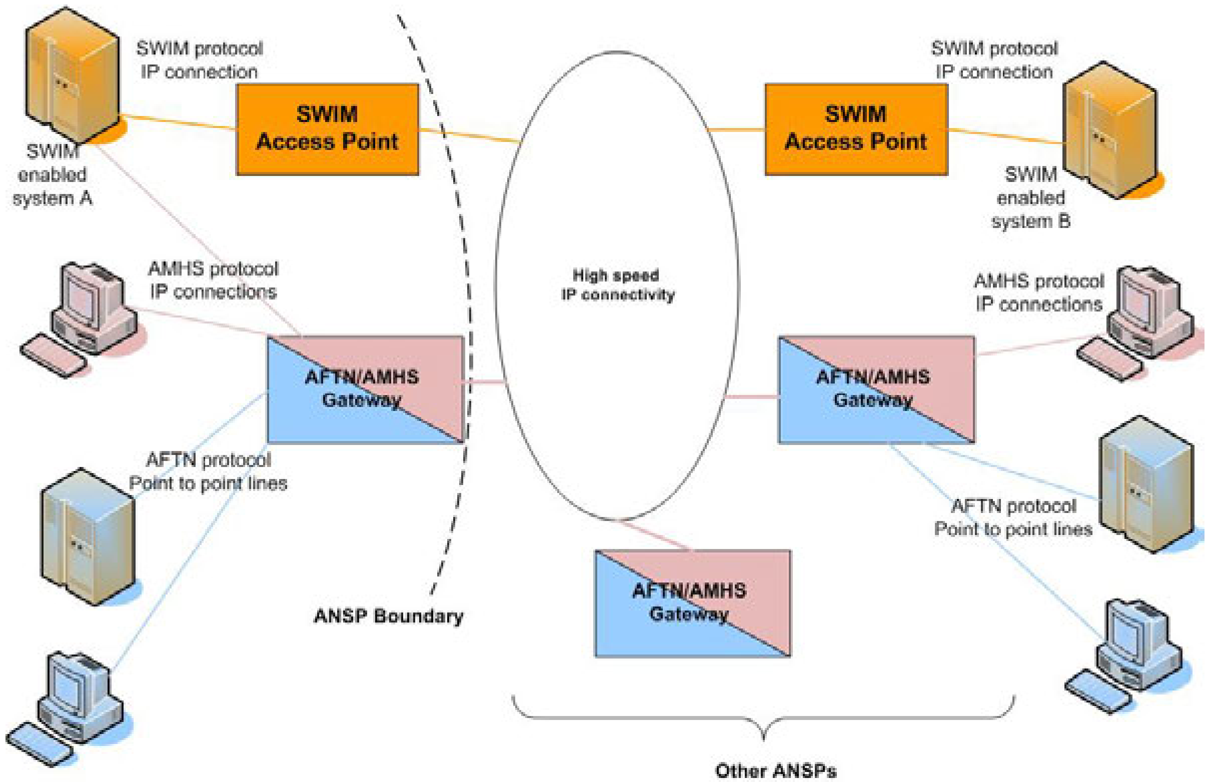

Figure 13. Interoperability ensured at application-level

4.3.7 As an example, the SWIM-enabled system A in Figure 13 might represent an upgrade or replacement of a legacy system managing and distributing NOTAM messages. This new system would both support the 'legacy' NOTAMs as well as a new SWIM service for digital NOTAMs. Other SWIM-enabled systems (e.g. system B in the figure) will be able to take advantage of advanced functionality provided by the digital NOTAM service (e.g. geographical filtering). Other 'legacy' systems will still be able to interoperate with the system A with 'legacy' NOTAMs as before, but they will not be able to benefit from the advanced functionality.

4.3.8 There might be other specific SWIM services which can justify (in operational and economic terms) the definition and implementation of gateways between SWIM and AFTN/AMHS. It can be expected that this case would be possible for SWIM services for which there is a straightforward mapping with existing AFTN/AMHS messages, so allowing the definition and implementation of the corresponding gateways. This case is represented in Figure 14.

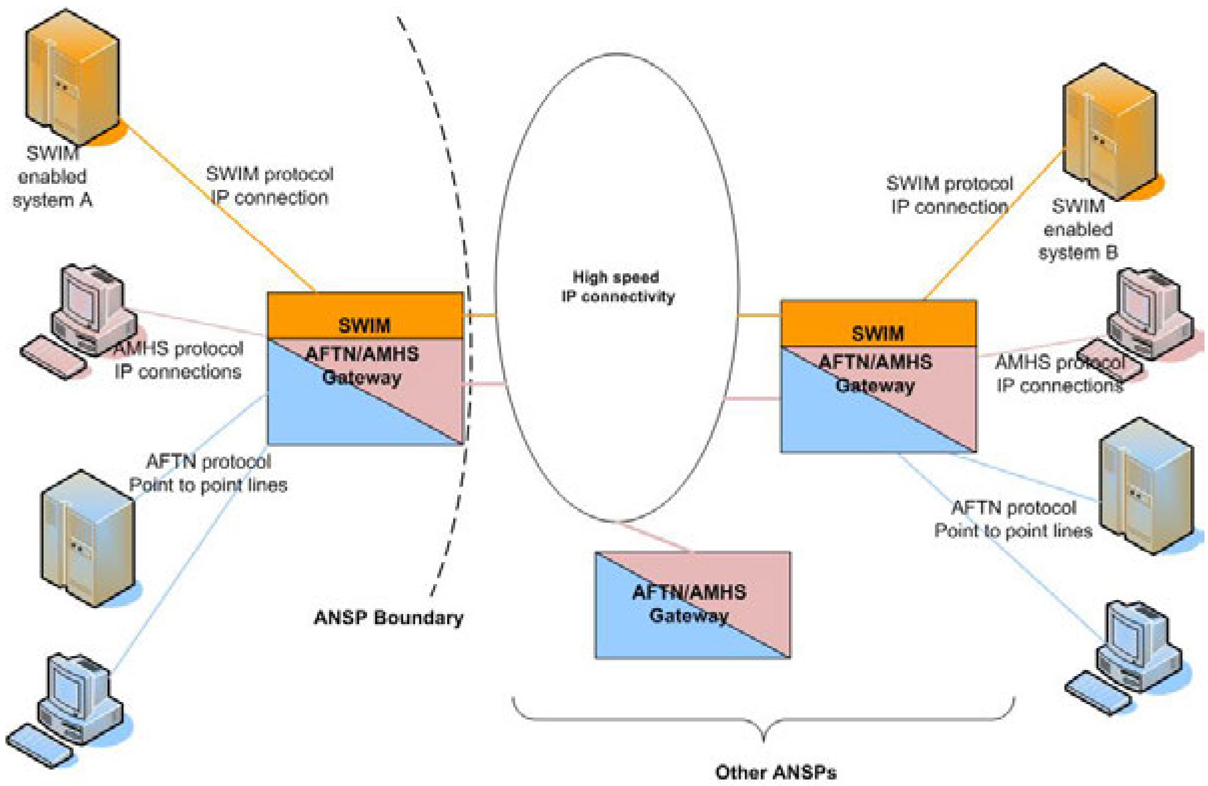

Figure 14. Interoperability ensured in the gateway

4.3.9 In this case, the SWIM-enabled system A in Figure 14 might represent an upgrade or replacement of a legacy system. This new system would implement a SWIM service (or several SWIM services). Other SWIM-enabled systems (e.g. system B in the figure) will be able to take advantage of advanced functionalities provided by such services. In this case, such SWIM service will have a straightforward mapping with AFTN/AMHS messages[6]. Therefore, it can make sense in operational and economic terms to define and implement gateways between SWIM and AFTN/AMHS which would allow other ‘legacy’ systems to exchange information with system A.

4.3.10 Finally, there might be some specific SWIM services for which there will be no interoperability with ‘legacy’ systems (Figure 16). Such services will be just provided and consumed by SWIM-enabled systems. This can be the case for services with a full new business logic that is not implemented or supported by the ‘legacy’ systems, so the interoperability with legacy systems cannot be justified in operational / economic terms.

[6] The straightforward mapping is not just required for the payload, but also for other aspects like addressing.

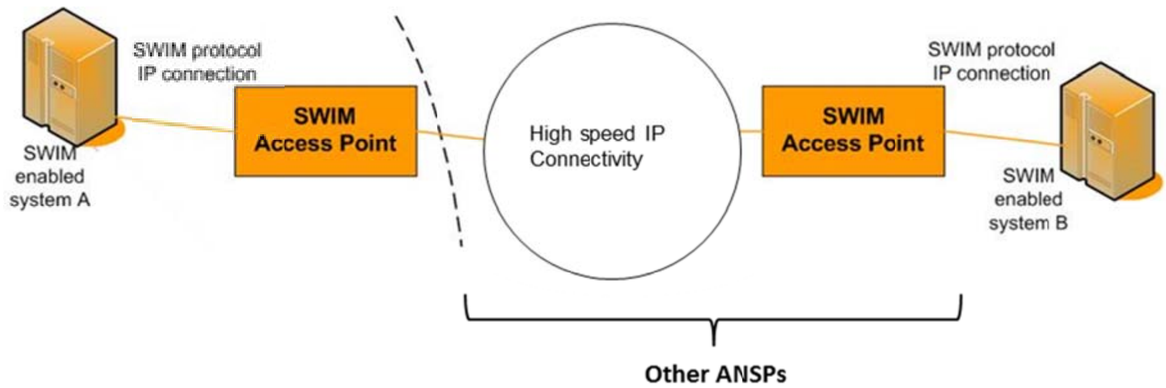

Figure 15. Some new SWIM Services will only be supported by SWIM-enabled systems

4.3.11 In summary, when considering interoperability between SWIM and legacy systems (in this case AFTN/AMHS), it should be noted that, while AFTN/AMHS are related mainly to the transport protocol, SWIM standardization intends to cover up to the service level. Therefore, the interoperability and the associated transition plans will depend on the specific SWIM services to be defined and the different option(s) available.

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Chapter 5

FUTURE DEVELOPMENTS

Three future SWIM-related developments that may be of interest to member States are introduced. The first one refers to the GANP ASBU modules on SWIM. The second refers to activities exploring SWIM air-ground alternatives. The third refers to the interconnections of SWIM services across regional boundaries.

5.1 GANP ASBU MODULES ON SWIM

5.1.1 SWIM is specifically included in the GANP (Doc 9750) as shown in Figure 16.

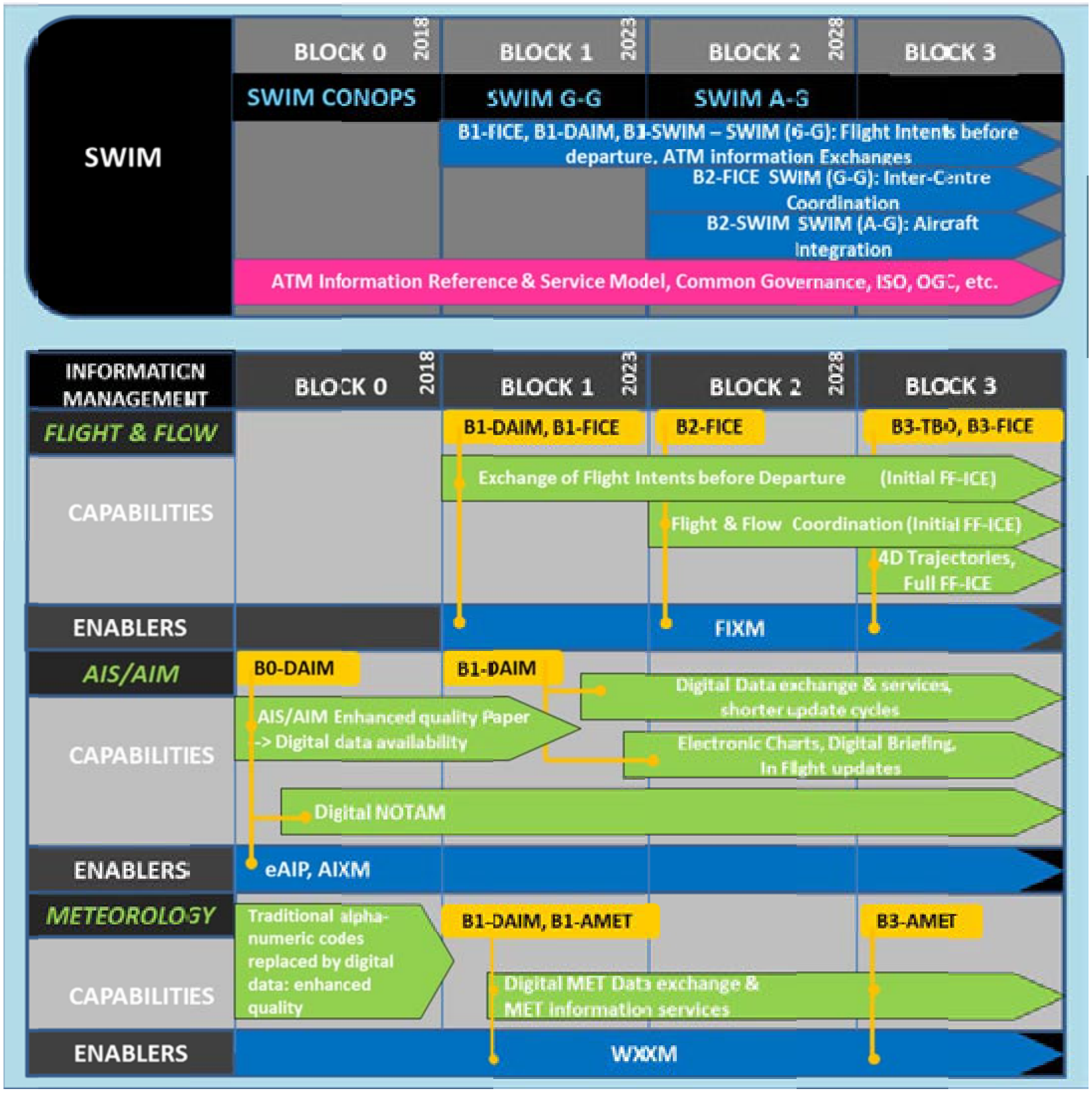

Figure 16. ICAO GANP Roadmap on SWIM

5.1.2 SWIM is mainly contained in the ASBU modules B1-SWIM and B2-SWIM. In addition, the modules relating to service improvement through digital aeronautical information management and integration (B0-DATM & B1-DATM) as well as modules for improving operational performance through FF-ICE (B1-FICE, B2 -FICE, and B3-FICE) are important early components of the overall SWIM.

5.1.3 SWIM will introduce a significant change in the business practices of the ATM community for managing information during the entire life cycle from data origination to its usage and decommissioning. Since a cost will be associated with implementing SWIM, it is recommended that regions and States determine if a positive performance case exists in their areas. Consequently, the deployment of SWIM will be staggered throughout the globe.

5.1.1 Technology requirements

5.1.1.1 The technological requirements for deploying SWIM are significant and essential. Harmonization of data communication infrastructure for air-ground communication at an appropriate performance level is necessary. On the ground, internet protocol (IP) should be available on all systems and the implementation of ATS inter-facility data communications (AIDC) as the basic means for automating ground-ground communications between ATS units could be considered as a facilitating intermediate step. A common data communication baseline is essential to ensure future benefits of SWIM developments. The implementation of an agreed common time reference for all systems (air and ground) is important for applications and services supported by SWIM.

5.1.1.2 At the first stage (Block 1), SWIM is composed of ground applications relying on IP networks, while most air-ground data exchanges remain based on point-to-point communication. Air-ground data link services and infrastructure are converging to ATN Baseline 2, along with development of enabling ground network technology and new commercial satellite communication.

5.1.1.3 Starting from Block 2 and into Block 3, the aircraft should be fully connected to the network as a SWIM access point, enabling full participation in collaborative ATM processes with access to voluminous dynamic data including meteorology. Initial implementations will be for non-safety critical exchanges supported by commercial data links.

5.1.1.4 Technological requirements and the linkages between the various blocks and modules of the ASBU framework are detailed in the technology roadmaps of the GANP (Doc 9750), fourth edition.

5.1.2 Deployment considerations

5.1.2.1 The development of ICAO provisions for access to information and use of SWIM-enabled applications is necessary. Performance requirements for various data-communication channels in terms of safety, security, throughput and latency should also be developed. Evaluation of data transmission volumes in relation to traffic forecasts as well as future applications and services will assist infrastructure planning including spectrum and bandwidth requirements. The definition of common data formats and information exchange protocols is considered a priority to support progressive deployment or adaptation of appropriate ATM system architecture.

5.1.2.2 The impact of SWIM implementation on various ATM systems is likely to be complex and should not be underestimated. Progressive deployments of SWIM in clearly-defined phases with transition arrangements that allow for a mixture of SWIM and non-SWIM systems must be considered. SWIM is intended to be implemented globally, as performance needs dictate. Agreement on global or regional implementation milestones for some stages could be beneficial in harmonizing deployment.

5.2 SWIM AIR-GROUND

5.2.1 The *Global Air Navigation Plan* (Doc 9750) introduces ASBU B2-SWIM “Enabling Airborne Participation in Collaborative ATM through SWIM” which considers the aircraft to be a fully connected information node in SWIM, enabling full participation in collaborative ATM processes with exchange of data, including meteorology, that starts with non-safety critical exchanges supported by commercial data links.

5.2.2 In general, the exchange and access to information between flight crews and ground operations[7] facilities are often imbalanced. Specifically, flight crews do not have access to a common or shared information platform to fulfil their advisory[8] needs in-flight or on the ground. The information unavailability, whether on demand or in near real-time, prevents flight crews from making informed decisions and hampers their ability to plan strategically and tactically.

5.2.3 Furthermore, ground-based systems and air traffic managers do not have a single mechanism to obtain real-time information updates about a specific flight, its operation, and its surrounding airspace conditions. These shortfalls inhibit the predictability, flexibility, and efficiency of the ATM system and have motivated an exploration of airborne use of SWIM by ATM System participants.

5.2.4 Air-ground solutions are being explored and will leverage the SWIM infrastructure to give flight crews access to relevant, system-wide information. The information delivered to flight crews via an alternative communications medium will come from a common infrastructure – SWIM. However, not all ATM information will be available in order to protect proprietary information and security. Making information available will increase common situational awareness between flight crews and ground operations, while promoting strategic/tactical planning and more informed decision making. It will also be the mechanism that will afford airspace users the ability to provide near real-time input, such as atmospheric conditions, to ground operations facilities and systems. This timely bi-directional communication link will help create a shared ATM system picture and is expected to contribute to increased predictability, flexibility, and efficiency within the ATM system.

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[7] “Ground operations facilities” are defined as all ASP facilities (centers, terminal facilities, central traffic flow management, towers, etc.) and operations centers (AOCs/FOCs).

[8] The term “advisory”, here, is not synonymous with ATM advisories such as Traffic Management Initiatives issued by traffic flow management. Advisory information is defined as supplemental information that is not necessary for command and control of an aircraft.

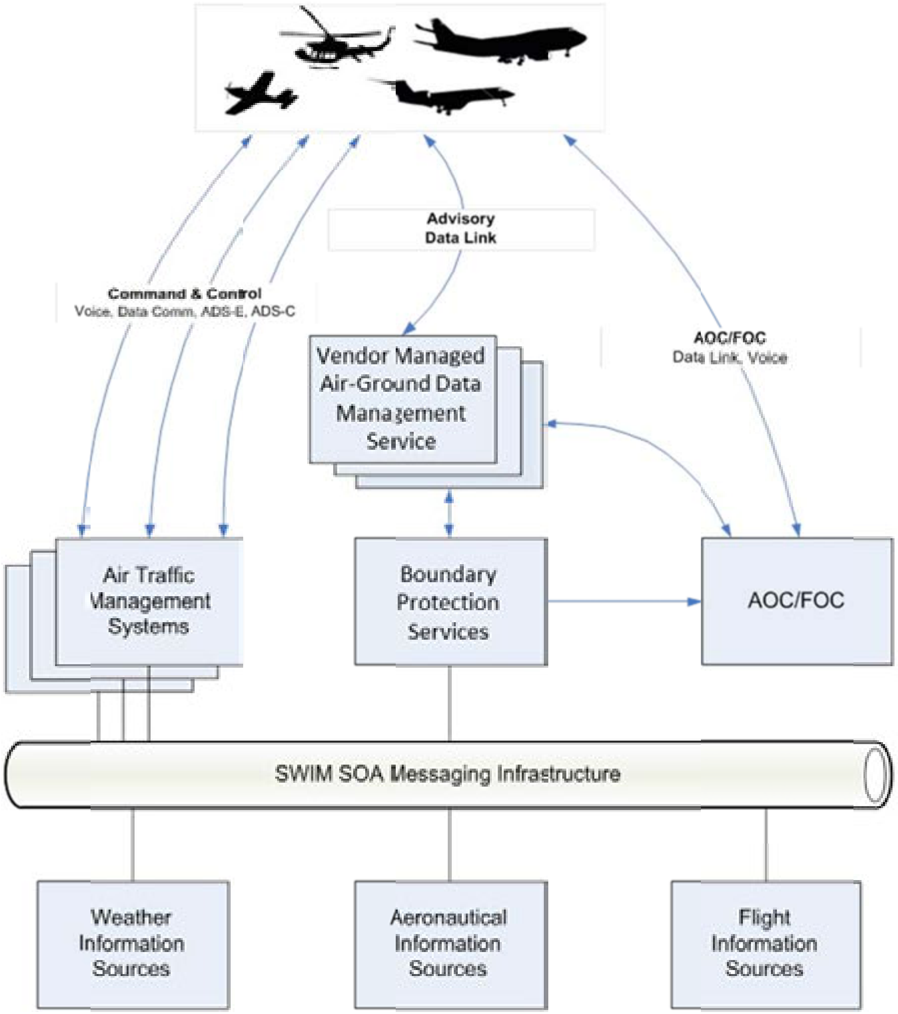


Figure 17. Example Far-Term Air-Ground Information Exchange

5.2.5 Figure 17 is a "to-be" representation of air-ground information exchange in the far-term environment including the important role air-ground solutions will fill. On the left side of the figure, primary command and control methods are depicted (e.g. voice, data comm). The middle of the figure portrays a bi-directional commercial data link via air-ground solutions used solely for advisory information. The operations centre, pictured here, may receive advisory information through either SWIM (across boundary protection services) or through the airborne solution (via the vendor managed air-ground data management service[9]). On the right the customary connections between airline operations centres (AOCs) to their aircraft are shown.

9 The data management service pictured is a vendor(s) managed service, accessing raw ATM data via SWIM, manipulating that data, and distributing relevant information in a usable format to their customers.

5.3 INTERCONNECTING SWIM SERVICES ACROSS ASP/REGIONAL BOUNDARIES

5.3.1 Several ATM service providers have already begun implementing SWIM. During transition to a global SWIM environment, these local SWIM enterprises are most likely to connect, by necessity, to similar enterprises through a series of bilateral agreements to achieve interoperability. Unless planned upfront, a global SWIM can, de-facto, emerge as a large collection of these agreements, thereby complicating the achievement of global interoperability. The result would be inflexibility at a global level owing to the complexity of managing change.

5.3.2 To avoid such an outcome, there needs to be a means for the global provision and connection of services across SWIM enterprises. Several strategies may be applied, including:

a) prescriptive global and regional interface specifications, as is current practice for ATM ground-ground communications. While this approach addresses the proliferation of agreements, its lack of flexibility is at odds with the desired agility. SWIM is expected to be agile and provide the information exchange necessary for future capabilities as they are deployed;

b) use of industry standards and development of additional standards for areas where none exist. Given the evolving nature of IT standards and the fact that differing SWIM Regions will implement standards in accordance with their needs, the use of gateways through the options as previously described in Section 3.2.2 will be required. Advantages include:

   (i) the application of existing standards enables the use of developed tools and an existing knowledge base thereby lowering development costs and risks; and

   (ii) new standards may be adopted where required as they become mature.

c) accept the proliferation of bilateral agreements initially, with the assumption that standardization will emerge organically as part of individual ASP's performance-based processes. The use of gateways remains during transition and has its advantages, as follows:

   (i) provides the simplest governance model;

   (ii) enables individual ASPs and their Regions to consider interoperability as part of their performance case; and

   (iii) allows first adopters the flexibility of implementing the newest technology, demonstrating tangible performance benefits for other ASPs.

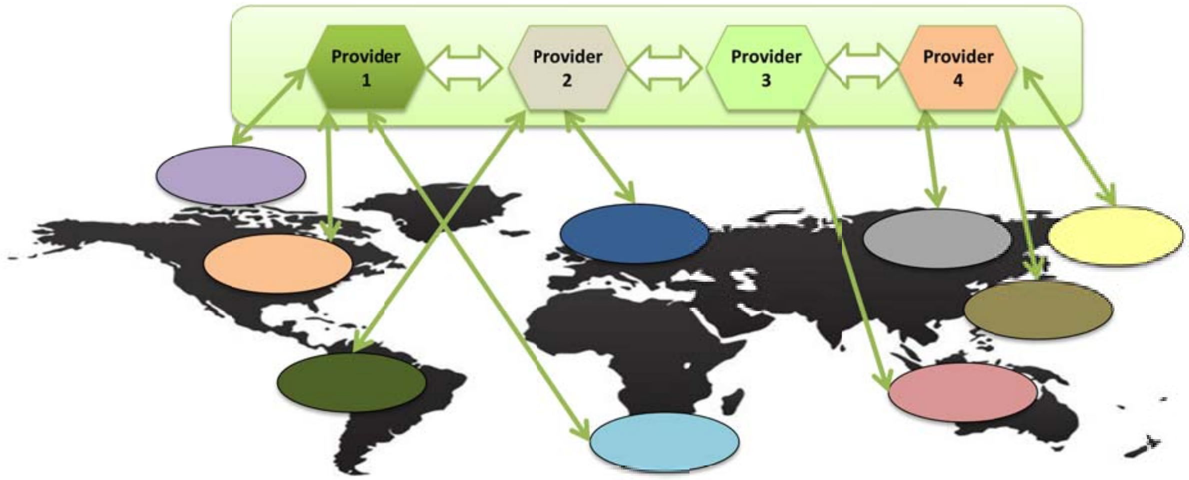
d) use of a public/private partnership for global SWIM in which a SWIM enterprise may use a third party provider, be it public or private, to enable the delivery and receipt of services from other SWIM enterprises (Figure 18). This approach provides advantages, such as:

   (i) enabling a service-based cost system for enterprises at different stages of SWIM implementation;

   (ii) cost-sharing of fixed development costs;

   (iii) providers can more easily take advantage of the latest technologies, architectures and governance models to manage interoperability; and

   (iv) greater flexibility as lower-level implementation changes can occur, subject to performance standards in accordance with service-level agreements, without necessitating review and consensus across ASPs.



Providers above may be public or private. An enterprise may serve as its own provider.

Figure 18. Public/private model for Global SWIM

Note.— The selected regions for SWIM are illustrative as more SWIM regions may develop.

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Appendix A

SWIM AND INFORMATION DOMAIN MANAGEMENT

This Appendix explains the relationship of SWIM with Information definition and information domain management. Section A.1 introduces four topics that arise regarding information management and harmonization especially in a global context. Sections A.2 and 0A.3 introduce the concept of information domains, and some criteria that may be applicable in ensuring consistency and avoiding duplication in domain definition. Sections A.4 through A.5 describe a process to manage, perform, and oversee the performance of activities within one or more information domains.

A.1 Major ATM IM Topics

The following four topics (in question/answer form) relating to information management are of interest to SWIM stakeholders:

1. **Who has the responsibility to define information relevant to ATM?** Pioneer States and the aviation stakeholders have cooperated in defining information relevant to ATM operations. These activities have been coordinated with ICAO and the definition continues to evolve as more sophisticated ATM concepts are introduced globally. As standardization of information is key to SWIM, and as SWIM is at the heart of the future ATM concept, more collaboration and coordination involving multiple parties will be required.

2. **How is information organized so that one can understand its meaning and build means to appropriately exchange and share?** This has progressed via multilateral efforts in defining the organization of information. This has led to the definition of data exchange models such as the AIXM, the WXXM and the FIXM and in the most mature cases to concrete implementations and commercially available solutions. ICAO has identified the ATM Information Reference Model (AIRM) under the ASBU Digital ATM Information Management (DATM) module to capture all types of information used by ATM in a consistent set of data and service models.

3. **How is information mapped to services delivered?** Traditionally each region defined its services for specific domains and identified the information elements associated with those services. The definition of agreed upon global information exchange services is still in progress. Reference models for information services have been proposed in some regions. A global service description template is required.

4. **How does one avoid duplication and ensure consistency between formats and data items?** This requires multilateral cooperation and coordination at the level of the architectural approaches to define the information elements applicable to ATM, and commonly agreed and understood processes and criteria. Amongst these criteria there is a need for clearly defined SWIM compliance criteria. The ICAO process is central to this cooperative endeavour.

A.2 Information Domains

An **information domain** is focused on identifying, defining, and satisfying the information needs of the set of business activities associated with a specific area. The concept of information domains, information exchange services, and information exchange models was introduced in Sections 3.4 and 3.5.

The concept of progressively achieving a seamless information space, supported by exchange models related to information domains within each user context, is realized by SWIM-enabled applications. This means applications may consume information services that relate to one or more domains. As a consequence, the provider side with the current domain realities needs to be combined with the consumer needs in a balanced and agile way. SWIM intends to address this balance.

Therefore, a first key SWIM concept is the separation between information provision and information consumption. A second key concept is the use of logical information services that can be instantiated at the physical level in different ways, thus enabling an architectural approach based on “one logic and multiple potential solutions”.

This implies that both provider and consumer views need to be considered at the specification and implementation levels to build fit-for-purpose solutions. To address this complex problem the ATM Information Reference Model and the Exchange models play ***complementary but clearly delineated*** roles.

Exchange models have been defined for the following domains of ATM operations: meteorological information (WXXM), aeronautical information (AIXM), flight and flow information (FIXM), and surveillance information (ASTERIX). In addition it is worth noting that other communities of interest are developing exchange models such as is the case for the industry requirements for aerodrome mapping, terrain and obstacle information involving organizations such as RTCA, EUROCAE and ARINC.

What ultimately binds the providers and the consumers together in data exchanges are the information services which represent a formal contract between provider and consumer. Information services themselves are identified and defined using the ATM information reference model. Information services implementation specifications are based on exchange models since they are closer to the solution space. Altogether Information services are made available through an information service reference model and their implemented instances exposed through the SWIM registry.

SWIM-enabled applications are thus enabled to access to multiple information domains via their respective domain services and via further cross domain services, built using SWIM-compliant exchange models, altogether providing improved situational awareness to different classes of users.

A.3 Criteria applicable to Information Domains

Each information domain identified serves a distinct business need; however, these domains may consist of shared interests and relationships. This means that harmonization must occur between information domains to ensure element data and information content matches the intent. As the aggregate pool of ATM data and information is quite broad, some criteria are necessary to identify which data and information should be organized and defined within which domain. An outcome of the rationalized framework for harmonization will be identification of dependencies. Examples include:

a) Information items that are contained in one domain but used by another.

b) Information items that might be ambiguously contained in two or more information domains.

c) Information items with dependencies (value of one affects the other, or they are correlated). These require processes for ensuring that update cycles are synchronized, or versioned in a manner to prevent errors.

A specific example of a dependency that has already surfaced is the communication code and flight type data represented in the aeronautical information domain and the flight information domain.

The paragraphs below provide a set of guidelines for identifying an information domain and the criteria are described separately. It is recognized, however, that identifying a new information domain is not a necessary task for most regions; most regions that are newly-adopting SWIM are likely to adopt those recommended by ICAO.

Essentially, any candidate information domain should:

a) ***represent a distinctive set of mission-related business activities***
Examples include: (a) navigation activities related to the Navigation Domain, and (b) Trajectory Management related to a series of cross domain activities such AIM, Flight, MET, etc. (these activity groupings may also be referred to as operational focus areas).

b) ***have requirements for data and information that are unique to it or can be used differently from other mission-specific activities or existing information domains.***

For example, surveillance and navigation activities both use geospatial data and information; but they use it differently and each has a different view of it. Surveillance activities use this data and information to answer the question "*Where are you?*" or "*Are you supposed to be there?*" versus Navigation activities that use it to answer the questions "*Where am I?*" and "*How do I get there?"* However in both cases the fundamental geospatial nature of coordinate information and the way the information is understood should not differ, hence allowing both domains to apply similar software components at a lower level and thus providing cost savings to the organizations at a higher level. For this reason the ATM information reference model provides foundation classes which could be used throughout ATM as a common and standardized pattern, structurally enabling cost savings. As a consequence this separation of concern is important in information management as it allows each domain to focus on those aspects which are specific to each of them. In this example neither the surveillance nor the navigation domain should define what a coordinate is as it would be provided by SWIM whilst respecting the different domain purposes.

c) ***represent the data and information needs of a specific group of people who perform these mission-specific activities*** (the practitioners) and who may be involved with: (a) the capture or generation and validation of data; or (b) the creation, update, processing, distribution, or use of information within these domain-specific activities.

A.3.1 Quality Criteria for Information Domain

This section identifies and describes an initial set of guidelines to ensure the formation of an information domain is of high-quality. The key criteria are presented in Table A-1, Information Domain Quality Criteria. These criteria can be used to develop and maintain information domain models and were identified by others who have created information domains and have passed on their recommendations, lessons learned, and best practices. Therefore, the citation (from sources) of these criteria is provided within the table, when a unique guideline was identified.

Table A-1. Information Domain Quality Criteria

Information Domain Quality Criterion	***Information Domain Quality Criterion Guideline***
Scope	One of the most important aspects to consider initially when developing an information domain model is to ensure all involved parties agree to an explicitly detailed definition of the scope. Specifically, where two or more organizations or groups are involved, the information domain model should identify and describe): (a) what activities and processes are to be modelled and whose are going to be modelled; (b) what information is to be modelled and whose information is going to be considered; (c) the applicable requirements and constraints, if any; and (d) the intended and desired results and outcomes. This ensures that the effort will address only those areas identified and eliminate any confusion later on. Also, the scope must be manageable and do-able by the specified parties – too large a scope and the process and products become unwieldy and costly and too small may not be worth the effort or be a waste of resources. (Lasschyut, van Hakken, Treurniet, & Visser, 2004) pp. 9-11, 9-12. "A system is said to be part of a domain when it is *able to interact* with other systems by making use of the domain's exchange language… The size or *scope* of a domain determines *how many* and *what kind of systems* belong to that domain. Since a domain represents an information standard, its scope can also be specified as the *kind of information* that is common and exchanged between systems within the domain. The scope must be clearly defined in order to avoid wrong usage of the standard." (Lasschyut, van Hakken, Treurniet, & Visser, 2004) p. 9-30 In a large environment or industry like air transportation, "…having multiple domains is usually unavoidable. The real challenge in this is finding an optimal partition of the total interoperability area. This comes down to finding a proper scope for each domain as well as the best subdivision of the whole area into domains." (Lasschyut, van Hakken, Treurniet, & Visser, 2004), 9-31
Purpose	The purpose of the modelling effort should be clearly and concisely stated and agreed to by all involved parties. It should also include a description of the intended and desired results and outcomes in as much detail as possible. It should include the different artifacts that are required to satisfy the description of the model, including (a) the type of artifacts to be provided, acquired, or developed; (b) the applicable descriptions and models of the information and mappings down to the types of data requirements involved; (c) the supporting scenarios and use cases necessary to describe the activities involved; and (d) a description of the development process methods, techniques, and tools to be employed. This will ensure that the desired result is obtainable and it is achieved for exactly those purposes for which it is meant to be (Lasschyut, van Hakken, Treurniet, & Visser, 2004), p. 9-11

Information Domain Quality Criterion	*Information Domain Quality Criterion Guideline*
Partitioning Scope into Multiple Domains	“A domain typically contains systems with much information in common, which is exchanged between them relatively frequently. So a domain represents a clustering of systems which are closely related [that can be based on similar information content, functionality of systems, quality requirements (such as security and timeliness), or the organizations that use or own the systems]. This implies that a suitable initial set of domains is largely derived by grouping systems that exchange much similar information. But enterprise-interoperability implies there is a need to interconnect potentially any system with any other. This means that systems out of different domains must be able to talk with each other as well. In other words, domains have to be linked somehow. This happens in the same way individual systems are clustered into domains; the initial (or ‘basic’) domains may be grouped into new domains at a higher level. A higher-level domain represents a set of domains (groups of systems) which are interconnected by means of a common exchange language.” (Lasschyut, van Hakken, Treurniet, & Visser, 2004), p. 9-31
Level of Detail	All involved parties should agree at the outset on the level of detail desired. Any modifications to that agreement should be documented and agreed before any changes are made. (Lasschyut, van Hakken, Treurniet, & Visser, 2004), pp. 9-12, 9-13
Shared Information and Artifacts	All involved parties should agree at the outset to information and artifacts that are to be shared. The agreement should clearly state who is going to provide whom the information or artifacts, where, when, and how often. The agreement should also identify who “owns” what information and artifacts to be shared and what: (a) “rights” are provided to or permitted by its recipients; and (b) “restrictions” or “constraints” apply, given specified circumstances and situations. This is particularly sensitive if commercial or “for profit” organizations are involved (Lasschyut, van Hakken, Treurniet, & Visser, 2004) p. 9-12
Methods of Communication among Involved Parties	It is always good project management practice to develop and execute a communications plan that identifies who, when, and how managers, team members, and stakeholders should be kept abreast of the involved parties efforts. The initial agreement should clearly state the roles and responsibilities and the communication expectations of these individuals. Of course, any amendments to the agreement should be clearly documented, agreed, and communicated to the respective parties.
Comprehensive	The quality of information (necessary to adequately cover the scope or a specific topic within the scope) must be: (a) determined up front; (b) agreed to by all involved parties; and (c) stated in such a way that it is satisfactory to and meets, if not exceeds, the needs of the information consumer. (Eppler, 2006). IAIDQ Glossary
Information should be Uniquely Identified and Unambiguously Defined	The information (and underlying data) must be captured and made available to all involved parties, in accordance with the agreement(s) and Communication Plan. The identity and definitions of this information (and corresponding data) should be captured and documented in such a manner that it can be uniquely identified and unambiguously defined across the specified organizational boundaries, domains, and heterogeneous systems. (Heath & Bizer, 2011) pp. 7-15.

Information Domain Quality Criterion	***Information Domain Quality Criterion Guideline***
Knowledge should be Captured and Available	Any knowledge (e.g. business rules, methods, techniques, best practices, lessons learned), that is deemed important to the task at hand, should be captured and made available to all involved parties as specified in the agreement. (Heath & Bizer, 2011) pp. 26-27
Flexible Design	The artifacts developed should be built or developed in such a way that they may easily be maintained and updated. The requisite information (and corresponding data) should be harmonized and semantically complete across the domain and organizational boundaries of the involved parties. (Lasschyut, van Hakken, Treurniet, & Visser, 2004) p. 9-14
Information should be easily Discoverable	The information (and underlying data) must be captured and made available to all involved parties, in accordance with the agreement(s), should be seamlessly and easily discoverable, and any new information (or underlying data) should be easily integrated with the existing information in the artifacts, registries, and repositories. (Heath & Bizer, 2011) p. 26
Complete	The description of the domain and associated information should be complete based on the definition of the agreed scope and, secondly, on the desired output or result specified in the purpose of the initiative. "The usual defects related to completeness include: a) The omission of domain concepts, and b) The omission of relationships. In a domain model there is actually a reverse kind of completeness fault. Domain models may actually include too much information. There is a tendency to include implementation details particularly when the project is reengineering an existing application. The risk of "over completeness" is that implication decisions may be made too soon. By inclusion in an analysis model these decisions may be viewed as requirements rather than the target of critical examination." (McGregor, unknown).
Each Data item should have a Unique Identifier	To ensure different data items are the same and can be easily found, each data item needs to have a unique identifier assigned. For those data items that are going to be exchanged, we recommend a universal or globally unique identifier be assigned. With the popularity of Web Ontology Language (OWL) [sic] and Resource Description Framework (RDF) on one end of the spectrum and taxonomies and ontologies on the other, semantic technologies are moving towards establishment of unique identifiers for each data item. Due to the need to exchange information at the global level, it is recommended the assignment of globally unique identifiers for each data item that is shared. (Heath & Bizer, 2011) pp. 7-27

A.4 Major Activities in Information Domain Management

Five major activities are associated with managing a domain. These are executed by different individuals or groups with different roles, as follows:

- ***Manage information domain community-related activities*** – this activity performed by the community manager(s), establishes and manages the activities of the information domain. Sub-activities include:

  a) establish information domain community;

  b) establish and maintain information domain membership; and

  c) manage activities of information domain community.

- ***Manage activities across domains*** – performed by the management council, this activity evaluates and resolves matters, interests, and issues which surface from the information domain communities that have a conflict or which need to be considered and resolved. Sub-activities include:

  a) resolve conflicts and issues within and among information domains;

  b) establish, maintain and ensure compliance with applicable policies, directives, methods and procedures; and

  c) establish maintain and ensure compliance with applicable standards and standard toolsets.

- ***Perform information domain community-related activities*** – performed by the community members, this activity performs the "real work" associated with the activities of the information domain. Sub-activities include:

  a) maintain information about information domain community member;

  b) perform activities of information domain community;

  c) comply with applicable laws, regulations and rules;

  d) comply with applicable policies, directives, methods and procedures;

  e) comply with implementation and execution of standards; and

  f) comply with implementation, execution and usage of standard toolsets.

- ***Oversee Performance and Management of Information Domain community-related activities*** – performed by the regulator, this activity assures the communities' compliance with applicable laws, regulations, rules, policies, methods, practices, procedures, standards and tools. Sub-activities include:

  a) assures compliance with applicable laws, regulations and rules;

  b) assures compliance with applicable policies, methods, practices and procedures; and

  c) assures compliance with applicable standards and standard toolsets.

- ***Govern Information Domain community-related activities*** – performed by the governance body this activity governs the activities of the communities at a global or international level. This activity adjudicates conflicts and issues among information domains.

A.5 Relationship to SWIM

A.5.1 Information Management

Information Management requires a process where the management of an organization or group plans, organizes, provides leadership, and controls the:

a) need for addition or improved information or information artifacts or resources based on business requirements;

b) acquisition of data (to make information) and information (from external sources);

c) production of information or information artifacts or resources (which may also include content management) that is fit for use/purpose of the domain;

d) processing (or transformation) of information;

e) retention, physical storage, and retrieval of desired information, information artifacts, and information resources;

f) distribution of information, information artifacts, and information resources to primarily information consumers and secondarily to information service brokers and information service providers (see definitions below in this section);

g) utilization of information, information artifacts, and information resources to limit unauthorized access and use, malicious and unintentional modification or destruction, and ensure conformance with applicable laws and regulations; and

h) maintenance of information, information artifacts and information resources to ensure they are up-to-date and remain relevant in their content or appearance or format.

Information management activities are performed by the management of information producers and are referred to as “Information Managers.”

Table A-2 summarizes the differences in the roles between the areas of responsibility and functions: information domain process, information operations, information management, information oversight, and SWIM. Areas of responsibilities/functions are described following the table. Further explanations of the terms used are in the following subsections.

Table A-2. Comparison of Roles among Information Domains, Information Management, Information Oversight, and SWIM

Information Domain Process	Information Operations	Information Management	Information Oversight	SWIM Technical Infrastructure
		Data Perspective		
	Data Producer	Data Manager	Data Overseer (Regulator)	
	Data Processor			
	Data Provider			
	Data Consumer			
		Information Perspective		
	Information Producer	Information Manager	Information Overseer (Regulator)	
	Information Processor			
	Information Provider			
	Information Consumer			
Community Member (Practitioner, Involved Party, Beneficiary)			Information Overseer (Regulator)	
Community Manager				
Management Council (group of Community Managers)				
		Service Perspective		
	Service Consumer		Service Overseer (Regulator)	Service Producer
				Service Broker
				Service Operator
				Service Provider
				Service Manager

A.5.2 Information Oversight

Information Oversight requires a process where overseers and regulators monitor, examine, and evaluate the performance of the operations and management to:

a) ascertain whether they are in compliance with the appropriate and applicable laws, regulations, rules, policies, methods, practices, procedures, standards, and standard toolsets;

b) assert vested authority and work with operations or management when non-compliance is identified to bring their actions back into the range of compliance; and

c) issue violations for infringements, or sanctions where enforcement is required, should operations or management still remain outside the boundary of compliance after initial notification of non-compliance.

Information oversight activities are performed by overseers; who may also be referred to as “Regulators.”

A.5.3 Information Service Management

Information Service Management is a process where the management of an organization or group plans, organizes, provides leadership, and controls the:

a) need for new or improved information services;

b) design of new or re-engineering of existing information services to ensure they meet, if not exceed, the needs of the information consumer;

c) development and subsequent implementation of new, re-engineering, or upgraded information services;

d) operation of information services (whether manual or automated);

e) provision or delivery of information services (whether manual or automated – and includes the provision of communications operations and management);

f) utilization of information services to: (a) limit unauthorized access, malicious and unintentional disruption or cessation of service, and ensure conformance with applicable laws, regulations, and service agreements and contracts; and (b) monitor the level of service provision and utilization to ensure up-to-date information services and high-quality information is available to information consumers to use to make informed, intelligent decisions or take action in response to a stimulus and ensure they are satisfied with the services they consume; and

g) maintenance of the information services to ensure the information services are kept up-to-date and appealing to the information consumers.

Information service management activities are performed by the management of Information service brokers, providers, and operators and are referred to as “information service managers.”

In summary, the information management activities are related to the creation of the information artifacts (products), and require an information manager role and information producer role. The information domain community activities involve preparatory work to get the information harmonized across different communities and made ready to be shared. The information service management activities are related to: (a) the actual delivery of the information or information artifact to an information consumer; or (b) the performance of an information-related service for an information consumer. The information service management activities involve a service manager role, a service broker role (optional), one or more service operator roles, and one or more service provider roles.

Appendix B

SHORT DESCRIPTION OF POTENTIAL CANDIDATE SWIM STANDARDS

This appendix provides a short description of the potential candidate SWIM standards[10] that were mentioned in Section 3.7.2 SWIM technical architecture.

B.1 Information Exchange Services

B.1.1 Service Interoperability

Information exchange services are still under definition and no interoperability standards for the services exist. However, there is general agreement that the initial information exchange services need to be defined for aeronautical information exchange, flight information exchange, and meteorological information exchange. Individual ASPs and some SWIM regions have undertaken some efforts in defining these services. The definition of these services is very important for member States in agreeing upon a global SWIM services and how they can make use of such services. Additional information exchange services are planned.

For example, Single European Sky ATM Research (SESAR) provided network operations plan Business-to-Business (B2B) Web Services have been grouped over 4 domains:

a) flight services (flight preparation, flight plan filing and management);

b) airspace services (management and publication of airspace information);

c) general information services; and

d) flow services (flow & capacity management).

B.1.2 Interface Definition

- **WSDL (Web Services Description Language)**

WSDL describes the abstract interfaces, protocol bindings and deployment details of services. It can be considered as a complement to the UDDI standard. Understanding the relationship between WSDL and UDDI and establishing a mapping between them allows the automatic registering of WSDL definitions in UDDI.

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[10] Not all potential candidate standards are listed in this appendix.

In SWIM services developed by the ASP, application systems will be exposed using WSDLs during design-time. A WSDL provided by an information provider is stored in a registry in accordance with the registry data model to be defined. Information consumers can then search the registry and discover the service they are seeking based on service characteristics including deployment details as provided by the WSDL. The information consumer is then able to invoke the service during run-time.

As part of the WS-I Basic standard and a widely used mechanism to describe services (e.g. ports and binding information), WSDL is a key enabler of the kind of technology (web services and SOA) SWIM is implementing for seamless information exchange.

- **Web Feature Service (WFS)**

WFS (OGC Web Feature Service, 2005) provides an interface allowing requests for geographical features across the web using platform-independent calls. Basic WFS allows querying and retrieval of features. Transactional WFS (WFS-T) allows creation, deletion, and updating of features.

- **Web Map Service (WMS)**

WMS (OGC Web Map Service, 2005) provides a simple HTTP interface for requesting geo-registered map images from one or more distributed geospatial databases. A WMS request defines the geographic layer(s) and area of interest to be processed. The response to the request is one or more geo-registered map images (returned as JPEG, PNG, etc.) that can be displayed in a browser application. The interface also supports the ability to specify whether the returned images should be transparent so that layers from multiple servers can be combined or not.

Note.— WMS 1.3 and ISO 19128 are the same documents.

B.2 Information Exchange Models and Schemas

B.2.1 Aeronautical, Meteorological, and Flight Information

Information exchange standards are the standards that are needed for domain applications to interoperate. The more mature domains are for flight data, aeronautical, and meteorological data. air traffic management information reference models for these domains (and other domains) have or are being developed by international bodies. While there are many exchange standards, examples include AIXM, WXXM, and FIXM.

- AIXM

The aeronautical information exchange model (AIXM) is designed to enable the management and distribution of aeronautical information services data in digital format. AIXM takes advantages of established information engineering standards and supports current and future aeronautical information system requirements. The major tenets are:

a) an exhaustive temporality model, including support for the temporary information contained in NOTAM;

b) alignment with ISO standards for geospatial information, including the use of the geography markup language (GML);

c) support for the latest ICAO and user requirements for aeronautical data including obstacles, terminal procedures and airport mapping databases; and

d) modularity and extensibility.

- FIXM

The flight information exchange model (FIXM) is a data interchange format for sharing information about flights throughout their lifecycle. FIXM is part of a family of technology independent, harmonized and interoperable information exchange models designed to cover the information needs of air traffic management.

- WXXM

The weather information exchange models and schema (WXCM-WXXM-WXXS) are designed to enable a platform independent, harmonized and interoperable meteorological information exchange covering all the needs of the air transport industry. [When the 3-tiered model (WXCM-WXXM-WXXS) is referred to as a single entity, the term used is 'WXXM'.]

The WXCM-WXXM-WXXS takes advantages of existing and emerging information engineering standards and supports current and future aeronautical meteorological information system requirements.

The major tenets are:

a) support for the latest ICAO and other user requirements for meteorological information by one single representation;

b) alignment with ISO standards for geospatial information, including the use of the geography markup language (GML);

c) alignment with OGC best practices for geospatial information, including the observation & measurement model; and

d) modularity to support future requirements.

B.3 SWIM Infrastructure

B.3.1 Enterprise Service Management Standards

Long term standards for WS management are still evolving and are not readily available in products. Web services manageability is defined as a set of capabilities for discovering the existence, availability, health, performance, and usage, as well as the control and configuration of a Web service within the web services architecture. This implies that web services can be managed using web services technologies. The importance of a standardized management model for web services and the promise of web services as a management integration technology is a future SWIM goal.

The most popular standards for monitoring and control in SWIM are likely to be the simple network management protocol (SNMP) and java management eXtension (JMX). These are not strictly service management standards such as WS-distributed management (WSDM). JMX only works for Java based platforms, and SNMP does not really support management at the service layer, only at network/platform infrastructure layer. Exchange of ESM information across organizations is also likely to be minimal unless enough trust has been built up and is likely to be bilateral in nature.

B.3.2 Policy Standards

WS-policy defines a general-purpose framework for representing and combining statements about the QoS properties. WS-policy is an extensible framework that can accommodate domain-specific dialects to represent these assertions and allow the attachment of policies to arbitrary types of subjects through the generic attachment mechanisms that WS-policy attachments define. One such example is the use of WS-policy to implement WS-security policy as defined below. WS-policy (version 1.5) was released as a W3C recommended standard in September 2007 though some vendor implementations have been available since.

B.3.3 Security Standards

Security standards are still an area of discussion and evaluation. There seems to be agreement that the two standards that are reasonably mature are WS-security and the secure sockets layer (SSL). A number of supplemental security standards such as OASIS security assertion markup language (SAML) are under consideration.

Agreements on security standards among organizations are more likely to be bilateral in practice and require memoranda of agreement. Organizations develop a trust level slowly among their respective communities of interest (stakeholders that they work with frequently). It is likely that each organization will decide to expose an agreed upon set of information services at their boundary protection gateways.

- **WS-Security 1.1**

The OASIS standard WS-security 1.1 is recommended to provide secure SOAP message exchange from message endpoint to message endpoint. The primary mechanism for implementing WS-Security is the incorporation of enhancements to the SOAP header and body.

The WS-I basic security profile makes additional recommendations for the interoperability of services defined by WS-Security; it also makes additional recommendations intended to improve the security of web services.

- **Secure Sockets Layer (SSL) Protocol v3.0**

SSL and its successor TLS were developed to address transport level shortcomings in HTTP. SSL is the commercially available implementation of the TLS standard. SSL and TLS are encryption technologies that can be used to provide secure transactions. SSL and TLS can provide for both server-only or server and client (mutual) authentication. SSL uses symmetric encryption for private connections and asymmetric encryption for peer authentication. It also uses a message authentication code (MAC) for message integrity checking.

While the use of transport level security may be simpler to deploy than WS-Security mechanisms, it can only be used for securing information between two web services, or for point-to-point connections without intermediaries.

B.3.4 Reliability Standards

- **WS-Reliable Messaging**

WS-reliable messaging is a standard for a reliable messaging architecture for web services.

While the use of a standard like WS-reliable messaging will allow the development of robust and reliable web services as well as ensure transport independence, its use in early implementations of SWIM should be predicated on the fact that it has matured. At this time the WS-reliable messaging standard has been approved by OASIS but needs to be evaluated for maturity for use in SWIM.

This leads to the consideration of more traditional mechanisms like JMS which is recommended for use in SWIM.

- ***WS-RM Policy***

This standard may be considered for use in later SWIM implementations for distributing declarative policy regarding use of reliable messaging.

B.3.5 Data Representation Standards

SWIM standards for data representation consist of XML and XML Schema Definition (XSD). XML provides a standardized method for describing data structures and data types while XSD formalizes how elements are described in an XML document.

Extensible stylesheet language transformations (XSLT) is a SWIM standard for XML data transformation.

XML path language (XPath) and XML query language (XQuery) are SWIM standards for querying for XML data via web services.

XML is a universally accepted standard way of structuring data that is a basis for how data is represented in web services. XSD, XSLT, XPath, and XQuery are all standards/tools which were created to facilitate the use of XML and are widely used.

The geography markup language (GML) is the XML grammar defined by the open geospatial consortium (OGC) to express geographical features. GML serves as a modeling language for geographic systems as well as an open interchange format for geographic transactions on the internet.

B.3.6 Messaging Standards

- **SOAP**

SOAP is the messaging envelope used to exchange information between producers and consumers in SWIM. SOAP can be transported either over HTTP or other transport mechanisms such as JMS or MQ. SOAP is listed as a messaging standard for SWIM because it is mature and currently the most widely used protocol for SOA implementations. In this context, a standard is mature if multiple commercial vendors provide software implementations conforming to this standard.

However, when necessary, due to performance, security or other concerns, other approaches may be used in SWIM. The REpresentational state transfer (REST) architectural style, using Plain old XML is also possible. REST may work well across organizational boundaries because of its simplicity.

- **JMS**

JMS is an application program interface (API) for accessing enterprise messaging systems. It is part of the java platform, enterprise edition (Java EE). JMS defines a common enterprise messaging API that is designed to be easily and efficiently supported by a wide range of enterprise messaging products such as IBM websphere MQ. JMS in conjunction with a product like IBM websphere MQ (via a Provider) can provide a reliable transport for SOAP. It can also support the publish/subscribe MEP. In case WS-notification and WS-reliable messaging are determined to be not suitable for SWIM, JMS is a viable alternative until the WS* standards mature.

Note.— JMS is only an API standard; it does not provide an "on the wire" standard for machine-to-machine message transfer. Interoperability of two communicators that use different JMS implementations may be accommodated by supporting multiple message queueing (MQ) protocols. There is also an on-going effort to define a common "on the wire" standard.

- **Data Distribution Service for Real-Time Systems (DDS)**

DDS is the first open international middleware[11] standard directly addressing publish-subscribe communications for real-time and embedded systems. It is published by the object management group (OMG) DDS portal. There are at least two commercial implementations available.

DDS introduces a virtual global data space where applications can share information by simply reading and writing data-objects addressed by means of an application-defined name (Topic) and a key. DDS features fine and extensive control of quality of service (QoS) parameters, including reliability, bandwidth, delivery deadlines*, and* resource limits. DDS also supports the construction of local object models on top of the global data space. The current DDS specification is version 1.2 and the current DDS interoperability wire protocol specification (DDS-RTPS) is version 2.1.

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[11] Middleware is software that serves to "glue together" or mediate between two separate and often already existing messaging standards (or implementations of an API such as JMS).

B.3.7 Transport Standards

- **Hyper Text Transfer Protocol (HTTP)**

HTTP is a widely available application layer transport mechanism. HTTP is listed as a transport protocol because of its traditional role as an application transport mechanism for SOAP. It is an ideal application transport for interactions that don't require reliability. Once WS-reliable messaging matures, it is expected that SOAP using WS-reliable messages can be transmitted reliably over HTTP.

- **Java Messaging Service (JMS)**

JMS was already described while considering the messaging layer. Because JMS is an API it can be considered at either layer.

- **Proprietary Message Oriented Middleware**

IBM websphere MQ, Oracle AQ, and sonicMQ are examples of proprietary message oriented middleware (MOM) that provide a reliable message transport infrastructure using message queueing. MQ products can be used as standardized products within SWIM not only because of their support for reliable messaging, but also because of their maturity and wide spread use in enterprises as well as its support for various legacy host systems. MQ also has the capability to support publish/subscribe messaging as well as reliable messaging.

MOM products and suitable bridges can ensure interoperability among communicators using different JMS implementations.

B.3.8 Service Registry Standards

- **UDDI (Universal Description, Discovery, and Integration)**

UDDI is a standard interface to a directory used for storing information about web services including web services interfaces. During design time developers are able to find WSDL files and create appropriate consuming applications based on those files to consume discovered services. Run time service exposure will be performed via a standard UDDI publishing service interface, defined as part of the UDDI Specification.

Despite some concerns with the complexity of UDDI, it is supported by many COTS products, and is used by many organizations. It is an established standard (also part of WS-I basic profile). The adoption of a single standard for data registry access and retrieval is important for SWIM. Other standards like electronic business using XML (ebXML) could be used in conjunction with UDDI.

Appendix C

MEETING THE ATM SYSTEM REQUIREMENTS

A summary of information management and services requirements identified in Section 2.2.1 of the *Manual on ATM System Requirements* (Doc 9882) is provided below. Notes explaining how this SWIM document addresses these requirements are also provided. The requirement number, referenced in Doc 9882, is in brackets.

The explicit requirements on information management are described as follows:

a) implement system wide information management [R70];

   (i) this document provides guidelines for this implementation.

b) establish information exchange protocols and procedures to ensure that appropriate performance can be achieved within the agreed rules [R12];

   (ii) this document describes the representative standards for exchange protocols and describes the applicable procedures.

c) be capable of collecting and integrating information from diverse sources to produce a complete and accurate view of the ATM system state [R76];

   (iii) operational use of SWIM as described in Section 3 indicates how SWIM is expected to accomplish this.

d) support a reduction in transactional friction for transmission of information across systems [R78].

   (iv) ensured through provision of *interoperable* information standards at all layers of the SWIM framework.

The following characteristics ensure that the requirements are met:

a) provide to the ATM community accredited, quality-assured, and timely information meeting the identified standards of performance, including quality of services [R74];

b) provide information systems that identify the nature of the information in terms of timeframe - historical, current, or planned [R75]; and

c) ensure that a relevant validity period of ATM system information is evident to the user of that information [R79].

The following requirements are met through the exchange of information (via SWIM) falling within various domains (aeronautical, flight, and meteorological):

a) provide a global, common aviation data standard and reference system to allow fusion and conflation and provide comprehensive situational awareness and conflict management [R06];

b) assemble the best possible integrated picture of the historical, real-time, and planned or foreseen future state of the ATM system situation and relevant, quality-assured and accredited information shall be made available to the ATM system [R123];

c) ensure that the airspace user makes available relevant, operational information to the ATM system [R07];

d) use relevant, airspace user operational information to optimize flight operation management [R08];

e) use relevant data to dynamically optimize 4-D trajectory planning and operation [R09];

f) provide the status of ATM system resources [R13];

g) make available to the ATM system flight parameters and aircraft performance characteristics [R31];

h) establish standards for meteorological model accuracy and resolution and agree performance requirements [R157];

i) provide timely access to all relevant meteorological information [R164]; and

j) utilize meteorological data, and information derived from it, to assist in analysis and evaluation of agreed environmental performance targets [R96].

— END —