



# ICAO

*International Civil Aviation Organization*

**The Fifth Meeting of System Wide Information Management Task Force (SWIM TF/5)**

*Video Tele-conference, 9 – 11 August 2021*

**Agenda Item 6:** Updates on the assigned tasks by task leads/contributors including progress report and issues

d) Governance

## **SWIM INTEROPERABILITY ASSESSMENT MATRIX (SIAM)**

(Presented by USA/FAA)

### **SUMMARY**

This paper introduces the SWIM Interoperability Assessment Matrix (SIAM). It describes how the SIAM can be used for interoperability assessments, articulation of requirements, and supporting the planning and validation of SWIM components in international geo-organizational settings.

## **1. INTRODUCTION**

- 1.1 As System Wide Information Management (SWIM) implementations continue to increase in number and complexity, the needs for establishing and managing interoperability in the context of SWIM continue to grow.
- 1.2 The Institute of Electrical and Electronic Engineers (IEEE) defines interoperability as “the ability of two or more systems or components to exchange information and to use the information that has been exchanged”<sup>1</sup>.
- 1.3 Early SWIM single-agency initiatives by FAA and EUROCONTROL focused almost entirely on the technical aspects of interoperability (e.g., context-driven data formats). The realization of SWIM on an international scale, where differences in technical approach, organizational and engineering practices have been entrenched over many years, has introduced multiple other factors in establishing interoperability.
- 1.4 Various methods are applied for achieving interoperability in SWIM environments. Interacting systems may adapt a common software product, or software components may be developed with knowledge of each component’s internal implementation details. Interoperability can be achieved through the use of mediating middleware<sup>2</sup>. In a service-oriented architecture – and inherently in

<sup>1</sup> IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries (New York, NY: 1990)

<sup>2</sup> An actual example of using middleware in a SWIM context is the deployment of an Enterprise Service Bus (ESB) by the FAA SWIM program for supporting interoperability among services and service consumer agents.

SWIM – interoperability is commonly established through *standardization*, that is, by a joint conformance with a given set of standards that enables systems to work together in a network environment.

- 1.5 The SWIM Interoperability Assessment Matrix (SIAM) presented in this working paper is a formal representation of interoperability solutions in service-centric environments implemented and managed by SWIM organizations. It is designed to be used for interoperability analysis, articulation of requirements, and support for planning and validating interacting components in SWIM contexts.

## 2. DISCUSSION

### 2.1 *Architecture*

- 2.1.1 The purpose of SIAM's architecture is to present an *interoperability solution* in a SWIM operational context. Hence, *interoperability solution* is a central point of interest in SIAM and is therefore a nexus of characteristics of interacting systems expressed as *dimensions*.
- 2.1.2 By using a combination of IS and dimensions, the SIAM architecture supports making a statement such as the following:
- 2.1.3 "*APAC SWIM deploys AIXM 5.0 to support syntactic interoperability among aeronautical services.*"
- 2.1.4 In this case:
  - "*AIXM 5.0*" is a standard, and therefore should be considered an *interoperability solution*,
  - "*syntactic*" is the dimensional value representing interoperability level,
  - "*aeronautical*" is the dimensional value representing service category,
  - "*APAC SWIM*" is the dimensional value representing geo-organizational category.
- 2.1.5 Figure 1 demonstrates how this statement can be visualized.

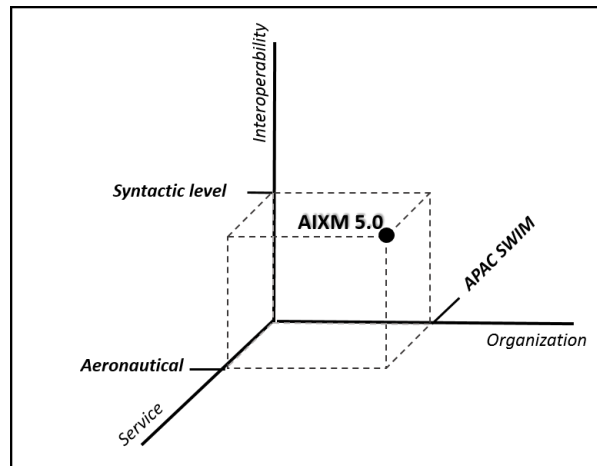


Figure 1 Conceptual vision of the SIAM architecture.

### 2.1.6 **Interoperability Solution**

2.1.6.1 The *interoperability solution* is a regulating document or identifiable mechanism that is used (or intended to be used) to manage interoperability. Typical examples of an *interoperability solution* are: open and proprietary standards, specifications, data exchange and semantic models, protocols, best practices, and policies, as well as software or hardware components such as networking infrastructure or services offering mediating capabilities.

2.1.6.2 An interoperability solution is always context-driven. A standard that is designed for defining a syntax for data exchange may be ill-suited for providing necessary semantics; the standard for a weather domain may not be applicable for an aeronautical domain, etc.

2.1.6.3 In SIAM, an *interoperability solution* is positioned in a specific context through a set of *dimensions where each dimension represents a characteristic of the interoperating systems and/or environment in which the systems operate*.

### 2.1.7 **Dimensions**

2.1.7.1 A *dimension* is understood as a set of descriptors – usually hierarchically organized – representing characteristics or constraints for a specific context.

2.1.7.2 SIAM defines three dimensions: Interoperability Level, Service, and Organization.

#### 2.1.7.3 **Interoperability Level Dimension**

2.1.7.3.1 The notion of interoperability – even at its most fundamental level – is broad and multifaceted. To make it more manageable, interoperability is commonly subdivided into *levels*, with each level presenting a different aspect or viewpoint of system interactions. A clean separation of these levels allows for more flexibility in developing analyses or requirements.

2.1.7.3.2 *The Interoperability level dimension is an ordered collection of interoperability levels.*

2.1.7.3.3 Table 1 lists levels of interoperability used in SIAM.

<i>Interoperability Level</i>	<i>Description</i>
<i>Technical Level</i>	This level concerns how a message can be transported between systems.
<i>Syntactic Level</i>	This level concerns that a standard data format is unambiguously defined and applied.
<i>Semantic Level</i>	This level concerns that the message content becomes understood in the same way by the senders and the receivers.
<i>Pragmatic Level</i>	This level means that services exchange messages in a predefined behavioral pattern to reach the collaboration objectives.

Table 1 SIAM's levels of interoperability

2.1.1 *Service Dimension*

- 2.1.1.1.1 Every component in a SWIM environment is either a service or interoperates with a service (e.g., a consumer agent). Therefore, identifying a service – or a group of services (category) – is essential in accessing interoperability solutions. To this end, SIAM deploys the Service dimension.
- 2.1.1.1.2 *The Service dimension is a collection of hierarchical classification levels and service designations that represents SWIM-enabled services.*
- 2.1.1.1.3 The structure of the Service dimension allows to relate an IS with a specific service or a whole category of services (e.g., information, flight services).
- 2.1.1.1.4 The Service dimension is modeled according to the Service Category Taxonomy<sup>3</sup>. A copy is provided in Appendix A.

2.1.2 *Organization Dimension*

- 2.1.2.1.1 The *Organization dimension* is a collection of hierarchical classification levels and organization designations that represent SWIM organizations in terms of geographic influence and coverage.
- 2.1.2.1.2 The Organization dimension identifies every SWIM implementation by a single state as *Local*. Every local representation could be associated with a single Region (e.g., ICAO Region<sup>4</sup>).
- 2.1.2.1.3 This hierarchy allows identifying interoperability either among systems within a local SWIM context or between SWIM initiatives within or across regions.
- 2.1.2.1.4 Table 2 shows a geo-organizational classification of SWIM organizations as modeled in the Organization dimension.

<i>Organization Level</i>	<i>Description</i>
<i>No SWIM</i>	This level is used to denote an organizational entity that is not considered a SWIM program but may interoperate with SWIM programs.

<sup>3</sup> WP/10 SWIM Service Category Taxonomy; USA, FAA; ICAO APAC SWIM TF-4; November 2020  
[https://www.icao.int/APAC/Meetings/2020%20SWIM%20TF4/WP10\\_USA%20AI.5d\\_Task1-5%20-%20SWIM%20Service%20Category%20Taxonomy.pdf](https://www.icao.int/APAC/Meetings/2020%20SWIM%20TF4/WP10_USA%20AI.5d_Task1-5%20-%20SWIM%20Service%20Category%20Taxonomy.pdf)

<sup>4</sup> ICAO Present Regional Structure  
<https://www.icao.int/secretariat/RegionalOffice/Pages/ro-structure.aspx>

<i>Local level</i>	This level represents a SWIM program that is governed and managed by a single state or state level agency.
<i>Regional level</i>	This level represents an organizational component whose goals are to manage and direct collaborative effort of <i>Local level</i> SWIM programs – usually geographically related – collectively identified as a Region.

Table 2 Geo-Organizational Classification of SWIM initiatives

2.1.3 **Implementation**

2.1.4 A matrix is commonly understood as a rectangular array of numbers, symbols, or expressions, arranged in rows and columns. In SIAM, an interoperability solution is represented as a matrix of elements, while rows and columns capture dimensional values.

2.1.5 The most practical way to utilize an instance of SIAM is to render it as a table or a spreadsheet.

2.1.6 Figure 2 demonstrates an example of SIAM in a fictitious SWIM environment. The row headers represent the Interoperability Level dimension. The column headers represent the Organization dimension: a local instance, FAA SWIM; a regional instance, North American (NAM) ICAO region; and a hypothetical Global SWIM. The tab represents a single value (Aeronautical service category) from the Service dimension. The cell values are ISSs, in this case, standards.

<b>Aeronautical Services</b>			
	<b>FAA SWIM</b>	<b>NAM Region</b>	<b>APAC Region</b>
<b>Pragmatic</b>	NA	NA	NA
<b>Semantic</b>	AIXM 5.0 Annotated	AIRM	AIRM
<b>Syntactic</b>	AIXM 5.x	AIXM 5.x	AIXM 5.x
<b>Technical</b>	JMS 1.1	AMQP 1.0	TBD

Figure 2 Example of instance of SIAM as a single table.

2.1.7 By looking at this example, it is easy to conclude that the local instance of SWIM (FAA SWIM) is not interoperable on the low message level with regional North American (NAM) SWIM, while the global standard for messaging network has not been established. Syntactic interoperability has been established from local to global level, while Semantic level interoperability has not yet been achieved. And this assessment describes the Aeronautical services only.

2.1.8 Appendix B demonstrates how the concept shown in Figure 3 can be implemented using a popular spreadsheet application. (For more examples of rendering SIAM instances see Appendixes B and C.)

2.1.9 It should be noted that this paper aims to introduce SWIM users to the notion of SIAM rather than provide templates or requirements. Further work will be required for creating formal and uniform representations of SIAM.

2.3.1 *Conclusion*

2.3.1.1 SIAM provides a structural and systematic approach for evaluating interoperability in the context of global SWIM initiatives.

2.3.1.2 SIAM is designed to be used as a tool for supporting interoperability analysis and articulating requirements, as well as for planning and validating.

2.3.1.3 SIAM is designed in a manner that promotes extensibility and scalability; it may be modified to meet business requirements that may emerge in the future.

**3. ACTION BY THE MEETING**

3.1 The meeting is invited to:

- a) note the information contained in this paper; and
- b) discuss any relevant matter as appropriate

## APPENDIXES

### Appendix A

The SWIM Service Category Taxonomy that contains all values for the Service dimension was originally presented for approval at ICAO APAC SWIM TF-4 in November 2020. The working paper that proposed this taxonomy provides detailed information about its structure and content. A machine-processable version of this taxonomy is also available at [semantics.aero](http://semantics.aero).

<i>Parent's Name</i>	<i>Name</i>	<i>Definition</i>
None	SWIM Service	An abstract class that represents any SWIM Service.
SWIM Service	Information Service	A service that offers capabilities for generating, making available, storing, managing, and analyzing information.
SWIM Service	Core Service	A service that offers capabilities by which to interconnect, adapt, and facilitate services provided by other parties.
Information Service	Aeronautical Service	A service that provides information used to describe, manage, and control aeronautical facts, concepts or instructions such as special use airspace restrictions, airport configuration, and Notices to Airmen (NOTAMS).
Information Service	Flight Service	A service that provides information used to describe, manage, and control the safe movement of aircraft in the airspace, including information such as flight itinerary, flight identification, flight planning, flight events and status, and air traffic management (ATM) control events associated with a single flight, where a flight normally includes one takeoff and one landing.
Information Service	Weather Service	A service that provides information used to describe current or predicted atmospheric conditions, including terminal and airborne weather observations, forecasts, and reports of weather phenomena.
Information Service	Infrastructure Service	A service that provides information used to describe the infrastructure and resources supporting a flight such as landing facilities, air space partitions, communications systems, navigation systems, surveillance systems, automation tools, etc.
Information Service	Surveillance Service	A service that provides information produced by technologies (e.g., radar, beacon interrogator, automatic dependent surveillance-broadcast) for detecting and locating airborne and taxiing aircraft and ground support vehicles.
Core Service	Discovery Service	A service that provides capabilities to a service consumer to obtain information about available services.
Core Service	Security Service	A service that provides capabilities for protecting systems from unauthorized access or interference with data transfers.
Core Service	Messaging Service	A service that provides capabilities for distributing messages exchanged by interacting components.
Core Service	Mediation Service	A service that provides capabilities for connecting systems that deploy different data representations, formats, or protocols.

### Appendix B

An implementation of the instance of SIAM depicted in Figure 3 using a Microsoft Excel application is provided below. All values in the Service dimension are shown as separate worksheets.

	A	B	C	D
1		<b>FAA SWIM</b>	<b>NAM Region</b>	<b>APAC Region</b>
2	<b>Pragmatic</b>	NA	NA	NA
3	<b>Semantic</b>	AIXM 5.0 Annotated	AIRM	AIRM
4	<b>Syntactic</b>	AIXM 5.x	AIXM 5.x	AIXM 5.x
5	<b>Technical</b>	JMS 1.1	AMQP 1.0	TBD

### Appendix C

The matrix below demonstrates two fully interoperable existing services.

	<b>Discovery Services</b>	
	<b>USA FAA SWIM</b>	<b>ROK KAC SWIM</b>
	<i>SWIM Metadata Exchange Service (SMXS)</i>	<i>SWIM Metadata Exchange Service (SMXS)</i>
<b>Pragmatic</b>	SDS Implementation Specification	SDS Implementation Specification
<b>Semantic</b>	SDCM	SDCM
<b>Syntactic</b>	SDM-J	SDM-J
<b>Technical</b>	Public Internet/HTTP 1.1	Public Internet/HTTP 1.1

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