



CONCEPT OF OPERATIONS
FOR THE
SWIM COMMON REGISTRY (SCR)

FAA/SESAR

APRIL 2015

Preface

The proposed SWIM Common Registry (SCR) is envisioned as a comprehensive, systematic, and dynamic mechanism for publishing, discovering, and understanding information about Air Traffic Management (ATM) service-oriented architecture (SOA)-based services that currently are catalogued in two separate service registries: the Single European Sky ATM Research Programme's (SESAR) European SWIM Registry and the U.S. Federal Aviation Administration's (FAA) National Airspace System (NAS) Service Registry/Repository (NSRR).

The SCR will provide System Wide Information Management (SWIM) stakeholders in both organizations with a shared view and insight into all known SWIM-enabled services, both currently available and under development. The SCR will help service implementers to improve reuse by taking advantage of parallel efforts, will support software developers in building interfaces to services, and will facilitate governance efforts in the context of participating organizations. The SCR will be flexible enough to adapt to current SWIM organizational, funding, and technological constraints, as well as to requirements that are expected to emerge in the future.

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1 Scope

1.1 Identification

This document is identified as “Concept of Operations for the SWIM Common Registry (SCR).”

1.2 Document Overview

This Concept of Operations (ConOps) document provides a conceptual overview of the proposed SWIM Common Registry (SCR).

The purpose of this document is:

- 1) To provide a clear vision of the intended use and resulting benefits of the proposed SCR;
- 2) To build consensus among sponsors, decision makers, stakeholders, and integrators participating in the SCR project;
- 3) To initiate the effort of defining the requirements and architecture for the future development of SCR.

The format of this document is consistent with the outline of a concept of operations document defined in the Institute of Electrical and Electronics Engineers (IEEE) Standard 1362-1998 [\[1\]](#).

This ConOps document contains the following sections:

- Section 1 - Provides an overview of this document and describes the general nature and concept of the SCR to which this document applies.
- Section 2 - Lists the references mentioned in this document.
- Section 3 - Describes the current situation and the issues that led to the proposed SCR.
- Section 4 - Justifies the proposed SCR based on the most current information available.
- Section 5 - Describes and discusses the concepts of the proposed SCR.
- Section 6 - Describes various operational scenarios.
- Section 7 - Summarizes operational, organizational, and other impacts of implementing the proposed SCR.
- Section 8 - Analyzes the proposed SCR.
- Section 9 - Provides additional information, including an acronym list and glossary.

1.3 System Overview

Rapidly growing demand for information exchange between FAA’s and SESAR’s System Wide Information Management (SWIM) implementations have created new emphasis on establishing efficient service discoverability¹ in SWIM-enabled environments. To address this concern, members of both organizations have worked together to promote the concept of a shared view of all SWIM services available or being developed in the context of both SWIM programs. Their white paper, *SWIM Common Registry: Concept, Architecture, and Implementation*, coined the term “SWIM Common Registry (SCR)” and asserted that “SCR, from a SWIM stakeholder perspective, should

¹ Service discoverability is generally understood as (a) the presence of a mechanism for service discovery in a SOA environment, such as a service registry; or (b) supplementing a service with metadata by which the service can be discovered and interpreted.

provide the appearance of a 'single organization' registry, while allowing participants to comply with their organization-specific governance regulations" [2]. The SCR is envisioned as a consolidation of two SWIM registries: the FAA's NAS Service Registry/Repository (NSRR) and the European SWIM Registry.

At the heart of the SCR lies the concept of a [service registry](#)². The registry is generally defined as an enabling infrastructure that uses a formal [registration](#) process to store, catalogue, and manage metadata relevant to a service. Both FAA and SESAR implementations of SWIM have established their respective registries, and although they were developed independently, they are very similar in terms of conceptual vision and set of basic functionalities.

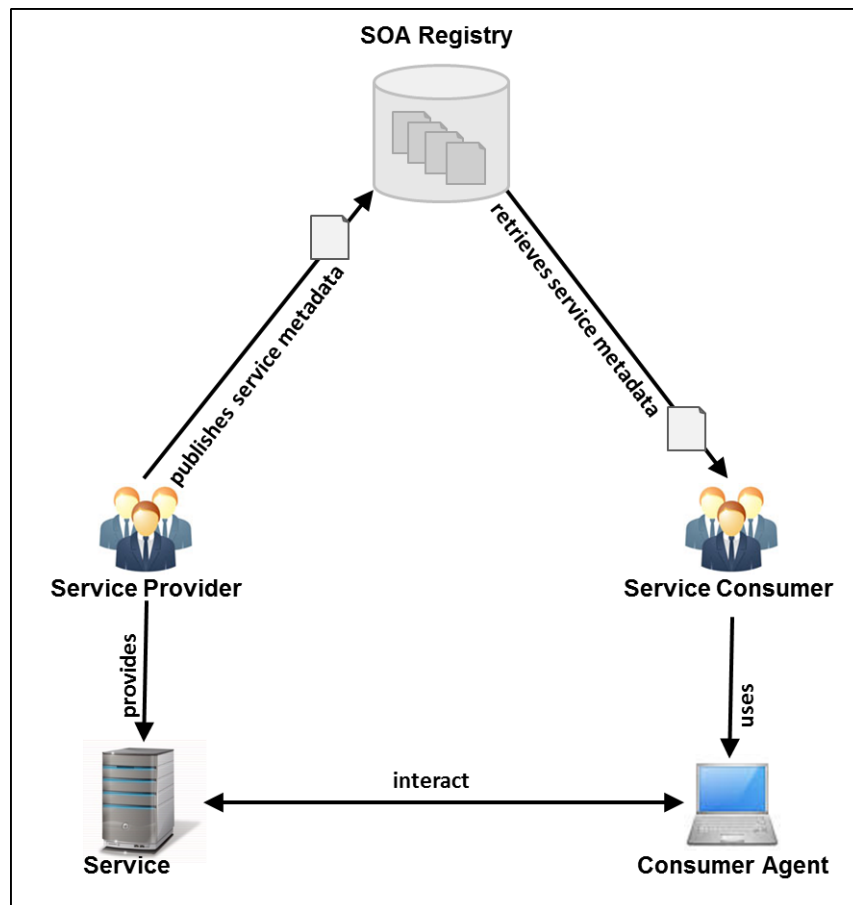


Figure 1 Conceptual view of a service registry

² Most of the registries are capable of storing not just service metadata, but also artifacts relevant to the services. Such a registry is usually referred to as a registry/repository. Both the NSRR and the European SWIM Registry are "registries/repositories" in this sense, but at this stage of SCR development only the "registry" part is being discussed, and the "repository" part is being deferred to future implementations.

Figure 1 depicts the role of a registry in the context of a typical SOA-based implementation. Here, a [service provider](#) establishes a service to offer some capabilities and creates a [service description](#). The service provider then advertises the service by publishing the service description in a service registry. The service description is a document or a set of documents that describes or represents the information needed in order to use or consider using a service [4]. A single service description in the context of a registry is also called a *meta-card*. A stack of document icons shown within the registry demonstrates registry's role as a repository of [service meta-cards](#). A [service consumer](#) browses the registry to find a service (i.e., an offered capability) that meets the consumer's particular need and uses the retrieved service description to determine how to build a [consumer agent](#) to interact with the service, that is, how to obtain information or capabilities provided by the service.

It also should be noted that the conceptual picture shown in Figure 1 describes a *design-time registry*; that is, a registry that supports activities performed by service providers and service consumers prior to the provisioning of a service (e.g., service development, service advertising and discovery, development of a consumer agent, or engaging the service). *Run-time registries*, which are registries capable of supporting service performance metrics management, monitoring compliance with security policies and service level agreements, and so forth, are not considered in this document.

2 Referenced Documents

- [1] IEEE Guide for Information Technology—System Definition—Concept of Operations (ConOps) Document (IEEE Std. 1362-1998), IEEE Computer Society, March 19, 1998
<http://standards.ieee.org/findstds/standard/1362-1998.html>
- [2] SWIM Common Registry: Concept, Architecture, and Implementation; FAA/SESAR; Pedro Fernandez-Sancho, Mark Kaplun, Eric Roelants, Carol Uri; June 2014
<http://www.faa.gov/nextgen/programs/swim/governance/outreach/media/SWIM%20Common%20Registry%20Concept%20Architecture%20and%20Implementation.pdf>
- [3] SWIM Controlled Vocabulary, FAA, May 2013
<http://www.faa.gov/nextgen/programs/swim/vocabulary/>
- [4] OASIS Reference Model for SOA 1.0, 12 October 2006
<http://docs.oasis-open.org/soa-rm/v1.0/soa-rm.pdf>
- [5] Service Description Conceptual Model (SDCM) 1.0; SESAR CP 2.1; Working Draft March 28 2014
<http://www.faa.gov/nextgen/programs/swim/governance/servicesemantics/view/SDCM%20March%2028%202014/SDCM%20March%2028%202014.html>
- [6] European Interoperability Framework for pan-European eGovernment Services; IDA Working Document; Version 4.2; January 2004

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- [7] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions 'Towards interoperability for European public services'; Annex 2; EUROPEAN COMMISSION; December 16, 2010
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- [12] ISO/IEC 11179, Information Technology – Metadata registries (MDR) – Part 6: Registration, Second Edition, 2005-01-15
<http://metadata-standards.org/11179/#A6>
- [13] ISO/IEC 2382-17:1999 17.02.05, Information technology -- Vocabulary -- Part 17: Databases
http://www.iso.org/iso/catalogue_detail.htm?csnumber=30853

3 Current System or Situation

Although SCR as a system currently does not exist, there are two major components already in place that are expected to be used as building blocks for constructing the proposed system: the NSRR and the European SWIM Registry.

3.1 FAA SWIM Registry (NSRR)

Figure 2 conceptually depicts using the NSRR in the FAA SWIM environment.

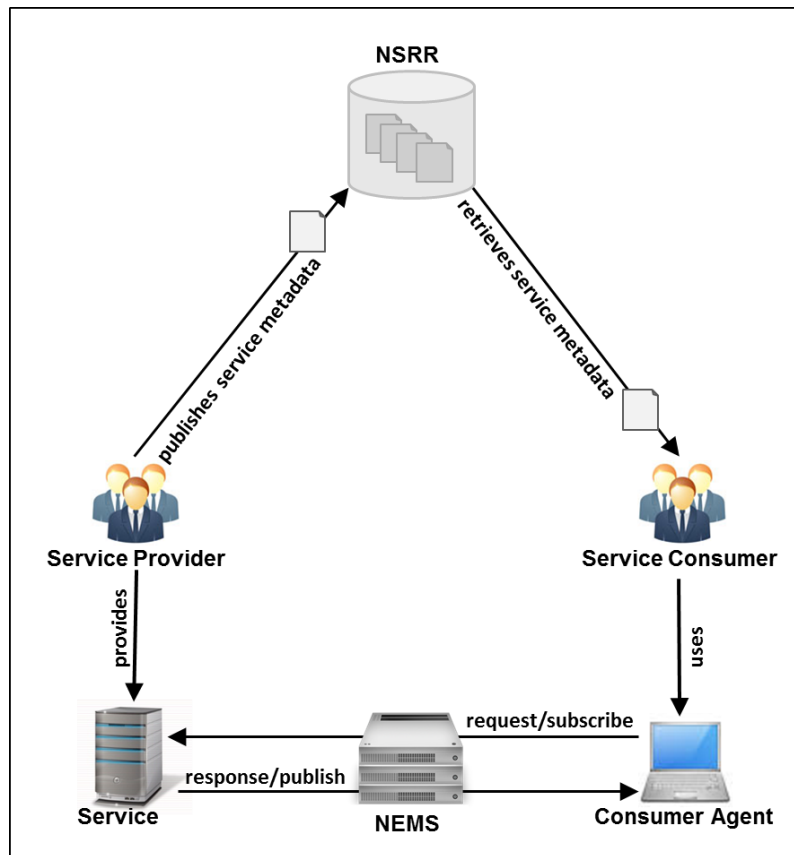


Figure 2 Conceptual view of the NSRR

It should be noted that while the NSRR is consistent with the vision described in Figure 1, it is also different in some ways. The major difference is predicated on the deployment of the NAS Enterprise Messaging Service (NEMS) in the FAA SWIM environment as a realization of the concept of enterprise service bus (ESB). For example, the NSRR – unlike a traditional UDDI registry – is not a repository of addresses; that is, the registry is not used to “look up” the service’s end point address and subsequently bind the consumer agent to the service. Instead, FAA’s SWIM relies on the NEMS to manage the end point addresses and support bindings.

Also because of the broad adoption of Java Messaging Service (JMS) as a paradigm for implementing SOA services in the context of FAA's SWIM, the *publish/subscribe* exchange model has become prevalent for NAS SOA-based services, and the method for describing JMS-based services differs from the method for describing WSDL-based services.

Note: NSRR does not provide visibility into NAS SOA during runtime. It does not monitor the behavior of registered services.

3.2 European SWIM Registry

Purpose

The European registry aims to become the source of reference for SWIM deployment in Europe.

- It gives service providers access to guidelines on how to implement SWIM compliant services in Europe. Part of these guidelines are: (1) a common service model (ISRM), (2) a common information model (AIRM) and (3) a common set of technical infrastructure profiles. These constitute the SWIM Compliance Reference Material.
- It provides service consumers with a consolidated and commonly structured description of SWIM services and their providers in Europe.
- It enables tracing the alignment of service implementations to the compliance guidelines. It supports the compliance assessment process.
- It consolidates news and events related to SWIM deployment in Europe relevant for its stakeholders.

Status

The European Registry is currently implemented as a prototype in the scope of SESAR's research development phase, and it has been identified as a candidate for early deployment as part of SESAR deployment in 2016.

Processes

There are three important processes that ensure a controlled evolution and quality of the registry information and that are relevant to describe in the scope of this paper.

- Organization registration. It enables organizations to be listed in the registry recognizing them as SWIM qualified parties.
- Service registration. It ensures that there is sufficient quantity and quality of information describing a service. The minimum criterion for registration is that registered services must enable the exchange of information in ATM. Alignment to SWIM guidelines is not validated in this process.
- Service compliance process. It provides transparency to the alignment of registered service implementations to SWIM guidelines and rules.

Architecture

The European Registry proposes for simplicity and cost efficiency a central infrastructure to provide a single point of access to SWIM implementation guidelines and rules. However, it envisages that there will be other registries in Europe that manage inventories of service implementations for

particular regions of Europe. A decentralized architecture to manage service information is deemed necessary at both global and European levels.

3.3 SWIM Registry Comparison

These registries are conceptually very similar as they both follow to a certain extent the “canonical” design of a service registry in a SOA-based environment (see Figure 1) and they both share the same information domain, i.e., Air Traffic Management services implemented in the context of the SWIM paradigm. However, they do not communicate with each other and have no established means for communicating. An FAA SWIM user is able to publish service metadata only in the NSRR, and a European SWIM user is able to publish service metadata only in the European SWIM Registry. In order to discover services in both registries, each user must log into one registry at a time. (It is assumed that all users have appropriate credentials for each registry.)

Figure 3 depicts the current situation. The collection of meta-cards with the FAA logo represents services published in the context of FAA SWIM, and meta-cards with the EUROCONTROL logo represent SESAR European SWIM-enabled services. This graphical convention is used throughout this document.

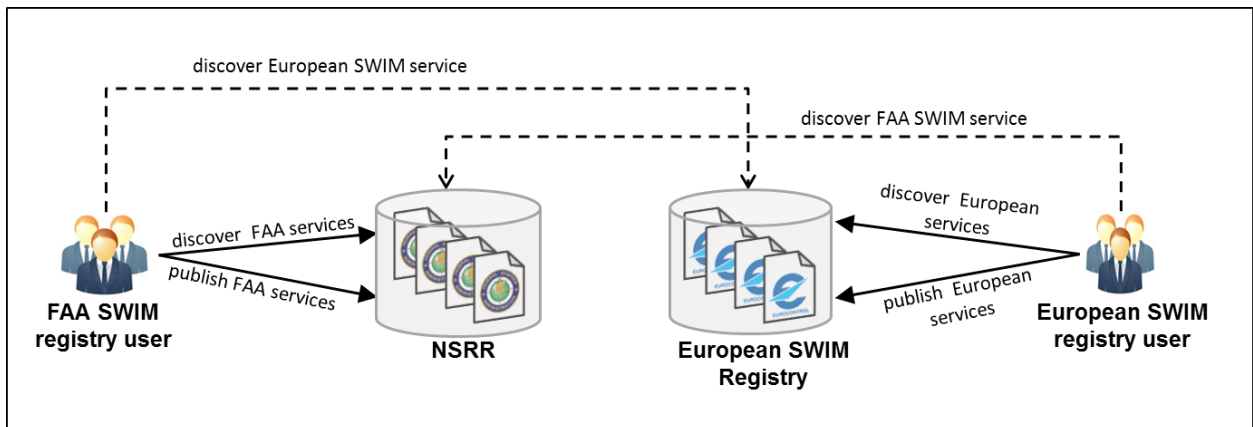


Figure 3 Conceptual view of current SWIM registries architecture

4 Justification for and Nature of Changes

Both the NSRR and European SWIM registries were developed independently and under different sets of organizational and architectural constraints. Although both registries share the same conceptual vision based on a universal understanding of principals of SOA [\[4\]](#) as well as similar mission objectives and scopes, their respective registry content architecture and service metadata structures and semantics still vary. (The latter is being addressed by a collaborative effort to develop a *Service Description Conceptual Model (SDCM)* [\[5\]](#).)

Since each registry has been built without the expectation of communicating with other registries, there is no communication protocol, data format or exchange model which can be used for information exchange. There are also some potential syntactical disconnects between data formats resulting from geographical and historical diversity. (E.g., the format for expressing a date is different in Europe and the United States (day/month/year vs. month/day/year), and while two dates are semantically consistent, divergence in syntax may lead to an error in interaction.)

It is also important to note that each registry is being used as a tool for supporting SOA governance in its respective SWIM program. For example, FAA SWIM NSRR provides an automated policies-based way to manage services throughout their lifecycle. Because registration is always a subject of rules and policies (i.e., governance) established by registry owners and because a shared governance approach to registration has not been established within the framework of the SWIM collaborative effort, rules and policies collisions are expected to happen. (E.g., a rules collision could occur if some metadata element in registry A is required and the same element in registry B is optional, and a user who follows the rules of registry B and does not provide the element in question might not be able to complete registration in registry A.)

To summarize: although both registries contain the information specific to the same domain – service metadata of SWIM-enabled services – it is difficult to correlate and/or integrate this information. The inability of registries to exchange or consolidate information should be attributed to the lack of [interoperability](#). This lack of interoperability can be further subdivided into three types: [technical](#), [semantic](#) and [organizational](#), where:

- The lack of technical interoperability pertains to the absence of common communication protocol and/or data format or exchange model;
- The lack of semantic interoperability pertains to the absence of common vocabulary in defining metadata elements;
- The lack of organizational interoperability pertains to the absence of shared policies and regulations for publishing and managing service metadata.

Addressing these interoperability shortfalls is necessary for creating the ability for the two SWIM registries to function jointly and to provide mutual access to their independently collected service information.

5 Concepts for the Proposed System

The proposed SCR will consist of two *interoperable* SWIM registries: FAA’s NAS Service Registry/Repository (NSRR) and the European SWIM Registry. The SCR will be implemented as a mechanism for communicating service metadata, i.e., exchanging service meta-cards, between two autonomously functioning service registries. Each registry will be able to ingest service metadata information made available by the other registry and present it in a single view to SWIM stakeholders who are logged into either registry.

Figure 4 depicts the proposed architectural solution.

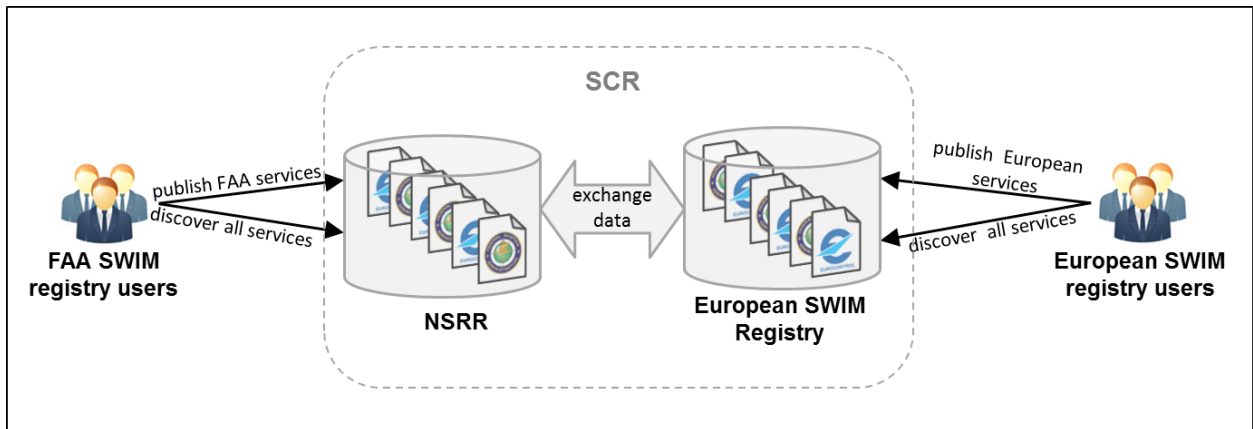


Figure 4 Conceptual view of proposed architecture for the SCR

Implementing the SCR as proposed will involve the following activities:

- The Internet will serve as a networking protocol for registry interactions.
- An interface between registries will be identified and adopted by both registries. The specification for the interface may vary depending on both registries’ capabilities and may change as capabilities evolve. E.g., the registries may initially use SMTP (e-mail protocol), but later implement a RESTful service or a SPARQL endpoint as part of a more “open” and accessible solution. The interface is expected to be identified during the prototyping stage of development.
- An exchange data model will be identified or developed and subsequently adopted by both registries. The SCR will use SDCM [5] as its conceptual data model, but the formal language elected for serializing the conceptual model will be driven by the interface in use (e.g., POX, RDF).
- Semantics for elements to be exchanged will be identified and agreed upon. Both organizations will either adopt an existing vocabulary of service metadata or jointly develop a vocabulary that would support consistent mapping between semantics used in both registries. Semantic agreement may also include a common set of taxonomies to leverage searches across all registered services.

- Both SWIM organizations will develop and agree on a set of rules and policies for registering and presenting service information. For example, both registries will have to agree on a common system of service identification in the context of SCR.
- The organizations responsible for development or modification of SWIM registries will assure that their respective registry's designs are fully compliant with jointly identified requirements for communication protocols, data exchange model, shared semantics, and policies and regulations. The organizations will also coordinate and cross-validate their designs to assure future interoperability.

5.1 Correlation with Interoperability Frameworks

It should be noted that the proposed interoperability solution described in the previous section is compliant with the approach established by European governmental and international aviation organizations.

Figure 5 provides the vision of four layers of interoperability from the European Interoperability Framework (EIF) [\[8\]](#).

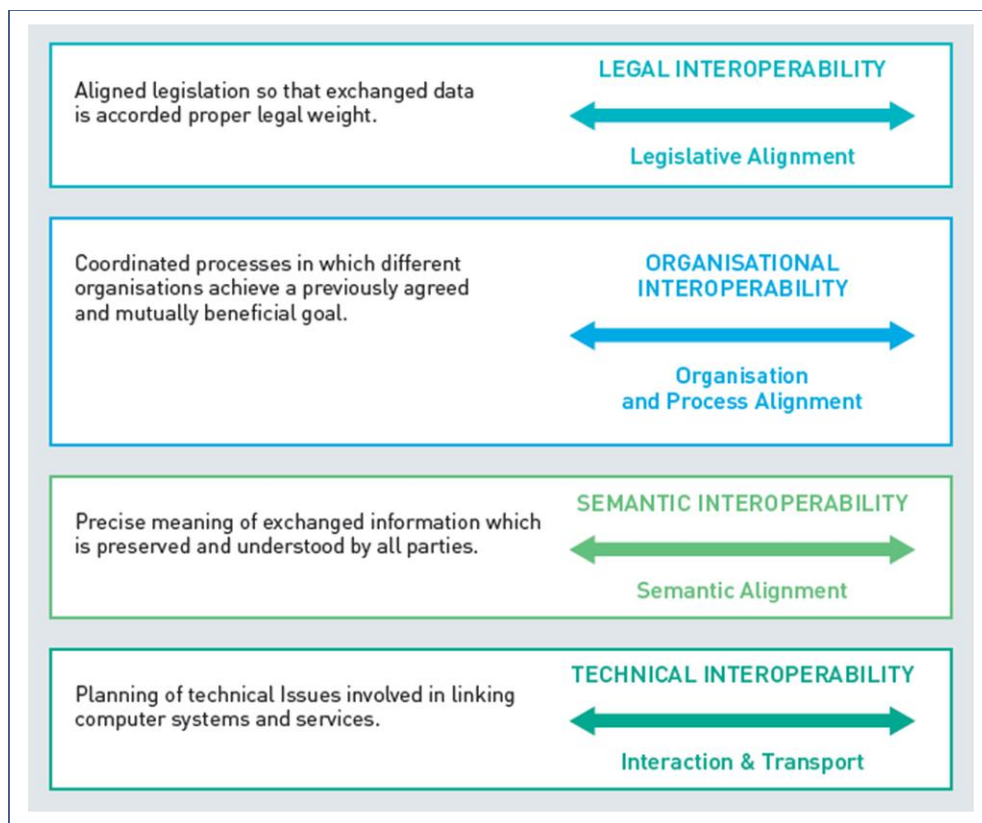


Figure 5 EIF Four layers of interoperability

Table 1 shows how the activities identified for establishing SCR are aligned with interoperability objectives defined in the context of EIF.

Table 1 SCR aligned with EIF interoperability objectives

<i>Type of Interoperability</i>	<i>EIF Definition</i>	<i>Implementation in SCR</i>
LEGAL	Aligned legislation so that exchanged data is accorded proper legal weight.	SCR is expected to comply with legal regulations established between both SWIM organizations, but developing artifacts to support legal regulations exceeds the scope of SCR.
ORGANISATIONAL	Coordinated processes in which different organisations achieve a previously agreed and mutually beneficial goal.	Shared set of rules and policies for registering and presenting service information will be developed and followed by both SWIM organizations in the context of SCR.
SEMANTIC	Precise meaning of exchanged information which is preserved and understood by all parties.	Common sets of vocabularies and taxonomies will be developed and/or adopted by both SWIM organizations.
TECHNICAL	Planning of technical Issues involved in linking computer systems and services.	Public internet with ubiquitous Internet protocols will be used for communication between SCR components. Both SWIM organizations will develop and/or adapt interface specifications and data models for exchange of service metadata.

5.2 Analysis of Alternative Scenarios

In previous discussions about SCR (see [\[2\]](#) and [\[10\]](#)), two architectural scenarios were elaborated: *integration* and *interoperation*. The first suggested that the two registries will be a fully integrated system at the physical, application and business levels, i.e., they will form a single registry shared by both SWIM organizations (see Figure 6); whereas the second suggested that the two registries, connected by a communication network, will exchange information while continuing to implement locally their own work flow and governance logic (Figure 4).

Broadly speaking, *integration* is consistent with the vision of a “tightly coupled” architectural paradigm where components (registries in this case) are interdependent and cannot be disintegrated without loss of functionality; and *interoperation* is associated with a “loosely coupled” architectural paradigm where a component (registry) has no built-in dependencies to any other registry.

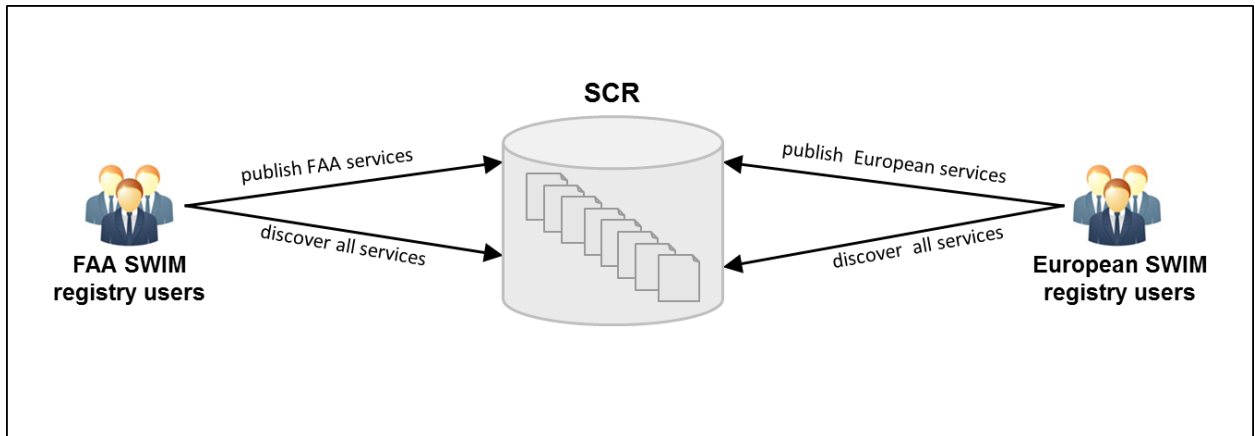


Figure 6 Alternative architecture for the SCR

The advantages and disadvantages of the two scenarios are described in Table 2.

Table 2 Alternative scenario analysis

	Pros	Cons
Integration	The single registry provides a single point of entry and a single interface, and therefore can be managed and maintained more easily at the physical, application, and business levels than two or more federated registries can.	The single registry must have shared ownership and shared funding, which is very hard to establish in the complex organizational and interrelational context of participating SWIM organizations. Adding another organization and/or registry in the future will increase these problems exponentially.

Interoperation	A local registry can continue operation even when disconnected from another registry or when the other registry is not available; i.e., both SWIM organizations can continue to develop and operate their respective registries independently from each other while maintaining mutual interoperation between registries. Funding and administrative issues are addressed independently. Adding another organization and/or registry in the future will not disturb the established architecture.	Both SWIM organizations will have to share communication protocols, an exchange model, and a vocabulary of metadata elements, as well as policies and regulations for service registration and management.
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6 Operational Scenarios

The scenarios that describe how the SCR interacts with users and how components interface in the context of SCR are presented in this document as a set of use cases. There are two major use cases: Service Registration and Service Discovery. Service Registration is further subdivided into two use cases: Direct Registration and Delegated Registration.

Note: all use cases describe processes performed with a single service meta-card; no batch processing is considered to be in the scope of this document.

Table 3 describes roles that participating [entities](#) or components play in the context of the use cases.

Table 3 SCR entities and components

<i>Role</i>	<i>Description</i>
Registry User	An individual or organization that can access and view the content of a service registry. For creating or modifying the content of the registry, special cases of this role are created (e.g., Service Publisher).
Registry Custodian	An individual or organization responsible for establishing and enforcing the policies for one of the SCR's Affiliated SWIM Registries, controlling the integrity of published data, and assuring that the registry's content is discoverable, understandable and accessible by Registry Users.

Service Publisher	An individual or organization responsible for publishing and subsequently maintaining a service's metadata in the SCR. Note: Service Publisher is a special case of Registry User.
Affiliated Registry	A SWIM Registry capable of service metadata exchange in the context of the SCR. For describing, creating or modifying SCR content, the Affiliated Registry is sub-classed into Originating and Replicating Registries.
Originating Registry	An Affiliated Registry in which the service has been initially published.
Replicating Registry	An Affiliated Registry into which service information has been replicated from the Originating Registry.

6.1 Use Case 1: Direct Service Registration

6.1.1 Actors

Originating Registry, Service Publisher

6.1.2 Preconditions

Service Publisher has an appropriate set of access privileges in Originating Registry.

6.1.3 Flow of activities

1. Service Publisher logs into Originating Registry.
2. Service Publisher publishes a service description, that is, initiates a service meta-card, in Originating Registry in accordance with policies and regulation established in Originating Registry by respective Registry Custodian.

6.1.4 Effect

Service is registered in Originating Registry.

6.2 Use Case 2: Delegated Service Registration

6.2.1 Actors

Originating Registry, Service Publisher, Registry Custodian, Replicating Registry

6.2.2 Preconditions

1. The service is registered in Originating Registry (Use Case 1).
2. Registry Custodian has an appropriate set of access privileges in the registry that he or she is affiliated with.

6.2.3 Flow of activities

1. Registry Custodian logs into Originating Registry.

2. Registry Custodian who has replicating and transferring custody over Originating Registry exports newly created service meta-card using exchange format adopted by the SCR.
3. Registry Custodian who has replicating and transferring custody over Originating Registry makes the created meta-card available to Replicating Registry.
4. Registry Custodian who has replicating and transferring custody over Replicating Registry imports the meta-card into Replicating Registry.

6.2.4 Effect

Service description initiated in Originating Registry is made visible in Replicating Registry.

6.3 Use Case 3: Service Discovery

6.3.1 Actors

Registry User, Affiliated Registry

6.3.2 Preconditions

1. Use Case 1 and 2 are successfully completed.
2. Registry User has an appropriate set of access privileges in Affiliated Registry, that is, in any of the SWIM registries.

6.3.3 Flow of activities

1. Registry User logs into any Affiliated Registry.
2. Registry User browses or queries registry to find a service that fits his or her criteria.

6.3.4 Effect

Registry User discovers a service.

6.4 Use Cases for Service Registration Update

Use cases for update of registered services are conceptually identical to service registration use cases (see 6.1. and 6.2) and are not elaborated here. A service is updated at the same registry where the service was originally registered (Originating Registry) and subsequently update information is transmitted to the Replicating Registry.

7 Information Exchange

In order to support the operational scenarios and use cases, information will need to be exchanged between registries. The information exchange should guarantee that services can be discovered independently of the registry instance where they were published. In order to facilitate the discovery of services, registries need to share information concerning the identification, description, and provenance of registered services.

In the scope of the first increment described in this document, the information exchanges will take the following into account:

- Registries have different data models to describe service information.

- There will not be a full replication of information between registries. The information provided by the originating registry will be a subset of the information available in that registry (e.g., documents will not be exchanged).
- Exchanges will be based on the SDCM [5], which might need to be adapted if required to support the exchanges.
- A common data set needs to be collaboratively managed to ensure consistent description (e.g., Taxonomies, Global Service Identifiers).

7.1 FAA SWIM Registry

The NSRR currently is undergoing a major upgrade with one goal being to become SDCM compatible. The data model deployed for the future version of NSRR will include all elements defined in SDCM and will also be extended to include the elements specific to FAA SWIM service governance processes and established FAA service documenting practices.

7.2 European SWIM Registry

The European SWIM Registry has a data model that is compatible with the SDCM in what concerns basic service attributes. The picture below provides an overview of the minimum information set expected by the European SWIM Registry for the description of a service, and its correspondent elements in the SDCM.

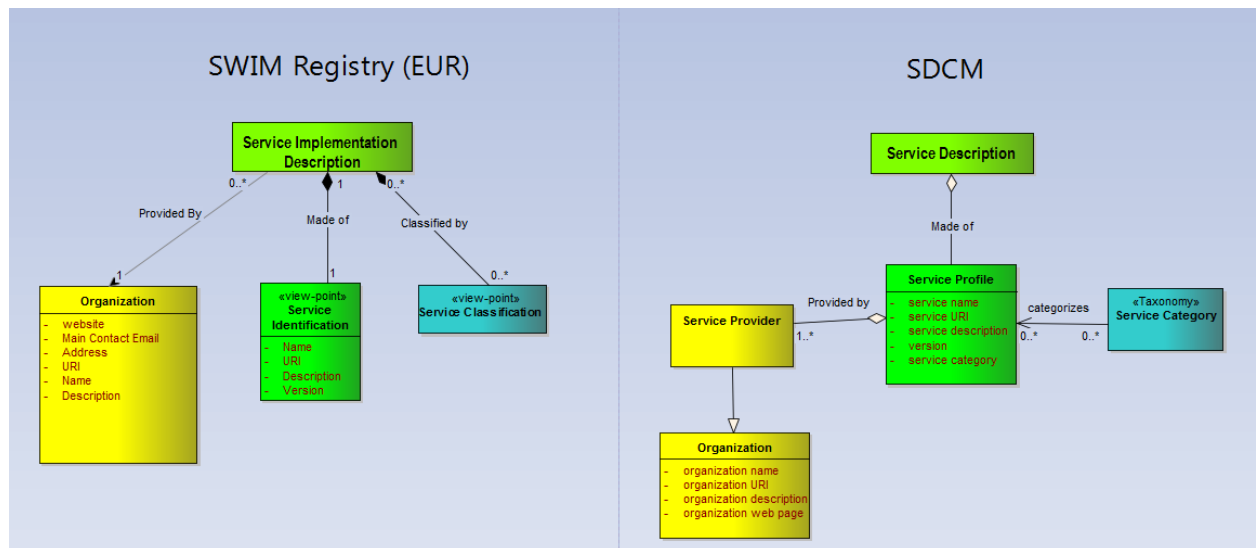


Figure 7 European SWIM Registry minimum information set

The European SWIM Registry requires a service description:

- To have one and only one provider organization;
- To track no information on the consumers of a service;
- To have a unique identifier;
- To be classifiable by one or more specific sets of values (taxonomies).

7.3 SCR Information Management Considerations

In order to enable an efficient exchange of service discovery information between registries, it is necessary to ensure that there is (1) no tight coupling between registries and (2) the creation of duplicated information is avoided.

Two types of data are essential for ensuring a consistent approach to distributed service information:

- Service Taxonomies. Cross-registry discoverability is dependent on the consistent classification of all services according to a common set of taxonomies.
- Global Service ID. With service descriptions created and modified in multiple registries, a common system of service identification is absolutely critical.

In the absence of a common centralized repository of data, and to ensure registries can evolve independently of each other, the use of mappings that uniquely identify taxonomy values and services with their correspondent values is recommended in both registries.

8 Summary of Impacts

Enabling the SCR will have the following impacts:

- It will improve exchange of ATM information between two SWIM communities, by making services -- regardless of original organizational affiliation -- readily discoverable, easily identifiable, and consistently understandable.
- It will leverage development of commonly shared artifacts and elements such as vocabularies, specifications and practices within interoperability frameworks legislated by both European and USA governmental and international aviation organizations [\[6\]](#) [\[7\]](#).
- It will promote a technological means for presenting all aspects of a service's metadata in a manner suitable for both human-readable and machine-processable representations.
- It will serve as a foundation for further advancement of a shared vision of service metadata in domain-specific areas.

Glossary

<i>consumer agent</i>	A software agent that is designed to interact with a service in order to request that a task be performed on behalf of its owner, the service consumer. [3]
<i>entity</i>	Any concrete or abstract thing that exists, did exist, or might exist, including associations among these things. [13] .
<i>interoperability</i>	The ability of two or more systems or components to exchange information and to use the information that has been exchanged. [9]
<i>organizational interoperability</i>	The aspect of interoperability that is concerned with defining business goals, modelling business processes and bringing about the collaboration of administrations that wish to exchange information, but that may have a different internal organization and structure for their operations. [6]
<i>registration</i>	The establishment of a relationship between the registered item and the registration authority, which is the organization responsible for the data stored in the registry. [12] . Registration accomplishes three main goals: identification, provenance, and monitoring quality. [11]
<i>semantic interoperability</i>	The aspect of interoperability that is concerned with ensuring that the precise meaning of exchanged information is understandable by any other application not initially developed for this purpose. Semantic interoperability enables systems to combine received information with other information resources and to process it in a meaningful manner. [6]
<i>service consumer</i>	An organization that seeks to satisfy a particular need through the use of capabilities offered by means of a service. [4]
<i>service description</i>	The information needed in order to use, or consider using, a service. [4]
<i>service meta-card</i>	A set of metadata attributes and artifacts associated with a single service.
<i>service provider</i>	An organization that offers the use of capabilities by means of a service. [4]
<i>service registry</i>	An enabling infrastructure that uses a formal registration process to store, catalogue, and manage metadata relevant to a service. A registry supports the search, identification, and understanding of resources, as well as query capabilities. [3]

***technical
interoperability***

The aspect of interoperability that covers the technical issues of linking up computer systems and services. This includes key aspects such as open interfaces, interconnection services, data integration and middleware, data presentation and exchange, accessibility and security services. [\[6\]](#)

Acronyms

ATM	Air Traffic Management
ConOps	Concept of Operations
EIF	European Interoperability Framework
ESB	Enterprise Service Bus
FAA	Federal Aviation Administration
IEEE	Institute of Electrical and Electronics Engineers
JMS	Java Messaging Service
NAS	National Airspace System
NEMS	NAS Enterprise Messaging Service
NSRR	NAS Service Registry/Repository
POX	Plain Old XML
RDF	Resource Description Framework
REST	Representational State Transfer
SCR	SWIM Common Registry
SDCM	Service Description Conceptual Model
SESAR	Single European Sky ATM Research Programme
SOA	Service-Oriented Architecture
SPARQL	Simple Protocol and RDF Query Language
SWIM	System Wide Information Management
UDDI	Universal Description, Discovery and Integration