GOF2.0 - Critical design document (CDD) and architecture blueprint

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GOF2.0

GOF2.0

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Abstract

This deliverable describes the GOF2.0 design and architecture. It serves as the architectural interoperability definition for the actual demonstrations.

A summary of the architecture based on the project's application document is provided.

Background is introduced to provide context.

A blueprint architecture for all trials is defined and explained. Information exchange services based on SWIM Standards within the defined Architecture are identified.

The actual realisation of the blueprint for a specific for an example trial is laid out.

Finally, the GOF2.0 architecture is put in context with ongoing regulatory work.

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1 Executive Summary

"The GOF2.0 Integrated Urban Airspace VLD (GOF2.0) very large demonstration project will safely, securely, and sustainably demonstrate operational validity of serving combined UAS, eVTOL and manned operations in a unified, dense urban airspace using current ATM and U-space services and systems.

Both ATM and U-space communities depend extensively on the provision of timely, relevant, accurate and quality-assured digital information to collaborate and make informed decisions." [30]

Therefore, the GOF2.0 architecture aims to provide a framework for actors in and connected to the ATM and UTM domain, adhering to SWIM and common principles for U-space architectures, described in the SESAR U-space reference architecture, ICAO 10039 and ongoing regulatory work [2].

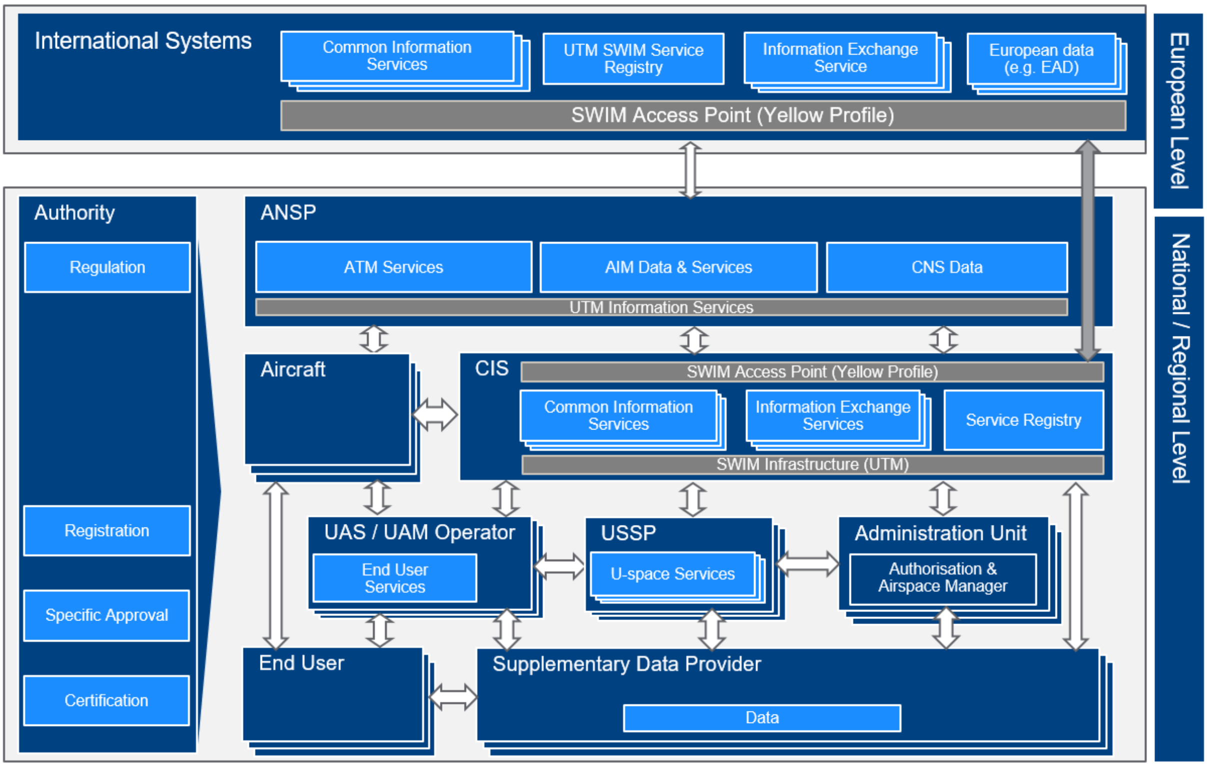

Figure 1 - High level Architecture based on grant agreement

Information exchange services are introduced to facilitate standardized data exchange. They are described using formal templates, separating logical, technical and runtime concerns into different standard documents. They enable a modular, interoperable, open system and highly resilient system of systems, allowing for technical variants in implementation.

The architecture ensures a flexible, yet strong technical frame to evolve U-space. It supports integrating existing work where reuse is applicable, providing guidance for new services where necessary. The GOF2 Architecture facilitates both central and federated concepts and can be considered to be a hybrid architecture.

2 Introduction

2.1 Purpose of the document

This deliverable describes a GOF2.0 USPACE architecture blueprint for any GOF2.0 trial. The trials, based on real world scenarios, demonstrate flights in U-space deployments focussed on urban airspace.

Its aim is to set a frame that facilitates system interoperability in line with ongoing work in research and regulation.

Ongoing regulation, e.g. the U-space regulation, already provides architectural boundaries. Within these boundaries, the GOF2 architecture supports adding new services and stakeholders to the ecosystem. It is not intended to provide a new architecture introducing new and eventually incompatible concepts.

The approach described in the application was critically reviewed, existing work was analysed and progress between project application and execution considered.

The result is therefore mainly based on existing work with regards to high level design, still considering extensibility to seamlessly integrate new services still in research.

Principles and guidance to explain the context within the architecture was created.

The underlying principles of Service Oriented Architecture and SWIM are summarized

Subsequent sections of the document describe the architecture blueprint:

- Interoperability based on SWIM Principles
- Centred around information exchange services
- Deployable with reasonable effort

A Common Information Service (CIS) will facilitate data exchange and provide the technical frame to integrate existing commercial off-the-shelf (COTS) UTM and ATM in an interoperable way. Furthermore, integration of Ground Control Stations and point to point communication between UTM services is supported. Supplemental Service Providers and Administrative Units are considered as important stakeholders in an urban airspace.

To realize the blueprint for a deployment, building upon a service registry concept, an approach based for an example trial is provided.

Finally, this deliverable intends to show the alignment of the chosen architecture with ongoing regulatory work.

2.2 Scope

This document contributes as initial starting point to all objectives of the GOF2.0 project, especially those listed below. In **bold** the main focus of contribution for this deliverable is highlighted.

- Objective O2: Integrated, lean, modular, resilient and interoperable system architecture supporting safe integration of all UAM vehicles on national and European level
    - Demonstrate **the exchange** of trajectory, weather, connectivity and aeronautical **information through information management, supported by SWIM interoperable services**, to enhance collaborative decision-making at network and global levels, and specifically to allow safe and affordable integration of UAM into a shared airspace at high vehicle densities and in mixed traffic scenarios. Demonstrate **interoperability through standardised interfaces for U-space, CIS and ATM information exchanges, to allow seamless U-space/ATM operations for all operational stakeholders.**
    - Project Results: **Documented service architecture, proposals for standardised interface service descriptions**, performance data from validation trials, tracking performance, probability and reliability of identification and authentication, availability of connectivity, availability of communication means for safety notifications and ATC instruction
- Objective O4: Air-ground and ground-air connectivity and sharing of information digitally
    - **Showcase technical means to enable the exchange of digital information** in support of collaborative management of UAM operations and remote provision of U-space/ATM services:
        - Ground-Air Data link using mobile networks
        - Air-ground Data link using mobile networks
        - **Information Exchanges using the SWIM Yellow Profile**
    - Project Results: Automated **data exchange between the supplementary connectivity data providers and the various stakeholders in the system architecture** for pre-flight and flight operations and services plus validation / audit via measurements
- Objective O7: Virtualisation - allowing more dynamic resource allocation
    - Demonstrate modern-day cloud deployment, **general-purpose communication, and computer processing capabilities** to allow for better performing and more cost-efficient U-space/ATM service provision. A Centralized cloud deployment serving ANSPs, USSPs and finally all airspace users lead to facilitate data sharing, new synergies, and more cost-efficient management of the U-space/ATM resource network. It facilitates effective interoperability between functional systems.
    - Project Results:
        - U-space service catalogue,
        - Operational and technical performance assessment (Response times for automated and manual flight authorisations.)

- Data models,
- ICDs
- Airspace assessment

- Objective O9: Definition of novel U-space service essential to enable UAM
  - Introduce novel **U-space services including concept, definition and validation** to serve a safe, orderly and efficient integration of UAM. Within the scope of GOF2.0 the following - but not limited to - services will be defined:
    - mobility data: population densities to calculate ground risks
    - connectivity data to ensure reliable communication links between airborne and ground segments
    - hyperlocal weather information
  - Project Results:
    - U-space services catalogue,
    - Data models,
    - ICDs

2.3 Intended readership

This documented is intended to be read by all members of the GOF2.0 USPACE project, specifically, technical Point of Contacts of members involved.

In general, the following entities are intended as readership:

- Air Navigation Service Providers (ANSPs)
- Civil Aviation Authorities (CAAs)
- Administrative Units
- Supplemental Data or Data Service Providers
- Drone Manufacturer
- Drone Operators
- General Aviation Operators
- Authorities
- U-Space / UTM Service Provides
- U-Space / UTM Infrastructure Providers

2.4 Structure of the document

This document is structured as follows.

The first chapter outlines the executive summary.

The second chapter introduces the document by giving an overview of the document, defining the scope and intended readership as well as describing the background and listing used terms and acronyms.

The third chapter outlines the underlying principles applied in the GOF 2.0 architecture blueprint. Particularly, the concept of System Wide Information Management (SWIM) as defined by ICAO (and implemented throughout Europe managed by the SESAR Deployment Manager) as well as the general concept of Service Oriented Architectures are explained in more detail as foundation for the subsequent chapters.

The fourth chapter explains how the blueprint can be realized for an example trial, utilizing interoperability achieved by information services, locating services using a service registry.

The fifth chapter puts the GOF 2.0 architecture blueprint in context to ongoing regulatory work.

2.5 Background

When producing this document several research and standardization activities, as well as projects, initiatives and existing solutions have been considered.

SESAR U-Space

Available input from other U-space projects and CORUS was ingested. Existing concepts of operations in the UTM domain were studied, namely draft CORUS results, the Swiss U-Space ConOps Document as well as the FAA ConOps. [3] As baseline GOF USPACE project provided major lessons learned and proved concepts used again in this project.

EASA

This project was applied for, granted, and executed while the initial U-space regulation was drafted and finalized. At the time of producing this deliverable, a final version of regulation and its annexes have been available. Guidance Material and Acceptable Means of compliance have been drafted, but have not been available in time to be considered in this deliverable.

SWIM

A key concept within GOF2.0 is utilizing SWIM concepts. This document is based on experience from SESAR project participation, especially the SWIM Global Demonstration and SESAR SWIM Masterclass projects. Guidance provided by the Eurocontrol SWIM Specifications and the ICAO Manual on SWIM Concept was used as base for the architecture. [3]

Standards

Several existing standards have been looked at to pre-validate the architectural concept. ATM Standards (AIXM, FIXM, ASTERIX, ..), UTM standards and standardisation initiatives as well as open source projects (EUROCAE, ISO, GUTMA, opendroneid, ASTM, …) were considered.

H2020

Major contributions to this document originate from Horizon 2020, SESAR and CEF projects. The proposed service and templates were adopted from work performed in EfficienSea2 (H2020) and STM – Sea Traffic Management (CEF).

2.6 Glossary of terms

Term	Definition	Source of the definition

Table 1: Glossary of terms

2.7 List of Acronyms

Acronym	Definition
AIXM	Aeronautical Information Exchange Model
ANSP	Air Navigation Service Provider
ASTM	American Society for Testing and Materials
ASTERIX	All Purpose STructured EUROCONTROL SuRveillance Information Exchange
ATC	Air Traffic Controller
ATM	Air Traffic Management
BVLOS	Beyond Visual Line Of Sight
CDM	Collaborative Decision Making
CEF	Connecting Europe Facility
COTS	Commercial off-the-shelf
CONOPS	Concept of Operations
CR	Change Request
EASA	European Union Aviation Safety Agency
EATMA	European ATM Architecture
E-ATMS	European Air Traffic Management System
HPAR	Human Performance Assessment Report
GUTMA	Global UTM Association
FAA	Federal Aviation Administration
FIXM	Flight Information Exchange Model

IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
ICAO	International Civil Aviation Organisation
SAC	Safety Criteria
SAR	Safety Assessment Report
SecAR	Security Assessment Report
SESAR	Single European Sky ATM Research Programme
SOA	Service-oriented architecture
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SWIM	System Wide Information Management
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
UTM	Unmanned Traffic Management

Table 2: List of acronyms

3 Design Principles / SWIM

GOF 2.0 is following U-space architecture principles as described by SESAR. Based on all those principles, one major design approach considered is decoupling conceptual and technical matters, providing guidance while allowing for flexibility in implementation and future extensibility.

It is based on SWIM principles laid out in ICAO's Doc 10039, Manual on System Wide Information Management (SWIM). Paragraph 2.3.5 summarizes:

> *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.*

Summarizing SWIM principles, information services should be described, by defining

- Harmonized conceptual and logical data models including definition of logical format, structure and data elements
- Service lifecycle, behaviour & performance levels
- Means to look up and access services

This enables information to reach and keep a state where it is "known and managed". The described conceptual/logical information services can be realized in different technical implementations, "thus enabling an architectural approach based on one logic and multiple potential solutions". It allows to keep concepts stable while technology changes and evolves.

On a conceptual level, following the SWIM principles laid out before, information should be described technology agnostic, e.g. in UML or by comparable means. The aim is to document the key aspects of a dedicated service at the logical level.

An example of this approach can be studied in EUROCAE ED-269, where a conceptual definition and its implementation in a standard data encoding are defined in one document.

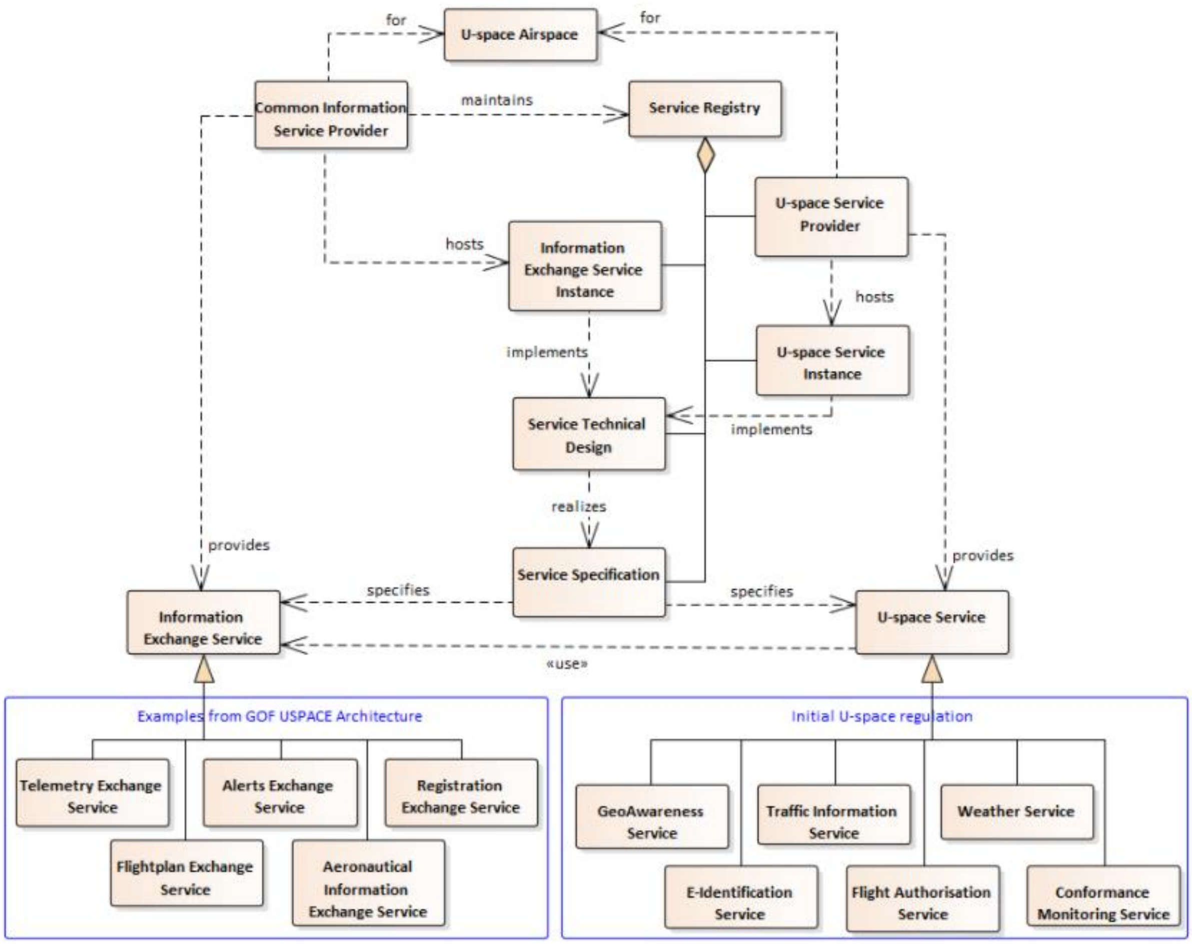

Figure 2: Service Provision landscape in context of a U-space airspace

The figure above tries to sketch an overview of a service provision landscape in the context of a U-space Airspace.

A Common Information Service Provider for a U-space Airspace shall

- Maintain a Service Registry, allowing all stakeholders to look up service related information, as described below.
- Provide Information Exchange Services for the U-space Airspace, by maintaining Information Exchange Service Instances.

The Service Registry (maintained by a Common Information Service Provider) shall offer the following service-related information:

- A list of U-space Service Providers that are offering U-space Services for the U-space Airspace.
- Access information to U-space Service Instances provided for the U-space Airspace.
- Access information to Information Exchange Service Instances provided for the U-space Airspace.

- Technical information about U-space Services and Information Exchange Services provided for the U-space Airspace.
- High level service specifications for U-space Services and Information Exchange Services provided for the U-space Airspace.

A U-space Service Provider provides one or several U-space Service(s) for the U-space Airspace via dedicated U-space Service Instances.

For the definition of U-space Service, please refer to the initial U-space regulation. The following U-space Services are listed in the initial U-space regulation:

- Network Identification service
- Geo-awareness service
- UAS flight authorisation service
- Traffic information service
- Weather information service
- Conformance monitoring service

A U-space Service Instance is the technical means (hosted by a U-space Service Provider) to provide a U-space Service. Such a service instance is characterized by the technical and administrative access details (e.g., URL, authentication mechanism, …). A service instance represents the implementation of a Service Technical Design.

Information Exchange Services facilitate data exchange for information provided and consumed by U-space services. Information Exchange services aim, for example, at publishing the „single truth“ of certain U-space related information to interested parties. The following example Information Exchange Services have been identified in the SESAR GOF 2.0 project:

- Traffic exchange service
- Flightplan exchange service
- Aeronautical information exchange service
- Alerts exchange service
- Registration exchange service
- Ground control station integration service

An Information Exchange Service Instance is the technical means (hosted by a Common Information Service Provider) to provide an Information Exchange Service. Such a service instance is characterized by the technical and administrative access details (e.g., URL, authentication mechanism, …). A service instance represents the implementation of a Service Technical Design.

In general, services (be it U-space services or Information Exchange services) are described using a layered approach to decouple logical, technical and runtime aspects. Runtime aspects are described in form of Service Instances, as mentioned above.

Technical aspects are described in form of Service Technical Design documents. The Service Technical Design describes, for example, the access protocols or the detailed data encoding rules and exchange formats (XML, JSON, …) used for a certain service implementation as implemented by a specific service instance.

The high-level logical aspects of a service are described in form of Service Specification documents. At this level, Information Exchange services as well as U-space services shall be specified and described in a technology-agnostic way, providing the following kind of information for each service:

- Requirements
- Service interfaces
- Service operations
- Service data model
- Dynamic behaviour

4 Architecture Blueprint

GOF2 integrates systems of project partners utilizing Information Exchange service based on SWIM principles in a service oriented architecture.

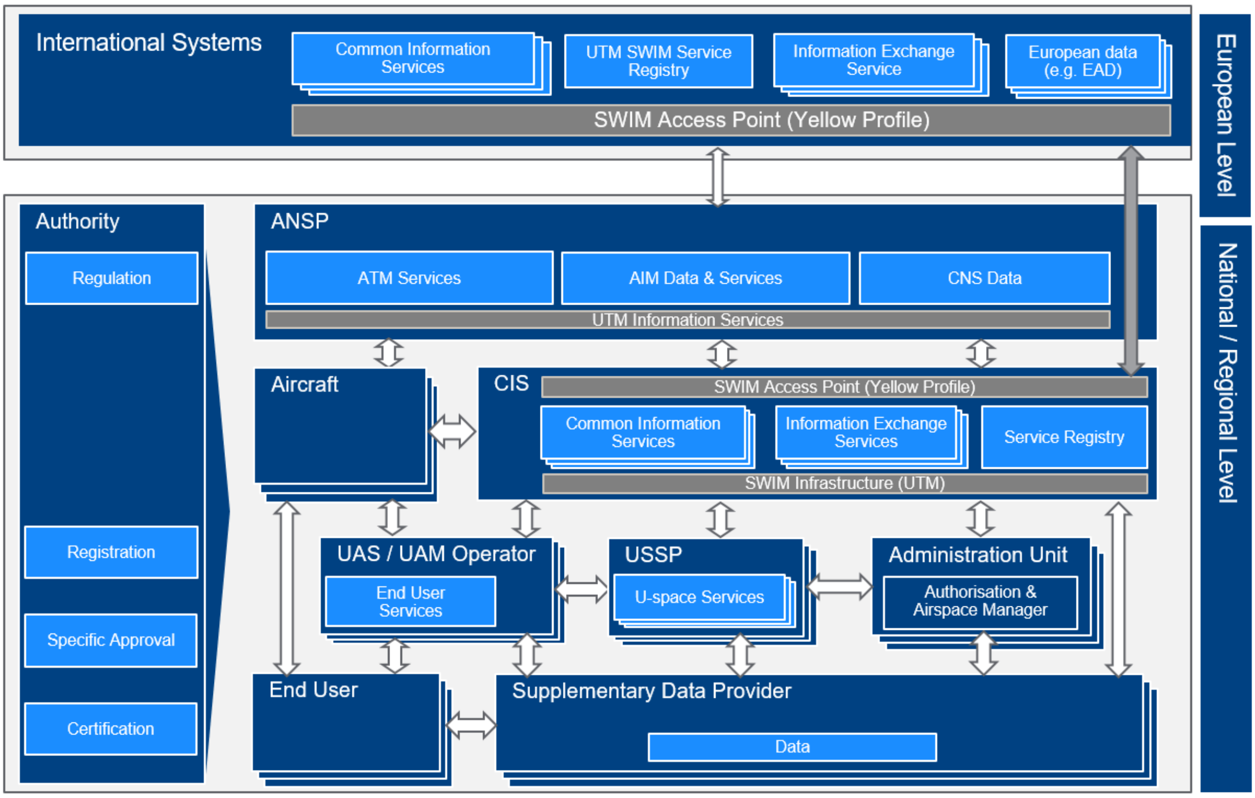

Figure 3 GOF2 High Level Architecture

Partners act in roles (or provide applications and services for roles simulated in trials):

- UAS Operator
- USSP
- Supplemental Data Provider
- CISP
- ANSP
- Authority
- International System
- Administrative Unit

Any information exchange between partners is based on service specifications on conceptual level, based on SWIM principles. Services provided by partners offer interfaces, which are mapped (traced) to the service specifications. Information exchange is decoupled from business services. Where necessary, conversion services are developed to achieve technical interoperability.

A multi-step approach is used

1. Operational needs and KPIs based on trials and project objectives are defined
2. Services required to meet the needs and KPIs are identified
3. On conceptual level, any information exchange between those services is documented and specified
4. On technical level, APIs and services are mapped to the conceptual level
5. Conversion services are developed where necessary.

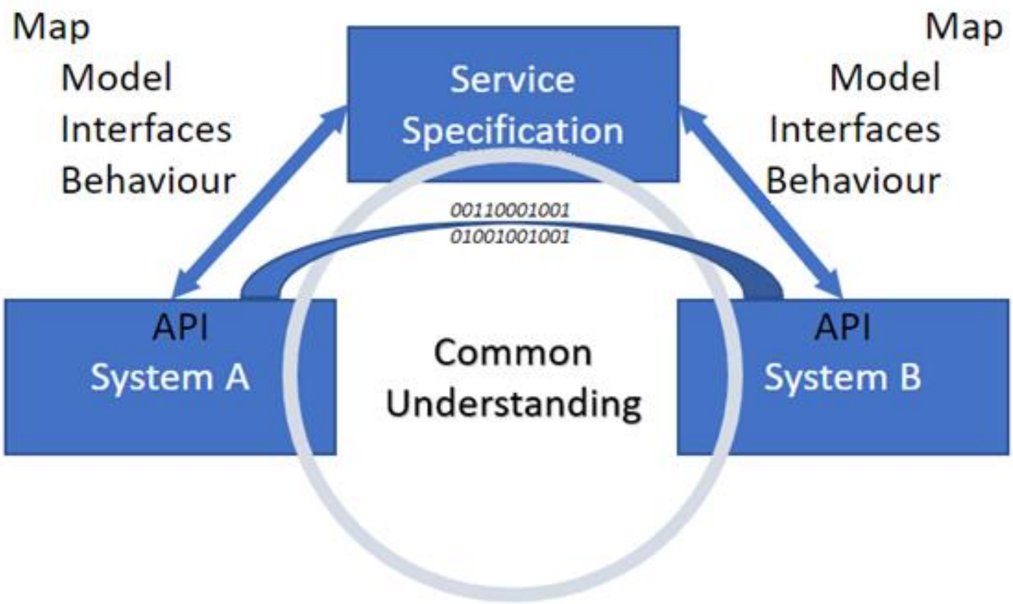

Figure 4 Multi step approach to achieve technical interoperability

As an example, the need to exchange aircraft position data between ANSP and UAS operator is identified. All relevant stakeholders in the digital data chain discuss and agree on how this position data is described, and which service operations are necessary to cooperate.

UAS operator and ASNP use different data formats, the UAS operator utilizes ReST services providing data in JSON Format, whereas the ANSP provides surveillance data in ASTERIX. Involving all roles that connect UAS operator and ANSP (e.g. USSP and CIS), all attributes required are identified and described in a technology agnostic way, including requirements (e.g., for data quality and latency).

Together they create a service specification, documenting that a position has to have an Identifier, Latitude, Longitude, Altitude and information on data precision.

Once this specification is agreed, both partners map their technical interface. Relevant elements of the JSON structure are traced to attributes in the service specification by the UAS operator. The ANSP traces the applicable elements of an ASTERIX record to the service specification. Both ASTERIX and JSON structure could hold additional information not listed in the service specification.

Finally, a conversion service has to be deployed, it is agreed that this service is provided by a CIS, allowing all stakeholders to use it.

To allow a flexible setup for deployments, a service registry is foreseen both on international and trial level. Service providers register their provided services in the service registry, providing

- Service endpoints (e.g. IP Address or Domain Name)
- The geographical area in which this specific service is provided (e.g. Tallin CTR)
- Technical Documentation (API Specification, Webservice Descriptor...)
- The service specifications implemented (e.g. Traffic/Telemetry, Operation Plan…)
- Means to identify the service provider

In a deployment, the service registry is used by stakeholders to locate

- CIS
- USSP
- Supplemental Services
- .. other relevant stakeholders

4.1 Service Documentation Overview

For the purpose of service regulation, it makes sense to define a documentation framework for services. The proposed three-layer approach for such a framework offers the required flexibility:

- It allows to specify important corner stones of a service on a high level, without restricting the possible technical realisations too much.
- It still allows different service providers to implement and provide their services in different technical realisations, as appropriate.
- It helps ensuring that running service instances are conformant to the specifications mandated by regulations.

The figure below illustrates three-layer approach, involving Service Specification, Service Technical Design and Service Instance.

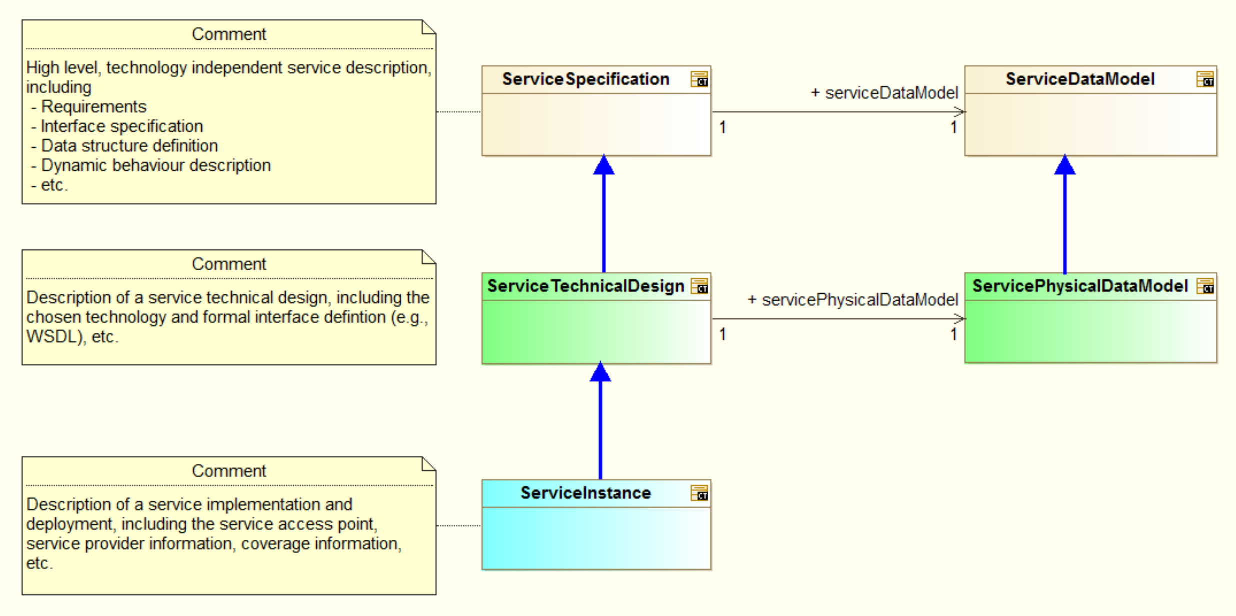

Figure 5: Three layer approach on service documentation

A service documentation framework for Information Exchange Services could look like the following figure.

Information Exchange Services are described on a high level in a technology agnostic way. This is done in a Service Specification Document, using a standardized document template (Service Specification Template). Service Specifications facilitate a common view on service context, interfaces, data model used and behaviour.

Actual implementations of those services will have to refer to the logical descriptions. The technical aspects are described in a Service Technical Design Description, again using a standardized document template. At a minimum, the logical contract defined in the Service Specification must be fulfilled. If more functionality (than a Service Specification requires) is implemented in an open and competitive market environment, it is not mandatory to document it.

Instances of services (compliant with a Service Technical Design) provided by actors are described in a Service Instance Descriptions, again using a standardized document template.

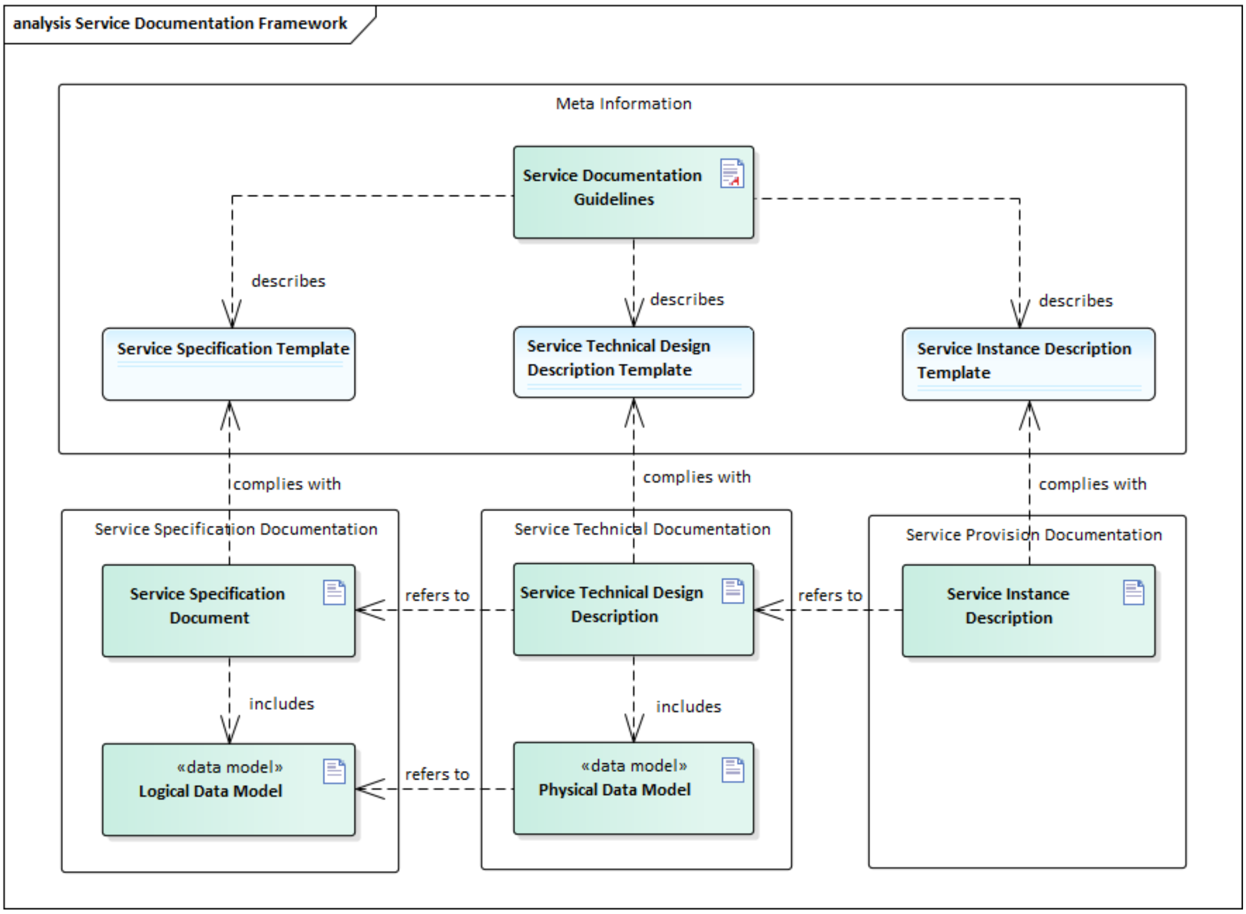

Figure 6: Service Documentation Framework

In the scope of EASA regulations, a Service Specification Template and corresponding Service Documentation Guidelines could be formally described in the regulation annex [2], or applicable guidance material and acceptable means of compliance.

4.2 Service Specification Template

Proposed Table of contents for a Service Specification Template:

- Service Identification
  - The purpose of this chapter is to provide a unique identification of the service and describe where the service is in terms of the engineering lifecycle.
  - It should contain
    - Service Name
    - Unique Identifier
    - Version
    - Short Description

    - Keywords
    - Points of contacts (authors, architects, and their organisations)
    - Lifecycle status (e.g.: Provisional, Released, Deprecated)
- Operational Context
- Service Overview
  - This chapter aims at providing an overview of the main elements of the service.
  - Architectural elements applicable for this description are:
    - Service:
      the element representing the service in its entirety.
    - Service Interfaces:
      the mechanisms by which a service communicates. Defined by allocating service operations to either the provider or the consumer of the service.
    - Service Operations:
      describe the logical operations used to access the service.
- Service Data Model
  - Describes the information model, i.e., the logical data structures to be exchanged between providers and consumers of the service
  - It is recommended to visualise the data structures by using UML diagrams.
  - The full information model (logical data structure) should be shown using diagram(s) and explanatory tables.
  - It is mandatory to give a description of each entity item (class), its attributes and the associations between entity items after each diagram showing data items.
- Interface Specification
  - Describes the details of each service interface.
    - purpose, message exchange pattern and architecture of the Interface.
    - A service interface supports one or several service operations.
    - Each operation shall be described by providing information about
      - Functionality
      - Parameters: referring to the Service data model defined above
  - The Service Interface specification covers only the static design description while the dynamic design (behaviour) is described in the next section.
- Dynamic Behaviour
  - Describes the interactive behaviour between service interfaces (interaction specification) and, if required, between different services (orchestration).
  - Following types of views and UML diagrams should be used to describe the dynamic behaviour
    - Sequence Diagrams
    - Interaction Diagrams
    - State Machine Diagrams

4.3 Service Instances and their relation to service documentation

Figure 7 shows how service instances relate to the three layers of service documentation and how they are used to implement, provide, register and lookup services.

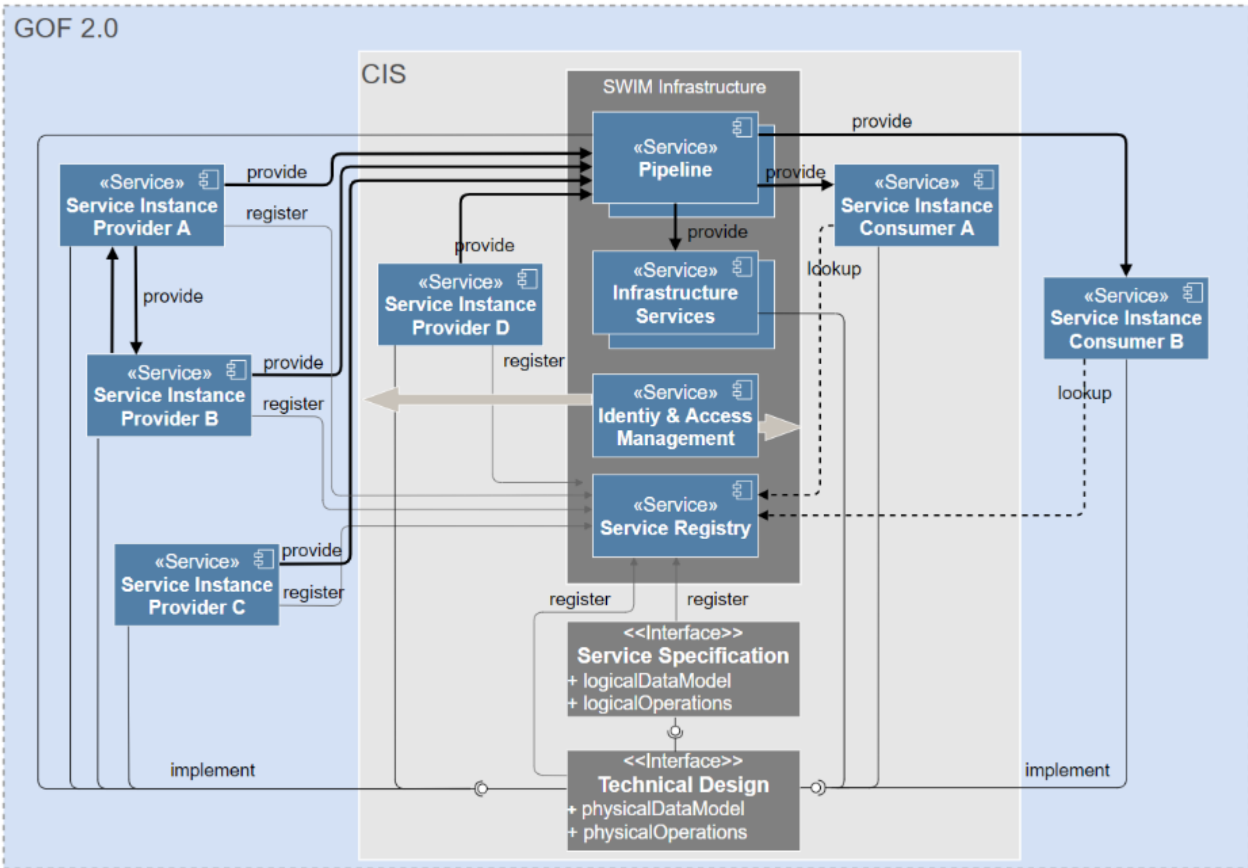

Figure 7: Service instances and their relation to service documentation

An example flow could be:

1. Service Provider C decides to provide an already specified U-space service in a new airspace
    a. An existing Technical Design is retrieved and implemented
2. Service Provider C enters operations and provides a service instance
    a. The instance is registered in the Service Registry

Now, it can be located by Service Consumer B, using the lookup functionality of the service registry.

B already has implemented the consumer interface described in the Technical Design from a previous operation (e.g. in a different U-space airspace), B can immediately use the service provided by B

4.4 Enabling reuse of conceptual work in new technology

Decoupling conceptual specification from technical design work has not only advantages in system integration, it facilitates evolvement of the respective layer at its own speed within its own governance body.

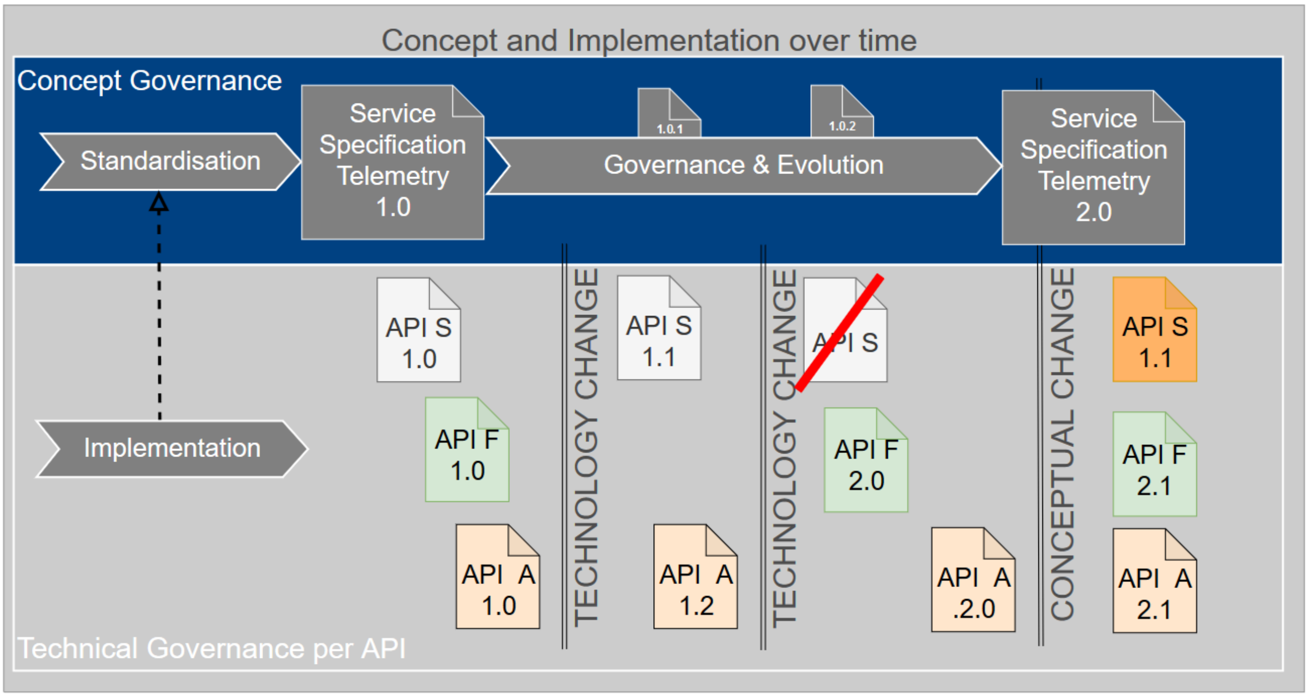

Figure 8: Concept & Technology over time

Typically, technology evolves in faster iterations than concepts. E.g. the concept of a flight. Flight phases and declaring indent could be considered to be similar for all aircraft – manned or unmanned. Naming might be different, level of detail could vary – in essence the general concept remains quite stable, the steps an aircraft performs or states it is in while operating.

Over time this concept was realized in different technologies. Early implementations relied on local interaction and coordination with local communities to prepare for single flights. With growth in traffic & distance, pen, paper and early telecommunications where involved, first formal processes designed and required. Scaling up and introducing IT systems, analogue concepts where mirrored in first digital systems supporting flight processing.

This does not mean that concepts are set in stone, pushed by progress in technology they as well will evolve. New enablers will allow to push for new concepts – introducing conceptual changes.

Therefore, the system constantly changes. It is upgraded, by adding new services and stakeholders. Or, more frequently, it is updated, maintaining services and stakeholders. In both cases interoperability should be sustained.

This challenge requires to keep a strong coordination between respective governance bodies and, maintaining formal traces/mappings between technology and concept.

5 Instance of blueprint for example trial

GOF2 trials will take place in Austria, Estonia, Finland, and Poland as well as other locations hosting trial 4.

All trials will have a similar setup with regards to partner roles as described in the project applications, services and capabilities demonstrated will differ depending on scope. The actual deployment configuration will be covered in project internal deployment diagrams.

Realizing the architecture blueprint follows a sequence of steps, indicated in Figure 9. Steps include

1. Prepare a high level trial plan, defining
    a. Scenarios
    b. Services
    c. KPIs
2. Identify relevant system components and perform a feasibility check
3. Agree on deployment
4. Prepare the system
    a. Start to integrate
    b. Register services in the service registry
        i. Registration includes the geographical area covered
        ii. Already in integration, utilize the service registry to lookup and utilize services
    c. Provide services (and provide KPI data)
    d. Perform integration tests
5. Check readiness, based on
    a. System availability note
    b. Confirmed KPI collection
6. Execute the trials
7. Report

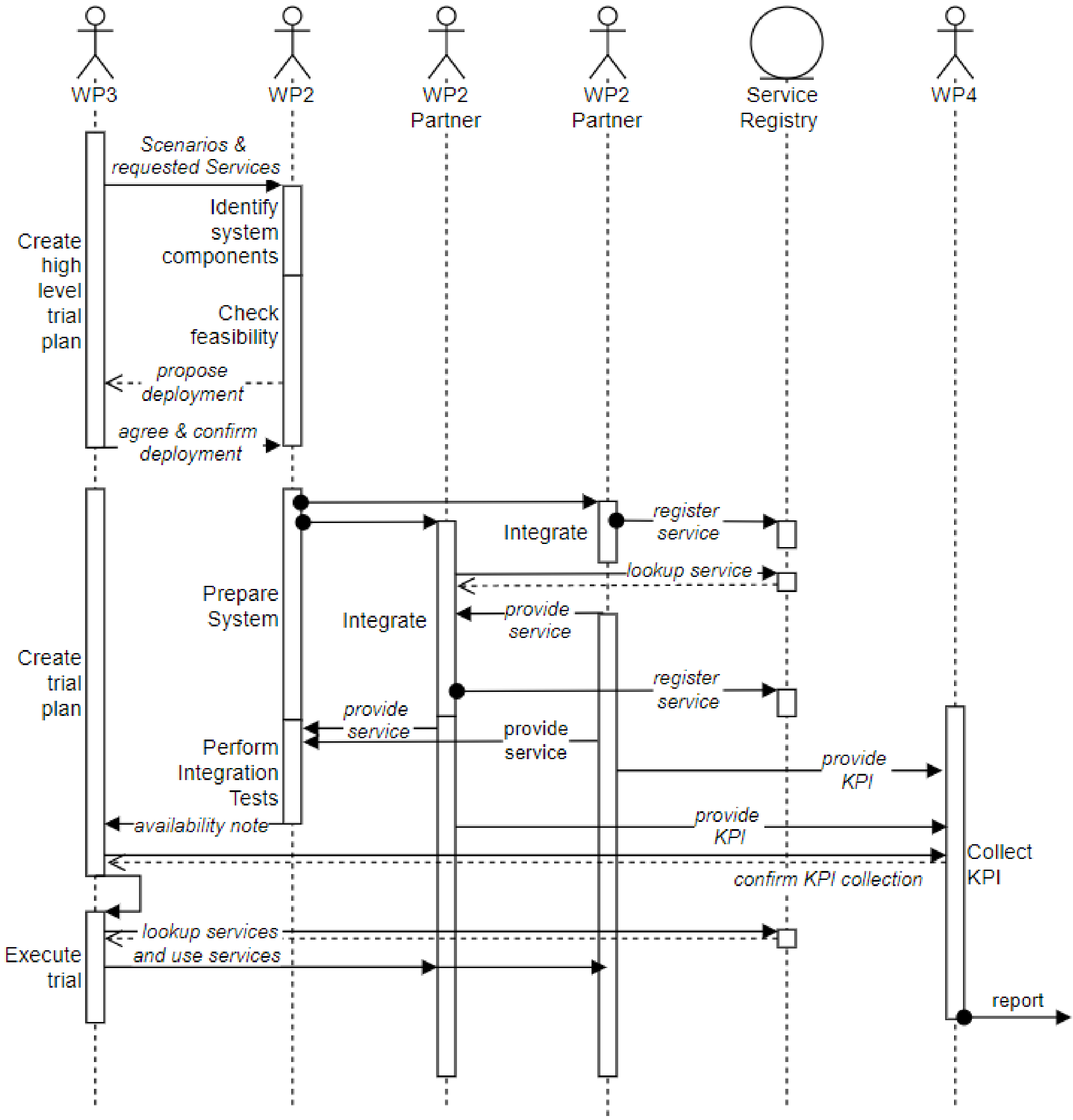

Figure 9: Configure trial instance

Where activities are performed, close collaboration between work packages will ensure a coordinated approach. It is foreseen to keep the trial system available between trials, over time this will reduce integration efforts and time.

Changes to the trial system required by local circumstances, e.g. additional regulatory needs, availability of local data providers will be realized by additional services or updating the area covered by an already deployed service.

Additional steps could be added over time, based on lessons learned from trials (e.g. trial readiness tests close before trial execution starts).

6 Architecture and ongoing regulatory work

SESAR's principles for U-space architecture, Chapter 2 [4], states:

> *U-space is a set of federated services and associated functions within a complete framework designed to enable and support safe and efficient multiple simultaneous drone operations in all classes of airspace. These services can be provided by different providers but such service providers will need to interoperate to performance requirements that are yet to be defined. The need to guarantee a seamless and safe operational environment will necessitate timely and accurate data transmission between implementation systems.*

It furthermore introduces the need to support unique and neutrally/centrally provided services as well as multiple service providers cooperating to operate in the same volume of airspace at the same moment:

> *The architecture must then ensure that all the U-space service providers have exactly the same situational awareness and the traffic is de-conflicted (i.e. strategic or tactical deconfliction).This will require cooperation and exchange of data between the various service providers: connectivity and interoperability of the U-space services and related systems will be then essential.*

> *However the nature of some services is so safety or security and data privacy critical that they might require to be unique and neutrally/centrally provided (e.g. registration, identification, geoawareness, interface with ATM). The architecture has to allow this as well.*

This concept of a hybrid architecture is reflected in the initial U-space regulation. Paragraph 9 and 16 in the preamble define

- Stakeholders
- Which should establish connectivity methods amongst each other
- Using common, interoperable open communication protocols
- Based on requirements for data quality, latency and protection
- To deliver standardised services

> *Preamble (9): Harmonised rules for UAS operations in the U-space airspace, standardised services delivered to UAS operators as well as connectivity methods between providers of the common information services, the U-space service providers, the air traffic service provider and the UAS operators should be established to ensure the safe, secure and efficient operation of UAS, while facilitating the free movement of services linked to UAS as well as U-space service providers in the Union.*

The initial U-space regulation requires U-space service providers to cooperate, they shall "exchange any information that is relevant for the safe provision of U-space services amongst themselves".

For so called common information, Common Information Services are introduced, required to allow access "on a non-discriminatory basis", unique and neutrally/centrally provided:

Article 5 (5): Access to common information services shall be granted to relevant authorities, air traffic service providers, U-space service providers and UAS operators on a non-discriminatory basis, including with the same data quality, latency and protection levels.

The GOF2 architecture is built to provide a strong & flexible framework to realize such hybrid architectures. U-space deployments can be shaped by member states within the boundaries the U-space regulation provides.

A key enabler in GOF2 are the service specifications for information exchange services, which are described in this deliverable and delivered in D2.2. Providing guidance and definitions on conceptual level, they allow to integrate interfaces from different system providers and stake holders using different technologies.

An API or service could be proprietary or open, using new or established technology. If a trace / mapping to the conceptual definition is available, interoperability can be achieved. Even though technical conversion might be necessary, the complexity and cost of such conversion services is expected to be low.

The information model and service interfaces defined are foreseen to be used to exchange information between all stakeholders. E.g. a position record and its substructures defined in the Traffic/Telemetry specification will be used to between UAS operators and USSPs, USSPs and USSPs, USSP and CIS, CIS and ATSPs, SDSP and …, no matter which roles two stakeholder have in in an information exchange, they can always rely on a well-defined standard. This lowers the entry barrier for new services and stakeholders, like the Supplemental Service Providers and Administrative Units participating in GOF2 demonstrations.

Ultimately, this facilitates the free movement for USSPs and UAS operators described in the initial U-space regulation.

International regulatory and standardisation work was considered for the GOF2 architecture as well. E.g. models and architecture foreseen in the United States (FAA, ASTM) and Asia were analysed and taken as input. Related work in the mobile network domain is ingested based on input from other research projects and standardisation activities (e.g. related to Network Coverage).

Summarized, the GOF2 architecture can be considered in line and compliant with ongoing regulatory work in Europe[1]. Its strong & flexible approach focussing on conceptual service definition and SWIM principles will allow for efficient alignment and integration with international UTM deployments.

[1] Please note, at the time of writing this deliverable, Guidance Material and Acceptable Means of Compliance where not yet available. While significant changes are not excepted, it is recommended to compare this chapter with current versions of relevant documents

7 References

[2] U-space regulationhttps://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeeting&meetingId=23814)SESAR 2020 GOF USPACE FIMS Design and Architecture – D4SESAR principles for U-space architecture https://www.sesarju.eu/sites/default/files/documents/u-space/SESAR%20principles%20for%20U-space%20architecture.pdf