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PJ.15-11 Aeronautical Digital Map Service High Level Architecture Description

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				and little focussed on the holistic impact, the options, the costs+benefits. Without this it makes it hard to debate at management and governance levels. (a try out based on the current status of deliverables made us fail) and add should serve to summarize all considerations that are needed to assess the need to continue more detailed service definition work, and if so, in which architecture.
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Copyright Statement

PJ.15 COSER

[PJ.15 COMMON SERVICES]

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Abstract

This document describes the High Level Architecture for the Aeronautical Digital Map Common Service.

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1 Introduction

1.1 Executive Summary

Solution 10 of Project 15, Common Services, is the Aeronautical Information Service. Solution 11 is the Aeronautical Digital Map Service and is very strongly linked to Solution 10. Where the Aeronaitical Information Service is designed to serve as a common Information Service for different kinds or aeronautical information, the Aeronautical Digital Map Service is designed to visualise the information in a harmonised way.

It is a common service that allows the harmonised and centralised visualisation of geographical information for different purposes of static and dynamic aeronautical information in accordance with AIRM based on well-defined standards.

The aeronautical information follows the SWIM standards for information payload (i.e. AIRM / AIXM) and for the service definition (i.e. ISRM). The SWIM Yellow profile is the most relevant for the Aeronautical Information Service, but other profiles can be supported as well.

Even though due to efficiency reasons of the overall SJU programme not all of the possible connections could be validated within the project, the visualisation of the Aeronautical Digital Map Service is relevant in different disciplines of ATM and is required by a broad range of actors.

These include e.g. airspace users or RPAS operators (requiring e.g. information about the status or geometry of airspaces, obstacles, runways or other airport surfaces, procedures etc.), data integrators (requiring similar information on behalf of the airlines), ATS or ATC units (e.g. requiring the airport layout, active procedures, airspace closures, airspace information etc.) on the one hand while data originators (airports, procedure designers, mobile phone companies or energy companies for providing obstacles or getting building permissions in the vicinity or airports) provide information that is required by the other actors. Visualisation of the data for all of these actors supports their work. Therefore, even though a specific information flow may not have been validated explicitly as part of SESAR 2020 (e.g. potential partner systems may have just simulated the availability of visualisation instead of actually implementing and testing an interface), that does not mean that in an operational scenario these interactions are not required. To the contrary: the duplication of visualisation tasks causes potential safety threats and is detrimental to the efficiency of the overall ATM system and in an operational scenario needs to be avoided where ever feasible.

In the context of the project, different deployment options were analysed. A Cost-Benefit-Analysis (CBA) has concluded that one common centralised system is commercially more beneficial than having multiple sub-regional systems or individual national systems due to the streamlining of efforts and costs that can be avoided by avoiding duplication. Moreover, safety benefits from operating a common service have been identified as it provides an efficient means to consolidate information and to detect any possible discrepancies.

1.2 Purpose of the document

This document describes the High Level Architecture for the Aeronautical Digital Map Service. It follows the architecting approach defined in the Common Services Foundation Method [1] from SESAR 1 and uses the Business Model [2] previously produced in PJ.15-11 to provide the definition of operational, service and system architectures for the Service.

1.3 Intended readership

The intended audience for this document is the SESAR Joint Undertaking, the members in the SESAR 2020 Programme, the ATM stakeholders (e.g. Airspace Users, ANSPs, Airports, and manufacturing industry) with those third parties directly affected by its findings and the contributions having dependencies with the Solution.

Other transversal projects, such as PJ19, and tasks within the SESAR 2020 Programme may also have an interest.

The document also provides inputs for future work in PJ.15-11 regarding the service definition activities.

1.4 Inputs from other projects

The basic notions of the Aeronautical Digital Map Service are described by PJ.15-11 in its Business Model document [2], including the potential customers of the service, the value propositions and the information flows needed between the stakeholders.

The reference architecture, including its individual elements, are from the EATMA Repository, which is maintained by using the MEGA modelling tool [3] and can be accessed via the European ATM Portal [4].

1.5 Glossary of basic concepts

Term	Definition	Source
Capability	The ability of one or more of the enterprise's resources to deliver a specified type of effect or a specified course of action to the enterprise stakeholders.	SESAR2020 PJ19.05 EATMA Guidance Material Version 9.0
Capability Configuration	A Capability Configuration is a combination of Roles and Technical Systems configured to provide a Capability derived from operational and/or business need(s) of a stakeholder type.	SESAR2020 PJ19.05 EATMA Guidance Material Version 9.0
Common Service	A service providing a capability in the same form to consumers that might otherwise have been undertaken by themselves.	SESAR B04.05 D02
Consumer	A user of a service	SESAR B04.05 D02
Customer	A consumer of a service under a specific contract.	SESAR B04.05 D02
Demand and Capacity Balancing	Assessment and balancing of demand and capacity at network and airport level to provide the NOP/AOP for the day of operation.	EATMA V9 - ATM Capability Model

Term	Definition	Source
Flow Manager	The Flow Manager is a role performed at sub-regional level which contributes to the Network Management Function.	SESAR2020 Concept of Operations Edition 2017
Node	A logical entity that performs activities. Note: nodes are specified independently of any physical realisation.	SESAR2020 PJ19.05 EATMA Guidance Material Version 9.0
Operational Node Interaction Description (NOV-2)	Defines the nodes and describe information exchanges and (services between nodes). Mapping capability and nodes. In EATMA it is a high level communication material	SESAR2020 PJ19.05 EATMA Guidance Material Version 9.0
Service	The contractual provision of something (a non-physical object), by one, for the use of one or more others. Services involve interactions between providers and consumers, which may be performed in a digital form (data exchanges) or through voice communication or written processes and procedures.	SESAR2020 PJ19.05 EATMA Guidance Material Version 9.0
Service contract (SLA)	A service contract represents an agreement between the stakeholders involved for how a service is to be provided and consumed. A service contract is specified through the service interface, the QoS and Service policies.	SESAR B.04.03 – Working method on service
Service instance	Service which has been implemented in accordance with its specification in the service catalogue (during the SESAR Development Phase, the service definitions are available in the ISRM) by a service provider (by itself or contracted to a third party).	SESAR B.04.03 – Working method on service
Service Provider	An organisation supplying services to one or more internal or external consumers.	SESAR B.04.05 – D02
Service taxonomy	The service taxonomy describes the categorisation of services provided between ATM stakeholders. It is used to organise the responsibilities of the service design as well as to provide a means of identifying services in the run-time environment.	SESAR B.04.03 – Working method on service
Stakeholder	A stakeholder is an individual, team, or organization (or classes thereof) with interest in, or concerns relative to, an enterprise (e.g. the European ATM). Concerns are those interests, which pertain to the enterprise's development, its operation or any other aspect that is critical or otherwise important to one or more stakeholders.	SESAR2020 PJ19.05 EATMA Guidance Material Version 9.0
System Interface Description (NSV-1)	Links together the Operational View and the System View by depicting which systems and system connections realize which information exchanges. It is based on the definition of Capability Configurations and describes the assets, both technical and human which are required in order to provide capability.	SESAR2020 PJ19.05 EATMA Guidance Material Version 9.0

Table 1: Glossary of basic concepts

1.6 Acronyms and Terminology

Term	Definition
AAS	Advanced Airspace Scheme
ACC	Area Control Centre
ADQ	Aeronautical Data Quality
AIM	Aeronautical Information Management
AIRAC	Aeronautical Information Regulation and Control
AIRM	ATM Information Reference Model
AIS	Aeronautical Information Service
AIXM	Aeronautical Information Exchange Model
AMAN	Arrival Manager (Controller Support Tool)
AMQP	Advanced Message queueing Protocol
ANSP	Air Navigation Service Provider
ATM	Air Traffic Management
ATS	Air Traffic Services
AU	Airspace Users
CBA	Cross-Border Areas TSAs or TRAs established over international boundaries
CC	Capability Configuration
CDR	Conditional Route
CNS	Communication Navigation Surveillance
COSER	Common Service
COTS	Commercial Off the Shelf
EASA	European Union Aviation Safety Agency
EATMA	European ATM Architecture
EFB	Electronic Flight Bag
FAB	Functional Airspace Block
FB	Functional Block
FMS	Flight Management System
GAT	General Air Traffic
GIS	Geographic Information System
HTTP	Hypertext Transport Protocol
HTTPS	Secure HTTP
IFR	Instrument Flight Rules
ISRM	Information Services Reference Model

Term	Definition
KPA	Key Performance Area
KPI	Key Performance Indicator
MET	Meteorological
METEO	Meteorological
NAF	NATO Architecture Framework
NM	Network Manager
NOTAM	Notice to Airmen
NOV	NAF Operational View
NPA	Notice of Proposed Amendment
NSV	NAF System View
OGC	Open Geospatial Consortium
PCA	Prior Co-ordination Airspace
PCP	Pilot Common Project
PCP IR	Pilot Common Project Implementing Regulation
PERM	Permanent
RCA	Reduced Co-ordination Airspace
RPAS	Remotely piloted Aircraft System
RTPS	Real-Time Publish Subscribe
SARPS	Standards and Recommended Practices
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SID	Standard Instrument Departure
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
STAR	STandard ARrival
SWIM	System Wide Information Management
TRA	Temporary Reserved Areas
TSA	Temporary Segregated Areas
UTM	ATM Services to Unmanned vessels
WCS	Web Coverage Service

Term	Definition
WFS	Web Feature Service
WMS	Web Map Service

Table 2: Acronyms and Terminology

2 Scope of the High Level Architecture Description

The main objective of the high level architecture is to describe the main architecture elements and their relationships across the different architecture layers of the Aeronautical Digital Map Service. This description starts with the business and operational needs, and goes down to the system resources that need to collaborate with each other to meet these needs, supported by the services that enable the actual exchange of data.

In order to clearly define the borders of this architecture description, some working assumptions have been made regarding the modelling activities and for this document. These are described later in this chapter. Before presenting them, it is necessary to understand the aspects of the Common Service that have motivated these assumptions.

2.1 Aeronautical Digital Map Service Business Aspects

Although the complete definition and the underlying principles of the Aeronautical Digital Map Service can be found in the Business Model [2], some extracts are provided below to better understand the scope of this document.

The concept of a Common Service was introduced in SESAR to address the need to reduce the cost of European Air Traffic Management (ATM). ATM is highly fragmented with each State having their own Air Navigation Service Providers (ANSP). Cross border provision of Air Traffic Services being limited to only a few local examples. As each ANSP provides much the same type of service, they all have similar capabilities and deployed systems. Common Services can potentially reduce the overall cost of ATM by making it possible for similar organisations to consume a service from one provider by giving them the same capability they would normally have provided themselves, but at a lower cost. This benefit can either be realised by the direct consumer, in many cases the ANSPs, or by their customers by broadening their choice of supplier.

The Aeronautical Digital Map Common Service provides users the capability to retrieve graphical representation of aeronautical data / information. The output is a standardized / harmonised graphic information that can be retrieved by individual requests demanding specific geographical areas. The retrieval can be performed using regular internet protocols or through SWIM services.

PJ.15-11 explores ways of improving overall cost efficiency for delivering the necessary capability to the interested stakeholders under a COSER pattern.

The business case for Aeronautical Digital Map COSER has a link with the Pilot Common Project [31] which mandates *Aeronautical information exchange* on iSWIM over the yellow profile among the ATM sub-functionalities that need to be implemented by a selected set of European ANSPs.

Assuming that users could consume the capability from a series of competing providers available within Europe, provision of Aeronautical Digital Map Service deploying a COSER could result in:

- the requirement to deploy fewer engineered capabilities - ANSPs only bear a cost consistent with the services they receive,

- service improvement roadmap across Europe is consistent and the associated costs are spread across common service ANSP consumers,
- facilitation of the extension of the PCP requirements to other States not originally addressed by the Implementing Rule.

Consequently, the benefit relates to:

- cost reduction through lower number of system deployments and lower number of technical systems to be securely maintained in operation,
- synchronisation of the evolutionary roadmap enabling consistency of concept and
- increased geographical coverage of the Solution because new incentives for ANSPs appear.
- A harmonised representation of the information supports the safety as airspace users can rely on a standardised way of representing information

In the TRL2 phase, the members of PJ.15-11 agreed to stay as open as possible to potential future scenarios of the Common Service and possible magnitudes of scale of the Common Service in regards of the number of potential consumers. TRL4 addresses benefits in more details, which lead to a new assessment of the scenarios.

2.1.1 Service Scenarios

The Capabilities can be considered to be provided through standardisation, outsourcing, consolidation or partnerships. It can also be deployed at a single location (centralised service) or at multiple locations (distributed services).

For TRL6, the Regional Level Deployment has been identified as the most commercially advantageous and most efficient option due to the synergies of co-utilizing assets by multiple clients in parallel. The remaining options are documented in Annex A but are not taken into account for the further evaluations.

2.1.1.1 Regional Level Deployment

In this scenario, the Aeronautical Digital Map service is operated resiliently for a complete region (e.g. ECAC area) similar to the EAD service today.

It can be used by regional AIM services, other national AIM services (partners) and other AIM services to generate a map output. Airspace Users, ATS Operations, Airport Operations, Data Integrators, ATS Operations, Data Originators, Procedure Designers, Aerodrome ATS and En-Route Approach ATS utilize the regionally deployed map service to generate visualisations.

The Aeronautical Digital Map Service can connect to one or more local, subregional, regional or global Aeronautical Information Services in order to retrieve the data that shall Sbe visualised. in case of a local, subregional or regional deployment for the Aeronautical Information Service, the data has to be retrieved from multiple sources.

The Aeronautical Digital Map Service would connect to the regional deployment for all regional information. If multi-national visualisation beyond the region is required, multiple services need to be contacted.

Advantages:

- avoidance of visual inconsistencies across a whole region, improvements are still possible for a global approach
- improvement regarding inconsistencies amongst all members of the region
- reduced infrastructure cost compared to local deployments and to subregional deployments
- less cost for resilience, as all ANSPs in a region share a common system
- cost optimization due to sharing of investments in a complete region
- simplest management
- data users only need to contact a single service for a whole region

Disadvantages:

- central system needs to be scalable
- other regions may still choose different visualisation strategies

KPA (KPI)		Performance Benefits Expectations Regional Level deployment
Predictability (Flight Duration Variability, against RBT)		None
Flexibility		None
Safety	Mitigation of safety risk	Low
Human Performance		None
Interoperability		None
Cost Efficiency	Cost of operation	High
Cost Efficiency	ATCO Productivity	None
	Technology Cost	High

2.2 High Level Architecture assumptions

The following assumptions have been made regarding the high level architecture description presented in this document:

- The service will be hosted centrally or de-centrally / distributed
    - Rationale: central hosting or de-centralised hosting are both viable options in order to ensure availability, performance an efficient operation
- However, there will be one service provider organisation taking care of the harmonisation and data validation beyond what can be done automatically
    - Rationale: Not all data conflicts can be resolved automatically, but in certain cases require human interventions in order to facilitate a consensual data update.
- All information exchange between the service and its users / consumers will take place via SWIM using the SWIM infrastructure within the Yellow Profile or via standard web service

technology (web map service (WMS), web feature service (WFS), web coverage service (WCS) etc. as defined by the OGC (Open Geospatial Consortium).

  - Rationale: SWIM is seen as a prerequisite for the communication with the service. OGC web-services are compatible with the SWIM infrastructure and are standardized means of distributing geospatial information

- The service visually integrates information from PJ15-10 and geographical information (e.g. geo terrain information)
  - Rationale: PJ15-10 delivers aeronautical information in AIXM, which is rendered by PJ15-11. Geo terrain information is not part of AIXM / AIRM, but is required as background information for certain types of visualisations. A fusion of the two data types can be achieved by layering.
- 2D and 3D visualisation was covered
  - Rationale: Certain types of information, especially obstacles (Vertical Structures) and airspace volumes require visualisation in 3 dimensions for some usecases, while other information is best viewed in 2D visualisations. The service shall therefore support both.
- The usage scenario covers real time visualisation and paper or digital chart production
  - Rationale: Real-time visualisation is required for data management and quality assurance as well as for situational awareness purposes, while paper / digital chart production is required for the generation of pre-generated aeronautical charts to be included in the AIP or as background for moving map displays in Electronic Flight Bags.

2.3 Impact Assessment on Functional Blocks

A potential impact of PJ15-11 on the following functional blocks in EATMA or a potential impact of the following functional blocks on PJ15-11 is analysed in the sub-chapters of this chapter. The impact can be a direct usage of the functional block within the project or a communication relationship / dependency.

Due to its strong relationship with PJ15-10, a number of indirect impacts are applicable to PJ15-11 too.

The sub-chapters below include the current description of the functional block from Mega plus a short assessment of the impact.

2.3.1 Aeronautical Data Collection

Data collection which ensures that the required up-to-date information is received from the appropriate authorised originating sources, e.g. Government Agencies, ANSPs, Airport Operators, CNS providers, METEO providers, etc.

Data Maintenance

Impact:

- Functional block required by 15-10

2.3.2 Aeronautical Data Storage and Management

This functional block represents functionalities ensuring the completeness, coherence and up-to-date of the Aeronautical Information data base.

Impact:

- Functional block required by 15-10

2.3.3 Aeronautical Data Validation and Verification

Data Quality Management which ensures that the data received from the data originators is verified against the quality requirements (i.e. accuracy, resolution, integrity, traceability, timeliness, completeness and format) before being committed (validation) into the database. Data Quality Management in this functional block includes all the processes and actions necessary to ensure that the delivered data meets the relevant data quality criteria.

Impact:

- Functional block required by 15-10

2.3.4 Aeronautical Information Distribution

In the scope of this Functional block the term “product” represents the information delivered to the end user. It can be in printed or electronic form, being the result of a standard or customised query.

The Functional block covers the activities necessary to make the required aeronautical information available to the end user in different form and formats (i.e. paper, file format (e.g. PDF file), text or digital message and dataset).

It provides following functionalities:

- Information Delivery which retrieves the data to deliver the required product (e.g. AIP in paper or electronic form, result of database query) containing the most up-to-date information. This sub-function is responsible for updating the products according either to required production cycle timeframe (e.g. AIRAC cycle) or to evolution in the production tools (e.g. maintenance of standard queries in relation with database evolution).

- Quality Management which ensures that the data produced meets the relevant data quality standards

Impact:

- Functional block required for PJ15-11 via PJ15-10

2.3.5 AIM Product Assembling

This functional block represents the data assembly into a product ensuring the quality aspects of aeronautical data within the various products. To reflect the difference in the production of the various types of aeronautical data, following functionalities have been identified:

· Production of Static Data (e.g. those used in AIP, AIC, SUP, Charts and Digital Data sets);

· Production of Dynamic Data (e.g. NOTAM and Digital NOTAM);

The data covered are the aeronautical data (i.e. those specified by Annex 15 and related ICAO SARPS, Guidance Documents and Procedures). Depending on local implementation it may include datasets (e.g. Terrain, Obstacles, Airspace, Aerodrome Mapping). This breakdown does not address the granularity in which the data are established (raw / integrated), nor the form (Digital / paper / semi-digital) in which they are produced / published.

Impact:

- Functional block is directly impacted by PJ15-11, as aeronautical charting is in scope for it directly

2.3.6 AIM System Management

This functional block represents following functionalities:

· Technical Monitoring and Control which ensure that the tools used in the data production chain, as well as in the AIS Provision chain are working properly in accordance with user requirements and service level agreement specifications.

· Quality Management System which is a collection of business processes focused on achieving the policy and quality objectives in order to meet customer requirements expressed in various international standards regulating the provision of aeronautical data/information. It is expressed as the organizational structure, policies, procedures, processes and resources needed to implement quality management.

Impact:

- Functional block required by PJ15-11 (used by PJ15-11)
- Modified in the project to match the scope of PJ15-11

2.3.7 Airport Surface Navigation

Lateral navigation assistance on the ground.

Impact:

- Functional block can utilize visualisation capabilities from PJ15-11 as support

2.3.8 Cooperative Airspace Design

This FB groups all functions related to Airspace Design. These functions support the development and co-ordination of design activities (at local and regional levels) of the ATS Route Network and ATC Sectors, in en-route and terminal airspace.

The Airspace design activities occur in the strategic phase (months before operations) with 3 time horizons:

Annual short-term improvements to develop remedial proposals to alleviate airspace problems and bottlenecks that become evident during the peak summer period

Medium-term airspace improvement to eliminate structural bottlenecks that require a more radical airspace re-organisation

Long term airspace improvement to develop a reference/target ECAC airspace structure (the current one has been established in 2010 and it is named Advanced Airspace Scheme (AAS).

In all cases, Airspace Design follows an iterative process based on 4 steps:

Step 1: Identify the problems. The design work highlights the problem areas and their causes in the airspace structure

Step 2: Build airspace structure proposals (both route segments and Air Traffic Control (ATC) sectors) to accommodate major traffic flows and balance ATC workload.

Step 3: Within this defined framework, detailed proposals of airspace structure are elaborated with their “modus operandi”, consolidated and validated through regional expert groups. The result of local studies feeds back into the initial proposals in an iterative process.

Step 4: A phased implementation programme is agreed and carried out.

Successful European airspace design is achieved through a coordinated and integrated approach for the collective benefit of all Member States and airspace users. National borders and Flight Information Region (FIR) boundaries should not be factors in the design process and Upper, Lower and Terminal Airspaces across Europe should be treated as a single continuum.

The design of airspace with regard to its structure, classification and utilisation has to be accomplished through a unified approach between local, sub-regional and regional levels.

Impact:

- Functional block can utilize visualisation capabilities from PJ15-11 as support

2.3.9 Cooperative Airspace Management

This FB groups all functions for Airspace management, at local, sub-regional and regional levels. These functions support the development and co-ordination of planning activities (at local and regional levels) related to the use of the Airspace (ATS Route Network and ATC Sector configuration), in en-route and terminal airspace.

In terms of time-horizon, Airspace Management activities start after the Airspace Design activities, taking into account the civil and military demand (in terms of airspace reservations and flight plans) as it becomes available: The main output is an airspace usage plan, on a daily basis. The functions related to the tactical activation of the elements of this plan (e.g. change of a sector configuration) are not parts of this FB: they are parts of the FB “Demand and Capacity Balancing”.

Airspace Management is to improve capacity optimisation and flexible utilisation of airspace structures through functions such as:

Impact assessment of the military airspace requests

elaboration of the daily airspace and route usage plan decisions (including danger areas)

enable interoperability with local and regional Airspace Management tools (via B2B Web services)

inform users on changes to airspace usage plan (via B2B and B2C services)

Assessment of the impact of sector configuration changes according to traffic patterns

Airspace Management allows the maximum shared use of airspace through enhanced civil/military co-ordination. The application of the Flexible Use of Airspace Concept ensures that any airspace segregation is temporary and based on real use for a specified time period.

Airspace Management plans the use of pre-defined flexible airspace structures that are suited to temporary use:

Conditional Routes (CDRs) - non-permanent Air Traffic Services (ATS) routes or route-portions

Temporary Segregated Areas (TSAs) and Temporary Reserved Areas (TRAs) - areas temporarily reserved for the exclusive use of specific users

Cross-Border Areas (CBAs) - TSAs or TRAs established over international boundaries

Reduced Co-ordination Airspace (RCA) and Prior Co-ordination Airspace (PCA) - procedures enabling General Air Traffic (GAT) to operate outside the ATS route structure

Impact:

- Functional block can utilize visualisation capabilities from PJ15-11 as support

2.3.10Flight Data Support Management

Flight Data Support Management' consolidates the functions and capabilities that are supporting the FBs Flight Planning, Flight Operations Management and Post Flight Analysis. This includes the maintenance of navigation data, the management of flight constraint data, the overflight permission handling and the management of aircraft configuration data.

Main Functions of this FB are:

- Navigation Data Maintenance

- Take-off and Landing Constraints

- Overflight Permission Handling

- Flight Constraints Management

- Aircraft Configuration Management

Impact:

- Functional block can utilize visualisation capabilities from PJ15-11 as support

2.3.11 Flight Management

'Flight Management' covers all activities within FOC system that deal with a particular flight. The activities are executed in the short-term planning and the execution phases of the flight.

Main Functions of this FB are:

- Flight and Trajectory Planning

- Flight Monitoring

  o Data Monitoring

  o Trajectory Adherence Monitoring

- Flight Deck Support

  o Briefing

  o Dynamic Data Provision

Impact:

- Functional block can utilize visualisation capabilities from PJ15-11 as support

2.3.12Flight Plan Management

Management of FMS 4D Trajectory (e.g. activ/secondary/alternate flight play waypoints, turn/holding patterns, etc)

Impact:

- Functional block can utilize visualisation capabilities from PJ15-11 as support

2.3.13SWIM Messaging

Provides interoperability between distributed systems with varying degrees of decoupling and including features for effective and reliable communication. following features:

· Support for a variety of Messaging Technologies & Protocols, Such as SOAP, RTPS, XML, HTTP(s), AMQP

· Support for a variety of routing mechanisms. The routing determines where a message will be delivered as well as define through which communication paths a message will reach its intended destination or destinations.

· Support for a variety of distribution mechanisms.

· Support for filtering mechanisms. The filtering allows the elimination of messages based on filtering criteria.

· Support of a variety of Quality of Services (QoS), including reliable delivery, best effort delivery, durable subscriptions, transaction management and message handling specification according to priority and response time requirements.

· Support for Protocol Bridge. The Protocol Bridge performs the transformation from source messaging protocol and underlying stack into an output messaging protocol and underlying stack

· Support for Data Management. The SWIM-TI Data Management is in charge of operations on the data that is transported by the SWIM-TI Messaging.

Support for Data Validation. Data Validation function is able to check data payload against the expected format prior to the service execution and allow or deny a service access or to check response data payload prior to further usage of the data in the same way described above for the provider but does not cover semantic checking that requires domain knowledge

Impact:

- Functional Block required for SWIM compatibility of PJ15-11

2.3.14SWIM Recording

Recording includes the ability to collect, store and on demand retrieval of information related to: communication being performed via the SWIM Interfaces; supervision actions and events.

This function collects the communication session data based on predefined configuration and can include: Service execution time stamp; Service name; Service requestor and provider identity information (user name, security token); Data payload (possible encrypted); Data payload signature

Impact:

- Functional Block required for SWIM compatibility of PJ15-11

2.3.15SWIM Registry

The Registry is the shareable function to retrieve meta-information about the Services and the ATM Information they provide. It covers:

· Discovery Functionality enabling to identify registered resources, obtain their descriptions, identify related resources and follow up their evolution.

· Registration Functionality enabling the controlled and structured registration of resources in the registry.

· Security Functionality ensuring that only authorized users are able to view or edit certain information in the registry

System Interface Functionality enabling the registry to exchange information with other systems

Impact:

- Functional Block required for SWIM compatibility of PJ15-11

2.3.16 SWIM Security

Security FB provides technical functions enabling the Access Control (Authentication and Authorization), Audit and Data Protection in a federation of security domains, This is used to control and to protect services and resources in the whole security chain (ATM specific and SWIM-TI). Access Control relies on Authentication (authentication of a Digital Identity - refer to a process used to achieve sufficient confidence in the binding between the entity and the presented identity), on Authorization (authorization of an authenticated Digital Identity to use a given resource - refer to the granting of rights and, based on these rights, the granting of access.) and on Identity Management (provisioning, mapping and federation - refer to a set of functions and capabilities (e.g., administration, management and maintenance, discovery, communication exchanges, correlation and binding, policy enforcement, authentication and assertions) used for assurance of identity information (e.g., identifiers, credentials, attributes); assurance of the identity of an entity and supporting business and security applications.

Impact:

- Functional Block required for SWIM compatibility of PJ15-11

2.3.17 SWIM Shared Object

Shared object Functional Block allows the sharing of data across multiple SWIM Nodes. This capability uses publish/subscribe and request/reply messaging pattern and allows multiple operations on an agreed data model: · Creation, update, delete, search; · Request for service; · Restore data; · Recovery Every shared object has a manager. If a participant has the manager role, it is responsible of the shared object and it is the only one allowed to update and delete that shared object. Every shared object has a distribution list. The distribution list is the list of participants interested in a shared object. The Shared Object function uses data validation to perform compliance checking of message payload.

Impact:

- Functional Block required for SWIM compatibility of PJ15-11

2.3.18 SWIM Supervision

Supervision supports all SWIM related supervision functions instantiated in a system - hardware, software, processes, service status

Impact:

- Functional Block required for SWIM compatibility of PJ15-11

2.4 Standardisation Needs

PJ 15-11 relies on AIRM and ISRM to be standardised to the greatest extent possible.

AIRM describes the payload / content to be transmitted over SWIM. This payload needs to be defined in detail in order to allow SWIM nodes / connected systems to seamlessly exchange information. For this purpose, the data format (syntax) and also the business rules governing the information need to be defined and standardised. As AIRM is a complex and flexible data model, in addition to formal rules, also a standardisation in terms of information harmonisation needs to be taken into account. Harmonisation concerns the fact that operators are free to choose to encode syntactically correct information in different ways, which still make it difficult for users to interpret it correctly. An example for this is the encoding of organisations / units providing services on airports or airspaces. This can be encoded correctly in different ways, but a common approach would be helpful for users.

ISRM describes the service model, i.e. the available functions that every compliant system has to support in order to interoperate with other compliant systems. ISRM standardisation is necessary in order to ensure that the same way of accessing a certain type of information is possible with every actor in a compliant system in order to allow seamless interoperability.

An example for such an interface is the definition of a query function for a data type with its parameters (data type, sequence), return values and pattern for executing.

In addition to the transport mechanism and payload, also visualisation standards that can guarantee global airspace users a standardised depiction with standardised symbology, contents scale levels, units, colours etc. are necessary.

A reliable data and service model are prerequisites for PJ15-11 in order to achieve interoperability.

The standardisation of SWIM in general is very important for PJ15-11 as its main communication channel to consumers of the service and to other services.

2.5 Challenges expected in terms of Compliance and Certification

Challenges in terms of compliance are expected due to the fact that not all necessary SWIM standards are fully defined and usable yet.

Industry therefore had to make assumptions and interpretations which can be detrimental to interoperability and reflect unilateral interpretations, which do not necessarily have to be shared by all stakeholders.

This applies to compliance with AIRM and ISRM.

Due to the complexity of the matter, it is difficult for ANSPs to pre-determine the compliance of a component with the SWIM standards. This potentially leads to difficulties when systems from different vendors need to be integrated.

Certification of systems can be challenging as the ADQ IR and the EASA NPA require a high maturity of software development processes and standards. The proof of such mature products and processes can be more difficult for existing COTS products than for new developments.

The certification can lead to additional unplanned costs and delays due to the assurance and certification process implied by the high standards safety standards and process maturity required.

3 Aeronautical Digital Map Service Architecture

3.1 Introduction

The Business Model describes a number of users that play a role in Aeronautical Digital Map Service, either as provider or consumers of the service.

Within SESAR, the Aeronautical Digital Map Service is used by the following projects / solutions:

Project/Solution	Title	Dependency
PJ.03a-09	Surface operations by RPAS	This solution may make use of the Common service for a validation exercise.
PJ.10-05	IFR RPAS Integration	This solution may make use of the Common service for a validation exercise.
PJ.15-09	Data Centre Service for Virtual Centres Service	This solution may make use of the Common service through SOA approach.
PJ.18-04a	18-04a: AIM information[1]	This solution may make use of the Common service for a validation exercise.

Table 3: Solutions Involved

PJ.15-11 can interact with PJ.03a-09 and PJ.10-05 in order to explore the possibility of using the Aeronautical Digital Map Service within the scenarios of RPAS surface operations and IFR RPAS integration, respectively, in Wave 1. The scope of the interactions relates specifically on the possible usage of the common service by tower or RPAS simulators. The Solution Leaders focussed on the possibility of using this Common Service in Wave 2.

PJ.15-10 and PJ.15-11 interact with PJ.18-04 in order to ensure a consistent approach to the S2020 management and sharing of static and dynamic aeronautical data and aeronautical digital map, taking into account the information available at the beginning of each service definition. PJ.18-04 is the core

[1] Following the latest version of the PMP (V1.0.0), PJ.18 decided to split the original WP3/18-04 into three independent stand-alone Technological Solutions. The Solution that PJ.15-11 can interact with is the new proposed PJ.18-04a AIM Information.

activity in the SESAR Programme to develop the AIM and MET Enablers. The interaction was facilitated via regular Solution Lead co-ordination.

3.2 Business Architecture

Please refer to the Business model for details on the business architecture.

3.3 Operational Architecture

3.3.1 Procedure Designer

Procedure designers require the display for visualising the approach and departure procedure information in conjunction with geographical information. Procedure designers utilize the Digital Map Service for their design tasks and for quality assurance.

3.3.2 Airport

Airports utilize the aerodrome related information, e.g. the aerodrome mapping data concerning aprons, parking positions, lights, taxiways, runways etc. During the data origination process, the Aeronautical Digital Map Service can be used to review information to be submitted to the ANSP. After processing by the ANSP, the Aeronautical Digital Map Service can be used to review the processed data. Moreover, airports can utilize some or all of the information for ground-side related tasks. A common map information set helps to avoid discrepancies between information used for aerodrome operational purposes (e.g. construction works, ground vehicle guidance etc.) and ATC related purposes.

3.3.3 Data Integrators / Providers of aeronautical software for airspace users

Data Integrators and providers of aeronautical software for airspace users utilize the harmonised aeronautical and geographical data within their applications to provide congruent and harmonised depictions of the aeronautical information for their users.

3.3.4 Tower Systems

Tower systems utilize the aeronautical digital Map Service as a basis for visualising their operational data on top of other relevant aeronautical information in order to get a complete common operational picture.

3.3.5 UTM Systems

UTM Systems are used to provide ATM services to unmanned vessels. The aeronautical digital map service is used to visualize e.g. no flight zones or prohibited areas or airspace reservations for drone operations, thereby allowing the controllers and the operators of unmanned vehicles to visually determine the airspaces to be reserved or to be avoided for their drone operations.

3.3.6 ATC/ATM Units

ATC and ATM units traditionally utilize local, non-harmonized not always up to date data sets for visualising aeronautical information, e.g. as basis for sector configurations, dynamic airspace activations / deactivations, activation of procedures or runways in electronic ATC / ATM systems.

Aeronautical information can be very complex and by obtaining a harmonised and always up to date visualisation in a tailored styling from the Aeronautical Digital Map Service, the level of safety can be increased and human error can be minimized.

3.3.7 Aircraft Operator

Aircraft operators utilize the aeronautical digital map service to aid their flight planning and to visualise important events potentially impacting their flights.

3.3.8 AIM Unit

AIM Units use the Aeronautical Digital Map services as a tool supporting their information maintenance and validation activities. It is used for quality assurance purposes and supports the users in order to allow a better understanding of complex aeronautical data structures on a visual display. Moreover, the Aeronautical Digital Map Service forms the basis for aeronautical chart production, procedure design and ETOD management.

3.3.9 Aeronautical Information Service

The Aeronautical Information Service is the main partner of the Aeronautical Digital Map Service, as it is the origin of most of the aeronautical information to be visualised within the service.

Figure 1 below depicts the interactions between the different Nodes, according to the information flows defined in the Business Model. These information flows have been modelled as Information Elements. Where possible, existing Information Elements in EATMA have been reused.

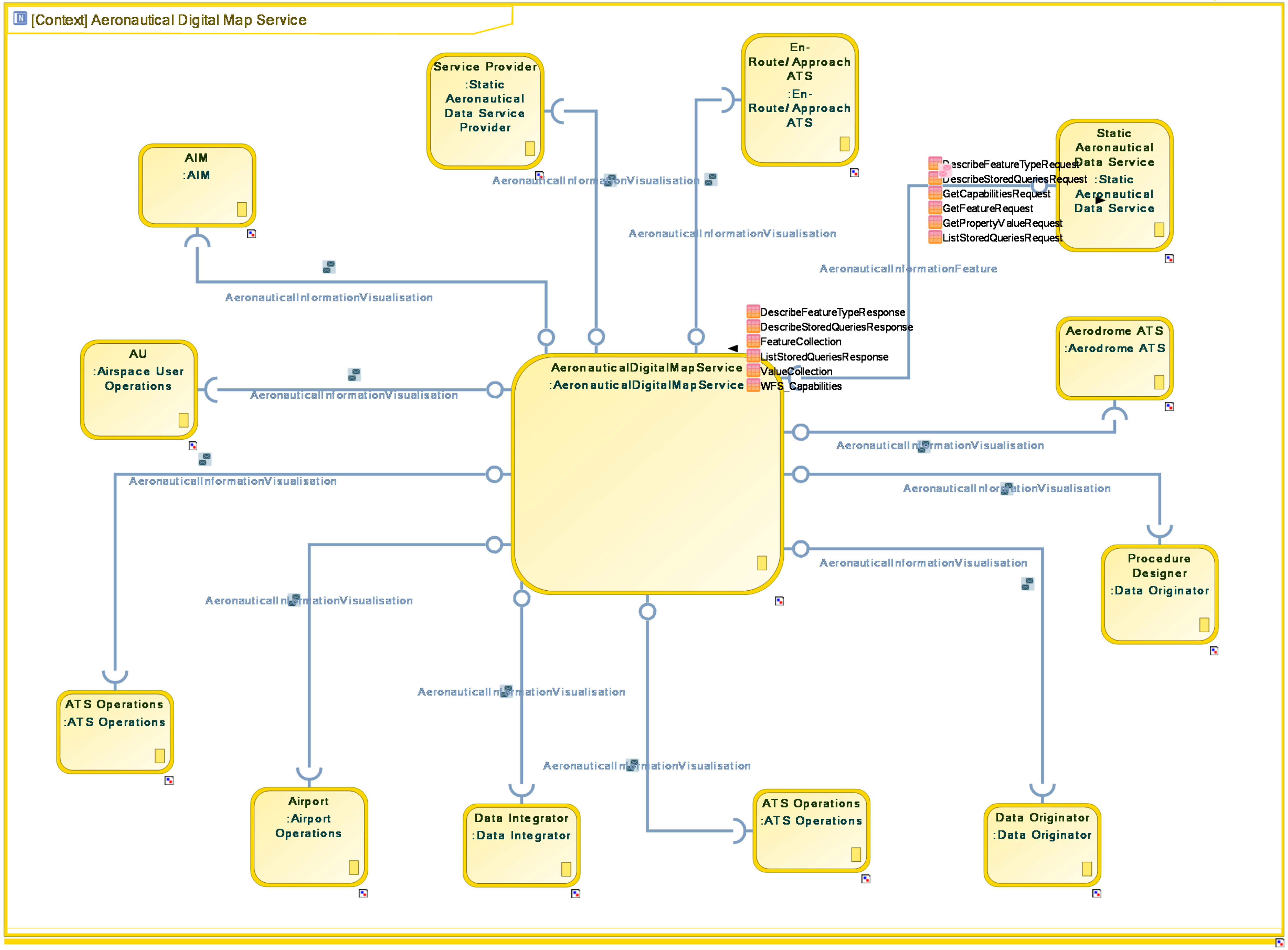

Figure 1: NOV-2 – Operational Node Context Diagram

3.4 System Architecture

The image below reflects the system architecture in line with the NSV-1 view.

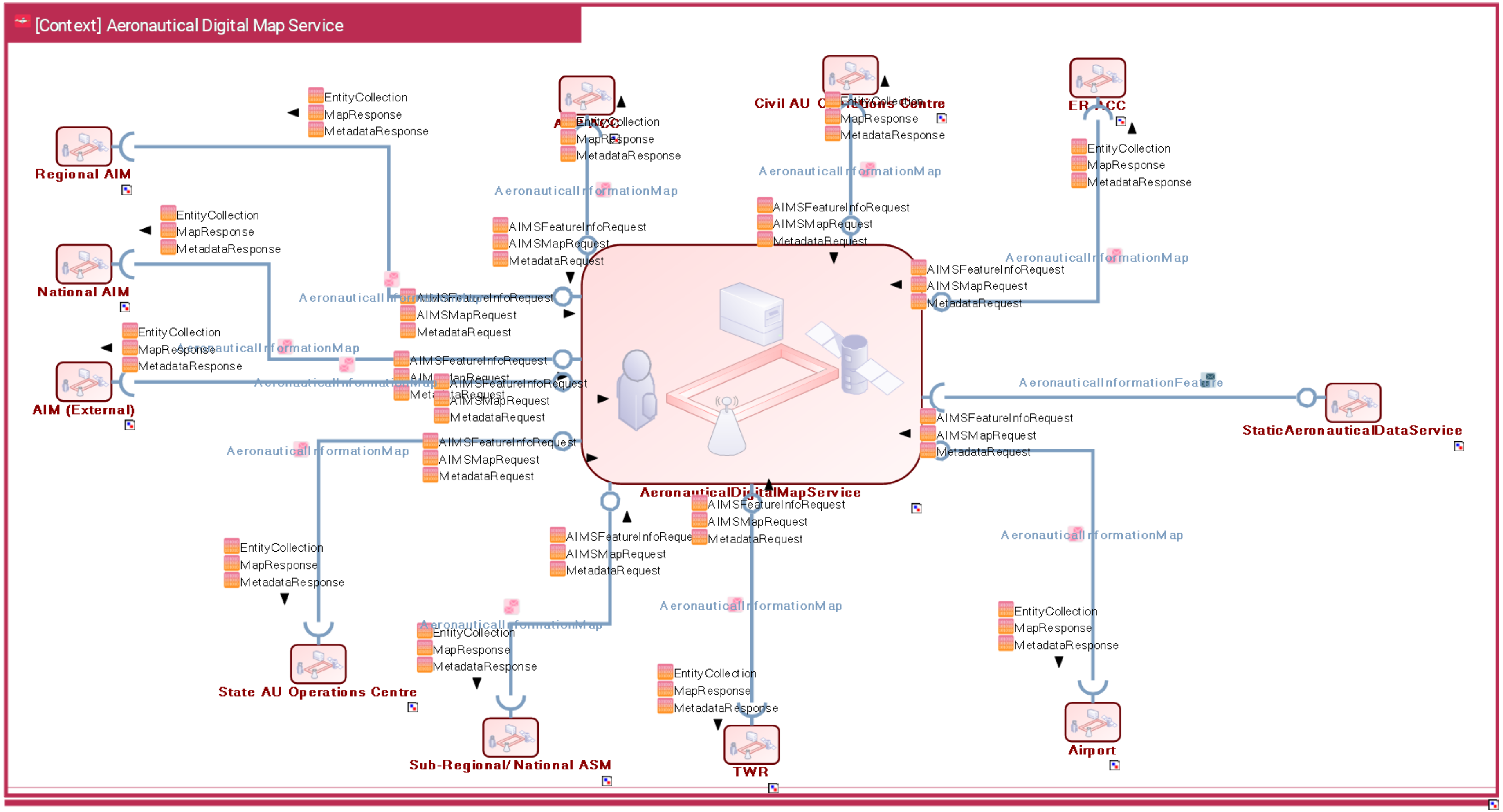

Figure 2: NSV-1 – Capability Configuration Context Diagram

3.4.1 Component Architecture

The components below correspond to an initial idea for a component architecture (currently kept local in the project and not yet reflected in Mega).

3.4.1.1 Aeronautical Information Service

The Digital Map common service is one of the prime users of the Aeronautical Information Service modelled in Solution PJ.15-10. The Aeronautical Information Service is therefore the most important information source for the Aeronautical Digital Map Service.

3.4.1.2 AIXMJSONConverter

JSON is a highly efficient format used for the visualisation of all types of geographical information and is useful for a direct rendering using browser capabilities.

The AIXM JSON Converter converts the much more complex AIRM / AIXM data structures into streamlined Geo JSON.

3.4.1.3 HighPerfRetrievalCache

The high performance retrieval cache ensures that the Aeronautical Information Service does not become a hot spot and bottle neck in the system. State of the art geographical filtering and indexing technologies are used in a horizontally scalable retrieval optimized Cache, which is used by the rendering components for their visualisation

3.4.1.4 RealtimeGISViewerEditor

This is an HMI component, which is capable of rendering aeronautical information provided by the Cache or by the DistributionMapServer for human consumption.

In order to provide a harmonised yet use case optimized styling, a styling engine can be used to represent the information according to different usage scenarios. E.g. An aerodrome operator may require different symbology and focus than a drone operator.

The component shall also be usable as a visual editor of geographical aeronautical information, allowing e.g. the definition of drone zones or no fly zones from a visual editor (also supporting mobile devices).

3.4.1.5 DigitalCharting

Digital Charting is the usecase of rendering aeronautical information for the purpose of generating aeronautical products to be used as paper charts or digital products e.g. for EFBs. This type of representation is more sophisticated and detailed than a real time GIS visualisation.

It is designed for very high resolutions and can be utilized as input for print processes.

3.4.1.6 DistributionMapServer

The distribution map server takes care of distributing the geographical information coming from geo he data repositories (geo databases or geo filestores) and also accepts data edits from the HMI components. It provides the information as OGC Webservices and on the SWIM infrastructure.

3.4.1.7 GISDatabaseStorage / GISFileStorage

These are the components taking care of the physical storage of geographical information (e.g. terrain data). Depending on the data source, geographical information may be most efficiently stored as files or in databases.

The Distribution map Server connects to the file or database storage and distributes the information.

3.4.1.8 DigitalMapManagementHMI

This is an HMI allowing the configuration and selection of geographical data to be handled by the DistributionMapServer. It allows defining the underlying map data sources, allows uploading and processing e.g. terrain information from geo data sources. etc.

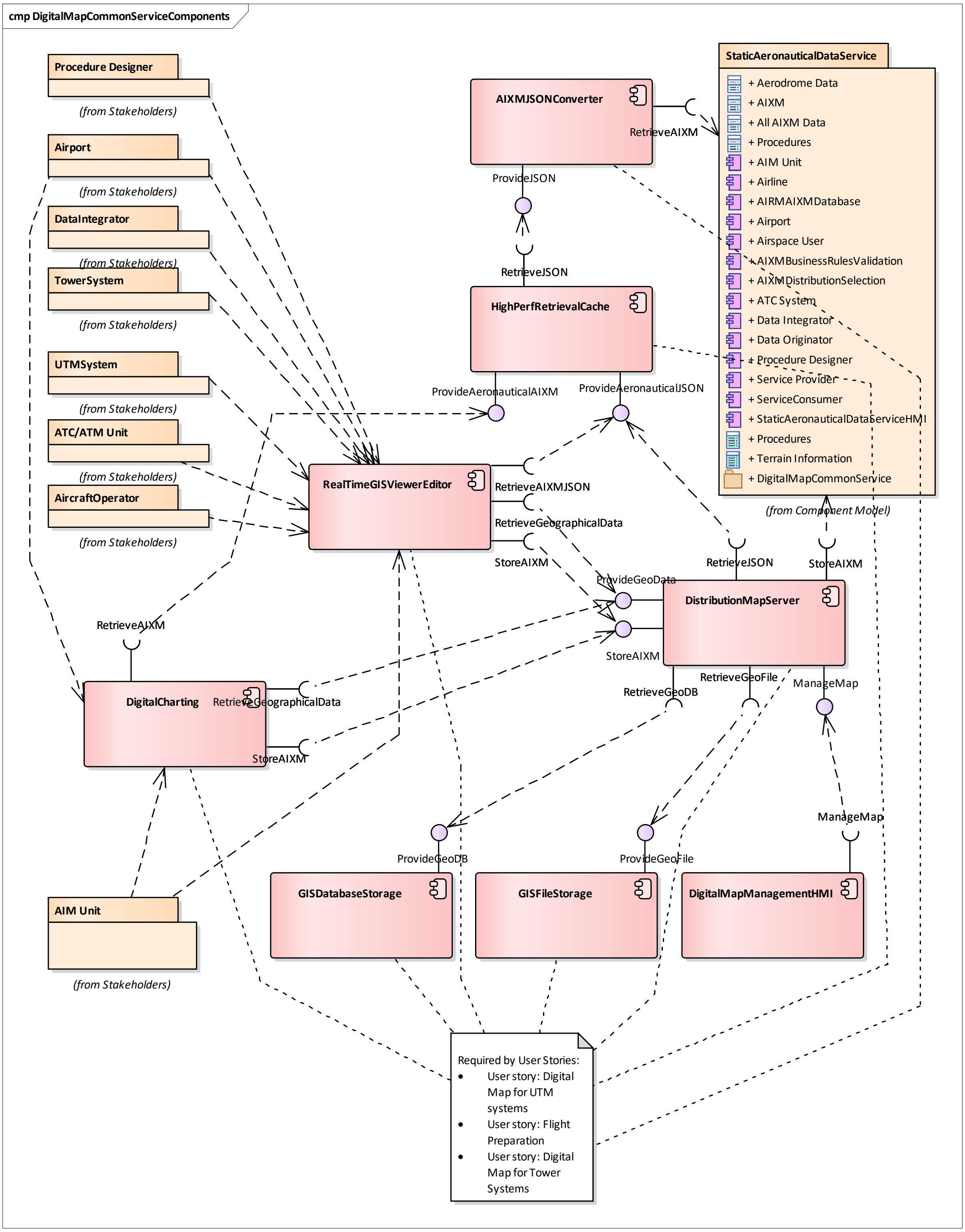

Figure 3: Component Architecture (local to Project, initial ideas)

4 Safety

No dedicated safety case of safety evaluation has been performed for the Aeronautical Information Service, however, it is assumed, that the Aeronautical Information Service will have a positive impact on safety compared to the current state, as it addresses some shortcomings of current systems by better solutions, which will contribute to safer air traffic management. The following sub-chapters try to summarize these safety arguments, which will have to be confirmed and substantiated by a formal safety analysis.

4.1 Compliance with standard data model

Currently, Aeronautical information is stored and distributed in different formats. The only binding standard currently is the dissemination in paper form in the AIP.

Industry standards like AIXM in different generations have improved the interoperability and the degree of automation, but the diversity of data formats and data models and the complexity of collecting and storing all the aeronautical information has so far led to a situation that not all required information is available in standardised formats and data models.

Even the existing centralised information management system EAD currently only requires a minimum dataset as mandatory, which is required for NOTAM and Flight Plan validation. However, e.g. details about the aerodrome runway and taxiway geometry, SID / STAR / IAP or detailed obstacles are not part of this mandatory dataset. Some ANSPs provide it, but not all.

As a result, airspace users had to make use of other, non-integrated and potentially inconsistent information (potentially inconsistent, as different data repositories with different versions of the truth may contain overall inconsistent information).

Compliance with AIRM / AIXM of the Aeronautical Information Service as a common service will help to harmonise this information and will make all of the data available.

As a result, the risk of human errors or undetected data inconsistencies, which may potentially lead to negative safety impacts, is reduced.

4.2 Standardised Interoperability / ISRM

Currently, aeronautical information is made available as data files or in paper form. Within the AIM domain, information is partially exchanged in digital form, but there are currently no standardised interfaces, which leads to interoperability problems.

As a result, some information exchanges are limited in scope to a minimum or in some cases do not occur in an automated way at all, but require human intervention.

By implementing standardised service interfaces, the information is made accessible and can be exchanged automatically. By avoiding having to use alternative data sources, which may be inconsistent and by avoiding human intervention potential data errors can be avoided.

4.3 Direct Integration into ATM / ATC

Currently, information maintained in AIM is only used for information exchange between AIM units but currently not in all cases directly shared with other ATM / ATC units. Instead, the required information is maintained manually or ingested from alternative sources.

By implementing a SWIM based information exchange, a seamless integration can be achieved. This integration avoids safety threats coming from inconsistencies, data errors and human error by automation and direct integration.

4.4 Potential Risks and Mitigations

Risks affecting the Aeronautical Information Service can be categorized into 3 classes:

- Information Discrepancy: Information items or sets are inconsistent between actors or nodes in the operational context.
- Information Corruption – Items or datasets are corrupted from their originally intended value due to errors or malicious activities
- Information Unavailability – Information items or data sets are fully or partially missing, delayed or otherwise lost

4.4.1 Risk: Aeronautical Information is valid but corrupt

4.4.1.1 Description of Risk / Hazard

Aeronautical information is consistent with rules and data formats and seems valid, but is actually incorrect or corrupt. This class of hazard cannot be detected solely by applying business rules or by correlating aeronautical information.

4.4.1.2 Mitigation

In order to mitigate such risks, an additional level of review for plausibility and correctness by human operators in the context of statistically relevant data quality reviews can be used to detect consistent and valid but incorrect information. The use of visualization (in PJ.15-11) supports human actors in identifying such errors.

4.4.2 Aeronautical Information distributed to Consumers is incomplete

4.4.2.1 Description of Risk / Hazard

Due to transmission errors or malicious activities, not all information reaches the information consumers or users.

4.4.2.2 Mitigation

By applying technical means to detect missing information (e.g. checksums, hashes, etc.) in the communication infrastructure and on application level, such risks can be addressed automatically.

SWIM ensures that the transmission of information is safe, secure and that transmission errors can be detected and mitigated.

4.4.3 Loss / Partial loss of Aeronautical Information

4.4.3.1 Description of Risk / Hazard

Substantial and relevant amounts of information are lost either during transfer or when stored in the systems. The reasons for such hazards can be system faults or failures or malicious intruders.

4.4.3.2 Mitigation

- Strong integrity and completeness checks
- State of the art cyber security
- Consequent management of access rights and authorizations
- Back-up with point in time recovery mechanisms
- Redundancy in systems and management
- SWIM ensures that the transmission of information is safe, secure and that transmission errors can be detected and mitigated.

4.4.4 Aeronautical information at Consumer is inconsistent

4.4.4.1 Description of Risk / Hazard

Aeronautical information – while consistent and complete in the common service may become inconsistent or incomplete when it reaches the information consumer. Such a hazard could e.g. occur as a result of transmission errors, malicious intruders or erroneous interpretation or processing of the downstream systems (correct information is received, but it is visualized or presented incorrectly due to errors).

4.4.4.2 Mitigation

SWIM ensures that the transmission of information is safe, secure and that transmission errors can be detected and mitigated.

By utilizing PJ.15-11, the aeronautical digital map service, it can be ensured, that a harmonized and correct representation of information is used.

By directly accessing the information from the Aeronautical Information Service instead of locally caching aeronautical information, errors coming from unavoidable replication conflicts (errors resulting from the fact that the consistency of information in distributed information repositories can not always be guaranteed) can be mitigated.

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Annex A – Additional Deployment Options

In the course of the project, the team has analysed different deployment options for the service.

The HLA for TRL2 included the following options:

- Local Deployment → no longer considered due to unfavourable risk / benefit ratio and unfavourable cost/benefit ratio
- Sub-Regional Level Deployment → no longer considered due to unfavourable cost/benefit ratio
- Regional Level Deployment → selected deployment
- Worldwide Level Deployment → currently not being considered due to the focus of SESAR 2020 on Europe

For completeness purposes, this annex describes the other options, which were not selected. Please refer to the Cost-Benefit Analysis document for further details on the commercial viability of the different deployment options.

A.1 Local Deployment

At a local level: providing static and dynamic aeronautical data within a local area (typically a country).

In this scenario, an ANSP runs the Aeronautical Digital Map Service. It can connect to regional AIM services, other national AIM services (partners) and other AIM services.

An Airport or multiple Airports would be connected as data originators and as data users to the local service.

Towers or other ATC systems would connect to the local service.

Airspace User Operational Centres would need to connect to multiple local deployments of Aeronautical Digital Map Services. Regional, Subregional and national ASM centres would also need to connect to potentially multiple Aeronautical Digital Map Service instances.

The Aeronautical Digital Map Service would connect to the local deployment of the Aeronautical Information Service for local information. If multi-national visualisation is required, multiple services need to be contacted.

Advantages:

- distributed solution, multiple parallel services
- ownership of local service
- load sharing amongst multiple instances

Disadvantages:

- Difficult cross-country alignment
- risk of inconsistencies
- cross-border conflicts
- high infrastructure cost
- each individual service needs to be disaster resilient, otherwise a part of the complete set is inaccessible
- data users need to use a registry to find valid services
- multiple services need to be contacted in order to get a complete picture
- difficult cross-country evaluation as every service takes into account only the national data set

KPA (KPI)		Performance Benefits Expectation Local deployment
Predictability (Flight Duration Variability, against RBT)		None
Flexibility		None
Safety	**Mitigation of safety risk**	Low
Human Performance		None
Interoperability		None
Cost Efficiency	**Cost of operation**	Low
Cost Efficiency	**ATCO Productivity**	None
	Technology Cost	Low

A.2 Sub-Regional Level Deployment

At a sub-regional level: providing static and dynamic aeronautical data within a sub-region (could be a FAB, grouping of countries or grouping of ANSPs)

In this scenario, instead of a single ANSP a group of ANSPs runs the Aeronautical Information Service and Aeronautical Digital Map Servoce. It can connect to regional AIM services, other national AIM services (partners) and other AIM services.

An Airport or multiple Airports would be connected as data originators and as data users to one or more sub-regional services.

Towers or other ATC systems would connect to sub-regional service instead of a local service.

Airspace User Operational Centres would need to connect to multiple sub-regional deployments of Aeronautical Information Services. Regional, other Subregional and national ASM centres would also need to connect to potentially multiple Aeronautical Information Service instances.

The Aeronautical Digital Map Service would connect to the sub-regional deployment of the Aeronautical Information Service for sub-regional information. If multi-national visualisation beyond the sub-region is required, multiple services need to be contacted.

Advantages:

- distributed solution, multiple parallel services
- load sharing amongst multiple instances
- simplified handling of inconsistencies
- improvement regarding inconsistencies amongst the members of the sub-region
- reduced infrastructure cost compared to local deployments
- less cost for resilience, as several ANSPs share a common system

Disadvantages:

- Difficult cross-country alignment
- risk of inconsistencies across sub-region borders
- cross-border conflicts across sub-region borders
- higher infrastructure cost than regional or global deployments
- each individual subregional service still needs to be disaster resilient, otherwise a part of the complete set is inaccessible
- data users need to use a registry to find valid services

- multiple services need to be contacted in order to get a complete picture
- difficult cross-border evaluation across sub-regions as every service takes into account only the subregional data set

KPA (KPI)		Performance Benefits Expectations Sub-Regional Level deployment
Predictability (Flight Duration Variability, against RBT)		None
Flexibility		None
Safety	Mitigation of safety risk	Low
Human Performance		None
Interoperability		None
Cost Efficiency	Cost of operation	Medium
Cost Efficiency	ATCO Productivity	None
	Technology Cost	Medium

A.3 Worldwide-Level Deployment

Worldwide: providing static and dynamic aeronautical data for the entire world

In this scenario, the Aeronautical Information Service is operated resiliently for a complete region (e.g. ECAC area) similar to the EAD service today. In addition to the regional deployment, the goal is for the worldwide level deployment, a worldwide data set is kept on the regional system and service is provided to world-wide clients.

So potentially, it can provide also services to users beyond the regional boundaries, e.g. airspace users coming from the US, Africa or Asia could still connect to the European system for getting a complete picture.

It can connect to regional AIM services, other national AIM services (partners) as data sources and seamlessly exchange information with other global AIM services.

Airports would be connected to a single system as data originators and as data users to a single service.

Towers or other ATC systems would connect to a single service.

Airspace User Operational Centres would only need to connect to a single deployment of a Aeronautical Digital Map Service in order to get a global picture. Regional, other Subregional and national ASM centres would also need to connect to a single Aeronautical Digital Map Service instance for global data.

The Aeronautical Digital Map Service would connect to the global deployment of the Aeronautical Information Service for all worldwide information.

Advantages:

- optimal handling of regional and global inconsistencies
- optimal regarding inconsistencies amongst all members of the region and global partners
- reduced infrastructure cost compared to local deployments and to subregional deployments
- less cost for resilience, as all ANSPs in a region share a common system
- cost optimization due to sharing of investments in a complete region
- simplest management
- data users only need to contact a single service for the whole world

Disadvantages:

- central system needs to be scalable
- multiple global services need to be synchronised → complexity

KPA (KPI)		Performance Benefits Expectations Worldwide Level deployment
Predictability (Flight Duration Variability, against RBT)		None
Flexibility		None
Safety	Mitigation of safety risk	Low
Human Performance		None
Interoperability		None
Cost Efficiency	Cost of operation	High
Cost Efficiency	ATCO Productivity	None
	Technology Cost	High