GOF2.0 D2.4 – Appendix C Geographical zones / AIM Exchange Service Service Specification

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Authoring & Approval

Authors of the document

Name/Beneficiary	Position/Title	Date
Shengnan Gao / EHANG	WP2	26.4.2021
Hui Zeng / EHANG	WP2	26.4.2021
Juha Lindstedt / Aviamaps	WP2	26.4.2021
Jose Ignacio Rodriguez / EHANG	WP2	26.4.2021
Ada Lu / EHANG	WP2	26.4.2021
Yuhang Yun / EHANG	WP2	26.4.2021
Piotr Luboński / PSNC	WP2	26.4.2021
Damian Soliwoda / PSNC	WP2	26.4.2021
Sven Jürgenson / Threod	WP2	26.4.2021
Piotr Dybiec / DroneRadar	WP2	26.4.2021
Thomas Wana / Dimetor	WP2	26.4.2021
Lukasz Gorny – Zajac / DroneRadar	WP2	26.4.2021
Tanel Järvet / CAFA Tech	WP2	26.4.2021
Parmentier Remy / Vaisala	WP2	26.4.2021
Piotr Szymaniak / PSNC	WP2	26.4.2021
Pawel Korzec / DroneRadar	WP2	26.4.2021
Gokul Srinivasan / Robots Expert	WP2	26.4.2021
Thomas Lutz / Frequentis	WP2 Lead	26.4.2021
Hubert Künig / Frequentis	WP2	26.4.2021
Peter Cornelius / Frequentis	WP2	26.4.2021
Gregor Mogeritsch / Frequentis	WP2	26.4.2021

Reviewers internal to the project

Name/Beneficiary	Position/Title	Date
Annely Aasalaid / EANS	WP2	29.4.2021
Heikko Jae / EANS	WP2	29.4.2021
Aigar Tarre / EANS	WP2	29.4.2021
Imre Rammul / EANS	WP2	29.4.2021
Armin Sutter / EANS	WP2	29.4.2021
Mateusz Kotliński/PANSA	WP2	29.4.2021
Mateusz Zych/PANSA	WP2	29.4.2021

Thomas Neubauer/Dimetor	WP2	29.4.2021
Sami Alkula / Fintraffic	WP2	29.4.2021
Nunzio Sciammetta / Airbus	WP2	29.4.2021
Maxime Meijers / Airbus	WP2	29.4.2021
Felix Lee/Ehang	WP2	29.4.2021
Pradyumna Vyshnav / Unmanned Life	WP2	29.4.2021

Approved for submission to the SJU By - Representatives of beneficiaries involved in the project

Name/Beneficiary	Position/Title	Date

Rejected By - Representatives of beneficiaries involved in the project

Name/Beneficiary	Position/Title	Date

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GOF2.0

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Abstract

This specification introduces a service of a Common Information Service (CIS) which ensures interoperability and hence transparent and reliable information flow between the stakeholders in an operational U-space environment. In accordance with ICAO SWIM, represents an Information Exchange Service.

This document describes one of these Bridge Services, the Geozones Exchange service in a logical, technology-independent manner.

Table of Contents

1 Introduction

1.1 Purpose of the document

This document describes the Geozones / AIM Service for the GOF2 USPACE project on a logical technology-independent manner, that is:

- the operational and business context of the service
    - requirements for the service (e.g., information exchange requirements)
    - involved nodes: which operational components provide/consume the service
    - operational activities supported by the service
    - relation of the service to other services
- the service description
    - service interface definitions
    - service interface operations
    - service payload definition
    - service dynamic behaviour description
- service provision and validation aspects

Furthermore, this document clearly defines the version of the service.

1.2 Scope

This document describes the Geozones / AIM service for the GOF2 USPACE project.

The Geozones / AIM service provides a means for the operational nodes of the GOF2 USPACE project to exchange necessary situational awareness information and make them available for further processing.

The Geozones / AIM service furthermore may be used in official specifications and recommendations.

1.3 Intended readership

This service specification is intended to be read by service architects, system engineers and developers in charge of designing and developing an instance of the Geozones / AIM service.

1.4 Background

1.4.1 EUROCONTROL Concept of Operations for U-space (CORUS)

EUROCONTROL CORUS [4] elaborates in 5.3 Geo-fencing and aeronautical information as follows.

"Geo-fencing appears in U1, U2 and U3 and is successively refined. It is supported by aeronautical information for drones. This table summarises the different features by level:

Service or Capability	Level	Features
Pre-Tactical Geo-Fencing	U1	Information provided before flight. The user should have access to AIP and NOTAM defined geo-fences in a form that can be used when planning and that can be loaded onto the drone if it has geo-fence fence features in its navigation system
On-drone Geo-Fencing	U1	The ability of the drone to keep itself on the correct side of a geo-fence by having geo-fence definitions (location, time, height) within its navigation system
Tactical Geo-Fencing	U2	This service delivers to the pilot and /or drone operator updates to and new definitions of Geo-Fences occurring at any time, including during flight. The creation of geo-fences with immediate effect may (tbd) require that they are defined outside the AIP. (See below)
Drone Aeronautical Information Management	U2	U2 may (tbd) include a non-AIP repository of Geo-Fences. The Drone Aeronautical Information Management service includes all information coming from such a source, combined with information from the AIP and NOTAMS together with any other drone relevant sources.
Dynamic Geo-Fencing	U3	This service delivers updates and new definitions of geofences directly into the drone, even in flight. This service relies on capabilities of the drone in U3 to receive communications from U-space and to deal with geo-fence updates.

Geo-Fences may be defined, even today, using the existing aeronautical information publishing (AIP) mechanism. A geo-fence may be defined as "Restricted Area". The existing aeronautical information *publishing mechanism is linked the 'AIRAC' cycle of 28 days. The process is well established but requires that changes, such as the definition of new geo-fences, are known weeks in advance. A "Danger Area" might also be used and has the advantage that it can be defined in advance but left inactive and then activated at short notice by a NOTAM. The Danger Area lacks the Restricted Area's concept of "entry is forbidden unless certain conditions are met" which is likely to be a necessary part of using geo-fences to define geo-cages for some operations – as in the red airspace of section 4.1.*

Creation of Geo-Fences requires accreditation. There needs to be a way for the relevant people or organisations to create geo-fences and there needs to be a way for them to establish that they are the relevant people and should have that ability. U-space will need tools and procedures for geo-fence creation and maintenance.

U2 brings the idea of Geo-Fences with immediate, or near-immediate, effect. The authors are not sure how these will be published, whether inside the AIP or outside, but that does not matter here. Immediate effect geo-fences will be used when emergency situations occur, like the need for an air ambulance to land, firefighters operating in an active fire area, or similar. U-space in U2 will have at least one channel to send this information to every drone pilot immediately. Thus we require that the U2 drone pilot is somehow connected to these communication channels and he/she monitors them.

The Emergency Management Service should signal to the pilot if an emergency has triggered the creation of a geo-fence with immediate effect in the vicinity of the flight.

If the pilot is using a Traffic Information Service for his flight (it may be mandatory, tbd) then that should signal to the pilot that the flight is the wrong side of a newly created Geo-Fence or when the flight approaches a Geo-Fence.

If the remote piloting station has a map display, then it should be updated via the Drone Aeronautical Information Management service to show any new Geo-Fence as soon as reasonably possible after its creation.

The correct response to finding that the drone is on the wrong side of a newly created geo-fence will probably depend on the exact situation but options might include landing, ditching, returning to base, flying as directly as possible to exit the geo fence or flying in some specific, prearranged way expected to minimise the chance of collision, such flying as at very low speed and very low altitude, or hovering. CORUS awaits the recommendations of the relevant bodies.

U3 brings the direct communication of Geo-Fences to the drone. This augments the U2 service by having the drone react without the need for the remote pilot to get involved. There will need to be a way to inhibit this for those drone flights that have permission to cross or be inside any geo-fence. Or for operators / pilots who prefer to maintain manual control. "

1.4.2 Institute of Aeronautics and Astronautics CONOPS

[5] Unmanned Aircraft Concept of Operation of the American Institute of Aeronautics and Astronautics defines ANSP and UAS Operator responsibility as follows.

Regulator/ANSP Responsibility	UAS Operator /USS Responsibility
• Set performance based regulatory environment • Define and update airspace constraints • Foster collaboration among UAS by setting up architecture for data and information exchange • Define data and information exchange specifications for collaboration among multiple stakeholders/operators • Real-time airspace control if demand/capacity imbalance is expected • Provide notifications to UAS operators and public • Set static and dynamic geo-fence areas • Provide flexibility as much as possible and structures (routes, corridors, altitude for direction, crossing restriction) only if necessary • Manage access to controlled airspace and entry/exiting operations	• Register UAS • Training and qualification of operators • Avoid other aircraft, terrain, and obstacles • Don't harm people and animals • Respect airspace constraints • Avoid dangerous and incompatible weather situations • Follow performance based regulation • Broadcast identity – no anonymous flying • Broadcast intent • Provide access to operations plans • Detect, sense and avoid manned aircraft predicated on right of way rules • Status and intent exchange according to ANSP standards • Participate in collaborative decision making • Contingency planning and response (large-scale outages – cell, GPS, security, an unanticipated severe weather)

"…The ANSP defines and updates the airspace constraints as necessary in real time, for example if airport configurations change or certain airspaces have to be closed. The interactions between the ANSP and UAS operators/USS will be primarily governed through Interface Control Documents (ICD) and Application Programming Interface (API) based integration of the components. This will create an architecture that will foster collaboration and information exchange among multiple stakeholders. The ANSP may add static or dynamic geo-fences or other means of airspace control and provide notifications to operators and other stakeholders. The regulator/ANSP will also manage access to controlled airspace. …"

1.4.3 Global UTM Association (GUTMA)

Global UTM Association (GUTMA) describes in the first version of the UAS Traffic Management Architecture [6] the UAS Traffic Management System as follows in Figure 1. Aeronautical Info Service is described between UAS Traffic Management System and ATM System(s).

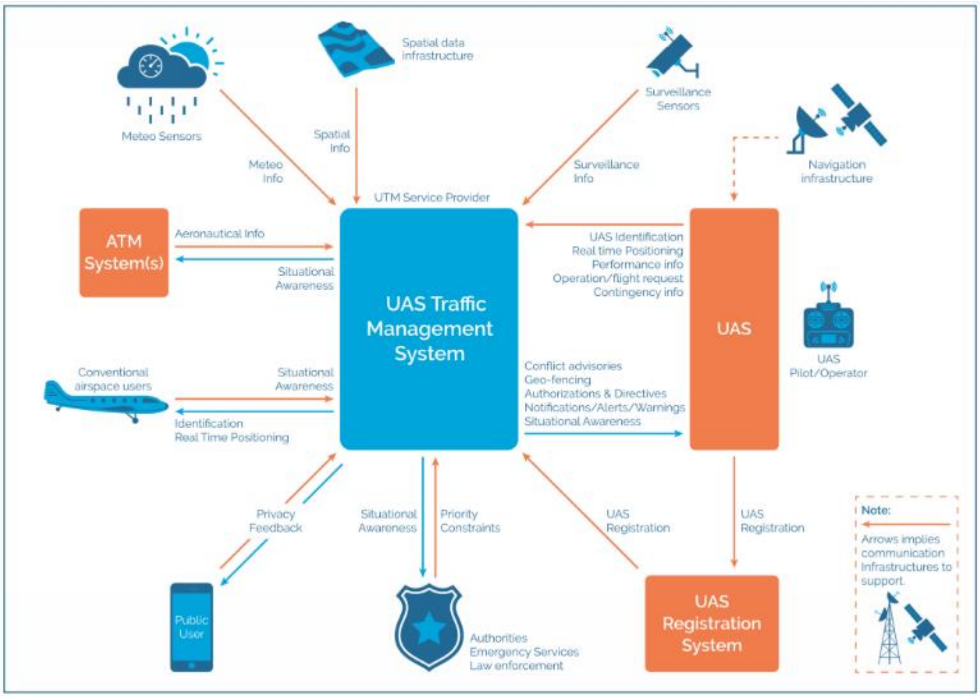


Figure 1: GUTMA UAS TM

1.4.4 Federal Aviation Administration (FAA) Concepts of Operations

"FIMS is a gateway for data exchange between UTM participants and FAA systems, through which the FAA can provide directives and make relevant NAS information available to UAS Operators via the USS Network. The FAA also uses this gateway as an access point for information on operations (as required) and is informed about any situations that could have an impact on the NAS. FIMS provides a mechanism for common situational awareness among all UTM participants and is a central component of the overall UTM ecosystem. FIMS is the UTM component the FAA will build and manage to support UTM operations."

The FAA defines a messaging service in its *Concepts of Operations v1.0 - Appendix C - UTM Services - Airspace Authorization Service*[7] as follows.

"A service which provides airspace authorization from the Airspace Authority/Air Navigation Service Provider to a UAS Operator."

1.4.5 Swiss Federal Office of Civil Aviation (FOCA)

From the FOCA *Concepts of Operations v1.0* [8], section 3.5.5 – Airspace Authorization Service:

"A service, which provides the needed authorizations to fly from the Airspace Authority/ANSP to a UAS Operator. It fulfils following functions:

- *To provide the opportunity for the pilot and/or the Operator to request an authorization.*
- *To automatically approve requests when possible*

- *To transmit authorization requests to competent authorities when automatic approval is not possible*
- *To support the Air Traffic Control (ATC) or other relevant stakeholders in managing the authorization requests*
- *To notify other relevant parties of issued authorizations*

This service benefits the UAS Operator, the pilot, as well as the competent authorities. Airspace Authorization will be managed digitally with efficiency gains for all actors involved."

1.4.6 International Civil Aviation Organization (ICAO)

ICAO Doc 10039 [2] elaborates in section *3.4 INFORMATION EXCHANGE SERVICES* on information exchange services as follow (para. 3.4.2).

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

1.4.7 SESAR-JU

The European Commission identifies an increasing demand for a non-segregated use of airspace which is being driven by a rapidly growing market of Very-Low-Level (VLL) airspace users, most of which are expected to be drones.

Via the Roadmap for the safe integration of drones into all classes of airspace [9], within the European ATM Masterplan [10], the European Commission seeks to ensure that this rapid growth of airspace use happens in a safe and controlled manner.

SESAR develops the required concepts and demonstrations for this process to happen. The roadmap [1], in alignment with ICAO recommendations, identifies three phases for the integration, from which SESAR derives the four U-space service blocks presented in the U-space blueprint [18],

- U-space foundation services,
- U-space initial services,
- U-space advanced services, and
- U-space full services.

These stages reflect the anticipated quick growth of demand for U-space services. The state of the art is being validated throughout Europe via several Very Large Demonstrator (VLD) projects such as the **Error! Reference source not found.** project.

The European ATM Master Plan describes the drone aeronautical information management as part of U2 – U-Space initial services as follows.

"Drone aeronautical information management.

This service provides the operator with relevant aeronautical information for drone operations. It will

connect to the Aeronautical information service (AIS) to guarantee coherent information provision for manned and unmanned operators."

1.4.8 SESAR-JU DREAMS

The SESAR JU DREAMS U-Space scenarios [11]are describing in Scenario 6, Long range operations, the aeronautical information service as follows.

"The U–space application requests the Drone aeronautical information management service (Drone AIM) service information about the drones flying in the vicinity. The Drone AIM service updates the information by requesting the Flight planning management service the active flight plans. As a bonus, the U–space application could also provide information about the presence of general aviation traffic to drone users, using the same interface."

As described in chapter 5.2 Gap analysis of DREAMS Gap Analysis, [12], data comparison between demand and supply was considered for further validation:

Information categories		Information supply		Information demand		
		Manned aviation	UTM service providers	U-Space Services	Survey results	Scenario Identification
Flow management	Urban airspace capacity management			U3		X
	High-density traffic management					X
	De-confliction management	FIXM	X	U1/U2	X	X
	Congestion management	FIXM				X
	Urban airspace intrinsic and strategic conflict risk reduction					X
	First/Last 50ft operations					X
	Drone delivery hub capacity management					X
	Controlled airspace data	AIXM	X	U1	X	X
	Hyperlocal airspace data					X
	Dynamic geofencing		X	U3	X	X
	Static geofencing		X	U1/U2	X	X
Communication	GNSS coverage map	AIXM/XML			X	X
	4G/5G coverage map				X	X
	ATC-Drone operator/User communication link			U2	X	X
	U-Space user chat service					X
	High quality video datalink					X
	Law enforcement	AIXM		U1	X	X
	Authorities			U1		

Figure 2: DREAMS Gap analysis extract [12]

Also within the GOF-U-space project, a thorough use-case centric analysis was brought underway focusing on how to leverage a common data storage and -management for ATM and UTM. This approach is highly important to satisfy needs for interoperability, stakeholder collaboration and data quality. In this context, a strong focus was put on the storage and management of geofences as airspace volume outer shells to convey geospatial restrictions for UTM operations.

Since AIXM (in its 5.1 version) constitutes a current industry standard to store and share aeronautical static and dynamic information within a SWIM enabled environment, the GOF-U-space project did also focus on assessing whether AIXM is suitable format to manage geofenced airspace volumes and properties needed.

GOF2 Update:

Although AIXM-based services are still standard in legacy airspace management, moving to UAS airspaces requires additional converters to provide data conforming to new data format.

1.5 Operational systems

1.5.1 PANSA

1.5.1.1 Geopraphical zones implementation

Legal background and assumptions

Airspace structures presented to UAS users on basis of art. 15 of the Regulation 2019/947 are called UAS geographical zones.

Art. 15 - Operational conditions for UAS geographical zones

When defining UAS geographical zones for safety, security, privacy or environmental reasons, Member States may: (a) prohibit certain or all UAS operations, request particular conditions for certain or all UAS operations or request a prior operational authorisation for certain or all UAS operations; (b) subject UAS operations to specified environmental standards; (c) allow access to certain UAS classes only; (d) allow access only to UAS equipped with certain technical features, in particular remote identification systems or geo awareness systems.

2. On the basis of a risk assessment carried out by the competent authority, Member States may designate certain geographical zones in which UAS operations are exempt from one or more of the 'open' category requirements.

3. When pursuant to paragraphs 1 or 2 Member States define UAS geographical zones, for geo awareness purposes they shall ensure that the information on the UAS geographical zones, including their period of validity, is made publicly available in a common unique digital format.

Art. 18 – Tasks of Competent Authority

(f) making available in a common unique digital format information on UAS geographical zones identified by the Member States and established within the national airspace of its State;

Common unique digital format will be published in the AMC to the Regulation 2019/947.

COMMISSION IMPLEMENTING REGULATION (EU) …/... of XXX on a regulatory framework for the U-space (U-space regulation)

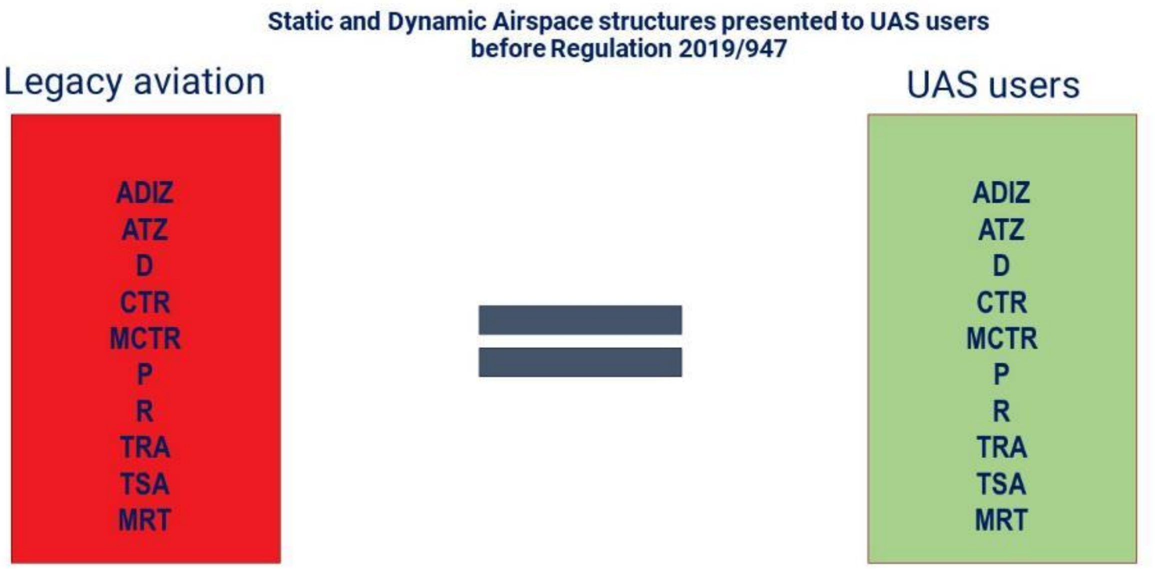
Art. 2 (1) 'U-space airspace' means a UAS geographical zone designated by Member States, where UAS operations are only allowed to take place with the support of U-space services;

According to *art. 5 (e) UAS geographical zones relevant to the U-space airspace and published by Member States in accordance with Implementing Regulation (EU) 2019/947;*

When Member States define UAS geographical zones for safety, security, privacy or environmental reasons as provided for in Implementing Regulation (EU) 2019/947, they may impose specific conditions for certain or all UAS operations or allow access only to UAS equipped with certain technical features.

Aeronautical information data publication for UAS operators.

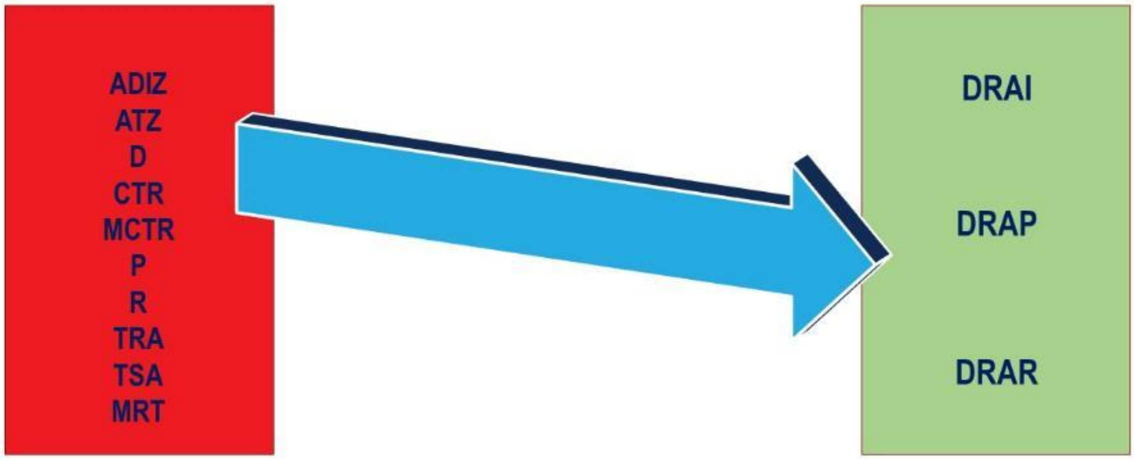
Before entering into force 2019/947 – static and dynamic airspace structures to UAS users. Airspace structures published for legacy aviation were published in the same manner to UAS users.



The regulation 2019/947 changed the way of presenting data to UAS users introducing the concept of geographical zones. In order to create consistency in the aeronautical data presented to the UAS users, the legacy aviation airspace structures should be translated to the language of geographical zones and new characteristics.

Note: The names of the geographical zones presented in this document are official in the certified PansaUTM system and may be used as an example of possible way to tackle them into European legislation.

Phase 1 Translation of „legacy airspace structures" to geographical zones



The geographical zones which will be published solely for the purposes of UAS operations will be not connected to existing airspace structures.

Phase 2 Publishing geographical zones on basis of 2019/947 and U-space regulation

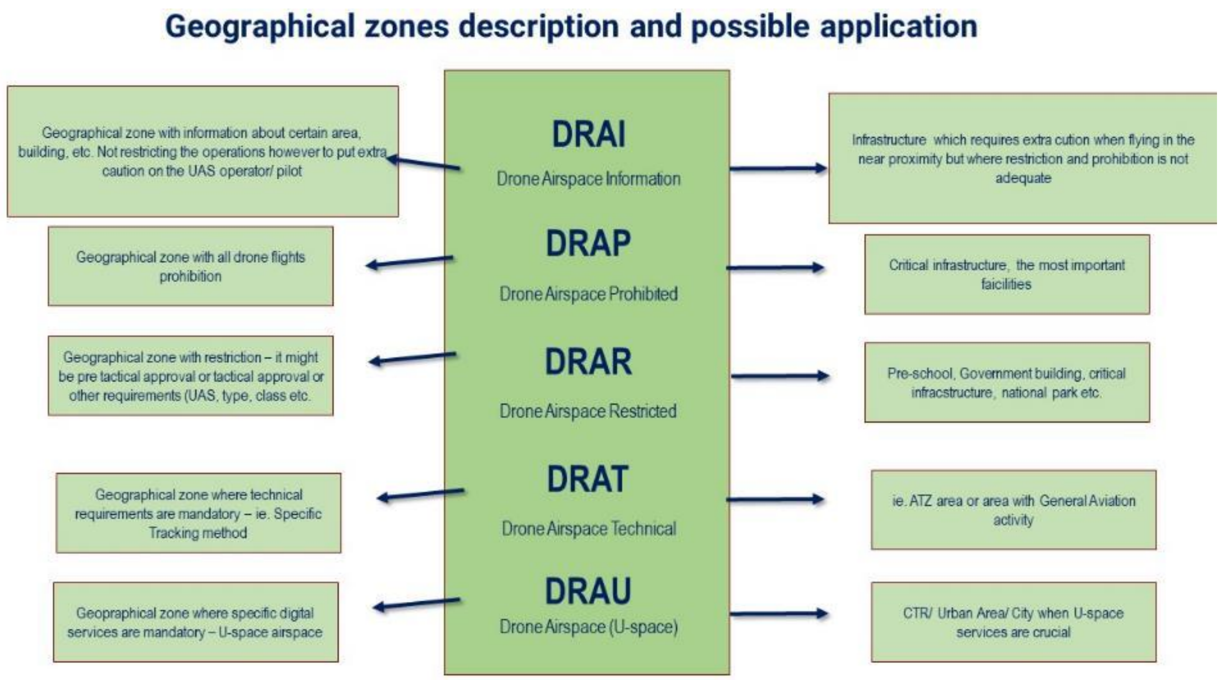
The approach proposed by PANSA also considers the needs of UAS Pilots. Based on the experience gained in managing tactical approvals (more than 10 000), the hereby proposed Geozones concept also includes information about the likelihood (probability) of obtaining approval to fly. Also bearing in mind that there may be a need for an airspace defining only the boundaries of the U-space, the proposal takes this need into account. Different type of geographical zone serve different purposes.

The example of geographical zones types:

No	Proposed name	Function / Description
1	DRA-RH	restricted area for UAS with a high probability of obtaining approval for the operations
2	DRA-RM	restricted area for unmanned aerial vehicle systems with average probability of obtaining approval for the operations
3	DRA-RL	restricted area for UAS with a low probability of obtaining approval for the operations
4	DRA-RL	restricted area for UAS with a low probability of obtaining approval for the operations
5	DRA-P	prohibited area for UAS, in which UAS operations cannot be performed
6	DRA-I	information area for unmanned aerial vehicles, containing information necessary to ensure the safety of operations with the use of unmanned aerial vehicles, including navigational warnings
7	DRA-T	a restricted area for UAS, in which UAS operations may be performed only with the use of UAS that meet the technical requirements indicated by the Agency and under the conditions specified by the Agency, if such conditions for a given zone have been determined
8	DRA-U	a geographic zone for UAS where UAS operations can only be performed with the support of specific, verified services provided in this area and under the conditions specified by the Competent Authority, after U-space regulation implementation – the U-space airspace

restricted area for UAS with a high probability of obtaining approval for the operations

All the proposed geographical zones could be used to address the general reasons for geographical zones publications stated in art. 15 of Regulation 2019/947, namely: safety, security, privacy or environmental reasons. The procedure of geographical zones publication is subject to competent authority.



Overall Geozones naming convention with activity triggers

	24h	AIRAC	FUA AUP/UUP	NOTAM	Non-aviation timing	Geozone naming convention ACTIVE
CTR		x		x		DRAR
CTR1km		x		x		DRAR
CTR6km		x		x		DRAR
RPA Blue		x		x		DRAR
RPA Green		x		x		DRAR
RPA Yellow		x		x		DRAR
RPA Red		x		x		DRAR
MCTR		x	x	x		DRAR
MCTR2km	x					DRAR
TMA		x		x		DRAP
MTMA		x	x	x		DRAP
RMZ		x		x		DRAR ?
TRA		x	x	x		DRAR
TSA		x	x	x		DRAP
P		x				DRAR
D		x	x	x		DRAR
R		x	x*	x		DRAR
ATZ		x	x	x		DRAR
ATZ1km		x	x	x		DRAR
ATZ6km		x	x	x		DRAR
MRT		x	x			DRAP
TFR		x	x			DRAP
AAA		x		x		DRAI
NW		x		x		DRAI
ADIZ	x					DRAR
DRAI					x	DRAI
DRAR					x	DRAR
DRAP					x	DRAP
DRAT					x	
DRAU					x	
FIS	x					

Figure 3 Table of proposed PANSA Geozones types mapping

**It should be taken into account the distinction between the entire volume of aeronautical R airspace and only the protected area, such as e.g. building*

1.5.2 AVINOR

In an integrated approach, geo awareness is provided for both UAS Operators and Air Traffic Controllers in daily operations. Aeronautical information is combined with so called NDZ (No Drone Zones) and displayed in map overlays, which are tailored for the user group.

NDZ can be retrieved from authorized sources, or manually created by authorized ATC personnel. They are modelled as 4D volumes, can hold additional information such as labels, reasons, restrictions/permissions, and metadata. For a short term NDZ, providing a 4D volume and very few mandatory attributes are sufficient.

The aim is to reduce workload on controllers and operators. Focus is put on presenting go/no go information, providing more details where relevant or on user request/action (e.g. for AIM data).

The UTM system uses NDZ to assist controllers in operation plan processing, e.g. in approval processes or in case airspace is closed, notifying affected operations.

1.6 Glossary of terms

Term	Definition
Alerting	The Geoawaraness function shell provide the remote pilot with Geowareness warning alert when a potential or actual breach of airspace restrictions (as defined by the UAS Geozone information) is detected, either in horizontal plane in vertical axis or both. The time or threshold to alert shall be defined by the manufacturer, taking into account the subsequent reaction time and trajectory correction manoeuvre span, in order to avoid the UAS penetrating the forbidden zone. Margin on limits (meaning additional distance to the border) shall be defined and implemented by the manufacturer, taking into account the accuracy of the UAS position/altitude measurement which is compared to the geographical limit. [25] Alerting as described here is a conformance service, which should be combined with telemetry service, not Geozones service.

UAS geographical zone	*4D* part of airspace defined as geoshape with vertical projection limits and time window, established by the competent authority that facilitates, restricts or excludes UAS operations in order to address risks part [24]
External Data Model	Describes the semantics of the domain (or a significant part thereof) by defining data structures and their relations. This could be at logical level (e.g., in UML) or at physical level (e.g., in XSD schema definitions), as for example standard data models.
Geofencing	The overall Geo-fencing provides the capability to use airspace volumes (geographic fences) to control operations of UAS. [13] Old umbrella term for defining airspaces function (it made a sense when only NFZs were used).
Geoshape	A series of geographical coordinates and dimensions that define a geometrical shape by means of polygons or circles.[25] While a term 'circle' is widely used in industry, its mathematical definition - every point on circle is equistand to centre – and projecting it on ellipsoid/geoid causes problems. Implementations of machine intersections/within checks and HMI display usually interpolates curves to lines, and due to lack of standard conversion definition, it may yield different results.
Height/Altitude limits	The Geozone data format enables to set per zone lower/upper altitude limits (Above Mean Sea Level) or heights (Above Ground Level). The reference and unit of measurement are sent along with the data. [25]
Message Exchange Pattern	Describes the principles how two different parts of a message passing system (in our case: the service provider and the service consumer) interact and communicate with each other. Examples: In the Request/Response MEP, the service consumer sends a request to the service provider in order to obtain certain information; the service provider provides the requested information in a dedicated response. In the Publish/Subscribe MEP, the service consumer establishes a subscription with the service provider in order to obtain certain information; the service provider publishes information (either in regular intervals or upon change) to all subscribed service consumers.
Operational Activity	An activity performed by an operational node. Examples of operational activities are: Route Planning, Route Optimization, Logistics, Safety, Weather Forecast Provision, …
Operational Model	A structure of operational nodes and associated operational activities and their inter-relations in a process model.

Operational Node	A logical entity that performs activities. Note: nodes are specified independently of any physical realisation. Examples of operational nodes are: Control Center, Authority, Weather Information Provider, …
Service	The provision of something (a non-physical object), by one, for the use of one or more others, regulated by formal definitions and mutual agreements. 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.
Service Consumer	A service consumer uses service instances provided by service providers.
Service Data Model	Formal description of one dedicated service at logical level. The service data model is part of the service specification. Is typically defined in UML and/or XSD. If an external data model exists (e.g., a standard data model), then the service data model shall refer to it: each data item of the service data model shall be mapped to a data item defined in the external data model.
Service Design Description	Documents the details of a service technical design (most likely documented by the service implementer). The service design description includes (but is not limited to) a service physical data model and describes the used technology, transport mechanism, quality of service, etc.
Service Implementation	The provider side implementation of a dedicated service technical design (i.e., implementation of a dedicated service in a dedicated technology).
Service Implementer	Implementers of services from the service provider side and/or the service consumer side.
Service Instance	One service implementation may be deployed at several places by same or different service providers; each such deployment represents a different service instance, being accessible via different URLs.
Service Instance Description	Documents the details of a service implementation (most likely documented by the service implementer) and deployment (most likely documented by the service provider). The service instance description includes (but is not limited to) service technical design reference, service provider reference, service access information, service coverage information, etc.
Service Interface	The communication mechanism of the service, i.e., interaction mechanism between service provider and service consumer. A service interface is characterised by a message exchange pattern and consists of service operations that are either allocated to the provider or the consumer of the service.
Service Operation	Functions or procedure which enables programmatic communication with a service via a service interface.

Service Physical Data Model	Describes the realisation of a dedicated service data model in a dedicated technology. This includes a detailed description of the data payload to be exchanged using the chosen technology. The actual format of the service physical data model depends on the chosen technology. Examples may be WSDL and XSD files (e.g., for SOAP services) or swagger (Open API) specifications (e.g., for REST services). If an external data model exists (e.g., a standard data model), then the service physical data model shall refer to it: each data item of the service physical data model shall be mapped to a data item defined in the external data model. In order to prove correct implementation of the service specification, there shall exist a mapping between the service physical data model and the service data model. This means, each data item used in the service physical data model shall be mapped to a corresponding data item of the service data model. (In case of existing mappings to a common external (standard) data model from both the service data model and the service physical data model, such a mapping is implicitly given.)
Service Provider	A service provider provides instances of services according to a service specification and service instance description. All users within the domain can be service providers, e.g., authorities, organizations (e.g., meteorological), commercial service providers, etc.
Service Specification	Describes one dedicated service at logical level. The Service Specification is technology-agnostic. The Service Specification includes (but is not limited to) a description of the Service Interfaces and Service Operations with their data payload. The data payload description may be formally defined by a Service Data Model.
Service Specification Producer	Producers of service specifications in accordance with the service documentation guidelines.
Service Technical Design	The technical design of a dedicated service in a dedicated technology. One service specification may result in several technical service designs, realising the service with different or same technologies.
Service Technology Catalogue	List and specifications of allowed technologies for service implementations. Currently, SOAP and REST are envisaged to be allowed service technologies. The service technology catalogue shall describe in detail the allowed service profiles, e.g., by listing communication standards, security standards, stacks, bindings, etc.
Spatial Exclusiveness	A service specification is characterised as "spatially exclusive", if in any geographical region just one service instance of that specification is allowed to be registered per technology. The decision, which service instance (out of a number of available spatially exclusive services) shall be registered for a certain geographical region, is a governance issue.

Table: Glossary of terms

1.7 List of Acronyms

Acronym	Definition
API	Application Programming Interface
HMI	Human Machine Interface
JSON	JavaScript Object Notation
MEP	Message Exchange Pattern
NAF	NATO Architectural Framework
REST	Representational State Transfer
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SSD	Service Specification Document
UML	Unified Modelling Language
URL	Uniform Resource Locator
WSDL	Web Service Definition Language
XML	Extendible Mark-up Language
XSD	XML Schema Definition

Table: List of acronyms

2 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.

Name	*GeozonesExchangeService*
ID	*urn:gof:services:GeozonesExchangeService*
Version	*2.0*
Description	An information exchange service which provides Geozones information
Keywords	*Airspace, Geozones, AIM*
Architect(s)	*2021-today The GOF 2.0 Project Consortium* *2020-2021 The Frequentis Group* 2020-2021 Droneradar Sp. z o.o. *2018-2020 The GOF U-Space Project Consortium*
Status	*Provisional*

Table: Service Identification

3 Operational Context

This section describes the context of the service from an operational perspective.

3.1 Functional and Non-functional Requirements

The table below lists applicable existing requirements for the Geozones service.

Requirement Id	Requirement Name	Requirement Text	References
[R-1]	Common Situational Awareness	At all times, all airspace users as well as ATC shall operate on the same common set of data, during pre-flight planning stages as well as during all stages of flight operations.	CORUS [4], 4.1.1.2 Amber airspace; B1-RPAS [17]; CEF-SESAR-2018-1 [1], Objective O5
[R-2]	SWIM	The implementation of a UTM Flight Information Management System (FIMS) shall be based on an ICAO SWIM-compliant architecture.	CEF-SESAR-2018-1 [1], 5.3.4 Overall approach and methodology
[R-3]	Interoperability	There shall be an implementation of a Flight Information Management System (FIMS) which ensures that, at all times, emerging unmanned traffic management systems and existing technologies from manned operations can exchange any data required to support such common situational awareness, be it for drone operations in areas where established ATC procedures apply, or in zones outside established ATC.	ICAO Doc 10039 [2]; CEF-SESAR-2018-1 [1], Objective O6; CEF-SESAR-2018-1 [1], Table 8 – Key Challenges
[R-4]	Regulatory Framework	The U-space concept shall allow regulators to define a framework to pro-actively steer unmanned traffic and declare restricted or closed areas for unmanned aviation. These properties may be permanent or activated according to schedules or following ad-hoc notice. Regulation is desired i.e. for the purpose of protection of critical infrastructure, privacy of residents, noise abatement, natural conservation or security	

Requirement Id	Requirement Name	Requirement Text	References
		concerns. The regulator may offer a granular definition of rules and procedures applicable for restricted areas.	
[R-5]	Georeferenced volumes	Restrictive airspace is to be defined as georeferenced volumes with altitude thresholds to offer maximal flexibility.	
[R-6]	Static Data Usage	There shall be a single source for static aeronautical data provision for pre-flight and inflight operations to be used for both, the U-space as well as legacy aviation.	
[R-7]	Static Data Management	Static Data shall be maintained by dedicated local ANSP in close collaboration with the local regulators and other relevant authorities. The Static Data maintenance shall follow the established process of data origination, data management and data provision.	
[R-8]	Dynamic Data Usage	There shall be a single source for dynamic aeronautical data provision to be referenced for both, the U-space as well as manned aviation.	
[R-9]	Dynamic Data Management for U-Space	Dynamic Data feeds relevant for unmanned aviation only , shall be retrieved by the ANSP as a trusted source input (e.g. a notification input from a public safety control centre) and automatically processed to the data store.	
[R-10]	Error Handling in Data Feeds	Dedicated ATM supervisors in the respective responsible area control centres or TMAs shall have access to an error queue to manually manage any inconsistences deriving from ad-hoc restrictions to certain areas for unmanned aviation.	
[R-11]	Incident Management	Registered aircraft (trusted source with privilege access) shall be able to trigger automated creations of restricted geofence volumes once they are involved in an incident inspection and transmit a data message with GML and radius information. This will allow a faster notification to other unmanned airspace users.	
[R-12]	Alert	In case an area (volume) has been restricted by the regulator or ad-hoc by public safety, etc., an	

Requirement Id	Requirement Name	Requirement Text	References
		alert shall be sent to all U-space users currently planning to depart, transit or arrive at the defined and recently restricted geofence.	
[R-13]	U-Space Flight Planning	Flight Plans shall be validated against established airspace volumes, their status and other airspace restrictions through which the unmanned aircraft is planning to fly. In case of a regulatory restriction, an alternative routing shall be offered to avoid restricted areas.	
[R-14]	Data Quality Assurance	All data consumed by the U-space shall be ADQ grade information (according to EU-Regulation 73/2010), thus ensuring the highest level of data quality for all airspace users regardless of manned or unmanned operations.	*European Regulation 73/2010 & ICAO Annex 15*
[R-15]	Basis for Open Market	The U-space concept shall be designed such as to ensure a well-established line of authority while at the same time ensuring that an open market for VLL services may develop.	*SESAR Drone Roadmap [9], Foreword, 4.1 and 4.2;* *U-space Blueprint [18], Benefits to European society and economy;* *CEF-SESAR-2018-1 [1], Table 8 – Key Challenges*
[R-16]	Open Interfaces	Any interface and protocol hence must be openly defined and its definition be freely accessible in order to ensure the lowest level of obstruction for an open VLL airspace use market to develop.	*CEF-SESAR-2018-1 [1], Table 8 – Key Challenges*
[R-17]	Latency	The AIXM store shall respond with minimal latency to not delay changes in airspace volume configuration and restrictions changed ad-hoc in daily operations.	
[R-18]	UAS Registration	Every unmanned aircraft shall be identifiable by UTM and ATM and relevant State authorities. Next to the unique registration identifier,	

Requirement Id	Requirement Name	Requirement Text	References
		information on the type of aircraft shall also be transmitted taccording to EASA specification	
[R-19]	Audit Trail	Any creation, update, withdrawal or exchange of data and notifications/alerts shall be logged in a detailed audit trail to be able to allow complete and transparent recovery of the history of actions.	

Table 1: Requirements for the Geozones service

3.2 Other Constraints

3.2.1 Relevant Industrial Standards

3.2.1.1 ICAO SWIM

The System Wide Information Management (SWIM, [2]) complements human-to-human with machine-to-machine communication, and improves data distribution and accessibility in terms of quality of the data exchanged. The SWIM Concept addresses the challenge of creating an "interoperability environment" which allows the SWIM IT systems to cope with the full complexity of operational information exchanges. The SWIM environment shifts the ATM information architecture paradigm from point-to-point data exchanges to system-wide interoperability.

3.2.1.2 AIXM – Aeronautical Information Exchange Model

To comply with ICAO global and regional requirements for the provision for aeronautical information in the context of the evolution towards SWIM, AIXM is aiming to enable the provision of aeronautical information in digital format. [14][12]

The following main information areas are in the scope of AIXM:

- Aerodrome/Heliport including movement areas, services, facilities, etc.
- Airspace structures
- Organisations and units, including services
- Points and Navaids
- Procedures
- Routes
- Flying restrictions

AIXM 4.5

AIXM 4.5 was published in 2005, as an update of an earlier AIXM 3.3 version, which was originally developed by Eurocontrol for the needs of the European AIS Database (EAD) project. It comprises an entity-relationship data model (called "AICM") and an XML Schema.

AIXM 4.5 is still in use in many systems around the world, in particular for the coding of a subset of the static aeronautical data.

AIXM 5.0

AIXM 5.0 constituted a significant leap-forward in the evolution of the model. Starting from the experience accumulated with the operational implementation of the earlier versions, in particular AIXM 4.5, the objective was to take advantages of established information engineering standards, in particular Unified Modelling Language (UML) and the ISO-OGC standards for geographical information encoding and provision.

Main differences between AIXM 4.5 and AIXM 5 are given bellow:

Topic	AIXM 4.5	AIXM 5
Data Scope	Only Static Data	Static and Dynamic Data, enabling Digital NOTAM
Geographical Elements	XML	XML/GML (ISO standard for geometry)
Temporality	Temporality is a property of the message Supports only static data	Temporality is a property of the aeronautical feature, Supports both static and dynamic data
Model Extensibility	Limited extensibility (part of local system)	Defined extensibility concept for the AIXM Schema

Current version: AIXM 5.1 /5.1.1

Followed soon (in 2010) as an updated version of the initial AIXM 5.0. Many existing implementations have made the transition from AIXM 4.5 to AIXM 5.1 and newly developed AIS systems use AIXM 5.1.

3.2.1.3 FIXM – Flight Information Exchange Model

The ICAO Flight and Flow Information for a Collaborative Environment concept provides a globally harmonized process for planning and providing consistent flight information. It is guided by the requirement to eliminate or reduce the limitations of the present Flight Plan and to accommodate the future environment detailed in the Global Air Traffic Management Operational Concept.

FIXM is one component belonging to the Information Exchange Models layer of the SWIM Global Interoperability Framework described by the ICAO SWIM concept (ICAO Doc 10039), which is being refined by the ICAO Information Management Panel (IMP). FIXM therefore monitors the work and conclusions of this panel and will align over time with any relevant recommendations from this panel, as appropriate. [15]

The current version of FIXM format is v4.1.0 and was released in December, 2017.

3.2.1.4 IWXXM – ICAO Weather Information Exchange Model

The Weather Information Exchange Models and Schema are designed to enable a platform independent, harmonized and interoperable meteorological information exchange covering all the needs of the air transport industry.

The WXXM follows the GML object-property model, which requires the properties of objects to be encapsulated by a simple type (domain value). Should a 'property' consist of a complex object or feature, the relationship must be represented through the use of an association. [16]

3.2.1.5 Network Availability Coverage

New service: Information about Network availability (Coverage) in 4D airspace - DIAMETOR

In order to enable Beyond Visual Line Of Sight (BVLOS) operations at scale, UAVs need reliable connectivity. To ensure that flight planning can include information on where such connectivity is available, additional data from connectivity providers is required.

In particular, for safety it is necessary to understand where cellular coverage is available to support the needs of the mission. "Coverage" implies a range of requirements such as signal level, interference, dynamic handover/switchover behavior and others to enable a minimum connectivity performance along a flight route in a technology and spectrum independent manner. "Coverage" for a communication service provider (CSP) is also a synonym for "signal availability", whereas in aviation terms it is typically a combination of sufficient availability, continuity, latency and integrity [EUROCAE ER012, RTCA DO 377].

Interfaces are being established to harmonize the data exchange between CSPs and the aviation eco-systems.

3.2.1.6 ASTM UTM Protocol

Based on publicly available OpenAPI specification, new ASTM protocol draft is similar to ED-269 but more concentrated on American/FAA approach, and little bit less suitable for GOF2

Source: https://github.com/astm-utm/Protocol

3.2.1.7 ISO/DIS 23629-7

In 2020 new ISO standard for UAS traffic management emerged. Important part for the scope of this document is ISO/DIS 23629-7: Data model for spatial data, (final draft stage at the moment of writing this document).

The standard is rather simple and format-agnostic. Supported airspace attributes are:

- Identifier
- Generate time
- Disappearance time
- Maximum height

- Minimum height
- Type of height
- Shape (polygon or circle)
- Location (centroid)
- Administration contact details
- Conditions for operation
- Availability of UTM services
- Type of airspace

In the light of above requirements, and missing attributes – especially time-related (I.e. missing activation times) - GOF 2.0 Geozones data-model should be a superset of ISO/DIS 23629-7 format.

As a side note: aforementioned standard also defines other important entities, like obstacles, flight routes, take-off and landing areas, CNS coverage and dynamic phenomena, but they are beyond of the scope of this document.

3.2.1.8 ED-269

Another new document is EUROCAE ED-269 - 'Minimum Operational Performance Standard for Geofencing'. It is probably most mature approach, supporting most of the requirements we've met during development of operational systems.

- Most important aspects are:
- Clearly defined format
- Support of multiple airspace volumes per airspace,
- Support of airspace activity periods.
- Services definition: both Pub-Sub and retrieval/updateRetrieval

Although there are some relatively minor issues within the format, we recommend to use it as a base of GOF 2.0 geozones service(s). For more in-depth view see chapters related to Service implementation.

3.3 Operational Stakeholders

Aeronautical information comprises both dynamic and static data enabling safe navigation for airspace users.

The data usually designated by the term 'Static Data' is the data known to the aviation world and documented in publications such as AIP, e.g. FIR(s), Aerodromes, Navigation Aids, Areas, Maps, Rules, Subjects to which a NOTAM may be related and other aeronautical information such AIC, etc.

Static data are long-term data and are updated according to AIRAC system that is a stringent and lengthy process involving multiple stakeholders. All data must also undergo a four-eyes principle for manual updates and business rule and CRC checks for structured data uploads. ICAO Annex 15 and the EU Regulation 73/2010 govern the collection, processing and provision of aeronautical data.

Dynamic data is a critically important information distributed at short notice as NOTAM and Pre-Flight Information Bulletin. NOTAM is a notice filed with an aviation authority to alert aircraft pilots of potential hazards along a flight route or at a location that could affect the safety of the flight.

Flight plan, changes thereto and Meteorological information (OPMET) are another type dynamic data. Meteorological reports are related to a specific time and location and shall be updated at specific period. OPMET shall be available at all phases of flight.

Flight plan and its changes are related to specific flight and indicate the status of flight (submitted, modified, current, closed, cancelled).

Different stakeholders are involved in update of OPMET and Flight Plan data at different phase of flight (e.g. Met Office, ATS units, ATC). The way of communication differs at each phase of flight: AFTN (NOTAM, FPL), Web page (PIB), radio (VCS), data-link (CPDLC).

The reporting of static and dynamic aeronautical data involves a stringent origination, maintenance and publication process to ensure data quality and accurate data flow. Information is originated from the following sources:

- Survey Data (Terrain and Obstacle Data) from civil engineers
- Sensors
- Airport Authorities
- Civil Aviation Authorities / Regulating Bodies
- ANSPs (e.g. for Instrument Flight Procedure and Airspace Design)
- Military Data (on no-fly areas, etc.)
- International Organisations (e.g. Eurocontrol Airspace Use Plan, Network Manager, etc.)
- EAD – European AIS Data Base

In the U-space, unmanned aviation must also consume relevant static and dynamic data to gain situational awareness on the aeronautical and physical surroundings along the actual or planned flight path as well as their current operational status and provide safety at area defined by flight plan. Obviously, weather is also an important factor with massive impact on flight performance and safety.

For unmanned aviation static/dynamic data is not limited by airspace volumes, restrictive airspaces. Additional information shall be provided by U-AIM such protected areas (airports, prisons) public areas (schools, stadium, park) etc.

As in manned aviation, drone operators shall validate their flight plans against the actual (real-time) status of the aeronautical and physical entities along the planned trajectory. Obviously not all information used in manned aviation will be relevant for drones. The following data are considered key to allow drones to operate in a unified airspace:

- Obstacle/terrain data
- Airspace reservation/activation (volumes defined by vertical and horizontal limits and Geoshape data) to convey procedures and limitations to manned and unmanned traffic.
- Points – predefined (published) in U-AIM points that could be used in flight plan, similar with VFR points published in AIP (entry/exit CTR VFR points etc).
- Airspace usage criteria: definition what operation/separation is allowed and what aircraft types (or even aircraft registration) with what type of equipment requirements are established (eg. ADS-B) in the respective airspace
- Flight Information of manned aircraft, particularly GAT aviation in uncontrolled airspace.
- Weather Information: global weather and microclimatic conditions for flight conditions and drift calculations

While obstacles/terrain are considered static data, airspace volumes may have permanent and dynamic nature i.e. some areas are permanently restricted when some are available for drone operations and others are activated ad-hoc or on a pre-defined schedule. Some dedicated drone operators (Police, SAR) shall be able to create ad-hoc geo-fences for special missions. Thus, the U-space users must consider the current operational status of the geofences during pre-flight planning phase (when filing the flight plan) as well as in-flight (so to react on ad-hoc activations of restrictions). Alerts to the drone pilot and/or its FMS is therefore key. It should be possible to obtain airspace status data from U-AIM at post-flight phase when it is required by authority for investigation.

Information needed for drone operations is originated following the standard process for data origination and therefore subject to EU-Regulation 73/2010 and ICAO Annex 15 quality assurance.

However, given the nature of unmanned traffic and its operation in very low altitude, the standard NOTAM process is considered not sufficient to the U-space concept. Ad-hoc airspace reservation and activations shall be possible for drone operators and may include:

- restrictions for volumes representing event arenas (e.g. stadiums during a match),
- incident sites (e.g. a roadside accident, search and rescue activity, etc.)
- public safety announcements (e.g. during demonstrations, etc.)
- and many more

Such creation, change or withdrawal of restricted volumes must be performed by trusted sources outside the usual context of aviation i.e. the public safety control centre, the city government or even sensors in case of a drone accident. This can be achieved by providing a simple, map-based Geofence Creation HMI. Incoming data transmissions to dedicated ANSP FIMS shall be processed automatically unless of a business rule validation error. A fall-back process on ANSP side shall therefore be elaborated to ensure that errors from incoming data origination can be manually corrected at all times to ensure a swift exchange of information to all airspace users. A NOTAM shall only be published in case the originated information is also of use for manned aviation. Otherwise, a notification/alert to the drone operators and/or their FMS is sufficient. Dynamic geofence information is also subject to ICAO Annex 15 and EU Regulation 73/2010 data quality regulations and must therefore pass business rule when provided to the central store.

4 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 Operations Parameter Definitions: identify data structures being exchanged via Service Operations.

The above elements may be depicted in one or more diagrams.

4.1 Service Data Model

This section describes the information model, i.e., the logical data structures to be exchanged between providers and consumers of the service.

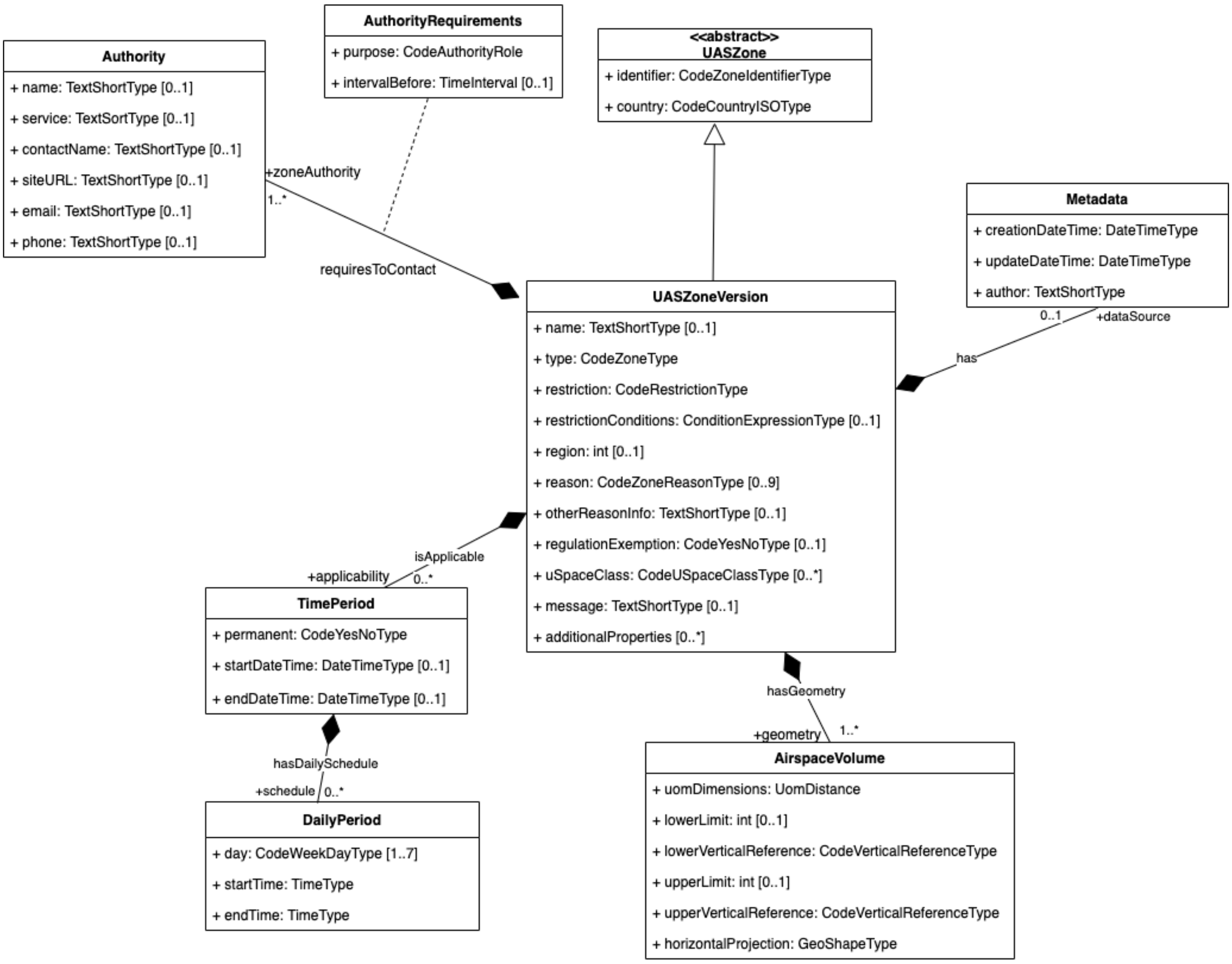


Figure (x). UAS GEOGRAPHICAL ZONE DATA MODEL (src: ED-269.pdf chapter 8 figure 2)

ED-269 based data-model supports most of the foreseen GOF 2.0 requirements, like multiple airspace volumes, activity time management and per-zone operational rules. There are still some relatively minor issues to be solved or reported during GOF 2.0 implementation like

- importing/mapping legacy AIXM-based airspaces (different timeslice relation), ED-269 7 chars limit for airspace identifier, AIXM curves support and alike)
- Circle support implementation.
- Polygon with holes implementation
- FUA integration

4.2 Service Interface Specifications

Overview

Service Interface Specifications should be replaced with new ones, and should follow ED-269 specs, possibly with some changes/extensions due to GOF2.0 scope/implementation.

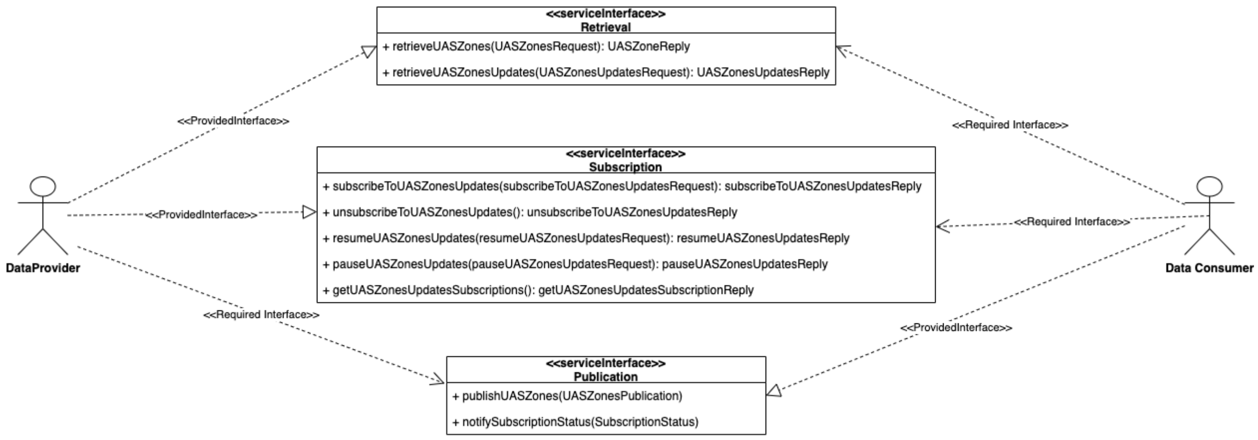


Figure (x). INTERFACES OVERVIEW (src: ED-269.pdf chapter 9 figure 4)

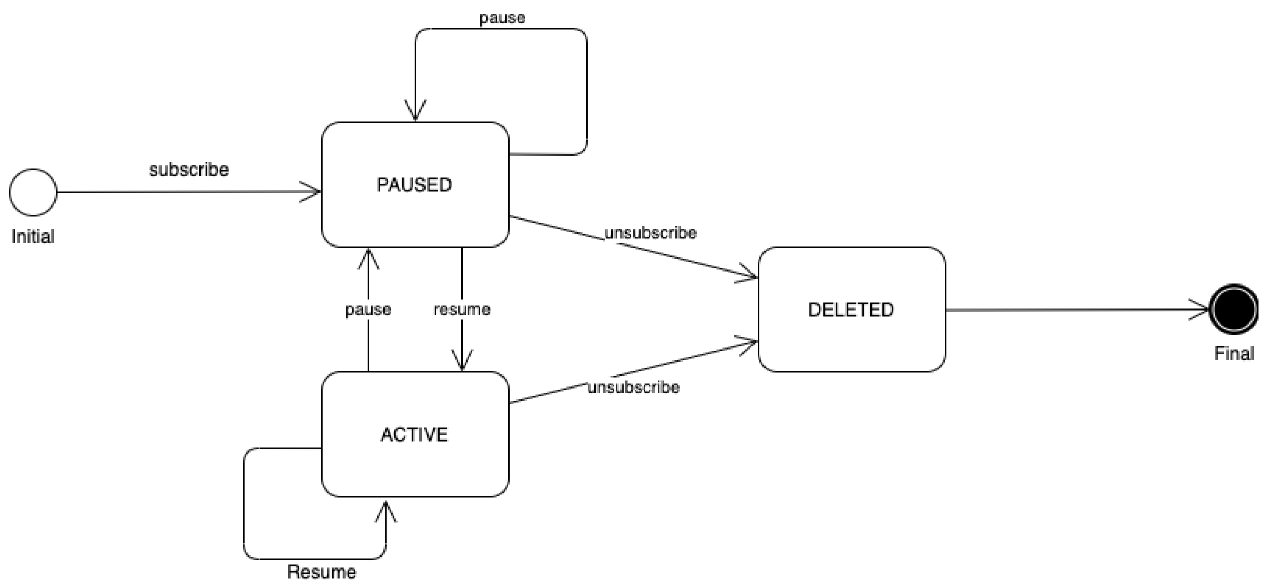


Figure (x). SUBSCRIPTION STATES (src: ED-269.pdf chapter 9 figure 5)

ED-269 based interfaces supports most of the foreseen GOF 2.0 requirements, I.e. defines pub-sub mechanism combined with queried retrievals for data sync

During GOF 2.0 implementation we should check if the there are some extra interfaces needed to solve possible issues with implementations

- Batch updates on AIRAC imports, per-type operational rules changes and alike
- Short-term airspace (PANSA 'alerts', FREQUENTIS 'dynamic UVR')

- Optimized queries for operation flight plans support

5 Service Provisioning

Left Empty.

6 References

NOTE: The list of references provided hereafter is for guidance. Before the documents are delivered to the SJU, please make sure that you are listing the latest applicable version of the relevant references as in the Programme Library.

Nr.	Version	Title
[1]	n/a	CFP Reference CEF-SESAR-2018-1, “Finnish-Estonian "Gulf of Finland" Very Large U-Space Demonstration”
[2]	Advanced Edition (unedited)	ICAO Doc 10039, Manual on System Wide Information Management (SWIM) Concept
[3]	00.05.00	SESAR 2020 GOF2 USPACE FIMS Design and Architecture, Appendix A Service Description Templates, document SESAR 2020 GOF2 USPACE Service Documentation Guidelines
[4]	Ed. 01.00.00, 25 June 2018	EUROCONTROL Concept of Operations for U-space (CORUS), D6.1, Grant Ref. 763551, Call Ref. 2016 SESAR 2020 RPAS Exploratory Research Call (H2020 – SESAR -2016-1)
[5]	n/a	Unmanned Aircraft System Traffic Management (UTM) Concept of Operation American Institute of Aeronautics and Astronautics
[6]	V1.0 April 2017	GUTMA UAS Traffic Management Architecture
[7]	V1.0	Federal Aviation Administration NextGEN Concept of Operations, Foundational Principles, Roles and Responsibilities, Use Cases and Operational Threads, Unmanned Aircraft System (UAS), Traffic Management (UTM)
[8]	1.0	Federal Office of Civil Aviation (FOCA), Swiss U-Space ConOps, U-Space Program Management, 29.03.2019, FOCA muo / 042.2-00002/00001/00005/00021/00003
[9]	n/a	SESAR, European ATM Master Plan: Roadmap for the safe integration of drones into all classes of airspace
[10]	n/a	SESAR, eATM PORTAL, European ATM Master Plan
[11]	V1.0 12-2018	SESAR-JU, DREAMS U-Space Scenarios
[12]	00.01.00	SESAR-JU, DREAMS, D4.2 - Gap Analysis,

	09- 2018	
[13]	V 1.0	EUROCAE,White Paper on Geofencing and Definitions
[14]	April 2019	Aeronautical Information Exchange Model, http://aixm.aero/
[15]	April 2019	Flight Information Exchange Model, www.fixm.aero
[16]	April 2019	ICAO Weather Information Exchange Model,
[17]	5th Ed. - 2016	ICAO Doc. 9750-AN/963, Global Air Navigation Plan (GANP) 2016-2030
[18]	2017	SESAR-JU, U-space Blueprint,
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[20]	Ed. 1.0	EUROCONTROL Specification for ATM Surveillance System Performance, EUROCONTROL-SPEC-0147,
[21]	1 Nov. 2006	Federal Aviation Administration, Project Report ATC-323, Required Surveillance Performance Accuracy to Support 3-Mile and 5-Mile Separation in the National Airspace System
[22]		EfficienSea2, a Horizon 2020 Project, Grant Agreement No 636329 https://efficiensea2.org https://efficiensea2.org/wp-content/uploads/2018/04/Deliverable-3.6.Standard-proposal-for-Maritime-Cloud-service-specification.pdf
[23]		IALA specification for e-navigation technical services https://www.iala-aism.org/product/g1128-specification-e-navigation-technical-serviceshttps://www.iala-aism.org/product/g1128-specification-e-navigation-technical-services
[24]	C(2021) 2671 final	COMMISSION IMPLEMENTING REGULATION (EU) …/664 of XXX on a regulatory framework for the U-space
[25]	June 2020	ED-269 Minimum Operational Performance Standard for Geofencing