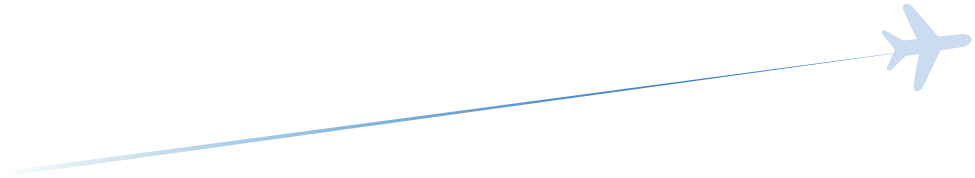

GOF2.0 D2.4 – Appendix Service Specification

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GOF 2.0

GOF2.0 INTEGRATED URBAN AIRSPACE VLD

This Updated Service Specification is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 101017689 under European Union's Horizon 2020 research and innovation programme.

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 Drone Flight Exchange service in a logical, technology-independent manner.

Table of Contents

List of Tables

List of Figures

1 Introduction

1.1 Purpose of the document

In accordance with according to the guidelines given in [3], this document describes the Drone Flight Exchange service for the GOF 2.0 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 Drone Flight Exchange service for the GOF USPACE project.

The Drone Flight Exchange service provides a means for the operational nodes of the GOF USPACE project to share information about drone flights and make them available for further processing.

The Drone Flight Exchange service furthermore provides a means for the operational nodes of the GOF USPACE project to consume information about drone flights from the U-space participants for further processing.

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 Drone Flight Exchange service as well as of the Operation Plan Information Exchange service.

Furthermore, this service specification is intended to be read by enterprise architects, service architects, information architects, system engineers and developers in pursuing architecting, design and development activities of other related services.

1.4 Background

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

EUROCONTROL CORUS [4] elaborates the Operation Plan Processing service as follows:

"The following can be taken as an approximate list of the steps taken by the Drone operation plan processing service when an operation plan is received.

- *Syntax check. Does whatever has arrived resemble a flight plan enough to be processed?*
- *Semantic check. Are all the expected pieces of information present?*
- *If OK so far, generate a unique identifier for the operation plan.*
- *Authorisation-check using the e-Registration service. Is there some reason this operator or this pilot or this drone should not be flying?*
- *Construction of a probabilistic 4D model of the flight's likely airspace occupancies, (a trajectory) using the plan, the Weather information service, the flight/performance characteristics of the drone, and any other relevant information. The trajectory will be subject to simple sanity checks.*
- *Weather warning, using the Weather information service. Is there a weather warning for the time and place of the operation*
- *Geo-Fencing, height maxima and other boundary checks, using the Drone aeronautical information service and the probabilistic trajectory. For any geo-fences that are penetrated, is there a corresponding permission in the operation plan? For any conditional access, are the conditions met?*
- *Procedural interface with ATC. If any controlled areas are penetrated by the probabilistic trajectory then the procedural interface with ATC is triggered for each.*
- *The Strategic conflict-management service is invoked.*
- *If available, the Dynamic capacity management service is invoked."*

In other words, the Operation Plan Processing service deals with the planning aspects of a drone flight. There is no mentioning about the dynamic execution of the drone flight, other than the following:

"The status of an operation plan also changes when start-of-flight is received or position reports arrive for the flight without start-of-flight. A further status change occurs on receipt of end-of-flight. Hence the Drone operation plan processing service consumes information from the Tracking service."

In this document we propose to introduce the Drone Flight Exchange service to bridge the gap between Operation Plan Processing service and Tracking Service.

1.4.2 Federal Aviation Administration (FAA) Concepts of Operations

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

"A service which provides on demand, periodic, or event driven information on UAS operations (e.g. position reports, intent information, and status information) occurring within the subscribed airspace volume and time. Additional filtering may be performed as part of the service."

1.4.3 International Civil Aviation Organization (ICAO)

In the Global Air Navigation Plan [9], ICAO defines three Aviation System Block Upgrade (ASBU) blocks, B1-RPAS, B2-RPAS, and B3-RPAS, referring to scheduled implementation years of 2019, 2025, 2031, and beyond, and expects increased situational awareness from B1-RPAS onwards.

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."

1.4.4 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 [11], within the European ATM Masterplan [12], 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 [13],

U1 U-space foundation services,

U2 U-space initial services,

U3 U-space advanced services, and

U4 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 GOF USPACE project.

During the U1 phases, SESAR expects drones capable to supply their position via telemetry. The U1 and U2 is anticipated to provide tracking capabilities and services.

1.4.5 Efficient, safe and sustainable traffic at sea (EfficienSea2)

The design method and terminology builds on experience from the EfficienSea2 project [14], [15].

1.5 Glossary of terms

Term	Definition

AIR-REPORT	A report from an aircraft in flight prepared in conformity with requirements for position, and operational and/or meteorological reporting.
Drone Flight	Information about the actual conduction of a drone flight.
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.
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.
Operation Plan	Information about the planning of a drone operation.
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 1: Glossary of terms

1.6 List of Acronyms

Acronym	Definition
API	Application Programming Interface
CARS	Common Altitude Reference System
MEP	Message Exchange Pattern
NAF	NATO Architectural Framework
OP	Operation Plan
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 2: 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	**DroneFlightExchange Service**
ID	**urn:gof:services:DroneFlightExchangeService**
Version	**1.0**
Description	**An information exchange service which provides drone flight information**
Keywords	**Operation Plan, Drone Flight execution, Drone Flight States, Correlation between Operation Plan and Position Reporting**
Architect(s)	**2022 The GOF 2.0 Project Consortium** **2022 The Frequentis Group**
Status	**Provisional**

Table 3: 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 DroneFlightExchange service.

Requirement Id	Requirement Name	Requirement Text	References
[R-1]	Common Situational Awareness	At all times, all U-space participants 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 [9];CEF-SESAR-2018-1 [1], Objective O5
[R-2]	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 [11], Foreword, 4.1 and 4.2;U-space Blueprint [13], Benefits to European society and economy;CEF-SESAR-2018-1 [1], Table 8 – Key Challenges
[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];[R-2];CEF-SESAR-2018-1 [1], Objective O6;CEF-SESAR-2018-1 [1], Table 8 – Key Challenges
[R-4]	Standard Protocols	Standard communication protocols shall hence be used where available, and such standard protocols be developed otherwise, in order to ensure the lowest level of obstruction for an open VLL airspace use market to develop.	[R-2];SESAR Drone Roadmap [11], 3.5, section 'Standards';CEF-SESAR-2018-1 [1], Table 8 – Key Challenges

[R-5]	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.	[R-2];CEF-SESAR-2018-1 [1], Table 8 – Key Challenges
[R-6]	SWIM	The implementation of a Flight Information Management System (FIMS) shall be based on an ICAO SWIM-compliant architecture.	[R-3];CEF-SESAR-2018-1 [1], 5.3.4 Overall approach and methodology
[R-7]	Latency	Under no operational circumstance, the processing of position data may add significant latency to the overall detection-to-display latency of position data. In particular, 1. The processing latency added by the processing of positional data shall never exceed 10 per cent of the maximum value of the corresponding value permitted for the entire ATM automation system. 2. The processing latency and delay added by the processing of positional data should not exceed 1 per cent of the maximum value of the corresponding value permitted for the entire ATM automation system. The maximum value for latency and delay is the minimum of the values defined by the ATM system performance requirements by EUROCONTOL and the FAA; for a 3 NM minimal separation, this is 2.2 s, for a 5 NM separation, 2.5 s.	[17], tables in the Executive Summary, [16], 3N_C-R8 and 5N_C-R8

Table 4: Requirements for the DroneFlightExchange 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.

3.2.2 Operational Nodes

A typical U-space flight goes through several stages, starting strategic-tactically, pre-flight, from Strategic Planning, over to Pre-Tactical Planning, to Tactical Planning. Then, tactical-operationally it enters into the actual in-flight stages from Departure, over to In-Flight, and, finally Arrival. Further post-flight stages may evaluate the results from the data produced during the prior stages.

The DroneFlightExchange service primarily is relevant during the actual operational in-flight stages of a U-space flight during which the flying device and/or the corresponding ground stations produce the position data which we convey via the Traffic/Telemetry service.

The DroneFlightExchange service may be seen as a means of correlation between the position reporting (provided by the Traffic/Telemetry service) on one side and the operation planning (provided by the OperationPlanInformationExchange service) on the other side.

There are several nodes in U-space which could provide position information to the DroneFlightExchange service.

(Figure TBD)

Figure 1: U-space nodes related to the DroneFlightExchange service

Operational nodes which may provide data for the DroneFlightExchange service include the following ones.

Operational Node	Remarks
Aircraft	?
Ground Station	?
UTM Service Provider	
Flight Information Management System	

Table 5: Operational Nodes providing the DroneFlightExchange service

Operational nodes which may consume the DroneFlightExchange service include the following ones.

Operational Node	Remarks
Flight Information Management System	
Information Display	
Legal Recorder	

Table 6: Operational Nodes consuming the DroneFlightExchange service

3.2.3 Operational Activities

Operational activities supported by the DroneFlightExchange service include the following ones.

Phase	Operational Activity	Remarks
Pre-flight	**Set-up**	**(Drone Flight not available yet at this stage)**
	Plan	**(Drone Flight not available yet at this stage)**
	Arm	**(Drone Flight exchange should start to run here)**
In-Flight	Depart	Drone Flight data available for the flight
	Cruise	Drone Flight data available for the flight
	Arrive	Drone Flight data available for the flight
Post-Flight	Disarm	**(Drone Flight exchange likely stops here)**
	Report	**(Post/flight analysis only)**

Table 7: Operational Activities supported by the DroneFlightExchange service

4 Service Interfaces

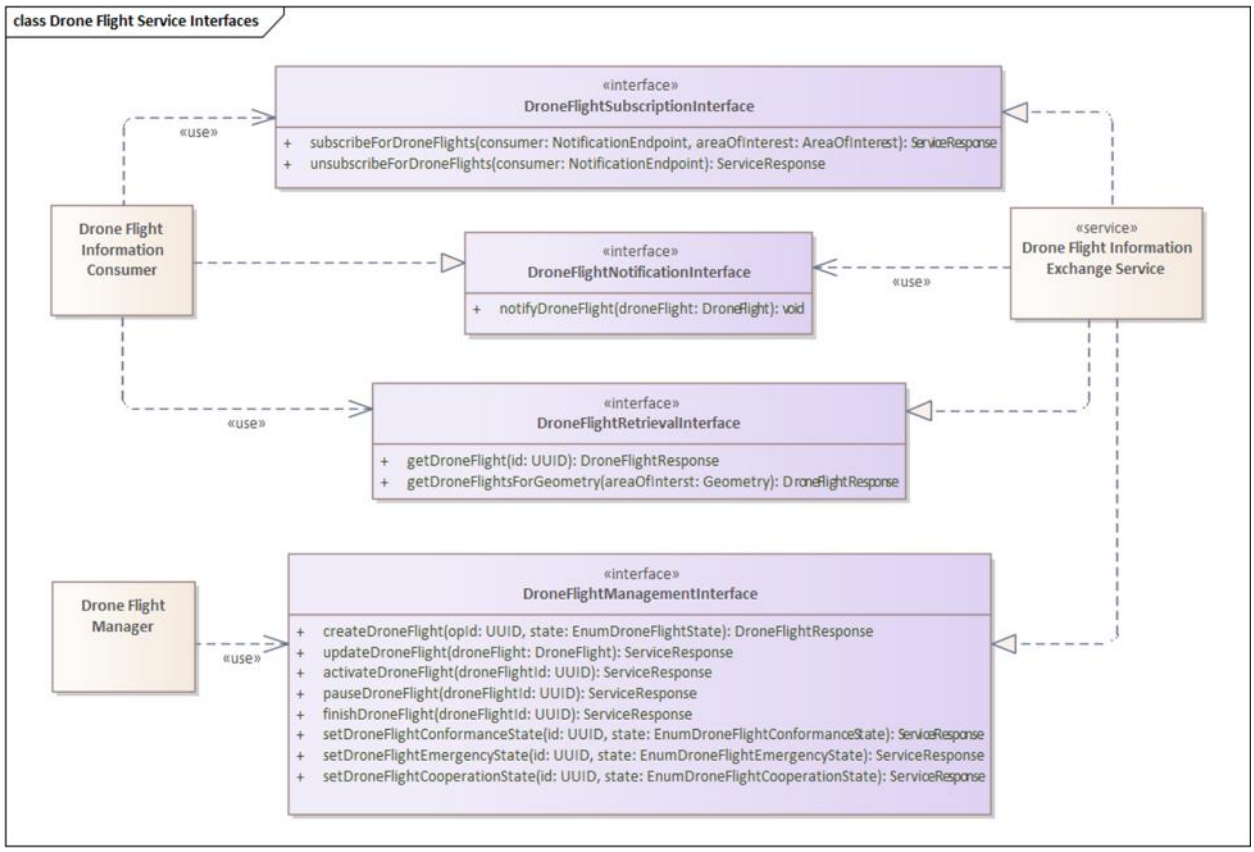

Figure 2: DroneFlightExchangeService Interface Definition diagram

ServiceInterface	Role (from service provider point of view)	ServiceOperation
DroneFlightManagementInterface	Provided	createDroneFlight updateDroneFlight pauseDroneFlight resumeDroneFlight finishDroneFlight setDroneFlightConformanceState setDroneFlightEmergencyState setDroneFlightCoorperationState
DroneFlightSubscriptionInterface	Provided	subscribeForDroneFlights unSubscribeForDroneFlights
DroneFlightNotificationInterface	Required	notifyDroneFlight

DroneFlightRetrievalInterface	Provided	getDroneFlight getDroneFlightsForGeometry

Table 8: Service Interfaces

5 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.

5.1 Overview

The DroneFlight exchange service transfers information about an ongoing drone flight and associated data. The central part of the data model for this service is the DroneFlight structure, which includes a summary of the drone flight state information, together with a reference to the related Operation Plan and optionally a reference to tracking information.

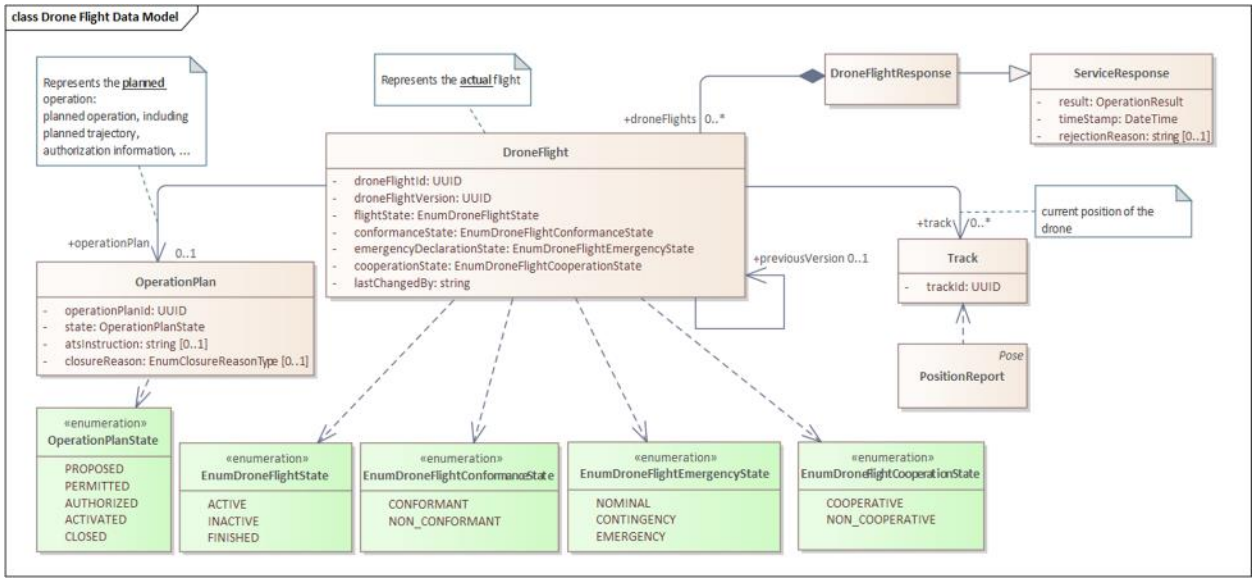

Figure 3: Drone Flight Service Data Model diagram

5.2 The DroneFlight Data Structure

DroneFlight is the central part of the DroneFlightExchange service data model.

Property	Type	Multiplicity	Description	Note
droneFlightId	UUID	1	Globally unique identifier of this drone flight.	

Property	Type	Multiplicity	Description	Note
droneFlightVersion	UUID	1	Globally unique identifier of this version of the drone flight.	
flightState	DroneFlightState	1	The basic life cycle state of the drone flight.	

conformanceState	DroneFlightConformanceState	1	The conformance state of the drone flight. It indicates whether the drone flight conforms to the referred, approved Operation Plan.	A drone flight is CONFORMANT if it has a reference to an Operation Plan that is in AUTHORIZED state and if the drone flight behaves as planned, i.e., if the spatial and temporal limitations given in the OP volume (and/or trajectory) are respected. Note that a drone flight is still CONFORMANT, even if it is in contingency mode, as long as it follows the contingency plan provided within the Operation Plan. A drone flight is considered NON_CONFORMANT if there is no reference to an Operation Plan, or if the referred Operation Plan is not approved, or if the drone is flying outside the approved (spatial and/or temporal) limits.

Property	Type	Multiplicity	Description	Note
emergencyDeclarationState	DroneFlightEmergencyDeclarationState	1	The emergency declaration state of the drone flight.	This state is to be explicitly declared by the drone operator. Note that a drone flight may be in EMERGENCY state while it is still CONFORMANT (e.g., in contingency operation).
cooperationState	DroneFlightCooperationState	1	The cooperativeness of the drone flight.	A NON_COOPERATIVE NON_CONFORMING drone flight is considered rogue!
lastChangedBy	String	1	Indicates who did the last update on this object.	
operationPlan	Reference to OperationPlan	0..1	The reference to the Operation Plan.	This reference is usually given by providing the operationPlanId of the referred Operation Plan.

Property	Type	Multiplicity	Description	Note
track	Reference to Track	0..*	Optional references to Track Identifiers.	By this reference, the DroneFlight is used to transmit correlation information between OperationPlan and Position Reporting.
previousVersion	Reference to DroneFlight Object	0..1	Refers to the historically previous version of this DroneFlight.	May be realized by simply adding the droneFlightVersion UUID of the previous version.

Table 9: The DroneFlight data structure

5.3 The DroneFlightResponse Data Structure

DroneFlightResponse is used to carry the result of query-operations asking for drone flights.

Depending on the operation result, it may contain zero, one or several drone flights.

Property	Type	Multiplicity	Description	Note
droneFlights	DroneFlight	0..*	Drone flight(s).	
< inherited >			**All properties inherited from ServiceResponse.**	**See common data types.**

Table 10: The DroneFlightResponse data structure

5.4 The OperationPlanState Enumeration

The OperationPlanState enumeration type specifies the possible states of an operation plan.

Property	Description	Note
PROPOSED	Initial state of the operation plan. This operation is not yet APPROVED. It may be awaiting information from the operator, it may be in conflict with another APPROVED or ACTIVATED operation and undergoing a negotiation process, or for some other reason it is not yet able to be declared APPROVED.	
PERMITTED	Authority has given permission to proceed (Certification Processes, SORA, ...)	
AUTHORIZED	This operation has been deemed approved by the supporting USS. This implies that the operation meets the requirements for operating in the airspace based on the type of operation submitted.	Authorization of an OP may include the approval by multiple stakeholders. ATM may be one such stakeholder. In some cases an OP may be AUTHORIZED without the approval of ATM (in cases where no ATM airspace is involved.
ACTIVATED	Operation plan has been activated. Drone is cleared to take off.	
CLOSED	This operation is closed. It is not airborne and will not become airborne again.	If the UAS and the crew will fly again, it would need to be as a new operation. A USS may announce the closure of any operation, but is not required to announce unless the operation was ROGUE or NONCONFORMING.

Table 11: The OperationPlanState enumeration

5.5 The EnumDroneFlightState Enumeration

The EnumDroneFlightState enumeration type specifies the possible life cycle states of a drone flight.

Property	Description	Note
ACTIVE	The drone has potentially taken off and is performing its mission according to the operation plan.	This is the initial state of a drone flight, as the drone flight is created with its activation.

Property	Description	Note
INACTIVE	The drone flight was activated but is currently pausing or has not taken off yet.	
FINISHED	The drone flight is completed.	

Table 12: The EnumDroneFlightState enumeration

5.6 The EnumDroneFlightConformanceState Enumeration

The EnumDroneFlightConformanceState enumeration type specifies the possible conformance states of a drone flight.

The conformance state indicates whether the drone flight conforms to an approved Operation Plan..

Property	Description	Note
CONFORMANT	The drone flight conforms to the referred Operation Plan. This means, the drone plan is currently in line with the planned 4D-constraints described by the Operation Plan.	Note that a drone flight is still CONFORMANT, even if it is in contingency mode, as long as it follows the contingency plan provided within the Operation Plan.
NON_CONFORMANT	The drone flight is currently not conformant to the referred Operation Plan, or there is no Operation Plan known for the drone flight. The Non-Conformance may be a violation of spatial or temporal constraints specified in the Operation Plans Operation Volume or Trajectory or Contingency Plan. Overdue is an example of Non-Conformant state.	

Table 13: The EnumDroneFlightConformanceState enumeration

5.7 The EnumDroneFlightEmergencyState Enumeration

The EnumDroneFlightEmergencyState enumeration type specifies the possible kinds of contingency/emergency states that can be declared by the drone operator.

Property	Description	Note
NOMINAL	The drone flight is in nominal conditions.	

Property	Description	Note
CONTINGENCY	The drone flight is in contingency conditions.	
EMERGENCY	The drone flight is in emergency conditions.	

Table 14: The EnumDroneFlightEmergencyState enumeration

5.8 The EnumDroneFlightCooperationState Enumeration

The EnumDroneFlightCooperationState enumeration type specifies whether the drone flight is co-operative or not.

Property	Description	Note
CO_OPERATIVE	The drone flight is behaving co-operatively.	If only a flight declaration is possible (without telemetry transmission), the CO_OPERATIVE flight may be a flight reported (submited) to the system.
NON_COOPERATIVE	The drone flight is not behaving co-operatively.	A NON_COOPERATIVE NON_CONFORMING drone flight is considered rogue!

Table 15: The EnumDroneFlightCooperationState enumeration

5.9 Common Data Structures Used in UTM Service Specifications

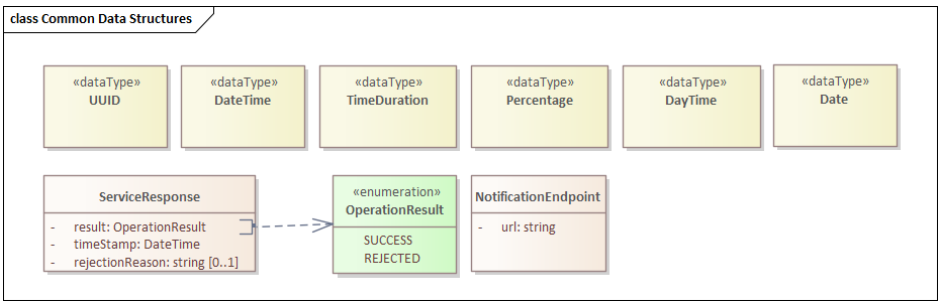

Figure 4: Common Data Types Used in UTM Service Specifications

5.9.1 NotificationEndpoint Data Structure

NotificationEndpoint is used in subscription and un-subscription operations to show the receiver of notifications as a result of the subscription.

Property	Type	Multiplicity	Description	Note

URL	**String**	1	Endpoint capable of receiving notifications	

Table 16: NotificationEndpoint Data Structure

5.9.2 ServiceResponse **Data Structure**

ServiceResponse is the generic response provided by each service operation. In some cases, this basic data structure may be extended by inheritance.

Property	Type	Multiplicity	Description	Note
result	**OperationResult**	1	Indicates the result of the request to the service	
rejectReason	**String**	0..1	Optional additional information to be provided in case of negative result	
timeStamp	DateTime	1		

Table 17: ServiceResponse Data Structure

5.9.3 OperationResult **Enumeration**

The **OperationResult** enumeration type specifies the possible outcomes of calling an operation.

Property	Description	Note
SUCCESS	Operation was successfully executed.	
REJECTED	Operation could not be executed.	

Table 18: OperationResult Enumeration

5.10 Common Geometry Data Structures Used in UTM Service Specifications

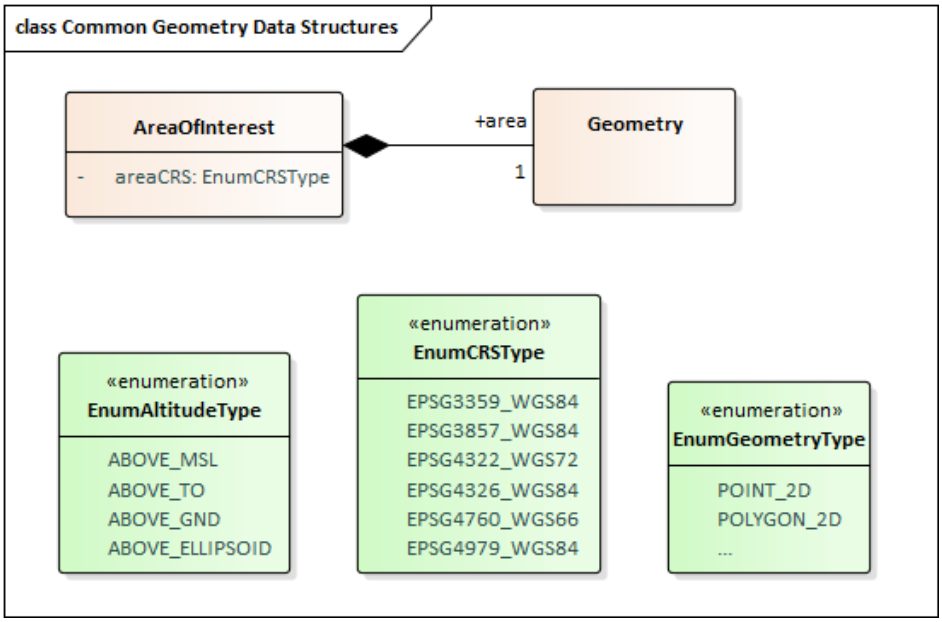

Figure 5: Common Geometry Data Types Used in UTM Service Specifications

5.10.1AreaOfInterest Data Structure

AreaOfInterest is used in subscription operations to provide an indication of the geographic area for which the subscriber is interested to receive notifications.

Property	Type	Multiplicity	Description	Note
area	**Geometry**	1	A geometric description of a geographic area.	Should be a 2-dimensional geometry in this case.
areaCRS	**EnumCRSType**	1	Coordinate reference system used (WGS-84, EPSG:4979)	

Table 19: AreaOfInterest Data Structure

5.10.2Geometry Data Structure

Geometry describes a geometrical shape of one, two or three dimensions.

The **Geometry** data structure **is not further detailed in this service specification**. One example of how a generic Geometry structure could be realized is sketched in the table below:

Property	Type	Multiplicity	Description	Note
coordinates	**Double**	2..*	Collection of the coordinates, describing the geometry.	

geometryType	**GeometryType**	1	Type of geometry being described by the coordinates.	Examples: Point, Polygon, Polyhedron, etc.

Table 20: Geometry Data Structure

5.10.3EnumAltitudeType **Enumeration**

The **EnumAltitudeType** enumeration type specifies the possible ways to express an altitude/height. The respective values should be measured or converted using CARS system.

Property	Description	Note
ABOVE_MSL	Altitude above mean-sea-level. Same as orthometric height; same as height above the earth geoid.	
ABOVE_TO	Altitude above take-off location.	
ABOVE_GND	Height above ground surface.	
ABOVE_ELLIPSOID	Altitude above the WGS-84 ellipsoid; value delivered by GNSS.	

Table 21: EnumAltitudeType Enumeration

5.10.4EnumCRSType **Enumeration**

The **EnumCRSType** enumeration type specifies the possible ways to express a coordinate reference system. The most common values used are noted in bold letters.

Property	Description	Note
EPSG3395_WGS84	World Mercator Geodetic CRS: WGS 84; Coordinate System: Cartesian CS. Axes: easting, northing (E, N). Orientations: east, north. UoM: metre.	Euro-centric view of world excluding polar areas.

EPSG3857_WGS84	Pseudo-Mercator -- Spherical Mercator, Google Maps, OpenStreetMap, Bing, ArcGIS, ESRI Geodetic CRS: WGS 84; Coordinate System: Cartesian CS. Axes: easting, northing (X, Y). Orientations: east, north. UoM: metre.	Uses spherical development of ellipsoidal coordinates. Relative to WGS 84 / World Mercator (CRS code 3395) errors of 0.7 percent in scale and differences in northing of up to 43km in the map (equivalent to 21km on the ground) may arise.
EPSG4322_WGS72	Geodetic CRS: WGS 72; Coordinate System: Ellipsoidal 2D CS. Axes: latitude, longitude. Orientations: north, east. UoM: degree.	Uses Historic World Geodetic System 1972. Horizontal component of 3D system.
EPSG4326_WGS84	WGS84 - World Geodetic System 1984, used in GPS Geodetic CRS: WGS 84; Coordinate System: Ellipsoidal 2D CS. Axes: latitude, longitude. Orientations: north, east. UoM: degree.	Horizontal component of 3D system. Used by the GPS satellite navigation system and for NATO military geodetic surveying.
EPSG4760_WGS66	Geodetic CRS: WGS 66; Coordinate System: Ellipsoidal 2D CS. Axes: latitude, longitude. Orientations: north, east. UoM: degree.	Uses Historic World Geodetic System 1966. Horizontal component of 3D system.

EPSG4979_WGS84	Geodetic CRS: WGS 84; Coordinate System: Ellipsoidal 3D CS. Axes: latitude, longitude, ellipsoidal height. Orientations: north, east, up. UoM: degree, degree, metre.	Used by the GPS satellite navigation system.

Table 22: EnumCRSType Enumeration

5.10.5 EnumGeometryType **Enumeration**

The **EnumGeometryType** enumeration type specifies possible geometrical shapes.

Property	Description	Note
POINT	Single point.	
POLYGON	Polygon.	
…		

Table 23: EnumGeometryType Enumeration

6 Service Interface Specifications

This chapter describes the details of each service interface. One sub-chapter is provided for each Service Interface.

The Service Interface specification covers only the static design description while the dynamic design (behaviour) is described later.

6.1 Service Interface DroneFlightRetreivalInterface

The service provider offers this interface to allow consumers to retrieve/query drone flight data.

6.1.1 Operation getDroneFlight

6.1.1.1 Operation Functionality

A consumer calls this operation to explicitly request a drone flight by submitting the known id.

6.1.1.2 Operation Parameters

Parameter Name	Direction	Data Type	Description
id	Input	UUID	Identifier of a drone flight.
response	Return	DroneFlightResponse	Query response, including the drone flight data, if the request was successful.

Table 24: Payload description of getDroneFlight operation

6.1.2 Operation getDroneFlightsForGeometry

6.1.2.1 Operation Functionality

A consumer calls this operation to explicitly request drone flight data for a certain geographical area.

6.1.2.2 Operation Parameters

Parameter Name	Direction	Data Type	Description
areaOfInterest	Input	Geometry	Geographical area of interest.
response	Return	DroneFlightResponse	Query response, including the drone flight data, if the request was successful. The DroneFlightResponse may contain a list of DroneFlights: all current drone flights for the area of interest.

Table 25: Payload description of getDroneFlightForGeometry operation

6.2 Service Interface DroneFlightSubscriptionInterface

The service provider offers this interface to allow consumers to subscribe/unsubscribe for drone flight data.

6.2.1 Operation subscribeForDroneFlights

6.2.1.1 Operation Functionality

A consumer calls this operation to subscribe to receive drone flight data.

6.2.1.2 Operation Parameters

Parameter Name	Direction	Data Type	Description
consumer	Input	NotificationEndpoint	Which endpoint shall be notified in case of new DroneFlight data.
areaOfInterest	Input	AreaOfInterest	Area of interest to the consumer
response	Return	ServiceResponse	Provide status information on subscription

Table 26: Payload description of subscribeForDroneFlights operation

6.2.2 Operation unsubscribeForDroneFlights

6.2.2.1 Operation Functionality

A consumer calls this operation at the provider to unsubscribe from drone flight data.

6.2.2.2 Operation Parameters

Parameter Name	Direction	Data Type	Description
consumer	Input	NotificationEndpoint	Which endpoint shall not be notified (anymore) in case of new DroneFlights.
response	Return	ServiceResponse	Provide status information on subscription

Table 27: Payload description of unsubscribeForDroneFlights operation

6.3 Service Interface DroneFlightNotificationInterface

Once and while subscribed, consumer receives drone flight data via this interface.

6.3.1 Operation notifyDroneFlight

6.3.1.1 Operation Functionality

The service provider uses this logical operation (implemented by the consumer) to publish drone flight data.

6.3.1.2 Operation Parameters

Parameter Name	Direction	Data Type	Description
droneFlight	Input	DroneFlight	A drone flight matching the filter criteria provided in the subscription

Table 28: Payload description of notifyDroneFlight operation

6.4 Service Interface DroneFlightManagementInterface

The service provider offers this interface to allow consumers to administrate / manipulate drone flights.

6.4.1 Operation createDroneFlight

6.4.1.1 Operation Functionality

The service consumer calls this operation to create a drone flight data object.

6.4.1.2 Operation Parameters

Parameter Name	Direction	Data Type	Description
opId	Input	UUID	Optional reference to an Operation Plan.
response	Return	DroneFlightResponse	indicates whether the creation was successful or not. In case of success it also contains the newly created DroneFlight.

Table 29: Payload description of createDroneFlight operation

6.4.2 Operation updateDroneFlight

6.4.2.1 Operation Functionality

The service consumer calls this operation to modify a drone flight data object.

6.4.2.2 Operation Parameters

Parameter Name	Direction	Data Type	Description
droneFlight	Input	DroneFlight	An updated version of a drone flight object.
response	Return	ServiceResponse	indicates whether the operation was successful or not.

Table 30: Payload description of updateDroneFlight operation

6.4.3 Operation pauseDroneFlight

6.4.3.1 Operation Functionality

The service consumer calls this operation to indicate that a drone flight is paused. This results in the drone flight state set to "PAUSED".

6.4.3.2 Operation Parameters

Parameter Name	Direction	Data Type	Description
id	Input	UUID	Identifier of a drone flight object.
response	Return	ServiceResponse	indicates whether the operation was successful or not.

Table 31: Payload description of pauseDroneFlight operation

6.4.4 Operation resumeDroneFlight

6.4.4.1 Operation Functionality

The service consumer calls this operation to indicate that a drone flight is re-activated. This results in the drone flight state set to "ACTIVE".

6.4.4.2 Operation Parameters

Parameter Name	Direction	Data Type	Description
id	Input	UUID	Identifier of a drone flight object.
response	Return	ServiceResponse	indicates whether the operation was successful or not.

Table 32: Payload description of resumeDroneFlight operation

6.4.5 Operation finishDroneFlight

6.4.5.1 Operation Functionality

The service consumer calls this operation to terminate a drone flight. This results in the drone flight state set to "FINISHED".

6.4.5.2 Operation Parameters

Parameter Name	Direction	Data Type	Description
id	Input	UUID	Identifier of a drone flight object.
response	Return	ServiceResponse	indicates whether the operation was successful or not.

Table 33: Payload description of finishDroneFlight operation

6.4.6 Operation setDroneFlightConformanceState

6.4.6.1 Operation Functionality

The service consumer calls this operation to update the conformance state of a drone flight data object.

6.4.6.2 Operation Parameters

Parameter Name	Direction	Data Type	Description
id	Input	UUID	Identifier of a drone flight object.
state	Input	EnumDroneFlightConformanceState	The new conformance state of the drone flight object.
response	Return	ServiceResponse	indicates whether the operation was successful or not.

Table 34: Payload description of setDroneFlightConformanceState operation

6.4.7 Operation setDroneFlightEmergencyState

6.4.7.1 Operation Functionality

The service consumer calls this operation to update the emergency state of a drone flight data object.

6.4.7.2 Operation Parameters

Parameter Name	Direction	Data Type	Description
id	Input	UUID	Identifier of a drone flight object.
state	Input	EnumDroneFlightEmergencyState	The new emergency state of the drone flight object.
response	Return	ServiceResponse	indicates whether the operation was successful or not.

Table 35: Payload description of setDroneFlightEmergencyState operation

6.4.8 Operation setDroneFlightCooperationState

6.4.8.1 Operation Functionality

The service consumer calls this operation to update the cooperation state of a drone flight data object.

6.4.8.2 Operation Parameters

Parameter Name	Direction	Data Type	Description
id	Input	UUID	Identifier of a drone flight object.
state	Input	EnumDroneFlightCooperationState	The new cooperationstate of the drone flight object.
response	Return	ServiceResponse	indicates whether the operation was successful or not.

Table 36: Payload description of setDroneFlightCooperationState operation

7 Service Dynamic Behaviour

7.1 Sequence of events, cooperation with other services

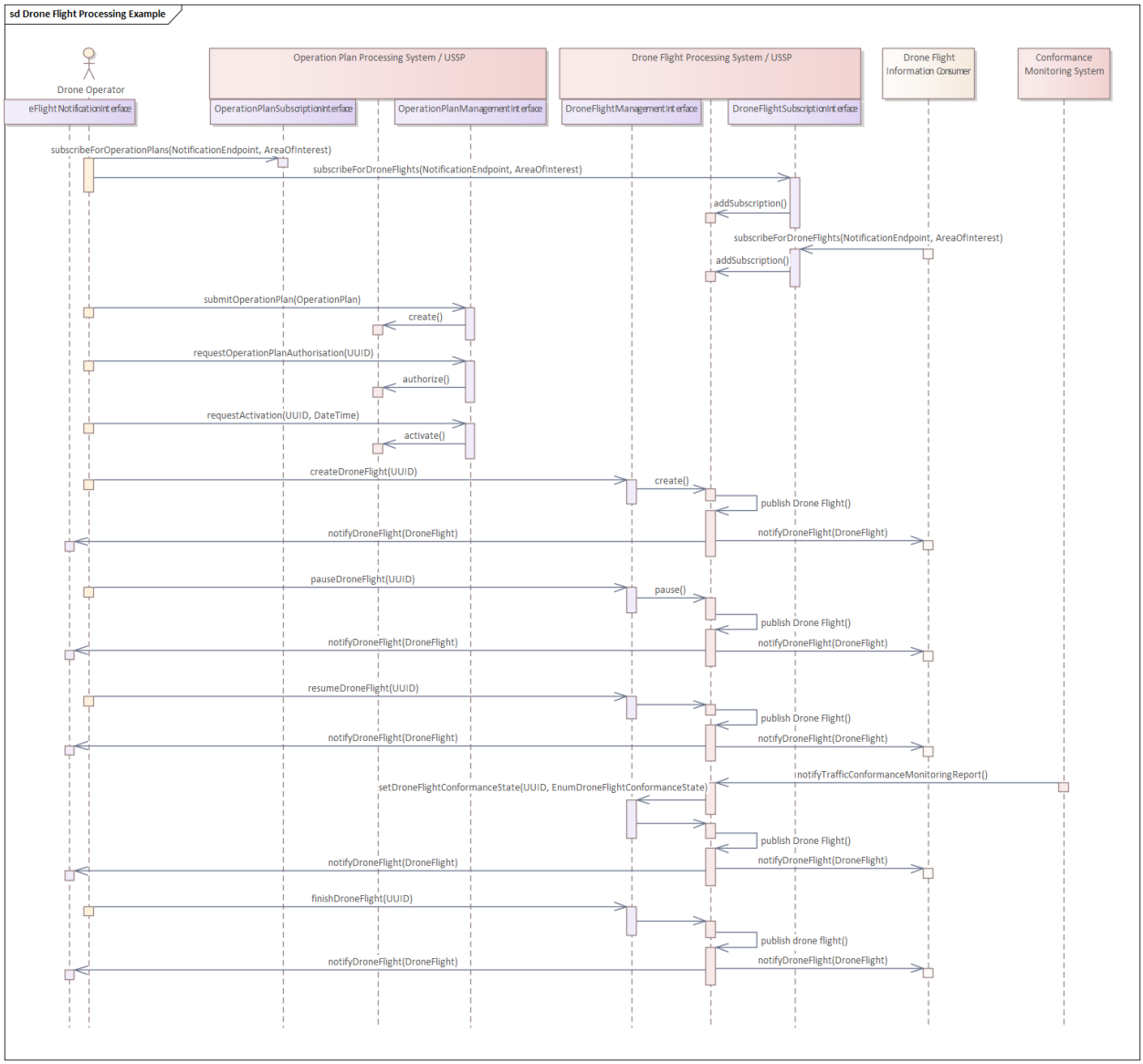

Figure 6: DroneFlightExchange service example operation sequence diagram

Note:
In order to illustrate the service operations in a realistic context, this Sequence Diagram contains additional operations (e.g. from OperationPlanExchange service), not only DroneFlightExchange service operations.

The figure above provides an example scenario for the DroneFlightExchange service. The scenario assumes an Operation Plan Processing system providing the OperationPlanExchange service interfaces

(OperationPlanSubscriptionInterface, OperationPlanManagementInterface). Furthermore, a Drone Flight Processing System provides the DroneFlightExchange service interfaces (DroneFlightSubscriptionInterface, DroneFlightManagementInterface). In addition, the scenario includes a Drone Operator (in the role of a consumer of both, the OperationPlanExchange service as well as the DroneFlightExchange service) and a second consumer of DroneFlightExchange service.

- The scenario starts with the service consumers subscribing for operation plans and drone flights:
  - Drone Operator subscribes at OperationPlanExchange service as well as DroneFlightExchange service.
  - Second consumer subscribes at DroneFlightExchange service.
- Drone Operator submits a tentative Operation Plan by using the OperationPlanManagementInterface.
- Drone Operator requests authorization of the OP by using the OperationPlanManagementInterface.
- Drone Operator requests take-off clearance for the Operation Plan by using the OperationPlanManagementInterface.
  - At this point in time, the Drone Flight object shall be created.
  - The DroneFlightManagmentInterface is used to create the Drone Flight.
  - In this example, the Drone Operator is responsible to create the Drone Flight.
  - Creation of the Drone Flight leads to the publication of the Drone Flight to subscribed consumers.
- Drone Operator may request a pause of the flight by using the DroneFlightManagmentInterface .
  - This leads to an update of the Drone Flight State being published to subscribed consumers.
- Drone Operator may request to resume the paused flight by using the DroneFlightManagmentInterface .
  - This leads to an update of the Drone Flight State being published to subscribed consumers.
- Drone flight processing system may be listening to conformance monitoring publications.
  - When receiving a non-conformance report, the drone flight processing system shall update the conformance state of the drone flight
  - The updated conformance state leads to a drone flight publication to subscribed consumers.
- Drone Operator declares the end of flight by using the DroneFlightManagmentInterface .
  - This leads to an update of the Drone Flight State, which is again published to subscribed consumers.

7.2 Drone Flight State Machine

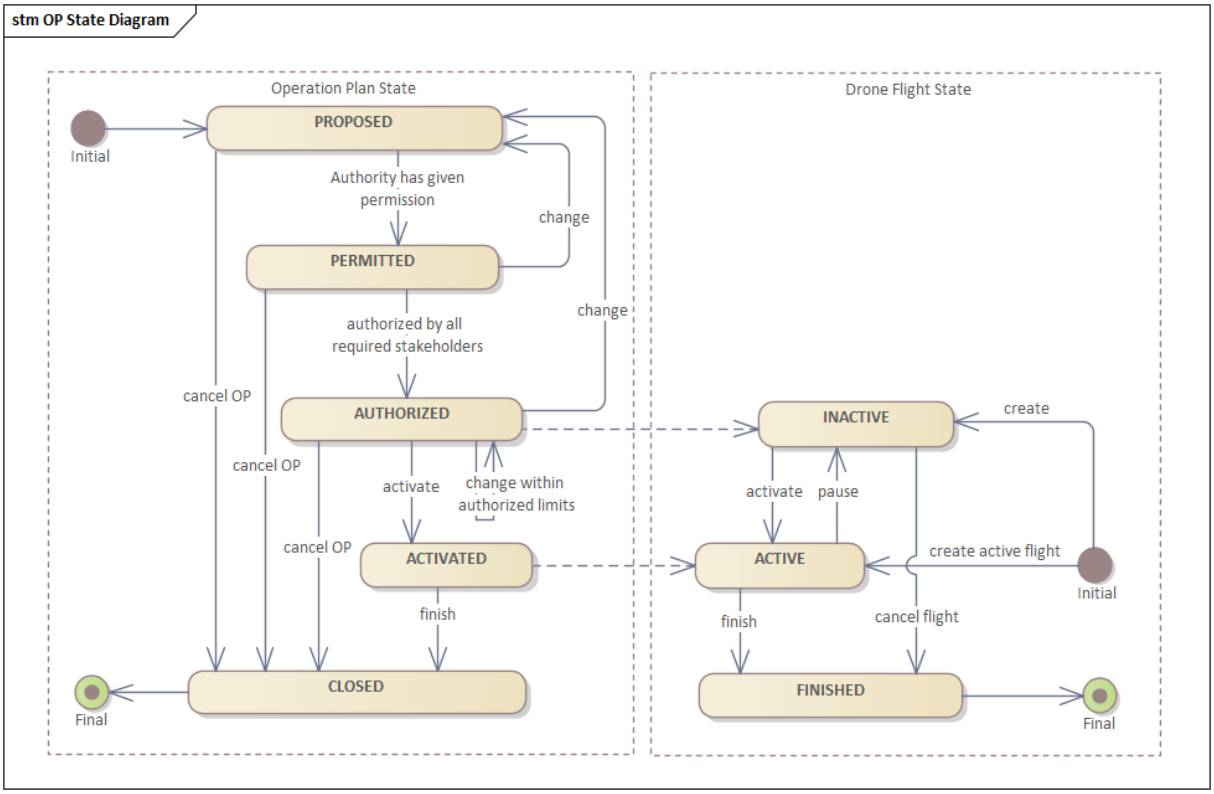

Figure 7: Drone flight states - state transition diagram in comparison with Operation Plan state machine

The figure above illustrates the state transitions of Drone Flights graphically aligned with an Operation Plan state diagram. Note that in a nominal life cycle, a Drone Flight usually gets created when the Operation Plan is going to be activated (i.e., the OP is already in state TAKEOFF_GRANTED).

However, there are also cases where a Drone Flight is activated without the existence of an Operation Plan. Imagine the case where an airborne drone flight is detected (e.g., by observation of surveillance tracks), but cannot be correlated to any existing OP. In such a case, a "NON_CONFORMANT" Drone Flight shall be published, indicating that there is an ongoing flight without known Operation Plan.

8 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	Reference
[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 GOF USPACE FIMS Design and Architecture, Appendix A Service Description Templates, document SESAR 2020 GOF USPACE Service Documentation Guidelines
[4]	Ed. 00.02.RC1, 1 March 2019	EUROCONTROL Concept of Operations for U-space (CORUS), D6.2, Grant Ref. 763551, Call Ref. 2016 SESAR 2020 RPAS Exploratory Research Call (H2020 – SESAR -2016-1), Release Candidate 1
[5]	n/a	Global UTM Association (GUTMA) Flight Logging Protocol, https://github.com/gutma-org/flight-logging-protocol/blob/master/Flight_logging_protocol.md
[6]	n/a	Global UTM Association (GUTMA) Air Traffic Protocol, https://github.com/hrishiballal/airtraffic-data-protocol-development
[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, 31.10.2018, FOCA muo / 042.2-00002/00001/00005/00021/00003
[9]	5th Ed. - 2016	ICAO Doc. 9750-AN/963, Global Air Navigation Plan (GANP) 2016-2030
[10]	0.61.1	Intel Corporation, Open Drone ID Message Specification, Draft Specification, November 13, 2018
[11]	n/a	SESAR, European ATM Master Plan: Roadmap for the safe integration of drones into all classes of airspace
[12]	n/a	SESAR, eATM PORTAL, European ATM Master Plan, https://www.atmmasterplan.eu/

[13]	2017	SESAR-JU, U-space Blueprint, https://www.sesarju.eu/u-space-blueprint
[14]	n/a	Efficient, safe and sustainable traffic at sea (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
[15]	n/a	IALA specification for e-navigation technical services https://www.iala-aism.org/product/g1128-specification-e-navigation-technical-services
[16]	Ed. 1.0	EUROCONTROL Specification for ATM Surveillance System Performance, EUROCONTROL-SPEC-0147, https://www.eurocontrol.int/publications/eurocontrol-specification-atm-surveillance-system-performance
[17]	1 November 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
		Operation Plan Information Exchange Service Specification
		Traffic/Telemetry Information Exchange Service Specification

Table 37: List of References