Intermediate Concept of Operations for U-Space

Enhanced Overview

Founding Members

EUROPEAN UNION EUROCONTROL

SESAR JOINT UNDERTAKING

Intermediate Concept of Operations for U-space

Enhanced Overview

Consortium coordinator: EUROCONTROL
Edition date: 6/5/2019
Edition: 01.00.01

This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme through grant agreement No. 763551.

Funded by the Horizon 2020 Framework Programme of the European Union

Drone images courtesy of HEMAV

Introduction

Principles for unmanned aircraft regulation

In the short time Unmanned Aircraft Systems (UAS) have been available to the general public and to commercial operators, they have been a major driver of innovation and have brought, will bring further, great benefit to society. However, the airspace in which these “drones” fly is already used by many others - general aviation (GA), helicopters, military exercises, gliders and paragliders, etc. Many states have implemented regulations to ensure that the integration of these new aircraft into the airspace takes place safely, both for other aircraft and for people and infrastructure on the ground, that people’s privacy is maintained and that environmental impact is minimised. These state-based regulations are not always compatible and others need to be implemented on a European level so that a common, open market for UAS can develop within the European Union (EU).

The European Commission (EC), the European Aviation Safety Agency (EASA), the SESAR Joint Undertaking (SJU), and EUROCONTROL are working together, and alongside such organisations as the Joint Authorities on Rulemaking for Unmanned Systems (JARUS), to develop rules and standards to make the safe execution of UAS operations easier and more understandable for both commercial and recreational pilots in Europe.

The EC has developed a vision for the phased introduction of procedures and services to support safe, efficient and secure access to airspace, called U-Space. EASA has proposed that regulation of UAS should be proportional, operation-centred, risk-based, performance-based, and progressive and has produced a draft implementing regulation, defining categories of operation and classes of drone.

In line with this, EUROCONTROL has produced a draft high-level UAS air traffic management (ATM) operational concept to describe the operational ATM environment in which manned and unmanned aircraft must co-exist safely. An operational concept is a statement of what is envisaged - it defines the outcomes required for integrating UAS into the ATM system of the future. It is a technology-independent vision statement rather than a technical manual or blueprint.

The UAS-ATM operational concept does not, however, specify how things will be enabled; that is the job of lower-level documents. These include technical standards and strategic plans, as well as concepts of operation (ConOps).

With part-funding from the EU’s Horizon2020 programme through grant 763551, and in the context of the SESAR2020 exploratory research programme, the SESAR Joint Undertaking (SJU) has sponsored the CORUS project to write this low-level ConOps for U-space. This ConOps describes how very low-level (VLL) airspace will need to be organised and what rules and regulations will need to be put in place so that drones may bring about the full potential they offer to many aspects of life in the 21st century in safety and security, respecting the environment and people’s privacy.

Some basic background

Operational practice

A drone pilot is a pilot in the sense of Annex 2 of the International Civil Aviation Organisation (ICAO) convention, transcribed into the Standardised European Rules of the Air (SERA), which applies unless stated in the draft implementing regulation or below. When there is no identifiable pilot, the drone operator takes that role and all associated responsibilities.

Many rules apply to all pilots; this section attempts to explain some of the basics of these.

Access

Pilots must obey geo-fences, restricted areas, and the boundaries of controlled areas unless they have documented permission to cross.

Pilots and operators must obey entry conditions for airspaces.

Flight plans

Section 4 of the SERA says that all flights that will require services or advisory notices must file a flight plan.

Airspace classes

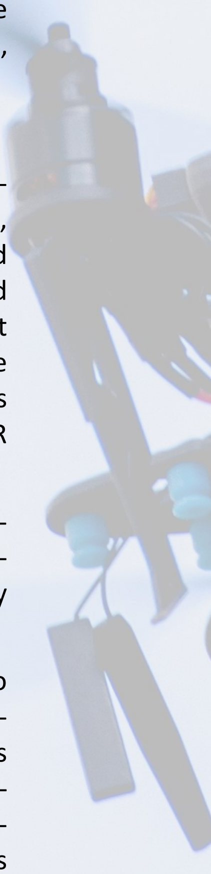
The airspace is divided into zones of different classes defined in section 6 of the SERA. At present, there are seven airspace classes labelled A to G, though F is not generally used.

The airspace classes are defined by the services offered in each of them, certain technical requirements, and by whether they are available to IFR and/or VFR traffic.

Flight rules

There are currently no specific rules governing drones other than those that regulate all aircraft. In order for the manned and unmanned operations to be compatible, there need to be clearly defined flight rules.

Flights are bound by the general Rules of the Air (RoA) defined in section 3 of the SERA. These concern, among other things, right-of-way, lights, etc.



VFR and IFR

Two further sets of rules define required visibility, maximal and minimal altitudes and speeds, conditions for night flying, flight over populated areas, equipage, reporting etc. These are called Visual Flight Rules (VFR) and Instrument Flight Rules (IFR). These are defined in section 5 of the SERA. As these names suggest, under VFR pilots must be able to see around them; under IFR they use instruments when visibility is poor.

It is foreseen that two new sets of rules are required at low level – low-level flight rules (LFR), - and high level (HFR), which would accompany the current VFR and IFR.

For LFR, it is clear that drones will not be able to operate in accordance with the full set of requirements in section 3 of the SERA, thus it is vital to clarify the necessary boundaries in a dynamic way. The development and implementation of LFR will be difficult in environments where the airspace is not organised in a standard way.

Automated flights must be able to apply the flight rules. If supervised, the supervisor must be informed of any infringement of the flight rules and stop the operation if necessary.

Right of way

Existing right of way rules are applicable not only to VFR traffic but also for VLL flights with drones. A pilot flying their drone in VLOS will have difficulty determining how far away an incoming VFR flight is and applying the correct right of way procedures. Similarly, a pilot would have trouble visually identifying a small drone from the cockpit even if it is only 50m away.

Uncontrolled drone flights are considered equivalent to balloons. Hereafter, “drone flight” refers to controlled drone flights.

- Drone flights shall give way to crewed flights.
- Drone flights without passengers shall give way to drone flights carrying passengers.
- Drone flights shall give way to all flights whose crewed or passenger carrying status uncertain to the remote pilot.

Deviations from ICAO Annex 2/SERA must come from practical consideration. For example ICAO Annex 2 section *3.2.2.3 Converging.*

> *When two aircraft are converging at approximately the same level, the aircraft that has the other on its right shall give way, except as follows:*

However, in visual line-of-sight (VLOS) operations, it may be difficult for the remote pilot to judge whether another aircraft is converging with theirs, whether both aircraft are on the same level, or which has the other to its right.

Collision Avoidance

The logic for drones and manned aircraft to avoid collisions must be compatible, whatever the intruder is. Drones must give way to manned aviation.

In any situation where the drone pilot is uncertain as to the trajectory, level, speed or status of another aircraft approaching their aircraft, they should assume a head-on approach and, following the right-of-way rules in ICAO Annex 2 and the SERA, change heading to the right for interoperability with VFR flights. If the drone is stationary, it should remain so unless such inaction seems likely to cause danger.

It is generally the fault of the moving drone if it collides with a stationary drone.

Very Low-Level airspace

Manned aircraft must generally remain above a certain minimum safe altitude, defined in the SERA as 500ft above any obstacle within a radius of 500ft, except with permission, or when taking off or landing. Over a populated area, it must not fly less than 1000ft above the highest fixed object within 600m of the aircraft. Member states are allowed to modify the low flying rule to suit their jurisdiction.

Very Low-Level (VLL) airspace is the airspace below this minimum safe altitude, but it is not empty. It is used by gliders and paragliders, emergency (HEMS) aircraft, aircraft landing and taking off, etc.

This ConOps defines a concept of operations for drones and other aircraft using this airspace.

Drone operation categories

The draft regulation specifies that any drone operation should be categorised as one of Open, Specific or Certified. Each category combines a risk category for the operation with an appropriate risk assessment and mitigation approach.

It is assumed that in traffic management terms, Certified and Specific flights may be indistinguishable. U-space services provide mitigations for risks in both cases.

OPEN

Safety is ensured through compliance with operational limitations, mass limitations as a proxy of energy, product safety requirements and a minimum set of operational rules. The 'Open' category UA has a maximum take-off mass (MTOM) of less than 25kg, and flies below a height of 120m in Visual Line of Sight (VLOS), far from aerodromes.

- Low risk
- Without involvement of aviation authority
- Limitations (visual line of sight, maximum altitude, distance from airport and sensitive zones)
- Flight over people is possible in sub-class A1 with drones in classes C0 and C1 only (less than 900g or 80J)
- No overflying of crowds
- CE marking

Online training and passing an online test is mandatory for all remote pilots of drones above 250g.

The Open category is further sub-divided into three subcategories:

A1: flights over people (but not over open-air assemblies of people) intended for hobby users flying UAs under 900g (or 80J) - class C0 or C1 (see below);
A2: flights close to people, but a safe distance from them for heavier UAs - class C2 - and require passing a recognised theory test;
A3: flights far from people – generally intended for model aircraft clubs - class C3 and C4.

Additionally, EASA has prepared draft regulation on making unmanned aircraft intended for use in the 'Open' category available on the market [EASA, 2018c]. These specify five classes of UA that, among other things, have the characteristics shown in Table . Categories C0, C1 and C2 must have no sharp edges and safe propellers.

Founding Members
EUROPEAN UNION EUROCONTROL

SPECIFIC

Requires a risk assessment, which should follow the JARUS Specific Operations Risk Assessment (SORA) methodology, performed by the operator.

- Increased risk
- Safety risk assessment
- Approved by NAA possibly supported by Qualified Entities unless approved operator with privilege
- Operation authorisation with operations manual
- Concept of accredited body
- Airworthiness of drone and competence of staff based on risk assessment

This ConOps assumes that the majority of professional flying in VLL will be as Specific operations. U-Space

CERTIFIED

Requirements comparable to those for manned aviation. Oversight by an NAA (issue of licences and approval of maintenance, operations, training, ATM/ANS and aerodromes organisations) and by EASA (design and approval of foreign organisations).

- High risk
- Comparable to manned aviation
- Type certificate (TC), Certificate of airworthiness, noise certificate, approved organisations, licences
- C2 link equipment and the remote pilot station could have separate TCs

Open operations do not require the operator to complete a specific operational risk assessment (SORA). This saving in effort and time is of interest to some professional users so some professional drone operations will be Open.

Many professional drones will be flown frequently to maximise return on investment. However, most private users not have this requirement and will fly their drones less often on average.

General characteristics of drone classes

Class	MTOM	Max speed	Max height	Max noise	eID	Geo-aware	Lights	Serial no.
C0	250g	19m/s	120m	-	N	N	N	N
C1	900g	19m/s	120m	60db(A)	Y	Y	Y	Y
C2	4kg	-	120m	60db(A)	Y	Y	Y	Y
C3	25kg	-	120m	-	Y	Y	Y	Y
C4	25kg	-	-	-	-	-	-	-

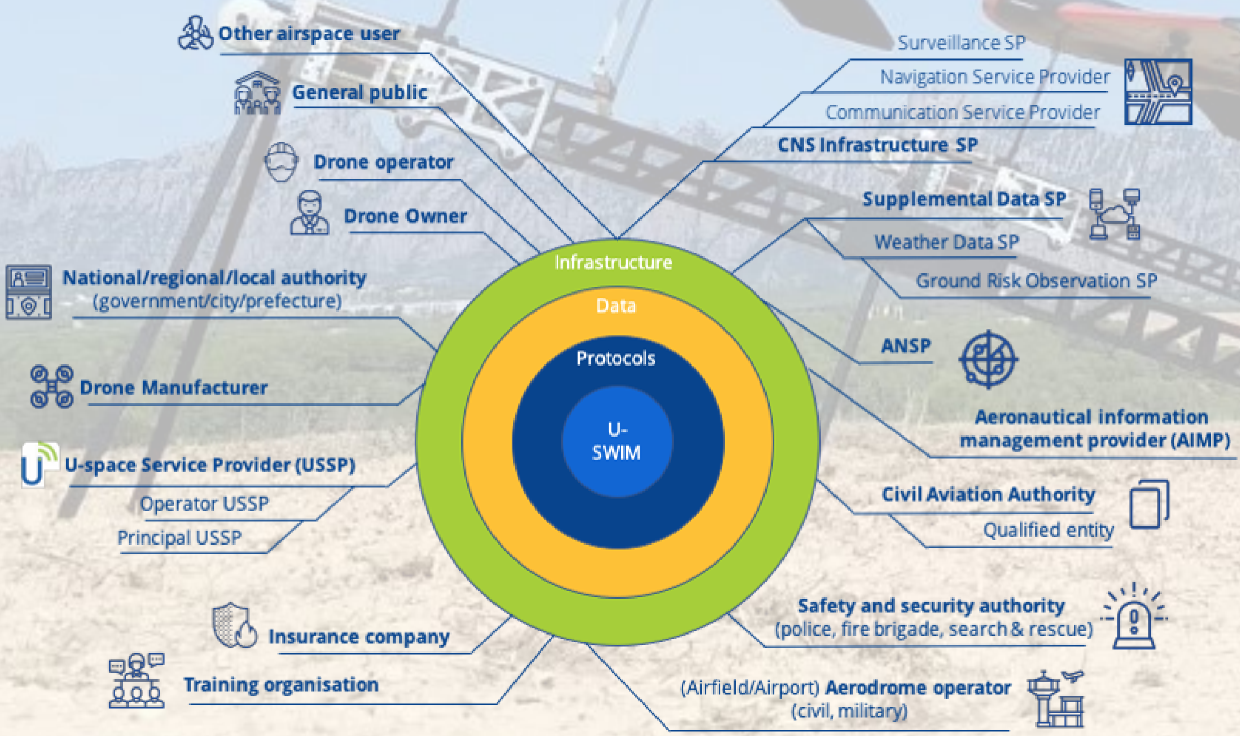
U-Space

The European Union has developed a vision called U-Space: the phased introduction of procedures and *"a set of services designed to support safe, efficient and secure access to airspace for large numbers of drones"* to encourage the growth of the UAS industry and the use of these aircraft in Europe. These services and procedures rely on a high level of digitisation and automation of functions, whether they are on board the drone itself, or are part of the ground-based environment.

U-space provides an enabling framework to support routine drone operations, as well as a clear and effective interface to manned aviation, ATM/ANS service providers and authorities. U-space is therefore not to be considered as a defined volume of airspace, which is segregated and designated for the sole use of drones.

U-space is capable of ensuring the smooth operation of drones in all operating environments, and in all types of airspace, in particular but not limited to very low-level (VLL) airspace. It addresses the needs to support all types of missions and may concern all drone users and categories of drone.

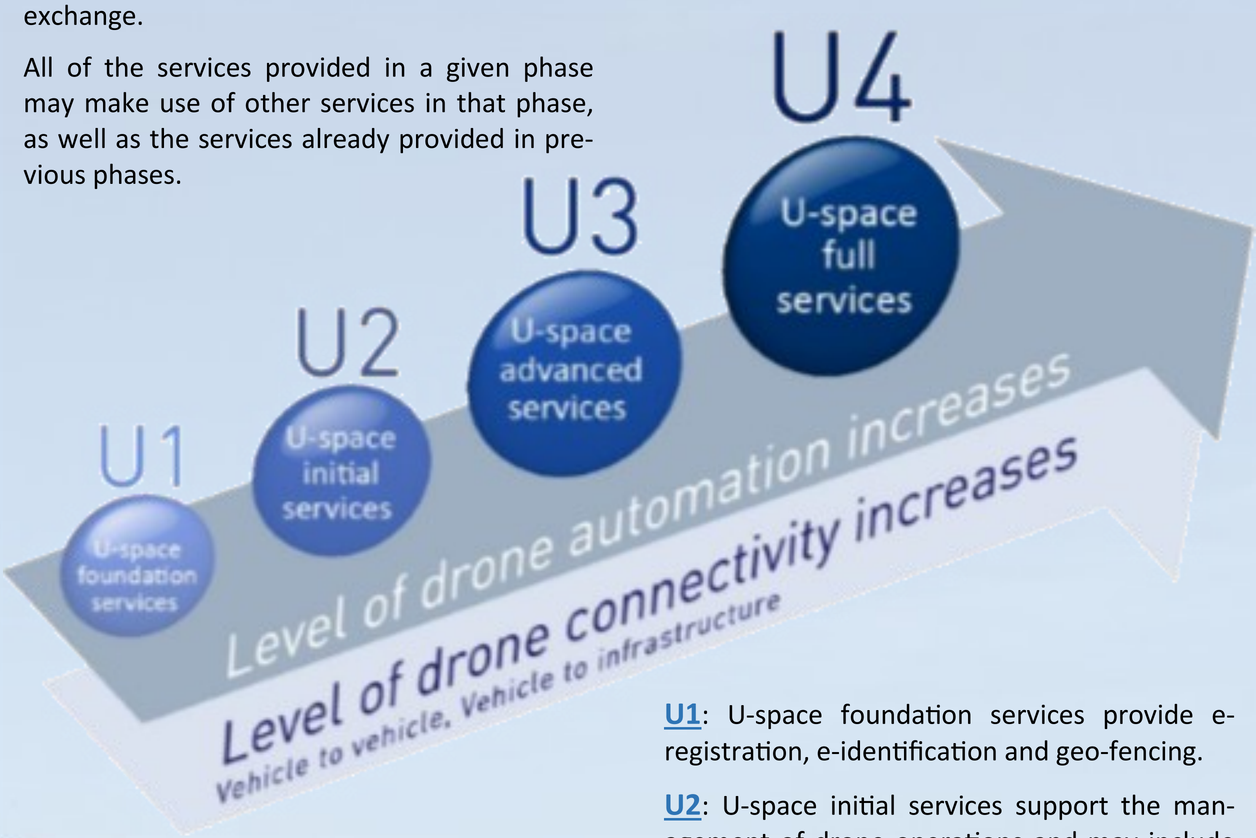
CORUS sees U-space as an environment that enables business activity related to drone use while maintaining an acceptable level of safety and public acceptance. CORUS has developed this concept of operations (ConOps) by considering the use-cases of U-space starting with the most frequent.



U-space implementation

The U-space services will be gradually introduced over four phases, U1 to U4, depending on the increasing availability of blocks of services and enabling technologies, the increasing level of drone automation, and advanced forms of interaction with the environment, mainly enabled through digital information and data exchange.

All of the services provided in a given phase may make use of other services in that phase, as well as the services already provided in previous phases.



U1: U-space foundation services provide e-registration, e-identification and geo-fencing.

U2: U-space initial services support the management of drone operations and may include flight planning, flight approval, tracking, airspace dynamic information, and procedural interfaces with air traffic control.

U3: U-space advanced services support more complex operations in dense areas and may include capacity management and assistance for conflict detection. Indeed, the availability of automated 'detect and avoid' (DAA) functionalities, in addition to more reliable means of communication, will lead to a significant increase of operations in all environments.

U4: U-space full services, particularly services offering integrated interfaces with manned aviation, support the full operational capability of U-space, and rely on a very high level of automation, connectivity and digitalisation for both the drone and the U-space system.

U-space services

U-space services will be introduced in four phases as technology and operational readiness allow (see "U-space implementation" above). These services relate to different aspects of the requirements for integration of drones with air traffic management and other airspace users.

The services introduced in the first three phases are indicated in the table below using the following colours.

U-space phase	U1	U2	U3

U4 is the full integration of drone flights into controlled airspace and is out of scope of this ConOps, which deals with VLL airspace only.

Identification and Tracking	Registration Registration assistance	e-identification	Tracking and Position reporting	Surveillance data exchange	
Airspace Management	Geo-awareness	Drone Aeronautical Information Management	Geo-fence provision (incl. Dynamic Geo-Fencing)		
Mission Management		Operation plan preparation/	Operational plan processing	Risk Analysis Assistance	Dynamic Capacity Management
Conflict Man-		Strategic Conflict			Tactical Conflict
Emergency		Emergency Man-	Incident / Acci-		
Monitoring	Monitoring	Traffic Information	Navigation infrastructure monitoring	Communication infrastructure monitoring	Digital Logbook Legal Recording
Environment	Weather Information	Geospatial infor- Population density	Electromagnetic interference information	Navigation coverage information	Communication coverage information
Interface with ATC		Procedural interface with ATC			Collaborative interface with ATC

This table only gives the services related to safety or security. Other, more business-related services, are outside the scope of this document.

Different services will be available in different types of airspace (see page 14) from different U-space phases. Some of these are mandatory, or at least strongly recommended, while others are offered if needed.

Service	X	Y	Z
Registration	Mandated	Mandated	Mandated
e-identification	Mandated	Mandated	Mandated
Geo-awareness	Mandated	Mandated	Mandated
Drone Aeronautical Information Publication	Mandated	Mandated	Mandated
Geo-fencing provision	Mandated	Mandated	Mandated
Incident / accident reporting	Mandated	Mandated	Mandated
Position report submission sub-service	Recommended	Mandated	Mandated
Tracking	Offered	Mandated	Mandated
Drone operation plan processing	Offered	Mandated	Mandated
Emergency management	Offered	Mandated	Mandated
Monitoring	Offered	Mandated	Mandated
Procedural interface with ATC	Offered	Mandated	Mandated
Strategic conflict resolution	No	Mandated	Mandated
Traffic information	Offered	Mandated	Offered
Weather information	Offered	Offered	Offered
Geospatial information service	Offered	Offered	Offered
Population density map	Offered	Offered	Offered
Electromagnetic interference information	Offered	Offered	Offered
Navigation coverage information	Offered	Offered	Offered
Communication coverage information	Offered	Offered	Offered
Collaborative interface with ATC	Offered	Mandated	Mandated
Dynamic capacity management	No	Recommended	Mandated
Tactical conflict resolution	No	No	Mandated

U-space Phase	U1	U2	U3

The following pages give a brief description of these services. The reader is encouraged to consult volume 2 of the ConOps for a more complete explanation.

U-Space Service	Description
Registration	Interaction with the registrar to enable the registrations of the drone, its owner, its operator, and its pilot. Different classes of user may query data, or maintain or cancel their own data, according to defined permissions.
Registration assistance	Provides assistance to people undertaking the registration process
e-Identification	e-identification enables information about the drone and other relevant information to be verified without physical access to the unmanned aircraft.
Geo-awareness	This provides geo-fence and other flight restriction information to drone pilots and operators for their consultation up to the moment of take-off. It includes existing aeronautical information, such as: • restricted areas, danger areas, CTRs etc.; • information extracted from NOTAMS, and legislation; • temporary restrictions from the national airspace authority; to produce an overall picture of where drones may operate.
Tracking and position reporting	Receives location reports, fuses multiple sources and provides tracking information about drone movements
Surveillance data exchange	Exchanges data between the tracking service and other sources or consumers of tracks – radar, other drone trackers, etc.
Drone Aeronautical Information Management	The drone equivalent of the Aeronautical Information Management service. This service maintains the map of X, Y and Z airspaces, and permanent and temporary changes to it. (e.g. a weekend festival will change an area from sparsely to densely populated). This service provides information to the geo-fencing services as well as operational planning preparation service.
Geo-fence provision (incl. dynamic geo-fencing)	An enhancement of geo-awareness that allows geo-fence changes to be sent to drones immediately. The drone must have the ability to request, receive and use geo-fencing data.
Operational plan preparation/ optimisation	Provides assistance to the operator in filing of a mission plan. This service functions as the inerface between the drone operator and the operational plan processing service
Operational plan processing	A safety-critical, access-controlled service that manages live flight plans submitted via the operational plan preparation service and checks them against other services. The service manages authorisation workflows with relevant authorities, and dynamically takes airspace changes into account.
Risk analysis assistance	Provides a risk analysis, mainly for Specific operations, combining information from other services – drone AIM, environment, traffic information, etc. This can also be used by insurance services.
Strategic Conflict Resolution	Checks for possible conflicts in a specific mission plan, and proposes solutions, during operational plan processing.
Emergency Management	Provides assistance to a drone pilot experiencing an emergency with their drone, and communicates emerging information to interested parties.
Accident / Incident Reporting	A secure and access-restricted system that allows drone operators and others to report incidents and accidents, maintaining reports for their entire life-cycle. A

U-Space Service	Description
Monitoring	Provides monitoring alerts (preferably audible) about the progress of a flight (e.g. conformance monitoring, weather compliance monitoring, ground risk compliance monitoring, electromagnetic monitoring)
Traffic Information	Provides the drone pilot or operator with information about other flights that may be of interest to the drone pilot; generally where there could be some risk of collision with the pilot's own aircraft
Navigation Infrastructure Monitoring	Provides status information about navigation infrastructure during operations. This service should give warnings about loss of navigation accuracy.
Communication Infrastructure Monitoring	Provides status information about communication infrastructure during operations. The service should give warnings about degradation of communication infrastructure.
Digital Logbook	Produces reports for a user based on their legal recording information.
Legal Recording	A restricted-access service to support accident and incident investigation by recording all input to U-space and giving the full state of the system at any moment. A source of information for research and training.
Weather Information	Collects and presents relevant weather information for the drone operation including hyperlocal weather information when available/required.
Geospatial information service	Collects and provides relevant terrain map, buildings, obstacles - with different levels of precision - for the drone operation.
Population density map	Collects and presents a population density map for the drone operator to assess ground risk. This could be proxy data e.g. mobile telephone density.
Electromagnetic interference information	Collects and presents relevant electromagnetic interference information for the drone operation.
Navigation Coverage information	Provides information about navigation coverage for missions that will rely on it. This information can be specialised depending on the navigation infrastructure available (e.g. ground or satellite based).
Communication Coverage information	Provides information about communication coverage for missions that will rely on it. This information can be specialised depending on the communication infrastructure available (e.g. ground or satellite based).
Procedural Interface with ATC	A mechanism invoked by the operation plan processing service for coordinating the entry of a flight into controlled airspace before flight. Through this, ATC can either accept or refuse the flight and can describe the requirements and process to be followed by the flight.
Dynamic Capacity Management	Responsible for balancing traffic demand and capacity constraints during operational plan processing.
Tactical Conflict Resolution	Checks for possible conflicts in real time and issues instructions to aircraft to change their speed, level or heading as needed.
Collaborative Interface with ATC	Offers verbal or textual communication between the remote pilot and ATC when a drone is in a controlled area. This service replaces previous ad-hoc solutions and enables flights to receive instructions and clearances in a standard and efficient manner.

CORUS airspace types

Drones in VLL

The majority of drones for private and leisure use will be as Open operations. Most of the rest are expected to be Specific operations in the context of flying clubs.

It is assumed that the majority of professional uses of drone flights in VLL can be achieved with Specific category. There will be some professional drone operations of Certified category.

VLL is divided into different parts according to the services provided. Three basic configuration types are:

X: No conflict resolution service is offered.

Y: Only pre-flight conflict resolution is offered.

Z: Pre-flight conflict resolution and in flight separation are offered.

Type Y airspace will be available from U2 and facilitate VLOS, EVLOS and BVLOS flight. Risk mitigations provided by U-space mean Y airspace is more amenable to other flight modes than X.

Type Z airspace may be sub-divided into Zu and Za, controlled by UTM and ATM respectively. Za is simply normal controlled airspace and is, therefore, immediately available. Zu airspace will be available from U3.

Because U-space provides more risk mitigations for Z type, it is more amenable to other flight modes than, and allows higher density operations than, Y airspace. Z allows VLOS and EVLOS and facilitates BVLOS and automatic drone flight.

As well as the services offered, these types of airspace differ by their requirements for access:

Type	Access requirements
X	• There are few basic requirements on the operator, the pilot or the drone. • The pilot remains responsible for collision avoidance. • VLOS and EVLOS flight are easily possible. • Other flight modes in X require (significant) risk mitigation.
Y	• An approved operation plan • A pilot trained for Y operation • A remote piloting station connected to U-space • A drone and remote piloting station capable of position reporting *Y airspaces may also have specific technical requirements attached to them*
Z	• An approved operation plan • A pilot trained for Z operation and/or a compatible, connected automatic drone • A remote piloting station connected to U-space • A drone and remote piloting station capable of position reporting *Z airspaces may also have specific technical requirements attached to them, most probably that the drone be fitted with collaborative detect and avoid system for collision avoidance.*

The following operations are possible in these airspaces:

<table>
<tr><th colspan="2">Operation</th><th>X</th><th>Y</th><th>Z</th></tr>
<tr><td rowspan="7">Drone</td><td>VLOS</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Follow-me</td><td>Yes</td><td colspan="2">Only be undertaken with reasonable assessment of the risk involved.</td></tr>
<tr><td>Open</td><td>Yes</td><td colspan="2">Yes, provided access requirements are met</td></tr>
<tr><td>Specific</td><td rowspan="5">Yes. However, the risk of unknown drone operations must be considered, evaluated and mitigated appropriately.</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Certified</td><td>Yes</td><td>Yes</td></tr>
<tr><td>BVLOS</td><td>Yes</td><td>Yes</td></tr>
<tr><td>AF or RSF</td><td>←</td><td>Yes in Zu</td></tr>
<tr><td rowspan="2">Crewed</td><td>VFR</td><td>Yes, but the use of U-space services by VFR flights is strongly recommended</td><td rowspan="2">Yes. However, type Za is controlled airspace. Crewed flights in Za will need to behave as such.</td></tr>
<tr><td>IFR</td><td>No</td><td>No</td></tr>
</table>

Some airspace below 500ft is “restricted” or “controlled” as Aeronautical Information Management (AIM) texts. Permission is required from a specific authority for authorisation to enter such areas.

<u>Restricted</u> areas may be areas of increased ground risk, national parks, nuclear power stations, hospitals and other “no drone zones”; G-class regions around airports which may be restricted for drone operations; model aircraft flying club airfields (restricted to keep other aviation away); cities with Urban Mobility systems, harbours, etc. Such areas are still type X, Y or Z, however and the access requirements above still apply.

<u>Controlled</u> areas all exist inside class A to E airspace and cannot contain types X, Y or Z. Drones must not enter controlled areas without coordination. In U1, the drone operator must coordinate directly with the authorities. From U2 onwards, the U-space “procedural interface with ATC” service can be used to coordinate before flight.

The modes of operation inside a controlled area will be determined by the controlling authority.

Access to restricted volumes

Drones must follow the rules applicable to segregated areas but drone operations have added new types of zone. No-drone zones, Limited-drone zones, and Exclusive-drone zones require manned aviation and drone pilots to be familiar with these restricted volumes.

Because of the governmental use of drones and their usefulness in accessing very dangerous areas, a system of privileges will be implemented for authorised drones. UTM must cater for these privileges.

The zones will most likely be enforced by geo-fencing. This could be a dynamic process and the drone airspace picture of all the types of geo-fencing, including geo-caging, must therefore be updated accordingly through a UTM service.

Operations in different airspace types and access conditions

Open operations

“Open” class drone operations are restricted to VLOS, EVLOS and certain automated flights.

There will be regions of type X airspace that are dedicated to ‘Open’ class operations – “dronodromes”. These will be restricted areas for other traffic. ‘Open’ flights are also possible in types Y and Z airspace if all conditions are met.

Specific and Certified operations

“Specific” operations can occur in airspace types X, Y and Z (and in ICAO classes A-G with prior coordination and depending on the local regulation and approval). Some type Y or Z airspaces may mandate the use of “Certified” drones for ground risk mitigation or similar reasons.

A risk assessment is required before “Specific” operations whereas the certification process prior to “Certified” operations includes this. Additionally:

- Operations will need to mitigate the risk of ‘surprise encounters’ with other aircraft, especially BVLOS, in type X airspace. Responsibility for accidents lies with the BVLOS operator in this case.
- Risk mitigations can include permitting one drone at a time to access a restricted airspace, using the U--space services available in types Y and Z airspaces, etc.
- Operational declaration and position reporting are mandatory in types Y and Z airspace and highly recommended in type X.

As separation provision is pre-flight (i.e. strategic) in Type Y, it must guard against uncertainties in 4D position, so traffic density in type Y may be low compared with Type Z, where separation is provided during flight (i.e. tactical).

Type Y airspace is available from U2 onwards. Type Z airspace is available from U3 onwards. It is likely that type Z zones will have mandatory use of collaborative detect and avoid.

Mandatory requirements for use		Type Y	Type Z
UAS Flights	VLOS, EVLOS or BVLOS	Y	Y
	Remotely supervised and AFU	N	Y
U-Space services	Operation declaration	Y	Y
	Strategic conflict resolution	Y	Y
	Position reporting	Y	Y
	Dynamic capacity management	N	Y
	Emergency management	Y	Y
	Tactical geo-fencing	Y	Y
	Traffic information	Y	Y
	Tactical conflict resolution	N	Y
	Dynamic Geo-fencing	N	Y

Risk management and mitigation

Risk management and mitigation enables the likelihood of accident in the air or on the ground to be reduced and preferably removed.

In U1, U-space does not provide mitigation for the risk of entering a type X airspace (types Y and Zu do not exist in U1) apart from restricted areas or geo-fencing. Crewed flights should assess the likely risk very carefully before flight.

U2 will be an intermediate phase when more services will become available to help pilots minimise their risks.

- A U-space operational declaration enables planned drone and crewed flights to be known to U-space and so to other flights. While essential for planned drone flights, this should also be used by a crewed aircraft that will fly close to VLL airspace so that the risk of unintentional entry can be evaluated.
- In types Y and Z, the strategic conflict resolution service resolves possible conflicts between planned flights, and its results must be followed. If this is not possible, the crewed flight should request protection through geo-fencing;
- The U-space position reporting service is mandatory in types Y and Z. The use of ADS-B might be sufficient if there is coverage at the location.
- The U-space traffic information service will also help reduce risk. Both this and the U-space position reporting service should be activated on a crewed aircraft when the need arises during unplanned or unintentional incursion.

For unintentional or unplanned, conscious entry into VLL, a crew should use the U-space emergency management service to report their incursion. This may involve some training.

In U3, when collaborative detect and avoid is in widespread use, crewed aircraft can be fitted with such a drone-compatible system, and the pilot trained to use it.

In U4, the safe interoperation of crewed and drone flights will be possible through standardised systems and procedures, and the general use of a compatible autonomous detect-and-avoid system.

Separation and conflict resolution

Separation

Separation is a concept for keeping aircraft at a minimum distance from each other to reduce the risk of collision. In controlled airspace, ATC is responsible for maintaining a minimum separation between manned aircraft based on the flight regulations that an aircraft must adhere to. In un-controlled airspace, aircraft assure self-separation with the Remain-well-Clear (RwC) rule. In both cases, minimum separation is maintained through procedural rules and/or a situational surveillance method (such as primary radar).

Each separation standard is usually based on the capabilities of the service offering it (e.g. radar resolution) or the capabilities of all aircraft involved (e.g. maintain a vertical "flight level" accuracy of at least 100ft). With the emergence of small high-accuracy positional location and tracking systems, the minimum distances for the safe separation of aircraft can now depend on the performance of the overall navigation and surveillance system. Separation can be defined as a function of performance-based navigation (PBN), defined in terms of accuracy, integrity, availability, continuity, and functionality. The prevailing weather conditions can also affect small drones in a variety of ways and must also be taken into account when defining the separation required between two aircraft.

Conflict management

Three layers of conflict management may be represented:

Strategic (pre-tactical) de-confliction	Tactical separation provision	Collision avoidance
The ability to plan a flight that does not conflict with other users, before departure. This involves operators sharing mission plans with relevant parties and reducing any potential loss of separation either by an agreed procedural separation or by planning routes that avoid other aircraft.	The ability to maintain situational awareness, visually or with instruments. ATC uses radar to predict aircraft trajectories and issues clearances to resolves potential conflicts. Similarly, VFR defines the tactical actions necessary to manage potential loss of separation between two aircraft in uncontrolled airspace.	The ability to prevent a collision as part of a last course of action, if the above separation plans and provisions fail.

In U-Space, these three layers of conflict management remain valid. Collision avoidance systems that predict a potential loss of separation can be used to aid these services. The "Collaborative interface to ATC" service can be used to propagate clearances when in controlled airspace (type Za) or the "Tactical conflict resolution" service can be used when in type Zu.

U-Space will also support detect and avoid (DAA) systems for ensuring the safe execution of flights. The goal of DAA on board drones is to give the UAS equivalent capabilities to those currently used through "see and avoid" by manned aircraft.

Separation between drones

Between VLOS and VLOS

The remote pilot flying the drone in VLOS is responsible for the avoidance of collisions, despite the difficulty in accurately judging height and distance by eye. However, if strategic and tactical de-confliction services are provided, no particular separation minimum is needed between VLOS, just as there is none between two VFR in class G.

Between VLOS and BVLOS

When a drone operation plan is submitted, the U-space system is able to consider separation minima before validating the plan. Even if collision avoidance is supported by the VLOS flight, separation minima must be defined between BVLOS and VLOS, to provide safety for the BVLOS flight.

Between BVLOS and BVLOS

Even assuming perfect surveillance, separation minima must take into account navigational accuracy and the speed of the aircraft. For instance, in airways dedicated to high-speed, long-haul flights, these minima should be higher than those in high-density areas, which should be a function of a maximum operational speed.

The use of Required U-space Navigation Performance (RUNP) could be a factor in determining these.

Between drones and manned aircraft

According to EASA regulations, drones must fly under 120m. National regulations in many European countries rule that they must fly far from manned aviation activity. But even when flying below 120m and far from manned aviation activity, an encounter with a manned aircraft is far from being rare.

VFR and IFR should avoid type X airspace. BVLOS can enter type X airspace only if the air risk is mitigated. However, if a VFR aircraft is planned to fly in such airspace at a known altitude, mitigation could involve limiting the drone's altitude to a safe height below the VFR flight by means of a tactical NDZ.

In the types Y and Z airspace, every operation will be known to U-Space and can be brought to a manned aircraft pilot's attention before they take off. Manned aircraft operating in these types of airspace would be able to request a permanent or ad-hoc "no drone zone" (e.g. hospital or building with heliport) based on drone activity. A layer dedicated to manned aircraft (e.g. HEMS and police helicopters, urban mobility) above 500ft over urban areas could also be envisaged, where justified.

Geo-fences

Geo-fences are a new machinery that does not exist in the current AIP and that provide a new means of mitigating risk. They are used to provide "barriers" to prevent unauthorised drones from entering/leaving a designated volume. Geo-fences have the following properties:

- Obeying geo-fences is mandatory, but exceptions, which will have a standard technical implementation, may be granted.
- While most geo-fences with exclude aircraft from restricted or controlled areas, a drone may be restricted to staying inside a geo-fence. (Geo-cage)
- Geo-fences may be temporary.
- Geo-fences may have times of operation.
- Geo-fences may be created with immediate effect.

Procedures

In the context of a UTM ConOps, it is important to understand how a UTM system could be used. This is best illustrated through a typical drone operation sequence, referring to roles, environment and services identified elsewhere in the ConOps. Three phases are considered: pre-flight; in-flight; and post-flight. Flight conditions can be nominal or anomalous, the latter resulting in a different post-flight workflow. It is assumed that U-space services are delivered via the internet to computers or mobile devices.

Many stakeholders play a role in a successful drone flight. The following table gives an indication of these roles.

Stakeholder	Role
UAS operator	Owner of the drones Plans the flight Requests permission if required
UAS pilot	Maybe a member of an operator company Executes the flight
CAA and local regulatory authorities	Evaluates and authorises or denies drone operations
Police, and safety and security authorities	Evaluates and monitors operations, ensures law enforcement Evaluates and authorises or denies local operations related to an authority's area of competence
ANSP	Evaluates and monitors operations close to and in controlled airspace Provides or denies ATC clearances
Airport, airfield	Evaluates and monitors operations close to its airport or airfield Provides or denies airport or airfield clearance
VFR pilot	Operates in VLL airspace, which is also used by drones

Strategic tasks

The basic starting conditions for flying a drone are set up in the "strategic" part of the pre-flight process. This part generally only needs to be performed once, or occasionally—for example when buying new drones or recruiting new pilots.

- Procuring one or more drones
- Registration of the drones if required
- Registration of the drone operator
- Any pilot training required
- Registration of any pilot training
- Procuring relevant insurance if not per-flight
- Signing up with a U-space service provider

Tactical tasks

Once a decision has been made to fly a specific mission, the "tactical" part of pre-flight starts to prepare for its safe and efficient execution.

- Becoming familiar with the location where the mission will occur and the information provided by the relevant environment services
- Selecting the appropriate drone and pilot to meet any airspace requirements
- Deciding on the type of operation: open, specific, or certified
- Planning the operation, including:
    - checking and planning appropriately for the airspace structure
    - obtaining any 'geo-fence crossing tokens' required
- Performing a SORA if required
- Submitting the operation plan, if required. This includes:
    - Geo-fence checks
    - Strategic conflict resolution
    - dynamic capacity management (if appropriate)
- Obtaining per-flight insurance if required

Once the pre-flight phase is completed, the drone can be prepared for take-off. For flights that have an operation plan, there is a normal minimum time between submitting the operation plan and flying.

Flying has a normal routine and particular actions to be taken if the something goes wrong. The normal sequence of events would be:

- Configure the drone and/or remote piloting station (as appropriate) including downloading the operational plan
- Prepare the flight area (if appropriate) including take-off and landing points
- Verify that the conditions for flight are within the limits planned: weather, airspace (geo-fences), other air traffic
- Check the flight area for unexpected risks (such as the presence of people)
- Check that the operation plan (if any) is still valid
- Prepare the drone for flight, check that it is airworthy and ready to operate, following a pre-flight checklist
- Prepare the payload
- Configure the Emergency Management Service for the current operation
- Start of Flight: enable position report submission (if used)

Pilot procedures in-flight and post-flight

- Fly the drone, during which continuously monitor
  - The drone's flight
  - The mission goal
  - Conformance with the operational plan
  - Other traffic – maintaining separation at all times
  - Ground risk (people in particular)
  - Warnings from the Emergency Management Service
  - Traffic information if available
  - Tactical conflict resolution if available
  - Collaborative interface with ATC if available
  - Communication and navigation infrastructure failure warnings if available
- Land
- Switch off position report submission, Send End-of-flight (as appropriate)
- Go through end-of-flight checklist, power-off etc.
- Log-off U-space

Normal post flight workflow makes little use of U-space services. Typical steps include:

- Fill in a log or flight report as the operator's processes require
- Check the mission has been successful
- Check the drone
- Either prepare for another flight or pack up

Please note that the above are not the complete set of activities to be performed but rather a selection of those considered important, especially in relation to U-space services.

Flight irregularities

If the flight should experience any irregularities, incidents or accidents, these must be noted and an ad-hoc analysis made. The corrective action or mission modification to be taken immediately should be decided upon and taken. Such irregularities should be fully analysed and reported as part of the process for ensuring that they do not re-occur.

Any remedial action necessary should be planned and undertaken before similar flights proceed. The pilot should make use of the Emergency Management service as appropriate.

Contingency and Emergency

This ConOps makes use of this procedural and technological enablers to overcome emergencies, mitigating risks or resolve emergencies successfully, including ensuring the safety of the operations in non-nominal situations. However, contingency plans should be provided to cover occasions when a failure of these procedures or technology occurs.

It is important to clearly differentiate between Mitigation and an Emergency, and to understand when a Contingency Plan is needed to come into force.

Mitigation:

Mitigation is a precautionary measure to avoid an unwanted threat or event happening.

Example: Redundant radio link. If the primary radio link fails, the secondary radio link can be used.

Emergency:

An Emergency occurs if there is a complete breakdown or loss of control.

Example: The GPS navigation system fails which causes the drone to be out of control; the pilot deploys the parachute.

Contingency Plan:

Plan B. A contingency plan describes procedures to follow in a possible incident. It aims to maintain the level of operation.

Example: The GPS system fails, but the drone is still controllable, so the pilot switches to manual/stabilised flight mode.

For a U-space service, a contingency plan enters into force if the service behaves incorrectly or input data from external sources are missing, wrong or arrive with high latencies. A service must be stable, be under control and be able to detect such occurrences.

Example: The monitoring service detects erroneous data from the tracking service, so it gives a warning to affected drone users/operators.

Best Practice

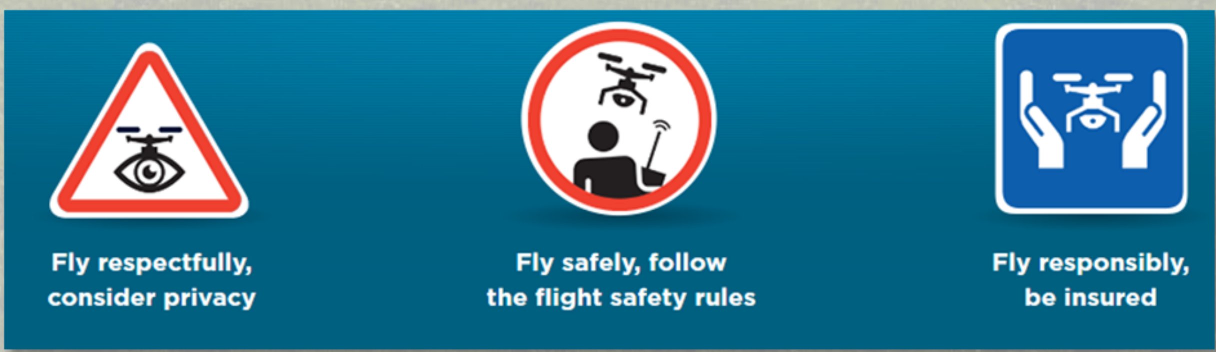
The future of the drone sector depends greatly on their acceptance by the public, which is linked to how safe drones appear to be. Risks on privacy, data protection and ethical issues in general are also very relevant for society. Failures in liability and the associated penalties could negatively affect the growth of this sector. In fact, every malpractice has the potential to affect progress. Many non-profit associations of drone operators and/or drone pilots have created and published a 'Best practices' or 'Code of Conduct' guide to maximize the safety of the drone operations and their perception by the public.

While the main role of these publications is to make drone operators aware of their responsibilities, these operators must also take firm action to minimise the risks.

The current tendency is centred on limiting the actions of pilots and on relying on their personal capacities. For example, the European Commission's Drones 2014 publication ends with the following recommendations for drones operators:

- Reduce the presence of uninvolved people by, for instance, flying at non-busy hours;
- Limit the photographing of identifiable objects (e.g. vehicles) by, for instance, applying blurring;
- Record images only when absolutely necessary (e.g. do not record during cruise);
- Store images/data only when absolutely necessary (e.g. transfer to client and delete copies);
- Use adequate technical means to secure the data storage against non-authorised access;
- Inform neighbours of frequent flight areas and/or ask for their consent;
- Do not sell images to third parties for other than the original purpose;
- Establish clear rules and obligations with the drone operator's client by contract.

The DroneRules-funded COSME project shows the basic rules that drone pilots must follow:



Edition date: 21/03/2019

Intermediate ConOps

D6.2	CO
CORUS	
Grant:	763551
Call:	2016 SESAR 2020 RPAS Exploratory Research Call (H2020 – SESAR -2016-1)
Topic:	Topic 01: SESAR UTM Concept Definition
Consortium coordinator:	EUROCONTROL
Edition date:	9th May 2019
Edition:	02.00.01

Founding Members

EUROPEAN UNION EUROCONTROL

SESAR JOINT UNDERTAKING

Authoring & Approval

Authors of the document

Name/Beneficiary	Position/Title	Date
Andrew Hately / EUROCONTROL	WP6 lead / Editor of the document	01/03/2019
Andres Van Swalm / Unifly	CORUS team	01/03/2019
Andreas Volkert / DLR	WP3 lead	01/03/2019
Anthony Rushton / NATS	WP2 lead	01/03/2019
Arnau Garcia / HEMAV	CORUS team	01/03/2019
Catherine Ronfle-Nadaud / DSNA	CORUS team	01/03/2019
Cristina Barrado / UPC	WP4 lead	01/03/2019
Daniel Bajiou / HEMAV	CORUS team	01/03/2019
David Martin / EUROCONTROL	CORUS team	01/03/2019
Davide Del Vecchio / ENAV	CORUS team	01/03/2019
Dominic Colin / EUROCONTROL	CORUS team	01/03/2019
Elina Millere / EUROCONTROL	CORUS team	01/03/2019
Ellen Malfleit / Unifly	WP7 lead	01/03/2019
Enric Pastor / UPC	CORUS team	01/03/2019
Gincarlo Ferrara / ENAV	CORUS team	01/03/2019
Koen Williame / Unifly	CORUS team	01/03/2019
Luca Bellesia / EUROCONTROL	WP1 lead	01/03/2019
Luigi Brucculeri / ENAV (Technosky)	WP5 lead	01/03/2019
Marc May / DLR	CORUS team	01/03/2019
Peter Hullah / EUROCONTROL	CORUS team	01/03/2019
Ralf Heidger / DFS	CORUS team	01/03/2019
Yannick Seprey / DSNA	CORUS team	01/03/2019
Other CORUS team members		

Reviewers internal to the project

Name/Beneficiary	Position/Title	Date

Reviewers external to the project

Name/Beneficiary	Position/Title	Date

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

Name/Beneficiary	Position/Title	Date
Ralf Heidger / DFS	DFS point of contact	26/04/2019
Robert Geister / DLR	DLR point of contact	26/04/2019
Catherine Ronfle-Nadaud / DSNA	DSNA point of contact	06/05/2019
Luigi Brucculeri / ENAV (Technosky)	ENAV point of contact	26/04/2019
Luca Bellesia / EUROCONTROL	CORUS Project coordinator	26/04/2019
Arnau Garcia / HEMAV	HEMAV point of contact	26/04/2019
Anthony Rushton / NATS	NATS point of contact	26/04/2019
Andres Van Swalm / Unifly	Unifly point of contact	09/05/2019
Enric Pastor / UPC	UPC point of contact	26/04/2019

Rejected By - Representatives of beneficiaries involved in the project

Name/Beneficiary	Position/Title	Date

Document History

Edition	Date	Status	Author	Justification
00.02.RC1	01/03/19	Release Candidate 1	AH, CORUS team	Based on draft 17 To be distributed for review
02.00.00	22/03/19	Release version (not yet reviewed by SJU)	Andrew Hately, CORUS team	RC1 with very minor changes: "Open Class" ➔ "Open Category" and similar Added some missing references Improved figures 2 & 4 Many typing errors fixed
002.00.01	09/05/19	Approved version	Peter Hullah Andrew Hately	Many minor editing changes following reviewers' comments, updated Figure 3, revision of section 3.4 first paragraph, approval table

CORUS

CONCEPT OF OPERATIONS FOR EUROPEAN UTM SYSTEMS

This document is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 763551 under European Union's Horizon 2020 research and innovation programme.

Abstract

This is the Intermediate Concept of Operations (ConOps) for U-space, and aims to be close to the content of the Final, due a few months after this one. This ConOps is input for the Validation workshop of the CORUS project to be held in April 2019. This particular volume is a reference manual and is the second of three parts; the first being the extended overview and the third being the annexes.

The ConOps describes from a users' perspective how operations should occur, supported by U-space. The first part of this reference manual describes the scope of the work, the foundations on which it is built, the assumptions of the authors, the approach taken and the guiding principles. The following section (3) is a proposal for an operating environment, explored in some detail, describing an airspace structure and possible modes of operation. The section after that examines operations and services in this environment, considering normal and contingency situations, accident investigation and best practice. Most of the ConOps describes a way of working in which drones and manned aircraft are intelligently segregated or there are accommodations between their respective environments. The ConOps concludes by looking forward to full integration of drone and manned aircraft.

1 Table of Contents

1 Introduction ... 8
1.1 Context, Aim of this work ... 8
1.2 Structure of this document ... 8
2 The context and scope of this Concept of Operations ... 9
2.1 Relation with the framing regulation ... 9
2.2 Safety, the risk approach, SORA ... 10
2.2.1 What is SORA ... 10
2.2.2 Discussion of the integration of the SORA into the CORUS ConOps ... 10
2.2.3 Safety Assessment methodology within U-Space ... 12
2.3 U-space ... 12
2.3.1 U-space levels ... 13
2.4 Area of interest of VLL U-space ... 14
2.5 Assumptions & definitions ... 15
2.5.1 Definition of Very Low Level, VLL ... 15
2.5.2 Altitude ... 16
2.5.3 Types of Operation ... 16
2.5.4 Detect and Avoid ... 18
2.5.5 EASA Categories of operation ... 19
2.5.6 Drone use in VLL ... 20
2.5.7 The technological environment ... 21
2.6 Overall Approach ... 21
2.6.1 Risk based ... 21
2.6.2 Performance based ... 21
2.6.3 Stepwise ... 21
2.6.4 Validation based ... 21
2.7 High level principles ... 21
2.7.1 Safety first ... 21
2.7.2 Open market ... 21
2.7.3 Social Acceptance ... 22
2.7.4 Equitable access ... 22
2.7.5 ECAC wide ... 22
2.7.6 Architecture principles ... 22
2.8 Stakeholders ... 23
2.9 Roles ... 28
3 Operations in Very Low Level Airspace ... 31
3.1 Ground and air risk terms ... 31
3.1.1 Ground risk ... 31
3.1.2 Airport related ... 31
3.1.3 Air risk & Traffic Density ... 31
3.2 Volumes ... 32
3.2.1 Types of airspace ... 32
3.2.2 Access & Entry conditions ... 36
3.2.3 Airspace Assessment ... 39
3.2.4 Operations in different airspace types and access conditions ... 39

3.2.5 Comparison of U-space types and other models of the airspace 44

3.3 Operational practice including rules of the air and flight rules 45

3.3.1 Rules of the air 45

3.3.2 Specific and General Flight rules in VLL 45

3.3.3 Avoidance of collisions 45

3.3.4 Access to restricted volumes (NDZ, LDZ, EDZ, etc.) 46

3.4 Separation 46

3.4.1 The impact of Weather on drone separation 47

3.4.2 Required U-Space Navigation Performance - RUNP 47

3.4.3 Conflict management 47

3.5 Examples of separation in Use Cases 48

3.5.1 Separation between drones 48

3.5.2 Separation between drones and manned aircraft 49

3.6 Privacy and Electronic conspicuousness 50

3.6.1 Privacy of DRONE OPERATIONS 50

3.6.2 Electronic conspicuousness in U-space 51

4 Operations and services in U-space 52

4.1 U-space services 52

4.1.1 Identification and tracking 52

4.1.2 Airspace management / Geo-Fencing 58

4.1.3 Mission management 60

4.1.4 Conflict management 66

4.1.5 Emergency management 67

4.1.6 Monitoring 68

4.1.7 Environment 70

4.1.8 Interface with ATC 70

4.2 Procedures 71

4.2.1 U-space usage model - summary 71

4.2.2 Virtue, virtuous behaviour, rewards for virtue 73

4.2.3 Reasonable time to act 74

4.3 Contingency 74

4.3.1 Mitigation: 74

4.3.2 Contingency plan: 74

4.3.3 Emergency: 75

4.3.4 Contingency plans for drones 75

4.3.5 Contingency plans for U-space services 75

4.4 Accident and Incident Investigation 77

4.4.1 Additional events to be reported 77

4.4.2 Proposed changes for reporting to responsibilities 79

4.4.3 Proposed changes for practices and reporting repository 79

4.5 Best practices 79

4.6 Uncooperative Drones 80

5 Integration of drones and manned aviation 83

6 Terms and acronyms, References 84

6.1 Terms and acronyms 84

6.2 References 86

List of Tables

Table 1 Operational Stakeholders 27
Table 2 Other stakeholders 28
Table 3 Roles 30
Table 4 Ground risk terms 31
Table 5 Airport related area terms 31
Table 6 Traffic Densities 32
Table 7 Services offered in different airspace types 34
Table 8 Operation types possible in X, Y and Z volumes 35
Table 9 Technical features required of UAS per airspace type 36
Table 10 Summary of e-Registration 53
Table 11 Pre-Tactical Geo-Fencing Roles and Actions 59
Table 12 Mission management specific terms 60
Table 13 Pre-Tactical Geo-Fencing Roles and Actions 64
Table 14 Contingency plans for U-space services 77
Table 15 Terms and Acronyms 86

List of Figures

Figure 1 U-space levels, from the U-space Blueprint 13
Figure 2 U-space in context 15
Figure 3 Stakeholders 24
Figure 4 Limited Drone Zone (LDZ) and No Drone Zone (NDZ) *from EASA NPA 2015-10* 37
Figure 5 U-space services 52
Figure 6 Example trajectories 64

1 Introduction

1.1 Context, Aim of this work

The CORUS project exists to write a Concept of Operation (ConOps) for U-space (UTM in Europe). The project is undertaken for the SESAR Joint Undertaking in the context of the SESAR2020 exploratory research programme, and is partly funded by Horizon2020 grant 763551.

The project is developing this ConOps iteratively. The first version was released in June 2018. Comments on the first version have been received and these have led to this second version, released in March 2019. Comments on this version will lead to the third and final version in the lifetime of the CORUS project, which will be released in September 2019.

1.2 Structure of this document

The ConOps version 2 is composed of three parts. It is structured in this way for ease of use both at the management and expert level.

Part 1 – U-space Extended Overview providing an extended summary of the U-space ConOps.

Part 2 – U-space Operational Concept Description providing a reference manual of U-space operations and environment.

Part 3 – U-space ConOps Annexes

The present document is Part 2. As this is a reference manual, it is concise but is not particularly easy to read. To get a better understanding of how the different parts of what are described here fit together, please consult Part 1, the extended overview, and then Part 3, the Annexes, in particular the use cases. These use cases refer back to specific sections of the reference manual.

2 The context and scope of this Concept of Operations

From Wikipedia [49] it is clear there are a number of broadly similar descriptions of a ConOps which may differ in their precise details. This document is in line with the opening paragraph which states: *A concept of operations (abbreviated CONOPS, CONOPs, or ConOps) is a document describing the characteristics of a proposed system from the viewpoint of an individual who will use that system such as a business requirements specification or stakeholder requirements specification. It is used to communicate the quantitative and qualitative system characteristics to all stakeholders.*

This document is a Concept of Operation for **U-space**, which is defined in the U-Space Blueprint [9] as "…a set of new services and specific procedures designed to support safe, efficient and secure access to airspace for large numbers of drones" which we equate to UAS Traffic Management in Europe.

2.1 Relation with the framing regulation

This is a ConOps for U-space, the UTM system in **Europe**. This ConOps has been built taking into consideration conceptual elements introduced by the European Aviation Safety Agency's (EASA) regulations, such as classification of drone operations.

The CORUS ConOps can be taken as input for defining the evolution of the framing regulation for the management of UAS traffic.

EASA is involved in a programme that will develop an implementing regulation and a delegated regulation for drones and drone operations in the European Union. This programme is described at the following web page which gives access to the current drafts of each (at the time of writing) – refs [1] [2] [3] [4]. The reader is invited to consult the Roadmap [6] on the same page for a good explanation of the reasons for the work and the plan of the activity. https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2018-1460265_en

Further, a set of Acceptable Means of Compliance (AMC) and Guidance Material (GM) are being developed for these regulations, and a draft [5] is available at the time of writing.

Several decisions which are embedded in the draft regulations. Briefly these are

- A drone operation is categorised as **Open, Specific** or **Certified**. Each category combines a risk level for the operation, and an appropriate risk assessment and mitigation approach.
- Drones that are to be sold as suitable for Open operations fall into one of five classes, **C0**, **C1**, **C2**, **C3** or **C4,** depending on various technical parameters. These classes are referred to in the descriptions of the **A1**, **A2** and **A3** sub-categories of the Open category.

- Preparation of a Specific operation should include a risk assessment using the JARUS "**SORA**" [7][1] method or any other assessment method, compliant with the draft Acceptable Means of Compliance (AMC) [5].[2]

The current draft of the regulations does not cover Certified operations.

2.2 Safety, the risk approach, SORA

2.2.1 What is SORA

The Specific Operational Risk Assessment (SORA) is a prominent methodology for the classification of the risk posed by a drone flight mission lying into the specific category of operations as defined in EASA's Notice of Proposed Amendment 2015-10 [53], where the regulatory framework for the operation of drones in Europe is introduced. It is based on the evaluation of ground risk and air risk. The ground risk is related to the risk of a person, property or critical infrastructure being struck by a UA and therefore considers the operating environment with respect to the population density, the type of operation (VLOS or BVLOS) and the UA size. On the other hand, the determination of the air risk considers the probability of encountering manned aircraft in the airspace environment, which is chiefly derived from the density and composition of traffic in the airspace. After obtaining the Ground Risk Class (GRC) and Air Risk Class (ARC) respective values, the combination of both leads to the final rating of the mission, the so-called SAIL (Specific Assurance and Integrity Level), with a high value representing a high potential risk. Mitigations, which can be either additional equipment or an adapted way of operation, can be used to reduce the ground and air risks and thereby the SAIL. An example of a safety assessment can be found in the annex C.

2.2.2 Discussion of the integration of the SORA into the CORUS ConOps

SORA allows a straightforward application for unexperienced users, thus lowering the inhibition to conduct a risk assessment. SORA was conceived as a suitable way to exchange information between drone operators wanting to apply for a mission in the specific category of operations and the competent authority. Consequently, enhances the awareness and conscientiousness of drone operators as the mission and the accompanying risk are examined thoroughly before take-off. In combination with the derived safety objectives, that leads to a safer deployment of drones, which in return could foster the general public acceptance [48]. Therefore, SORA is considered an important element of the flight planning process. Flight planning and SORA show a strong interdependency which might lead to an iterative process, as operators will try to find risk-minimised flight paths to avoid excessively stringent requirements for their intended missions. Note that a flight plan is mandated for operations in volumes Y and Z only. However volume X offers a "Drone operation plan processing" service in U2 where voluntarily permitted flights plans would be processed too.

[1] SORA is being developed at the time of writing and some of its annexes are not yet published. The authors of this ConOps have seen some of the draft annexes and make reference to them in this document in the expectation that the contents do not change significantly before publication.

[2] The draft Acceptable Means of Compliance [5] states in AMC1 UAS.SPEC.020 that the acceptable means of risk assessment is SORA. Section GM1 UAS.SPEC.020 allows for methods other than SORA to be proposed

Nevertheless SORA does not intends to be a complete safety assessment process and hence it is not sufficient to address the risk imposed by the U-Space where multiple drone operations will be conducted simultaneously, with different services running and cooperating, possibly with different U-Space/UTM service providers exchanging information and in coordination with ATM/ATS through dedicated interfaces. Those challenges are not addressed by SORA, which in fact has not being planned to answer them since one of the key aspects of this methodology is that the responsibility of conducting the assessment rests with the operator. In this case, the operator cannot manage and/or will never have the complete set/flow of information required to achieve this task due to multiple reasons as privacy issues, competency with other drone operators or security aspects.

In addition, the amount of information and workload that the submission, administration and approval of a SORA assessments could produce to the regulator and/or U-Space service providers will make rather difficult to allow all the operations to be approved and conducted in a reasonable period.

SORA has been investigated thoroughly in the course of CORUS and was deployed on various drone use cases. The derived considerations for improvement are mentioned briefly to support the further development of the methodology.

a. The determination of GRC does not include the flight over risk areas, such as scenes of accidents, critical infrastructure, properties, highways and railway facilities when the operation is mostly over sparsely populated (or unpopulated) area and therefore results in a low GRC. Single occasions of high risk areas which would state a high ground risk cannot be taken into account. These occasions should have a strong impact on the GRC. Also, an adapted way of operation (e.g. 1:1 rule) could be considered to lower the GRC in this case.

b. The current ARC is determined only with respect to manned aviation, while drone operations in the vicinity would increase the probability of an incident. As this affects both the air and ground risk, an adaption of the SAIL due to nearby operations shall be considered.

c. The SAIL is dominated by the ARC. Therefore, drone operations in ARC-c or ARC-d offer little motivation for an operator to reduce the GRC, as the SAIL stays almost unaffected.

d. The determination of the final ARC should be regulated or able to be reduced through the availability of U-Space/UTM services. For instance, a certain set of services could be required to reduce the ARC from d to c.

Moreover, as it has been remarked by the European Cockpit Association (ECA) in its paper about Specific Operations Risk Assessment (SORA) [54] which the CORUS team has examined and share the proposed ideas, the following key points are considered of great relevance:

- The intrinsic risk of mid-air collisions (MAC) must be taken into account by any statistical analysis used for SORA rather than solely looking at potential fatalities.

- SORA should not be regarded as a purely quantitative process (comparable to a computer-algorithm) but at the same time as a qualitative process. For this, an adequate detailed knowledge and expertise within both the operator and the competent authority is required.

- Every manned aircraft has a layered approach to collision avoidance which builds its resilience. Greater consideration should be given to how similar resilience can be achieved for unmanned aircraft, since simply relying on statistical analysis is deemed insufficient.

2.2.3 Safety Assessment methodology within U-Space

Taking the previous considerations into account and preserving the principle of the risk based approach an alternative safety assessment strategy is proposed by CORUS called MEDUSA. The MEthoDology for the U-Space Safety Assessment (MEDUSA) is a strategy to identify and manage the hazards posed by drone traffic in the U-Space. The main principle of this methodology is based in the EUROCONTROL Safety Reference Material (SRM) where a broader approach to assess safety is adopted. The broader safety approach addresses both the positive contribution of U-Space to aviation safety (success approach), as well as U-Space's negative effect on the risk of an accident (failure approach). The success approach is required to show whether the U-Space is intrinsically safe, in the absence of failure.

The MEDUSA process provides a holistic approach to the U-Space safety assessment incorporating different viewpoints, not only the operator perspective but also the airspace perspective of the U-Space service provision and the interoperability of these services with the ATS/ATM. The operator perspective remains within MEDUSA considering the outcome of different SORA assessment and integrating the result of these into a single MEDUSA assessment.

The ultimate objective of MEDUSA is to derive a complete set of Safety Requirements for the U-Space service implementation and associating these requirements with mitigation means that are able to maintain the level of safety that stands today for manned aviation in both air and ground. An extended overview of this safety assessment method for the U-Space can be explored in the annex D.

2.3 U-space

The CORUS project has been initiated by the SESAR Joint Undertaking (SJU). The following text is extracted from the call [8]:
This project addresses those drones that are expected to operate in the VLL [Very Low-Level] environment, covering many types of aerial activity, including leisure, remote infrastructure inspection, rural operations, flights in densely-populated and urban areas, and flights near protected sites, such as airports or nuclear power stations. Although manned aviation operating in this airspace is typically uncontrolled, it will be necessary to address how drones might operate within controlled airspace near, for example, airfields. In addition, VLL airspace is also used by other classes of airspace users, such as military aircraft, rotorcraft, balloons, hang-gliders, micro-lights, parachutists and so on. The Concept must enable safe interaction with all these users. Operational considerations must include contingencies and emergencies, and societal issues must also be addressed.

As well as the references mentioned in section 2.1, CORUS takes as its input the existing SESAR work:

- U-space Blueprint [9]
- SESAR roadmap for the safe integration of drones into all classes of airspace. [10]
- European Drones Outlook Study [11]

CORUS is following the work being done in the eight other SESAR research projects in the same call [8]. Final reports are not yet available but information has already been exchanged. CORUS is also following the activities of and exchanging information with the ten ongoing SESAR U-space demonstration projects, the first of which to start was PODIUM; see https://www.sesarju.eu/index.php/U-space

CORUS also considers as relevant inputs at least (but not limited to) the following list:

- Unmanned Aircraft Systems (UAS) ATM Integration Operational Concept from EUROCONTROL and EASA [12]

- The EASA Concept of Operation for Drones [26]
- ICAO Annex 2 to the convention on Civil Aviation, Rules of the Air. [13]
- ICAO Annex 11 to the convention on Civil Aviation, Air Traffic Control Service, Flight Information Service, Alerting Service [14]
- 'SERA' = EU regulation 923/2012 "…laying down common rules of the air… " [15]
- ICAO Manual on remotely piloted aircraft systems (RPAS) – ICAO doc 10019 [16]
- ICAO Procedures For Air Navigation Services, Air Traffic Management, ICAO doc 4444 [17]
- The three consultation studies of EUROCONTROL & EASA ongoing as this ConOps is written: UAS ATM Flight Rules [18], UAS ATM Airspace Assessment [19] and UAS ATM Common Altitude Reference System [20]
- The FAA / NASA Unmanned Aircraft Systems (UAS) Traffic Management (UTM) Concept of Operations [25]
- The wealth of fascinating reports on the NASA UTM portal [51]
- Blueprint for the Sky, The roadmap for the safe integration of autonomous aircraft by Airbus / Altiscope [21]
- Airbus / Altiscope's Technical Report series [22] for example TR-004 Metrics to Characterise Dense Airspace Traffic [23]
- The Global UTM Association (GUTMA) UAS Traffic Management Architecture [50]
- The Swiss U-space ConOps. [27]
- JARUS publications in general [52] and SORA [7] in particular

Further CORUS members have had sight of a number of draft documents that are not yet published, but whose ideas have influenced the thinking behind this ConOps, for example in the work of EUROCAE working group 105, ICAO and a SESAR Joint Undertaking study of U-space Architecture.

As this ConOps' authors see the situation, U-space aims to be an environment which enables business activity related to drone use as well as leisure use of drones while maintaining an acceptable level of safety and public acceptance. This ConOps has been developed considering the use-cases of U-space starting with the most frequent.

2.3.1 U-space levels

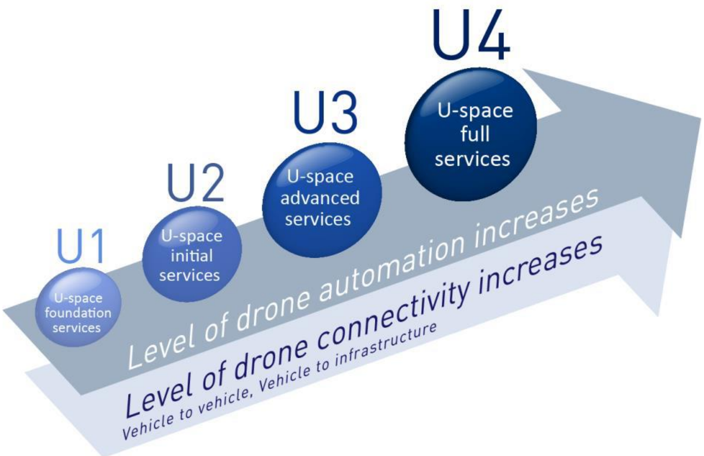


Figure 1 U-space levels, from the U-space Blueprint

The U-space Blueprint [9] describes U-space has having four levels. The Blueprint describes U-space by means of a list of services that are offered. Each level is a set of services. The expectation is that these levels will be deployed progressively. U1 is expected in 2019, U2 should follow shortly afterwards.

The particular set of services that are available leads to the way of working that is possible, safe and/or optimal. Hence, in essence, this document has to describe four concepts of operation, one for each level. This document does not describe combinations of "mostly one level plus a few features from the next" as each such combination requires a specific way of working, hence a different concept of operation. There are many services and hence very many different possible combinations of services. The CORUS project had neither the time nor the effort to explore them all and hence only describes U1, U2, U3 and U4 operations assuming a complete set of services in each. The descriptions of the services is in section 4.1.

2.4 Area of interest of VLL U-space

Having defined the element characterising the context and scope of U-space, the following are considered in scope:

- All size of drones, including those carrying passengers
- VLL Operations in vicinity of airports
- UAS with different kind of automation (including fully autonomous)
- UAS with different level of supervision (multiple UA supervision by a pool of RP)
- Obstacles such as stationary infrastructure, either permanent (e.g. buildings, wind turbines) or temporary (e.g. cranes)
- Mobile obstructions (vehicles, trains and vessels)
- Significant turbulence, very low visibility conditions or other weather phenomena impeding safe drone operation as well as other environmental hazards to drone operation such as electromagnetic interference
- Day and night operations
- Flocks of birds, both airborne and on ground[3]

Considered out of the scope of this Conops are:

- Operations directly managed by ATC using current procedures, e.g. landing in an airport in the same way as a manned aircraft.
- VHL U-space services. (VHL is approximately the airspace above the range of altitudes in common use)
- IFR RPAS.

Figure 2 indicates the area of interest of U-space.

[3] Assuming such flocks are detectable and can be made known to U-space

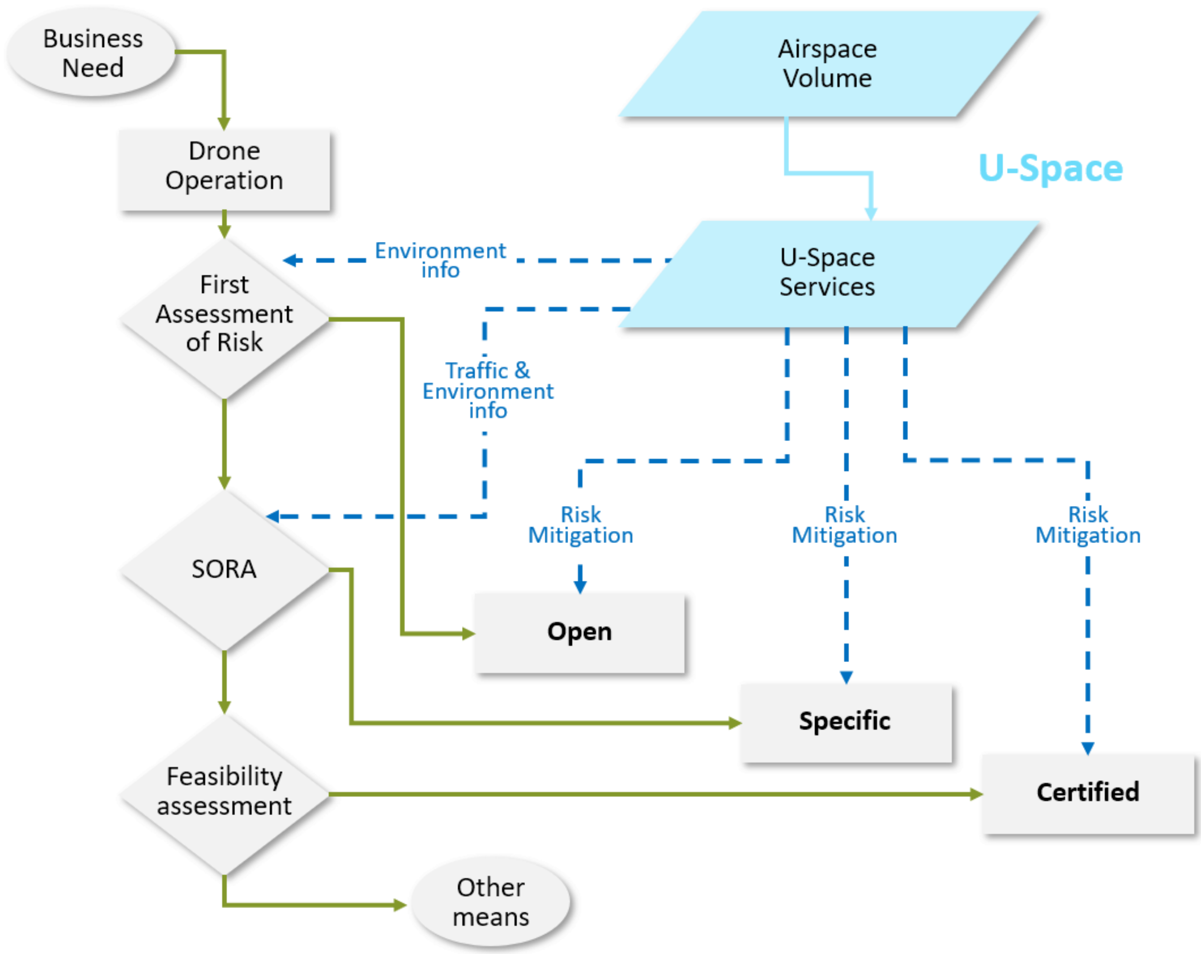


Figure 2 U-space in context

In Figure 2, a business need leads to the proposal of a drone operation. A first assessment of risk considers the airspace class and other aspects of the operating environment. The first risk assessment informed by the U-space services, but considers other factors. This assessment may lead to the decision to fly an Open category operation. If the conditions for an Open operation are not met, then a specific operational risk assessment should be performed which draws on information supplied by U-space services. This leads to the decision that the operation is possible as Specific or Certified. If the operation needs to be Certified then a further process concludes either that the operation is viable as a certified operation or not. Execution of an Open, Specific or Certified category flight is supported by U-space services.

This ConOps is concerned with airspace organisation, U-space services and how these services support risk assessment, provide risk mitigations and further meet the traffic management needs of society – which is not shown in Figure 2.

2.5 Assumptions & definitions

2.5.1 Definition of Very Low Level, VLL

VLL is the airspace below that used by VFR. In ICAO Annex 2 [13] and SERA [15] there are statements about the minimum height for VFR. For example in SERA section 5005 is written:
(f) Except when necessary for take-off or landing, or except by permission from the competent authority, a VFR flight shall not be flown:

(1) over the congested areas of cities, towns or settlements or over an open-air assembly of persons at a height less than 300 m (1 000 ft) above the highest obstacle within a radius of 600 m from the aircraft;

(2) elsewhere than as specified in (1), at a height less than 150 m (500 ft) above the ground or water, or 150 m (500 ft) above the highest obstacle within a radius of 150 m (500 ft) from the aircraft.

The SERA text above and similar text in ICAO Annex 2 section 4.6 essentially define the lower limit for VFR operation above urban (1) and rural (2) areas. Below that limit is VLL. There are many reasons why manned aircraft might fly in VLL, but these do not in themselves impact the definition of VLL. Much more is said about VLL in section 3. In this document VLL is considered to extend laterally into airports.

2.5.2 Altitude

As is discussed in section 5, and in the UAS ATM Common Altitude Reference System discussion document [20], heights used in manned aviation are based on barometric measures, while most drones flying in VLL use orthometric altitudes based on GNSS.

Altitudes of interest in VLL are heights above the ground immediately below. GNSS heights are determined relative to the orbital ellipses of the navigation satellites, or to the centre of those ellipses, meaning the gravitational centre of the earth. Calculation of the height above the ground requires a look-up table (or map) to give the height of the ground at the current location, relative to that datum. Such look-up tables trade off accuracy against size (and potentially cost.)

Although not described in this ConOps, traffic organisation schemes based on layers may require minimum performance standards for height measurement accuracy in the volumes where they are applied.

2.5.3 Types of Operation

2.5.3.1 Remotely Controlled flight

In this ConOps, Remotely controlled flight is all operation under the active control of a remote human pilot. Active control means that the remote pilot is in tactical control of the aircraft and is responsible for his/her own aircraft "Remaining Well Clear" of other aircraft. As a rough heuristic, it is assumed that this means the pilot shall respond within 5 seconds of receiving information concerning the safety of the operation. Any mode of control not meeting this criterion is not Remotely Controlled - see Remotely Supervised and Automatic below.

Remotely controlled flight falls into three types, VLOS, EVLOS and BVLOS.

VLOS is Visual Line of Sight. This mode of operation requires that the remote pilot maintains visual contact the aircraft at all times during flight. VLOS operation is described in the draft implementing regulation [1] and annex [2] and also defined in the ICAO Manual on Remotely Piloted Aircraft Systems (RPAS) [16]

Extended Visual Line of Sight, EVLOS, is a mode of operation in which one or more trained assistants are in communication with the pilot and at least one of these or the pilot maintains visual contact the aircraft at all times during flight, in a coordinated way. This mode of operation extends VLOS allowing, for example flight behind a building. EVLOS is not defined using that name in the draft regulations but is described in section 4 of UAS.OPEN.070 in the draft annex to the Implementing regulation [2].

Similarly un-named, it is mentioned in the VLOS section of the ICAO Manual on Remotely Piloted Aircraft Systems (RPAS) [16]

Beyond Visual Line of Sight, BVLOS, is a mode of operation in which the pilot is not in visual contact with the aircraft. BVLOS operation is described in the draft implementing regulation [1] and annex [2] and in the ICAO Manual on Remotely Piloted Aircraft Systems (RPAS) [16]

“First Person View” (FPV) operation may be considered to be a variant of EVLOS or BVLOS. FPV operation is EVLOS if and only if an assistant maintains visual contact and the active control condition is met. FPV is considered a variant of BVLOS in the absence of an assistant, if the active control condition is met.

Collision avoidance systems which can automatically intervene to change the course of the aircraft in in the final seconds before a crash do not compromise the classification of Remotely Controlled.

2.5.3.2 Automated Flight (AF)

The glossary of the ICAO RPAS Manual, doc 10019 [16], without giving the definition official status, defines **Autonomous Operation** as “An operation during which a remotely piloted aircraft is operating without pilot intervention in the management of the flight.**”**

Automated Flight is defined here as “An operation during which a remotely piloted aircraft is operating without pilot intervention in the management of the flight and during flight on-board functions provide Remain Well Clear and/or follow instructions from ground-based services that achieve Tactical Separation.” The separation issue is crucial for this ConOps.

The Society of Automotive Engineers describe six levels of automation in SAE J3016A which have been mapped onto UTM in the Airbus Blueprint [21]. Considering how these levels apply to the flight of a single drone, Automatic flight in all phases of flight would equate to “full automation, level 5”, and Automatic flight in cruise to “high automation, level 4”. The defining feature of Automatic Flight is the drone itself providing Remain Well Clear.

Two modes of Automated Flight concern this ConOps; with and without connection to U-space. Common to both is that in Automatic Flight, no human is involved in controlling the aircraft during flight, either in the tactical time scale or in the supervision timescale. The flight may be planned or unplanned – the latter includes the ‘**follow-me**’ mode of operation described in the draft implementing regulation [1] and annex [2]

2.5.3.2.1 Automated flight with connection to U-space (AFU)

The risks associated with automated flight may be diminished by means of the services provided by U-space, such as Dynamic Geo-fencing, Tactical Conflict Resolution and Emergency Management – see section 4.1. In order to achieve this the aircraft will need a direct connection to U-space, by means of mobile internet or similar. The risk mitigation offered means that Automated flight with connection to U-space is identified as a mode of operation distinct to Automatic flight with no connection to U-space.

It is assumed in this ConOps that ‘follow-me’ mode described in the draft implementing regulation [1] and annex [2] is AFU. As the draft implementing regulation [1] and annex [2] describe ‘follow-me’ within certain limits as Open operation, this particular form of AFU is supported from U1 in this ConOps

2.5.3.2.2 Automated Flight with No connection to U-space (AFN)

Automated Flight with No connection to U-space may be the only option for automated flight in remote areas or over the sea, either due to a lack of connection or no U-space services being offered in that area. AFN in areas where there is U-space available will need careful risk assessment and mitigation – for example it may require a geo-cage.

2.5.3.3 Remotely supervised flight (RSF)

Remotely supervised flights are those in which the tactical control of the aircraft is automated but a human operator may take some action during flight. In this mode the remote piloting station remains connected to the aircraft, possibly with longer latency allowable than is required for remote controlled flight. The remote operator is not able to Remain Well Clear but he or she may update the operation plan or make changes of that nature.

This mode of operation is not described in the draft Regulations [1] [2] [3] [4] and is not any of VLOS, EVLOS or BVLOS. It is a mode which is of considerable interest to commercial drone operators.

It is assumed in this document that all RSF involves connection to U-space and is a form of supervised AFU. Any remotely supervised flight that does not involve connection to U-space is functionally equivalent to AFN for this ConOps.

2.5.3.4 Swarms

Swarms are considered in this ConOps to be examples of Automated Flight or Remotely Supervised Flight. The swarm is considered by U-space to be a single, solid object. U-space will not attempt to pass another flight through a swarm. Swarms will have a single operation plan and this plan will include dimensions for the swarm. Swarms may be prohibited in some airspaces.

2.5.3.5 Formation Flights

This ConOps views a formation flight as several flights[4] that have a special relationship. The special relationship means that U-space will not attempt to separate the flights from each other and will never consider them to have lost separation between each other. Operation is explained in section 3.2.4 and establishing the relationship in section 4.1.3.4

2.5.4 Detect and Avoid

Detect and Avoid (DAA) is intended to provide the Operational Services, comprising a number of airborne traffic surveillance and de-confliction assistance capabilities. These provide remote pilots with traffic information, and different levels of alert and decision aid to assist them in flying the UA

[4] The flights in a drone formation are considered to be distinct flights. This is different from how the ICAO doc 4444 flight plan currently considers formation flight. Formation flights in U-space may be parts of longer operations; with distinct flights coming together for formation and then separating again. As the swarm flight also exists in this ConOps the operator can choose which is most appropriate.

'well clear' (remain well clear part - RWC) of, and avoiding collisions (collision avoidance part - CA) with, other traffic, terrain, fixed and mobile obstacles, hazardous weather, people and animals.

The remote pilot, or in the case of autonomous flight the UA itself, will use the DAA provided traffic information, alerts and decision aids to select manoeuvres to avoid operating in such proximity to other traffic as to create a collision hazard, by respecting the VLL flight rules.

Detect and avoid is assumed in this ConOps to be standardised and widely deployed in U3 as collaborative detect and avoid, meaning all participating aircraft make themselves detectable in some agreed way. (See Electronic conspicuousness in U-space, section 3.6.2)

Non cooperative detect and avoid (sometimes called sense and avoid) is not expected to be standardised and widely deployed before U4, if at all. However it may come into isolated use much earlier.

Collision avoidance due to detect and avoid is assumed in this ConOps to be entirely achieved within the aircraft and is not a function of U-space. It is unrelated to the U-space service Tactical Conflict Resolution described in section 4.1.4.2

Collision avoidance by means of detect and avoid is, in isolation, not a viable means of traffic management for the following reasons:

- In the absence of demand and capacity management, there is no mechanism to prevent the airspace being filled beyond the level at which detect and avoid can work, or allow efficient flight.
- It is currently considered difficult to build safety cases with systems built from very large numbers of agents each with different possible states. The number of possible states of the whole system soon becomes intractable. This problem may be solved in which case the question could be revisited.

Detect and avoid sensors may form part of an automatic tactical controller for a drone, as required by Automatic Flight (see section 2.5.3.2). How Detect and Avoid sensors are used in the implementation of Automatic Flight is considered to be out of the scope of this ConOps.

2.5.5 EASA Categories of operation

EASA defined Open, Specific and Certified categories of operation in their Concept of Operations for Drones [26]. The definition of Open and Specific appear most recently in the draft Regulations [1] [2] [3] [4].

This ConOps does not seek to revise these definitions.

2.5.5.1 Open

The reader's attention is drawn to the draft annex to the Implementing regulation [2], sections UAS.OPEN.020, UAS.OPEN.030 and UAS.OPEN.040 which define sub-categories A1 to A3 respectively of Open operations. Note that

- Open category operations may be performed by relatively untrained and inexperienced pilots
- Open category operations may be performed with UAs incapable of submitting position reports
- Open category operations include "follow-me" mode, with limitations – see UAS.OPEN.020

Open operations have certain restrictions on where they be undertaken. Identifying that an area is amenable to Open operation will be supported by U-space services. (see Geo-awareness service, section 4.1.2.2)

2.5.5.2 Specific

The draft annex to the Implementing regulation [2] indicates that Specific operations are conducted

- either following a SORA for the operation
- or the operator should hold a Light UAS operators Certificate (LUC), indicating the operator has a good record in terms of risk assessment and mitigation using their own processes
- or the operations should be under the umbrella of a flying club whose internal processes are accepted as managing risk

The specific operational risk assessment (SORA), involves identifying and assessing risks and then finding mitigations for them. The assessment must be described in an Operational Declaration which has to be lodged with the authorities. U-space services exist to help identify risks and to provide mitigations to risks; see 4.1.3.2. It is assumed that tools and services will appear to support SORA, reducing the time and effort of completing the SORA process. The national civil aviation authority will be involved in this process.

2.5.5.3 Certified

Operations that present higher risks than can be addressed under Specific may be possible as Certified. Certified operations have not been described in the draft Regulations [1] [2] [3] [4], but are considered to provide legal certainty to the Regulation.

This ConOps assumes that obtaining a Certificate for a general category of operations would be a process involving the national civil aviation authority and that, like SORA, the process involves identifying risks and their mitigations. However, the involvement of the national civil aviation authority is not limited to the 'certified' category, but to the 'specific' category as well.

It is assumed that in traffic management terms, Certified and Specific flights may be indistinguishable. U-space services provide information for aiding risk identification and assessment, and mitigation for risks, in both of these operational categories.

2.5.6 Drone use in VLL

It is assumed that the majority of private and leisure use of drones will be as Open category operations. Most of the rest are expected to be Specific operations in the context of model clubs, due to the possibility of operating without an operational declaration – see section UAS.SPEC.010 of the draft annex to the Implementing regulation [2]. A few private users will probably complete SORA to undertake Specific category operations outside a flying club or even make Certified category operations.

Open operations do not require the operator to complete a SORA. This effort and time saving is of interest for some professional uses. Hence it is assumed that while the majority of professional uses of drones in VLL will be achieved with Specific category and others will be, by necessity, Certified category, many professional drone operations will be Open category.

2.5.7 The technological environment

In this ConOps it is assumed that all technical communications and information processing are fast enough to be considered as taking negligible time compared to the up-to-five-seconds reaction time of the remote pilot required to be a tactical intervention – as mentioned in section 2.5.3.1

2.6 Overall Approach

2.6.1 Risk based

This ConOps, in line with the EASA regulation, follows a risk based approach. Broadly this means that the level of 'effort' devoted to maintaining safety is proportional to the risk associated with not doing so. Examples of this risk based approach in the ConOps are the different modes of operation in the different airspace types, as well as the different densities of operation allowed under the different modes of operation.

2.6.2 Performance based

The ConOps adopts a performance based approach; airspaces may have minimum performance criteria for drones to fly in them – see section 3.4.2 – that will be set in response to the anticipated traffic demand, meaning the number of flights expected in the airspace.

2.6.3 Stepwise

The ConOps describes the stepwise evolution of U-space through U1, U2, U3 and U4. Each progressive step allows more efficient use of the airspace while maintaining or improving safety. The services are expected to be introduced in groups rather than whenever available. The grouping means that they will be deployed in a cohesive way and the mode of operations will fit with what is described in this ConOps

2.6.4 Validation based

The ConOps takes the view that the various concept elements in the operational concept should be validated before deployment. This approach is visible in the resemblance of some of what is proposed to existing aviation practice. The over-riding concern of the authors for safety drives this 'fondness for the conventional' which some may view as a weakness but the authors believe is a strength of this ConOps.

2.7 High level principles

2.7.1 Safety first

This ConOps is about the safe operation of drones. The U-space services described are all concerned with safety. It is likely that many more U-space services will come to exist, to serve business needs or for other reasons. They are not described here.

2.7.2 Open market

The aim of U-space is to create a business environment. The European Union champions the European consumer and promotes business competition as a way of delivering the best service, innovation and value, while allowing business the space to flourish. U-space will allow many businesses to operate, to innovate, to compete, and to deliver cost-efficient services. The lightest possible involvement of the regulator would be to oversee a purely commercial deployment of U-space so as to ensure its safe operation. The fact that ATM already exists and may offer closely related services, or the lack of commercial viability of such an approach (at least at first) may lead to a hybrid approach with the state taking a larger role.

This ConOps tries to describe the services being delivered in a manner that allows any deployment but aims to keep the door firmly open to an open market.

2.7.3 Social Acceptance

Further to the two first principles on safety and economic growth, drone operators and other U-space stakeholders should consider that the flight of drones at low altitudes can disturb the people and nature on the ground nearby. The aim of the ConOps is to balance the commercial pressure for growth of drone use with the preservation of nature, people's health, personal privacy and European security. Consideration of social acceptance from the start of drone operations is likely to produce a better result in the long term than a brief boom in drone use followed by a public backlash.

2.7.4 Equitable access

Another aim of U-space is to enable drone flight. Not just the flight of some people's drones, but all drones. The U-space services should be open to all – within reason; there will be general obligations like insurance, there will be operational and performance requirements for some airspaces and there may be costs – which will be regulated as any other aspect of service provision – but any drone that is fit to fly should be treated equally, as far as safe operation allows.

Instances where non-equitable treatment are forced by circumstance should be as dealt with as described in section 4.2.2

2.7.5 ECAC wide

This ConOps is guided by EASA regulation and aims to be applicable throughout the European Union. Further, the authors hope that the ConOps can be applied throughout the member states of ECAC (the European Civil Aviation Conference) and with minor adaptations, beyond.

2.7.6 Architecture principles

The architecture principles taken into consideration when defining the U-space architecture are:

Service-oriented architecture: A service-oriented approach will be applied to ensure that the solutions are built based on a set of services with common characteristics.

Modular: the architecture will be decomposed into self-contained elements (Functional Blocks) which contain a meaningful set of functionalities with the required inputs/outputs, that can be re-used or replaced.

Safety-focused: The architecture shall always consider the safety of its stakeholders or of other people and places that may be affected by U-space operations.

Open: a system architecture shall be developed which is component-based and relies on published or standardised interfaces based on SWIM principles to make adding, upgrading or swapping components easier during the lifetime of the system. Some other expected benefits of an open architecture are to facilitate re-use, to increase flexibility, to reduce costs and time to market, to foster competition, to improve Interoperability and to reduce risks.

Standard-based: whenever there are exchanges between roles, the interfaces must be defined and based on open standards.

Interoperable: the main purpose of the interoperability is to facilitate homogeneous and non-discriminatory global and regional drone operations.

Technology agnostic: to allow platform independent design, the architecture shall be described independently of the later implementation specifics, e.g. platforms, programming languages and specific products which shall be consistent with the operational architecture.

Based on evolutionary development (incremental approach): architecture work is an incremental and iterative process, building upon the previously consolidated baseline.

Automated: the architecture will be developed to facilitate the delivery of safe and secure U-space services with a high degree of automation of the processes as manual operations will be too labour intensive.

Allowing variants: the architecture work will allow variants and alternative solutions to be described. The principles listed in this document and later in the CONOPS aim for ensuring interoperability between different implementations.

Deployment agnostic: architecture work will not constrain different deployment choices according to the business and regulatory framework established.

Securely designed: architecture work will address security issues such as cyber-security, encryption needs and consequences, and stakeholder authentication. It is needed to follow the SWIM principles, that is to use a central or federated Public Key Infrastructure (PKI) for identity management.

2.8 Stakeholders

The U-space undertaking can be defined as a collection of organisations that share a set of common goals and collaborate to provide specific products or services to customers. In that sense, this undertaking covers various types of organisations, regardless of their size, ownership model, operational model, or geographical distribution. It includes people, information, processes, and technologies.

A U-space stakeholder is an individual, team, or organisation with interest in, or concerns relative to, the U-space undertaking. Concerns are those interests, which pertain to the undertaking's development, its operation or any other aspect that is critical or otherwise important to one or more stakeholders.

Stakeholder Role (aka role) is representing an aspect of a person or organisation that enables them to fulfil a particular function.

The U-space stakeholders have been classified as:

- Operational stakeholder, who are actively consuming and/or providing services of U-space. For this class of stakeholders, roles have been identified.

- Other stakeholders, which are not operational stakeholders. No specific role in using the system has been identified for them. It is not excluding these stakeholders to access to some information (e.g. statistics) to accomplish their businesses (out of scope).

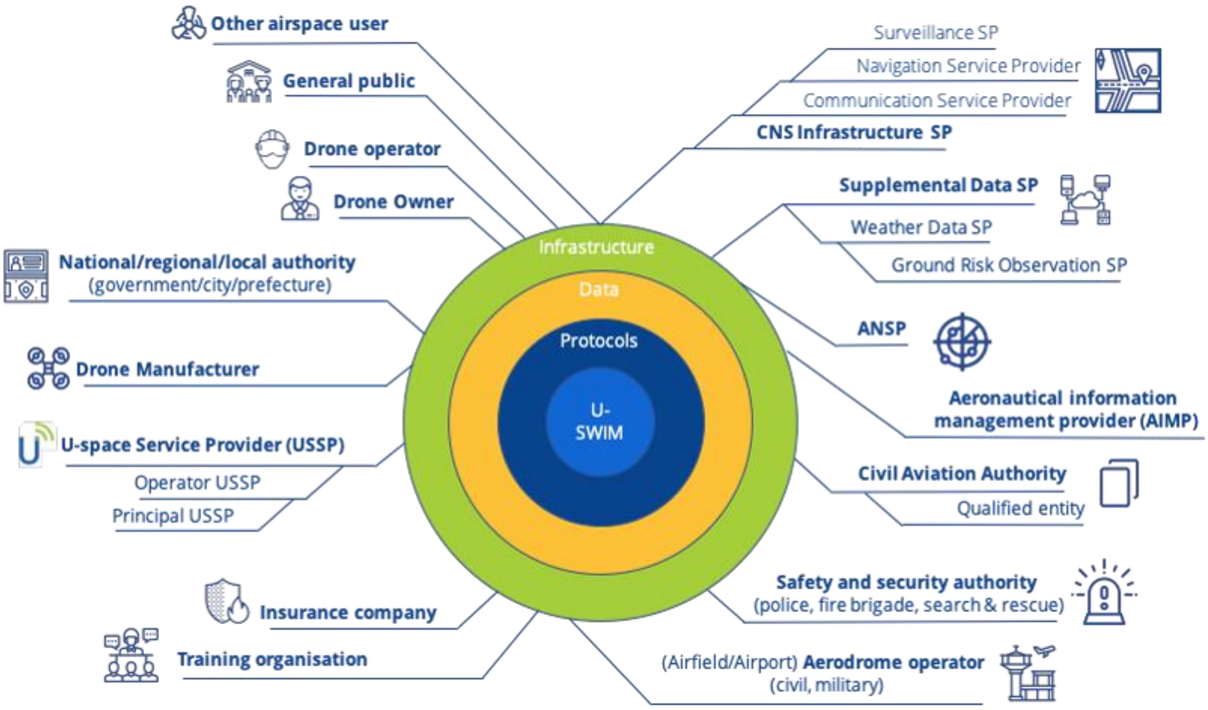


Figure 3 Stakeholders

Stakeholder	Why U-space matters to the stakeholder / what they expect
Drone operator	The legal entity, which can be a natural person, accountable for all the drone operations it performs. The equivalent of the airline for the pilot in manned aviation. Could be civil, military, an authority (special) or a flight club. Obtains fair, flexible & open access to the airspace. Accountable for safe and secure operations. Expects that U-space further develops drone operations safe and socially acceptable which enables the development of new business models, spur jobs & market growth. Expects that U-space services protects privacy and confidentiality of competitive information (e.g. customer identity).
Drone owner	The legal entity, which can be a natural person, owning the drone. May be different from the Drone Operator legal entity (e.g. leasing rental mechanisms).

Stakeholder	Why U-space matters to the stakeholder / what they expect
Drone manufacturer[1]	Produces drones and ensures their compatibility with U-space (technical feasibility, interoperability).
U-space service provider (USSP)	Generic stakeholder who provides one of the U-space services. The entity that provides U-space service access to drone operators, to pilots and/or to drones, to other operators visiting non-controlled very-low-level airspace. Depending on the architecture deployment options: multiple services could be provided by different U-space service providers. It is possible to distinguish between the providers of centralised services (i.e. principal USSP) and concurrent service providers (operator USSP)
Supplemental data service provider (SDSP)	An entity that provides access to supplemental data to support U-space services. Multiple services could be provided by different supplemental data service providers.
Weather data service provider	Provides weather information data (hyper local weather data, solar flare information and TAFs and METARs) and ensures that these are reliable, accurate, correct, up-to-date and available.
Ground risk observation service provider	Provides supplemental data which contribute to the knowledge/observation of the ground. It encompasses: ground and terrain data modelling (building heights, digital elevation model) and ensures that these are reliable, accurate, correct, up-to-date and available. population density
CNS infrastructure service provider	CNS infrastructures are constituting important U-space supporting systems. CNS Infrastructure service providers in general provide the technological infrastructure with which the CNS service providers provide the actual CNS services. Where applicable, they also provide relevant monitoring and coverage services. Satellites, for example, are infrastructure, provided by one or more infrastructure providers, that are used by the different providers of all three CNS services
Communication service provider	Responsible for the provision of a reliable and safe communication link between systems. May contract different SLA to several communication Service Providers, depending on the drone operations requirement and provide services to check coverage and monitor the status. For the C2 Link, also known as a C2-Link service provider

[1] Economic operator, as introduced by EASA Opinion, generalise the stakeholder in case manufacturer is not in Europe. Economic operator means the drone manufacturer, the authorised representative of the drone manufacturer, the importer, and the distributor of the drone.

Stakeholder	Why U-space matters to the stakeholder / what they expect
Navigation service provider	Responsible for the provision of a reliable navigation infrastructure to allow safe drone operations. May contract different SLA to several navigation service providers, depending on the drone operations requirement and access to airspace and provide services to check coverage and monitor the status. E.g. Satellite navigation service providers.
Surveillance service provider	Responsible for the provision of surveillance services with different technologies/methodologies and SLA. This encompasses anti-drone surveillance for non cooperative traffic. Provides services to check coverage and monitor the status of the surveillance service offered. Drone neutralisation is out of scope of the architecture,
Air navigation service provider (ANSP)	Provides services to airspace users that may be operating in airspace where U-space services are also being provided
Aeronautical information management provider (AIMP)	Existing ATM provides sources of some data consumed by U-space service providers and users
(Airfield/Airport) Aerodrome operator (civil, Military)	Supports the definition of operating procedures and interoperability requirements Expects that U-space ensures safe integration of drones in airspace, especially in airport vicinity
Civil aviation authority	Generic term to encompass national or local aviation authority. Expects that U-space ensures aviation law is followed, ensures safe and secure operation of all aircraft, promotes the minimisation of environmental impact and anticipates deployment challenges
Authority for safety and security (police, fire brigade, search and rescue orgs)	Publishes danger areas in real time – relating to medical evacuation, police helicopter or similar (Police only) Develops law enforcement methods related to illegal drone use.
Local authorities (government/city / prefecture)	Supports the definition of operating procedures and rules. Explores applications of U-space to urban needs – for example active measures limit noise “dose” in any one place Expects U-space develops methods to support among the others: privacy assurance enforcement of drone regulations publishing VLL hazards as they arise – cranes, building work, … derive added value from data generated by routine drone operations
Insurance companies	Collect statistics about drone accident rates in U-space. Propose more affordable insurance for drones that use enabling factors that lowers the risk of incident. Offer per operation insurance based on the specific operational plan. Providers supplemental data related to the insurance related to the U-space services. In that case it is an Insurance data service provider.
Training organisation	Remote pilot schools & Training centres Responsible for pilot and operator training.
Aviation user	Users of the airspace other than drone operators / pilots. Includes those concerned with manned aircraft, parachuting and similar

Stakeholder	Why U-space matters to the stakeholder / what they expect
The general public	Those who may hear, see or otherwise be concerned by a drone

Table 1 Operational Stakeholders

Stakeholder	Why it matters to stakeholder / what they expect
Operation customer	The final stakeholder of the drone operation who may have some roles in the authorisation of the mission itself.
U-space service industry	Develops sw/hw products to realise U-space services. Expects that standards are issued for ensuring U-space interoperability.Provides a range of services implementation from basic to advanced solutions.
National supervisory authority	Ensures that aviation law is followed, ensure safe and secure operation of all aircraft, promote the minimisation of environmental impact and anticipate deployment challenges.
EASA/JARUS	Validate the assumptions underpinning Opinion 01/2018 and provide inputs contributing to implement an operation-centric, proportionate, risk- and performance-based regulatory framework for all UAS operations conducted in the ‘open’ and ‘specific’ categories; ensure a high and uniform level of safety for UAS; foster the development of the UAS market; and contribute to addressing citizens’ concerns regarding security, privacy, data protection, and environmental protection
European institutions (European Commission, SJU, Directorate General for Mobility & Transport (DG MOVE), Directorate General for Internal Market, Industry, Entrepreneurship & SMEs (DG GROW), EUROCONTROL, European Defence Agency (EDA)	Promotion of economic activity related to drone use They expect that U-space ensures protection of privacy, EU consumer rules conformance and safety with regards to protected sites (geofencing)
Universities and academic institutions and research projects (e.g. CLASS, CORUS, SECOPS) + Industrial research projects + test range	Feedback, outcomes, results on current research issues, recommendations for additional industrial / research needs
Drone association (manufacturers & operators)	Represents drone pilots/operators/manufacturers and provide them assistance. Expect that U-space services realise an important enabling factor for the safe growth of the drone marker.
Model club	Represents modellers which needs to be distinguished from drone operators in the U-space access considering peculiarity of their activities.

Stakeholder	Why it matters to stakeholder / what they expect
Specialised press	Responsible for communicating and disseminating information/news about this drone market.

Table 2 Other stakeholders

2.9 Roles

Stakeholders, in section 2.8, play no part in any process described in this ConOps unless they have a specific Role. All known Roles are listed in the following table.

Role	Explanation
Drone pilot	UAS Pilot, Pilot-in-command (PIC) or remote pilot. Responsible for the safe execution of the flight according to the U-space rules, whatever it is recreational or professional with one of the different training levels, according to the typology of the drone used. (Recreational drone pilot, professional drone pilot) Expects: • more efficient flight preparation, including getting permission (easier, quicker and more efficient); • safer and more efficient flight execution due to improved situational awareness in all operations – VLOS and BVLOS The person registered in the pilot registry. A pilot is a human being, currently. The registry should be able to record some information about the pilot's qualification; mentions different levels of qualification. The drone pilot should be able to update some parts of their registry entry, such as changing their address and they may be allowed to create the record initially. How they interact: user of geo-fence definitions during flight; user of situation awareness computed from the dynamic online traffic situation based on maintained tracks; user of weather nowcast to assist them in the in-flight phase; the person receiving warning and alerts from the monitoring service.
Drone crew	The drone pilot or any person following the drone's progress during flight. This term generalises the pilot, any kind of dispatcher, any mission specialist. Additional recipient of messages about flights. Drone pilot assistant. Assists the pilot in their duty. Observer. Assists the pilot in their duty, e.g. during EVLOS operations.
Drone operator representative	The operator registered in the operator registry. An operator representative is a legal entity; meaning a natural person or a business. An operator representative has contact details. How they interact: user of geo-fence definitions during flight planning, user of situation awareness computed from the dynamic online traffic situation based on maintained tracks, Generalised player who submits a flight plan, the person receiving warning and alerts from the monitoring service
Drone owner representative	When any drone is registered, it will have a registered owner. An owner is a legal entity; meaning a natural or a business. An owner representative has contact details. How they interact: user of drone registration.

Role	Explanation
ATS operator	ATS should have access to the air-situation generated from e-identification reports, with the usual controller-working-position tools to filter out those of no interest, give conflict alerts and so on. Main roles: air traffic controller, tower supervisor, tower runway controller, tower ground controller, (A)FIS and RIS operator. How they interact: user involved to achieve the interface with ATS.
Police or security agent	Security actors would be interested in the air situation, to identify operators and to apply relevant procedures. Law enforcement unit, responsible to develop law enforcement methods related to illegal drone use. How they interact: user of registration, e-identification and interested in the situational awareness and monitoring alerts.
Pilot	The pilot of a glider, parachute, paraglider, ballon, GA, military flight that shares the airspace (even if occasionally) in VLL operations. How they interact: In some environments, user of situational awareness and monitoring alerts.
Citizen	Generic person who wants to be aware of drone operations impacting their privacy. How they interacts: a kind of authorised viewer of air situation
Registrar	A registrar has a legal duty to operate a registry securely, reliably and adequately. The registrar will be a legal person, probably with staff. How they interact: who may intervene in case of problems in the registration
Accredited registry updater	This category groups together pilot training schools, LUC issuers, nominated agents of the courts and any others who have the power to create, read, update or delete registry entries in any way – which may be very restricted for some. How they interact: user of (operator/school/pilot) registrations.
Accredited registry reader	This category groups the police, accident investigators, other agents of the authorities or anyone else who might need – and be given permission - to look into the registry. (or registries). How they interact: may query registration information.
Drone aeronautical information manager	A body that is independent of the Aeronautical Information Office and allows drone specific aeronautical information to be registered, combines the information, assesses it and then published the result.
Drone specific aeronautical information originator	The person or representative of the organisation that creates drone specific aeronautical information. This player is accredited and trained in the processes of creating, updating or deleting drone specific aeronautical information. This is reflecting the possibility to have a different originator of "constraints" for drones.
Authorised viewer of air situation	This groups actors like U-space operators, city authorities and some others such as researchers who can be trusted with the commercially sensitivities of the overall air-situation. How they interact: may be allowed to have a situational awareness according to privileges and privacy.

Founding Members

Role	Explanation
USSP Supervisor	Being the level of automation high, it is not envisaged the role of “Controller”. Nevertheless, it has been envisaged a person who will arbitrate or impose a solution in some cases (in case of escalation required) who may intervene manually imposing ad-hoc solutions or taking over other USSP roles.
Authorisation Workflow Representative	A person having the rights to participate in the authorisation workflow (e.g. when local authority/USSP/CAA must express the approval or does not object).
Capacity Authority	A person receiving warning and alerts from the monitoring service Responsible for setting the minimum safe operating conditions that determine the capacity of an airspace or an aerodrome due to safety Responsible for setting noise level limits that limit capacity due to noise footprint and “dose”
Drone Manufacturer Representative	Responsible for drone registration and using the system for all other obligations the drone manufacturer must comply with (e.g. drone model/characteristics/performance publication).
Airport Operator Representative	Responsible for interacting with the system to protect airport perimeter (anti drone) to contribute to the safe integration of drones in airspace, especially in airport vicinity. Responsible to establish proper coordination with other relevant stakeholders.

Table 3 Roles

3 Operations in Very Low Level Airspace

Very Low Level Airspace or VLL is defined in section 2.5.1.

3.1 Ground and air risk terms

3.1.1 Ground risk

The ground risk is a very rough classification of the harm that is likely to result from a drone falling to earth. Numerous terms are used in the reference material; rural, urban, sparsely populated, crowds of people, etc. The classifications usually consider the density of human life and the density of buildings or property.

This ConOps uses the following terms:

Term	Meaning	Examples
Populated area	areas where people are always present, frequently present or have gathered temporarily	Urban area, Residential area, Industrial zone, Highway, Harbour Recreational park Tourist beach (when crowded) Open-air music festival or agricultural show
Sparsely populated area	area where people and buildings are few but not absent	Farm land, Rural area
Non-populated area	Area where few people are present, infrequently	Remote forest, moor or mountain Open sea, Open desert

Table 4 Ground risk terms

3.1.2 Airport related

The ConOps has specific terms for the zones in and around Airports (as in airports for manned operations). These zones present a “low altitude” risk combining ground and air risks. Three terms are defined:

Term	Meaning
Near Airport	Outside the fence of the airport but close enough to penetrate the airport in a short time, should something go wrong.
Movement area	The runways, taxiways, apron. Any place where the presence of a drone – flying or crashed – could endanger manned aviation
Airport, outside movement area	Inside the fence of the airport but not in the movement area.

Table 5 Airport related area terms

3.1.3 Air risk & Traffic Density

JARUS’ SORA [7] proposes four categories of “Air Risk Class,” ARC-a (least) to ARC-d (most) depending on the probability of manned aircraft being present. The reader’s attention is directed to Annex G of SORA (when available) which explains this in more detail.

The JARUS SORA Air Risk Class is a measure of traffic density. Altiscope (Airbus) explore similar ground in their TR-004 “Metrics to characterise dense airspace traffic” [23] which mentions the metric “the fraction of a flight that the aircraft will spend in the normal state” [and not deviating to avoid other aircraft].

CORUS does not have the resources to explore this in detail but proposes a five level scheme expressed in non-scientific terms.

Level	Rough description	ARC
Very low	Flights seldom encounter any other aircraft	a
Low	Flights generally encounter another aircraft, but seldom need to take avoiding action	b
Medium	Flights usually encounter a few other aircraft and may need to take avoiding action	c
High	Flights frequently encounter other aircraft and can expect to take avoiding action for some of these.	d
Very high	Flights encounter so many other aircraft that the time spent on avoiding action has a significant impact on their ability to complete their operation. The airspace is too densely filled for efficient use.	d

Table 6 Traffic Densities

3.2 Volumes

U-space divides the VLL airspace into different volumes as is explained in this section. These volumes differ in two ways; the type of airspace which relates to the services being offered and the type of operation, and then the access and entry requirements for the airspace.

3.2.1 Types of airspace

There is more than one criterion to categorise the VLL airspace, but the most important is to distinguish the airspace by the services that are offered and the type of operation that is expected. Three airspace types are identified and in this ConOps they are referred to as **X**, **Y** and **Z**[5]. The most significant difference is in the provision of separation services, known in U-space as *conflict resolution* services:

X: No conflict resolution or separation service is offered

Y: Pre-flight (“strategic”) conflict resolution is offered only

Z: Pre-flight (“strategic”) conflict resolution and in-flight (“tactical”) separation are offered

This difference has a large impact on how drones should fly in that airspace. The following three sections provide a brief introduction to the more detailed descriptions of these given in section 3.2.4.

[5] X, Y and Z are placeholders. The authors are actively searching for better names.

3.2.1.1 X Volumes

There are few basic requirements on the operator, the pilot, or the drone for accessing airspace type X. In this airspace, the pilot remains responsible for separation at all times. VLOS and EVLOS flight are easily possible. Other types of operation in X require significant attention to air risk mitigation.

3.2.1.2 Y Volumes

Access to Y requires an **approved operation plan** (see section 4.1.3 for more information on the operation plan approval process), as well as:

- A pilot trained for Y operation
- A remote piloting station connected to U-space
- A UAS capable of position report submission
- Y airspaces may have specific technical requirements attached to them – demonstrating that these are met is part of the operation plan approval process.

Y airspace appears in U2 and facilitates VLOS, EVLOS and BVLOS flight. Y airspace is more amenable to other types of operation than X as there are risk mitigations provided by U-space. In Y airspace conflicts between flights are resolved before take-off. As there is not a tactical (in flight) separation service being offered in the airspace, the pre-flight conflict resolutions will result in widely spaced aircraft. In Y airspace there is Traffic Information (see 4.1.6.2), the provision of which requires that all aircraft in Y airspace be tracked.

3.2.1.3 Z Volumes

Access to Z requires an **approved operation plan**, as well as:

- A pilot trained for Z operation and/or a compatible, connected automatic drone
- A remote piloting station connected to U-space
- A UAS capable of position report submission
- Z airspaces may have specific technical requirements attached to them – demonstrating that these are met is part of the operation plan approval process.

Z airspace appears in U2, and changes in U3. Z airspace may be supplied with a tactical separation service by U-space (see section 4.1.4.2) known as Zu or by ATS, known as Za, for example in an airport.

Z airspace facilitates BVLOS and automatic drone flight and allows VLOS and EVLOS. Z is more amenable to other flight modes than Y as there are more risk mitigations provided - so long as the pilot is trained to use them. Z also allows higher density operations than Y; residual risks from pre-flight separation can be reduced by in-flight conflict resolution.

3.2.1.4 The services available in the different Volumes

The following table lists significant U-space services which are offered or whose use is mandated in each Volume. Note that services only become mandatory when available; U1, U2, U3, U4.

Service	**X**	**Y**	**Z**	Available
Registration	Mandated	Mandated	Mandated	U1
e-Identification	Mandated – see note 11	Mandated	Mandated	U1

Service	X	Y	Z	Available
Position report submission sub-service	Recommended – See note 1	Mandated See note 2	Mandated	U2
Tracking	Offered	Mandated See note 2	Mandated	U2
Drone Aeronautical Information Publication	Mandated	Mandated	Mandated	U2
Geo-awareness	Mandated	Mandated	Mandated	U1
Geo-Fencing provision	Mandated	Mandated	Mandated	U2
Drone operation plan processing	Offered	Mandated	Mandated	U2
Dynamic Capacity Management	No	Recommended – see note 3	Mandated	U3
Strategic Conflict Resolution	No	Mandated	Mandated	U2
Tactical Conflict Resolution	No	No	Mandated – see note 4	U2
Emergency Management	Offered	Offered	Offered	U2
Incident / Accident Reporting	Mandated	Mandated	Mandated	U2
Monitoring	Offered	Mandated	Mandated	U2
Traffic Information	Offered	Mandated See note 2	Offered See note 5	U2
Legal recording	Mandated – see note 5	Mandated	Mandated	U2
Digital logbook	Mandated – see note 6	Mandated	Mandated	U2
Weather Information	Offered	Offered	Offered	U2
Geospatial information service	Offered	Offered	Offered	U2 See note 8
Electromagnetic interference information				
Population Density Map				
Navigation Coverage information				
Communication Coverage information				
Procedural Interface with ATC	Offered – See note 9	Offered – See note 9	Mandated	U2
Collaborative Interface with ATC	Offered – See note 10	Offered – See note 10	Mandated	U3

Table 7 Services offered in different airspace types

The U-space services are described in section 4.1.

Notes:

1. Position report submission is strongly recommended for all flights that are capable in type X airspace in order to warn of the general presence of drones - see section 3.2.4.4

2. Tracking is required in Y to allow Traffic Information to be provided.
3. Provision of dynamic capacity management is at the choice of the airspace authority concerned
4. Tactical conflict resolution is offered by the U-space service of that name in Zu from U3 and by ATS in Za from U1
5. The provision of Tactical Conflict resolution effectively makes Traffic Information unnecessary.
6. Legal recording will contain traces only of operational declarations and position reports, hence not all flights in X
7. Digital logbook features are limited to flights with position report submission
8. Like Weather Information, the Terrain Map, Building & Obstruction Map and Population Density Map become standardised data services in U2. The same information may be available in some places earlier than U2. The quality of the information available may vary, but shall be indicated to the consumer of the service.
9. Procedural Interface with ATC only offered to flights which submit operational declarations which plan entry into airspace controlled by ATS.
10. Collaborative Interface with ATC only offered to flights which submit operational declarations which plan entry into airspace controlled by ATS.
11. E-identifation is mandated apart from the smallest drones. See the draft Annex to the Delegated regulation [4].

Access to both Y and Z volumes requires an operation plan. As the operation planning service is only available in U2, neither volume type is practical before this phase, but is in effect a no-drone zone (NDZ) (see section 3.2.2.1).

The following operations are possible in these airspace volumes

Operation type	**X**	**Y**	**Z**
Drone: Open	Yes	Yes – see note 1	Yes – see note 1
Drone: Specific	Yes – see note 2	Yes	Yes
Drone: Certified	Yes – see note 2	Yes	Yes
Drone: VLOS or EVLOS	Yes	Yes	Yes
Drone: 'Follow-me' See note 3	Yes	See note 3	See note 3
Drone: BVLOS	See note 4	Yes	Yes
Drone: AF or RSF	See note 5	See note 5	Yes in Zu
Manned: VFR	See note 6	See note 7	See note 8
Manned: IFR	No	No	See note 8

Table 8 Operation types possible in X, Y and Z volumes

Notes:

1. Open operations are allowed in airspace type Y and Z if and only if:
    a. the pilot is trained for operation in that type of airspace type
    b. there is an accepted operation plan
    c. the operation has position report submission
    d. the remote piloting station is connected to U-space
    e. the drone, remote piloting station and pilot training meet the specific requirements of the airspace
    f. all conditions for Open flight are met.
2. Specific and Certified operations are possible in airspace type X, however the presence of unknown drone operations must be considered as a risk and appropriately evaluated and mitigated.

3. The ‘Follow-me’ mode is as described in the draft implementing regulation [1] and annex [2]. While it is part of Open operation, its use in Y or Z type airspace volumes should be preceded by a reasonable assessment of the risk involved.
4. BVLOS operation in X-type airspace volumes needs very careful attention paid to risk mitigation.
5. Automatic flight or remotely supervised flight in airspace volumes of type X or Y or Za need very careful attention paid to risk mitigation. In Za, explicit permission would be needed.
6. VFR operations in type X must consider the risk of the presence of Open category drone operations for which no plan has been filed. This risk and its mitigations are explored in section 3.2.4.2.1
7. The possible conduct of VFR operations in type Y are discussed in section 3.2.4.2.1
8. Type Z may be Za, ATS controlled airspace. Manned flights in Za would need to behave as such. Manned flights in Zu are discussed in section 3.2.4.5

The following technical features are required to fly in these airspaces

UAS feature	X	Y	Z	Available
e-Identification	Mandated see note 1	Mandated	Mandated	U1
Position report submission	Recommended	Mandated	Mandated	U2
Pilot able to receive messages from U-space during flight	Recommended	Mandated	Mandated	U2
Collaborative detect and avoid	Recommended	See note 2	See note 2	U3
Compatability with the Geo-fencing provision service – note 3	Recommended	Recommended	Recommended	U3
Detect and avoid compatible with manned aviation – note 4	Recommended	Recommended	Recommended	U4

Table 9 Technical features required of UAS per airspace type

Notes:
1. E-identifation is mandated apart from the smallest drones. See the draft Annex to the Delegated regulation [4].
2. Collaborative detect and avoid is recommended everywhere but may be mandated in some airspaces. For practical reasons (weight, power) it may never be mandated for all Open category operations, but if possible it should be.
3. Geo-fencing provision is, in summary, the term used to signify the supply of geo-fence information to drones during flight – see section 4.1.2.4. Geo-fencing provision is of most value in terms of safety for drones with inexperienced pilots, or those whose pilots for some reason cannot reliably receive messages from U-space. Hence it may be mandated in some situations.
4. How Detect-and-avoid, compatible with manned aviation functions, can be implemented has yet to be agreed with the manned aviation community. See section 5 where U4 is discussed. Depending on decisions made in the implementation of U4, detect and avoid compatible with manned aviation may be mandatory in some or all types of airspace.

3.2.2 Access & Entry conditions

A further division of the airspace into different volumes is by consideration of the access criteria. There are areas where drones are more and less welcome, there are areas that require particular equipment. The following diagram appeared in EASA’s Notice of Proposed Amendment 2015-10 [53] and illustrates a Limited Drone Zone (LDZ) and several No Drone Zones (NDZ)

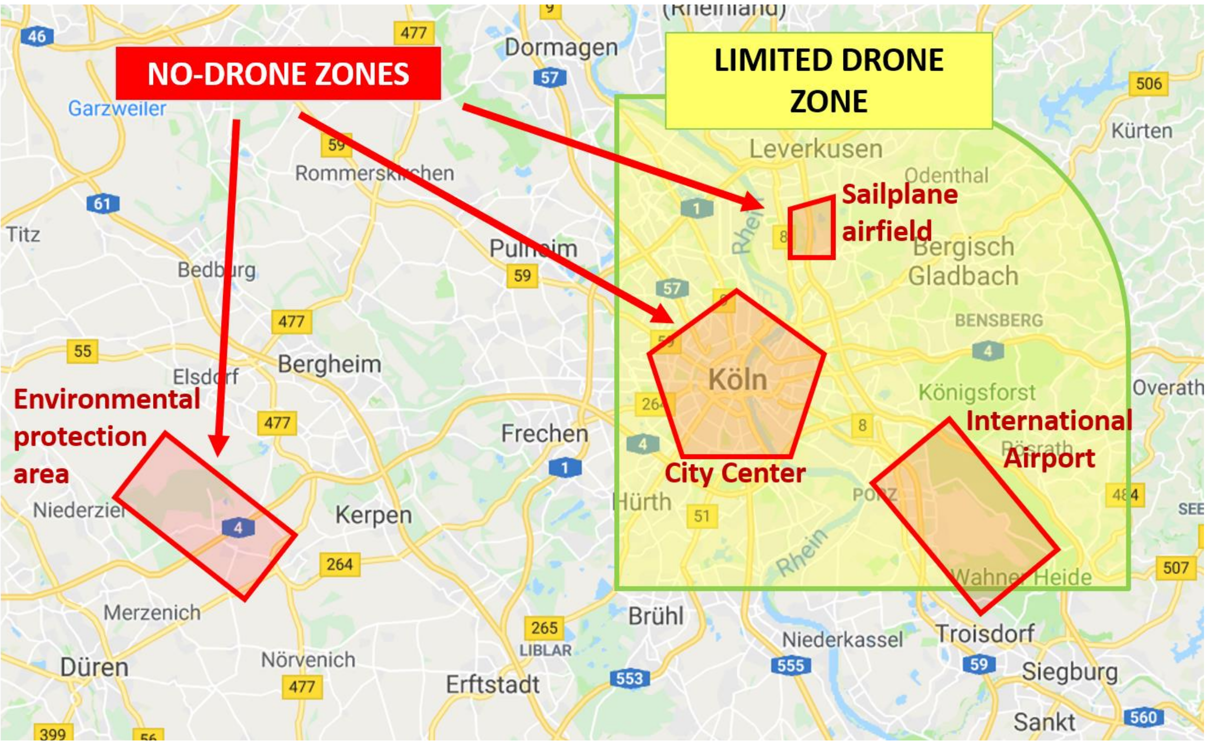


Figure 4 Limited Drone Zone (LDZ) and No Drone Zone (NDZ) *from EASA NPA 2015-10*

In U1, U-space's Geo-awareness service, described in section 4.1.2.2, makes drone users aware of where LDZ and NDZ are. In U2, U-space offers some support in accessing these spaces, if permission to access is granted for the operation.

3.2.2.1 No Drone Zone (NDZ)

NDZ may be created to protect areas from drones for reasons of:

- Safety, for example over an oil refinery
- Security, for example over a prison
- Noise abatement or visual nuisance, for example over a national park

In each of the examples mentioned, a case can be imagined when a drone flight may be permitted, for example if the oil refinery operator might use a drone to inspect a tower on its site. Hence the No Drone Zone is really an "only by special permission" zone and for each zone there is a specific authority able to give this special permission.

NDZ may be used in drone geo-awareness to present Restricted Areas and other special use zones which are defined for manned aviation. NDZ may also implement drone specific restrictions, for example relating to gatherings of people.

NDZ will be implemented by classifying the airspace as type Y or Z. In U1, getting "special permission" is outside the scope of U-space. From U2 onward, the process may be facilitated by the Operation plan processing service of U-space. However despite being marked as Y or Z volumes, some NDZ may be inaccessible to all, in which case all operation plans crossing the volume will be rejected.

Having permission to enter an NDZ shall be managed in a standard way – see 4.1.3.4.2

3.2.2.2 Tactical NDZ

NDZ may be created at short notice and with short durations. These are referred to as Tactical NDZ. They may be created to protect an emergency manned flight in VLL, for example a Helicopter Emergency Medical Service (HEMS) flight evacuating an injured person from an accident, or for other sudden needs.

3.2.2.3 LDZ, Limited Drone Zone

LDZ are areas with specific technical limitations. These are implemented in U2 as Y and Z volumes with published entry criteria. These criteria may be in terms of

- Communication technical standards
- Surveillance technical standards
- Navigational performance – see section 3.4.2
- Drone reliability / airworthiness
- Noise level
- Detect and avoid equipment
- Pilot training
- …and so on

3.2.2.4 EDZ, Exclusive Drone Zone

EDZ is an area in which drone traffic is expected and other air traffic is not. EDZ may contain any of X, Y or Z volumes in drone terms. The exclusion of manned aviation may be achieved with a restricted area or similar.

3.2.2.5 Unrestricted zones

Areas that are not NDZ, LDZ, or EDZ are unrestricted. It is expected that in U1, most of VLL is either unrestricted X or NDZ, which will be implemented as Y or Z. As U2 begins and the use of Y and Z is possible by means of operation planning, the amount of NDZ should decrease. From U2 onwards, NDZ, LDZ, and EDZ may become relatively uncommon, with much of VLL being unrestricted X, Y, or Z.

3.2.2.6 Geo-fences

Geo-fence barriers are used in U-space to enforce boundaries between different airspace volumes, for drones.

- Not all boundaries are geo-fences
- Obeying geo-fences is mandatory, but exceptions may be granted. Exceptions will generally have a standard technical implementation – see section 4.1.3.4.2
- Most geo-fences are permanent structures, but some geo-fences might have times of operation.
- If a drone crosses into a geo-fenced area it becomes an 'intruder' drone.

A relatively complex example of a geo-fence would be a hypothetical airport, which is a type Za airspace volume, surrounded by type Y-type volume, access to which requires the drone to have ADSB. Surrounding this is a large X-type volume. A delivery flight needs to fly near the airport and enter the Y-type volume. The operation plan for the flight mentions the drone has ADSB and permission is granted to enter the Y-type volume. The operator and drone see a geo-fence at the boundary of the

Z-type volume (the CTR of the airport.) A recreational drone pilot with a small drone flying as an Open operation is subject to a geo-fence at the boundary between X and Y-type volumes.

3.2.2.7 Geo-cages

A geo-cage is a virtual barrier linked to a drone operation. The geo-cage defines the outer boundaries of the approved operation with the objective to ensure that the drone remains within the boundary of the geo-cage. For safety reasons the boundaries of the geo-cage would not be automatically enforced on the drone. The drone pilot is alerted when the drone is approaching the outer boundaries of the geo-cage. If he crosses the outer boundaries of the geo-cage the drone pilot needs to explain himself. If a drone leaves a geo-caged area it becomes a 'rogue' drone.

High risk operations may have a geo-cage which is also a Tactical NDZ for other drones. This method could, for example, contain a BVLOS flight made in U1.

3.2.3 Airspace Assessment

The airspace authority, typically the Civil Aviation Authority of the state, is responsible for deciding, or revising, which volumes of their airspace have which classification, and which parts have which access conditions. Hence the decision of what is X, Y and Z, as well as NDZ, LDZ and EDZ rest with the airspace authority. A full description of the process of airspace assessment is out of the scope of this ConOps, but it can be stated that the process should consider:

- Ground risk – the safety of what is below
- Air risk – what is likely to be flying
- Social acceptability factors such as noise and privacy
- Security criteria to ensure trusted and correct functioning of U-Space
- The need to provide opportunities for legal drone flying to reduce the risk of illegal drone flying
- The interests and needs of specific authorities
- Requests from potential future operators of drones
- The cost of providing the services needed to operate Y or Z volumes compared to the additional safety or capacity that they provide

The division of the airspace into volumes of different types or access conditions may be by place (lat-long) and/or by height.

3.2.4 Operations in different airspace types and access conditions

3.2.4.1 Open operations

Open operations are described in section 2.5.5.1. They are restricted to

- VLOS
- EVLOS
- "follow-me" – with limitations

There are specific restrictions on the aircraft used for Open operations and the environment in which they can be flown. The reader is invited to look at the draft regulations [1], [2], [3] and [4] for more details. By virtue of the restrictions on Open operations, the pilot training requirements are light and there is no obligation to make a Specific Operational Risk Assessment (nor, thus, to submit an Operational Declaration.)

3.2.4.1.1 Open in Type X

Open category of drone operations are a good match for type X airspace.

It is expected that (in some countries) some regions of type X airspace will be dedicated to Open operations and will be restricted areas for other air traffic. This EDZ is sometimes referred to as a Drone-o-drome.

It is recommended that Open category drones in type X airspace use a U-space position report submission service, where feasible. At the very least the drone operator is strongly encouraged to signal start-of-flight and end-of-flight if at all possible – see section 4.1.1.4 Doing so may serve as a warning to other aviation that this drone flight is present.

3.2.4.1.2 Open in Type Y and Z

Types Y and Z airspace have some specific requirements for flight including an appropriately trained pilot, operation planning, having a connected remote piloting station and position report submission. There may be specific technical requirements for entering an airspace.

If all of those requirements are met and yet the operation still meets the description of Open in the legislation, for example concerning the ground risk and the technical specification of the drone, then an Open operation may take place in a type Y or Z airspace.

3.2.4.1.3 Open in CTR, type Za

ICAO controlled airspaces exist in VLL, for example around airports. Access to the controlled airspace prior to U2 will be by a process outside U-space. From U2 onward, one means of requesting access to a controlled airspace volume will be via Drone operation plan processing services (section 4.1.3) triggering the Procedural interface with ATC (section 4.1.8.1). Permission may be granted with conditions and or instructions. In U3 the Collaborative interface with ATC service becomes available (section 4.1.8.2) and may be mandated in the permission to enter.

Operation inside the controlled airspace volume will require a suitably trained pilot and the technical equipment specified for the airspace. If despite all this the operation still resembles an Open operation, then permission may be given for the operation to take places as an Open category operation, at the prerogative of the authority for the airspace.

3.2.4.2 Specific and Certified operations

Specific operations can occur in airspace types X, Y and Z. There may be some type Y or Z airspaces that for ground risk mitigation or similar reasons mandate Certified operations.

Specific operations are preceded with a risk assessment and a consideration of how risks are mitigated. Certified operations should be preceded by a process that would include an assessment of whether Certified operation is possible which considers risks and their mitigations. The following general statements apply:

- There is a risk of 'surprise encounters' with drones not having position report submission or operation plans in Type X airspaces. Operations will need to mitigate this risk, in particular BVLOS, RSF or AFU operations which may need detect and avoid capable of working with non-coooperative targets.
- The U-space services available in Type Y and Z airspaces are risk mitigations.

- An operational plan is mandatory in type Y and Z airspace and highly recommended in type X, even for specific operations by holders of LUC or those following standard scenarios.
- Position report submission is mandatory in type Y and Z airspace and highly recommended in type X, if only to reduce the risk to other airspace users.

3.2.4.2.1 Specific and Certified operations in type Y

Type Y airspace is available at the latest from U2 onward. Type Y includes mandatory

- Operation Declaration
- Strategic conflict resolution
- Position report submission
- Mandatory use by the pilot of on-line U-space services:
    - Emergency management
    - Tactical Geo-fencing
    - Traffic information

VLOS, EVLOS and BVLOS are possible in type Y volumes. As separation provision is pre-flight (i.e. Strategic) the separations must be relatively robust against uncertainties in 4D position. The Traffic Information service reduces the residual risks of conflict in flight to some extent. Hence the density of traffic in type Y airspace will be lower than that in type Z, but not excessively so.

RSF and AFU may be possible in type Y airspace with sufficient risk mitigation.

3.2.4.2.2 Specific and Certified operations in type Z

Type Za Airspace is available from U1, type Zu from U3 onward. Type Z includes mandatory:

- Operation declaration
- Strategic conflict resolution
- Dynamic capacity management
- Position report submission
- Use by the pilot and/or drone of on-line U-space services:
    - Tactical conflict resolution
    - Emergency management
    - Tactical geo-fencing
    - Dynamic geo-fencing

Some of the above services will not, however, be available before U3. Operations in Za before U3 must coordinate closely with ATM to ensure safety of both manned and unmanned flights.

It is likely that type Zu zones will have mandatory use of collaborative detect and avoid for collision avoidance.

VLOS, EVLOS and BVLOS as well as RSF and AFU flight are possible in type Z. As there is separation provision during flight (i.e. Tactical) the separations given pre-flight may leave a higher residual risk than is safe in type Y. Hence the density of traffic in type Z will be generally higher than in type Y. This high density makes type Z especially inhospitable to AFN operations.

3.2.4.3 Open, Specific or Certified operation in NDZ

NDZ are either Y or Z-type airspace volumes. Although they are called no-drone zones, drones are allowed to fly in them on permission of the owner of the airspace volume or the property overflown. This will generally be for work undertaken by or on behalf of the owner or user of the airspace or property. Once the operation has permission to enter, which would normally be granted through application to the owner using the channels they define, the operation should continue as for Y or Z-type airspace.

From U2, operation plans are required for NDZ, even when the operation is likely to be alone, if only to warn other airspace users of the presence of the drone.

3.2.4.4 VFR operations

Manned operations may enter type X, Y or Z unintentionally, for example due to the way height is measured - see the UAS ATM common altitude reference system (CARS) discussion document [46]. Manned operations may also enter type X, Y or Z intentionally, for example for training emergency landings, or in case of a real emergency landing.

Manned operations in X, Y and Z are at risk of colliding with drones, but this risk can be mitigated if the manned flight is conducted making use of U-space services. Such operations should be recognised as being a deviation from VFR as it is known today and may merit specific training.

A VFR flight might be in VLL because of a planned entry, an unplanned, but conscious, entry, or an inadvertent entry. There are many reasons for these types of entry:

Planned entry into VLL:

- HEMS or police flight
- Military training
- (in a few places) low altitude routes exist for helicopters
- VFR training for emergency landings and similar
- Balloon or microlight take-off or planned landing using ad-hoc location
- (in some countries) microlights may fly in VLL
- (in many countries) there are geographic areas where VFR may fly in what this ConOps defines as VLL under the provisions of ICAO Annex 2 or SERA

Unplanned, conscious entry into VLL:

- Emergency landing, other emergency
- Gliding loss of altitude
- Ballooning loss of altitude or ad-hoc landing

Inadvertent entry into VLL may be associated with:

- hilly terrain or obstacles that raise the top of VLL. The VFR pilot should know height above ground from his/her map but might make an error
- local changes in air-pressure (or air temperature) that might invalidate the current setting of the barometric altimeter in the VFR aircraft

If not segregated into a specific volume of airspace, parachuting, base-jumping, hang-gliding and paragliding might also be considered to be potential planned or unplanned (or even inadvertent) entry into VLL, although they are not VFR flights.

Permanent structures in VLL that are used by manned aircraft such as low level helicopter routes, frequently used hospital helicopter landing pads and similar should be protected from drone operations by means of NDZ status.

Priority operations such as HEMS or Police flights or military training shall be systematically protected by Tactical NDZ, and hence geo-fences.

Predictable non-priority activities like parachuting or hot-air-balloon festivals, glider airports or similar may also be protected by NDZ.

Planned, non-priority entry into VLL may be handled in different ways depending on the type of airspace.

- In U1, there is no mitigation for the risk of entering a type X airspace apart from Tactical NDZ. The manned flight should assess the likely risk very carefully before flight.
- From U2, planned entry into type VLL can be made known to U-space by the manned flight submitting a U-space operational declaration, and then following it. See section 4.1.3.1. In type Y and type Z airspace, the results of the Strategic Conflict Resolution service shall be followed. If the conflict resolution cannot be followed, the manned flight might request being protected by a Tactical NDZ. The operational declaration brings less risk reduction in type X airspace.
- From U2, the risk associated with planned entry VLL may be reduced by use of the U-space Position report submission service on the manned aircraft – see section 4.1.1.4, which is mandatory in types Y and Z. The use of ADS-B might be sufficient if there is coverage at the location.
- From U2 the risk associated with planned or unplanned entry into VLL can be reduced by the crew making use of the U-space Traffic Information service – see section 4.1.6.2, which might require some training for the crew.
- From U2, the risks of entering type X airspace might be very slightly reduced by submitting an operational declaration, but the manned aircraft will get much more protection from a Tactical NDZ.
- From U3, when collaborative detect and avoid is in widespread use, the manned aircraft can be fitted with a drone compatible collaborative detect and avoid system, and the pilot trained to use it.
- In U4, when means of allowing safe interoperation of manned and drone flights are standardised, these should include a detect and avoid system that is compatible with both, in general use, and which should reduce the risk in all types of airspace

Unplanned, conscious entry in VLL should be considered as risky. The following can reduce the risk:

- From U2, the crew of the aircraft may wish to use the U-space Emergency management service – see section 4.1.5.1 to report their incursion. This may involve some training and the availability of a mobile device connected to the internet (e.g. smartphone)
- From U2, the use of the U-space Position report submission service on the manned aircraft. This might be done in some way that the pilot can turn on when the need arises. Use of ADS-B may be sufficient as the ATM and U-space trackers shall be interconnected.
- From U2, the use of the U-space Traffic Information service, if the crew have sufficient connectivity and time to do so.
- In U4, a detect and avoid system compatible for use on drones and manned aircraft

The risk associated with inadvertent entry into VLL may be mitigated by

- From U2, some types of inadvertent entry into VLL can be detected by the manned flight submitting a U-space operational declaration. Submitting an operational declaration may also reduce the risk in the case of an unpredicted entry into VLL when in combination with position report submission.

- From U2, the use of the U-space Position report submission service on the manned aircraft. This might be done in some way that the pilot can turn on when the crew feel that it is needed, or may be left running permanently. Use of ADS-B may be sufficient as the ATM and U-space trackers shall be interconnected.
- From U2, the crew of the aircraft may wish to monitor information sent out by the U-space Emergency management Service – see section 4.1.5.1. This may involve some training and the availability of a mobile device connected to the internet (e.g. smartphone)
- From U3 the fitting of the manned aircraft with a collaborative detect and avoid system as used by drones.
- In U4, a detect and avoid system compatible for use on drones and manned aircraft

3.2.4.5 IFR operations in type Z

IFR may exist in VLL in ATS controlled airspace, which is labelled Z (or Za) for the drone community. IFR flight in Zu is not foreseen, currently.

3.2.4.6 Summary of volumes, uses and operations

- There are three types of airspace volume in the VLL: X, Y, and Z
- X offers no separation services, all responsibility for safe operation is with the remote pilot
- Y offers strategic (= pre-flight) conflict resolution and usually traffic information during flight
- Z offers strategic conflict resolution and tactical (= in flight) conflict resolution
- Access to Y and Z requires an approved operation plan. Hence Y & Z may implement NDZ.
- Any part of X, Y, or Z can be an EDZ. VFR operations are not permitted in an EDZ.
- Either Y or Z can be LDZ. The limitations are published and met in the operation plan.
- Open, Specific and Certified operations are all possible in X, Y, or Z.
- As well as an approved operation plan, flying in Y or Z involves appropriate training, technical equipment and a connected remote piloting station.

3.2.5 Comparison of U-space types and other models of the airspace

The EUROCONTROL/EASA UAS ATM Integration Operational Concept (2018, Lissone, Colin, Hullah et al) [12] mentions No-drone-zone (NDZ) and Limited-drone-zone (LDZ), as described in section 3.2.2. Exclusive drone zones (EDZ) are mentioned, subdivided into EDZu for unplanned, EDZp for planned and EDZm for passenger carrying operations. Each is possible in the terms if this document, EDZu is a Restricted area for manned aviation which is dedicated to drones as type X. Both EDZp and EDZm may be implemented as being type Y or Z (either) within restricted areas for manned flight. The same document gives an example in which classes of traffic are separated in height. Such a scheme could be achieved by layering type Z or Y above type X.

The Airbus Blueprint for the Sky (2018, Mooberry, Polastre, Sachs et al) [21] describes corridors and zones. Corridors could be constructed from type Y or Z in regions otherwise filled with type X, or Z corridors could join Y volumes. Airbus (Altiscope) have done further work considering traffic organisation in their “Technical Report 004: Metrics to Characterise Dense Airspace Traffic” (2018, Golding) [23]. The systems described in that paper can (with some effort) be constructed using the tools described in sections 3.2.1 and 3.2.2 of this ConOps. *Traffic organisation for efficiency is not described in this ConOps.*

3.3 Operational practice including rules of the air and flight rules

3.3.1 Rules of the air

Current sources of the rules of the air are the Standardised European Rules of the Air (SERA) [15], ICAO Annex 2 “Rules of the Air” [13], and the draft implementing regulations on the rules and procedures for the operation of unmanned aircraft [1] and on unmanned aircraft intended for use in the ‘open’ category [etc.] [2]. The drone pilot is a pilot as defined in the SERA, and this applies unless stated in the draft implementing regulations. When there is no identifiable pilot, the drone operator takes that role and all associated responsibilities.

In order for manned and unmanned operations to be adaptable, there need to be clearly defined flight rules at low level. At present there are no specific rules for drones in the SERA, other than those that regulate all aircraft. Two new sets of rules are required for drones – low-level (LFR) and high-level (HFR) flight rules - which would accompany the current visual and Instrumental flight rules.

For LFR, it is clear that drones will not be able to operate in accordance with the full set of requirements in section 3 of the SERA, thus it is vital to clarify the necessary boundaries in a dynamic way. The upcoming EU UAS Regulation (Implementing Act) will clearly define the responsibilities of both the UAS operator and the remote pilot.

3.3.2 Specific and General Flight rules in VLL

General flight rules are supplemented by the more specific VFR or IFR. Even though drone operations are known to be in VLOS and BVLOS, they are not compatible with VFR and IFR. It is foreseen that the development of LFR will become challenging if it shall be implemented in environments where the airspace is not organised in standard way.

It is crucial to understand the difference between operations and flight rules, thus it is a common mistake to identify VLOS/BVLOS as means for flight rules.

Existing right of way rules are applicable not only to VFR traffic but also for VLL flights with drones. It is challenging to apply right of way procedures knowing that a pilot flying its drone in visual line of sight will have to determine how far the incoming VFR flight is. Equivalently the pilot from the cockpit would have trouble visually identifying a small drone even if its 50 m away.

Automated flight: the system must be able to apply the flight rules. If supervised, the supervisor must be informed if the flight rules are infringed (to stop the operation for example) – see sections 2.5.3.2 and 2.5.3.3

3.3.3 Avoidance of collisions

First step into ensuring a safe self-separation and anti-collision between a drone and a manned aviation is to conduct separate analysis between several densities of traffic, with high-density demanding flow control.

The logic for drones and manned aircraft to avoid collisions must be compatible, whatever the intruder is. At this point, the drones give way to manned aviation.

In any situation where the drone pilot is uncertain as to the trajectory, level, speed or status of another aircraft approaching the pilot’s aircraft, the pilot should assume a head-on approach and follow

SERA.3210 (or section 3.2.2.2 of ICAO Annex 2 above the high seas) and change heading to the right for interoperability with VFR flights. If his/her drone is stationary, then that drone should remain stationary unless doing so seems likely to cause danger.

3.3.4 Access to restricted volumes (NDZ, LDZ, EDZ, etc.)

Drones must follow the rules applicable to segregated areas but drones operations added new types of zones. No drone zones (NDZ), Limited drone zones (LDZ), Exclusive drone zones (EDZ) require manned aviation and drone pilots to be familiar with these restricted volumes.

Because of government use of drones and their usefulness in accessing very dangerous areas, a system of permissions must be implemented for authorised drones. U-space must cater for these permissions.

Geo-fencing must be dynamically enforced and the drone airspace picture must therefore be updated accordingly through a UTM service. This is valid for all the types of geo-fencing, including geo-caging.

3.4 Separation

In aviation, separation is a concept for keeping aircraft outside of a minimum distance from each other to reduce the risk of a Mid-Air Collision (MAC). Today different minimum separations apply in different surveillance conditions; for example during procedural control over the Atlantic Ocean, where there is no radar coverage, separations of 60 nautical miles are used, while in continental Europe where there is radar coverage, in class A airspace separations of 5 nautical miles are used. VFR pilots in class G using “See and Avoid” do not have a minimum distance specified but must Remain-well-Clear (RwC) of each other. In all cases, a minimum separation takes into account how well the relative positions of the aircraft are known. Historically, the parameters that define each Separation Standard were based on the capabilities of the service offering (e.g. the radar resolution, altimeter accuracy) or the generalised set of abilities that all aircraft can procedurally conform, considering factors such as the time taken to respond to a control input, the ability to maintain a vertical “flight level” accuracy of at least 100ft, and so on.

With the emergence of small high-accuracy positional location and tracking systems, the minimum distances that aircraft can be safety separated can now depend on the performance of overall navigation and surveillance system. ICAO defines Performance-based navigation (PBN) in terms of a requirement set [43]

- Accuracy - The volume of space the drones will be confined.
- Integrity - A measure of correctness of the navigation data provided.
- Availability - The proportion of time which reliable navigation information is available.
- Continuity - The capability to provide uninterrupted navigation information.
- Functionality - Functional requirements.

For manned aviation, PBN has been implemented by examples such as required navigation performance (RNP) specification of on-board monitoring and alerting, or the area navigation (RNAV) specification that relies on navigation beacons. Both specification methods define a separation distance based on the criteria above.

Safe deployment of a PBN separation specification can be defined as

$$\text{Separation} = \text{Function}(Accuracy, Integrity, Availability, Continuity, Functionality)$$

Examples include: *RNP-2 implemented for US en-route arrival/departure and requires a monitored accuracy of +/- 2nm available, 95% of the time.* – see [55]

3.4.1 The impact of Weather on drone separation

Weather impacts small drones in a variety of ways and drones can be used to measure this effect. Newton's second law states that every force has an equal and opposite reaction, meaning that an aircraft that can measure a weather system is also affected by the meteorological conditions. Increased weather severity can cause loss of control of a drone and ultimately an increase in LoS events. An RUNP-20m (see section 3.4.2) operating zone would have to validate, by some means, that (cooperative) drones can safely fly in a wind speed of up to:

Wind speed = speed(aircraft type)

New fan arrays, with numerous small fans, can generate variable wind profiles that allow better control in higher wind speeds. In winds of 30 kts, a light UAS of less than 900 grams will naturally be less stable than a large 100 kg UAS in the same winds, and will also be much more susceptible to gusts. However, in still air, the light UAS can naturally hold their position much more accurately. Therefore, navigational accuracy depends on the drone's capabilities for a given weather condition and cannot be considered to have the same response function across different drones models.

3.4.2 Required U-Space Navigation Performance - RUNP

A U-Space validated RUNP would use the same ICAO principles of validation that are used in RNP and RNAV. The specification would use the same requirements set, although the parameters of what produced a safe operation will have to be validated for a given geospatial implementation (e.g. at a particular airport). RUNP is written with a distance suffix, as is done for RNP. In the case of RUNP the distance unit is given by SI abbreviation, and is usually metres.

Examples high-level RUNP parameters:

An international airport: RUNP-5m
- Accuracy - +/- 5 metres
- Integrity - Greater than 1-1x10-7/h with a Time-To-Alert of less than 1 second
- Availability - Better than 99% link-time (in nominal conditions)
- Continuity - At least 1-1x10-4/h continuous link-time
- Functionality - Managed: "ATZ"

A small town: RUNP-50m
- Accuracy - +/- 50 metres
- Integrity - Greater than 1-1x10-7/h with a Time-To-Alert of less than 5 second
- Availability - Better than 99% link-time (in nominal conditions)
- Continuity - At least 1-1x10-4/h continuous link-time
- Functionality - Declared: "Sub-urban region"

The safety impacts of RUNP will require certified aircraft fitted with certified dependent surveillance.

3.4.3 Conflict management

The separation minima defined above allow for the implementation of three layers of conflict management:

- **Strategic (pre-tactical) de-confliction**; the ability to plan before flight operations of a strategy that does not conflict with other users. Typically this involves operators sharing drone mission plans to relevant parties and reducing any potential loss of separation either by an agreed procedural separation or by planning routes that are unlikely to cause interactions with other airspace users. U-space' Strategic Conflict Resolution service is described in section 4.1.4.1

- **Tactical separation provision**; the ability to maintain a situational awareness through either visual or instrumental aid that monitors for potential loss of separation. Typically, in non-segregated controlled airspace, ATC uses radar to track aircraft to predict their trajectory and issue clearances that resolves potential conflicts. Likewise, VFR defines the tactical actions required to manage the potential loss of separation between two aircraft in un-controlled airspace by RwC of each other. U-space' Tactical Conflict Resolution service is described in section 4.1.4.2

- **Collision avoidance**; the ability to prevent a MAC as part of a last course of action, if the above separation plans and provisions fail.

In U-Space, the three layers of conflict management will remain valid, although the service provisions of each layer will become increasingly merged. With increased connectivity between (semi-autonomous) aircraft, 4D trajectory can be updated and shared mid-flight, allowing tactical provision services to take more strategic reaction. Collision avoidance systems that can also predict a potential loss of separation can be used to aid tactical provision services that keep aircraft RwC.

U-Space will also support drone "**Detect and Avoid** (DAA)" systems which are defined by ICAO Annex 2 [13] as – "the capability to see, sense or detect conflicting traffic or other hazards and take the appropriate action". It defines a capability aim to ensure the safe execution of flight with all airspace users. The principles are to mitigate hazards such as
- conflicting traffic,
- terrain and obstacles,
- hazardous meteorological conditions,
- ground operations,
- other airborne hazards,

…through either the technical capabilities of the tactical DAA system or pre-emptive strategic mitigation (e.g. procedural separation). Drone DAA is expected to include Collision Avoidance and Remain well Clear. Ultimately, the goal of DAA on board drones is to give the UAS equivalent capabilities as currently used by manned aircraft.

3.5 Examples of separation in Use Cases

3.5.1 Separation between drones

3.5.1.1 Between VLOS and VLOS

In the rules of the air, we stated that
- the remote pilot flying the drone in VLOS is responsible for the avoidance of collisions,
- there is no value in setting any minimum separation as distance cannot be accurately judged by eye from the ground.

Where the strategic and tactical de-confliction services are provided, there is no particular reason to set any separation minima between VLOS, just as today there is no minimum separation set between two VFR in class G, except the semi-circular rule. This rule has no sense for a VLOS operation where the drone may change its heading several times during the mission at moments not specifically planned in advance. A criteria to be taken into account could be a limited volume capacity, in order to not overcharge VLOS pilot's attention.

3.5.1.2 Between VLOS and BVLOS

Where a drone operation plan is submitted, the U-space system is able to consider separation minima before validating the plan. Even if the collision avoidance is supported by the VLOS actor, separation minima could be defined between BVLOS and VLOS, in order to secure BVLOS pilot who has no global view of the environment around his drone.

3.5.1.3 Between BVLOS and BVLOS

These minima must take into account the navigation precision and the speed of the aircraft. For instance, in airways dedicated to high speed transit for long haul journey, the separation minima should be higher than in high traffic density areas where the separation minima should be correlated to a maximum operational speed.

Some requirements such as **RUNP** (Required U-space Navigation Performance), the equivalent of RNP for manned aviation, could be an entry in the different volumes defined by CORUS. It could be RUNP-1m in managed volumes and RUNP-0.5m in declared volumes. The RUNP figures need to be confirmed by performance navigation validations.

3.5.2 Separation between drones and manned aircraft

EASA regulations, and most European countries' national regulations, highlight the necessity to fly under 120m (~400ft), or to fly far from manned aviation activity. But even then, an encounter with a manned aircraft is far from being rare.

In airspace volumes of type X, the VLOS pilot should be responsible for the avoidance of collision with all the aircraft and no figure can be put on separation minima since it is impossible to verify.

BVLOS drones can enter these volumes only if the air risk is mitigated. In France for instance, an aircraft can fly at 50m AGL for forced landing training, so a mitigation could be for the drone to fly below 20m AGL. Whether a separation of 30m is acceptable, or whether it should be greater or less, has to be defined. (Further, flying a drone below 20m AGL may be perceived as a nuisance by those on the ground.) This mitigation is only valid if the manned aircraft flies at a known minimum altitude (or height), and therefore other means of mitigation are needed. These will have to include separation minima. The pre-tactical geo-fencing service, available from U1, will also protect planned manned aircraft activities (e.g. aerial work, HEMS landing and take-off). The size of the geo-fence needed to give minimum separation must be defined.

In airspace volumes of types Y and Z, every operation will be known to U-Space and can therefore be brought to a manned aircraft pilot's attention before they take-off. At the very start of U-space, this information is crucial. Manned aircraft operating in type Y or Z volumes would be able to request the creation of a permanent or temporary NDZ (e.g. hospital or building with heliport) based on drone activity. The size of the NDZ will set the separation minima. Above urban areas, a layer above 500 feet could be dedicated to manned aircraft (e.g. HEMS and police helicopters).

3.6 Privacy and Electronic conspicuousness

3.6.1 Privacy of DRONE OPERATIONS

The right-to-privacy is a critical concept for U-Space and is considered fundamental when the safety of a flight does not impose an immediate danger to life. The right to privacy applies to all stakeholders of U-Space, including: UTM service providers, drone operators, and the general public.

Data sharing between U-Space Service providers must not violate the GDPR that protect the individuals' right-to-privacy. These include the unnecessary monitoring and tracking of people or objects, widespread broadcast of a person's identity and the excessive collection and processing of personal data. The purpose of U-Space must not be to use drones to track patterns-of-life and the identity of a drone operator must only be shared where appropriate.

The default U-Space assumption should always be to protect privacy and identity sharing should be based on the local geographical requirements, such as being near a school, an airport or some other managed airspace. In such instances there are many reasonable reasons to exchange identity and location data with the local stakeholders.

3.6.1.1 Identifying a drone

Reasons for identifying a drone include:

- Security reasons – suspicion that the aircraft is violating the law e.g. infringement of an airport control zone.
- Privacy reasons – suspicion that the aircraft is illegally photographing the observer or an otherwise private location.
- Environmental reasons – a drone is making excessive noise.
- Social reasons – a citizen sees a drone and wants to know more, even if they don't suspect there is anything wrong.

Some of these reasons are more important than others and different actors will naturally have different priorities e.g. bird watchers and security guards have different justifications for wanting more information. The solution to drone identification needs to be proportionate to solving the problem above. For example, a hobbyist "drone watcher" does not have a safety reason to know where a drone took-off or its plan operation (e.g. the track); however, at a minimum, they are justified to ask U-Space "Are you aware of the drone I've just seen?"

3.6.1.2 The Public Portal

A Public Portal is recommended to enable the general public to request information about a drone sighting. This ConOps does not define the technical specification for this portal, rather but defines the high-level principles. Fundamentally, if someone can "see" a drone flying near them they should be able to easily interact with U-Space to request more information.

In principle, the portal should be able to automatically establish the reason(s) why a citizen is requesting to about know details about a private operation. This could be as simple as the drone is in local proximity and they want to know if the drone is known to U-Space. The citizen should be able to report back to U-Space if they believe a drone is non-compliant or possibly infringing into a UAS flight restriction zone. They may also request information about the operator or U-Space service provider. Depending on the local legislation or industrial (self) regulation a level of detailed information will be responded; however, for security issues, the response might be more like “this is a government non-commercial UAS vehicle” with little further information.

In order for the public portal to be effective, the majority of drone sighting should be discoverable through the portal. If a solution which uses a mobile phone camera can discover less then only 10% of all visual drones then the general public will not have an effect portal into U-Space. Any solution must therefore be widely deployable.

3.6.2 Electronic conspicuousness in U-space

There are three applications of electronic conspicuousness in U-space:

- E-Identification, described in section 4.1.1.3, primarily intended to allow an authorised observer to identify a drone and its operator.
- Dependent Surveillance, described in sections 4.1.1.4 and 4.1.1.5, and assumed to be an important source of surveillance data for U-space
- Detect and Avoid, discussed in section 2.5.4

The draft regulations [1], [2], [3], [4] mention that e-Identification involves a signal radiated by the drone and is expected for all but the very smallest drones. This ConOps assumes that e-Id can be a basis of dependent surveillance - in the absence of a better means.

Detect and Avoid is discussed in this ConOps in terms of drone-drone interactions (section 2.5.4) and to a lesser degree interactions between drones and manned aircraft (section 5). Crucial to further exploration of detect and avoid will be the choice of whether detect and avoid involves ground systems – and hence may take advantage of U-space track data – or is a function purely inside the aircraft based only on information the aircraft can receive. The latter option might be simpler hence possibly more robust, but it would imply that electronic conspicuousness broadcast more and more strongly.

4 Operations and services in U-space

4.1 U-space services

The Blueprint [9] listed some U-space services. These services were described in more detail in the Roadmap [10]. CORUS has reworked the set of services slightly, as described in the Appendix section on Architecture. The following diagram, Figure 5, presents the services together, indicating which can be traced back to the Roadmap [10] and which have been added

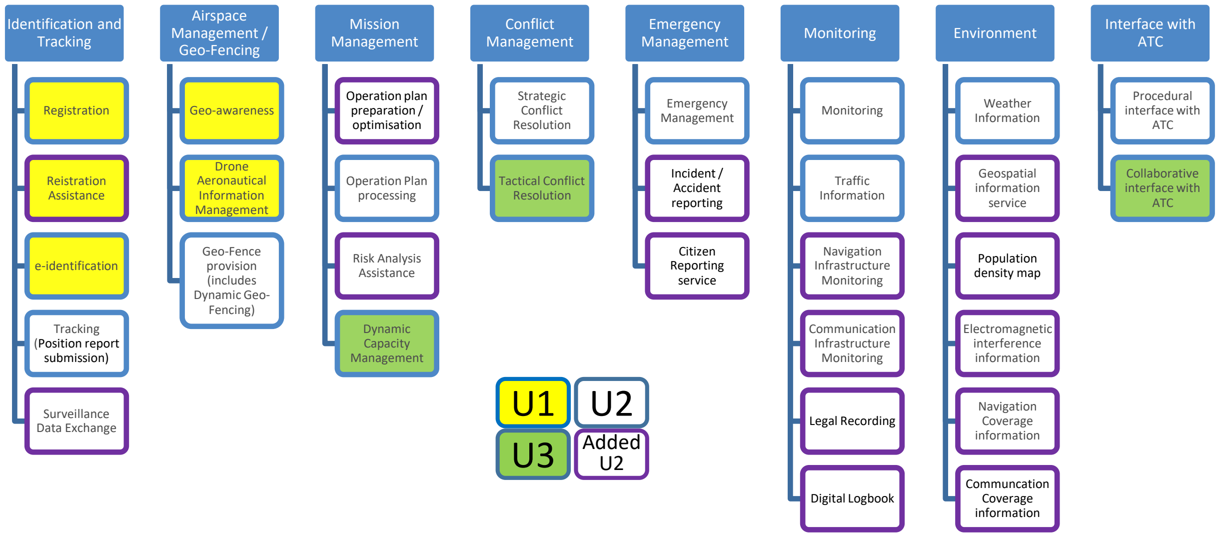


Figure 5 U-space services

The services listed in Figure 5 are all related to safety and or security. There will be other U-space services which are business related. CORUS views such business related services as being outside the scope of this document.

The services are now described in detail, grouped in the clusters given in Figure 5.

4.1.1 Identification and tracking

e-Identification, as described in section 4.1.1.3 involves the emission of the current position of the drone. CORUS assumes that in some cases this signal will be the basis of position report submission of the drone to U-space and hence makes a link with Position report submission and Tracking.

4.1.1.1 Registration service

The U1 service Registration is a basis that enables many other functions of U-space. The U-space e-registration service answers the requirement for registration that appears in the draft implementing legislation [1] Article 14, “Registration of UAS operators and certified UAS,” which lists fairly precisely what information is expected. The U-space registration service is the digital implementation of the requirement. To achieve Registration, there should be some secure and high availability registry (data store), with appropriate means available for different classes of user to input/update their own data or (when permitted) query the contents of the registry. There will need to be agreed processes to determine who is permitted to query or even change the contents of the registry and in what circumstances, for example to remove a record following a death or winding up of a company, or after a court order. The Registry will also need to be connected to other systems so as to confirm that people, businesses, addresses and other information mentioned in inputs really exist.

As is explained in section 4.1.1.3, the registry must give rapid responses to queries.

The following table lists (most of) the roles, as defined in section 2.9, and actions that are supported by the e-registration service.

Role / Node	**Action**	**notes**
Drone operator representative	Register operator: - Create new registration of self - Review own registration - Update own registration - Delete own registration	Registering of drone operators is required in many but not all cases. Update might be provoked by change of address.
Drone owner representative	Register operator: - Create new registration of self - Review own registration - Update own registration - Delete own registration	*Only in cases where drawn owner registration is required.*
Accredited registry reader	View some information in the registry, as appropriate for that person's permissions.	Police or security agent are examples of stakeholders that would also have Accredited registry reader status
Accredited registry updater	Register pilot and/or pilot training: - Create new registration of pilot or training - Review pilot registration or training - Update pilot registration or training - Delete pilot training *or registration*	Drone pilot schools hold this role. Pilot schools deletion of pilot registration would be in exceptional circumstances
Drone pilot	Register pilot: - Create new registration of self - Review own registration - View / Print own training records - Update own registration - Delete own registration	Update might be provoked by change of address, for example.
Registrar	Create / Review / Update / Delete accreditaion of persons / organisations allowed to access the registry to write or read information.	Impacts: Accredited registry updater Accredited registry reader
Registrar	Create / Review / Update / Delete registration entries in exceptional conditions	…generally when the usual actor is unable, unwilling or untrusted.

Table 10 Summary of e-Registration

Note in the actions above, deleting will probably not remove the record but mark it as no longer active. How this is presented would depend on who is looking.

There shall be standard protocols for querying and describing pilot training. When answering such queries, the registry itself should be able to recognise any elements that are too old to still be valid.

The registry needs to be connected to other registries to allow cross border operations. Any drone operator or pilot from anywhere in Europe should be able to operate in any European country, as long as national laws and local rules are followed. Hence any registry should be able to respond to queries about an operator or pilot by consulting the relevant registry in which the operator or pilot is known.

4.1.1.2 Registration assistance service

It may be that some specific registrations occur routinely, for example that a shop owner register a drone (if required) or drone operator each time a drone is sold, or that a training school register pilot training. Services may be offered to assist such routine registrations, presenting a user interface that is simplified and/or partly filled in with standard information.

4.1.1.3 e-Identification service

The U1 e-Identification service is primarily aimed at enabling the detection of illegal activity and aiding law enforcement. The U-space service called e-identification is referred to in the draft legislation [1], [2], [3] and [4] as remote identification. The whole intent is described in Article 2(L) of the draft implementing regulation [1] as

‘remote identification’ means a system that allows for the verification of the identity of the unmanned aircraft operator as well as verification of other relevant information without physical access to the unmanned aircraft ;

Remote identification consists of two parts, 1) a service offered from the ground, and 2) a technical capability of the drone. The drone capability is described in some detail in the draft Annex to the Delegated regulation [4]. The same description appears in the technical requirements for drones of class C1, C2 C3 and C4:

have an remote identification system that:

> *(a) allows the user to insert a UAS operator registration number;*
>
> *(b) ensures, in real time during the whole duration of the flight, the radio transmission on the 2.4 or 5 GHz frequency band, using an open and documented transmission protocol, of the following data in a way that they can be received directly by mobile devices within the broadcasting range:*
>
> > *– the UAS operator registration number;*
> >
> > *– the unique physical serial number of the UA compliant with standard ANSI/CTA-2063,*
> >
> > *– the geographical position of the UA and its height above the take-off point;*
> >
> > *– the direction and speed of the UA; and*
> >
> > *– the geographical position of the UA take-off point.*

The e-Identification service offered from the ground will allow any authorised user to

- Use the broadcast UAS operator registration number to consult the Registry (see section 4.1.1.1) and find details of the operator
- View, on suitable equipment, the current position of the drone, the take off point and probably also recent position reports (if available in U-space), images of the drone type, and any other relevant information in a manner that aids visual identification.

All of these are to be accomplished quickly, before the drone is out of sight of the law officer or out of range of the detection equipment.

Hence the "ground" part of e-identification consists of

- lookup of the Registry
- association of the vehicle with any existing track or mission in U-space and if successful fetching of relevant information (referring to the Tracking service and the Drone Operation Plan Processing service)
- lookup of the type and hence provision of visual recognition information
- fetching of contextual information; nearby tracks or landmarks
- presentation of the above information in an accessible way
- (possibly) integration of the above information in real time with images from a camera to produce an 'augmented reality' view

4.1.1.4 Position report submission sub-service

The Tracking service of U-space (section 4.1.1.5) cannot work unless U-space receives position reports concerning drones. The Position report submission sub-service has been added in this ConOps to allow that. It is not a service on its own but rather an important part of the Tracking service.

Position report submission will be an obligation in some airspaces and optional in all others. As stated at the start of section 4.1.1, position reports could originate as e-Identification signals, received at the remote piloting station and forwarded to U-space; but many other technical means exist for position report submission. The service must be flexible in which technologies it supports as long as performance based requirements can be met.

Where position report submission is an obligation, the drone operator or pilot will also be required to monitor that position reports are being received by U-space. Hence the Position report submission sub-service should not just allow reports to be sent, it should also give feedback that they are being received. There should be alerts when some agreed time passes without a report; that time will relate to the previous rate of pre-mission report submission and the precise navigational performance needs of the airspace concerned. (See section 3.4.2)

Position report submission will need to be secure, reliable and low latency. The information in Position Reports is safety critical[6]. The Position report submission sub-service must be deployed in a robust and reliable manner because of its safety criticality.

Position report submission will involve the drone or the remote piloting station or some specific ground equipment being connected to U-space, possibly by mobile internet. Implementations of the sub-service shall include an appropriate level of cyber security to assure that the transmissions are coming from the declared source and are being reliably received at intended end-point. To enable the secure identification of the source, there will probably be a specific logon protocol, probably linked to start-of-flight.

[6] Not all position reports for all flights are always safety critical, but that fact that some are, some of the time, for some flights requires that all be handled as if they were.

To distinguish between a flow of position reports stopping because the flight has ended and because of a failure, there will be specific logoff protocol, probably linked to end-of-flight. The failure of position reports in an airspace in which they are mandatory (for long enough to be considered real) will constitute an emergency. See section 4.1.5

Drone position report submission will be an automatic process (the pilot will not type lat-longs) hence the technical implementation will probably be fed by some software that is running at the drone or remote-piloting station. The feedback that is given is intended for the pilot and may be delivered the same way or through a web or similar interface that the pilot can conveniently consume.

All drone position reports should be recorded to allow the provision of the Accident and Incident investigation (section 4.1.5.2). Hence the Position report submission service will feed the Legal Recording service (section 4.1.6.3).

The Position Reports sent to U-space should include

- The current 3D position of the drone, expressed in the agreed measurement system and frame of reference, to the precision expected in the airspace concerned.
- The uncertainty in the reported position (perhaps in the manner of ADS-B)
- The precise time at which the position has been measured, if available
- The means by which the position has been determined, and/or some identifier of the origin of the report – so as to help the tracking service combine multiple sources of reports for the same flight.
- If available the current speed vector of the vehicle, together with its uncertainty
- The identity of the vehicle, if available (see section 4.1.1.3)
- The identity of the operator of the vehicle, if available (see section 4.1.1.3)
- The identity of the mission plan being executed – if any and if available – though this can generally be deduced by the system
- In the absence of the vehicle's e-ID identifier, if possible, a temporary identifier for the flight to ease the job of the tracker.

A **Start of Flight** report is a special report and will always originate from the remote piloting station or by delegation the drone operator's flight operations centre. It unambiguously identifies the operator and identity of the vehicle. If there is a mission plan for the flight then that mission plan is identified in the start of flight report. The time at which the flight will start is stated accurately (e.g. 1 minute or closer). Start of Flight will include an indication of the expected rate of position report submissions. Other than these conditions start of flight will resemble position reports described above. The start of flight report may be part of a sign-on process to allow position report submission to commence. The start of flight must not be sent too far in advance (e.g. more than 5 minutes) before the flight begins in order that the flight start time can be believable. If the situation changes after Start of Flight has been sent, then a new Start of Flight message will be sent giving the revised start time, or an End of Flight sent to cancel the active status of the flight. The time given in the Start of Flight is the time that the position report submissions begin.

An **End of Flight** report is a special report and always originates from the remote pilot station or by delegation the drone operator's flight operations centre. It unambiguously identifies the operator and identity of the vehicle. If there is a mission plan for the flight then that mission plan is identified in the end of flight report. The end of flight report must only be sent once the drone has landed and the position report submissions end. It accurately indicates (e.g. to an accuracy of 1 minute or better) the time at which the flight ended. The End of Flight report is sent as soon as possible after the landing and the end of the position report submissions (e.g. within 2 minutes) to avoid an emergency alert being triggered.

Pilots and operators of drones that cannot or will not send position reports during flight are still encouraged whenever possible to send Start of Flight and End of Flight.

4.1.1.5 Tracking service

Because of the role of tracking in the processes of conflict resolution and traffic information, this ConOps assumes that there will only be one safety-critical instance of tracking in any location, and that is described here.

The U-space Tracking service incorporates the Position report submission sub-service described in 4.1.1.4. Any instance of the Tracking service receives all position reports in its area of interest. Tracks are built using a statistical process that can be assisted by having access to the operation plans of the flights, hence the Tracking service is also a client of the Drone operation plan processing service 4.1.3.3.

The Tracking service should be able to deal with multiple sources of reports for the same flight, as well as ('uncorrelated') reports that do not contain the identifier of the aircraft or flight such as would come from primary radar, or that contain another (perhaps previously unknown) identifier for the flight or vehicle, such as would come from cellular telephone triangulation, or from ADS-B.

The Tracking service should contain some sanity checks on the data being received and should be able to flag suspicious position reports.

The Tracking service should produce track updates at a rate that is appropriate for the airspaces that are in its area of interest. A track is a series of reports, each of the form:

- The identity of the vehicle and operator - if available (see section 4.1.1.3)
- The identity of the mission plan being executed – if any and if available - or an automatically generated identifier for the flight. (see section 4.1.3.3)
- The identifier of the system that has calculated the track
- The time for which the track position has been calculated
- The 3D position of the vehicle at the time calculated, expressed in the agreed measurement system and frame of reference
- The speed vector of the vehicle at the time calculated, expressed in the agreed measurement system and frame of reference
- The (estimated) uncertainties in the calculated position and speed vector (or confidence if this is more appropriate)

In the same channel as track reports as described above, the Tracking system should be able to signal start of flight, end of flight – both derived from the corresponding signals in the position report submission sub-service – as well as unexpected start of position reports and unexpected end of position reports. The service should be able to signal significant changes of state, such as when a track suddenly becomes correlated, when two tracks are reclassified as being the same, or when one track is reclassified as two, and so on. Further anomalous conditions should be handled gracefully by the tracking service but signalled such as when a series of position reports suddenly changes Identifier but appears to be the same track, or when improper calibration causes a drone to report a heading or speed that is inconsistent with the track - beyond what can be expected from the reported accuracy.

The Tracking service will need to be secure, reliable and low latency. The information in Tracks is safety critical.

The Tracks generated in the Tracking service are consumed by the Monitoring service (section 4.1.6.1), the Traffic Information service (section 4.1.6.2), the Tactical Conflict Resolution service (section 4.1.4.2), the Legal Recording service (section 4.1.6.3) and the Drone operation plan processing service (section 4.1.3.3). Tracks will also be sent to ATM when appropriate and sent in a format acceptable to ATM. Tracks should be sent to (and received from) neighbouring U-space trackers as needed by cross-boundary flights.

The presentation of Tracks is the job of Traffic Information service. The human-interface of the Tracking service concerns alerting in case of problematic position reports or other anomalies.

4.1.1.6 Surveillance data service

The Surveillance Data service exchanges information between the Tracking service and other sources or consumers of tracks (rather than individual position reports) such as

- Primary radar and drone detection similar systems, for example used at airports
- Drone tracking services based on cellular telephony information and similar
- Motion capture systems and similar that use their own tracking process
- ATM aircraft surveillance systems
- Neighbouring drone trackers

4.1.2 Airspace management / Geo-Fencing

This section draws together the three Geo-fencing services expected in U1, U2 and U3, together with the Drone AIM service, expected in U2.

4.1.2.1 On the presentation of drone environment data

The community of drone users contains very varied levels of familiarity with aeronautical practices and terminology. It is important that displays of geo-fence and drone airspace information be comprehensible by their intended users. For example Open drone operations in category A1 are available to a pilot of a class C0 drone “familiarised with the user manual provided by the manufacturer of the UAS.” All UAS intended for use in the Open category will include an information notice that includes the dos & don'ts that all Open category UAS operators shall be aware of. Displays intended for such drone pilots should directly address questions like “where can I fly today?”

This document has described a lot of types of airspace in section 3.2 but these need not always be distinguished in a display; they might be generalised to fewer groups depending in the intent of the display. Likewise few drone users would be happy to have to read the contents of NOTAMS, it is expected that the information in NOTAMS is extracted and relevant parts are shown when needed to the drone pilot. This document leaves the choices of how to display geo-fence and drone aeronautical information to the ingenuity and imagination of the businesses building software tools for drone operators.

4.1.2.2 Geo-awareness service

The Geo-awareness service provides geo-fence and other flight restriction information to drone pilots and operators for their consultation up to the moment of landing.

This service is available from U1. In U1, the Geo-awareness service takes in information from existing aeronautical information, such as restricted areas, danger areas, CTRs and so on. It also adds information extracted from NOTAMS. Further it adds information coming from national and local drone legislation. From the national airspace authority (CAA) or when available the Drone Aeronautical Information Management service, temporary and drone specific restrictions are added, to produce an overall picture of where drones may operate. All restrictions on airspace access are included in this service – see section 3.2.2.

In (or by) U2 the service adds inputs from the Drone aeronautical information management service, described in 4.1.2.3, including geo-fences with immediate effect. Geo-fences with immediate effect exist to protect HEMS and similar unexpected manned operations in VLL. They may also be used for other purposes. They must be communicated very quickly and may impact operation plans already known to the Drone operational plan processing service – some of which may be for drones already in the air.

The data delivered by this service will most likely be presented to the operator or pilot on a map, either generated by the service or integrated in an operation planning management tool or service. The service may offer a dedicated view for Open operations and another for Specific operations.

In U1, the data delivered by this service may be used in operation planning, the operator may have a tool to check plans are compliant, or loaded into the flight management system of the drone. In U2 and after the pre-tactical geo-fences will be checked by the Drone operation plan processing service.

The following table lists the roles involved in this service

Role	Action	notes
Aeronautical Information Service	Supply aeronautical publications Supply NOTAMs	This service and these publications already exist for the benefit of existing aviation.
National airspace authority (CAA) Or Drone Aeronautical Information Management service	Supply drone specific restrictions - E.g. where Open is not allowed - Where are types X Y Z - Where Geo-fences exist	The duty should pass to the Drone Aeronautical Information Management service by U2. From U2 the amount of data and its rate of change increase
Pre-Tactical Geo-fencing service provider	Synthesise all data into a single image and supply the service (to an adequate level of performance)	
Drone operator respresentitive	Consume the service in the process of operation planning and optimisation	
Drone pilot	Consume the service in the process of pre-flight check and upload into drone.	
Drone operation plan processing service provider	Consume the service in the process of Drone operation plan processing	

Table 11 Pre-Tactical Geo-Fencing Roles and Actions

4.1.2.3 Drone aeronautical information management service

The Drone aeronautical information management service is the drone equivalent of the Aeronautical information management service. It is concerned with collecting together temporary and permanent changes to the drone “flying map” which are not of interest to other aviation. An example of such information might be that due to a music festival over a weekend an area changes from sparsely populated to densely populated. This results in a change to ground-risk. Operating the service will probably involve:

- Collecting inputs from occasional suppliers of information who have little knowledge of aviation
- Operating a service for more frequent suppliers of information who have been trained and authorised to upload changes
- Vetting and training of organisations to establish that they are trusted to make updates directly in the system.
- The provider of the service will probably have to negotiate at times with those providing inputs which are unduly cautious (restricting drone flight unnecessarily) or incautious, …

This service may be embedded in the Aeronautical information management service of a country or may be kept separate for any number of reasons, for example cost transparency or ease of implementation.

This service is standardised in U2 but may appear earlier. In U2 this service will maintain the map of where X, Y and Z airspaces are defined. The Drone aeronautical information management service provides information to the Geo-fencing services as well as Mission management services in section 4.1.3.

4.1.2.4 Geo-fencing provision

This service, referred to in the Blueprint [9] and Roadmap [10] as dynamic geo-fencing, will be available in U3. It provides drones with 4-D coordinates of, and information about, geo-fences. This service depends on the technical geo-awareness capability of the drone to request, receive and use the geo-fencing data. The only human actor involved is the drone operator who must configure and maintain the drone appropriately to allow the service to work.

4.1.3 Mission management

The following specific terms are used in this section:

Term	**Meaning & source**
Operational declaration	The draft regulation [1], [2], [3], [4] mentions operational declaration as a feature of specific operation. It is considered here an output of SORA.
ICAO flight plan	The flight plan of manned aviation described in ICAO doc 4444
Drone mission plan	Many small drones operated with batteries can only fly for a short time before the battery needs to be changed. Many business objectives cannot be fit into only one such flight but may require a series of flights. A mission plan is a plan for a series of flights to achieve one business objective that will be broken into separate flights ad-hoc as battery life dictates.
Drone flight plan	A plan for one drone flight
Drone operation plan	Either a drone mission plan or a drone flight plan.

Table 12 Mission management specific terms

An operation plan broadly contains

- Who is flying – the pilot, any significant pilot training, also the operator/owner
- What is flying – the identity and technical details of the drone, including any that are mandated

- Where the flight will be – as well as it is known in advance
- When the flight will occur – as well as it is known in advance – and for how long
- Supplementary information like documents giving access to airspaces, evidence of SORA, certification of the flight, …

These details are expand in the following sections. These sections do not cover any ICAO flight plan that may need to be submitted for a flight in unsegregated, controlled airspace (classes A-E).

4.1.3.1 Drone operational plan preparation assistance

There will probably be many different drone operational plan preparation assistance services offered. These will vary in their target market, ease of use, cost, scope, level of integration with the operators other tools, level of optimisation offered and so on. There will also be equivalent "tools" that are not "services" but run at the drone operator's site. Some operators will develop their own tools. (All of these are referred to as drone operational plan preparation assistance services in this section.)

The common features of these services will be their interaction with the Drone operation plan processing service:

- They allow the operator to prepare an operation plan and submit it to the Drone operation plan processing service
- They allow the operator to display (and hopefully understand) the information coming back when an operation plan is submitted
- They allow the operator to check on the status of an operation plan that has been submitted
- They allow the operator to cancel or submit an update to an operation plan that has been submitted

Further many will support

- loading the operation plan into the drone,
- SORA processes, to some extent,
- integration with "Insurance as a Service" businesses
- integration with remote piloting stations to aid conformance monitoring and similar

4.1.3.2 Risk analysis assistance

Preparation of Specific operations involves SORA (see the Draft Acceptable Means of Compliance (AMC) and guidance material (GM) to… [5]) which involves analysing risks associated with the operation. It is expected that a service is offered to support that analysis using the draft operation plan as well as information coming from the Drone Aeronautical Information Management service (section 4.1.2.3), various Environment services (section 4.1.7) and Traffic Information (section 4.1.6.2)

The risk analysis assistance service may also provide access to "per flight insurance" services.

4.1.3.3 Drone operation plan processing service

The Drone operation plan processing service is deployed in U2. It receives operation plans and uses these for a number of safety-related activities. The Drone operation plan processing service must be deployed in a robust and reliable manner because of its safety criticality.

The Drone operation plan processing service maintains a pool of data containing the histories of all submitted flights that have not yet been archived. Archiving occurs at some time after the flight lands or is cancelled. The data in this pool is considered to be commercially sensitive and may additionally be restricted for other reasons – such as for state operations. Hence access to this data is controlled.

The description of operation presented here is as if the system providing the Drone operation plan processing service is a single integrated instance. This is the operational view. The implementation may be made otherwise – that choice is out of the scope of this ConOps.

The role that submits an operation plan to the Drone operation plan processing service is the drone operator representative. To do this they use an Operation plan preparation / optimisation service or tool. The submission will be by some secure means.

The sum of all the operations known in the Drone operation plan processing service is "the traffic." The impact of an operation plan being submitted is to an extent felt by all other drone operators as a change in the traffic.

The Drone operation plan processing service is the doorway through which a number of services are reached. 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[7].
- 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. See section 4.1.4.1
- If available, the Dynamic capacity management service is invoked. See section 4.1.3.5

The response from the processing should be a copy of the accepted plan including its unique identifier, together with any conditions, for example from the procedural interface with ATC, or an explanation of any problems that have prevented acceptance.

The Operation plan management service will also offer a validation mode in which the operation plan is checked, but not submitted (i.e. not added to the set of operations.) This mode supports risk

[7] The unique identifier should be unique EU-wide (preferably world wide) and unique over a minimum of two years, preferably longer. The concept is inspired by the GUFI of FF-ICE. See ICAO doc 9965. [47]

assessment processes as well as optimisation. Some parts of the process – such as the procedural interface with ATC – will not be fully executed in validation mode.

Once an operation plan has been accepted by the Drone operation plan processing service, the operator may send further messages to

- Cancel the operation plan
- Change the operation plan
- Ask for the current status of the operation plan

Further an operator can query the service to get a list of all the operation plans known that have been submitted by that operator.

The status of an operation plan can change after the operation plan is accepted if a tactical NDZ is created that makes the operation plan unacceptable. Further the arrival of other operation plans may make this plan subject to strategic conflict resolution or dynamic capacity management. The operator should be notified directly by the Drone operation plan processing service if such an event occurs that changes the status of the flight. See Reasonable time to act in section 4.2.3.

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 described in 4.1.1.5.

The following table summarises the different interactions that involve the Drone operation plan processing service

Role / Node	**Action**	**notes**
Drone operator representative	Submit plans, changes, cancellations Receive positive or negative acknowldgements Query plans or status Receive status change warnings	Uses an Operation plan preparation / optimisation service or tool.
Aeronautical information service	Supply aeronautical publications Supply NOTAMs	This service and these publications already exist for the benefit of existing aviation.
Drone aeronautical information service	Supply X, Y , Z volumes and other drone sepcific information	
e-Registration service	Confirming the validity of the operator, any pilot training, the type of drone mentioned in any plan	
Weather information service	Supplying weather forecasts and warnings	
Procedural interface with ATC	Triggering a coordination for a flight to penetrate a controlled area.	
Strategic conflict-management service	Detecting and resolving conflicts before flight	
Dynamic capacity management	Detecting and resolving demand and capacity imbalances	

Role / Node	Action	notes
Tracking	Signalling start of flight. Querying the existance of a plan. Retrieving a plan for a track Creating an ad-hoc plan for a track Updating the current position of a plan Signalling end of flight.	
e-identification	Query plans	

Table 13 Pre-Tactical Geo-Fencing Roles and Actions

The Tracking service works closely with the Drone operation plan processing service. The existence of an operation plan helps the tracking service work. The operation plan provides a unique ID for a flight and hence a track. If the tracking system has a track for which there is no plan, it will trigger the Drone operation plan processing service to create an ad-hoc plan based on the data the tracking service has in order to generate a unique id for the track.

4.1.3.4 Some aspects of operation plan contents

4.1.3.4.1 Trajectory uncertainty

To operate effectively, the Strategic Conflict Resolution service requires precise operation plans giving the 4D trajectory to be flown. Further, to use the airspace efficiently requires the amount of "buffer space" around flights to be minimised.

Unfortunately some drone operations are not very precisely plannable – for different reasons. Hence the general requirement is that the 4D trajectory should be described as precisely as is possible for that operation. Further the operation plan should include uncertainties as far as they are known, for example "take off time between 14:00 and 14:30." Some of this uncertainty will decrease as the flight time approaches. Updating the plan to reduce uncertainty is considered virtuous behaviour – see section 4.2.2. Messages coming via the position report submission sub-service will further reduce uncertainty as the flight starts.

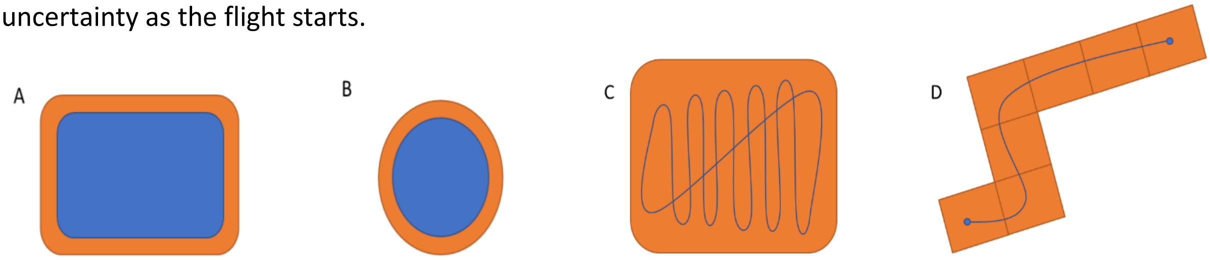


Figure 6 Example trajectories

The examples show a blue flight trajectory in an orange probable operation zone. The examples are two dimensional for illustration reasons, but the process will be four dimensional including height and time uncertainties.

The first two examples, A and B, are possibly plans for VLOS operations; as can be seen, they are volumes of operation rather than linear trajectories. C is a typical scan pattern as might be flown as a pre-programmed operation. D might be a delivery or a linear survey, perhaps BVLOS.

4.1.3.4.2 Geo-fence crossing tokens

A technical means, referred to hereafter as a token, is needed to show that a particular drone operation has permission to cross a geo-fence. This token is needed in the Operation planning phase and during flight where it may need to overcome geo-fencing implemented inside the drone itself, or in the remote piloting station, or in U-space.

The token should be trustworthy and secure. Ideally it should be linked to a specific operation by a specific drone, perhaps being associated with the unique identifier of that drone operation.

4.1.3.4.3 Operational declaration of SORA

The submission of the drone operation plan is an opportunity for depositing the operational declaration generated by the operator's SORA for the operation with the authorities. Whether this is done as part of operation plan submission is to be decided by the state concerned.

4.1.3.4.4 Contingency plans

The drone operation plan may include contingency plans to be followed in case of emergency. These may be alternate landing sites or more complex procedures.

4.1.3.4.5 Formation flights

In contrast with the established practice of the ICAO doc 4444 flight plan, drone formation flights are individual operation plans that are linked, rather than single plans for multiple aircraft. It is expected that formation flights will be indicated in the respective operation plans by mentioning an association with another plan or plans. To describe an operation in which drones A and B fly in formation, the sequence would be something like:

- Submit an operation plan for A
- Get an acknowledgement back including a unique identifier for A's operation plan
- Submit an operation plan for B that mentions formation flight with the unique identifier for A's operation

This approach can be extended to as many flights as needed. The system providing the Drone operation plan processing service will make the associations bidirectional and associative. A formation flight is then simply a pair (or set) of drone operations for which U-space will not give any warning or protection against loss of separation within the formation, though these services are maintained between the formation and other flights.

Swarm flights, in contrast, are single operations of multiple aircraft. Hence for a swarm there is one operation plan. See sections 2.5.3.4 and 2.5.3.5.

4.1.3.5 Dynamic capacity management service

U3 brings Tactical Conflict Resolution, in type Z airspace. The level of confidence in how well this service will work can be matched to the difficulty of the task the service faces by limiting the number of flights in a particular volume of air, which is the job of the Dynamic Capacity Management Service.

4.1.3.5.1 Inner working

There will be a process to predict times in the future when an airspace will be "full". The details of this process are out of the scope of this document but it will be related to the probability that flights lose safe separation. The parameters for this decision may be set as a function of other characteristics of the airspace.

When this process determines that the airspace is full, what follows is based on a parameter known as the “reasonable time to act” (RTTA) – see section 4.2.3.

The solution is generally to propose delay for flights or to propose rerouting away from the full airspace. If this has to happen, then:

- First all operation plans submitted after RTTA for that flight are the first candidates to be proposed a plan change due to the airspace being full at the time they are planned to cross.
- Second the operations are examined to find those causing the most risks of conflicts, hence whose removal would cause the larges overall reduction in risk of the airspace.
- Third, all operation plans submitted before RTTA for their respective flights take part in a process that proposes changes to those with the least virtue until the problem is solved.

4.1.3.5.2 Other applications

The machinery of the Dynamic capacity management service can be employed for any measure of “fullness,” not only collision risk. The same machinery might be used in some airspaces to manage noise.

4.1.3.5.3 Invocation

The Dynamic capacity management service is expected to appear generally in U3. It is invoked by the Drone operation plan processing service. It has no independent use. It is invoked if and only if the airspace requires it.

The Dynamic capacity management service uses the probabilistic 4D models calculated by the Drone operation plan processing service.

4.1.4 Conflict management

As discussed in section 3.4.3, Conflict Management is more than these two U-space services.

4.1.4.1 Strategic conflict resolution service

The Strategic conflict resolution service is invoked by the Drone operation plan processing service. It can be invoked because a new operation plan has been submitted or because an already submitted operation plan has changed. Strategic conflict resolution is before flight.

The service has two phases. First it detects conflicts, then it proposes solutions.

Detection broadly involves examining the probabilistic 4D trajectories predicted by the Drone operation plan processing service and looking for pairs which have a reasonable probability of coming closer than is allowed in any given airspace. The precise meaning of the previous sentence – what is a reasonable probability and so on – is outside the scope of this ConOps.

Resolution is by changing either of the pair – following similar rules about RTTA (section 4.2.3) and Virtue (section 4.2.2) as were followed in section 4.1.3.5, Dynamic capacity management service. The changes will come from a standard set of “recipes” which are tested and those that resolve the problem (and do not cause another problem) retained. The possible solutions are proposed to the operator who will refine the plan further before resubmitting or changing it.

4.1.4.2 Tactical conflict resolution

Tactical conflict resolution is the process of resolving conflicts that occur during the flight by changing the flight while it happens. The service might be implemented as an advisory service or a system giving instructions, the latter is assumed here. The description given here assumes the service is implemented on the ground and not as a distributed function within the aircraft, which is referred to in this ConOps as detect and avoid.

The Tactical conflict resolution service requires that the positions of all aircraft in the airspace being served are known and updated frequently, and further that the precision with which these positions are known can be reliably determined. The service then issues instructions to aircraft to change their speed, level or heading as needed. These instructions should reach the remote pilot rapidly and reliably. In case the drone concerned is automatic or 'remotely supervised' then the instructions should reach the drone itself rapidly and reliably.

Efficient operation of the traffic is aided when the service has a model of the flight envelope and characteristics of each aircraft concerned. Further efficiency gains may be made if the service is aware of the intention (that is the operation plan) of each flight.

The Tactical conflict resolution service is a client of the Tracking service, the Drone operation plan processing service and the Drone aeronautical information management service.

4.1.5 Emergency management

Emergency management combines U-space services and technical capabilities of the drone and remote piloting station to detect and recover from emergencies.

4.1.5.1 Emergency management

The Emergency management service of U-space has two aspects

- assistance to a drone pilot experiencing an emergency with his/her drone
- communication of emergent information to those who may be interested
    - pilots whose drones may be impacted
    - manned aviation, air traffic services
    - police

The assistance given to a pilot may include:

- enabling the reporting of an emergency
- detection and alert of an emergency (when possible)
- proposals for action to be taken to minimise risk
- reminders of contingency plans

The Emergency management service needs to be configured for the "current operation." The pilot will need to identify his drone and/or drone operation plan if any. If the drone is not using the position report submission service then the pilot will need to give the location of the flight during the 'log-on'. Emergencies that are communicated to the drone pilot are those likely to come near his/her operation and hence pose a risk to it.

The communication channel of the Emergency management should be monitored at all times by the drone pilot. Human factors should be considered during the deployment of this service; the channel may be inactive much of the time and the pilot may be under stress during any emergency. The U-space service will add value by filtering the information sent on the communication channel in order to maintain relevance for the pilot.

The Emergency management service consumes information from the Tracking, Monitoring and Operation plan processing services – if active for the operation concerned. In case the flight has an operation plan, the Emergency management service shall warn the pilot when a geo-fence-with-immediate-effect has been created which impacts the current flight.

4.1.5.2 Accident and incident reporting

The process of Accident and Incident reporting is described in detail in section 4.4. The U-space Accident / Incident reporting service supports that process. The service allows drone operators and others to report incidents and accidents. The service allows these reports to mention drone identifiers and operation plan identifiers in order to help later investigation.

The service shall maintain the reports for their whole life-cycle. The system shall be secure and give access only to authorised persons.

The Accident and Incident reporting service is a client of the Legal Recording service and hence indirectly all parts of U-space. There may be some linkage between the Emergency Management service and the Accident and Incident reporting service; some Emergency events may trigger automatic creation of an Accident/incident report.

4.1.5.3 Citizen reporting service

Similar to the Accident and Incident reporting service, U-space should allow citizens to report what they have observed when they believe incidents or accidents involving drones have occurred. The user-interface should be designed to encourage the reporting of sufficient information to identify the flights concerned.

The details of the Citizen reporting service are rather similar to the Accident and Incident reporting service.

4.1.6 Monitoring

The Monitoring family of services groups functions derived mostly from Tracking that are of value in flight.

4.1.6.1 Monitoring

Subject to appropriate data-quality requirements, this service retrieves data from the tracking service and combines it with information related to non-cooperative obstacles and vehicles to provide an air situation status report for authorities, service providers, and operators, including pilots. This service may include operation plan conformance monitoring, weather limit compliance monitoring, ground risk compliance monitoring, electromagnetic risk monitoring.

Alerts from the Monitoring service should be emitted in a manner compatible with all drone operations, hence audio alerts are preferred.

Monitoring is a client of Tracking, Drone aeronautical information management and the different environmental services.

4.1.6.2 Traffic information

This service provides the drone pilot or operator with traffic information and warnings about other flights – manned or unmanned - that may be of interest to the drone pilot. Such flights generally have some risk of collision with the pilot's own aircraft.

Traffic information is also the presentation of "air situation." As mentioned in section 4.1.3.3, there is some commercial sensitivity to drone flight information. Air situation display may be restricted.

The Traffic information service also gives access to the traffic densities expected in the near future at any location, as calculated from operation plans that have been submitted.

4.1.6.3 Legal recording

The aim of the legal recording service is to support accident and incident investigation. The service should record all inputs to U-space and allow the full state of the system at any moment to be determined. A second use of legal recording is as a source of information for research and training. Finally, post-processing of legal recording data by dedicated (e.g. AI-based) algorithms can identify high risk situations and adapt parameters for risk assessment of future operations.

In view of the commercial sensitivities of drone operators, it is likely that access to the recordings will be restricted.

4.1.6.4 Digital logbook

The digital logbook service extracts information from the legal recordings to produce reports relevant for whoever is using the service. It shall give users access to their own information only.

Drone operators and pilots will be able to see summaries of information for flights they have been involved in; start and end times, places, aircraft id, and so on.

Drone pilots will be able to see histories of and statistics about their flight experience.

Drone operators will be able to see histories / statistics for their aircraft.

The digital log book service needs to be securely implemented. Various query functions should be available.

Authorise users, such as accident investigators or police may have general access to all data.

4.1.6.5 Navigation Infrastructure Monitoring

The service to provide status information about navigation infrastructure. This service is used during operations. The service should give warnings of loss of Navigation accuracy.

4.1.6.6 Communication Infrastructure Monitoring

The service to provide status information about communication infrastructure. This service is used during operations. The service should give warnings of degradation of communications infrastructure.

4.1.7 Environment

The environment group of services cluster many similar services offering data. These services each provide information that has a cost to collect and maintain.

4.1.7.1 Weather information

The service to collect and present relevant weather information for the drone operation. This include hyperlocal weather information when available/required.

4.1.7.2 Geospatial information service

The Geospatial information service collects and provides relevant Terrain map, buildings and obstacles for the drone operation. The information may be available at different precisions from different sources.

4.1.7.3 Population density map

The Population density Information service to collects and present relevant density map for the drone operation. This map is used to assess ground risk.

Proxies for instantaneous population density information might be found to be reliable; such as mobile telephone density – to be confirmed.

4.1.7.4 Electromagnetic interference information

The service to collect and present relevant electromagnetic interference information for the drone operation.

4.1.7.5 Navigation coverage information

The service to provide information about the navigation coverage. It can be specialised depending on the navigation infrastructure available (e.g. ground or satellite based). This service is used to plan relying on required coverage.

4.1.7.6 Communication Coverage information

The service to provide information about the communication coverage. It can be specialised depending on the communication infrastructure available (e.g. ground or satellite based). This service is used to plan relying on required coverage.

4.1.8 Interface with ATC

Two interfaces with ATC are proposed. Procedural, available first, and Collaborative.

4.1.8.1 Procedural interface with ATC

The procedural interface with ATC is a mechanism to coordinate an entry of a flight into controlled airspace. The interface works before flight. The Operation plan processing service will invoke the service and through it:

- ATC can accept or refuse the flight
- ATC can describe the requirements and process to be followed for the flight

4.1.8.2 Collaborative interface with ATC

The collaborative interface with ATC is introduced in U3 and is a service offering communication between the Remote Pilot (or the drone itself in case of automatic flight) with ATC while a drone is in a controlled area. The communication may be verbal or textual. The Collaborative interface allows flights to receive instructions and clearances in a standard and efficient manner, replacing ad-hoc solutions used prior to this service being used.

The Procedural Interface with ATC is the normal method to get approval to enter a controlled area. ATC may refuse to accept flights as they choose. The collaborative interface is not a means to avoid such approval.

4.2 Procedures

4.2.1 U-space usage model - summary

This section is an abridged version the usage model of a UTM system, presented in more detail in annex.

In the context of UTM ConOps it is important to understand, how a UTM system could be used. To elaborate on this, we introduce a model of a typical drone operation sequence, referring in the workflow to Roles, Environment and Services identified elsewhere in the ConOps. It is assumed that the U-space services are delivered via the internet to computers or mobile devices. The model considers three phases or any drone operation;

- Pre flight
- In flight
- Post flight

The model considers that during flight conditions can be nominal or anomalous. An anomalous flight results in a different post-flight workflow.

The basic starting conditions are set up in the “strategic” part of pre-flight. These steps include:

- Procuring a drone
- Registration of the drone if required – see 4.1.1.1 and 4.1.1.2
- Registration of the drone operator – see 4.1.1.1 and 4.1.1.2
- any Pilot training
- Registration of any pilot training – see 4.1.1.1 and 4.1.1.2
- Procuring relevant insurance if not per-flight
- Signing up with a U-space service provider

Once a decision has been made to fly, the “tactical” part of pre-flight starts to prepare a specific mission. This includes:

- Becoming familiar with the location where the mission will occur – see 4.1.2.2 and 4.1.2.3 as well as all Environment services – see 4.1.7
- (if appropriate) Selecting the appropriate drone and pilot to meet any airspace requirements – see 3.2.2.3
- (if appropriate) Deciding on the type of operation; open, specific, certified
- Planning the operation – see 4.1.3.1 and if appropriate 4.1.3.3 (validation mode) which includes
    - checking and planning appropriately for the airspace structure
    - checking whether any 'geo-fence crossing tokens' are required
- (if appropriate) Performing SORA – see 4.1.3.2
- (if appropriate) Submitting the Operation Plan – see 4.1.3.1 and 4.1.3.3, which results in:
    - Granting of any geo-fence tokens requested
    - Flagging any geo-fences that cannot be crossed
    - Strategic conflict resolution
    - (if appropriate) dynamic capacity management
    - Acceptance or refusal of the operational plan
- Downloading the plan into the drone and/or remote piloting station (as appropriate)

Once the pre-flight phase is done, the drone can be prepared for take-off. As explained in section 4.2.3, for flights that have an operation plan, there is a normal minimum time between submitting the operation plan and flying.

Flying has a normal routine and particular actions to be taken if the something goes wrong. The normal sequence of events would be:

- Prepare the flight area (if appropriate) including take-off and landing points
- Verify the conditions for flight are within the limits planned: Weather – see 4.1.7.1, Airspace (geo-fences) – see 4.1.2.2, Other air traffic – see 4.1.6.2
- Check the flight area for unexpected risks (such as the presence of people)
- Check the Operation plan (if any) is still OK – see 4.1.3.3
- If not done previously, download the plan into the drone and/or remote piloting station (as appropriate)
- Prepare the drone for flight, check it is airworthy and ready to operate, follow pre-flight checklist
- Prepare the payload
- Log on to U-space and configure the Emergency Management Service for the current operation – see 4.1.5.1
- Log on to the Position report submission sub-service send Start of Flight, enable position report submission (if used) – see 4.1.1.4
- Take-off
- Fly, during which continuously monitor
    - The Drone's flight
    - The Mission goal
    - Conformance with the plan
    - Other traffic – maintaining separation at all times
    - Ground risk (people in particular)
    - Warnings from the Emergency Management Service 4.1.5.1
    - Traffic information 4.1.6.2 if available
    - Tactical conflict resolution 4.1.4.2 if available

  - Collaborative interface with ATC 4.1.8.2 if available
  - Comms and Navigation infrastructure failure warnings if available – see 4.1.6.5 and 4.1.6.6

- Land
- Switch off position report submission, Send End-of-flight (as appropriate) – see 4.1.1.4
- Go through end-of-flight checklist, e.g. power-off…
- Log-off U-space

If the flight should experience any irregularities an ad-hoc analysis made. The corrective action or mission modification to be taken immediately should be decided upon and taken. The pilot should make use of the Emergency management service as appropriate – see 4.1.5.1

Normal post flight workflow makes little use of U-space services. Typical steps include:

- Fill in a log or flight report as the operator's processes require
- Check the mission has been successful
- Check the drone
- Either prepare for another flight or Pack up

A flight which has experienced some sort of problem may lead to the use of the Accident and incident reporting service, 4.1.5.2. Any such irregularities should be fully analysed and reported as part of the process for ensuring that they do not re-occur. Any remedial action necessary should be planned and undertaken before similar flights proceed.

A much more exhaustive exploration of the usage model can be found in annex.

4.2.2 Virtue, virtuous behaviour, rewards for virtue

U-space gives priority to emergency services and similar operations.

U-space occasionally needs to make choices between seemingly equal priority flights that disadvantage one or some and advantage others. This typically happens during Dynamic Capacity Management 4.1.3.5 and Strategic Conflict Resolution 4.1.4.1. In these cases, U-space compares the relative Virtue of the operators of the flights.

Virtue points are awarded for behaviour that increases the efficiency of the overall traffic in U-space. Virtuous behaviour includes:

- Submitting operation plans in good time
- Submitting operation plans that do not consume excessive amounts of airspace; that is by describing the 4D trajectory reasonably precisely
- Updating an operation plan to reduce uncertainty
- Following any operation plan within the uncertainties given in the plan
- Accepting changes to submitted operation plans due to conflict resolution or capacity management
- Accurate and timely position report submission

Virtue points have a lifespan after which they expire. When two operators are compared, the number of operations each flies is used to balance the weight their respective points, to avoid that operators with big fleets always score higher.

Rewards for virtue include being allowed to fly as planned while the other flight has to take account of the limited capacity or need to change the plan to avoid a conflict.

Management of Virtue points should be secure, reliable and trusted. The scheme should be overseen by a trusted body among drone operators, perhaps a trade association of drone operators. Rule changes should have broad support before being adopted. The scheme can only work if considered as fair.

4.2.3 Reasonable time to act

For any drone operation, there is a time period far enough before flight that a disturbance to the operation has minor repercussions. After that time the effect of change becomes harder to accept. (It could be argued that the time depends on the nature and size of the disturbance as well as the type of flight – but this process needs to be simple.)

This time is known as the “reasonable time to act” (RTTA) and is taken to be **five minutes before take-off**. Five minutes is clearly an arbitrary choice and should be revised when operational experience indicates a more appropriate value.

RTTA impacts how the flight is treated in processes like strategic conflict resolution and dynamic capacity management. Both of these processes need to act as close as reasonably possible to the take-off time of the flight in order to work with the most precise picture of the traffic, and to avoid an implicit prioritisation of operations in the order in which they are planned, which is disadvantageous to operations which cannot be planned long in advance.

If an operation plan has been submitted before RTTA, from RTTA until take-off that flight will be protected from any further change in all but the most extreme situations.

If an operation plan is submitted later than RTTA then that flight will be processed at a disadvantage in strategic conflict resolution and dynamic capacity management. (It is as if it has low Virtue – see 4.2.2)

4.3 Contingency

In this chapter some proposed Contingency Plans for drones and U-Space Services are presented. To understand when a Contingency Plan comes into force, it is important to clearly differentiate between a Mitigation, Contingency or Emergency. The (non-exhaustive) definitions below explain when they come into force. *Note: A full definition of these three terms is presented in annex*

4.3.1 Mitigation:

Mitigation is a precautionary measure to avoid that an unwanted threat/event is happening.

Example: Redundant radio link. In case the primary radio link fails, the secondary radio link engages and mitigates a failure of the whole radio system.

4.3.2 Contingency plan:

U-space service: A contingency plan of a U-space service enters into force if misbehaviour of the service is detected or the plausibility check of the service detects input data from external sources that are missing, wrong or arrive with high latencies. It is a precondition that the service itself be stable, be under control and be able to detect those occasions.

Example: Monitoring service detects erroneous data from tracking service, so it gives a warning to affected drone users/operators.

Drone user/operator: A contingency plan for a drone user/operator is a backup plan (Plan B) for the pilot, describing procedures to follow in a possible incident. It aims to maintain the level of operation.

Example: The navigation GPS system fails, but the drone is still controllable, so the pilot switches to manual/stabilised flight mode.

4.3.3 Emergency:

U-space service: An emergency of a U-space service enters into force if the service is out of control or lost completely.

Drone user/operator: An emergency for a drone user/operator is an incident/accident which causes the drone to be out of control.

Example: The navigation GPS system fails which causes the drone to be out of control, so the pilot deploys the parachute.

4.3.4 Contingency plans for drones

Some examples are given here. More appear in Annex

CP1: If the drone experiences a loss of datalink, position emitter/receiver failure, directional loss, or flies through an area of electromagnetic interferences, it must either return to home/launch or land at a dedicated landing area, automatically.

CP2: If a drone experiences a flight controller failure, unintentionally loses altitude, flies through severe weather, collides with an obstacle or other air traffic, or is totally lost, it must activate the emergency landing protocol immediately. Emergency equipment (e.g. parachute, lights to be seen at night, and a signal to be heard on ground) must be activated. Furthermore, either the pilot or the drone must immediately send an emergency signal via the emergency management service - 4.1.5.1.

CP3: In the case of a critical human error or medical issue with the remote pilot, a backup pilot must take over the flight immediately, if available. If no control input is received by the drone for longer than a determined time period, CP1 must be activated.

4.3.5 Contingency plans for U-space services

Service	Contingency Plan
E-Registration:	None
E-Identification:	None
Pre-tactical Geofencing:	If the service detects that received data is faulty, it has to correct the missing data and send a message to the affected users/operators.

Service	Contingency Plan
Tracking:	If the service detects that data from drone(s) is missing or faulty, it has to send a message to the affected users/operators. In U3 a dynamic geofence must be put around the predicted position (triggers Emergency Management notification).
	If a received track cannot be correlated to a flight plan, the service has to send a message to the drone user/operator. If necessary it can command the pilot/drone either to hold position/circle until correlated/situation awareness is restored or land at dedicated landing area.
Drone AIM:	If the service detects that received data is faulty, it has to correct the missing data and send a message to the affected users/operators.
Tactical Geofencing:	If a drone flies through prohibited area, because the upload of the geo-fence was unsuccessful/delayed, the service has to send a message to the drone user/operator and, if necessary, warn other drones/aircraft in the affected geo-fence.
Drone operation plan processing:	None
Strategic Conflict Resolution:	None
Emergency Management:	In case of an emergency, the service has no working datalink to a drone operator; the drone user/operator must be contacted by phone. (This demands a requirement for all drone users/operators to be on call)
	In case of an emergency, a drone user/operator has no working datalink to the emergency management service; the drone user/operator has to contact the service provider via hotline/emergency phone.
Monitoring:	If the service is not fully operative due incoming faulty data or high latencies, it has to give a warning to all affected drone users/operators. If necessary, a different (higher) separation between drones can be demanded from the dynamic capacity management and/or tactical deconfliction service.
Traffic Information:	*Same as Monitoring*
Weather Information:	If the service limited due to insufficient data or other reasons, it has to give a warning to all affected drones and drone users/operators. Furthermore it has to provide the calculated forecast.
Procedural Interface with ATS:	If the datalink between the U-Space System and ATS fails, the permission of a take-off can be denied if the drone is not airborne yet. (If the drone is already airborne it is not a contingency but an emergency and therefore out of scope of the Contingency Plans)
Dynamic Geofencing:	*Same as Tactical Geofencing*
Collaborative Interface with ATS:	*Same as Procedural Interface with ATS*
Tactical Deconfliction:	None *Note: If the service fails to detect or solve a conflict, it is backed-up by DAA (Detect and Avoid) in U3, Monitoring Service and Traffic Information*

Service	Contingency Plan
Dynamic Capacity Management:	If the capacity of a certain area in airspace has exceeded the defined limit, the service has to warn the affected drones and drone users/operators. Furthermore it can deny requested access to the particular area of airspace for other drones until density is under threshold. If access is denied, this service shall report to the Tactical Deconfliction Service to reroute affected drones.

Table 14 Contingency plans for U-space services

4.4 Accident and Incident Investigation

4.4.1 Additional events to be reported

The following are the proposed modifications to the existing EU 2015/1018 implementing regulation concerning the occurrences that must be reported. It is an addition to what is already written and is subdivided per different Annexes sections:

Annex I: AIR OPERATIONS

- 1.1 Flight Preparation
  - incorrect data inputs in the drone navigation software (4D trajectory, geo-awareness update)
- 1.2 Aircraft preparation:
  - Drone improperly assembled (including software)
- 1.3 Take-off and landing:
  - Non-respect of safety distance from obstacle, or persons, during take-off or landing
- 1.4 Any phase of flight:
  - Lack of activation of the flight envelope protection, including stall warning, stick shaker, stick pusher, automatic protections and geo-awareness manoeuvres.
  - Misinterpretation of automation mode or of any flight deck information provided to the remote pilot, which has or could have endangered the aircraft, its occupants or any other person.
  - Unintentional deviation from intended or assigned track
- 1.5. Other types of occurrences:
  - loss of communication with the observer in case of extended visual line of sight (E-VLOS) operation.
  - loss of visual contact in case of visual line of sight (VLOS) operation.
  - Drone flying in airspace type not corresponding to his assigned category (X, Y, Z)
- 3. INTERACTION WITH U-SPACE SERVICES AND U-SPACE TRAFFIC MANAGEMENT (UTM)
  - Unsafe clearance.
  - Prolonged loss of communication with UTM Unit.
  - Conflicting instructions from different UTM Units potentially leading to a loss of separation.

- Intentional deviation from UTM services instruction which has or could have endangered the RPAS, its occupants (if any) or any other RPAS or Aircraft

- 4. EMERGENCIES AND OTHER CRITICAL SITUATIONS
  - Failure to apply the correct non-normal or emergency procedure by *the remote pilot* to deal with an emergency
  - Remote pilot fatigue impacting, or potentially impacting, the ability to perform safely their flight duties.

- 6. SECURITY
  - Difficulty in controlling, intoxicated, violent or unruly payload[8] *endanger the flight*
  - Discovery of a stowaway
  - Hack of the communication C2 channel

Annex II: OCCURRENCES RELATED TO TECHNICAL CONDITIONS, MAINTENANCE AND REPAIR OF THE AIRCRAFT

- 2. DESIGN
  - Any failure, malfunction, defect or other occurrence related to a product, part, or appliance which has resulted in or may result in an unsafe condition.

- 3. MAINTENANCE AND CONTINUING AIRWORTHINESS MANAGEMENT
  - Wrong assessment of a serious defect, or serious non-compliance with MEL (Minimum Equipment List) and Technical logbook procedures.
  - Significant malfunction, reliability issue, or recurrent recording quality issue affecting a flight recorder system (such as a flight data recorder system, a data link recording system or a cockpit voice recorder system) or lack of information needed to ensure the serviceability of a flight recorder system.

Annex III: OCCURRENCES RELATED TO AIR NAVIGATION SERVICES AND FACILITIES

- 1. AIRCRAFT-RELATED OCCURRENCES
  - Detect and avoid Resolution Advisory
  - Aircraft deviation from applicable air traffic management (ATM) or U-space regulation:
    - aircraft deviation from applicable published ATM or U-space procedures;
    - airspace infringement including unauthorised penetration of airspace;
    - deviation from aircraft ATM or U-space-related equipment carriage and operations, as mandated by applicable regulations.

- 2. DEGRADATION OR TOTAL LOSS OF SERVICES OR FUNCTIONS
  - Inability to provide ATM *or U-space* services or to execute ATM *or U-space* functions:
  - Failure of ATM *or U-space* system security which had or could have a direct negative impact on the safe provision of service.
  - Prolonged loss of communication with *a remote pilot* or with other ATS unit.

[8] Payload maybe constituted by passenger on taxi service

Annex IV : OCCURRENCES RELATED TO AERODROMES AND GROUND SERVICES
- 1.SAFETY MANAGEMENT OF AN AERODROME
  - 1.1. Aircraft and obstacle-related occurrences
    - Foreign object on the aerodrome maneuvering area which has or could have endangered the aircraft, its occupants or any other person

4.4.2 Proposed changes for reporting to responsibilities

Concerning the witnesses of occurrence the following recommendations are identified:
- Verifying training needs about reporting practices for witness (who is obliged to report occurrences). Are all witnesses aware of how to do that?
- Maintaining the level of safety culture from manned aviation to RPAS users and operators, so that to build awareness on the importance of an efficient reporting system.
- Availability of a user-friendly tool to ease the process of events reporting

4.4.3 Proposed changes for practices and reporting repository

The overall objective of aviation safety improvement cannot be sufficiently achieved by the Member States, because reporting systems operating in isolation are less efficient than a coordinated network, where exchange of information and identification of possible safety problems with associated key risk areas take place. Therefore, it is highly recommended that analysis at national level should be complemented by analysis and follow-up at Union level, to ensure better prevention of aviation accidents and incidents.

Furthermore current EU Regulation 996/2010 invites single states in doing investigations networking through the setting up of -ENCASIA (European Network of Civil Aviation Safety Investigation Authorities) and through invitation of EASA and its representatives to national investigations. It is recommended that further inputs to users will be provided by clarifying the role and associated responsibilities of a trans-national investigation authority, which would have the possibility to build the European wide picture.

On the other side, no changes are expected in terms of central repository to be used (i.e. ECCAIRS), as well as for timing of the expected notification to the competent authorities and timing for investigations. However, adaptation of current taxonomy to take RPAS operations into account should be performed. Particularly, a gap analysis on what is existing today and what is missing should be performed by EASA, which has a dedicated sub-group working on taxonomy updates for the relevant regulations (Safety Recommendations Taxonomy working group) The outcome of this analysis will identify the terms missing and may trigger connected updates.

Finally, experience has shown that accidents are often preceded by safety-related incidents and deficiencies revealing the existence of safety hazards. Safety information is therefore an important resource for the detection of potential safety hazards. In addition, whilst the ability to learn from an accident is crucial, purely reactive systems have been found to be of limited use in continuing to bring forward improvements. Therefore, reactive systems should be complemented by proactive systems.

4.5 Best practices

The emergence of remoted pilot aircraft systems (RPAs) as a resource for a wide variety of public and private applications quite possibly represents one of the most significant advancements to aviation, the scientific community, and public service since the beginning of flight. Rapid advancements in the technology have presented unique challenges and opportunities to the growing RPAs industry and to those who support it. The future of RPAs will be linked to the responsible and safe use of these systems. Our industry has an obligation to conduct our operations in a safe manner that minimises risk and instils confidence in our systems.

The CORUS initiative offers recommendations to advance flight and ground safety, airmanship, and professionalism. It presents a set of recommended practices—a vision of excellence—to help RPAs pilots interpret and apply standards and regulations, and to confront the real-world challenges to avoid mishaps. It is designed to help RPAs stakeholders to develop standard operating procedures, effective risk management, safety management systems, and to encourage the industry to consider themselves aviators and participants in the broader aviation community.

The code and practices are built on three specific themes: Flight and ground safety, professionalism, privacy and respect. Each theme and its associated recommendations represent a “common sense” approach to RPAs operations and address many of the concerns expressed by the public and regulators. This code is meant to provide RPAs industry manufacturers and users a convenient checklist for operations and a means to demonstrate their obligation to supporting the growth of our industry in a safe and responsible manner.

A much more detailed study of best practice can be found in Annex.

4.6 Uncooperative Drones

U-Space and UTM-systems fundamentally deal with cooperative UAS, which are UAS that emit identification of some kind, 3D position, timestamp and property data to remote receivers and systems which create a dynamic overall air situation picture for the further processing and service provision of U-Space functions. However, there will also be uncooperative UAS, rogue UAS, hostile UAS, or “lost” UAS, which might expose a threat to critical infrastructure like airports, test sites, or gatherings of people for sports etc. Drone Detection Systems (DDS) are an upcoming technology that is dedicated to identify uncooperative UAS at a range of 500m to 5000m today. Their scope is local, different from UTM where the scope is at least regional, if not national. UTM systems cannot embody DDS functionalities due to cost and complexity, but it is useful to consider system collaboration.

DDS typically consist of

- Surveillance sensors
- Multi-sensor data fusion servers
- Database servers
- Map-based situation displays

Some variants also include C² (Command and Control) servers that allocate effectors or weapons to detected objects, plus the effectors for drone intercept. Such effectors today are: Jammers, HPEM (High Power Electro-Magnetic) emitters, nets, anti-drone drones, water guns, or – in military context – missiles and cannons. The use of effectors may be a critical issue in airport contexts. The surveillance sensors of DDS have to detect comparatively small objects down to half a meter in diameter, therefore the range of detectability is limited. Usual sensor settings are combinations of

- Phased-array/holographic type of primary radar
- Multi-static primary radar for passive coherent location
- Electro-optical/infrared sensors and cameras
- Acoustic arrays
- HF, VHF, UHF, SHF scanners

- laser sensors and scanners (e.g. LIDAR)

Due to surveillance range, complexity and cost, DDS are local systems, based on client-server architectures with local area networks. Cost grows proportional to detection range. Some variants using cloud technologies and web-based clients also exist, but have to take additional measures for cyber-security and vulnerability resilience. Because of its multi-sensor nature, effective multi-sensor fusion and tracking is an utmost requirement in DDS. The result are primary tracks of detected drones with associated properties gathered by the various sensors. Besides track number, 4D position, speed, and heading this might include UAS type/brand, subtype, power type, number of rotors, shape, size, link version, the involved RPS type. If DDS communicates this track information to UTM, the UTM track fusion may determine whether there is a kinematic fit with existing tracks of cooperative UAS, and report this information back to the DDS. The remaining tracks are then to be considered as uncooperative, and eventually hostile. At the end of this system communication both systems – the DDS and the UTM – agree which uncooperative UAS and which cooperative UAS are in the given range of surveillance. While the DDS remains local in scope, the cloud-based trans-regional or even national UTM system may have several attached DDS-systems, and may serve this way as a trans-regional information exchange platform for classification purposes. However, there will always be a limitation in completeness of the surveillance of uncooperative UAS, the full coverage of a whole country with DDS capacity will be too costly.

It might be expected that DDS will be installed at major airports to protect airport operations against uncooperative UAS as seen in the Gatwick case of December 2018. A national UTM might collaborate with the related DDS for drone information exchange and intelligence data collection for police forces. Other hotspots of critical infrastructure may be added stepwise, and thus contribute to better surveillance and intelligence. Defence against rogue drones everywhere, however, must be considered as unrealistic for the current state of technology.

As the Gatwick case has shown for the attacked airports it is very relevant

- to detect such threats as early and as reliably as possible with the help of such DDS
- to have an existing communication infrastructure between the necessary stakeholders
- to have defined workflows and procedures between the necessary stakeholders
- to have an established and proven decision structure for situation assessment and planning of measures
- to have a legal basis for taking action

Once such collaboration between UTM and DDS is emerging, it might be useful to extend the ConOps aspects of UTM for these issues, covering

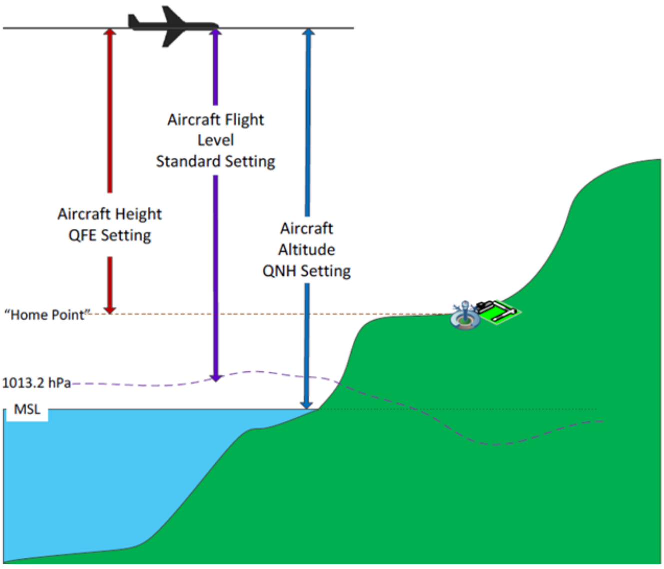
- Operational workflows between UTM and DDS users, including
    - data flow (information, warning, alerts)
    - data contents (track, features, imagery, acoustic patterns, context)
    - intelligence collection
- Workflows between operational users, authorities, and law enforcement
    - Situation assessment
    - Monitoring
    - Reporting
    - Alarming
    - Countermeasures
    - Return to normal operations
    - Postprocessing (lesson learning)

5 Integration of drones and manned aviation

The ConOps describes U1, U2 and U3 in which U-space accommodates drones in the airspace. Full integration of drones with manned aviation is foreseen in U4. There are those that would like that the problems are all solved "at the drone end" but for practical reasons this may be impossible.

Key among the subjects that need to be addressed are:

- Shared use of a single height frame of reference and measurement unit. Manned aviation typically use one of several schemes based on air pressure (see figure) while small drones often use satellite navigation for height as well as lateral position. (Small rotorcraft drones may be incapable of measuring air pressure accurately.) Further, small drones in VLL typically need to know their height relative to the ground directly below while manned aviation is usually concerned with other references (QFE, QNH, …)



- Shared use of a single navigation frame of reference. Manned aviation makes use of magnetic north. Small drone navigation is frequently based satellite navigation and often refers to true north.
- Electronic conspicuousness. It is likely that drones in VLL quickly standardise means to detect each other collaboratively. The safest approach would be for manned aviation to adopt a compatible system. Such adoption may need to be mandated, especially if there is an expectation that drones should be able to get out of the way of manned flights. Further safety would come from air-crew being capable and trained to use the information coming from detection of other air traffic by electronic means.
- Part of the job of ATS will need to change if U-space tools support the ATM-UTM boundary, particularly if UTM is supplying a communication channel from ATS to either a remote pilot or an automatic drone.
- Training. The range of sizes and speeds of small drones are outside what may be familiar to current ATS and air-crew. The existing experience of current aviators and controllers may not be the best basis for making safety critical decisions as small drones come into use.

6 Terms and acronyms, References

6.1 Terms and acronyms

Come back later and build the index by marking each term using the References menu: Mark Entry. Index entries should also be made in the document where the terms are explained.

Term or Acronym	Meaning / Expansion	Remarks
Aircraft	Any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface.	Definition from ICAO. Aircraft either manned or unmanned. Size is irrelevant.
Air-crew	The on-board pilot(s) of a manned aircraft	As opposed to remote-pilot for a drone
AF	Automatic Flight	Local defnition – see section 2.5.3.2
AFN	Automatic Flight with No connection to U-space	Local defnition – see section 2.5.3.2.1
AFU	Automatic Flight with connection to U-space	Local definiton – see 2.5.3.2.2
AMC	Acceptable Means of Compliance	See [5]
ASM	AirSpace Management	
ATFCM	Air Traffic Flow and Capacity Management	
ATM	Air Traffic Management	ATM consists of Air Traffic Services (ATS), Airspace Management (ASM), and Air Traffic Flow and Capacity Management (ATFCM).
ATS	Air Traffic Service(s)	
BVLOS	Beyond Visual Line of Sight *Defined in the draft Implementing regulation [1]*	A manner of operating a drone; contrasts with VLOS and EVLOS. In BVLOS the drone flies out of sight of the remote pilot or any assistant.
CA	Collision avoidance	Defined in ICAO doc 9854 [54].
C2	Command and Control	Usually C2 refers to the communication link from a remote piloting station to a drone. The link may be bi-directional in which case the information coming from the drone is often referred to as Telemetry
DAA	Detect and Avoid.	Defined in ICAO Annex 2 [13] - See section 3.4.3 Cooperative implementations involve potential targets emitting special signals to facilitate detection.
DDS	Drone Detection System	Generally refers to a system to detect a non-cooperative drone.
DTM	Drone Traffic Management	Variant of UTM
Drone	A type of aircraft that is not being piloted from on board by a human.	Contrasts with manned aircraft

Term or Acronym	Meaning / Expansion	Remarks
EASA	European Aviation Safety Agency	https://www.easa.europa.eu/
EATMA	European ATM Architecture	… ATM being Air Traffic Management
EC	European Comission	https://ec.europa.eu/commission/index_en
ECAC	European Civil Aviation Conference	https://www.ecac-ceac.org/
EDZ	Exclusive Drone Zone	See UAS/ATM integration Operational Concept [12] section 3.3.1
EGNOS	European Geostationary Navigation Overlay Service	A satellite based augmentation system for satellite navigation providing a service for Europe, augmenting Galileo, GLONASS and GPS
EU	European Union	https://europa.eu/european-union/index_en
EVLOS	Extended Visual Line of Sight *Defined in the draft Implementing regulation [1]*	A manner of operating a drone; contrasts with VLOS and BVLOS. In EVLOS, the drone remains in the sight of the remote pilot or an assistant at all times.
Galileo	A European GNSS	
GLONASS	A Russian GNSS	
GNSS	Global Navigation Satellite System	General term for satellite navigation.
GPS	'Global Positioning System' A GNSS operated by the USA.	The term GPS is sometimes used to mean satellite navigation in general.
HEMS	Helicopter Emergency Medical Service	HEMS flights often penetrate VLL.
HF	High Frequency	ITU: Refers to a specific radio frequency band from 3MHz to 30 MHz. See also VHF, UHF, SHF
HPEM	High Power Electro-Magnetic	
IFPS	Integrated Initial Flight Plan Processing System	Europe's flight planning system for manned aircraft.
ITU	International Telecommunication Union	
LDZ	Limited Drone Zone	See UAS/ATM integration Operational Concept [12]
LFR	Flight rules for low level	see UAS/ATM integration Operational Concept [12]
LIDAR	"Light Detection and Ranging"	Laser equivalent of RADAR
LoS	Loss of Separation	See section 3.4
LUC	Light UAS operator's Certifiate	See the draft Implementing regulation [1] and annex [2]
MAC	Mid Air Collision	
Manned	Of an aircraft; being controlled by an on-board pilot	Note that a drone carrying a passenger is not manned in the sense meant here.
NAF	NATO Architecture Framework	
NDZ	No Drone Zone	See UAS/ATM integration Operational Concept [12]
RNP	Required Navigation Performance	See ref [43]
RP	Remote Pilot	
RPS	Remote Piloting Station	
RSF	Remotely Supervised Flight	See section 2.5.3.3
RTTA	Reasonable Time To Act	See section 4.2.3

Term or Acronym	Meaning / Expansion	Remarks
RUNP	Required U-space Navigational Performance	See section 3.4.2
RwC	Remain well Clear	
SHF	Super High Frequency	ITU: Refers to a specific radio frequency band from 3GHz to 30 GHz. See also HF, VHF, UHF
Traffic	The collective term for flights.	Current Traffic is airborne Predicted Traffic is derived from plans Forecast Traffic is estimated
U1, U2, U3, U4	U-space levels	See the Blueprint [9] and Roadmap [10] documents
UA	Unmanned Aircraft	
UAS	Unmanned Air System, Unmanned Aircraft System	UAS includes the UA and everything else needed to make it work.
UAV	Unmanned Ar Vehicle	Equivalent to UA.
UHF	Ultra High Frequency	ITU: Refers to a specific radio frequency band from 300 MHz to 3 GHz. See also HF, VHF, SHF
UTM	UAS Traffic Management Or Unified Traffic Management	UAS Traffic Management by analogy with Air Traffic Management. (see also DTM) “Unified” from the aim to have one system combinging both UAS and [manned] air traffic management.
U-Space	Europe’s drone traffic management system	See https://www.sesarju.eu/U-space -> “WHAT”
VHF	Very High Frequency	ITU: Refers to a specific radio frequency band from 30 MHz to 300 MHz. See also HF, UHF, SHF
VHL	High level	An airspace above that normally used by manned operations. See UAS/ATM integration Operational Concept [12]
VLL	Very Low Level airspace	Very Low Level (VLL) refers to the portion of airspace below that normally used by VFR. See sections 2.5.1 and 3.2
VLOS	Visual Line of Sight *Defined in the draft Implementing regulation [1]*	A manner of operating a drone; contrasts with EVLOS and BVLOS. In VLOS, the drone remains in the sight of the remote pilot at all times.
Za	Z volume controlled by ATS	See Z Volumes, 3.2.1.3
Zu	Z volume in which Tactical Collision Resolution is provided by U-space	See Z Volumes, 3.2.1.3

Table 15 Terms and Acronyms

6.2 References

[1] Draft implementing regulation on the rules and procedures for the operation of unmanned aircraft - Ares(2018)5119803 https://ec.europa.eu/info/law/better-regulation/initiative/1642/publication/308263/attachment/090166e5be2da4d0_en

[2] Annex to the Draft implementing regulation on the rules and procedures for the operation of unmanned aircraft - Ares(2018)5119803/1 https://ec.europa.eu/info/law/better-regulation/initiative/1642/publication/308263/attachment/090166e5be2da4cf_en

[3] Draft delegated regulation on unmanned aircraft intended for use in the 'open' category, and on third-country operators of unmanned aircraft systems - Ares(2018)5119839 https://ec.europa.eu/info/law/better-regulation/initiative/1642/publication/308287/attachment/090166e5be2d9db5_en

[4] Annex to the Draft implementing regulation on unmanned aircraft intended for use in the 'open' category, and on third-country operators of unmanned aircraft systems - Ares(2018)5119839/1 https://ec.europa.eu/info/law/better-regulation/initiative/1642/publication/308287/attachment/090166e5be2da054_en

[5] Draft Acceptable Means of Compliance (AMC) and guidance material (GM) to Regulation …/… [IR] laying down rules and procedures for the operation of unmanned aircraft and to the Annex (Part-UAS — UAS operations in the 'open' and 'specific' categories)https://www.easa.europa.eu/sites/default/files/dfu/Draft%20AMC%20%20GM%20to%20draft%20Regulation%20...-...%20and%20to%20the%20draft%20Annex%20%28Part-U....pdf

[6] Roadmap for detailed rules on unmanned aircraft, Ares(2018)1460265, https://ec.europa.eu/info/law/better-regulation/initiative/1642/publication/194527/attachment/090166e5b94b4804_en

[7] JARUS guidelines on Specific Operations Risk Assessment (SORA) http://jarus-rpas.org/sites/jarus-rpas.org/files/jar_doc_06_jarus_sora_v1.0.pdf - see also http://jarus-rpas.org/content/jar-doc-06-sora-package which gives access to the annexes (when available) *Update expected March 2019. Revise this reference accordingly!*

[8] SESAR ER RPAS Call Technical Specification for H2020-SESAR-2016-1 http://ec.europa.eu/research/participants/data/ref/h2020/other/call_fiches/jtis/h2020-call-doc-er-sesar-ju-2016_en.pdf

[9] SESAR Joint Undertaking: U-space Blueprint https://www.sesarju.eu/sites/default/files/documents/reports/U-space%20Blueprint%20brochure%20final.PDF

[10] SESAR Joint Undertaking: Roadmap for the safe integration of drones into all classes of airspace. 1st March 2018 https://www.sesarju.eu/sites/default/files/documents/reports/European%20ATM%20Master%20Plan%20Drone%20roadmap.pdf?

[11] SESAR Joint Undertaking: European Drones Outlook Study https://www.sesarju.eu/sites/default/files/documents/reports/European_Drones_Outlook_Study_2016.pdf

[12] EUROCONTROL & EASA: Unmanned Aircraft Systems (UAS) ATM Integration Operational Concept, https://www.eurocontrol.int/publications/unmanned-aircraft-systems-uas-atm-integration-operational-concept

[13] ICAO: Annex 2 to the convention on Civil Aviation, Rules of the Air, available from http://www.icao.int

[14] ICAO: Annex 11 to the convention on Civil Aviation, Air Traffic Control Service, Flight Information Service, Alerting Service, available from http://www.icao.int

[15] EU / EASA: Regulation (EC) No 923/2012 of the European Parliament and of the Council of 26 September 2012 laying down common rules of the air… Including amendment by Regulation (EC) No 1185/2016 of 20 July 2016. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02012R0923-20171012

Also available at https://www.easa.europa.eu/sites/default/files/dfu/Easy%20Access%20Rules%20for%20Standardised%20European%20Rules%20of%20the%20Air%20%28SERA%29.pdf

[16] ICAO: Manual on remotely piloted aircraft systems (RPAS) – ICAO doc 10019, available from http://www.icao.int

[17] ICAO: Procedures For Air Navigation Services, Air Traffic Management, ICAO doc 4444, available from http://www.icao.int

[18] EUROCONTROL & EASA: UAS ATM Flight Rules https://www.eurocontrol.int/publications/uas-atm-flight-rules

[19] EUROCONTROL & EASA: UAS ATM Airspace Assessment https://www.eurocontrol.int/publications/uas-atm-airspace-assessment

[20] EUROCONTROL & EASA: UAS ATM Common Altitude Reference System https://www.eurocontrol.int/publications/uas-atm-common-altitude-reference-system

[21] Airbus (Altiscope): Blueprint for the Sky, The roadmap for the safe integration of autonomous aircraft, 5/9/18. https://www.utmblueprint.com

[22] Altiscope (Airbus): Technical Report Library, currently available at https://medium.com/altiscope/altiscope-library-b6f35007b34e

[23] Altiscope (Airbus): Technical Report 004: Metrics to Characterize Dense Airspace Traffic http://bit.ly/altiscopetr004

[24] Altiscope (Airbus): Technical Report 008 A Quantitative Framework for UAV Risk Assessment: Version 1.0 http://bit.ly/altiscopetr008

[25] FAA / NASA: Unmanned Aircraft Systems (UAS) Traffic Management (UTM) Concept of Operations, Version 1, 18/5/18. https://utm.arc.nasa.gov/docs/2018-UTM-ConOps-v1.0.pdf

[26] EASA: Concept of Operations for Drones https://www.easa.europa.eu/sites/default/files/dfu/204696_EASA_concept_drone_brochure_web.pdf

[27] Swiss Federal Office of Civil Aviation: Swiss U-Space ConOps, 31/10/18 (received by CORUS, not generally available)

[28] EATMA, the European Air Traffic Management Enterprise Architecture is not described online but its current contents are presented as part of the EUROPEAN ATM Master Plan. https://www.atmmasterplan.eu/

[29] The EUROCONTROL ATM Lexicon https://ext.eurocontrol.int/lexicon/index.php/Main_Page

[30] EATMA Guidance material, version 9. https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5b2deab5c&appId=PPGMS (ignore web page – the correct file is downloaded)

[31] [NTIA 2016] The US National Telecommunications and Information Administration "Voluntary Best Practices for UAS Privacy, Transparency, and Accountability" Convened

Multistakeholder Process. May 2016. Available at https://www.ntia.doc.gov/files/ntia/publications/ uas_privacy_best_practices_6-21-16.pdf

[32] [AEDRON 2016] Asociacion Española de drones y afines. “Codigo etico de conducta de profesionales de RPAS, tanto pilotos, como empresas operadoras”. Jun 2016. Available at https://www.aedron.com/codigo-etico/

[33] [Guidelines 2012] International Association of Chiefs of Police Aviation Committee. Recommended Guidelines for the use of Unmanned Aircraft, August 2012.

[34] [Guidelines 2015] Best Practices for Protecting Privacy, Civil Rights & Civil Liberties in Unmanned Aircraft Systems Programs. U.S. Department of Homeland Security, Dec 2015.

[35] [Drones 2014], Rachel L. Finn et al. “Study on privacy, data protection and ethical risks in civil Remotely Piloted Aircraft Systems operations. Summary for industry”, European Commission Nov 2014.

[36] [Grids 2014] Workshop "The Future of Social Acceptance". Available at http://renewablesgrid.eu/activities/events/detail/news/first-bestgrid-workshop-the-futureof-social-acceptance.html

[37] [HEMAV 2018] HEMAV SL. “Configuración de Plataformas (P-05-4.1-05)”. 2017

[38] [JARUS 2016] JARUS, “CS-LUAS Recommendations for Certification Specification for Light Unmanned Aeroplane Systems”. 2016 http://jarus-rpas.org/sites/jarus-rpas.org/files/jar_05_doc_cs-luas_v0_3.pdf

[39] [DR1 2018] Dronerules, “Recommendations for a pilot performing a professional mission” 2018.

[40] [DR3 2018] Dronerules, “Recommendations for recreational pilots” 2018

[41] [TP 2016] Department of Transport of Canada, “Flying for fun? Rules for recreational drones users”. 2016.

[42] [GNL 2017] The Google News Lab, “Drone Journalism Code of Ethics”. 2017

[43] ICAO Performance-Based Navigation Manual, ICAO doc 9613, https://www.icao.int/SAM/Documents/2009/SAMIG3/PBN%20Manual%20-%20Doc%209613%20Final%205%2010%2008%20with%20bookmarks1.pdf

[44] Regulation (EC) No 785/2004 of the European Parliament and of the Council of 21 April 2004 on insurance requirements for air carriers and aircraft operators https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32004R0785

[45] ICAO Global Air Traffic Management Operational Concept, Doc 9854, first edition, 2005. Available at https://www.icao.int/Meetings/anconf12/Document%20Archive/9854_cons_en%5B1%5D.pdf and https://store.icao.int/global-air-traffic-management-operational-concept-doc-9854-english-printed.html

[46] UAS ATM common altitude reference system (CARS) discussion document https://www.eurocontrol.int/publications/uas-atm-common-altitude-reference-system-cars-discussion-document

[47] ICAO Doc 9965 Manual on Flight and Flow — Information for a Collaborative Environment (FF-ICE) https://www.icao.int/Meetings/anconf12/Documents/9965_cons_en.pdf

[48] Office of Inspector General (United States Postal Service), 2016, “Public Perception of Drone Delivery in the United States”, RARC-WP-17-001 https://www.uspsoig.gov/sites/default/files/document-library-files/2016/RARC_WP-17-001.pdf

[49] Wikipedia definition of ConOps in English: https://en.wikipedia.org/wiki/Concept_of_operations

[50] The Global UTM Association UAS Traffic Management Architecture, https://www.gutma.org/docs/Global_UTM_Architecture_V1.pdf

[51] NASA UTM portal https://utm.arc.nasa.gov/documents.shtml

[52] JARUS publications http://jarus-rpas.org/publications

[53] EASA Notice of Proposed Amendment 2015-10 https://www.easa.europa.eu/sites/default/files/dfu/A-NPA%202015-10.pdf

[54] ICAO Global Air Traffic Management Operational Concept. ICAO doc 9854 https://www.icao.int/Meetings/anconf12/Document%20Archive/9854_cons_en%5B1%5D.pdf

[55] ICAO Performance-based Navigation (PBN) Manual, doc 9613 https://www.icao.int/SAM/Documents/2009/SAMIG3/PBN%20Manual%20-%20Doc%209613%20Final%205%2010%2008%20with%20bookmarks1.pdf

[56] ECA Position Paper on Specific Operations Risk Assessment (SORA), available at https://www.eurocockpit.be/sites/default/files/2019-01/SORA_ECA_Position_Paper_19_0128_F.pdf

Annexes to the CORUS Intermediate ConOps

A. Use-cases
B. Requirements
C. A SORA example
D. A short description of the MEDUSA process
E. A list of threats and events
F. Safety occurrence reporting
G. An example of a contingency plan
H. Social acceptance indicators
I. Best practice for Drone Operators
J. A snapshot of the current regulations in Europe
K. U-space architecture

EXPLORATORY RESEARCH

Intermediate ConOps

Annex A, Use Cases

D6.2	CO
CORUS	
Grant:	763551
Call:	2016 SESAR 2020 RPAS Exploratory Research Call (H2020 – SESAR -2016-1)
Topic:	Topic 01: SESAR UTM Concept Definition
Consortium coordinator:	EUROCONTROL
Edition date:	18 Mar 2019
Edition:	01.00.00

Founding Members

EUROPEAN UNION EUROCONTROL

SESAR JOINT UNDERTAKING

Table of Contents

1 About the use cases ... 3

2 Use cases ... 4

2.1 Mission 1: Photo activity ... 4

2.2 Mission 2: Farming activity ... 4

2.3 Mission 3: Building inspection ... 5

2.4 Mission 4: Vineyard fungicide spraying ... 6

2.5 Mission 5: Seed sowing ... 8

2.6 Mission 6: Police surveillance ... 8

2.7 Mission 7: Recreational activity ... 9

2.8 Mission 8: Runway inspection ... 10

2.9 Mission 9: ILS measurement ... 10

1 About the use cases

The use cases presented in this annex are an extract from the ongoing project work on the future deliverable D2.2 Final Operations and UTM Requirements, planned to be delivered in May 2019. They are meant to be indicative of the operations that will be routinely enabled by U-Space and the associated services. The example use cases are not extensively written to cover every possible use of U-Space, but rather attempt to show the different level of interactions between UAS and other airspace users.

The use cases attempt to cover the uses at different phases of U1, U2, U3 and U4 deployment of U-Space. In the first instance of U1 we cover the most basic operations of VLOS that are common today and start adding complexity to the situation. The aim is to show how the operations scale as we introduce concepts like EVLOS and BVLOS into flight activities that could be seen as standard or popular missions in the near-term. The first few uses are therefore limited to allow only require the U-Space service offerings seen in the initial phase deployed and are thus constrained by their geographical location.

The latter use cases describe the more complex interactions caused by mixing manned aviation with UAS. The aim is to show how services in U3 and U4 can be used to enable what is difficult or impossible in U1 and U2; although like all emerging technologies it is not possible to predict exactly which solutions will eventually solve which challenges.

Each use case has a brief description of the situation that has arisen. It also described the specification of the drone and the operation (i.e. weight and EASA operation classification). There is also a table that described the generalized parameters, such as flight class, operating areas, mission type, etc. Finally, there is a brief summary of the activities that would be undertaken during each use case.

2 Use cases

In this part, we are taking some of the use cases from the WP2 deliverable M.211. The goal is to “classify” the operations in a “volume” type and to explain with more details the use case.

2.1 Mission 1: Photo activity

One professional photographer is taking pictures of the countryside or wildlife. The conditions during the entire working time are visual line of sight.

- ✓ The drone is equipped with its own camera, nothing else is added.
- ✓ Weight of the drone is above 250g and below 900g, so class C1; the operation category is open, and the drone may fly over uninvolved people, so the subcategory is A1.
- ✓ We assume the pilot has followed an online training and passed the online test, as per European regulation.
- ✓ The pilot is limiting the height at 120m, owing to the selectable height limit of the drone, as per the European regulation.

Type of operation	General flight	Area	Mission	Payload
VLOS	Area and stationary(combined)	Non-populated	Commercial photo/video	Visual camera

The operation is taking place in the countryside, far from houses and people, to observe the wildlife.

This area is far from any airport or aerodrome, and usually far from aerial activity.

It has been classified as an area where the operator does not need neither to notify flight intents nor to submit a drone operation plan, from ground to 400 feet.

The pilot just follows the regular process of registrations (drone, pilot, operator) and pre-flight activity (e.g. aeronautical information, weather and drone check).

The pilot is responsible for the avoidance of collision, as much as they are responsible for avoiding to fly above people (e.g. hikers).

2.2 Mission 2: Farming activity

This example shows the case of a farmer observing his field with a drone; the field is big and the farmer cannot see the drone when it is at the opposite side of his position. Thus, he requires the help of another person, standing at the other side of the field, who will see the drone. They both communicate with cellular phone, keeping the contact during all the flight. This situation is called extended-visual line of sight (E-VLOS).

- ✓ The drone is equipped with a sensor detecting humidity and fungus.
- ✓ Weight of the drone is more than 900g but less than 4kg, so class C2; the operation is in the specific category (E-VLOS). The operator found a standard scenario to refer to.
- ✓ The pilot created a geo-cage in order to stay in the limit of the field and no more than 15m height.

Type of operation	General flight	Area	Mission	Payload
E-VLOS	Area	Sparsely populated	Commercial - farming	No additional equipment

The operation is taking place in the countryside, but in sparsely populated area due to many farms around. There is no airport or aerodrome in the vicinity, but most of farmers around use drones. Nevertheless, the distance between the fields and the probability that two drones fly at the same time is very low.

The area is classified as an area where the operator does not need neither to notify flight intents nor to submit a drone operation plan, from ground to 400 feet.

The pilot follows the regular process of registrations and pre-flight checks. The operator limits height of the operation at 15m. If a manned aircraft approaches for a landing, the pilot and/or the observer would see it and the pilot would be able to land the drone.

2.3 Mission 3: Building inspection

An architect wants to check the state (if no cracking) of a bridge after a tornado. While the drone is moving around the bridge, the pilot is staying at his position. Part of the mission is BVLOS.

- ✓ The pilot has been trained to fly the drone out of sight and has basic aeronautical knowledge.
- ✓ The Drone will be flown BVLOS. The operation category is specific, even after SORA has been performed.

Type of operation	General flight	Area	Mission	Payload
BVLOS	Area	Sparsely populated	State - Inspection	Laser pod, thermal and visual cameras

The location is sparsely populated but the bridge is well known by VFR pilots as a reference point for their navigation; moreover, a lot of leisure drone pilots are used to flying around the bridge.

The area has been classified as an area where the operator must submit a drone operation plan from ground to 400 feet, and the operation will be strategically de-conflicted with other unmanned users of the airspace.

The pilot follows the regular process of registrations, pre-flight checks and fills a drone operation plan. The system informs him that no drone activity is scheduled at this time. Nevertheless, the pilot would be informed before take-off if another drone is expected to fly at the same time, nearby.

The pilot is responsible for avoidance of collision as he is responsible to avoid flying above or near people.

2.4 Mission 4: Vineyard fungicide spraying

A drone is used in a research project to explore future standard operations in vineyards for regular fungicide protection of valuable crops (Riesling in Rheingau needs protection 12 – 16 times a year). A large drone (> 5m perimeter, 8 rotors, >150 kg incl. ca. 40 kg liquid) operates not more than 1-1.5m above the vineyards rows and sprays fungicides on the wine leaves which are whirled by the downwash of the rotors (thus exposing the bottom side of leaf to the spray).

- ✓ Drone's weight leads to consider the operation as Specific. As a research project, no standard scenario has been developed in SORA; nevertheless, results of SORA determine the specific risk classification.

Type of operation	General flight	Area	Mission	Payload
BVLOS	Route and area	Sparsely populated	Commercial agrarian	10-40l fungicide tanks, cameras with NIR range

The area is sparsely populated but as mentioned below, military airfield and international airport are not far, so the area has been classified as an area where the operator must submit a drone operation plan and the operation will be strategically de-conflicted with other unmanned users of the airspace.

The pilot follows the regular process of registrations, pre-flight checks and fills a drone operation plan.

The strategic/pre-tactical de-confliction service advises the operator that the slot chosen is empty.

The pilot would take advantage of the traffic information service if another drone was supposed to fly nearby.

Manned aviation pilots are encouraged to check the expected drone activity in this area if they plan to fly close to 500 feet. The weather forecast and the ceiling are important data.

Additional information about the use case:

Involved in these operations are:

- The ANSP (provision of situational awareness to operator and pilot)
- The vineyard owner (customer)
- The community (village or city eventually impacted by the operation)
- The federal air work oversight authority (Landesluftfahrtbehörde; authorization of operation)
- The research institute (service provider)
- The drone operator and the drone pilot in the field (in charge of the service provider).

The following map indicates the area of operations, which is between Geisenheim and Rüdesheim, ca. 1-5 km from the North shore of the Rhine river, West outside the control zones of Wiesbaden mil. Air field and Frankfurt international airport:

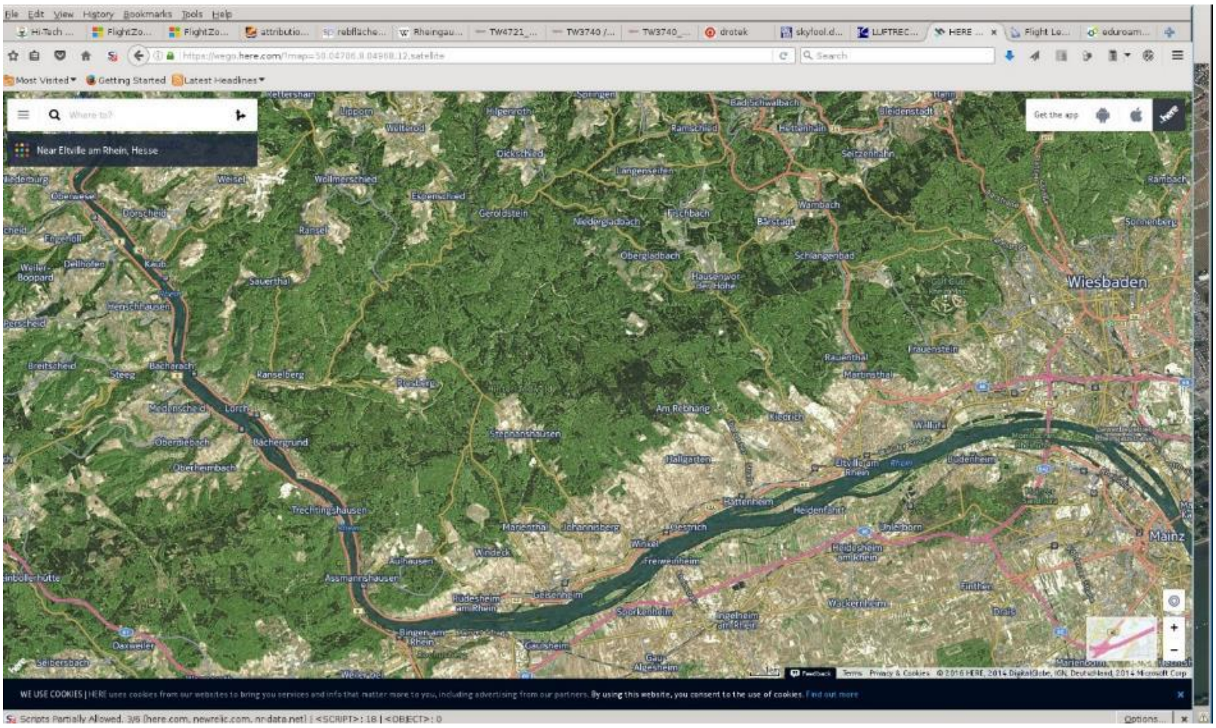


Figure 1 Satellite view of Rheingau region

The operations are started from a landing area (later a lorry) with drone, battery packs, and tanks for fungicides, continue to the nearest field of wine rows, perform an accurate (1.5m and less) agrarian pattern right above the vines in constant altitude and slow speed (1-3 m/s) that is automatically adapted to the terrain structure, fly back and forth for tank and battery reloading automatically, and continue to the next vineyard as defined in the total mission plan. These transit flights shall happen in higher altitude and higher speed (~5-10 m/s) to avoid ground risks, but expose the aircraft to collision risks with other aircraft in VLL. Operations take place partly in line of sight, and largely out of sight, where the pilot seeks to get a situational awareness display of his drone operation and surrounding risks. The flight path must automatically adapt to the terrain shape to maintain constant altitude above the vines.

When the research project activities demonstrate sufficient maturity, it is planned that one operator/pilot in the field monitors up to 5 large drones in the vineyards, spread over a region of ca.

10 x 30 km. The role of the service provider will shift from the research institute to a commercial drone operator.

2.5 Mission 5: Seed sowing

A state decides to use a drone in order to reforest an area after a fire. The surface is so wide that the mission is BVLOS.

- ✓ The drone needs to carry a huge amount of seed in order to limit the number of operations.
- ✓ The pilot is a professional pilot highly qualified.
- ✓ The drone used is a fixed-wing of more than 100kg. After SORA, the operation remains Specific.

Type of operation	General flight	Area	Mission	Payload
BVLOS	Wide area	Non-populated	Commercial-agriculture	Seed dispatcher and infrared sensors

The area is sparsely populated, but the forest is the property of the national park authority. It has been classified as an area where the operator must submit a drone operation plan and receive a special authorization from the national park authority. The operation will be strategically and tactically de-conflicted by the authority of the park or by a U-Space services provider which received by delegation the responsibility to manage the traffic within the area.

The authority has details of all authorized flights and may decide to postpone an operation if two occur at the same time at the same place, or provide the operator with special instructions.

The operator connects to U-space, processes to the regular registrations and pre-flight checks, fills a drone operation plan and waits for the authority authorization through the U-space service provider.

2.6 Mission 6: Police surveillance

The police department uses a drone to overfly a city during 8 hours, in order to be able to provide help to the police officers in case of intervention. This mission is BVLOS.

- ✓ The pilot has a professional pilot license.
- ✓ The drone is fixed-wing for a better autonomy. SORA shows that the operation is certified (ground risk is very high).

Type of operation	General flight	Area	Mission	Payload
BVLOS	Stationary or pattern	Populated	State - surveillance	Infrared sensor

The area overflown is urban (populated), other drones are expected to fly, including taxi-drones, as well as manned aircraft such as EMS helicopter, helicopter of the fire department, or other.

Traffic in this volume is said to be strategically and tactically de-conflicted, due to the traffic density which could be more than low. Thus, the operator must create a drone operation plan.

The operator connects to U-space, processes to the regular registrations and pre-flight checks, fills a drone operation plan and wait for the drone operation plan validation from the U-space service provider.

2.7 Mission 7: Recreational activity

A young teenager wants to play with his drone in the field located in a runway axis of a small AFIS aerodrome where the traffic is rare, except during the summer season. The mission type is VLOS.

- ✓ This young teenager has no knowledge in aeronautic, except the online training followed to steer drone of class C2, and theoretical test passed, according to EASA regulation.
- ✓ The drone, Class C2, will be flown VLOS away from any people; the category of the operation is open.

Type of operation	General flight	Area	Mission	Payload
VLOS	Area	Near airport	Recreational-leisure	No additional equipment

Due to the presence of an aerodrome, and with respect to the distance between the leisure area and the runway, the volume has been classified, from the ground to 20m, as an area where the operator does not need neither to notify flight intents nor to submit a drone operation plan. Above 20m, the traffic will be strategically and tactically de-conflicted, consequently the operator must submit a drone operation plan.

The teenager connects to U-space, processes to the regular registrations and pre-flight checks. As he is close to the “managed” volume, he decides to set the Geo-fencing of his drone with a maximum height of 15m and set the boundaries of the fence with a margin with the limit between the “two volumes.

2.8 Mission 8: Runway inspection

A pilot thinks he has seen an object on the runway while landing. The airport traffic control operation proceeds to a runway inspection with a drone.

- ✓ The pilot has no professional license but is authorized to use the drone above the maneuvering area.
- ✓ He has a full knowledge of the rules and procedures in effect on the airport. He will be in radio contact with the air traffic control during the whole flight.

Type of operation	General flight	Area	Mission	Payload
BVLOS	Route and area (combined)	Airport movement area	Public or commercial-inspection	Wide angle visual camera

The operation takes place on the maneuvering area of a big airport; the volume, as a controlled area, is classified as an area where the operator must submit a drone operation plan and will receive tactical advisory and/or instructions in case of conflict.

The operator has already registered to U-Space, the pre-flight checks are often done early in the mornings, so that the drone is ready for urgent mission. The operator has not time to fill a drone operation plan and wait for the authority (ANSP) authorization.

Instructions to proceed has been directly given to the remote pilot by ATC, with a perfect knowledge of every other drones, manned aircraft and vehicles' movements on or above the manoeuvring area.

U-space will receive the tracking information and display it on the ATC collaborative interface.

2.9 Mission 9: ILS measurement

As part of the ground maintenance of Instrument Landing Systems (ILS), Localizer and glide path signals are today measured with a van equipped with a telescopic mast and an antenna. This is an expensive and preparation-intense activity, and for the GP certain areas of interest cannot be reached with this set-up. It is likely that in the future, drones (e.g. octocopters, > 1m diameter, > 5kgs weight), equipped with suitable antennas and measurement receivers, will be employed for these tasks instead. After the successful completion of development, integration and validation of antennas, receivers, drone operational systems and data processing, these operations are likely to be carried out in regular intervals at major national and international airport equipped with ILS. Potentially, both the quality of the measurements can be improved due to the superior flexibility of the measurement drone, while reducing the time the runway is blocked.

Similar to the current measurements using a vehicle, the runway must be closed during the drone measurements. Therefore these operations must be carried out during periods of low activity (e.g. at night), and require good coordination between the drone team and the control tower using a VHF

COM radio. Furthermore, the drone must carry an electronic identification device (e.g. a transponder and/or a hook-on-device for live tracking) to make it visible on the tower's air situation display.

The measurements are performed along the airport runway center-line in the ILS Localizer radiation field, and in certain areas of interest of the ILS Glide path antenna. Altitudes will vary from 5m to 150m approximately, and speeds will range from stationary hovering for increased data sampling, to about 5m/s. The operations are partly VLOS (segment close to pilot and observer), and partly BVLOS at the more remote segment of the operations down the runway.

Type of operation	General flight	Area	Mission	Payload
VLOS and BVLOS	Stationary and area (combined)	Airport Movement area	Public inspection	ILS emitter measurement equipment

The following screenshot indicates the context of these operations at an airport (example):

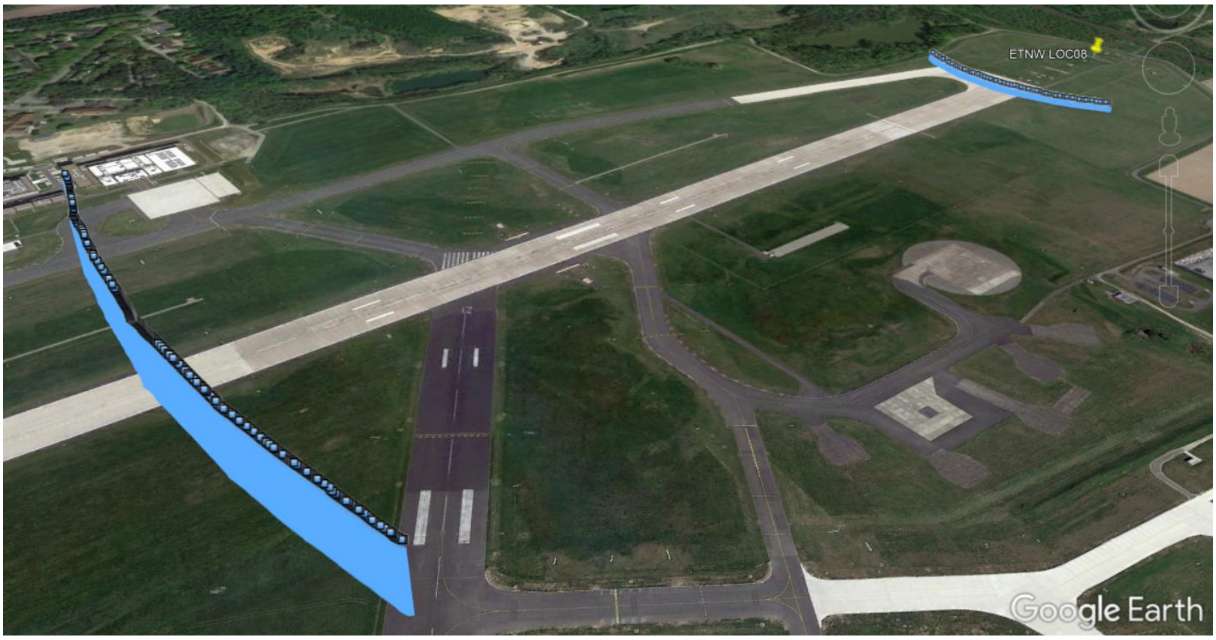


Figure 2 Satellite view of a part of an airport runway

Involved in these operations are:

- The ANSP (customer, and oversight)
- The ANSP Tower control unit at the selected airport (local ATC and operations monitoring).
- The airport authority/operator/owner (impacted by the operation).
- The federal airport oversight authority (authorization of operation).
- The calibration company (service provider) operating the drone.

- The drone operator company and the drone pilot in the field (in charge of the service provider).

During drone operation the relevant runway, eventually the airport as such, is blocked. Therefore, such operations are intended to happen at the fringe of normal airport operation times, and should be executed as quickly as possible. Strong coordination with tower control is required, therefore the operators are equipped with radio on the tower frequencies, and the drone carries electronic identification devices to be visible on the tower air situation display (transponder and/or hook-on-device for live tracking).

The ILS measurement takes place in an area where the traffic will be strategically and tactically de-conflicted, as a controlled airspace. A drone operation plan must be submitted. This operation has been scheduled several days ago so the operator had time to fill a drone operation plan and receive the ATC approval through the collaborative interface (procedural?).

As soon as the drone takes-off, the ATC receives the tracking information of the drone on the collaborative interface and can follow the drone flight.

EXPLORATORY RESEARCH

Intermediate ConOps

Annex B - Requirements

D6.2	CO
CORUS	
Grant:	763551
Call:	2016 SESAR 2020 RPAS Exploratory Research Call (H2020 – SESAR -2016-1)
Topic:	Topic 01: SESAR UTM Concept Definition
Consortium coordinator:	EUROCONTROL
Edition date:	18 Mar 2019
Edition:	01.00.00

Founding Members

EUROPEAN UNION EUROCONTROL

SESAR JOINT UNDERTAKING

Table of Contents

1 Introduction 3
2 List of services per flight phase(s) 4
3 Requirements 5
4 Conclusion 30

List of Tables

Table 1-list of services per flight phase 4
Table 2 SJU requirements presentation format 13

1 Introduction

In the framework of U-space ConOps development, CORUS partners have developed a set of high-level requirements.

The goal of this Annex is not to propose an exhaustive list of the high-level requirements but to highlight some of the most important requirements for U-Space.

Further development of requirements is expected in the other on going U-space technical projects for detailing and tracing back to CORUS ConOps list.

The document is divided into two main parts.

The first part (section 2) is a table listing the services required per each part of a drone operation.

The second part (section 3) introduces a list of general requirements and requirements for each part of a drone operation, and the same main requirements in the SJU requirement format.

2 List of services per flight phase

The table below tries to show which services are involved with respect to the phase of an operation, from the registration to the post-flight.

U-Space services	Flight phases
e-registration	Registration
e-identification	In-flight
Pre-tactical Geo-fencing	Pre-flight
Tactical Geo-fencing	In-flight
Tracking	In-flight
Flight planning management	Pre-flight
Weather information	Pre-flight and in-flight
Drone aeronautical information management	Pre-flight and in-flight
Procedural interface with ATC	Pre-flight
Emergency management	Pre-flight and in-flight
Strategic conflict resolution	Pre-flight
Monitoring	In-flight
Traffic information	In-flight
Geographical information	Pre-flight
Accident & incident reporting	Post-flight
Legal recording	In-flight and post-flight
Dynamic Geo-fencing	In-flight
Collaborative interface with ATC	Pre-flight and in-flight
Tactical conflict resolution	In-flight
Dynamic capacity management	Pre-flight and in-flight

Table 1-list of services per flight phase

3 Requirements

3.1 General requirements

These few requirements are general high level requirements on U-space system and services. This list is absolutely not exhaustive and requirements below are just examples.

1- All users shall have access to right information at right time as required for their need.

2- Drone data shall be publicly accessible, except for those data which could lead to the user or drone pilot.

3- The user shall be informed of any service failure.

4- User information shall be accessible to the user itself and any authorized persons or entities.

5- User data and information must be clearly assigned to a user. Users with the same name must be clearly distinguishable.

6- Each service shall guarantee a service performance compatible with specific service level of agreement (e.g. to ensure continuity of the service it is possible to have redundant backup systems).

7- U-space rules / laws / requirements shall be enforced.

8- U-space shall only collect and use information relevant to its purposes, taking care of privacy of the users.

3.2 Registration

3.2.1 Registration of drone model by the manufacturer or importer

1- The manufacturer shall authenticate in U-space

2- The manufacturer shall indicate to U-space the drone information (e.g. type, the drone engine energy, the drone noise level, the drone performances, the drone maximum take-off mass, the UA class identification).

3- The manufacturer shall provide U-space with the drone documentation.

4- The manufacturer shall receive a drone model registration certificate.

3.2.2 Registration of a drone

1- The drone owner shall authenticate in U-space, indicating information (e.g. natural or legal person, the operational contact).

2- The drone owner shall register the drone indicating (e.g. the drone model and the drone serial number(s)) or the drone information if the drone characteristics have been changed (compared to the characteristics recorded by the manufacturer).

3- The drone owner shall receive a drone registration certificate and a unique ID attached to the drone

4- The drone owner shall maintain the drone owner registration information.

3.2.3 Registration of the drone pilot licenses and training

1- The training school shall authenticate in U-space.

2- The training school shall register the pilot identification and certification obtained (e.g. online training, online test results, theoretical test results, medical certificate).

3- The training school shall provide U-space with the evidence of the certification.

4- The training school shall receive a pilot licenses and training registration certificate.

3.2.4 Registration of the drone pilot

1- The drone pilot shall authenticate in U-space.

2- The drone pilot shall provide U-space with pilot's information (e.g. name, phone number, date of birth, name of the training school).

3- The drone pilot shall receive a unique drone pilot ID number and a drone pilot registration certificate.

3.2.5 Registration of the drone operator

1- The drone operator shall authenticate in U-space.

2- The drone operator shall provide U-space with operator information (e.g. name of the company, date of creation, type of activity).

3- The drone operator shall select drone(s) of his fleet registered by the owner.

4- The drone operator shall provide U-space with its pilot(s)'s name(s) or selected from registered ones.

5- The drone operator shall receive a unique operator registration number and a drone operator registration certificate.

3.2.6 Registration of any other entity (other user of the system e.g. ANSP, local authority, police, training school)

1- The entity shall authenticate in U-space.

2- The entity shall provide U-space with contact details of a supervisor or a responsible person (e.g. e-mail address, phone number)

3- The entity shall provide U-space with area of responsibility (e.g. government department, third party user, training school)

4-the entity shall receive an entity registration certificate.

3.3 Pre-flight

3.3.1 Check flight condition

Flight planning management

1- The drone operator shall provide U-space with his operation information.

2- The drone operator shall check volume's requirements before flying.

3- The drone operator shall be able to evaluate that the flight is achievable according to the information received.

Weather information service

1- The drone operator/pilot shall take into consideration the weather now cast and forecast.

2- The weather information shall be customized with respect to the location and the operation".

Drone aeronautical information

1- Drone operator/pilot shall have access to all aeronautical information required to prepare the mission.

2- Drone operator/pilot shall have access to the latest version of updated drone aeronautical information.

Geographical information

1- The operator/pilot shall have access to the latest geographical information available.

Pre-tactical Geo-fencing

1- Drone operator/pilot shall see the geo-fenced area on the USP interface.

2- The service shall be able to collect data from different sources (e.g. AIP, non-AIP).

3.3.2 The drone operation plan

Flight planning management

1- The flight planning management service shall indicate the operator/pilot the inconsistencies in and of the drone operation plan.

2- The drone operator shall select the drone which will be used for the operation.

3- The drone operator shall provide U-space with his drone operation plan with required details.

4- URD: the drone operator shall wait from U-space the approval of the drone operation plan before proceeding to the operation.

Dynamic capacity management

URD: the dynamic capacity management service shall be available in managed volumes by U-Space.

3.3.3 Strategic conflict management

<u>Strategic conflict resolution service</u>

1- The drone operator shall receive a notification if no strategic conflict is detected.

2- The drone operator shall receive conflict resolution proposal which solves a possible conflict.

3- The drone operator shall notify U-space with the acceptance or denial of the drone operation plan change(s) (e.g. height, time departure) proposed by the system.

3.3.4 Authorization process

<u>Flight planning management service</u>

1- The drone operator shall provide U-space with required specific document(s) to enable the drone operation plan authorization.

<u>Procedural interface with ATC</u>

1- The procedural interface with ATC shall allow the operator/pilot to submit a drone operation plan request in volume managed by ATC.

2- The service shall forward procedures and constraints to the flight planning management service.

3.3.5 Prepare the flight

1- The drone pilot shall proceed to every actions required to prepare the drone for the flight.

2- The drone operator/pilot shall subscribe to any deemed useful services.

<u>Collaborative interface with ATC</u>

1- The drone operator/pilot shall proceed to a check of the connection with the collaborative interface with ATC.

3.4 In-flight

Depending on the conditions of the flight, these services may be useful for the users of the volume of airspace.

<u>Tactical and dynamic Geo-fencing services</u>

1- The drone operator/pilot shall receive airspace restrictions notifications and updates.

2- Any authorized/accredited authority shall be able to create or request the creation of a geo-fence.

3- Clearances shall be made available to the drones at suitable times during flight, without the necessity of having the ground station in the loop.

<u>Drone aeronautical information service</u>

1- The drone operator/pilot shall receive any aeronautical information update while flying the drone.

Tactical de-confliction service

1- The drone operator/pilot shall receive and execute the tactical conflict resolutions sent by U-Space.

Weather information service

1- The drone operator/pilot shall receive weather conditions updates while in-flight .

Emergency management service

1- The drone operator/pilot shall receive emergency management notification.

2- The drone pilot shall continuously check, listen or read the available emergency communication channels/means.

3- The drone operator/pilot shall communicate emergencies immediately through any available emergency channels/means of communication.

4- Emergency management service shall provide a set of standard procedures and a database of alternative landing spots and crash areas.

Traffic information service

1- The drone operator/pilot shall see a visual air situation display of the flying drone track and all air traffic (manned/unmanned around it) for situation awareness.

2- Tracking data from other USP for drones flying at the boundaries of its volume responsibility shall be shared with adjacent USP.

Monitoring service

1- The drone operator/pilot shall be informed of any deviation from the drone operation plan accepted by U-Space.

3- The drone operator/pilot shall receive warnings and alerts in their situation displays against no fly zones, other UAS and manned aircraft.

4- The system shall monitor a flight and provide the information to the other surrounding traffic as soon as an emergency has been triggered.

Tracking service

1- The unique ID generated during the drone registration shall appear in the drone label while flying, for tracking purpose.

2- the tracks shall be available to any authority or accredited or authorized user who may need them.

E-identification

1- the drone operator/pilot shall check that his drone broadcasts the e-identification signal.

2- the e-identification code shall be activated and broadcast as soon as the drone is powered on.

Collaborative interface with ATC

1- The collaborative interface with ATC shall allow the management of the drone flight and communication between the operator/pilot and ATC

Dynamic capacity management

1- The dynamic capacity management service shall postpone drone operation acceptance until the volume capacity has been recovered.

2- The dynamic capacity management shall have the authority to refuse or delay flight demand.

3- The dynamic capacity management shall know all the flight in a pre-defined volume.

Legal recording

1- The legal recording service shall record the tracks of the drones and the communications messages exchanged by any means between the drone pilots and U-Space and between drone pilots.

3.4.1 Start-up request in controlled airspace

1- The drone operator/pilot shall request start-up authorization using the pre-defined method (e.g. radio, CPDLC, ATC collaborative interface).

2- The drone shall start to broadcast the e-identification.

3.4.2 Taxiing on controlled aerodrome

1- The drone operator shall request authorization to taxi to the ATC using the pre-defined method (e.g. radio, CPDLC, ATC collaborative interface).

3.4.3 Take-off from a controlled area

1- The drone operator shall request line-up authorization to the ATC using the pre-defined method (e.g. radio, CPDLC, ATC collaborative interface).

2- The drone operator shall inform the ATC the drone lines-up using the pre-defined communication means (e.g. radio, CPDLC, ATC collaborative interface).

3- The drone operator shall inform the ATC the drone takes-off using the pre-defined method (e.g. radio, CPDLC, ATC collaborative interface).

3.4.4 Take-off from an uncontrolled area

1- The drone operator shall inform U-space the drone takes-off.

2- After a failsafe landing, the drone operator shall provide U-space with a new drone operation plan.

3- The drone operator shall check that the drone operation plan is still approved before taking-off.

3.4.5 Route

1- The drone operator/pilot shall check that the drone broadcast its position and the unique identification of the flight.

2- The drone pilot shall ensure a safe conduct of the flight taking as well into consideration information provided by U-space (e.g. traffic information, monitoring alerts)

3- The drone operator, when authorized, shall contact the ATC before entering a controlled airspace using the pre-defined method (e.g. radio, CPDLC like, collaborative interface).

4- The drone pilot of a VLOS operation shall ensure the see and avoid.

3.4.6 Landing in a controlled area

1- The drone operator shall contact the ATC using the pre-defined method (e.g. radio, CPDLC like, collaborative interface) in order to get the landing clearance.

2- If no clearance received, the drone operator shall inform U-space he proceeds with a landing on alternate aerodrome.

3- The drone operator shall inform U-space the drone has landed and flight/drone operation plan completed.

3.4.7 Landing in an uncontrolled area

1- The drone operator shall inform U-space the drone lands.

2- The drone operator shall close the flight/drone operation plan.

3.5 Post-flight

1- The drone operator/pilot shall perform the post-flight drone and mission checks.

2- The drone operator/pilot shall report any relevant incident or accident occurred.

3-If the urgency of the operation prevented the drone operator/pilot to declare the drone operation plan (e.g. emergency operation), the drone operator shall declare the operation in the post-flight phase.

Accident and incident reporting

1- The operator/pilot shall declare accident and incident to the U-space services provider.

Legal recording

2- Legal recording shall be available to any legal, accredited or authorized authorities upon request.

3.6 Requirements – definitions

The below requirement definitions are presented in a format, as per the U-space requirements guidelines document dated on 26 June 2018.

The table below shows the different categories of sections which have to be filled.

Identifier (R)	REQ-<PROJECT NAME>-DZZ-YYYY.XXXX *or* REQ-<PROJECT NAME>-DZZ-XXXX
Title (R)	*Free text (short)*
Description (R)	*Free text*
Type (R)	*Enumerate (only one)* <Service>; <Capability>
Service/Capability name (R)	Enumerate (one or more) If "Service" is selected as Type: <e-Registration>; <e-Identification>; <Pre-tactical geo-fencing>; <Tactical geo-fencing>; <Emergency management>; <Strategic de-confliction>; <Weather information>; <Tracking>; <Flight planning management>; <Monitoring>; <Traffic information>; <Drone aeronautical information management>; <Procedural interface with ATC>; <Emergency management>; <Dynamic geo-fencing>; <Tactical de-confliction>; <Tracking>; <Monitoring (U2)>; <Monitoring (U3)>; <Traffic information (U2)>; <Traffic information (U3)>; <Drone aeronautical information management>; <Collaborative interface with ATC>; <Dynamic capacity management>; <Legal recording>; <Accident and Incident reporting>; <Digital Logbook>; <Geographic Information>; <Flight plan preparation / optimization assistance> If "Capability" is selected as Type: <e-Identification>; <Geo-fencing>; <Security>; <Telemetry>; <Command & control>; <Communication, navigation and surveillance>; <Operations management>; <Tracking>; <Emergency recovery>; <V2V>; <Detect & avoid>; <V2I>
Category (R)	*Enumerate (one or more)* If "Service" is selected as Type: <Operational>; <Performance>; <Safety>; <Security>; <Human Performance>; <IER>; <Interoperability>; <HMI> If "Capability" is selected as Type: <Functional>; <Safety>; <Security>; <Adaptability>; <Maintainability>; <Reliability>; <Performance>; <Data>; <IER>; <Design>; <Interoperability>; <Interface>; <HMI>
Environment type (R)	*Enumerate (one or more)* <Rural> ; <Suburban>; <Urban>; <Maritime>; <Forestry>
Additional information (O)	Free text This field may be used to identify if multiple service provider, the type of mission, the airspace, the type of flight, the density of drones, etc.
Rationale (O)	Free text This field may be used for requirements traceability to CORUS CONOPS (for Service requirements) or to Service requirements (for Capability requirements).

Status (R)	Enumerate (only one) <Defined>; <Validated>; <Deleted>

(R) Required / **(O)** Optional

Table 2 U-Space requirements presentation format

3.6.1 General requirements

Identifier	REQ – CORUS – ConOps V2 – FUNC.0010
Title	Access to information
Description	All users shall have access to information at the right time as required for their need.
Type	Capability
Service name	General requirement
Category	HMI
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SEC.0010
Title	Access to data
Description	Drone data shall be publicly accessible, except for those data which could lead to the user or drone pilot
Type	Service
Service name	General requirement
Category	Security
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 – SAFE.0010
Title	Service quality alert
Description	The user shall be informed of any service failure
Type	Service
Service name	General requirement
Category	Safety
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 – SEC.0020
Title	Data protection
Description	User information shall be accessible to the user itself and any authorized persons or entities
Type	Service
Service name	General requirement
Category	Security
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 – SEC.0030
Title	Identity management
Description	User data and information must be clearly assigned to a user. Users with the same name must be clearly distinguishable
Type	Service
Service name	General requirement
Category	Security
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 – PERF.0010
Title	Service performance
Description	Each service shall guarantee a service performance compatible with specific service level of agreement(e.g. to ensure continuity of the service it is possible to have redundant backup systems)
Type	Service
Service name	General requirement
Category	Performance
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 – SEC.0040
Title	U-Space enforcement
Description	U-Space rules, laws and requirements shall be enforced
Type	Capability
Service name	General requirement
Category	security
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 – FUNC.0020
Title	Use of data collected
Description	U-Space shall only collect and use information relevant to its purposes, taking care of privacy of the users
Type	Capability
Service name	General requirement
Category	service
Environment type	All
Status	Defined

3.6.2 Registration

3.6.2.1 Common requirements to all registration types

Identifier	REQ – CORUS – ConOps V2 – SEC.0010
Title	Authentication
Description	User of the e-registration service shall authenticate in U-Space

Type	Service
Service name	Drone model/drone/drone pilot licenses and training/drone pilot/drone operator/any user e-registration
Category	security
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 – SEC.0020
Title	Registration certificate
Description	The manufacturer/the drone owner/the drone pilot/the drone operator/the training school/any user shall receive a registration certificate
Type	Service
Service name	Drone manufacturer/drone owner/drone pilot/drone operator/drone pilot training school/any user e-registration
Category	security
Environment type	All
Status	Defined

3.6.2.2 Registration of drone model

Identifier	REQ – CORUS – ConOps V2 – SEC.0030
Title	Drone information
Description	The manufacturer shall indicate to U-space the drone information (e.g. type, the drone engine energy, the drone noise level, the drone performances, the drone maximum take-off mass, the UA class identification).
Type	Service
Service name	Drone model e-registration
Category	Security
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SEC.0040
Title	Drone documentation
Description	The manufacturer shall provide U-space with the drone documentation
Type	Service
Service name	Drone model e-registration
Category	Security
Environment type	All
Status	Defined

3.6.2.3 Registration of a drone

Identifier	REQ – CORUS – ConOps V2 – SEC.0050
Title	Drone affiliation to an owner
Description	The drone owner shall register the drone indicating (e.g. the drone model and the drone serial number(s)) or the drone information if the drone characteristics have been changed (compared to the characteristics recorded by the manufacturer).
Type	Service
Service name	Drone e-registration
Category	Security

Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SEC.0060
Title	Drone owner unique ID
Description	The drone owner shall receive a unique ID attached to the drone
Type	Service
Service name	Drone e-registration
Category	Security
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SEC.0070
Title	Drone information update
Description	The drone owner shall maintain the drone registration up to date(e.g. drone destroyed, drone modified)
Type	Service
Service name	Drone e-registration
Category	Security
Environment type	All
Status	Defined

3.6.2.4 Registration of drone pilot licenses and training

Identifier	REQ – CORUS – ConOps V2 –SEC.0080
Title	Pilot identification and certification registration
Description	The training school shall register the pilot identification and certification obtained (e.g. online training, online test results, theoretical test results, medical certificate).
Type	Service
Service name	Drone pilot licenses and training e-registration
Category	Security
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SEC.0090
Title	Evidence of the certification
Description	The training school shall provide U-space with the evidence of the certification
Type	Service
Service name	Drone pilot licenses and training e-registration
Category	Security
Environment type	All
Status	Defined

3.6.2.5 Registration of a drone pilot

Identifier	REQ – CORUS – ConOps V2 –SEC.0100
Title	Drone pilot information
Description	The drone pilot shall provide U-space with pilot's information(e.g. name, phone number, date of birth, name of the training school).
Type	Service
Service name	Drone pilot e-registration

Category	Security
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SEC.0110
Title	Drone pilot registration unique ID
Description	The drone pilot shall receive a unique drone pilot ID number
Type	Service
Service name	Drone pilot e-registration
Category	Security
Environment type	All
Status	Defined

3.6.2.6 Registration of the drone operator

Identifier	REQ – CORUS – ConOps V2 –SEC.0120
Title	Drone operator registration information
Description	The drone operator shall provide U-space with operator information (e.g. name of the company, date of creation, type of activity).
Type	Service
Service name	Drone operator e-registration
Category	Security
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SEC.0130
Title	Drone operator drone selection
Description	The drone operator shall select drone(s) of his fleet registered by the owner
Type	Service
Service name	Drone operator e-registration
Category	Security
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SEC.0140
Title	Drone operator pilot selection
Description	The drone operator shall provide U-space with its pilot(s)'s name(s) or selected from registered ones.
Type	Service
Service name	Drone operator e-registration
Category	Security
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SEC.0150
Title	Drone operator registration number and certificate
Description	the drone operator shall receive a unique operator registration number
Type	Service
Service name	Drone operator e-registration
Category	security

Environment type	All
Status	Defined

3.6.2.7 Registration of any other entity

Identifier	REQ – CORUS – ConOps V2 –SEC.0160
Title	Other user registration information
Description	The entity shall provide U-space with contact details of a supervisor or a responsible person (e.g. e-mail address, phone number).
Type	Service
Service name	Other user e-registration
Category	Security
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SEC.0170
Title	Other user area of responsibility
Description	The entity shall provide U-space with area of responsibility (e.g. government department, third party user).
Type	Service
Service name	Other user e-registration
Category	Security
Environment type	All
Status	Defined

3.6.3 Pre-flight

3.6.3.1 Check flight condition

Identifier	REQ – CORUS – ConOps V2 – OPS.0010
Title	Operation information/details
Description	The drone operator shall provide U-space with his operation information.
Type	Service
Service name	Flight planning management service
Category	Operational
Environment type	Undeclared, Declared and managed volumes
Status	Defined

Identifier	REQ – CORUS – ConOps V2 – SAFE.0010
Title	Pre-flight volume's requirements check
Description	The drone operator shall check volume's requirements before flying.
Type	Service
Service name	Flight planning management service
Category	Safety
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 – HUM.0010
Title	Achievability of the operation

Description	The drone operator shall be able to evaluate that the flight is achievable according to the information received.
Type	Service
Service name	Flight planning management service
Category	Safety
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0020
Title	Weather condition awareness
Description	The drone operator/pilot shall take into consideration the weather now cast and forecast
Type	Service
Service name	Weather information service
Category	Safety
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0030
Title	Weather condition awareness
Description	The weather information shall be customized with respect to the location and the operation"
Type	Service
Service name	Weather information service
Category	Safety
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0040
Title	Updated drone aeronautical information availability
Description	Drone operator/pilot shall have access to the latest version of an updated drone aeronautical information
Type	Service
Service name	Drone aeronautical information service
Category	Safety
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0050
Title	Drone aeronautical information access
Description	Drone operator/pilot shall have access to all aeronautical information required to prepare the mission.
Type	Service
Service name	Drone aeronautical information service
Category	Safety
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0060
Title	Geographical information access
Description	The operator/pilot shall have access to the latest geographical information available.
Type	Service
Service name	Geographical information service
Category	Safety
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –HMI.0010
Title	Geo-fenced areas visibility
Description	Drone operator/pilot shall see the geo-fenced area on the USP interface.
Type	Service
Service name	Pre-tactical Geo-fencing service
Category	HMI
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –INT.0010
Title	Geo-fenced data collection
Description	The service shall be able to collect data from different sources(e.g. AIP, non-AIP)
Type	Service
Service name	Pre-tactical Geo-fencing service
Category	Interoperability
Environment type	All
Status	Defined

3.6.3.2 The drone operation plan

Identifier	REQ – CORUS – ConOps V2 –OPS.0020
Title	Drone operation plan conformance
Description	The flight planning management service shall indicate the operator/pilot the inconsistencies in and of the drone operation plan(e.g. flight in Geo-fenced areas, use of a drone for which the pilot is not qualified, use of the right format, filled in the adequate manner)
Type	Service
Service name	Flight planning management service
Category	Operational
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –OPS.0030
Title	Drone operation plan details
Description	The drone operator shall provide U-space with his drone operation plan with required details.
Type	Service
Service name	Flight planning management service
Category	Operational

Environment type	Declared and managed volumes
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0070
Title	Drone operation plan acceptance
Description	The drone operator shall wait from U-space the approval of the drone operation plan before proceeding to the operation.
Type	Service
Service name	Flight planning management
Category	Safety
Environment type	Managed volumes
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0080
Title	Dynamic capacity management availability
Description	The dynamic capacity management service shall be available in managed volumes by U-Space
Type	Service
Service name	Dynamic capacity management service
Category	Safety
Environment type	Managed volumes
Status	Defined

3.6.3.3 Strategic conflict management

Identifier	REQ – CORUS – ConOps V2 –HMI.0020
Title	No strategic conflict detected confirmation
Description	The drone operator shall receive a notification if no strategic conflict is detected
Type	Service
Service name	Strategic conflict resolution service
Category	HMI
Environment type	Declared and managed volumes
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –HMI.0030
Title	No strategic conflict detected confirmation
Description	The drone operator shall receive approval if no strategic conflict is detected
Type	Service
Service name	Strategic conflict resolution service
Category	HMI
Environment type	Declared and managed volumes
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0090
Title	Conflict resolution proposal
Description	The drone operator shall receive conflict resolution proposal which solves a possible conflict.

Type	Service
Service name	Strategic conflict resolution service
Category	Safety
Environment type	Declared and managed volumes
Status	Defined

Identifier	REQ – CORUS – ConOps V2 – OPS.0040
Title	Conflict resolution proposal “acceptance or denial” notification
Description	The drone operator shall notify U-space with the acceptance or denial of the drone operation plan change(s) (e.g. height, time departure) proposed by the system.
Type	Service
Service name	Strategic conflict resolution service
Category	Operational
Environment type	Declared and managed volumes
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0100
Title	Drone operation plan validation
Description	The drone operator shall wait from U-space the approval of the drone operation plan before proceeding to the operation.
Type	Service
Service name	Strategic conflict resolution service
Category	Safety
Environment type	Declared and managed volumes
Status	Defined

3.6.3.4 Authorization process

Identifier	REQ – CORUS – ConOps V2 –SEC.0180
Title	Document upload for authorization process
Description	The drone operator shall provide U-space with required specific document(s) to enable the drone operation plan authorization.
Type	Service
Service name	Flight planning management service
Category	Security
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –OPS.0050
Title	Procedural interface
Description	The procedural interface with ATC shall allow the operator/pilot to submit a drone operation plan request in volume managed by ATC.
Type	Service
Service name	Procedural interface with ATC
Category	Operational
Environment type	Managed volumes
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –INT.0020
Title	Procedures and constraints handover
Description	The service shall forward procedures and constraints to the flight planning management service
Type	Service
Service name	Procedural interface with ATC
Category	Interoperability
Environment type	Managed volumes
Status	Defined

3.6.4 Prepare the flight

Identifier	REQ – CORUS – ConOps V2 –SAFE.0110
Title	Drone check
Description	The drone pilot shall proceed to every actions required to prepare the drone for the flight.
Type	Capability
Service name	Command and control
Category	Safety
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –PER.0010
Title	Service subscription
Description	The drone operator/pilot shall subscribe to any deemed useful services.
Type	Capability
Service name	Operation management
Category	Performance
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –INT.0030
Title	Connection check
Description	The drone operator/pilot shall proceed to a check of the connection with the collaborative interface with ATC.
Type	Service
Service name	Collaborative interface with ATC
Category	Interoperability
Environment type	Managed
Status	Defined

3.6.5 In-flight

Identifier	REQ – CORUS – ConOps V2 –OPS.0060
Title	Airspace restrictions messages/updates
Description	The drone operator/pilot shall receive airspace restrictions notifications and updates.
Type	Service
Service name	Tactical and dynamic Geo-fencing services

Category	Operational
Environment type	All(in undeclared if service subscribed- could be a mitigation for BVLOS)
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0120
Title	Geo-fenced area creation
Description	Any authorized/accredited authority shall be able to create or request the creation of a geo-fence.
Type	Service
Service name	Tactical and dynamic Geo-fencing services
Category	Safety
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0130
Title	Data availability
Description	The data shall be made available to all drones at any time also during flight, without the necessity of having the ground station in the loop.
Type	Service
Service name	Tactical and dynamic Geo-fencing services
Category	Safety
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –PER.0020
Title	Drone aeronautical information update
Description	Drone operator/pilot shall receive any aeronautical information update while flying the drone.
Type	Service
Service name	Drone aeronautical information service
Category	Performance
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –OPS.0070
Title	Receipt and execution of tactical de-confliction resolutions
Description	The drone operator/pilot shall receive and execute the tactical conflict resolutions sent by U-Space.
Type	Service
Service name	Tactical de-confliction service
Category	Operational
Environment type	Managed volumes
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –PER.0030
Title	Receipt of weather conditions update
Description	The drone operator/pilot shall receive weather conditions updates while in flight.
Type	Service

Service name	Weather information service
Category	Performance
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0140
Title	Receipt of Emergency management notification
Description	The drone operator/pilot shall receive emergency management notification.
Type	Service
Service name	Emergency management service
Category	Safety
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –HUM.0020
Title	Emergency communication channels/means watch
Description	The drone pilot shall continuously check, listen or read the available emergency communication channels/means.
Type	Service
Service name	Emergency management service
Category	Human performance
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –HUM.0030
Title	Communication of emergencies
Description	The drone operator/pilot shall communicate emergencies immediately through any available emergency channels/means of communication.
Type	Service
Service name	Emergency management service
Category	Human performance
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0150
Title	User assistance un case of emergency
Description	Emergency management service shall provide a set of standard procedures and a database of alternative landing spots and crash areas.
Type	Service
Service name	Emergency management service
Category	Safety
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –HMI.0040
Title	Situational awareness
Description	The drone operator/pilot shall see a visual air situation display of the flying drone track and all air traffic (manned/unmanned around it) for situation awareness.

Type	Service
Service name	Traffic information service
Category	HMI
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0160
Title	Drone operation plan deviation alert
Description	The drone operator/pilot shall be informed of any deviation from the drone operation plan accepted by U-Space.
Type	Service
Service name	Monitoring service
Category	Safety
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0170
Title	Warnings and alerts display
Description	The drone operator/pilot shall receive warnings and alerts in their situation displays against no fly zones, other UAS and manned aircraft.
Type	Service
Service name	Monitoring service
Category	Safety
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0180
Title	Emergency monitoring
Description	The system shall monitor a flight and provide the information to the other surrounding traffic as soon as an emergency has been triggered.
Type	Service
Service name	Monitoring service
Category	Safety
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –HMI.0050
Title	Drone label information
Description	The unique ID generated during the drone registration shall appear in the drone label while flying, for tracking purpose.
Type	Service
Service name	Tracking service
Category	Human machine interface
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SEC.0190
Title	Tracks availability
Description	The tracks shall be available to any authority or accredited or authorized user who may need them.
Type	Service
Service name	Tracking service
Category	Security
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –INT.0040
Title	Tracks sharing
Description	Tracking data from other USP for drones flying at the boundaries of its volume responsibility shall be shared with adjacent USP.
Type	Service
Service name	Tracking service
Category	Interoperability
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SEC.0200
Title	E-identification broadcast
Description	The e-identification code shall be activated and broadcast as soon as the drone is powered on
Type	Service
Service name	e-identification
Category	Security
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –PER.0040
Title	E-identification broadcast check
Description	The drone operator/pilot shall check that his drone broadcasts the e-identification signal
Type	Service
Service name	e-identification
Category	Human performance
Environment type	All
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –INT.0050
Title	Management and communication between ATC and drone pilot
Description	The collaborative interface with ATC shall allow the management of the drone flight and communication between the operator/pilot and ATC
Type	Service
Service name	Collaborative interface with ATC
Category	Interoperability
Environment type	Managed

Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0190
Title	Dynamic capacity management requirement
Description	The dynamic capacity management shall know all the flight in a pre-defined volume.
Type	Service
Service name	Dynamic capacity management
Category	Safety
Environment type	Declared and managed
Status	Defined

Identifier	REQ – CORUS – ConOps V2 – OPS.0080
Title	Dynamic capacity management requirement
Description	The dynamic capacity management shall have authority to refuse or delay a flight demand.
Type	Service
Service name	Dynamic capacity management
Category	Operational
Environment type	Declared and managed
Status	Defined

Identifier	REQ – CORUS – ConOps V2 – OPS.0090
Title	Legal recording function
Description	The legal recording service shall record the tracks of the drones and the communications messages exchanged by any means between the drone pilots and U-space and between drone pilots.
Type	Service
Service name	Legal recording
Category	Operational
Environment type	Declared and managed
Status	Defined

3.6.6 Post-flight

Identifier	REQ – CORUS – ConOps V2 –SEC.0210
Title	Legal recording availability
Description	Legal recording shall be available to any legal, accredited or authorized authorities upon request.
Type	Service
Service name	Legal recording
Category	Security
Environment type	Declared and managed
Status	Defined

Identifier	REQ – CORUS – ConOps V2 –SAFE.0200
Title	Accident and incident declaration

Description	The operator/pilot shall declare accident and incident to the U-space services provider.
Type	Service
Service name	Accident and incident reporting service
Category	Safety
Environment type	Declared and managed
Status	Defined

4 Conclusion

This annex defines the high-level requirements of U-Space into the pre-flight, in-flight and post-flight phase. More than seventy requirements have been introduced in the sections above. Only general requirements have been written for each service with respects to each phase of flight they are concerned. These requirements are not an exhaustive list as a complete set would include at least several hundreds of detailed requirements, which is beyond the scope of this annex.

The requirement presented in the annex are intended to cover all high-level aspects of the three flight phases, including registration, planning, authorisation, tactical decisions and logging. This shows that the same service, depending on when it is used, would have different requirements over a complete operation. It is not the intention of the annex to map the requirements of each service, but rather to scope the complete requirements for U-Space; as-such it should be expected that some services will make a requirement redundant when modelled from holistic systems point-of-view.

Intermediate ConOps

Annex C - SORA example

D6.2	CO
CORUS	
Grant:	763551
Call:	2016 SESAR 2020 RPAS Exploratory Research Call (H2020 – SESAR -2016-1)
Topic:	Topic 01: SESAR UTM Concept Definition
Consortium coordinator:	EUROCONTROL
Edition date:	18 Mar 2019
Edition:	01.00.00

Founding Members

EUROPEAN UNION EUROCONTROL

SESAR JOINT UNDERTAKING

1 General

As mentioned in section 2.2 of the ConOps [1] an example of a SORA assessment shall be given. A use case was chosen from the developed use cases (refer to Annex A, Use Cases) to demonstrate the evaluation of the SAIL (Specific Assurance and Integrity Level) and OSOs (Operational Safety Objectives).

In U-Space there will be multiple airspace users of all of the three categories: open, specific and certified. Risk assessments are necessary in all of the categories, depending on the operation they plan to perform. SORA is a tool to make the risk assessment for the specific category, but it would be too strict/conservative for the open category and too tolerant for the certified category. So the reader should note that this example of a “Specific Operations Risk Assessment” is applicable to the specific aircraft category only.

2 Scenario

The pharmacy on duty has to deliver a treatment to a patient. An urban environment with moderate building height is assumed, giving the drone the opportunity to fly below 500 ft AGL. The drone will reach its destination in less than 5 minutes.

Intention:	*Treatment delivery of medication to a patient (not urgent)*
Drone:	*Multicopter*
Dimensions:	*approx. 1 m*
MTOW:	*6 kg*
Payload:	*Small and light parcel*
Distance:	*about 2 km*
Mission type:	*BVLOS/BRLOS*
Area:	*Populated*
Flight Path:	*4D trajectory*
Pilot:	*Trained for BVLOS missions, good aeronautical knowledge*
Mission:	*highly automated*

3 Specific Operation Risk Assessment

3.1 Ground Risk Class (GRC)

The GRC is determined based on the largest dimension of the drone on the one hand and the operational scenario on the other, the latter being defined by the way of operation (VLOS or BVLOS) and the operational environment. The corresponding values are provided in a table in the range from one to eleven, whereby a high GRC correlates with a high risk.

Max UAS characteristics dimension	1m / approx. 3ft
Typical kinetic energy expected	<700J (approx. 529ft lb)
Operational scenario	
BVLOS over populated environment	5

3.2 Harm Barriers for GRC

SORA offers several opportunities to mitigate the Ground Risk. The robustness of the offered mitigations must be chosen from a list and allows correcting the initial GRC. A rationale is needed to justify the chosen robustness, except for “Low/None”. If the operator can offer additional mitigations, he can add them to a list, allocate robustness and give a rationale. In these cases an entitled entity has to review the additional mitigations.

Harm barriers for GRC adaptation	Robustness	***Rationale***	***Correction Factor***
An Emergency Response Plan (ERP) is in place, operator validated and effective	**High**	It can be assumed, that the pharmacy has terms and conditions to comply with, thus having an ERP is one of them.	**-1**
Effects of ground impact are reduced (e.g. emergency parachute, shelter)	**High**	Since the drone is flying over populated area a parachute should be obligatory.	**-2**
Technical containment in place and effective (e.g. tether)	**Low/None**	N/A	**0**

3.3 Air Risk Class (ARC)

The ARC reflects the probability of encountering manned aviation, which is chiefly dependent on the operational airspace. However, the collision risk of a local operational volume might deviate from this assignment. If the classification is too stringent or if mitigations are in place, the ARC can be adapted to the individual risk of the operation. The ARC ranges from a to d, where d states the highest risk.

Airspace Encounter Categories (AEC)	Operational Airspace	Air Risk Class (ARC)
9	Operations below 500 ft AGL within Uncontrolled Airspace over Urban Environment	ARC-c

3.4 Adjacent Airspace Considerations

The adjacent airspace may be a controlled airspace (AEC = 8) for this example, which is an ARC-c too. The table below states the operator what level of robustness his containment mitigations have to fulfil. In our example the final ARC is not ARD-d and is not conducted adjacent to ARC-d airspace, so the robustness is low.

Containment Objectives			
Operational Case	Final ARC is ARC-d	The final ARC is other than ARC-d and the operation is **not** conducted adjacent to ARC-d airspace	The final ARC is other than ARC-d and the operation is conducted adjacent to ARC-d airspace
Containment Robustness Level	N/A	Low	High

3.5 Tactical Mitigation Performance Requirements (TMPR) and Robustness Levels

The TMPR is just a result of the ARC and has no influence on the SAIL. The TMPR indicates what level a tactical mitigation has to have and how robust this tactical mitigation has to be.

Operational Airspace	**Air Risk Class (ARC)**	**TMPR**	**TMPR Level of Robustness**
Operations below 500 ft AGL within Uncontrolled Airspace over Urban Environment	ARC-c	Low	Low

3.6 Specific Assurance and Integrity Levels (SAIL)

The intention of SORA is to assess drone operations with respect to the risk posed to the environment and derive requirements from this classification. The representative result is the SAIL, which is derived by the combination of the predefined GRC and ARC. It ranges from I to VI, where a high value again corresponds to a high risk.

Final GRC	2
Final ARC	ARC-c
SAIL	**IV**

3.7 Identification of Operational Safety Objectives (OSO)

Resulting from the SAIL follows an OSO list. The letters in the right column state the required robustness level of the safety objectives the operator has to fulfil to fly this specific operation with this drone.

O = Optional
L = low robustness
M = medium robustness
H = high robustness

OSO Number		SAIL IV
	Technical issue with the UAS	
OSO#01	Ensure the operator is competent and/or proven (e.g. ROC)	H
OSO#02	UAS manufactured by competent and/or proven entity (e.g. industry standards)	M
OSO#03	UAS maintained by competent and/or proven entity (e.g. industry standards)	M
OSO#04	UAS developed by competent and/or proven entity (e.g. industry standards)	L
OSO#05	C3 link performance is appropriate for the operation	M
OSO#06	UAS is designed considering system safety and reliability	M
OSO#07	Inspection of the UAS (product inspection) to ensure consistency to the ConOps	M
OSO#08	Operational procedures are defined, validated and adhered to	H
OSO#09	Remote crew trained and current and able to control the abnormal situation	M
OSO#10	Safe recovery from technical issue	M
	Deterioration of external systems supporting UAS operation	
OSO#11	Procedures are in place to handle the deterioration of external systems supporting UAS operation	H
OSO#12	The UAS is designed to manage the deterioration of external systems supporting UAS operation	M
OSO#13	External services supporting UAS operations are adequate to the operation	H
	Human error	
OSO#14	Operational procedures are defined, validated and adhered to	H

OSO Number		SAIL **IV**
OSO#15	Remote crew trained and current and able to control the abnormal situation	M
OSO#16	Multi crew coordination	M
OSO#17	Adequate resting times are defined and followed	M
OSO#18	Automatic protection of critical flight functions (e.g. envelope protection)	M
OSO#19	Safe recovery from human error	M
OSO#20	A Human Factors evaluation has been performed and the HMI found appropriate for the mission	M
	Adverse operating conditions	
OSO#21	Operational procedures are defined, validated and adhered to	H
OSO#22	The remote crew is trained to identify critical environmental conditions and to avoid them	M
OSO#23	environmental conditions for safe operations defined, measurable and adhered to	M
OSO#24	UAS designed and qualified for adverse environmental conditions (e.g. adequate sensors, DO-160 qualification)	H

4 References

[1] CORUS ConOps intermediate version

Intermediate ConOps

Annex D - MEthoDology for the U-Space Safety Assessment (MEDUSA)

D6.2	CO
CORUS	
Grant:	763551
Call:	2016 SESAR 2020 RPAS Exploratory Research Call (H2020 – SESAR -2016-1)
Topic:	Topic 01: SESAR UTM Concept Definition
Consortium coordinator:	EUROCONTROL
Edition date:	18 Mar 2019
Edition:	01.00.00

Founding Members

EUROPEAN UNION

EUROCONTROL

SESAR JOINT UNDERTAKING

1 Table of Contents

2 Introduction 3
3 Holistic safety assessment approach 4
3.1 Introduction 4
3.2 A broader success based approach to assess safety in U-Space 4
3.3 The acceptable level of Safety 6
3.4 The different steps in the process 6
3.5 U-Space safety objectives and safety requirements definition 7
4 U-Space Integrated Risk Models 8
5 Steps of MEDUSA process to evaluate U-Space operations safety 10
5.1 Definition Phase (DP) 10
5.2 Operational Specification phase (OSP) 10
6 Acronyms and Terminology 12
7 References 13

2 Introduction

The MEthoDology for the U-Space Safety Assessment (MEDUSA) is a method proposed by the CORUS team for identifying and managing hazards posed by drone traffic in the U-Space. The main principle of this methodology is based in the SESAR Safety Reference Material (SRM) where a broader approach to assess safety is adopted. The broader safety approach addresses both the positive contribution of U-Space to aviation safety (success approach), as well as U-Space's negative effect on the risk of an accident (failure approach). The success approach is required to show whether the U-Space is intrinsically safe, in the absence of failure.

The MEDUSA process provides a holistic approach to the U-Space safety assessment incorporating different viewpoints, not only the operator perspective but also the airspace perspective of the U-Space service provision and the interoperability of these services with the ATS/ATM. The drone and operator perspective is in fact taken into account within MEDUSA considering the outcome of different SORA assessment and integrating those results in a single U-Space safety assessment. The intent of the MEDUSA is to identify and develop safety requirements and/or recommendations for U-space services in different operational environment/scenario.

3 Holistic safety assessment approach

3.1 Introduction

In order to perform a coherent and comprehensive U-Space safety assessment a holistic safety assessment approach is necessary. This holistic approach is provided considering two main viewpoints, a first one from the airspace assessment viewpoint side provided by the SESAR Safety Reference Material (SRM) [1] and a second one taking into account the drone and operator viewpoint provided by the Specific Operations Risk Assessment (SORA) methodology **Error! Reference source not found.**.

In relation with the risk determination, three areas of interest are proposed to assess the mitigation level provided by U-space services (s):

- Level of mitigation of air risk with U-space services in order to prevent collision between un-manned and manned aircraft as well as between un-manned aircraft and un-manned aircraft.
- Level of mitigation of ground risk with U-space services in order to prevent fatalities on the ground and damage to critical infrastructure including aviation infrastructures like Control towers, Ground Navaids, Comm antenna mast, etc.
- Level of mitigation of incursion into "no-fly zones" (airspace infringement) in order to prevent un-manned aircraft to penetrate into predefined airspace/areas

3.2 A broader success based approach to assess safety in U-Space

The increase of automation and development of new technologies in the frame of unmanned aerial systems (UAS) oblige to have a "broader" safety approach in contrast to other classical methodologies. Assessing how reliable the U-Space (as a combination of equipments, procedures and human resources organised to perform a function within the context of U-Space) needs to be in order to ensure an adequate protection against internal failures of the system's elements does not seem to be sufficient to demonstrate that drone operations supported by UTM systems will be safe. The U-Space system cannot be seen just as a combination of equipment, technological solutions, procedures and human resources instead of the organization and interaction of all these elements performing a function. Additionally the interfaces that make possible the interconnection with manned ATM system have to be taken into account.

Assuming that the U-Space is intrinsically safe when no failure occurs is not a valid argument for a new concept of aviation that will rely mainly in technology and automation and where the level of safety has to be commensurate to the risk level. Consequently, a safety assessment for U-Space will require examining the so-called "success based approach" in addition to the internal system failures (termed "failure based approach").

The success based approach determines the functionality and performance that would need to be incorporated into the design of the U-Space Services to ensure that when the system is working as intended it is able to provide, at the very least, a tolerable level of safety but also ensures that the potential safety benefit of the design is maximised. The aggregate of the success and failure contributions needs to be at the very least neutral to demonstrate that safety will not deteriorate and substantially positive for the devised safety nets. Therefore, this means that the threshold of what is considered a system failure cannot be determined until a complete definition of what is success is provided. Success approach not only completes the failure approach perspective but also is necessary to its own definition. Hence, the U-Space safety methodology continues to require that safety assessments examine internal system failures (termed "failure based approach") but additionally requires the consideration of the "success based approach".

3.2.1 Success and failure approach

The U-Space Safety assessment must encompass a "broader" approach considering safety from the two aforementioned perspectives:

- Firstly, a success approach in which it is assessed how effective the new concepts and technologies would be when they are working as intended – i.e. how much the pre-existing risks that are already in unmanned aviation will be reduced by the U-Space operations and services placed. This is concerned with the positive contribution to aviation safety that the U-Space services introduction make in the absence of failure.

- Secondly, a failure approach in which we assess the U-Space system generated risks, i.e. induced by the U-Space services and operations failing. This is concerned with the negative contribution to the risk of an accident that the U-Space concepts might make in the event of failure(s), however caused.

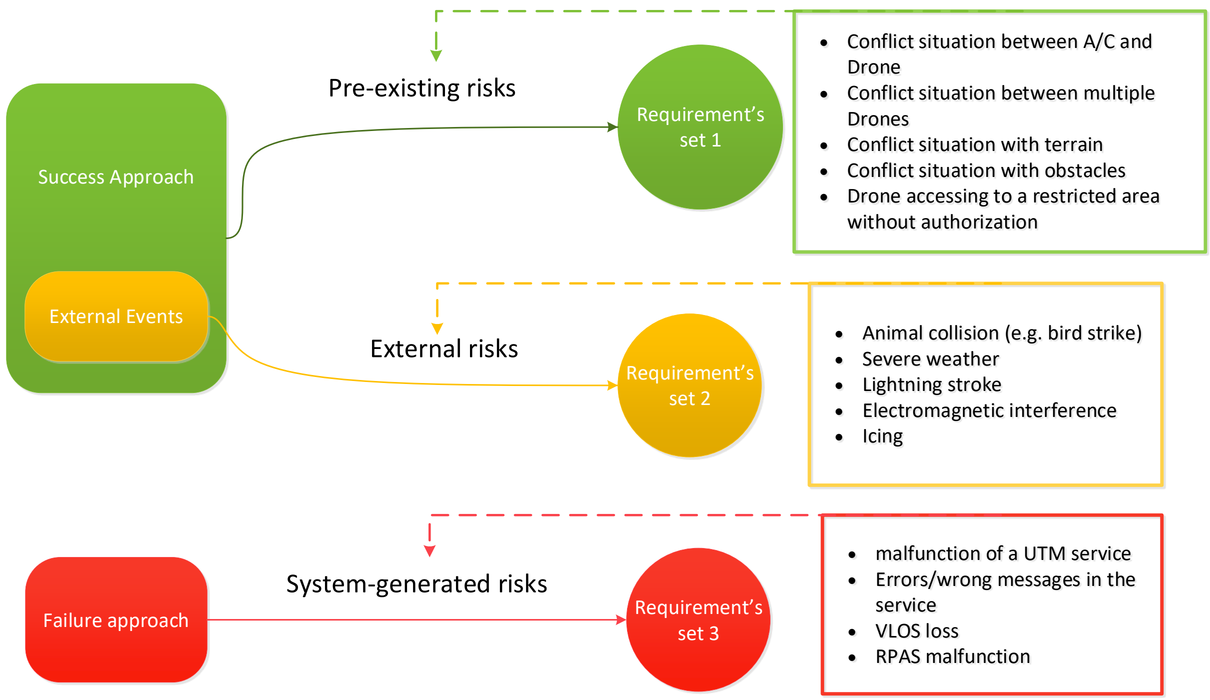


Figure 1 - U-Space risks' derivation from success and failure approaches

3.3 The acceptable level of Safety

The acceptable level of safety shall be determined by considering the relevant risks associated to the drone operations, which is then characterised by the U-Space Safety Criteria. One or several U-Space Safety Criteria could be derived for a given operation depending on the risk identified.

To illustrate U-Space Safety Criteria determination, let us consider the risk of air collision introduced by VLOS and BVLOS operations at or near a controlled aerodrome. In this operational environment, a ground UAS conflict detection assistance service is deployed as a U-Space service. In such case if we want to introduce drone operations without detrimental impact to the current level of safety in this operational environment, the U-Space Safety Criteria should be determined as follows:

> SAC#1: The probability of imminent collision per flight hour between manned IFR flight and un-manned VLOS flight shall not be greater than current probability of imminent collision per flight hour between manned IFR flight and manned VFR flights when ground UAS conflict detection assistance service is deployed.
>
> SAC#2: The probability of imminent collision per flight hour between manned IFR flight and un-manned BVLOS flight shall not be greater than current probability of imminent collision per flight hour between manned IFR flight and manned IFR flights when ground UAS conflict detection assistance service is deployed.

3.4 The different steps in the process

When U-Space Safety Criteria are determined, the following three steps are essential to assess in a holistic and exhaustive way the safety risks arising from drone operations in a given operational environment:

- The pre-existing hazards (associated to air risk, ground risk and/or airspace infringement) shall be considered in order to demonstrate that the level of mitigation associated to U-Space services deployed in a given operational environment is sufficient to satisfy the U-Space Safety Criteria. This assessment is first carried out in normal conditions (fault-free conditions) and shall consider all drone operations (e.g VLOS, BVLOS,…) which are foreseen in this operational environment (VLL, Aerodrome, TMA, controlled or uncontrolled airspace,…). The result of this safety assessment in normal conditions is essential in order to specify/design/implement/evaluate the proper U-space services for safe operations in a given operational environment when considering all potential simultaneous or non-simultaneous drone operations.

- The level of U-space mitigations shall then consider abnormal conditions, which will/might be encountered in this operational environment. These abnormal conditions are external events and are rare events that might impact drone operations and/or U-space services like severe weather conditions, GNSS interferences, solar storm… The result of this safety assessment in abnormal conditions might lead to derive additional requirements/mitigations. These requirements/mitigations might complement U-Space services requirements or be directly allocated to drone operators or to external elements than those constituting the U-space service provision (e.g. ATSP)

- Finally, the level of U-space mitigations shall considered faulted conditions where U-space service provision fails. U-space services are relying on ground, airborne and spatial elements meaning that “system-generated” hazards associated to these faulted conditions might be caused by failure of one or more of these elements (individually or in combination). The result of this safety assessment in faulted conditions might lead to derive integrity/reliability requirements and/or mitigations. The integrity/reliability requirements will be applicable to U-Space services and mitigations might complement U-Space services' requirements or be directly allocated to drone operators or to external elements than those constituting the U-space service provision (e.g. ATSP)

This holistic safety assessment approach could be summarised as a safety assessment of the air risk, ground risk and airspace infringement risk in a given operational environment considering all the drone operations planned in this environment to satisfy U-Space Safety Criteria. The level of mitigation necessary to achieve, to be introduced in this operational environment is determining the U-Space services to be implemented from a safety point of view. The safety assessment shall be conducted considering normal, abnormal and faulted conditions in order to derive a complete and correct set of safety requirements/mitigations to be implemented at U-Space service level, at drone operators' level and/or at non U-space service providers level (e.g. ATSP).

U-Space safety objectives and safety requirements definition

The outcome of the MEDUSA process is to define safety objectives and derive safety requirements. These Safety objectives and Safety Requirements are defined by considering:

- What the U-Space services and systems are required to do/offer in order to minimize the level or risk or meet a required Target level of Safety (TLS).
- The integrity required of the U-Space services and system in order to limit the risk caused by the failure of the U-Space system.
- Any additional means of mitigating the consequences of the hazards caused by failure of the U-Space services and systems or the UAVs.

The definition of what is meant by safe in the process is described by the SAfety Criteria (SAC) which are then allocated to safety objectives (SOs), and then safety requirements (SRs) which set both the minimum positive (success approach), and maximum negative (failure approach), safety contributions of the UTM system.

Hence 'Safety requirement' shall mean the necessary risk reduction measures identified in the risk assessment to achieve a particular safety objective. They describe the functional, performance and integrity safety properties at different levels as the operational, procedural, environmental characteristics, in relation with interoperability requirements and in the final term at a system-design level.

Overall the MEDUSA process is an iterative process of requirements specification – a requirements satisfaction exercise that is completed when it is demonstrated that the actual Concept of Operation (ConOps) is realistic, i.e. achievable in terms of the safety requirements it places on the human, procedural and technological elements of the system.

4 U-Space Integrated Risk Models

The Integrated Risks Models applied to the U-Space consists of aviation risk models, which shows the risks of drone's accidents and provides a structured breakdown of their causes, with particular emphasis on U-Space service provision contributions (both positive and negative). The U-space Integrated Risk Models will be composed by a set of templates (one for each accident type) that can be used to identify where and how each U-Space service will impact the safety of the whole U-Space management concept. In this sense, a new classification of accidents/incidents typology within the U-Space airspace versus the classical accident categorization may be considered. Each new future U-Space service introduced or modified can be modelled through adjustments representing its expected impacts on appropriate elements of the risk model.

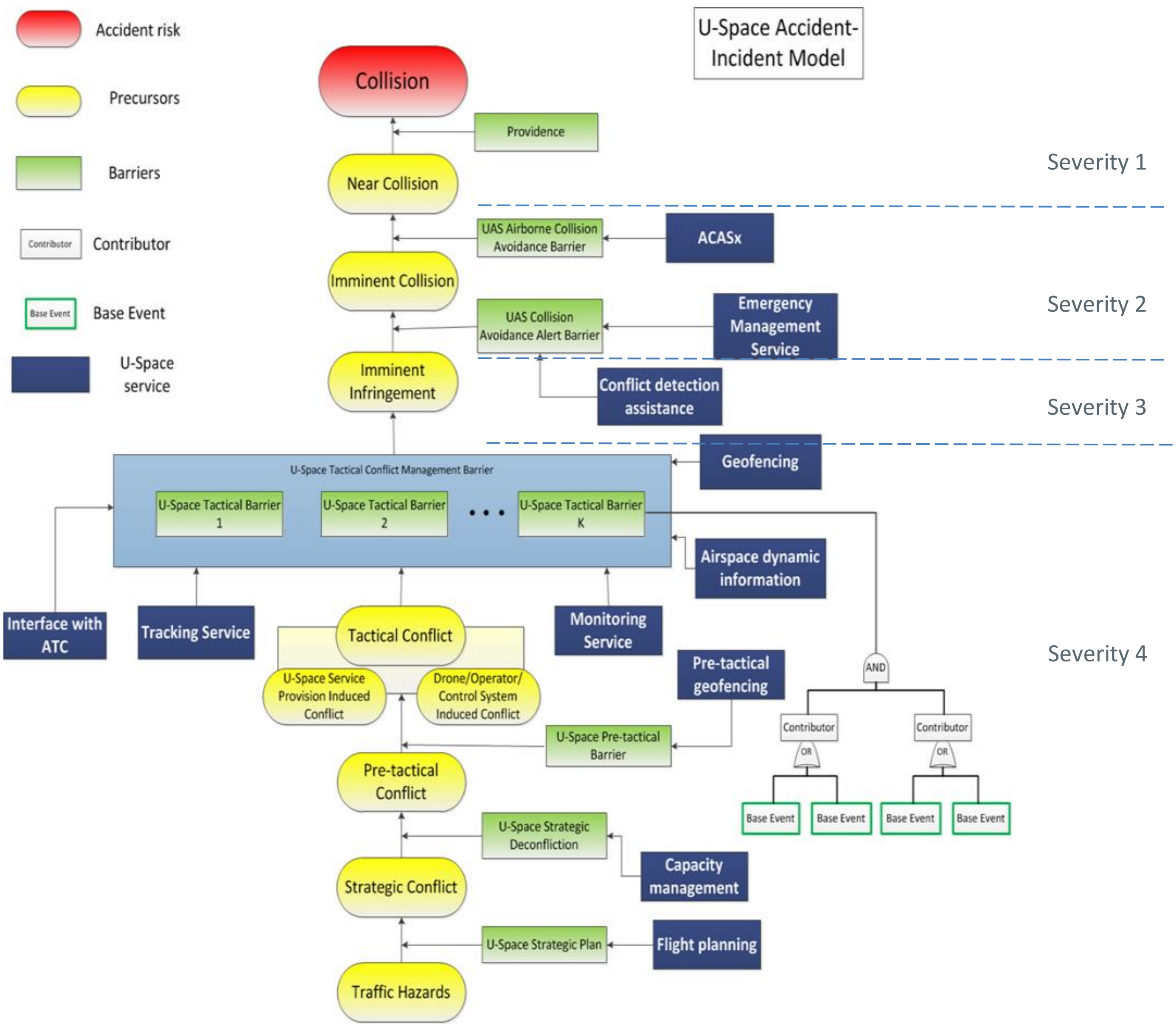
The use of integrated risk models could facilitate/standardise the safety assessment by identifying more easily the U-Space Safety Criteria.

Currently the only available model is the integrated risk model relative to air collision (see figure 1) which represents the main services associated to a Drone Traffic Management System[1]. Considering the novelty of this model, it is expected that the development and testing of the different U-Space services will contribute to the improvement and refinement of the model based on specific environments, UAS operations, U-Space services being tested, validated or implemented.

In the following Figure 1 the skeleton of the integrated risk model relative to air collision for U-Space is presented. This Figure 1 shows the evolution of the possible traffic hazards for unmanned aviation that may derive to a mid-air collision in the U-Space. Each yellow type-box leads to a higher risk accident precursor or a precursor closer to a collision event. At the same time each link between a pair of precursors or between a near collision and a collision is prevented by a barrier or multiple barriers intended to avoid the chain of events that result in a higher level or risk and consequently to an accident.

This integrated risk model (figure 1) should be used to determine the U-space Safety Criteria relevant in each operational environment/UAS operation examining the U-Space services under consideration in each case. In other words U-Space Safety Criteria should be determined at precursor levels (yellow bubbles) and more precisely at the output of any U-Space Service barrier (green rectangle) considered. To illustrate this, let us consider the introduction of a tracking service supporting the U-Space tactical conflict management barrier (see figure 1). In this example, the associated U-Space Safety Criteria should be relative to imminent infringement and worded for example as follows: "*The probability of imminent infringement* per flight hour *between manned IFR flight and un-manned VLOS flight shall not be greater than current probability of imminent infringement between manned IFR flight and manned VFR flights* per flight hour *when UAS tracking service is deployed*".

[1] The Drone Traffic Management System is the system supporting the U-Space services.



U-Space Accident-Incident Model
Accident risk
Precursors
Barriers
Contributor
Base Event
U-Space service
Collision
Providence
Near Collision
Severity 1
UAS Airborne Collision Avoidance Barrier
ACASx
Imminent Collision
UAS Collision Avoidance Alert Barrier
Emergency Management Service
Severity 2
Imminent Infringement
Conflict detection assistance
Severity 3
Geofencing
U-Space Tactical Conflict Management Barrier
U-Space Tactical Barrier 1
U-Space Tactical Barrier 2
U-Space Tactical Barrier K
Airspace dynamic information
Interface with ATC
Tracking Service
Tactical Conflict
Monitoring Service
Pre-tactical geofencing
Severity 4
AND
U-Space Service Provision Induced Conflict
Drone/Operator/ Control System Induced Conflict
U-Space Pre-tactical Barrier
Contributor
OR
Base Event
Pre-tactical Conflict
U-Space Strategic Deconfliction
Capacity management
Strategic Conflict
U-Space Strategic Plan
Flight planning
Traffic Hazards

5 Steps of MEDUSA process to evaluate U-Space operations safety

The evaluation of the safety of drone operations supported by U-Space services will be the main goal of MEDUSA. In order to support this safety evaluation, in the following paragraphs the safety assurance steps at an exploratory research level are proposed:

5.1 Definition Phase (DP)

- Step 1: Identify precisely the operational environment where the drone operations will be conducted (VLL, controlled or uncontrolled airspace, Aerodrome, TMA, Enroute (Lower, Upper), level of ATS service provided to manned aviation, level of traffic/ complexity of manned aviation, level of VFR traffic, level of IFR traffic, rural environment, urban environment, density of overflown population, etc…).

- Step 2: Identify precisely all UAS operations which will be conducted in this operational environment (VLOS, BVLOS, EVLOS, UAS class (open, specific, certified), UAS traffic density,…). Review the SORA results (if available) for each individual drone operation and identify candidate safety requirements/mitigations for the different risks per SORA assessment.

- Step 3: Identify the risk inherent to UAS operations considering the operational environment (Step 1) and UAS operations (Step 2). Risks inherent to aviation are e.g. air risk (manned/unmanned, unmanned/unmanned), ground risk (people, critical infrastructure including aviation infrastructure), airspace infringement risk (prohibited area, restricted area, dangerous area or areas where drone operations are forbidden).

- Step 4: Identify the U-space services to be assessed.

- Step 5: Conduct an initial assessment of these U-Space services (Step 4) to mitigate the risks inherent to UAS operations (Step 3) and identify any gap. Gap in this context means a missing U-Space service to mitigate a specific risk. If a gap is confirmed, check if a U-Space service should be added or if the risk should be suppressed from the safety assessment with duly justification.

- Step 6: Based on the previous step and using the U-Space integrated risk model, determine the relevant U-Space Safety Criteria.

5.2 Operational Specification phase (OSP)

- Step 1: Conduct a safety assessment at an early operational level (to complement DP Step 5) to show that proposed U-Space services mitigate the different risks inherent to UAS operations to satisfy the Safety Criteria in normal conditions (conditions encountered on a day to day basis). If needed:
    - Refine/complete the proposed U-Space services from an operational safety point of view.
    - Identify if needed any Air Traffic Service (ATS) which is required to satisfy U-Space Safety Criteria

- **Step 2:** Identify the relevant abnormal conditions for the operational environment/UAS operations and determine if:
    - additional/refined U-Space services and/or
    - dedicated Air Traffic Services (ATS)

  are needed to mitigate the operational consequence of these abnormal conditions to satisfy U-Space Safety Criteria.
- **Step 3:** Identify the operational hazards (system-generated hazards) caused by failures of the U-Space services and assess the severity of the effects (distance from the accident) from each Operational Hazard. This step should determine the level of integrity/reliability of the U-Space service. Common mode of failure at operational level must be assessed at that stage in order to determine if a single faulted condition could lead to the simultaneous failure of several U-Space services leading to a more severe effect.
- **Step 4:** Verify that the safety assessment at operational level has been conducted considering normal, abnormal and faulted conditions (Step 1 to Step 3). At that stage it is shown that proposed U-Space services (refined/modified/adapted in accordance with the safety assessment) should be able to mitigate risks inherent to UAS operations and system-generated risks in order to satisfy the U-Space Safety Criteria.

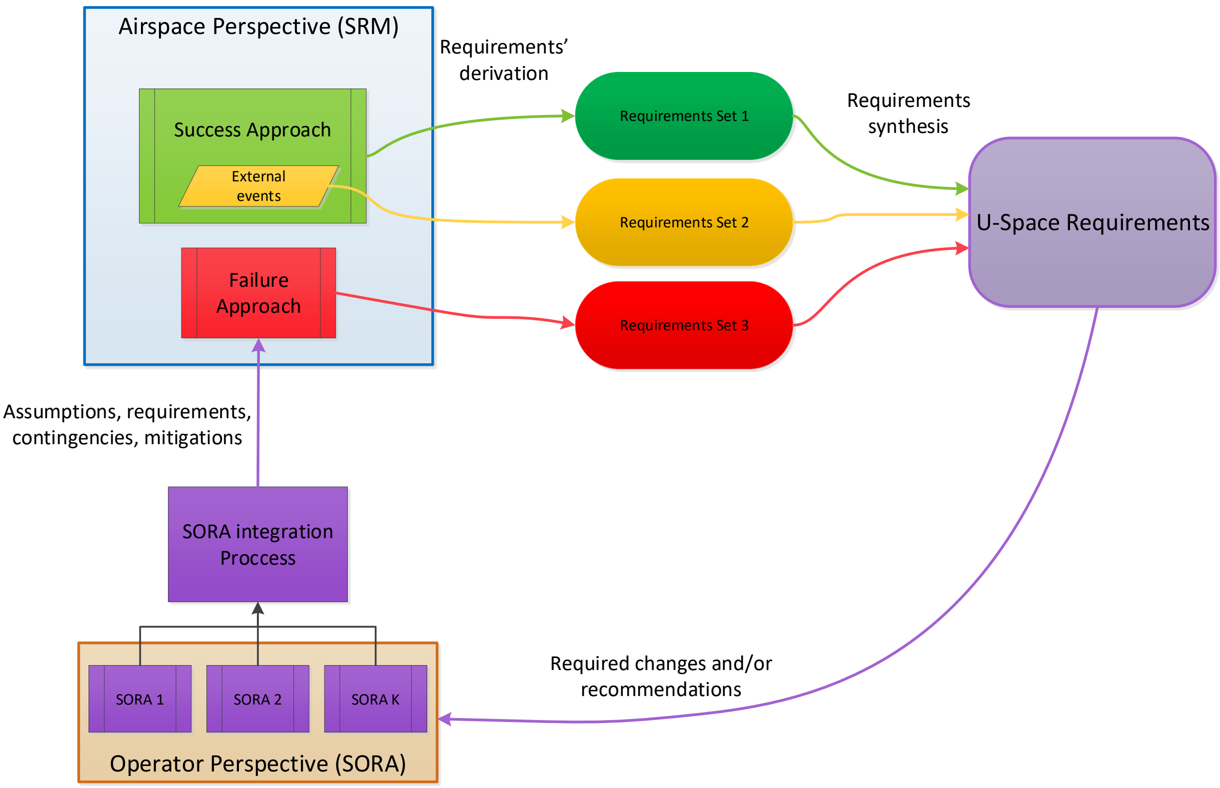


Figure 2 - Outline diagram of the Methodology for U -Space Safety Assessment

6 Acronyms and Terminology

Term	Definition
ATM	Air Traffic Management
ATS	Air Traffic Service
ATSP	Air Traffic service Provider
BVLOS	Beyond Visual Line Of Sight
DP	Definition Phase
IFR	Instrument Flight Rules
OSP	Operational Specification Phase
RTS	Real Time Simulation
SAC	Safety Criteria
SORA	Specific Operational Risk Assessment
SOs	Safety Objectives
SRM	Safety Reference Material
SRs	Safety Requirements
TMA	Terminal Area
TLS	Target Level of Safety
UAS	Unmanned Aerial System
VFR	Visual Flight Rules
VLL	Very Low Level
VLOS	Visual Line Of Sight

Table 1 : Acronyms and terminology

7 References

[1] SESAR, Safety Reference Material, Edition 4.0, April 2016

[2] JARUS guidelines on Specific Operations Risk Assessment (SORA)

Intermediate ConOps

Annex E - list of Threats and Events

D6.2	CO
CORUS	
Grant:	763551
Call:	2016 SESAR 2020 RPAS Exploratory Research Call (H2020 – SESAR -2016-1)
Topic:	Topic 01: SESAR UTM Concept Definition
Consortium coordinator:	EUROCONTROL
Edition date:	19 Mar 2019
Edition:	01.00.00

Founding Members
EUROPEAN UNION
EUROCONTROL

SESAR
JOINT UNDERTAKING

Table of contents

1 Scope ... *3*

2 Drone threats/events ... *4*

2.1 TECHNICAL / MECHANICAL FAILURES ... 4

2.2 METEOROLOGICAL / ENVIRONMENTAL EVENTS ... 5

2.3 HUMAN / OPERATIONAL ... 6

2.4 SECURITY ... 6

3 U-Space threats/events ... *7*

1 Scope

During the study on how to approach the assessment for safety, it has been considered necessary to generate a simplified and generic list that includes all possible threats and events during a drone operation.

There are two groups of threats depending on whether the risk analysis is performed from the operator's point of view (i.e. SORA) or if the system is evaluated as a whole to identify possible safety gaps in the proposal of new U-Space scenarios. For the first group, **Drone Threads/Events**, the list includes the threads that affect the UAS set (drone, ground station and pilot) and can compromise the safety of an operation. For the second one, the **U-Space Threats/Events** list, all the possible situations that can compromise the safety derived from the use of U-Space services are included in a few main threats. In other words, the drone part focuses on the execution of an operation and would be equivalent to the SORA methodology while the U-Space threats part involves an analysis of the global system, as proposed in the MEDUSA methodology.

Both groups are based on the commercial drone technology existing at the time of publication of this document and it is possible that the lists of threats/events will evolve in the future.

In order to use this list as a reference during a Risk Assessment, it is necessary to divide some threats (in black) into sub-threats (in gray) when there are different mitigations or consequences.

Finally, it should be noted that for the sake of simplicity not every event/failure/error that could occur is listed. E.g. “fire in/on the drone”, “engine failure” and “drained energy source” probably all lead to an unintentional loss of altitude. Therefore, only “unintentional loss of altitude” was listed as a threat/event since this risk assessment is not for the drones but for the U-Space services and systems only. Thus, it is not important which drone system/equipment lead to the drone failure; instead, the overall non-nominal behaviour of a drone is important for this risk assessment.

> *Note: A risk already contains information about probability and impact. Therefore, the terms “threat” or “event” must not be confused with the term “risk”.*

2 Drone threats/events

2.1 TECHNICAL / MECHANICAL FAILURES

	ID	Threat/Event	Description (optional)
TECHNICAL / MECHANICAL FAILURES	RT001	Datalink loss (telemetry & FPV)	
	RT001.1	Direct datalink loss (radio signal, video signal)	includes video streaming (FPV)
	RT001.2	Indirect datalink loss	Mobile network, satellite link, repeaters, etc.
	RT002	Datalink loss (telecommand)	
	RT002.1	Direct datalink loss (radio signal Rx-Tx)	
	RT002.2	Indirect datalink loss	Mobile network, satellite link, repeaters, etc.
	RT003	voice-link failure	with ATC or with 2nd pilot for E-VLOS
	RT004	Sensor/Camera failure	payload or for control (FPV, computer vision navigation, range sensor, etc.), depends on the mission description
	RT005	Position Emitter/Receiver failure (e.g. Transponder)	not visible for U-Space, TCAS or ATC
	RT006	Directional loss	
	RT006.1	GPS failure	incl. GPS perturbations (e.g. multipath, signal shadow, ionosphere)
	RT006.2	Compass failure	
	RT006.3	IMU (Inertial Measurement Unit) failure	
	RT006.4	Altitude sensor failure (barometric or radar)	
	RT007	Flight controller failure	
	RT008	Unintentional loss of altitude	
	RT008.1	Engine failure	
	RT008.2	Drained energy source	Tank, Battery, Alternator, etc.
	RT008.3	ESC (Electronic Speed Control) failure	
	RT008.4	Multiple engine failure	
	RT008.5	Helix / propeller failure	
	RT009	Total loss	
	RT009.1	Structural failure	Write-off, not partly damaged where autopilot is still able to limp to ground
	RT009.2	Battery failure (battery for C2 and servos)	
	RT010	Parachute failure	
	RT011	Loss of payload	Parcel, dangerous goods, etc.
	RT012	Erroneous data	Drone sends erroneous data to services
	RT013	Latency	Drone sends relevant information too late
	RT014	Processing error	Derivation of faulty/wrong results by drone processing unit
	RT015	Datalink loss with Service	no connection between drone/operator and Service

Table 1. Technical/Mechanical failures

2.2 METEOROLOGICAL / ENVIRONMENTAL EVENTS

	ID	Threat/Event	Description (optional)
METEOROLOGICAL / ENVIRONMENTAL EVENTS	RM001	Animal collision (bird strike)	
	RM002	Inappropriate weather	
	RM002.1	Rain/Hail/Snow	
	RM002.2	Mist / Fog	
	RM002.3	High wind	
	RM002.4	Gusty wind (irregular speed and direction)	
	RM003	Severe weather	
	RM003.1	Lightning strike	
	RM003.2	Extreme temperatures (e.g. battery temp range)	
	RM004	Air pollution	
	RM005	Electromagnetic interference	
	RM005.1	Metal structures	
	RM005.2	Antennas	
	RM005.3	Other UAVs	
	RM005.4	Electrical motors	
	RM005.5	Radio signals	
	RM006	Solar storms	
	RM007	High altitudes (service ceiling)	
	RM008	Icing	
	RM009	Corrosive environments (Sea Water)	
	RM010	Dust/Sand (e.g. engines inoperable)	

Table 2. Meteorological/Environmental events

2.3 HUMAN / OPERATIONAL

	ID	Threat/Event	Description (optional)
HUMAN / OPERATIONAL	RH001	Mission planning error	
	RH002	Drone enters segregated airspace inadvertently	
	RH003	PiC distraction while manual flight	
	RH004	VLOS loss	
	RH005	Obstacle collision	
	RH005.1	Body collision	e.g. trees, buildings, object of inspection, persons
	RH005.2	Terrain collision	
	RH006	Collision with manned aviation	incl. parachutes, ultralight, balloons, etc.
	RH007	Collision with RPAS/UAS	
	RH008	Medical issue / human disease	
	RH009	Human error	
	RH009.1	Skill-based errors	e.g. failed to prioritize attention, inadvertent use of flight controls
	RH009.2	Decision errors	e.g. misdiagnosed emergency, wrong response to emergency
	RH009.3	Perception errors	e.g. misjudged distance/altitude/airspeed, spatial disorientation
	RH010	Immediate give-way event	
	RH010.1	Emergency/Police helicopter	
	RH010.2	Manned vehicle emergency landing	
	RH010.3	First-aid drone	

Table 3. Human/Operational threats

2.4 SECURITY

	ID	Threat/Event	Description (optional)
SECURITY	RI001	Intentional collision	
	RI001.1	Projectile damage	
	RI001.2	Human attack	
	RI002	Intentional interference	
	RI002.1	Cyber attack	

Table 4. Security threats

3 U-Space threats/events

	ID	Threat/Event	Description (optional)
SERVICES	RS001	Technical failure	
	RS001.1	Datalink loss	Loss of datalink to the drone or the pilot/operator
	RS001.2	Loss of data	Loss of relevant data, e.g. due to server failure
	RS001.3	Processing error	Derivation of faulty/wrong results
	RS002	Total loss	Causes an emergency of the service
	RS003	Latency	Relevant information/instruction is sent too late
	RS004	Dependency	Dependency on another service

Table 5. U-Space services threads/events

EXPLORATORY RESEARCH

Intermediate ConOps

Annex F - Safety Occurrence Reporting

D6.2	CO
CORUS	
Grant:	763551
Call:	2016 SESAR 2020 RPAS Exploratory Research Call (H2020 – SESAR -2016-1)
Topic:	Topic 01: SESAR UTM Concept Definition
Consortium coordinator:	EUROCONTROL
Edition date:	19 Mar 2019
Edition:	01.00.00

Founding Members

EUROPEAN UNION EUROCONTROL

SESAR JOINT UNDERTAKING

Table of Contents

1 Examples of RPAS/UAS related Safety Occurrence Reporting 3

1.1 Background 3

1.2 Safety Occurrence Reporting Requirements 3

2 Proposed Safety Occurrence Reporting Regulation Improvements 5

2.1 Annex I: AIR OPERATIONS 6

2.2 Annex II: OCCURRENCES RELATED TO TECHNICAL CONDITIONS, MAINTENANCE AND REPAIR OF THE AIRCRAFT 7

2.3 Annex III: OCCURRENCES RELATED TO AIR NAVIGATION SERVICES AND FACILITIES.......... 7

2.4 Annex IV: OCCURRENCES RELATED TO AERODROMES AND GROUND SERVICES 8

3 Some Examples of Safety Occurrence Reporting 9

3.1 Accident Report.. 9

3.2 Some Examples of incident/accident reporting WRT CORUS WP2 Use Cases 11

List of Tables

Table 1 Existing safety occurnece reporting requirements 4

List of Figures

Figure 1 Reporting requirements for example 1 11

Figure 2 Reporting requirements for example 2 12

1 Examples of RPAS/UAS related Safety Occurrence Reporting

1.1 Background

The number of RPAS pilots flying commercially is increasing, as well as the number of people flying unmanned aircraft for hobby or recreational use, so it is important to be familiar with the EU CAAs and AAIBs rules for unmanned aircraft incident/accident reporting.

The EU CAAs and AAIBs have different rules to ensure proper oversight of certain RPAS operations, and different rules mean that some events may have to be reported to one Authority but not the other.

The Commission Implementing Rule 2015/1018 states that EU Regulation No 376/2014 applies to all aircraft defined and covered by that Regulation, including manned aircraft and Remotely Piloted Aircraft Systems.

Based on that, incident and accident reporting requirements shall apply to unmanned aircraft as well as conventional manned aircraft (excluding, based on the specific national regulation, very small RPAS with a defined Maximum Take-Off Weight). So far, these events (generally indicated with the term *"occurrences"*) only refer to interference with manned aviation operations, not taking into account other types of interactions like the ones between RPAS for example that could contribute to the ground risk of aviation.

Service Providers and, more in general, all the involved aviation actors involved in an event have a legal responsibility to report to their national authorities all occurrences of which they become aware. The responsibilities for the reporting, collection and exchange of safety data and investigation of safety occurrences are established by EU Regulations and Directives and by national regulations too.

1.2 Safety Occurrence Reporting Requirements

Specific occurrences should immediately be reported to the Civil Aviation and/or other appropriate Authority in line with the following time constraints, depending on their initial classification:

	Notification to the national Air Accident Investigation Body (AAIB)	**Mandatory notification to Organization (Individuals)**	**Mandatory Report submission to the Competent Authority (Organizations)**	**Organizations Investigation Report to the Competent Authority**
Accident	Immediate/ASAP	Within 72 hours	Within72 hours from notification	N/A
Serious Incident	Immediate/ASAP	Within 72 hours	Within72 hours	90 days

Incident	N/A	Within 72 hours	Within 72 hours	90 days (when applicable)

Table 1 Existing safety occurnece reporting requirements

Accident and/or serious incidents that apply to RPAS could include the following events but are not limited to those listed here:

- Flight control system malfunction or failure.
- Inability of any required flight crewmember to perform normal flight duties as a result of injury or illness.
- In-flight fire, which is expected to be generally associated with batteries.
- Aircraft collision in flight.
- Release of all or a portion of a propeller blade from an aircraft.
- Etc.

2 Proposed Safety Occurrence Reporting Regulation Improvements

The most relevant occurrences for RPAS to be mandatorily reported observed in the commission implementation rule 2015/1018 are the following[1]:

- Annex I – Occurrences Related to the Operations of the Aircraft
  - Point 5 – External Environment and Meteorology
    - (8) Interference with the aircraft by firearms, fireworks, flying kites, laser illumination, high powered lights, lasers, Remotely Piloted Aircraft Systems, model aircraft or by similar means
- Annex III – Occurrences Related to Air Navigation Services and Facilities
  - Point 3 – Other Occurrences
    - (3) Interference with an aircraft, an ATS unit or a radio communication transmission including by firearms, fireworks, flying kites, laser illumination, high-powered lights lasers, Remotely Piloted Aircraft Systems, model aircraft or by similar means
- Annex V - Occurrences Related to Aircraft other than complex motor-powered aircraft
  - Point 3 – External Environment and Meteorology
    - (3) report "Interference with the aircraft by firearms, fireworks, flying kites, laser illumination, high powered lights lasers, Remotely Piloted Aircraft Systems, model aircraft or by similar means"

Based on the initial analysis performed by CORUS project experts some preliminary modifications and recommendations on the existing regulations and practices should be noted making reference to the following requirements:

- Adaptation of existing safety reporting related regulations for U-space;
- Minimisation of the impact on the additional work to be performed by involved U-space stakeholders/organizations;
- Definition of clear and concise reporting requirements to simplify proposed modifications as much as possible.

The following are the proposed modifications to the existing EU IR 2015/1018 concerning the occurrences that must be reported. It is an addition to what is already written and is subdivided per different Annexes sections:

[1] Note that the numbering structure of the implementation rule has been maintained within this document. For more detail is recommended to consult the reference document.

2.1 Annex I: AIR OPERATIONS

- 1.1 Flight Preparation
  - incorrect data inputs in the drone navigation software (4D trajectory, geo-awareness update)
- 1.2 Aircraft preparation:
  - Drone improperly assembled (including software)
- 1.3 Take-off and landing:
  - Non respect of safety distance from obstacle, or persons, during take-off or landing
- 1.4 Any phase of flight:
  - Lack of activation of the flight envelope protection, including stall warning, stick shaker, stick pusher, automatic protections and geo-awareness manoeuvres.
  - Misinterpretation of automation mode or of any flight deck information provided to the remote pilot, which has or could have endangered the aircraft, its occupants or any other person.
  - Unintentional deviation from intended or assigned track
- 1.5. Other types of occurrences:
  - loss of communication with the observer in case of extended visual line of sight (E-VLOS) operation.
  - loss of visual contact in case of visual line of sight (VLOS) operation.
  - Drone flying in airspace class not corresponding to his assigned category (X,Y,Z)
- 3. INTERACTION WITH U-SPACE SERVICES AND U-SPACE TRAFFIC MANAGEMENT (UTM)
  - Unsafe clearance.
  - Prolonged loss of communication with UTM Unit.
  - Conflicting instructions from different UTM Units potentially leading to a loss of separation.
  - Intentional deviation from UTM services instruction which has or could have endangered the RPAS, its occupants (if any) or any other RPAS or Aircraft
- 4. EMERGENCIES AND OTHER CRITICAL SITUATIONS
  - Failure to apply the correct non-normal or emergency procedure by *the remote pilot* to deal with an emergency
  - Remote pilot fatigue impacting, or potentially impacting, the ability to perform safely their flight duties.
- 6. SECURITY

- Difficulty in controlling, intoxicated, violent or unruly payload[2] *endanger the flight*
- Discovery of a stowaway
- Hack of the communication C2 channel

2.2 Annex II: OCCURRENCES RELATED TO TECHNICAL CONDITIONS, MAINTENANCE AND REPAIR OF THE AIRCRAFT

- 2. DESIGN
  - Any failure, malfunction, defect or other occurrence related to a product, part, or appliance which has resulted in or may result in an unsafe condition.
- 3. MAINTENANCE AND CONTINUING AIRWORTHINESS MANAGEMENT
  - Wrong assessment of a serious defect, or serious non-compliance with MEL (Minimum Equipment List) and Technical logbook procedures.
  - Significant malfunction, reliability issue, or recurrent recording quality issue affecting a flight recorder system (such as a flight data recorder system, a data link recording system or a cockpit voice recorder system) or lack of information needed to ensure the serviceability of a flight recorder system.

2.3 Annex III: OCCURRENCES RELATED TO AIR NAVIGATION SERVICES AND FACILITIES

- 1. AIRCRAFT-RELATED OCCURRENCES
  - Detect and avoid Resolution Advisory
  - Aircraft deviation from applicable air traffic management (ATM) or U-space regulation:
    - aircraft deviation from applicable published ATM or U-space procedures;
    - airspace infringement including unauthorized penetration of airspace;
    - deviation from aircraft ATM or U-space-related equipment carriage and operations, as mandated by applicable regulations.
- 2. DEGRADATION OR TOTAL LOSS OF SERVICES OR FUNCTIONS
  - Inability to provide ATM *or U-space* services or to execute ATM *or U-space* functions:
  - Failure of ATM *or U-space* system security which had or could have a direct negative impact on the safe provision of service.
  - Prolonged loss of communication with *a remote pilot* or with other ATS unit.

[2] Payload maybe constituted by passenger on taxi service

2.4 Annex IV: OCCURRENCES RELATED TO AERODROMES AND GROUND SERVICES

- 1.SAFETY MANAGEMENT OF AN AERODROME
  - 1.1. Aircraft and obstacle-related occurrences
    - Foreign object on the aerodrome manoeuvring area which has or could have endangered the aircraft, its occupants or any other person

3 Some Examples of Safety Occurrence Reporting

Hereafter you have some specific examples of potential events/occurrences that may happen and may help to better understand what should be considered as incident, a serious incident or an accident:

- A small multirotor has a fly-away and crashes into a tree, destroying the aircraft. Even if this could be considered most probably as a serious incident but not an accident, (though substantial damage, too small, and no injuries), the operator is required to notify, within the prescribed terms, the AAIB and the Competent Authority and of a flight control malfunction. AAIB may initiate an investigation and report with a determination of relevant cause(s).
- A small multirotor has a fly-away event and strikes some people causing them injuries. This shall be surely considered as an accident (resulted in serious injury). The operator is required to immediately notify, within the prescribed terms, the AAIB and the Competent Authority. The AAIB must investigate the accident and determine the relevant cause(s).
- A small multirotor hits a tree due to pilot inattention on a windy day. It should not be considered as an accident (too small, even if substantial damage). However, the operator is required to notify, within the prescribed terms, the Competent Authority.
- A heavy certified RPAS has a structural failure and crashes in a remote area. This should be surely considered as an accident (substantial damage). The operator is required to immediately notify, within the prescribed terms, the AAIB and the Competent Authority. AAIB must investigate and determine the relevant cause(s).

3.1 Accident Report

As indicated above, in case of a serious incident or an accident a notification must be immediately and by the most expeditious means submitted to the AAIB and, within the prescribed terms, to the Competent Authority. The report, based on the initial classification of the occurrence, may be then submitted to the CAA in written form within the prescribed terms reported in the table above. In this case the report should include at least the following information:

1. RPAS PIC's name and contact information;
2. RPAS PIC's CAA flying certificate/licence number;
3. RPAS registration number, if required (CAA/UTM registration number);
4. Location of the serious incident/accident;
5. Date of the serious incident/accident;
6. Time of the serious incident/accident;
7. Person(s) injured and extent of injury, if any or known;
8. Property and/or aircraft and/or goods damaged and extent of damage, if any or known; and
9. Description of what happened.

The serious incident/accident reported to the national AAIB will be further evaluated and a determination will be made whether or not the occurrence shall be investigated. If an investigation is opened by the AAIB into an event, an investigator could then contact the operator/reporting party to request additional information.

The RPAS operator involved in an accident or serious incident is responsible for preserving to the extent possible any RPAS wreckage and all records, including all recording mediums of flight and maintenance log pertaining to the operation and maintenance of the RPAS until the AAIB takes custody thereof or a release is granted.

3.2 Some Examples of incident/accident reporting WRT CORUS WP2 Use Cases

3.2.1 Example 1 of Safety Occurrence reporting making reference to Annex A, Standard Mission 7: Recreational activity

A young teenager wants to play with his drone in the field located in a runway axis of the Airport B where the traffic is not heavy, except during the summer season. The RPAS mission type is VLOS.

- This young teenager has no knowledge in aeronautic, except the online training followed to steer drone of class C2, and theoretical test passed, according to EASA regulation.
- The drone, Class C2, is flown VLOS away from any people; the category of the operation was open.

At the same time a Beechcraft King Air is on an instrument flight rules flight from Airport A to Airport B with 2 pilots and 6 passengers on board.

As the aircraft started the approach to Airport B, the aircraft is cleared for a visual approach to Runway 24. When on final approach, the flight crew observe a drone in front of the left wing. The pilot has no time to take evasive action. The impact is unavoidable and the drone disintegrated.

The crew declares an emergency, then completes the landing without further incident. There are no injuries.

In this case the involved actors (i.e. ATC, RPAS Operator and the Beechcraft Pilot/Airline) shall immediately notify the AAIB that will trigger an ad-hoc investigation. In addition to that the following mandatory reporting process to the Competent Authority shall be implemented by the involved actors:

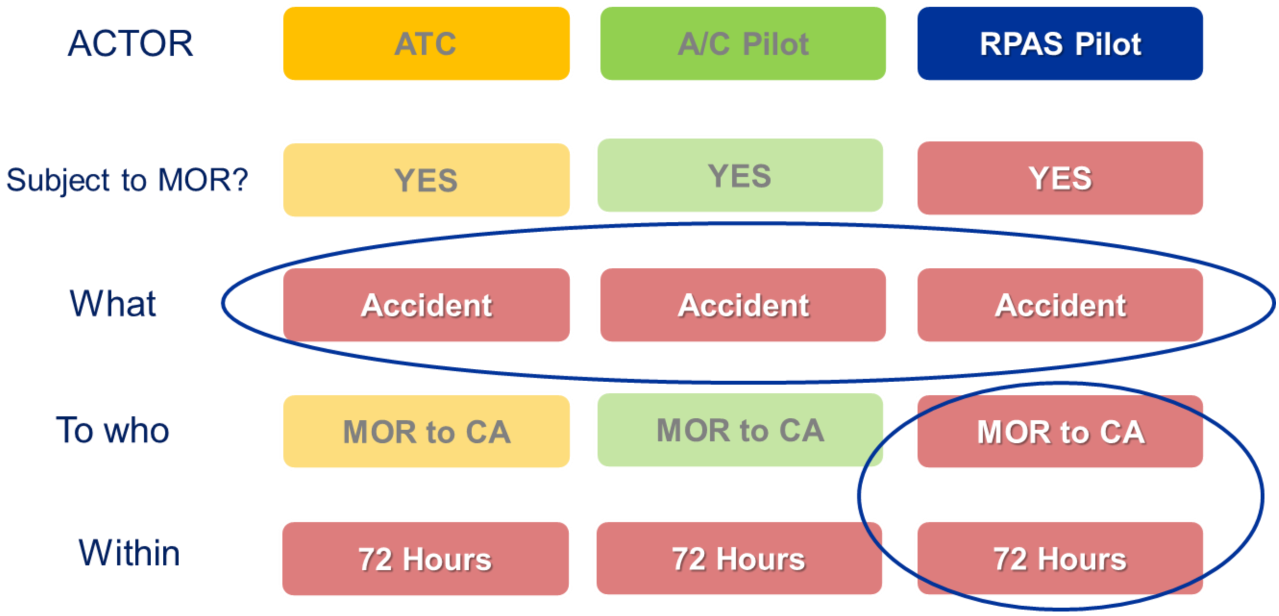


Figure 1 Reporting requirements for example 1

3.2.2 Example 2 of Safety Occurrence reporting making reference to Annex A Standard Mission 8: Runway inspection

A potential FOD has been seen by a pilot on the runway while landing. The airport traffic control operation proceed to a runway inspection with a drone.

- The pilot has no professional license but is authorized to use the drone above the maneuvering area.
- He has a full knowledge of the rules and procedures in effect on the airport. He is in contact with the air traffic control during the whole flight.

At the same time, due to an ATC mistake, an A319 is cleared for the approach and while on short final reports a drone in sight and quite close to his plane.

No avoiding action is required and the landing is normally performed by the A319 crew.

In this case the involved actors (i.e. ATC, RPAS Operator and the A319 Pilot/Airline) shall immediately notify the AAIB that could decide to trigger an ad-hoc investigation. In addition to that the following mandatory reporting process to the Competent Authority shall be implemented by the involved actors:

ACTOR	ATC	A/C Pilot	RPAS Pilot
Subject to MOR?	YES	YES	YES
What	Airprox	Airprox	Airprox
To who	MOR to CA	MOR to CA	MOR to CA
Within	72h	72h	72h

Figure 2 Reporting requirements for example 2

Intermediate ConOps

Annex G - Contingency Plans

D6.2	CO
CORUS	
Grant:	763551
Call:	2016 SESAR 2020 RPAS Exploratory Research Call (H2020 – SESAR -2016-1)
Topic:	Topic 01: SESAR UTM Concept Definition
Consortium coordinator:	EUROCONTROL
Edition date:	19 Mar 2019
Edition:	01.00.00

Founding Members

EUROPEAN UNION

EUROCONTROL

SESAR JOINT UNDERTAKING

1 Definition of specific terms

1.1 Mitigation:

Mitigation or Risk Mitigation are the steps taken to control or prevent a hazard from causing harm and to reduce risk to a tolerable or acceptable level.

The objective to define mitigations is to establish and implement appropriate strategies and effective measures in order to reduce risk associated with the provided services to a level that is as low as reasonably practical. When a risk has been found to be unacceptable, control measures need to be introduced. The level of risk can be lowered by:

- Reducing the **severity** of potential consequences;
- Reducing the **probability** of occurrence harmful effects;
- Reducing the **exposure** to that risk.

The optimum solution may vary depending on the operational environment, local circumstances and urgency of the situation.

> *Example: Redundant radio link. In case the primary radio link fails, the secondary radio link engages and mitigates a failure of the whole radio system.*

1.2 Contingency Plan:

A Contingency Plan of U-Space demonstrates how the aims from the set of the U-Space requirements will be achieved. Accordingly, the contingency plan describes the specific measures that a U-Space Service Provider or drone operator will have to put in place in order to prepare for adverse contingencies that might affect future operations. This is achieved outlining the strategies/actions and resources required to meet the defined requirements. Thus, the objective of contingency planning is to develop a set of detailed plans that will satisfy the requirements so that they can be executed during a future adverse event.

The Planning activities may be organised as follows:

1. Inventory of the services/functions of a U-Space service provider - it is essential that the process be applied to the whole portfolio of U-Space services and functions (either provided or supplied). An inventory of resources (e.g. systems, procedures, and staff) should also be made.
2. Identification of “realistic events” - the “events” that may lead to loss or disruption of service or function should be identified. The likelihood of the events is to be considered to identify which ones are “realistic”.
3. Check if a plan already exists to manage the consequences of the “realistic events”. This question is the foundation of the contingency planning process.
4. Develop or change contingency measures: In this step, a U-Space service provider should ensure first that safety and security requirements are met. Plan(s) should be developed to deal with “emergency” and “degraded modes” of operation. In addition, if there is a need to

ensure service continuity, and if this is "viable", "service continuity" plan(s) might be developed.

5. For all plans, safety and security assessments should be conducted. The aim of this step is to ensure that the planned contingency measures meet safety and security requirements.
6. For "service continuity" measures, an economic assessment of the viability of the plan would also be required since "business" considerations are likely to drive the development of such plan(s).
7. Contingency plans shall also develop measures for "recovery back to normal operations".

1.3 Emergency Plan:

An Emergency Plan for U-Space is intended to cater the appropriate guidance following unforeseen or sudden catastrophic events that may lead to potentially unsafe situations and/or partial or full interruption of the U-Space service provision. Therefore an emergency plan must prompt an immediate response to contain the adverse impact and, where feasible, initiate recovery actions. Even if not all situations can be foreseen and in addition, no two situations will be the same and so no emergency plan can cater for every eventuality. U-Space service providers and drone operators must be prepared for certain common factors. For example, they must be able to deal with unexpected events and it is the ability to respond to these in a safe, orderly manner which provides the overriding rationale for the development of emergency plans. Safety is, and must remain, the number one priority. A system (technical, people and procedures) working in 'Normal' operation can evolve directly into an "emergency" situation; or a system can deteriorate into a "degraded mode of operation" that further evolves into an "emergency" situation.

For 'emergency', 'degraded' modes of operation' and 'service continuity', it is important to conduct both; a safety assessment and a security risk assessment. The aim is to ensure that the planned contingency measures meet safety and security requirements.

1.4 Interaction of Mitigation, Contingency and Emergency

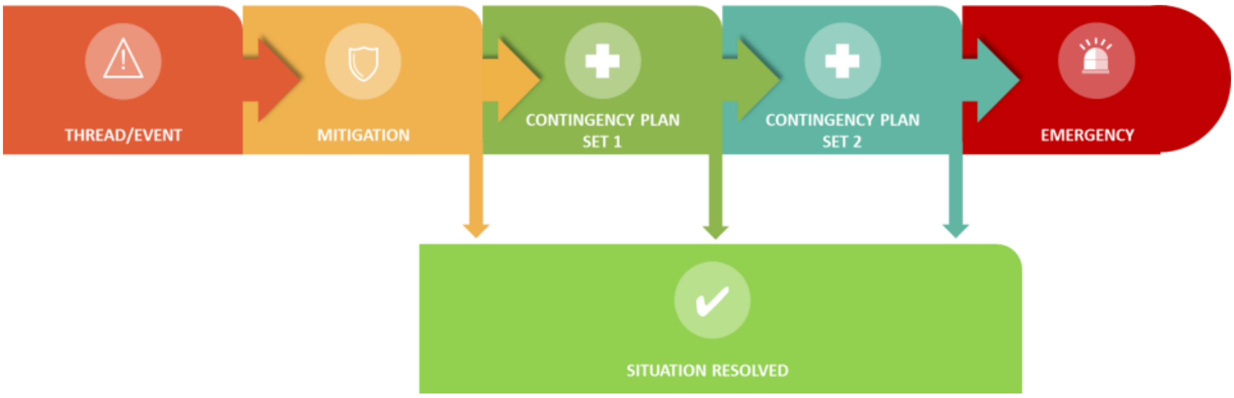


Figure 1 - Interaction of Mitigation, Contingency and Emergency

For each threat/event there should be at least mitigations to reduce the severity of a threat/event. If the mitigation is not robust enough to reduce the severity to an acceptable level, a first set of contingency plans have to be checked for applicability. If the first set cannot solve the problem a second set of Contingency Plans have to be checked. When it is applicable and robust enough for this situation it should be executed. Note that the Contingency Plans and sets of Contingency Plans have to be developed and setup before an operation is executed. They have to be tailored to the threats/events that could occur on a certain operation. However, most of the Contingency Plans will be generic. At least a second set of contingency plans shall be developed.

If no set of Contingency Plans is able to solve the problem an emergency plan must be executed. An emergency is expected to be very generic, since the options to solve the problem are very limited and almost always come to the same result.

2 Contingency Plans

If a drone experiences one or multiple threats/events (refer to Annex E – the list of threats/events), one or multiple contingency plans have to be executed. Several threats/events can have the same contingency plan; moreover the probability and impact of the threat/event have an effect on the chosen contingency plan(s). The contingency plans below are just examples developed in the project. They are not exhaustive but shall give an idea how contingency plans could look like. Contingency plans for drones are not in the accountability of a U-Space service (provider), but every drone operator is responsible for developing their own contingency plans.

CP1: If a drone experiences a flight controller failure, loses altitude unintentionally, is totally lost, flies through severe weather or collides with obstacle or other air traffic, it must activate the emergency landing protocol immediately and appropriate emergency equipment has to be activated (e.g. parachute, flash lights to be seen at night and sound a signal to be heard on ground). Furthermore either the pilot or the drone has to send an emergency signal immediately via the emergency management service.

CP2: If a drone flies through dense air pollution, inappropriate or severe weather, or experiences solar storms or other electromagnetic interference, either the pilot or the drone must send weather information to the weather information service.

CP3: As soon as the mission planning error is noticed, the flight plan must be rejected or suspended immediately. If the drone is already airborne, it has to return to launch or land at an alternative site immediately.

CP4: If a drone enters segregated airspace inadvertently the Monitoring service must inform the drone and ground control station (GCS) about the airspace violation immediately. The pilot must manoeuver the drone out of the segregated airspace immediately.

CP5: In case of an immediate give-way event the Tactical deconfliction service must give information to drone and to GCS immediately. The drone has to execute an evasive manoeuver to remain well clear.

CP6: If a collision with manned aviation has occurred, ATC and the drone pilot have to report immediately to the emergency management service. The emergency management service broadcasts the crash to all drones and remote pilots in the vicinity.

CP7: In case of a critical human error or medical issue with the remote pilot, a backup pilot has to take over the flight immediately, if available. If no control input was received by the drone for longer than a determined time period, it shall CP10 or CP1 must be activated.

CP8: If a fault is detected in one of the drone’s critical systems (i.e. parachute system, DAA system), CP10 must be activated.

CP9: If a voice-link failure with ATC or with 2nd pilot/spotter (for E-VLOS) is detected for a determined time period, the procedural and collaborative interface service, the emergency management service and the drone pilot must be notified immediately. If possible, ATC must put appropriate measures in place.

CP10: If the drone experiences a loss of datalink (telecommand), position emitter/receiver failure, directional loss, flies through inappropriate weather, dense air pollution, solar storms or other electromagnetic interferences, or the pilot make a critical human error, the drone must either return to home/launch or land at a dedicated landing area, either by pilot command or automatically.

3 Examples of Contingency Plans

It shall be presented how Contingency Plans are executed in certain use cases. Therefore two of the CORUS-developed use cases where chosen: delivery (described below) and runway inspection (Annex A - Use-cases, Mission 8)

The use cases are taken and a few threats/events presented in Annex E (list of threats/events) are chosen to trigger a contingency. In turn a suitable contingency plan will be executed. This process shall be shown in this annex.

3.1 Use Case #1 – Delivery

The pharmacy on duty has to deliver a treatment to a patient. An urban environment with moderate building height is assumed, giving the drone the opportunity to fly below 500 ft AGL. The drone would reach its destination in less than 5 minutes.

Intention:	*Treatment delivery of medication to a patient (not urgent)*
Drone:	*Multicopter*
Dimensions:	*approx. 1 m*
MTOW:	*6 kg*
Payload:	*Small and light parcel*
Distance:	*about 2 km*
Mission type:	*BVLOS/BRLOS*
Area:	*Populated*
Flight Path:	*4D trajectory*
Pilot:	*Trained for BVLOS missions, good aeronautical knowledge*
Mission:	*highly automated*
Event #1.1:	*GPS failure/directional loss (RT006.1)*
Event #1.2:	*Drained energy source/Unintentional loss of altitude (RT008.2)*

3.1.1 Event #1.1

Situation: If the GPS fails, the UAV does not know its position and speed. Thus it cannot return to home on its own or hold the current position. It would drift with the wind. However it is able to hold its altitude and transmit its heading to the ground station. The pilot is still able to control it, but is probably unaware of the current orientation and position.

CP-2: Either the drone or the pilot has to send an emergency signal immediately to/via the emergency management service.

CP-11: The drone must either return to home/launch or land at a dedicated landing area, either by pilot command or automatically.

The pilot must fly the drone manually either to home or to a dedicated landing spot. He can do that by looking at the telemetry data provided by the drone and guessing its rough position. The drone should always maintain a safe altitude above populated areas. When the drone is VLOS, the pilot can land it. If the pilot is not able to bring the drone back home manually, CP-1 must be activated.

CP-1: The drone must activate the emergency landing protocol (immediately) and appropriate emergency equipment has to be activated (e.g. parachute, flash lights to be seen at night and sound a signal to be heard on ground).

3.1.2 Event #1.2

Situation: The energy source could be a fuel tank or a battery. Petrol-engine powered drones have a dedicated battery to run the onboard systems. The battery of battery powered drones is usually able to keep the onbaord systems alive (flight controller, GPS, telemetry, etc.), but not enough to power the drone sufficiently. In case of a fixed-wing the pilot is still able to manoeuvre the gliding drone to a certain degree. In case of a multicopter the drone would decent very rapidly.

CP-1 and CP-2 (see above) shall be executed. In case of a fixed-wing drone the pilot can try to manoeuver to a more suitable spot before executing both Contingency Plans.

3.2 Use Case #2 – Runway inspection

The airport traffic control operation executes a runway inspection with a drone, where the UAV takes off and lands on a taxiway next to the runway. The first waypoint of the drone is one end of the runway; the second waypoint is the opposite site of the runway. Afterwards it will return to launch on a direct way. While flying over the runway a dedicated onboard system inspects the runway. The drone operation is executed during the day in a time slot where no aircraft is taking off or lands.

Intention:	*runway inspection*
Drone:	*Multicopter*
Dimensions:	*approx. 1 m*
MTOW:	*6 kg*
Payload:	*(optical) sensors*
Distance:	*about 3 km*
Mission type:	*BVLOS/BRLOS*
Area:	*Airport*
Flight Path:	*3D trajectory*
Pilot:	*Trained for BVLOS missions, good aeronautical knowledge*
Mission:	*automated*
Event #2.1:	*voice-link failure (RT003)*
Event #2.2:	*Electromagnetic interference (RM005)*

3.2.1 Event #2.1

Situation: The communication to ATC can be via radio, cellular phone, VoIP, etc. If the communication is lost, CP-10 shall be executed. No imminent risk goes along with this event, but safety measures should be fulfilled.

CP-10: If ATC or drone pilot recognizes voice link failure for a determined time period, the procedural and collaborative interface to ATC, the emergency management service and the drone pilot must be notified immediately. If possible, ATC must put appropriate measures in place.

If the communication to ATC cannot be regained, the pilot should return to land or land at an alternative safe spot.

3.2.2 Event #2.2

Situation: Electromagnetic interference can be produced by metal structures, antennas, electrical motors, radio signals, etc. But also by solar storms (Kp-value) which is a factor that shall not be underestimated. Usual symptoms of electromagnetic interference are usually a wrong compass indication and a misleading GPS signal. This in turn creates a range of undesired reactions from unpredictable behaviour of the drone to a complete crash.

CP-3: The pilot has to send weather information to the weather information service.

Note: The weather information is also responsible for Kp-values (solar storms) and permanent sources of electromagnetic interferences (buildings, antennas, etc.)

CP-11: The drone must either return to home/launch or land at a dedicated landing area, either by pilot command or automatically.

If the drone is out of control, CP-1 and CP-2 have to be executed.

Intermediate ConOps

Annex H – Social Acceptance Indicators

D6.2	CO
CORUS	
Grant:	763551
Call:	2016 SESAR 2020 RPAS Exploratory Research Call (H2020 – SESAR -2016-1)
Topic:	Topic 01: SESAR UTM Concept Definition
Consortium coordinator:	EUROCONTROL
Edition date:	19 Mar 2019
Edition:	01.00.00

Founding Members

EUROPEAN UNION EUROCONTROL

SESAR JOINT UNDERTAKING

Table of Contents

1 Introduction 3

2 Objectives 4

3 Proposal of Social Acceptance Indicators 5

3.1 The SAI survey 6

3.2 Assignment of survey questions to SAI values 9

3.3 Conducting the surveys 11

3.4 Responses processing and visualization 12

4 Results 14

5 Conclusions 17

Appendix I 18

List of Figures

Fig A8.1: Symbols for fast response 6

Fig A8.2 shows the final format of the SAI survey 10

Fig A8.3 – Summary of the Use Cases of ConOps V1 12

Fig A8.4 – Examples of visualization of the SAI 13

Fig A8.5 – Distribution of the responses to all metrics grouped by indicators 14

Fig A8.6 – Distribution of the responses to one metrics grouped by mission and by profile of respondent 15

Fig A8.7 – Distribution of the responses to one metrics grouped by mission and by profile of respondent 16

1 Introduction

Any emergent technology in history has raised an initial rejection by part of the society. Added to the several problems that the non-mature technology may have, the lack of any previous experience about side effects and the human's psychological fear to the unknown play an important influence in its acceptance.

In order to succeed in the introduction of a new technology, experts believe that the balance between the beneficial usages and the inconvenient issues derived from the emergent technology deployment must lean towards the 'good'. Similar to a weighing scale, in the 'good' arm we have the benefit in terms of additional safety for people (e.g. transport of urgent medicament, blood, search and rescue) and also the high economical expectations around the drone industry. In the 'bad' arm we have the disturbances of these low altitude, noisy and nosy flying machines to the citizens.

In the special case of the airspace and aeronautics world, with a strong safety culture embedded in all their stakeholders, a third arm on that balance appear: safety. Seen as a new obstacle, small and almost imperceptible to the current VLL airspace users (VFR, gliders, parachutes, etc.), drones can also provide the opportunity introduce changes that benefits all.

With this annex we propose a tool to measure the social impact of the drones through these three arms: safety, economic impact and social perception. Each arm is summarize in an indicator with values from 1 to 5, been 1 the most negative and 5 the most positive.

The structure of the document is as follows: first objectives are presented, then the composition of the three social acceptance indicators (SAI) and their final presentation plot. In section 4 the process of collecting information to obtain the SAI values is shown, including examples to assess the current situation and the future proposal of the airspace classification. Finally conclusions and future work are given.

2 Objectives

Drones are one of the most challenging current emergent technologies. They appear after a very high historical growth of aviation, in the era of the Internet, the autonomous cars, the Internet-of-things and the smarts cities. In many urban areas the mobility on ground is very saturated while the demand is still increasing. The environment preservation is addressing mobility towards electrical-powered vehicles and the sharing paradigm. Drone can provide a solution perfectly compatible with the current trends. For these reasons drones bring high social and economic expectations as presented in the European Drones Outlook Study. But social acceptance of drones is key for the full development of the economical expectations

The principal objective of these social acceptance indicators is to contribute to convert these expectations in facts. Nevertheless, the growth must follow the principles of sustainability, as proposed by United Nations: non-exclusiveness, health and nature preservation, sustainable cities, climate action, peace and justice.

More specifically we can list the objectives of the SAI in:

- Provide an assessment tool to measure the deployment of drones
- Help to detect any unbalance situation and to propose regulations to avoid unfair situations
- Check the necessity of funding
- Be transparent with the drones inconveniences
- Serve as a performance evaluation tool for new drone technologies, new airspace organization or changes in legislation
- Extend the safety culture also across drone operators, pilots and industry
- Assess the level of compromise of the airspace safety
- Help citizens to have a funded opinion about drones

3 Proposal of Social Acceptance Indicators

The development of social acceptance indicators (SAI) must comply with the following **requirements**:

1. SAI shall consider all aspects of the impact of drones on society, not only economical.
2. A feasible methodology shall be proposed to obtain SAI values for different scenarios, use cases, type of drones, technologies, etc.
3. SAI values shall be easy to understand
4. SAI shall be useful for the CORUS ConOps assessment

To consider all aspect of social impact (Req.1) we propose **three indicators** that we named as safety (SAI_SA), economic (SAI_EC) and political (SAI_PO):

- **SAI_SA** is the Safety indicators and measures the benefits/risks that drones pose to rest of air space users and to people on ground
- **SAI_EC** is an Economic indicator that measures the accomplishment of economical expectations of the new emerging drone market
- **SAI_PO** encompasses any other social issue, named as Political, which includes aspects such as the citizens' affectations from the drones' noise, the privacy potential compromise, the visual impact etc. SAI_PO also includes the increase of governments and administrations complexity and new management requirements. Moreover SAI_PO includes the potential affectation (positive and negative) on emergency situations resulting from the introduction of drones. Finally, environmental considerations are included also as part of the impact of drones for future generations and Earth preservation.

Following Req.2 we propose as the **methodology** to obtain the final values of the three indicators, the collection of the experts' opinion using surveys.

A specifically dedicated survey was created with specific questions in the three areas. For the design of this survey we used as inputs all the raised concerns found in the extensive literature review done and available in CORUS Deliverable D4.1-V0.1. We also conducted a number of dissemination activities with elder citizens. During such activities we had the opportunity to contact with the general public, citizens who had no previous opinion and/or knowledge of drones. From their feedback, and the feedback of other publicly available surveys (from European Commission, NATS, UVS International, Airbus, USPS, Altiscope, the National League of Cities, Purdue University, UNLV, Aachen University, Fortem Technologies, St. Leo University and Munich Re) we tried to capture the full spectrum of considerations and design our SAI survey.

Using the SAI survey we collected answers from the CORUS members, the CORUS advisory board, the U-space Community Network (UCN) and rest of participants of the 2nd CORUS Workshop. Also the survey has been responded by aerospace engineering students. Answers were collected for different use cases (from the list of use cases proposed in CORUS Deliverable D2.1). Moreover, Use cases were assessed for the current situation (before ConOps) and also to evaluate the tentative airspace volume denomination of the CORUS ConOps-V1 (green, amber and red volumes).

Finally the methodology ends with the processing of the collected data. For this we have developed and ad-hoc R program, a state-of-the-art statistic tools, able to automatically process a CSV file containing the survey results and generate automatically a number of visual charts. The code of the R program can be found in the Appendix I of this Annex.

3.1 The SAI survey

In order to capture the complete view of the society up to 10 different profiles were used:

1. Drone operator
2. Current and potential users/clients of drones
3. Drone industry, including manufacturers and suppliers
4. Future generations, Earth and environment
5. (Current) Citizens
6. Emergency responders and police
7. Administrations and governments
8. General aviation (VFR) and other VLL airspace users
9. Airports, ANSP, air-safety agencies
10. Airlines (IFR)

Up to 45 questions that may concern to any of these profiles have been proposed. For instance, a drone operator (Profile.1) is concerned about "How flexible is the system for last minute changes of a planned drone operation?" while citizens (Profile.4) may wonder "How cameras on drones are useful or dangerous to citizens?"

Answers to these questions are entered with an easy symbol based with 5 degree levels, as in a satisfaction feedback device, but substituting the images by '+' and '-' as shown in Fig A8.1:

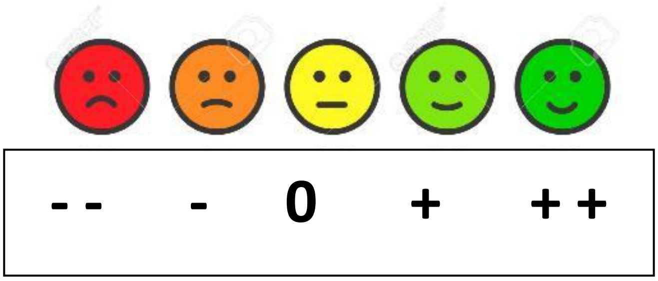


Fig A8.1: Symbols for fast response

The full list of questions per profile is the following:

Profile 1 – Drone Operator:

1. Is it easy to scale business by incrementing of the potential number of missions?
2. Can a drone operation be conducted with full access to VLL airspace?
3. Is the management effort for implementing a drone mission low?
4. How flexible is the system for last minute changes of a planned drone operation?
5. Is it possible to extend an operation to multiples drones?
6. How much of the cost of an operation is derived by non-mission equipment?
7. How ease is to integrate non-mission devices in the drone?
8. How the non-mission equipment is affecting the flight plan (time, weight, endurance)?
9. How the mandatory services subscription improve business?
10. How much cost the ground resources devoted to non-mission requirements?
11. How the additional / qualified personnel required by the current system is worth?
12. Are there available and affordable insurances for drone operations?
13. How easy/difficult is to obtain an insurance contract?

Profile 2 – Current and potential users/clients of drones

14. Are there sufficient availability of drone services with affordable costs?
15. Is the drone market an open and competitive market?

Profile 3 – Drone industry, including manufacturers and suppliers

16. The number of enterprises will grow or will shrink because of the drones' business
17. The number of jobs will grow or will shrink thanks to the drones
18. The economy of the European countries will increase or decrease benefits?

Profile 4 - Future generations, Earth and environment

19. Do drones help or danger the natural life?
20. Will drones help in decrease or will increase the CO2 emissions?
21. How drones facilitate new applications in live science and environment?

Profile 5 - Citizens

22. Will drones substitute noisy vehicles or increase total noise?
23. How is the sound of an individual the drone?

24. How often is a drone disturbing you?
25. How useful can be a drone recording around my home?
26. How drones help to reinforce existing privacy rights?
27. Do drones help to reinforce existing liability laws?
28. How easy or complex is to claim damages in case of a situation involving a drone?
29. Are drones producing a positive or negative visual impacting?
30. Do drones provide amazing leisure activities?

Profile 6 – Emergency responders and police

31. Which is the potential of drones in saving or endanger human lives?
32. In the event of emergency situations are drones a useful tool or a thread?
33. How drones may affect the response time of an emergency situation?
34. How law enforcement tasks can benefit or difficult from drones?

Profile 7 – Administrations and government

35. Which is the impact of drone expansion for the administration and its organization?
36. Which is the potential of using drones for the provision of public services?

Profile 8 – General aviation (VFR) and other VLL airspace user

37. How drones help in democratising the access to the airspace?
38. How the drone decrease or increase the perception of risk?
39. Which impact has the drones' market in the cost of electronic equipment?
40. How the access to the airspace evolves with the incorporation of drones?

Profile 9 – Airports, ANSP, air-safety agencies

41. Which is the impact of the new drone U-Space services (such as geo-fencing)?
42. Are drones promoting the development of new and useful interchange standards and/or new technology providers?
43. How the new drone regulations affect to the current airspace safety?

Profile 10 – Airlines (IFR)

44. Which has more potential: drones for aircraft maintenance or drones threating an aircraft?
45. How drone introduction will affect the situation awareness of the airspace?

3.2 Assignment of survey questions to SAI values

To aggregate the 45 questions into the three selected indicators, the 10 profiles have been assigned to each one of the indicators. Although one same profile may have interest in more than one area, such as for instance the Airport, which can be potential users of drone services (Profile 2), but also part of Profile 9, we have assigned then only to the most significant indicator. With this we want to avoid the excessive representation of some roles in the results.

The assignment of profiles (and questions) to each indicators is as follows:

- SAI_SA: General aviation, VFR and other VLL airspace users; Airports, ANSP, air-safety agencies; and Airlines (IFR).
- SAI_EC: Drone operator; Current and potential users/clients of drones; and Drone industry, including manufacturers and suppliers
- SAI_PO: Future generations, Earth and environment; (Current) Citizens; Emergency responders and police; and Administrations and governments

Further, the responses to the questions are also group in 22 metrics according to the topic. For instance there are three questions about the noise of the drones which are merge into a unique metric named SAI_PO04.

Figure A8.2 shows the final format of the SAI survey, divided by indicator:

SAI	Stakeholder	ID	Benefits	Risks
SAFETY	Airspace users: VFR, Passengers	SAI_SA01	Easy access to new and cheap airspace services	Increase of VFR flight preparation and airspace complexity
		SAI_SA02	Perception of decreased risk	Perception of increased risk
		SAI_SA03	Availability of new COTS equipments/services	Cost of additional equipments/services
		SAI_SA04	Extended airspace access	Limitations to airspace access
	ATM, Airports, Safety Agencies	SAI_SA05	Opportunity for digitalization and automation	Increase of complexity
		SAI_SA05.1	Increase of safety thanks to geofencing	Increase of NOTAMs/geofences notifications
		SAI_SA05.2	Increase of technological providers	Danger due to lack of interchange standards
		SAI_SA05.3	Confusion with new regulations	Improvements to existing airspace safety regulations
	IFR, airlines	SAI_SA06	Improve maintenance using drones	Potential damage from drones
		SAI_SA07	Improved situation awareness with drones info	Lack of situation awareness about drone flights

SAI	Stakeholder	ID	Benefits	Risks
ECONOMICAL	Drone operator	SAI_EC01	Fast and easy implementation of a mission	Complex and slow the implementation of a mission
		SAI_EC01.1	Increase of the potential number of missions	Reduction of the potential number of missions
		SAI_EC01.2	Full access to VLL airspace	Limitations to VLL airspace access
		SAI_EC01.3	Low management effort	High management effort
		SAI_EC01.4	Flexibility in last minute changes	Limitations to last minute changes
		SAI_EC01.5	Capacity of operating multiples drones	Complexity of operating multiples drones
		SAI_EC02	Low cost of onboard equipment	High cost of onboard equipment
		SAI_EC02.1	Few and affordable non-mission devices	Large number or high cost of non-mission devices
		SAI_EC02.2	Seamless integration of non-mission devices	Complex integration of non-mission devices
		SAI_EC02.3	No impact of non-mission devices in the mission	Impact of non-mission devices in the mission
		SAI_EC02.4	Improvements due to U-space services	Cost of U-space services
		SAI_EC03	Low cost of ground station and personnel	High cost of ground station and personnel
		SAI_EC03.1	Integrated and affordable non-mission systems on ground	Large number or high cost of non-mission systems on ground
		SAI_EC03.2	Availability of additional personnel and/or training	Large number or high cost of additional personnel and/or training
		SAI_EC04	Good insurance	Insufficient insurance
		SAI_EC04.1	Affordable insurance	High cost of insurance
		SAI_EC04.2	Ease to contract insurance	Difficult to contract insurance
	End-Users	SAI_EC05	Availability of drone services	Limitations to drone services
		SAI_EC05.1	Affordable	Too expensive or exclusive
		SAI_EC05.2	Wide offer	Monopoly
	Industry & suppliers	SAI_EC06	Creation of a new and growing economical sector	Destruction of some economical sector
		SAI_EC06.1	Creation of new enterprises	Reduction of existing enterprises
		SAI_EC06.2	Creation of new jobs	Reduction of existing jobs
		SAI_EC06.3	Economical benefits	Economical losses

SAI	Stakeholder	ID	Benefits	Risks
POLITICAL	Environment	SAI_PO01	Preserve natural life (wild animals, forest, ...)	Danger natural life (wild animals, forest, ...)
		SAI_PO02	Reduction of CO2 Emissions	Increase of CO2 Emissions
		SAI_PO03	New application in live science and environment (reduce pesticides, water management, ...)	New application will stress the environment (extra-production, high use of resources...)
	Citizens	SAI_PO04	Substitution of more noisy vehicles	Noise increase
		SAI_PO04.1	Very quiet	Too loud
		SAI_PO04.2	Not noticeable	Too disturbing
		SAI_PO04.3	Very infrequent	Too repetitive
		SAI_PO05	Reinforcement of privacy laws	Privacy compromised
		SAI_PO05.1	Self-protection (own recordings at my home)	Someone else recording my home
		SAI_PO05.2	Creation of new stringent laws to penalize privacy violators thanks to drones	Someone else can record me anyplace
		SAI_PO06	Reinforcement of liability laws	Non-Liability
		SAI_PO06.1	Increase of transparency	Problems in identifying owner of drone
		SAI_PO06.2	Improved rules for claims	Complexity of damage claims
		SAI_PO07	Positive visual impact	Negative visual impact
		SAI_PO08	Increase of leisure activities	Decrease of leisure activities
	Emergency & police	SAI_PO09	Potential for saving humans in danger	Potential of creating additional danger
		SAI_PO09.1	Convenience for using drones in emergencies	Possible threats created by drones
		SAI_PO09.2	Reduction of emergency response time	Increase of emergency response time
		SAI_PO010	Efficient tools for law-enforcement	Difficulties in law-enforcement to non-legal drones
	Administration	SAI_PO11	Potential for administration reorganization	Increase of administration complexity
		SAI_PO11.1	Increase of public services	Increase of citizens complains

Fig A8.2 shows the final format of the SAI survey

3.3 Conducting the surveys

The surveys were conducted during CORUS workshop 2. Each participant was asked to fill one to three use cases. This is, setting a specific scenario in a specific area and with a specific drone type and mission the questions were revisited to adequate them to the use case.

As a reminder, the following summary of the use cases description (see Fig A8-3) was available at the workshop social room:

	Use cases	Range	Type of operation	General flight	Mission	Payload
Non-populated areas	**Mission 1: Photo activity**	Short	VLOS	Area + stationary	Commercial photo/video	Visual camera
	Mission 2: Seed sowning	Short	BVLOS	Wide area	Commercial agriculture	Seed dispatcher and infrared sensors
Sparsely populated areas	**Mission 3: Farming activity**	Short	E-VLOS	Area	Commercial farming	No additional equipment
	Mission 4: Building inspection	Short	BVLOS	area	State Inspection	Laser pod, thermal and visual cameras
	Mission 5: Infrastructure inspection	Long	BVLOS	Route	Commercial Inspection	Laser pod
	Mission 6: Vineyard fungicide spraying	Short	BVLOS	Route and area	Commercial agrarian	10-40l fungicide tanks, cameras with NIR range
Populated areas	**Mission 7: Police surveillance**	Long	BVLOS	Stationary or circular route	State - surveillance	Infrared sensor
	Mission 8: Delivery	Long	BVLOS	Route	Commercial transportation	Small parcel
	Mission 9: Passenger transportation	Long	BVLOS	Route	Commercial transportation	Passenger

	Use cases	Range	Type of operation	General flight	Mission	Payload
Near/ In Airports	**Mission 10: Recreational activity**	Short	VLOS	Area	Recreational	No additional equipment
	Mission 11: Runway inspection	Short	BVLOS	Route and area(combined)	inspection	Wide angle visua camera
	Mission 12: Building inspection	Short	BVLOS	Area	Public or commercial-inspection	Laser pod
	Mission 13: PAPI calibration	Short	BVLOS	Route	Public or commercial-calibration	No additional equipment
	Mission 14: ILS Inspection	Long	BVLOS	Route	Commercial calibration	Specific sensors and communication devices
	Mission 15: ILS measurement	Short	VLOS + BVLOS	Stationary and area (combined)	Public inspection	ILS emitter measurement equipment

Fig A8.3 – Summary of the Use Cases of ConOps V1

Once the surveys were filled on paper by experts using the symbols (+), or (+ +) for the positive and very positive perception, (-) and (- -) for the negative and very negative perception and (0) for neutral the responses were entered in a CVS file coding positive and very positive answers with 1 and 2 respectively and negative and very negative answers with -1 and -2 respectively.

3.4 Responses processing and visualization

Using an R program all responses were processed and converted into plots. All values had a translation of +3 units, converting the answers into the scale 1-5. The responses were then averaged to their corresponding SAI. The main outcome of a single response is a triangle such as the example shown in Fig A8-4a. In this one can easily observe a very socially accepted drone use case, but with a very low economic viability. This visualization tool is very convenient for instance to compare situations, as shown in Fig A8-4b. Three imagined use cases (green, black and red) can be compared very fast: while the green drone mission is the most balanced in the three axis, the back has a very promising acceptability and viability but fails in safety, and red is too expensive.

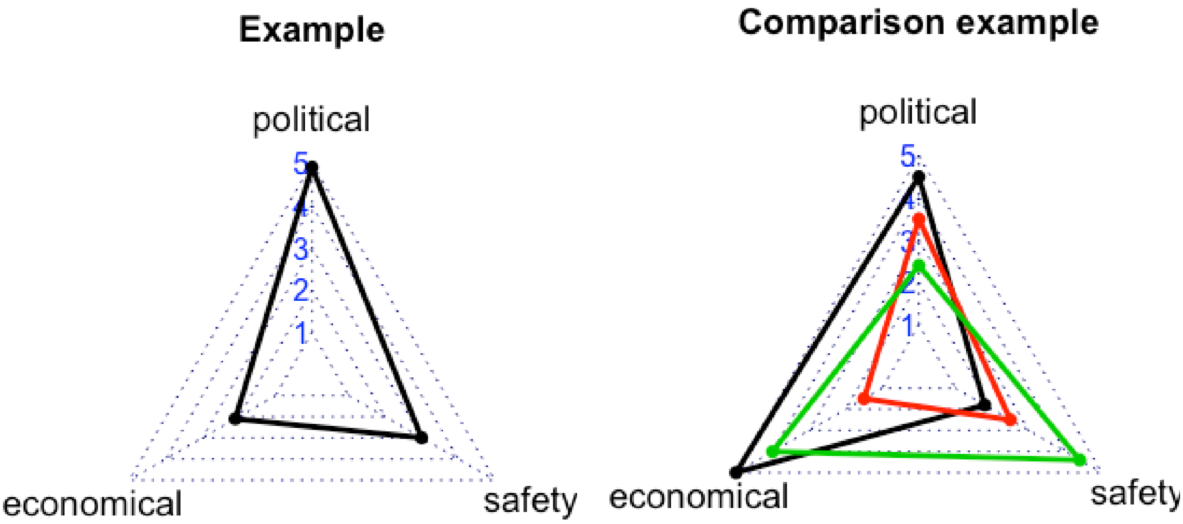


Fig A8.4 – Examples of visualization of the SAI

4 Results

This section provides the results of the processing of two different surveys. First the current situation of drone deployment was assessed with the help of the experts attending to the CORUS 2nd Workshop. A total of 92 surveys where collected, and their main statistics are show in the following boxplots of Fig A8.5.

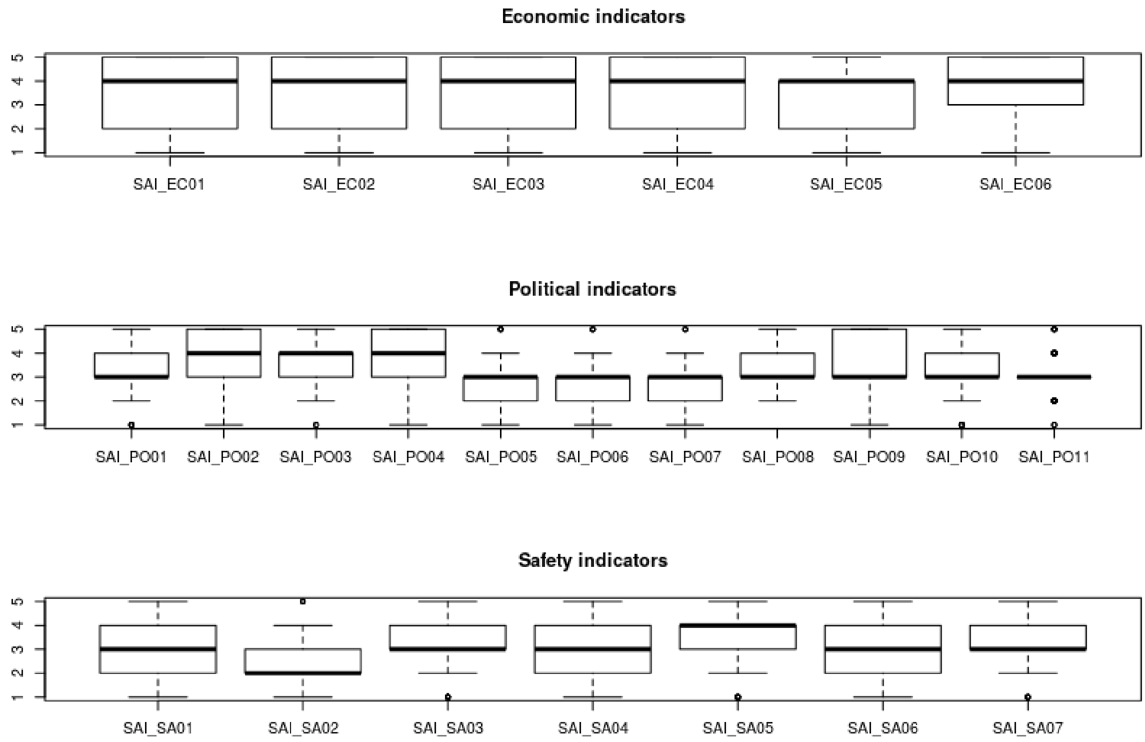


Fig A8.5 – Distribution of the responses to all metrics grouped by indicators

Looking at the main statistics we observe that the current situation is considered good in general (means >=3) except SA02 (perception of risk) that was evaluated with an average of 2. We may consider the elimination of PO11 (how administration is affected) since all responses are neutral and does not provide any trend. Finally we can observe that the metrics from PO05 to PO07, related to citizens privacy, drones liability and visual impact, may need actions to improve their perception.

By looking only to the answers of one metric (SAI-EC01 related to the ease of a drone mission execution) we can observe very different trends depending on the specific use case. No so significant is the differences of trends according to the profile of the responders. See both results in Fig A8.6.

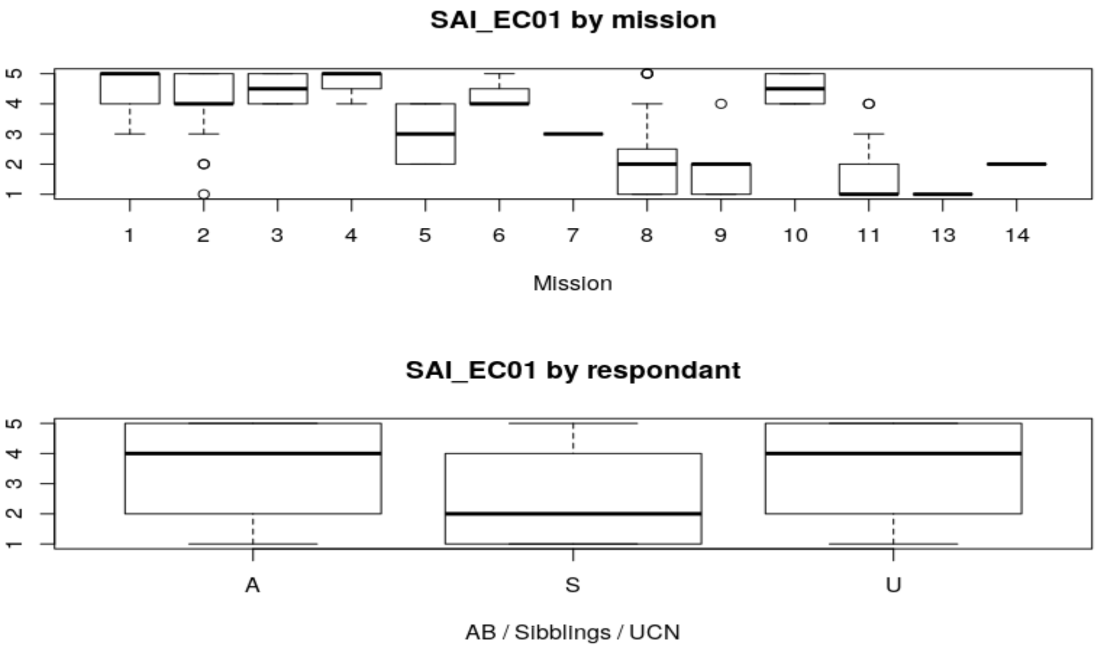


Fig A8.6 – Distribution of the responses to one metrics grouped by mission and by profile of respondent

Observe that missions from 1 to 4 have a positive trend about the facility of conducting a mission today. These missions are in non-populated areas, farming, recreational and with highly localized flights (building inspection). In contrast with the negative trends for the current possibilities of drones to fly in cities and airports. Observe also that sibling projects are less optimistic respect to the EC01 in relation with the other profiles.

The final results of the SAI obtained from the surveys are shown in Fig A8.7, for all use cases except 7 and 12 that no one responded. We can observe that the SAI_EC indicator is, in general, positive, especially for the low cost payload use cases. In contrast the economic indicator is neutral for city transport and airports use cases. Some economic promotion action may be needed to make them a reality.

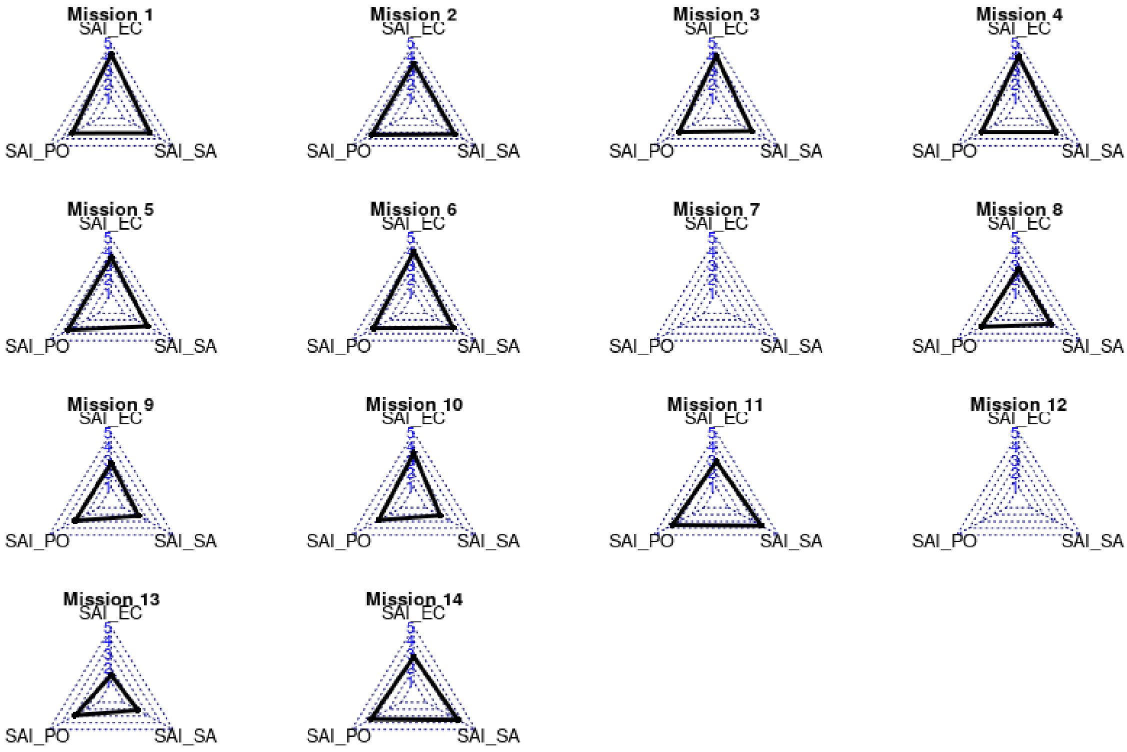


Fig A8.7 – Distribution of the responses to one metrics grouped by mission and by profile of respondent

In case of the safety indicator we observe that only with the implication of ATC in the use case the value of the indicator raises the safety indicator above neutral. Anyway most of the use cases show values very close to neutral. We may understand that the proposed missions do not strongly affect the current levels of safety. The only exceptions are the use cases 9, 10 and 13, all of them potentially involving passengers. In particular use case 13 (PAPI calibration) had a strong negative perception for all three indicators, very different from other similar use cases conducted in airports.

Finally, the political indicator is also mostly neutral, with some positive trends for use cases 5 , 11 , 14 (related with inspection tasks).

Most unbalances between the 3 indicators are due to a high positive economic perception. Also some unbalanced use cases are found for missions 9 and 11 (passenger and recreational near airport) which show a low/negative safety.

5 Conclusions

In this annex we have presented three indicators to measure the social acceptance of the drones and have shown the potential of using them to assess the perception of the drone from three dimension: the safety, the economic growth and the political considerations.

The indicators have been calculated for all the use cases using a methodology based in the responses of experts. Main results and conclusions have been presented in section 4.

The requirement 4 about the use of the indicators in the assessment of the individual proposals of the CONOPS is still pending, waiting for the consolidation of the ConOps expected during CORUS Workshop 3. Moreover we propose the following improvements and future work:

- Make a uniform presentation of the three SAI triangle, showing always the Safety indicator at the top, the Economic indicator on the right and the Political indicator on the left. In this way the reading of the results will be even more rapid.
- Add the name or short description of use case in the plot, instead of the number.
- Eliminate metric SAI_PO11, which does not contribute to any assessment.
- Add the number of individual answers used when showing the SAI results of a use case, to better show the credibility of the numbers.
- Eliminate redundant or too similar use cases (such as 12+13).
- Work an assessment of the indicators for the use case 7 about police surveillance in populated areas, which is one of the near in the future uses.
- Assess the impact of airspace classes for another near in the future use case, such as use case 5 about a long route BVLOS inspection conducted in low populated areas.
- Check and validate individual metric responses, such as metrics SAI_PO05, 11 and 14, which show a much more positive trends than the rest.

Appendix I

In this appendix, we provide the code written in R to obtain the plots given above and some additional ones not shown.

```
rm(list = ls())      # clear workspace
setwd("~/Documents/Code/R/KPIs_CORUS")

library(xlsx)
library(ggplot2)
library(fmsb) #contains radarchart function

A<-read.xlsx('CORUS-WS2-SocialRoomResponses.xlsx', sheetName="AB", header=TRUE,
stringsAsFactors = FALSE)
S<-read.xlsx('CORUS-WS2-SocialRoomResponses.xlsx', sheetName="SIBLINGS", header=TRUE,
stringsAsFactors = FALSE)
U<-read.xlsx('CORUS-WS2-SocialRoomResponses.xlsx', sheetName="UCN", header=TRUE,
stringsAsFactors = FALSE)

resp <- cbind(A[c(3:26),3:length(A)], S[c(3:26),3:length(S)] ,U[c(3:26),3:length(U)]) + 3
#extend column 1 names to all its indices
sai <- rbind(cbind(c(A[3,1]),A[3:8,2]),cbind(c(A[9,1]),A[9:19,2]),cbind(c(A[20,1]),A[20:26,2]))
indicators <- paste(sai[,1], sai[,2], sep='')

#create the new table
#Each column is one indicator
# + Two factors to do subsets: Mission#, Respondant group

tresp <- as.data.frame(t(resp))
colnames(tresp) <- indicators
mission <- c(A[1,3:length(A)], S[1,3:length(S)] ,U[1,3:length(U)])
tresp$mission <- factor(as.numeric(mission))
tresp$who <- factor(substr(rownames(tresp),1,1))

######################## results ###############################################
summary(resp)
summary(tresp)

####################### plots #################################################
grid.draw.matrix <- function(x){
  print(x)
}
```

```
barplot(colSums(is.na(resp[1:94])), main="Number of 'NA' answers per respondant")
ggsave("NAsXresp.png")

#barplot(colSums(!is.na(tresp[1:24])), main="Number of answers per indicator")
#ggsave("AnswersOK.png")
barplot(colSums(is.na(tresp[1:24])), main="Number of 'NA' answers per indicator")
ggsave("NAsXind.png")

#################################### BOX PLOTS ################################
op <- par(mfrow=c(3, 1))
boxplot(tresp[1:6], main="Economic indicators")
boxplot(tresp[7:17], main="Political indicators")
boxplot(tresp[18:24], main="Safety indicators")
ggsave("GlobalBoxPlot.png")

op <- par(mfrow=c(2, 1))
boxplot(SAI_EC01~mission, data=tresp, main="SAI_EC01 by mission", xlab="Mission")
boxplot(SAI_EC01~who, data=tresp, main="SAI_EC01 by respondant", xlab="AB / Sibblings /
UCN")
ggsave("SAI_EC01 partial BoxPlots.png")

##################################  RADAR PLOTS ################################
KPIs=c(A[3,1],A[9,1], A[20,1])
maxmin <- data.frame(matrix(rep(c(5,1),3), ncol=3))
colnames(maxmin) <- KPIs

op <- par(mar=c(0,0,1,0),mfrow=c(4, 4)) # group plots by 4
plotdat <- maxmin
for (mission in seq_along(1:14)) {
  mi <- tresp[tresp$mission==mission,]   #Filter by Mission
  mi_ec <- mean(colMeans(mi[1:6],na.rm=TRUE)) #calculate mean per KPA
  mi_po <- mean(colMeans(mi[7:17],na.rm=TRUE))
  mi_sa <- mean(colMeans(mi[18:24],na.rm=TRUE))

  dat <- data.frame(matrix(c(mi_ec, mi_po, mi_sa), ncol=3))
  colnames(dat) <- KPIs
  plotdat <- rbind(maxmin,dat)

  radarchart(plotdat, axistype=1, seg=4, caxislabels=c("1", "2", "3", "4", "5"), plty=1, plwd=3,
         title=paste("Mission",mission), vlcex=1.2)
}
ggsave("SAIsxMission.png")
```

Intermediate ConOps

Annex I – Best practices

D6.2	CO
CORUS	
Grant:	763551
Call:	2016 SESAR 2020 RPAS Exploratory Research Call (H2020 – SESAR -2016-1)
Topic:	Topic 01: SESAR UTM Concept Definition
Consortium coordinator:	EUROCONTROL
Edition date:	19 Mar 2019
Edition:	01.00.00

Founding Members

EUROPEAN UNION EUROCONTROL

SESAR JOINT UNDERTAKING

Table of Contents

1 Introduction 3
2 Organization 4
3 Complete example of drone operation based in best practices and code of conduct. . 11
4 Liability Assurance 21
5 A proposal for a "DO/DO NOT" leaflet 25

List of Tables

No table of figures entries found.

List of Figures

No table of figures entries found.

1 Introduction

As any emergent industry, the drone operators must overcome several problems raised by the lack of a previous history. The best way to overcome such problems is in group, thus many drone operators and drone pilots group themselves in non-profit association. Prodronepilots, AOPA, ARPAS-UK, ACUAS, DPF, ACUO and AEDRON are just an example of associations creating code of conduct and best practices such as [NTIA 2016, AEDRON 2016, Guidelines 2012, Guidelines 2015].

One of the main tasks of these associations has been in influencing the rule makers. But another important task has been the discussion and publication of 'Best practices' and 'Code of Conduct' to maximize the safety of the drone operations and their perception by the public. In this document we summarize the most relevant best practices found related to the drone industry. This kind of information is usually meant to be used as a guideline.

On one hand, a good practice can be defined as follows: "A good practice is not only a practice that is good, but a practice that has been proven to work well and produce good results and is therefore recommended as a model. It is a successful experience, which has been tested and validated, in the broad sense, which has been repeated and deserves to be shared so that a greater number of people can adopt it."

In the other hand the Code of Conduct offers recommendations to advance flight safety, ground, safety and professionalism.

It presents a vision of excellence for RPAs pilots and operators and includes general guidance for all stakeholders. The code offers broad guidance a set of values to help any RPAs stakeholder to interpret and apply standards and regulations, and to confront real world challenges to avoid incidents and accidents. It is designed to help RPAs pilots to develop standard operating procedures, effective risk management, safety management systems and to encourage RPAs pilots to consider themselves aviators and participants in the broader aviation community.

The aim of the present document is improving the public acceptance for a planned and sustainable grid development based on the transparency principles and the enabling of the public participation.

2 Organization

The present document has six sections, each presenting principles and sample recommended conducts and practices.

The proposed sections are the followings:

1. General responsibilities of RPAs pilots
2. Manned aircraft & people on the surface
3. Training and proficiency
4. Security and privacy
5. Environmental issues
6. Use of technology

The principles are recommended best practices addressing safety, risk management, technology and training. Ultimately, the principles are designed to provide a base for professional development and a foundation for safety.

The benefits of the present document are:

- Recommending best practices to support safety and professionalism among RPAs stakeholders.
- Encouraging RPAs pilots and operators to recognize themselves as aviators and members of the broader aviation community.
- Promote improved training, conduct, personal responsibility, and pilot contributions to the RPAs community and society at general matters.
- Encouraging the development and adoption of ethical practices and good judgment.
- Advancing self-regulation and responsibility in the RPAs community, supporting improved communications between pilots, regulators and the rest of the stakeholders.

Finally, a complete operation execution is presented as an example of all the steps that can collect good practices and an appropriate code of conduct that this document intends to convey to all stakeholders.

2.1 General responsibilities of RPAs operators

RPAs stakeholders should:

Make safety a top priority,

I. Search excellence in knowledge, skill, ability, and attitude that promote safe and efficient operations.

II. Adopt sound principles of aeronautical decision-making which is the process used in aviation to consistently determine the best course of action in response to the circumstances and develop and exercise good judgment.

III. Use sound principles of risk management.

IV. Act with responsibility, integrity, and courtesy, and adhere to applicable laws, regulations, and industry guidance.

Examples of best practices and code of conduct:

- Recognize, plan for and accept the costs of implementing effective safety practices.
- Operators should apply the principles of a safety management system such as understand the risks in their operations, take steps to control them, and monitor operations to assure that these controls are working.
- Improve safety margins and reduce unnecessary risks through planning and a consistent flight.
- Recognize that use of a visual observer enhances safety, even when not required.
- Create an emergency response plan and implement it in the event of an incident or accident.
- Follow manufacturer's instructions if provided. In the absence of provided guidance, use conservative loading practices.
- Consider conducting a stability and control test at the start of each flight.
- Internalize the difficulty of visually estimating altitude and distance.
- Incorporate Threat and Error Management[1] into the operations to aid in identifying errors and external threats that could compromise safety.
- Consider the effect of weather such as wind, precipitation and temperatures
- Refuse to operate a RPAs that is unsafe for flight because of mechanical, electrical or control system failures.
- Considering fly over national parks, specific natural areas for the conservation of fauna such as birds and cetaceans.
- Keep operations well clear of airports. Where applicable, make notification, and obtain authorization from proper authorities.
- Study and recognize areas classified as dangerous, restricted or prohibited such as prisons and / or nuclear power plants.

[1] TEM - process of detecting and responding to threats and errors

- Check relevant Notices to Airmen (NOTAMs).
- Ensure that your aircraft's firmware (software that controls essential system functions) and other software is updated.
- Recognize the restrictions associated with flying near airports or other aircraft, in controlled airspace, over people, in inclement weather and during the night. Be aware of the increased risk associated with flying in urban areas and near buildings or other obstacles.
- As part of pre-flight planning, identify options for emergency landing locations.
- Before take-off, understand the mission plan. The mission plan should include consideration of the objectives, pilot capabilities, platform, operations area, environmental conditions, and other external factors affecting flight safety.
- Comply with manufacturer's operating manuals and instructions, especially about performance, limitations, and abnormal/emergency conditions.
- Understand the requirements and benefits of complying with manufacturer's recommended inspections and maintenance guidance, and in the absence thereof, consider developing a scheduled maintenance plan that achieves the longest and safest service life of the platforms.
- Use caution when charging, transporting, discharging, storing, disposing or otherwise handling batteries to minimize risk to persons or property.

2.2 Manned aircraft & people on the surface

RPAs stakeholders should:

I. Manage and avoid unnecessary risk to manned aircraft, and to people and property on the surface, and avoid operations that may alarm or disturb people on the surface and surroundings.

Examples of best practices and code of conduct:

- Do not operate over people without authorization, proper training and equipment. Consider using a covered area or safety line to segregate flight operations from non-participants and minimize risk to people.
- Use aircraft and payloads composed of frangible or energy-absorbing materials, propeller guards, and other available mechanisms to mitigate risk of injury to persons such as parachutes.
- Monitor people within the proximity of your intended operations closely and keep them informed at all time until the operation is finished.
- Contract the coverage of liability insurance. Understand and comply with all the terms and limitations of the policy.

- Ensure adequate separation from people, other aircraft, and unauthorized airspace.
- Develop and maintain an operation manual to help identify and describe the system and operations characteristics, including specifications of the aircraft, responsibilities of the operator organigram, pre- and post-flight checklists.

2.3 Training and Proficiency

RPAs stakeholders should:

I. Participate in regular training to maintain and improve their aptitude as pilots.

II. Train to have an effectively respond to emergencies and maintain an accurate log to document your experience and improve future aeronautical decision-making and risk management.

Examples of best practices and code of conduct:

- Develop and follow a training regimen that incorporates the assessment of your progress. Obtain guidance and search for feedback from an experienced pilot or operator.
- Learn appropriate use of the platform manufacturer's manual or instructions to conduct flight planning, properly secure payloads, determine aircraft limitations, performance, and power requirements and assess weight and balance.
- Applicable safety, informational registrations numbers or identification plates placed on the platform. Ensure those plates are visible and properly affixed.
- Become familiar with orientation of the platform status lighting and their related meaning to enhance situational awareness.
- Design a ground safety plan and an access to appropriate fire suppression equipment and other emergency accessories and the proper channels to contact emergency services and other.
- Select an appropriate training area, taking into consideration properties of third parts, controlled or non-controlled airspace, local restrictions, and potential safety and privacy issues.
- Fly with enough frequency to maintain the attitude according to your certificates and authorizations.
- Ensure before each flight that your safety, failsafe, and other settings are configured appropriately.
- Understand and train to use appropriate procedures in the event of system malfunctions or failures such as electrical, rotor, propulsion, or loss of control link.

2.4 Security and privacy

RPAs stakeholders should:

I. Take measures to maintain the security of persons and property affected by RPAs activities.

II. Remain vigilant and immediately report suspicious, reckless, or activities which do not respect approved or declared usage of RPAs.

III. Become familiar with current security and privacy rules and best practices.

IV. Recognize and respect the public's privacy.

Examples of best practices and code of conduct:

- Determine the ownership of property on which you desire to overfly and seek prior permission or authorisation.
- Do not deactivate or degrade geo-fencing or other security features without the explicit authorization of the appropriate authority.
- Comply with applicable requirements for electronic identification, tracking, and authorization.
- Consider use of systems that improve data security (including encrypted command and control systems, and relevant security standards), and provide at least the level of security required to satisfy information security requirements.
- Avoid UAS operations near prisons, power plants, military bases, and other critical infrastructure. Notify and ask for uthorization such entities prior to operating nearby.
- Limit data capture to mission-related objectives.
- Retain personal data only when legally and purposefully collected, and only for the duration necessary.
- Avoid the collection of personal data without the subject's consent. Delete such data immediately upon discovery and maintain a de-identified log of the deletion.
- Implement a written privacy policy that is appropriate and responsive to your RPAs operations.

2.5 Environmental Issues

RPAs stakeholders should:

I. Recognize and seek to mitigate the environmental impact of RPAs operations.

II. Minimize the discharge of fuel, oil, and other chemicals into the environment during refuelling, pre-flight preparations, servicing, and flight operations.

III. Recognize that some RPAs components, including batteries, other fuels, and lubricants, may be hazardous and require special handling procedures.

IV. Respect and protect environmentally sensitive areas and avoid flight over noise-sensitive areas and comply with applicable noise-abatement procedures.

Examples of best practices and code of conduct:

- Learn and adopt environmentally responsible methods for all aspects.
- Adopt organizational policies for managing environmental issues.
- Adopt environmentally sound and legally compliant procedures for battery transportation and storage.
- Consider the potential impact of RPAs on animal life, and comply with recommended practices when flying near wilderness, wildlife, marine sanctuaries, and other environmentally sensitive areas. Recognize that RPAs may attract, frighten, or injure birds and other animals.
- If practicable, avoid residential and other noise-sensitive areas.
- Be aware of the noise signature of your aircraft, take steps to limit ambient RPAs noise, and consider system modifications if possible.
- Flight always above a minimum height to avoid disturbances.

2.6 Use of Technology

RPAs stakeholders should:

I. Become familiar with RPAs equipment and related technologies.

II. If automated is authorised, practice effective system monitoring and ensure you are prepared to revert to manual operations if available.

III. Identify failure modes, and where practicable.

IV. Understand the limitations of, position-indicating technologies including detect-and-avoid if available.

Examples of best practices and code of conduct:

- When practicable, invest in new technologies that enhance your proficiency, knowledge, situational awareness, and advance flight safety.
- New technologies will increasingly provide enhanced safety capabilities, including, e.g., detect-and-avoid, obstacle avoidance and supporting beyond visual line of sight (BVLOS) operations.
- Conditions that may induce control signal attenuation, interference, or disruption such as electromagnetic fields near power lines, transmission towers, or other transmitting devices may disrupt control signals. Determine the potential impact and develop contingency plans.
- Consider the use of flight data monitoring, tracking, and flight recording to improve training, flight operations, post-flight review or debrief, and investigation after crash.
- Accuracy limitations of your GPS and other navigation systems, learn to identify degradation or failures, and how to apply effective recovery procedures.

- Consider keeping backup devices including extra batteries or power supplies.

3 Complete example of drone operation based in best practices and code of conduct.

The Corus proposal of a fully successful operation identifying all the existing phases. The following table summarizes them. The guideline has been adapted from the generic value chain, starting from the UAV Setup and ending after the flight.

PLATFORM	UAV Setup	Construction
		Initial Setup
		Airworthiness
		Maintenance
OPERATIONS	Before flight	Material checklist & Mission Planning
	During flight	Safety
	After flight	Incident reporting
		Data storage

Table 1 phases

Before any drone commercialisation and any flight the involved industry stakeholders have a role in ensuring best practices that affect the platform. Making sure your drone is safe to operate should be the main priority when both selling and planning on operating a drone. A variety of sources, professional, governmental, and non-profit, have been researched to provide the following guideline.

During the first phases of any design, construction or test of any platform, rigorous consignments must be taken to have as a maximum priority the security and certainty that all components, materials, devices, software comply with the protocols and quality standards.

3.1 Construction of the drone

Following precautions should be taken when designing and assembling a drone while being under construction:

1. **Load**: Motor power requirements are determined by the limit load (maximum load to be expected) and the ultimate load (limit load multiplied by factor of safety).
2. **Interaction of Systems and Structures**: If the drone would be affected by interference or malfunction of one of its systems, these cases should be considered before flight.
3. **Structure**: The structure must be capable of supporting the ultimate loads.

3.2 Initial Setup of the drone

It is critical to setup every drone properly before attempting to fly. As an example of professional drone operator companies, this state-of-the-art analysis uses some of the HEMAV's documents, one of the four companies with more number of operations in the world. For this case, as recommended in the following steps should be taken for the initial setup:

1. **Initial configuration**: First on, the flight controller should be connected to a computer via the USB port or any other connection standard to ensure:

    a. The firmware has the ultimate update. Most devices will have the ability to be upgraded or repaired remotely, by downloading new firmware or software and the operator must check it.

    b. The flight parameters such as altitude, velocities, flight modes, sensor and cameras work and respond correctly.

2. **IMU calibration**: The IMU (inertial measurement unit) has to work properly. Ensure that is always calibrated. In case it isn't, execute the calibration menu.

3. **Radio controller link**: Ensure that the drone and the ground control station are well linked and the orders, status information and flight telemetry are transmitted.

3.3 Airworthiness of the drone

Airworthiness is by definition the ability of an aircraft or other airborne equipment or system to be operated in flight and on the ground without significant hazard to aircrew, ground crew, passengers or to third parties; it is a technical attribute of materiel throughout its lifecycle. This capability is determined by drone manoeuvrability, maximum flight time, and structural integrity. Every drone should be inspected on a regular basis (as published by manufacturer) to ensure airworthiness. Operating a faulty drone presents significant safety and liability concerns. To ensure airworthiness, only drones with CE certification should be used.

3.4 Maintenance of the drone

All drones should undergo regular maintenance checks to ensure safety and mission success. The maintenance cycle is determined by the specific drone manufacturer. During these check-ups, every system should be tested for functionality, efficiency, and airworthiness. Maintaining a proper maintenance schedule is crucial for the maximum insurance coverage in the event of an accident. It is recommended to perform a test flight after any maintenance.

In this subsection propose a generic maintenance program that can be extrapolated to any platform.

3.4.1 Power plant group maintenance

This section explains how to proceed to perform a correct revision and maintenance of the aircraft's engines.

For brushless motors, it is recommended to make a visual check before each flight to verify its correct structural integrity, as well as its attachment to the structure.

In addition, the correct rotation of the propellers will be checked to verify that they rotate freely and there is no foreign body inside that prevents rotation.

The ESC (Electronic Speed Controller) does not require any special maintenance. It is estimated a longer life than the engine.

The propellers must be checked regularly, replacing them if any damage is detected. It is necessary to verify especially the unions of these in a habitual way, as well as the presence of cracks along its surface.

3.4.2 Structure maintenance

The structure needs a general maintenance to detect any type of oxidation or deterioration over time.

It is recommended that a visual inspection of the entire body be made before each flight to detect possible cracks, bumps or mobility of certain parts that should be rigid. The screws, glue paste must be replaced or re-welded if necessary.

3.4.3 Maintenance of batteries

Batteries are one of the most essential components in all remotely piloted aircraft. It is recommended to carry out two complete load cycles before using them for the first time, so that they recover the maximum load capacity in case they have lost it during their previous storage. For this purpose, loading and unloading will be done only and exclusively with the chargers recommended by the manufacturer.

In addition, one of the characteristics of the batteries is the so-called memory effect. The batteries should be completely discharged.

They will be stored at room temperature and in a dry and sun-protected place, with an approximate load of 50% of their capacity (equivalent to about 3.7 V per cell)

In operation, they will be replaced at the moment when the battery telemetry indicates in flight a voltage lower than 3.6V per cell, so that they never reach a complete discharge.

3.4.3.1 Tips on the use of lithium polymer batteries

- Use only specific chargers for lithium polymer (LIPO) batteries to make the charge safe and effective. Most LiPo batteries should be charged at a maximum of 4.2 volts per cell. In case of misuse or a bad charge of the LIPO battery this could cause fire, injury or damage to people or objects.
- You must always monitor the battery during the charging process.
- Do not charge batteries near flammable materials or conductors of electricity. For more precaution, use special fireproof bags to insert the LiPo for your charge.
- Never charge a battery that is swollen, dilated or damaged.
- Never recharge the battery in a moving vehicle.

- Never overload the battery, when the charging process is finished disconnect the battery from the charge.
- Unplug the battery charger when you are not using it.
- Store the batteries in a metal or ceramic container or flameproof bags specially prepared for this. Always store the battery at room temperature, extreme temperatures are not recommended. Store the batteries in places with temperatures between 4 and 27 degrees to keep them in perfect condition. When transporting batteries, the temperature should always be maintained between -5ºC and 66ºC.
- Always store batteries away from fire or other sources of heat. Do not expose the batteries to direct sunlight for long periods of time.
- Always store the batteries with a partial charge (30%) if they are going to be unused for a while. Do not store completely discharged. Batteries lose approximately 5% per month when stored in good condition.
- Do not store damaged batteries in plastic bags.
- After using the batteries wait an approximate time of about 25 minutes to cool down and then reload them safely.
- Make sure that connections have been made correctly. A placement reversing the polarity can cause risk of damage, fire and even explosion.
- Never short-circuit the battery, cut it or break it.
- Check the battery after an impact. In case of having to discard it remember to comply with the legal dispositions in force for the elimination of waste.
- Never insert or remove the battery when the vehicle is in operation.
- Disconnect the battery immediately if it detects a strange smell, noise or smoke.
- In case of fire do not try to extinguish the flames with water. Use an extinguisher.
- Always leave the battery disconnected from the aircraft when it is not in use.
- Never completely discharging the battery, the voltage of each element should never fall below 3 volts in case of lowering that limit will ruin the battery without remedy. It is recommended not to discharge the battery below 12-18% of its total capacity or a voltage of 3.4 volt for each of the elements that make up the battery.
- In all cases, always follow the manufacturer's recommendations.

3.4.4 Maintenance of tank

In case of an aircraft powered by any type of fuel, the tank that hold the fuel must be check and clean. As a general rule:

- Always follow the manufacturer's recommendations.

3.4.5 Maintenance of control and command devices

Does not require special maintenance. Possible updates of the firmware version should be checked periodically (every 2 months). Stable versions will be used after having adapted the possible modifications of the different parameters with the platform itself.

3.4.6 Program of revisions

The review program consists on the set of actions that ensure the correct level of airworthiness of the aircraft, and does not include, under any circumstances, operations that involve modifications of the constituent elements. Only modifications contemplated by the manufacturer in the corresponding manual or maintenance instructions can be made on the aircraft.

3.4.6.1 First revision after assembly

Once the RPAS is assembled and before its first flight, a complete revision will be made, which will include a verification of the structure in general, the configuration and the operation of the system. The following are maintenance tasks for this review:

- Review of all the elements: The structure, propellers, power unit, general fasteners, fixing of the identification plate once assembled to verify its functionality and structural resistance will be reviewed.
- Battery: checking the batteries, including the state of charge and securing the batteries to the vehicle.
- Functional test on the ground:
  - Calibration and verification of sensors and equipment necessary to carry out the intended operations (Calibration of controls and sticks, correct channels, numbering and direction of rotation of correct electric motors, correct placement of the propellers, correct balancing of the propellers)
  - Check its operation (including flight controls at least 10 m away from the aircraft).
  - Installation of the appropriate software version and verification of its operation.
  - Operation of video transmission equipment. Power and quality of the signal and image.
  - Correct check fixing and operation of the payload.
- Functional test in flight:
  - Check its operation. (Check the correct operation of the aircraft in its different flight modes and test all the advanced functionalities, safe flight termination systems, emergency systems).

3.4.6.2 Pre-flight check

The pre-flight check that must be carried out before the flight and aims to ensure that the RPAS is able to perform the planned flight safely. The following are maintenance tasks for this review:

- Documentation: necessary that the staff of the operation should always carry with them.

- Structure of the aircraft: Revision of blows, cracks or misalignments in the chassis, fuselage, landing gear and arms. Identification plate (Conservation and correct fastening).
- Motors (electric): General cleaning, blade hubs, support arms.
- Motors (fuel): Check general status, connections and cleanness.
- Propellers or Blades: Adjustment of the same and direction of rotation, physical state (Clean, without fissures or symptoms of fatigue, without erosions or wear), correctly balanced.
- Energy:
  - Batteries of the Aircraft: visual check, without blows, or swollen, or perforated. Measure pre-flight and post-flight charge level.
  - Fuel of the Aircraft: In case of an explosion engine check fuel status.
  - Batteries of the station: visual check, without blows, or swollen, or perforated. Measure pre-flight and post-flight charge level.
- LED and / or painting lights: Position/Navigation lights are not fused.
- Payload: Fixation and correct movements of the Gimbal.
- Emitter-Ground Station: Correct position of switches (Attitude, GPS, Fails Safe, etc.), Sticks in position 0, free movements of the sticks, antennas correctly fixed, straps and harness in good condition
- Software Update: Verify the implemented version and its correct operation.
- Functional Test: Turning on the aircraft, checking diagnostic lights and sounds, starting engines, checking correct rotation and speed of all, absence of vibrations, stationary lift 2 meters from the ground, smooth forward and backward movement, right bank and left, yaw turn right and left.

3.4.6.3 Post-flight check

The inspection carried out after the flight aims to verify that the RPAS is in correct condition after carrying out the planned flight.

After each flight it is advisable to make a visual inspection of the aircraft (mainly check that the temperature of the battery and motors is correct).

3.5 Material and Operation Checklist

Before departing for a mission, the pilot should perform a material checklist to ensure that all the components are ready for transportation. The list will vary depending on the mission requirements (ex. payload) and drone used.

In the same way, an operation checklist should be used as a tool of help to reduce the errors caused in the limits of the memory and the attention in the human being. It will ensure consistency and completeness in the performance of a task.

Here find attached an example of each checklist.

3.5.1 Material checklist

- Allen type keys of various metrics. (2,3,4,5 mm).
- Multiple hexagonal flat keys, metrics. (2,3,4,5 mm).
- Star screwdriver of various sizes.
- Flat screwdriver of various sizes.
- Layered forceps.
- 35-50W soldering iron
- Tin of 0.75-1mm
- Electric tester.
- Infrared thermometer.
- Thermo-retractable insulation.
- Heat gun.
- Glue.
- Pliers set.
- Flat files set.
- Set of round files.
- Scissors.
- Small hammer.
- Cutting blade.
- Battery tester.
- Power and signal quality tester.
- Cleaning elements (rags, cleaners).
- Magnifying glass and third arm for welding.
- Micro / mini USB cable.
- Replacement micro SD card with adapter
- Replacement propellers
- Replacement screw screws
- Replacement propeller washer
- Laptop and Charger
- Car investor
- Technical sheet copy of the insurance of the aircraft and responsible declaration
- Protective Equipment:
    - Gloves
    - Vest
    - Non-metallic boots / toes
    - Helmet
    - Glasses

3.5.2 General operation checklist

MATERIAL	OK	KO
Platform		
Remote control		
Connecting cables		
Screen/video receiver + protector		
Camera/s		
SD Card		
Batteries		
Replacements propellers set		
Batteries charger pack		
Operator documentation		

PRE-FLIGHT CHECK			
		OK	KO
Antennas	Check that they are well positioned and positioned in the RC control		
Engine	Check that they are not damaged		
Propellers	Check if there are damages, if they are well fixed and if they turn freely		
Fuselage	Check for any damage to the fuselage and landing gear.		
Gimbal	Check the normal operation of the gimbal		
SD Card	Check that it has been placed, if necessary.		

BEFORE TAKE-OFF			
		OK	KO
Security perimeter	Ensure a security perimeter around the RPAS		
Briefing	- Take-off and landing areas - Emergency procedures - Others		
Turn on remote control	The battery must be at least 90%		
Turn on the RPA	Check for any damage to the fuselage and landing gear.		
Initialization	Wait until the RPA is initialized and check if there is any abnormal alert		
Check battery voltage	Battery or batteries are charged		

TAKE-OFF			
		OK	KO
Weather conditions	Visually check meteorology		
Check the control mode	Verify (usually in P mode)		
Surroundings	Check the environment		
Verify GPS	Verification of GPS quality		
Start engines	Start engines		
Verify that there are no warning messages	Check if there are any relevant checks		
Verify that the Home point has been updated	Verify that the Home point has been updated		
Control of the aircraft	Check the manual controls of the aircraft (pitch, roll & yaw), about 2 meters above the ground and in front of the pilot.		

DURING THE FLIGHT			
		OK	**KO**
Status	Check for any warning		
Signal intensity	Verify the power of the RPA signal		
Coverage of satellites	Check that the number of satellites is sufficient (minimum 4)		
Battery	Monitor batteries and voltage. Minimum 20%		
Aeronautical communications	If applicable for the area. Need for radiophone support and corresponding protocol.		
Landing	Verify that the space is free of objects and people, with sufficient space of security.		

LANDING			
		OK	**KO**
Disarm	Check for any warning		
Turn off the RPA	Verify the power of the RPA signal		
Turn off the remote control	Check that the number of satellites is sufficient (minimum 4)		
Batteries	Take off and let it cool until next charging cycle		
Debriefing	Inform to all active parties in the operation about the end of operation and notify any relevant information		

Table 2 Checklists

4 Liability Assurance

4.1 Insurance

Although the use of drones offers a variety of advantages, they also present new liability concerns. Drone accidents/malfunctions can cause both bodily harm and property damage, making it important to follow the best practices for legal protection in the case of an incident. To receive maximum coverage for liability, the drone pilot must comply with all the country drone laws, have the proper certificates and training, inspect the area, log and audit operations, ensure fulfilment of maintenance cycle, and respect privacy concerns.

Regulation (EC) 785/2004 defines the minimum level of coverage per accident depending on the drone's maximum take-off mass, where the minimum is 1.000.000€. Most recent drone accidents fall into two categories 'Property damage' and 'Near miss' [DR5 2018].

4.2 Incident Reporting

From the drone operator point of view, active reporting is a crucial aspect of keeping any operation organized and efficient. It is important to log every mission (including date, departure time, arrival time, aircraft, etc), as well as which pilots and drones are available. As an example, one of the project partner is currently working on a solution with a complete Maintenance and Operations Management (MOM) software, foreseen to be made public in 2019. MOM is one of many examples from software tools that allow users to log all important data, as well as to stay organized with a flight calendar and maintenance reminders. See the following figure:

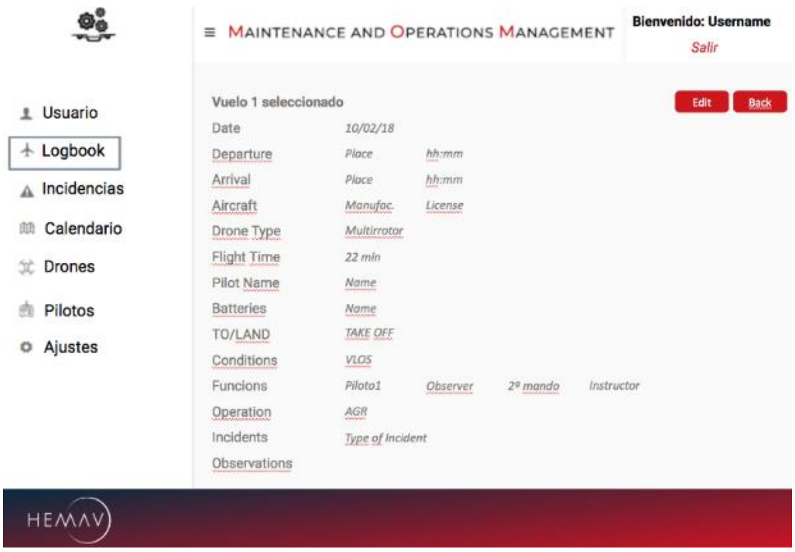


Figure 1 A Maintenace and Operations Management application

Pilots and operators should always log the flight records as soon as possible, as well as keep the calendar up to date. With this information, the drone operators and the companies are able to report, in turn, the most relevant incidences to the correspondent National aviation authority.

4.3 Data storage and dissemination

Google News Lab [GNL 2017] states the following basic principle: one should never do with a drone what one would not do on the ground. Storing images or videos of identifiable people or property can result in personal damage and legal claims. Therefore, it is recommended to record only when necessary, and to delete captured data once the required processing is completed. Drone users should adhere to the same dissemination schedules as other professionals collecting data, such as photographers and inspection officers.

4.4 Precautions relative to health while operating RPAs

This section includes the health and hygiene conditions that are considered necessary for the flight staff of the operator to be able to join their workstation in good physical and mental condition to be able to take charge of a flight service. It also details the recommendations on healthy living habits and a self-assessment that has been considered appropriate.

Here are the measures to be taken regarding:

- Alcohol and other liquors that produce intoxication.
- Narcotics and drugs.
- Sleep medications.
- Pharmaceutical preparations.
- Vaccines.
- Blood donation.
- Food precautions before the flight and during the flight;
- Surgical operations.
- Sleep and rest.

It is forbidden to perform any flight operation when the work capacity is diminished due to illness, traumatism, low physical or mental condition, fatigue, or by ingestion of some medications.

In case of stress, it is up to the pilot to decide if he is in the right conditions to carry out his work. However, in the slightest doubt, the service must be aborted. In addition, if the pilot appreciates that any member of the operator's team has diminished his capabilities, he must prevent him from exercising his functions until his capacity for work is normal.

4.4.1 Alcohol

As a general rule, alcohol consumption is not allowed.

Alcohol will not be consumed during the 8 hours preceding the flight, although it is recommended that this period be extended to 24 hours, and therefore it is also not allowed to consume alcohol during that flight.

4.4.2 Narcotics and drugs.

The use and consumption of these substances is strictly prohibited, unless a doctor has ruled that such consumption is absolutely necessary for the good of the patient's health. However, these personnel will not be able to carry out their mission in a service unless a specialist in Aeronautical Medicine certifies that health, both physical and mental, is not affected.

4.4.3 Sleep medications.

They are incompatible with the flight service.

4.4.4 Pharmaceutical preparations.

Antihistamine preparations will not be taken during the 12 hours preceding the flight service. These preparations are usually prescribed to combat dizziness and allergic diseases. In many cases, the combinations of different preparations cause their effects to be enhanced or produce unforeseen reactions that compromise the safety of the flight service.

4.4.5 Vaccines.

A vaccine should not be given unless at least 24 hours have elapsed from it until the start of a flight service, in case of adverse reactions. In addition, alcohol should not be consumed within 24 hours after vaccination.

4.4.6 Blood donation.

Team members must not donate blood unless there is a separation of at least 48 hours from donation to the start of a service

4.4.7 Food precautions before the flight and during the flight.

It is recommended not to start any flight without having taken small refreshments. The gases that can be generated during the digestive process (aerophagia) are producing some discomfort such as headache, earache or feeling of heaviness in the stomach. To avoid or reduce aerophagia it is recommended not to eat too quickly, chewing and salivating foods, eat in moderation, avoid drinking large amounts of liquid (especially carbonated drinks), avoid eating foods such as beans, cabbages, onions, apples, cucumbers, melons, etc. Check the status of perishable foods, particularly seafood.

4.4.8 Surgical operations.

No service will be assigned to any member of the team that has undergone surgical intervention until they have a certified medical discharge by their general practitioner.

4.4.9 Sleep and rest.

Flight safety requires that team members be rested and have enough sleep before starting a flight service.

4.4.10 Recommendations on healthy living habits

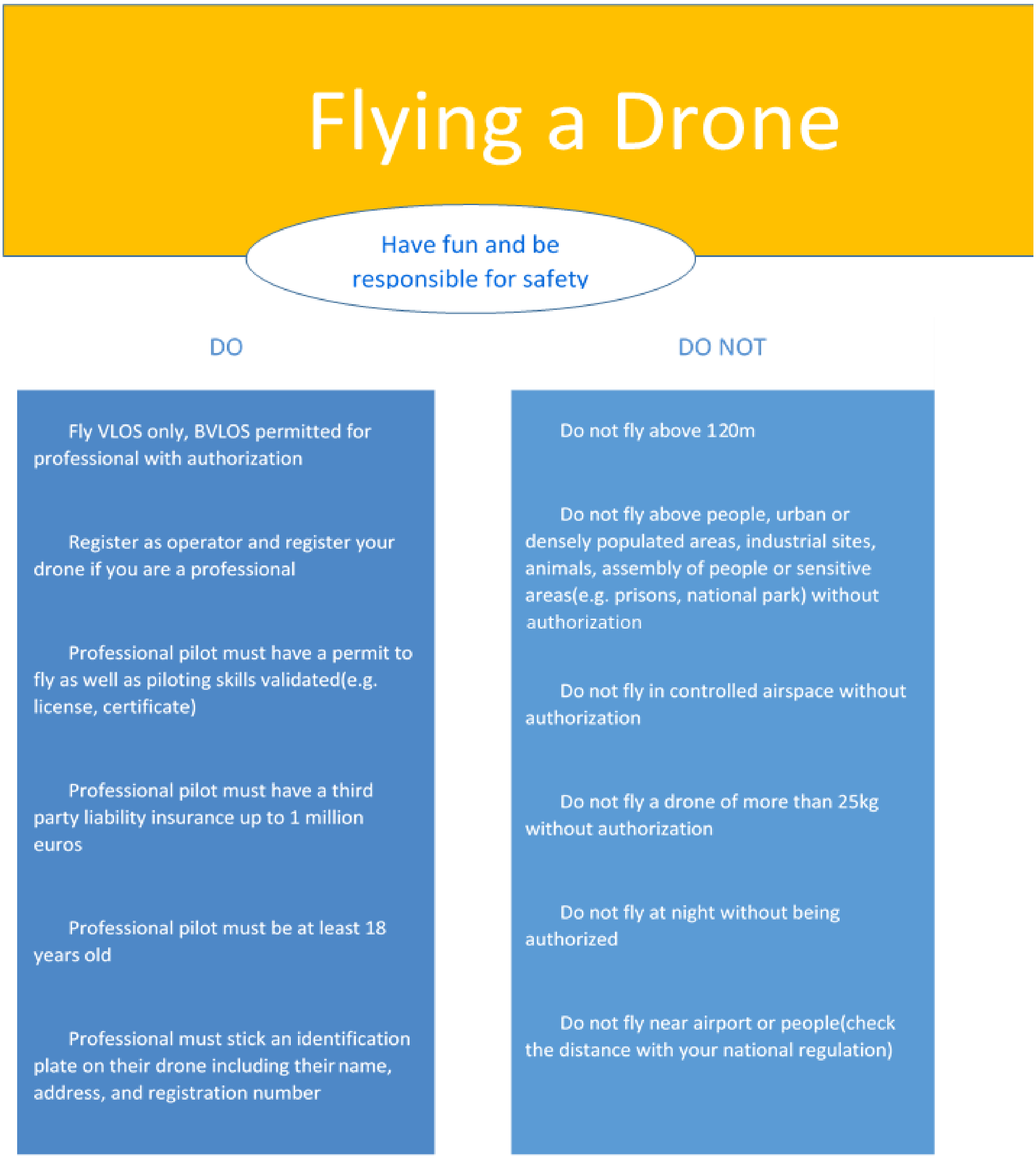
It is recommended for the members of the crews:

- Maintain an appropriate physical form.
- Perform exercise regularly and avoid sedentary lifestyle and inactivity.
- Sleep and rest properly.
- Avoid the use of stimulants.
- Maintain an adequate diet.
- Respect work and rest periods.
- Avoid the use and consumption of alcohol, tobacco and other drugs.
- Avoid self-medication.

The crew and other personnel involved in any way in the operation must know and strictly apply all safety and hygiene standards at work, in order to minimize occupational risks, and carry and properly use PPE (personal protective elements) that are necessary for the safe performance of their functions.

5 A proposal for a "DO/DO NOT" leaflet

Most of the best practices listed above are already covered by most countries' current regulations. Based on the most common topics and characteristics found in European regulations, the current do/do not leaflet could be as follow:



Founding Members
EUROPEAN UNION EUROCONTROL

SESAR JOINT UNDERTAKING

Intermediate ConOps

Annex J – Current regulatory environment of Europe

D6.2	CO
CORUS	
Grant:	763551
Call:	2016 SESAR 2020 RPAS Exploratory Research Call (H2020 – SESAR -2016-1)
Topic:	Topic 01: SESAR UTM Concept Definition
Consortium coordinator:	EUROCONTROL
Edition date:	19 Mar 2019
Edition:	01.00.00

Founding Members
EUROPEAN UNION
EUROCONTROL

Table of Contents

1 *Introduction* 3
2 *General most common regulation topics* 1
3 *Specific regulations* 1
4 *Documentation* 2
5 *Drone equipment* 3
6 *General conclusion on regulations* 4
7 *The do/do not leaflet* 5

1 Introduction

Since the previous survey of European countries regulations for drones, a lot of regulations have been enriched and have become more precise, including limitations, lists of documents and pilot's training requirements, registration, insurance requirements for instances.

Most of them are now matching more or less with the EASA regulation as published in the Opinion 01/2018.

Nevertheless, the European countries regulations in the summary below are probably incomplete, many websites of the national civil aviation authorities being only in the native language.

Regulations of Spain, France, Germany, Italy and Belgium have been confirmed, as CORUS welcome members of these countries.

All the other information shown in the two tables below and are a summary of the information found on the websites uavcoach.com and dronerules.eu.

If a box is white/empty, it means no information has been found for the corresponding topic. It does not necessarily mean that the information does not exist, but it has not been found.

It maybe shows how hard it is for an operator to find a regulation today. We could assume that a professional would be able to find the regulation of the country he would like to operate, but a recreational operator, wishing to use his drone during vacations, will have difficulties to find the regulation of the country he plans to spend the vacations. With the risk that he adopts a dangerous behaviour.

After the tables, we have added a list of particular regulations or recommendations as defined by some countries.

This work allows us to propose a kind of leaflet of what could be the do/ do not list in most European countries, excluding very specific regulations on particular points.

This page is intentionally blank.

2 General most common regulation topics

The two tables following show a global picture of the most common regulated topics per country.

Table 1. Legal administrative and other requirements

	Administrative						Additional requirements					
Pays	**Registration**		**Permit to fly, drone pilot license, certificate required**		**Other document (e.g. flight manual, flight log, license)**		**Mandatory equipment (e.g. fail- safe system)**		**Insurance**		**Age *adult supervision**	
Type of user	**Rec**	**Pro**	**Rec**	**Pro**	**Rec**	**Pro**	**Rec**	**Pro**	**Rec**	**Pro**	**Rec**	**Pro**
Austria	Yes	Yes	+25kg	+25kg		Yes			Advised	+1M€		+16
Belgium		Operator		Pilot Certificate				Yes		+1M€		
Czech republic		Drone	YES	Work permit		Yes	>910g	Yes	Yes	880000€		
Denmark	✓ Drone+250g ✓ owner	✓ Drone+250g ✓ owner			+7kg	+7kg			750000€	750000€ 7kg-25kg	+16	+18
Finland		Operator							Yes	+1M€		+18
France	Drone(+800g)	Operator	Certificate(+800g)	Aerial work permit					Yes	+1M€		
Germany			+2kg	+2kg					Yes			
Ireland	Drone +1kg on ASSET +25kg with CAA	Drone +1kg on ASSET +25kg with CAA								+1M€		
Italy		Drone		License		Yes		e- chip	Yes	+1M €		+18
Lithuania		Drone & operator		License & pilot certificate					Yes	+1M€		+18
Malta				If required								
Netherland		Operator		Both						+1M€		+18
Poland				Pilot Certificate & medical								

Portugal										+1M€		
Slovenia		Drone +5kg		Pilot license		Yes			Yes	+1M€		+18
Spain	Not required	Operator and drone Depending on its MTOW. (0 – 5kg / 5-15 kg / 15-25kg	Not required	Pilot certificate & operation permit	Not required	Yes	Not required	Yes	Advised	+1M€	-18 *	+18
Sweden		Drone		License				Yes	+20kg	+1M€		
Switzerland									+500g	+1M FS		
United Kingdom	Drone +250g	Drone +250g	Tests									
Latvia							Yes	Yes	+1.5kg	+1.5kg	+18	
Greece	Drone	Drone		Permit								
Romania	Drone	Drone		Permit	+15kg	+15kg				+1M€		
Bulgaria			Permit	Permit						+1M€		
Hungary				Both						+1M€		
Croatia				Work certificate						+1M€		
Slovakia	Drone	Drone & operator		Certificate					Yes	+1M€		+18
Estonia	Operator	Operator		Work certificate & permit						+1M€		
Norway		Drone + 2.5kg		Certificate & license +2.5kg		+2.5kg	+2.5kg	Yes		+1M€		

Table 2: Legal operational requirements

	Operational requirements														Airworthiness	
Pays	VLOS, BVLOS *BVLOS with authorization		Maximum height In meter *exceptions		Out of clouds		Distance from people in meter Horizontal/vertical *with permission		Distance from airport in km		Max drone weight in kg *or special permission		Night flight *with special license		Drone ID plate And/or label with name and address, etc…	
Type of user	Rec	Pro	Rec	Pro	Rec	Pro	Rec	Pro	Rec	Pro	Rec	Pro	Rec	Pro	Rec	Pro
Austria	VLOS		150		Yes	Yes										
Belgium	VLOS	VLOS	10	90	Yes		SD/0				1				No	Yes
Czech republic	VLOS	VLOS	300	300					5.5						Yes >910 g	Yes or>20kg
Denmark	VLOS	BOTH*	100	100	Yes		50/0		5		7	25	No	No*		Yes
Finland	VLOS		150	150			/0	/*	5		25	25				Yes
France	VLOS	BOTH*	150 *	150(-2kg) *			/0	/0			25*	25*	No	No		Yes
Germany	BOTH*	BOTH*	100	100			100/0	100/0	1.5	1.5	5*	5*	No	No		Yes(+250g)
Ireland	VLOS(300m)	VLOS(300)	120	120			30/0	30/0	5	5						
Italy	VLOS	VLOS	150	150	Yes		/0	/0				25*				Yes
Lithuania	VLOS	VLOS	120	120			50/0	50/0	1.8	1.8	25	25			No	Yes
Malta							/0	/0								
Netherland	VLOS	BOTH*	120				50/0	50	?	?	25		No	No		
Poland	VLOS	VLOS	150	150			30/0	30/0	5	5	25*	25*				
Portugal	VLOS	BOTH*	120 *	120 *			30/0	30/0			25*	25*	No	Yes*		
Slovenia	VLOS(500m)		150				150		1.5				No		Yes	
Spain	VLOS	VLOS	120	120	Yes	Yes	SD/0	SD/0				25*	No	No		
Sweden	VLOS(500)	BOTH*	120	150			SD/0	SD/0			7*	7*			Yes	Yes
Switzerland	BOTH*	BOTH*	150	150			100/0	100/0	5	5			No	No		

United Kingdom	VLOS	BOTH	120				150		1km (boundary)		20kg					
Latvia	VLOS(500)	VLOS(500)	120	120			50/0	50/0	?	?			No	No	Yes	Yes
Greece	BOTH*	BOTH*	120	120	Yes	Yes	/0	/0			25	25	No	No	Yes	Yes
Romania	VLOS	VLOS	300	300			?/0	?/0							No	Yes
Bulgaria					Yes	Yes										
Hungary			100	100			SD/0	SD/0					No	No		
Croatia	VLOS(500)	VLOS(500)	300	300	Yes	Yes	30/0	30/0	3	3			No	No	No	Yes
Slovakia	VLOS	VLOS	30	30			50/0	50/0					No	No	No	Yes
Estonia			150	150	Yes	Yes										
Norway	BOTH*	BOTH*	120	120			150/	50/	5	5						

SD=safe distance

?=restriction but no distance.

For the distance from airport, the reference of the distance is not always specified (e.g. from the perimeter fence, the center of the airport or the runway).

3 Specific regulations

About rules of the air:

- Give ways to manned aircraft.
- Give priority to all other aircraft.
- Do fly at a distance of 30m from obstacles.

About privacy:

- Do not capture images or video without permissions.
- Respect the privacy of others (Estonia, Norway).

About safety:

- Basic safety obligation (Hungary, Lithuania).
- Have a parachute for rotary wing drones if professional use (Croatia).
- Extend distance if assembly of people (150m in Croatia).
- Do not interfere or impede with manned aircraft.
- Do not fly in a negligent or reckless manner.
- Do fly at a safe distance from persons, structures, densely populated areas, animals, objects.
- Do not fly near accident sites.

Other:

- Drone pilot identifiable (e.g. hat, shirt).
- Specific rules for use of FPV, binoculars, automated flight in VLOS (Switzerland).
- Manual flight control only (Greece).
- Do not carry persons, luggage, cargo and mail (Slovakia).
- Do not fly in restricted areas, national park, about private property without owner permission (Greece, Hungary).
- The pilot shall take updated information about restrictions, AIP, etc…

4 Documentation

For an administrative purpose, and mostly in order to check that the operator, the pilot have the skills to operate with a certain kind of drone, for a certain category of operation in a certain environment, the regulator should request the procurement of specific documentation. Some documents may have to be provided also for the drone itself.

The below list is not exhaustive, and one or all the documents are not necessarily required in all the countries.

- Characterization of the RPAS.
- Liability insurance.
- Pilot documentation.
- Flight tests.
- Maintenance programme.
- Measures against illicit interference.
- Operations manual.
- Aeronautical safety study.
- Pilot license.
- Operation permit.
- Medical certificate.

5 Drone equipment

Some countries also require mandatory equipment for the drone, sometimes depending on the drone's weight, such as:

- Communications equipment.
- Safe termination of the flight.
- Over agglomerations of buildings a limiting impact energy device.
- Geo-caging/Geo-fencing.
- Lights/paint or other devices to guarantee visibility.

6 General conclusion on regulations

If the regulations are far from being uniform, the safety, as much for people on ground as for the other airspace users, is globally clearly the most important concern.

The list of measures, from the pilot qualifications to the distances(vertical and horizontal) from the people, including the distance from the airport or the restrictions of flight at night or in the clouds, just to name a few, demonstrate it.

Nevertheless, some statements are insufficient or not clear enough.

- From where or when does a drone interfere or impede with a manned aircraft?
- What is negligent or reckless?
- What is near accident sites?

These statements are left to the lectures of each pilot, which is clearly very dangerous. Probably a distance from the accident or the manned aircraft will have to be defined, even if this distance is not observed closely.

7 The do/do not leaflet

Based on the most common regulations topics and characteristics, the current do/do not leaflet could be as follow:

Flying a Drone

Have fun and be responsible for safety

DO	DO NOT
Fly VLOS only, BVLOS permitted for professional with authorization	Do not fly above 120m
Register as operator and register your drone if you are a professional	Do not fly above people, urban or densely populated areas, industrial sites, animals, assembly of people or sensitive areas(e.g. prisons, national park) without authorization
Professional pilot must have a permit to fly as well as piloting skills validated(e.g. license, certificate)	Do not fly in controlled airspace without authorization
Professional pilot must have a third party liability insurance up to 1 million euros	Do not fly a drone of more than 25kg without authorization
Professional pilot must be at least 18 years old	Do not fly at night without being authorized
Professional must stick an identification plate on their drone including their name, address, and registration number	Do not fly near airport or people(check the distance with your national regulation)

Intermediate ConOps

Annex K - U-space Architecture

D6.2	CO
CORUS	
Grant:	763551
Call:	2016 SESAR 2020 RPAS Exploratory Research Call (H2020 – SESAR -2016-1)
Topic:	Topic 01: SESAR UTM Concept Definition
Consortium coordinator:	EUROCONTROL
Edition date:	15 Mar 2019
Edition:	00.01.00

Founding Members

EUROPEAN UNION EUROCONTROL

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL

SESAR JOINT UNDERTAKING

Table of Contents

1 Introduction ***5***

2 Drivers ***10***

3 U-space Architecture Framework ***16***

4 Business Architecture ***20***

5 Operational Architecture ***27***

6 Service Architecture ***44***

7 System Architecture ***48***

8 Reference ***67***

List of Tables

Table 1 Specific uses of terms in this document 8

Table 2 U-space Blueprint service levels 11

Table 3 Architecture layers 17

Table 4 Architecture elements 18

Table 5 Architecture Sub-views 19

Table 6 Capability descriptions 23

Table 7 On drone capabilities towards U-space Capability 25

Table 8 Traceability Roadmap elements vs. Capabilities 26

Table 9 Nodes 29

Table 10 Information exchanges 33

Table 11 Mapping of Information Exchanges to Services 43

Table 12 U-space Services and their description. 46

Table 13 Supplemental Data Services and their description 46

Table 14 Infrastructure Services and their description. 46

Table 15 Mapping of Services to Capabilities 47

Table 16 Operational Stakeholders 51

Table 17 Other Stakeholders 52

Table 18 Stakeholder Roles 55

Table 19 Possible breakdown in systems. 56

Table 20 Possible breakdown in functional block of a DTM system. 60

Table 21 A possible realisation of a DTM system. 62

List of Figures

Figure 1 U-space levels 10

Figure 2 Services in each of the U-space levels 11

Figure 3: Principles for U-space architectures 13

Figure 4: EATMA Layered Structure 16

Figure 5 U-space Capability Model 21

Figure 6 U-space services in the roadmap document towards U-space Capabilities 24

Figure 7: Main Node Interaction Diagram 30

Figure 8: Supplementary Information Provision Diagram 31

Figure 9: Registration of the Professional Pilot 34

Figure 10 Registration of the Drone Operator 34

Figure 11 Flight Route 35

Figure 12 The Flight Plan with Strategic Deconfliction 36

Figure 13 Start Up, Taxi and Take Off 37

Figure 14: Tactical de-confliction 38

Figure 15: Post-flight Operations 39

Figure 16: Landing on a controlled airfield/airport/aerodrome 40

Figure 17: e-Identification, tracking monitoring and traffic information 41

Figure 18: Check flight conditions (e.g. weather, terrain, traffic density, regulations) 42

Figure 19 Service portfolio classification 44

Figure 20 Stakeholder roles using U-space services 48

Figure 21 Service providers Stakeholders classification in U-space 51

Figure 22 Possible breakdown in functional blocks for DTM System 57

Figure 23 An example of realization of a DTM System 61

Figure 24 Drone system breakdown in subsystems 63

Figure 25 Possible breakdown in functional blocks for Drone System 63

Figure 26 Deployment overview 65

1 Introduction

1.1 Purpose

This document is used to give to the reader visibility of the intermediate architecture development work of CORUS which required for Conops document.

This document is not aiming to be complete in this iteration of the work which is expected to be performed iteratively from a coarse grain definition to a fine grain to be published in next release of this document.

Main purpose of this document is to be used for stimulating its validation with the U-space Community during the CORUS Workshop 3 – Validation.

1.2 Scope

The CORUS project is exploratory research. In EOCVM terms the subject is at V0 and this project aims towards V1. In this document a description of the U-space architecture for Very Low level operations will be provided from a business and operational view point, supporting the incremental versions of the Use Cases prepared by WP2.

It will provide, as secondary objective, an overview of the service and system view points to support bottom–up coherencies of the concept of operations, as a result of the cooperation with SJU architecture group and sibling projects.

The objective of developing CORUS architecture is to support the definition of a Concept of Operation (the CORUS ConOps) and thus provides the foundation for U-space. The architecture addresses VLL and all U-space service levels. It addresses VLL operations in both uncontrolled (Class G) and controlled (Classes A, B, C, D, E and F) airspace, such as in and around airports for building inspections, aircraft maintenance, ILS and or VOR/DME calibration, calibration of runway lighting etc.

1.3 Document Structure

Chapter 1 – Introduction; it is the synopsis of this document.

Chapter 2 – Drivers; it addresses main inputs and architecture principles taken into consideration for developing the U-space architecture in CORUS.

Chapter 3 –U-space Architecture Framework; it presents high level description of the framework used to describe the architecture establishing a common language for architecture elements and views.

Chapter 4 –Business Architecture; it presents architecture elements and views to describe the U-space architecture from a business point of view. It provides the description of the U-space Capability Model.

Chapter 5 –Operational Architecture; it presents architecture elements and views to describe the U-space architecture from an operational point of view. It provides the description of the Operational Process Model.

Chapter 6 –Service Architecture; it presents architecture elements and views to describe the U-space architecture from a service-oriented point of view. It provides the description of identified services and their orchestration.

Chapter 7 –System Architecture; it presents architecture elements and views to describe the U-space from a system point of view. It provides the description of possible breakdown of the U-space in systems (in some cases with a further possible breakdown in functional blocks) and their relationships.

Chapter 8 – References; it lists relevant documentation

1.4 Intended readership

The primary readership for this document is those who have a responsibility for the management and maintenance of the U-space Architecture and its content. These readers can be divided into the following groups:

- CORUS Members – Those who are responsible for the development of the Architectural content and those who are involved in other CORUS activities which may review/complement and take as input the architecture developed.
- Sibling Project Managers – The managers of other relevant SJU projects which may be interested in the content that is collected within the CORUS architecture and in providing feedback for ensuring the overall quality and consistency of the U-space Architectural content.
- SJU - who wants to have the visibility of the CORUS work and contribute in the architecture definition.
- U-space Community – Those who are stakeholders of the U-space which are interesting in the ConOps and architecture principles and descriptions.

1.5 Acronyms and abbreviations

Term or Acronym	Meaning	Remarks
	Air vehicle which is not piloted from on-board by a human.	The term drone is used in the media[1] and in popular culture in an imprecise way. Drone is used in this document similarly imprecisely.
	Unmanned Aerial Vehicle	May or may not be remotely piloted – the term does not specify. It is representing the aerial part of the drone system.
	Unmanned Aircraft System	The final word "system" means this acronym includes more than just the aircraft.

[1] The word *drone* is short and hence often used in newspaper headlines.

Term or Acronym	Meaning	Remarks
	Remotely Piloted Aircraft System	Also RP = Remote Pilot and RPA = Remotely Piloted Aircraft. RPAS is a subset of drones; explicitly those with a remote (human) pilot. The term RPAS has – until recently – been used almost synonymously with drone in the community. With growing awareness that *there might not be a remote pilot* this mis-use is deprecated.
	Of drone flight: Not actively being piloted by a human at that instant.	There seems to be an ongoing search in the drone community for a precise meaning for the term “autonomous”, so that term is avoided. A single drone flight could include remotely piloted and highly automated phases.
	Air vehicles which are piloted from on-board by humans.	Hence also Manned Aircraft.
	Driverless Personal Air Vehicle	Effectively a drone with a passenger. https://en.wikipedia.org/wiki/Personal_air_vehicle
	An aircraft is a machine that is able to fly by gaining support from the air.	Manned or unmanned. Any size.
	Drone traffic management in the European Union	The CORUS project is concerned by U-space. *Note the term U-space was coined after the call that CORUS answered, hence the name of the CORUS project and many tasks within the project include the term UTM.*
	Air Traffic Management	A general term for all aspects of the control and organisation of air traffic and the services dedicated to doing so. ATM is currently focussed on manned aviation.
	UAS Traffic Management *or* Unmanned Traffic Management	In this document the term UTM refers to the general notion of management for unmanned air traffic and is analogous to ATM. The term UTM is used in this way by ICAO and in current literature. U-space is the European instance of UTM. Note there is a project being run by NASA to research UTM, which may lead to an instance of UTM in the USA. That project and instance will be referred to in this document as “NASA UTM”.
	Drone Traffic Management	As part of the Ground infrastructure, The DTM system encompasses the functionalities and services attached to the safe and efficient management of drone flights (ref. [6]).

Term or Acronym	Meaning	Remarks
	Very Low Level airspace	The ICAO Rules of the Air. in section 4.6 state that VFR traffic should stay above 500ft unless taking off or landing. Further restrictions exist for urban areas. Very Low Level (VLL) refers to the portion of airspace below 500ft, hence to a region in which manned aviation is not common
	Concept of Operations	Also written CONOPS
	Command and Control link for a drone.	From ICAO. *In the call "H2020-SESAR-2016-1" the term datalink seems to have been used with this meaning.*

Table 1 Specific uses of terms in this document

The following acronyms are used in this document and are listed here for convenience. For expansions of acronyms or that do not appear below, the reader is directed to AERIAL and for explanations of terminology, to the ATM Lexicon [7].

Acronym	Expansion	Remark
	Advisory Board	of CORUS: A group of organisations that have agreed to assist the CORUS work.
	Air Traffic Control	
	Air Traffic Management	
	Air Traffic Service	
	European Operational Concept Validation Methodology	
	European ATM Architecture	
	Exploratory Research	A classification of activity in the context of SESAR.
	Grant Agreement	Usually refers to the Grant Agreement of the CORUS project, number 763551, ref [1]
	Instrument Flight Rules	From ICAO. Contrasts with VFR.
	Instrument Landing System	

	Industrial Research	A classification of activity in the context of SESAR.
	NATO architectural Framework	
	NAF Operational View	
	NAF Service Oriented View	
	NAF System View	
	Project	S2020 industrial research is broken into Projects referred to by numbers. These projects are then subdivided into Solutions which are also numbered.
	Project Management Plan	Refer to the Project Management Plan of CORUS.
	SESAR 2020	The current instantiation of SESAR.
	Single European Sky ATM Research	The research activity associated with the "Single European Sky" initiative.
	SESAR Joint Undertaking	The body coordinating the work of SESAR.
	Transversal Activities	In SESAR, this term indicates activities influencing and involving several projects. *Projects are metaphorically vertical.*
	Technology Readiness Level	An assessment of maturity for a technology. See https://en.wikipedia.org/wiki/Technology_readiness_level EOCVM describes as similar scale for concept maturity.
	U-space Community Network	A collection of organisations and individuals interested in the CORUS work who may pose (or answer) questions relevant to the ongoing work and might attend CORUS workshops.
	Visual Flight Rules	From ICAO
	VHF omnidirectional range (VOR) and distance measuring equipment (DME)	A combination of two types of navigation aid commonly used in aviation today. See https://en.wikipedia.org/wiki/VOR/DME
	Work Package	

2 Drivers

2.1 U-space Blueprint, European ATM Master Plan Drone roadmap and U-space Architecture document

As the U-space blueprint [5] makes clear, a U-space Concept of Operations (ConOps) is required, especially for Very Low Level drone operations[2] and should describe the services and interfaces that are necessary to enable full development of the economic potential of drones while ensuring adequate levels of safety.

The U-space blueprint [5] defines four levels of services, as shown below. Each level is a package of related services. CORUS will make use of this terminology.

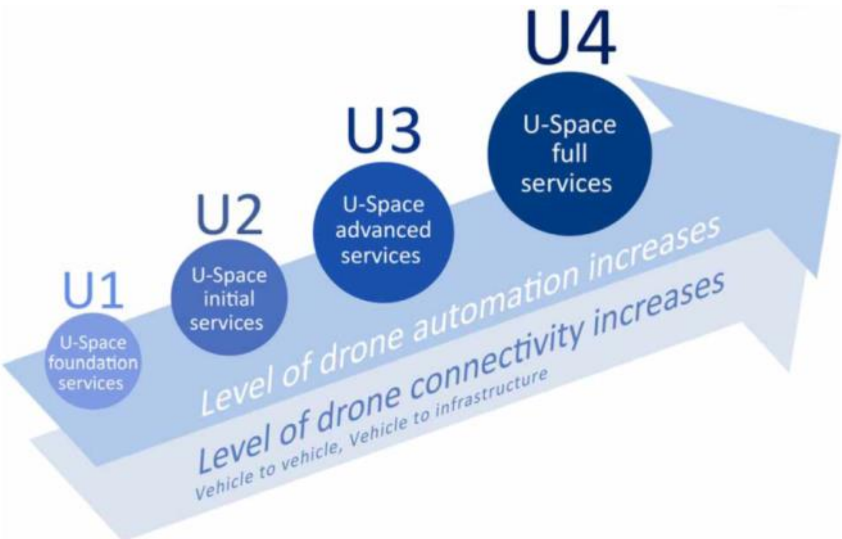


Figure 1 U-space levels

The U-space blueprint [5] lists a number of services, clustering them into "levels" that differ in terms of their deployment timeline. The following table summarises the document.

Level	Name	Target	Example services
	U-space foundation services	2019	Electronic registration (e-registration) Electronic identification (e-identification) Geofencing
	U-space initial services	2022..25	flight planning flight approval tracking airspace dynamic information

[2] Including operations beyond visual line of sight (B-VLOS), as well as in visual flight rules (VFR) environments. In accordance with the call, instrument flight rules (IFR) integration will not be addressed.

			procedural interfaces with air traffic control
	U-space advanced services	2025..30	capacity management assistance for conflict detection …
	U-space full services	2030+	integrated interfaces with manned aviation high level of automation, connectivity and digitalisation

Table 2 U-space Blueprint service levels

The U-space Blueprint is a brief document. The European ATM Master Plan Drone roadmap document provides more detailed description of services and drone capabilities which constitutes main top-down input taken into consideration in this first iteration in the CORUS architecture development work.

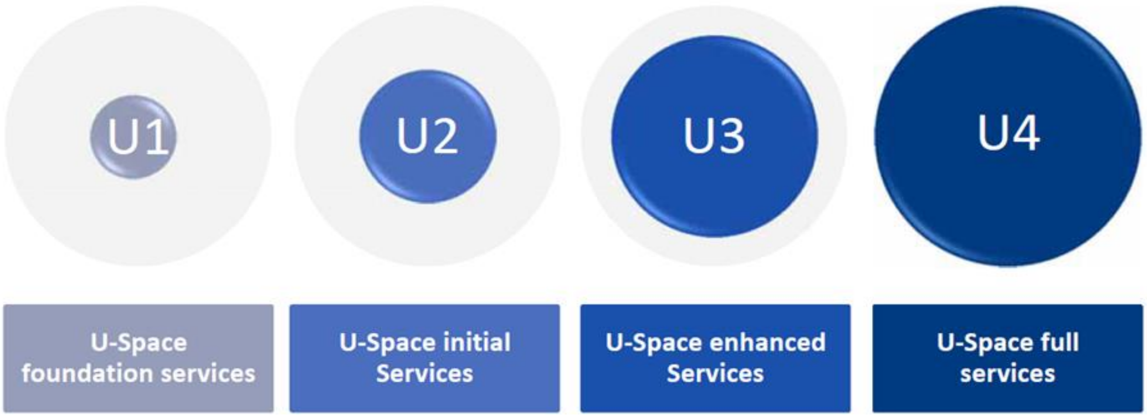


Figure 2 Services in each of the U-space levels

CORUS takes these inputs and seeks to

- Explain how these services are used to ensure safe, efficient operations.
- Provide, where appropriate, more precise descriptions of the services
- Elaborate more complete lists of services for levels U3 and U4 - as far as is possible today.
- Maintain the lists of services during the life of CORUS, interacting with other projects or actors who have contributions to make to those definitions.

2.2 CORUS Internal Drivers

CORUS splits the work in several work packages. CORUS internally developed among the others the definition of Use Cases, environment, requirements, services, constraints to operation in relation with failure and emergency. All these are important inputs are fed in the development of the U-space architecture.

2.3 CORUS Sibling projects

The CORUS project has no hard dependencies on the sibling projects in the sense of waiting for deliverables from those projects. But CORUS is transversal for these sibling projects. The sibling projects explore technology that should underpin the work done in CORUS, and as such there will be an interest in collaboration with siblings; U-space architecture links to the siblings will be the most sensitive as to agree a common/reference/precise terminology in the descriptions of elements.

Ad-hoc meetings with sibling projects have been hold to organise a mutually acceptable process and program. CORUS encourages sibling project representatives to attend CORUS workshops – at their own expense.

2.4 Architecture Principles

The U-space architecture has to support this vision and related principles. To go a step further, the U-space architecture is defined as:

- **Service Oriented Architecture**: A Service Oriented Approach shall be applied to ensure that the solutions are built based on a set of services with common characteristics.
- **Modular**: the architecture shall be decomposed in self-contained elements (Functional Blocks) which contain a meaningful set of functionalities with the required inputs/outputs, that can be reused or replaced.
- **Safety Focused**: The architecture shall always consider the safety of its stakeholders or of other people and places that may be affected by U-space operations.
- **Open**: a system architecture shall be developed which is component-based and relies on published or standardized interfaces based on SWIM principles[3] to make adding, upgrading or swapping components easier during the lifetime of the system. Some other expected benefits of an open architecture are to facilitate Reuse, to increase Flexibility, to reduce costs and Time to Market, to foster competition, to improve Interoperability and to reduce Risks.
- **Standard-based**: whenever there are exchanges between roles, the interfaces have to be defined and based on open standards.
- **Interoperable**: the main purpose of the interoperability is to facilitate homogeneous and non-discriminatory global and regional drone operations.
- **Technology agnostic:** to allow platform independent design, the architecture shall be described independently of the later implementation specifics, e.g. platforms, programming languages and specific products which shall be consistent with the operational architecture.
- **Based on evolutionary development (incremental approach)**: architecture work is an incremental and iterative process, building upon the previously consolidated baseline.
- **Automated:** the architecture shall be developed to facilitate the delivery of safe and secure U-space services with a high degree of automation of the processes as manual operations will be too labour intensive.
- **Allowing variants:** the architecture work shall allow variants and alternative solutions to be described. The principles listed in this document aim for ensuring interoperability between different implementations.
- **Deployment agnostic:** architecture work shall not constraints different deployment choices according to the business and regulatory framework established.
- **Securely designed:** architecture work shall address security issues such as cyber-security, encryption needs and consequences, and stakeholder authentication. It is needed to follow the SWIM principles- i.e. go for a central or federated PKI for identify management.

[3] separation of concerns of technology stack, information model, and logical service definition. Technology stack (Yellow Profile G/G or Purple Profile A/G) and information model (as part of the AIRM) should be common for all services. The separation of concerns allows for agility in future development (which surely will be required for drones – it will evolve for quite a while)

As illustrated in the figure below, this leads to a set of principles that drive any implementation of a U-space architecture.

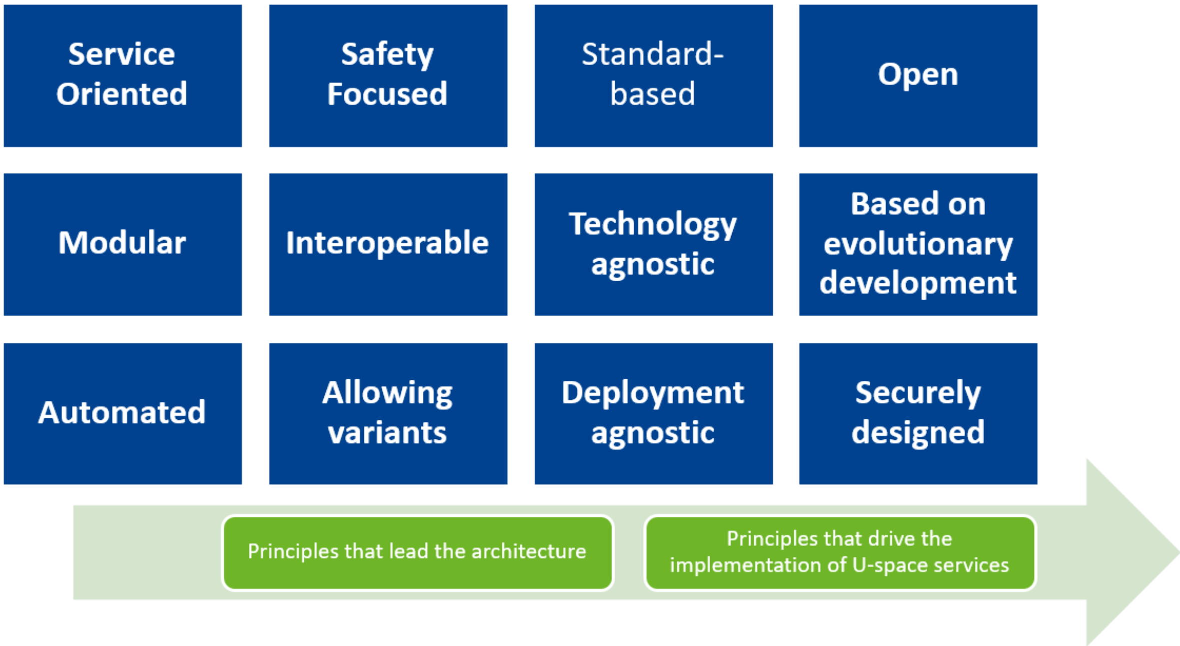


Figure 3: Principles for U-space architectures

These principles[4] are phrased here to confirm that any proposed service meets the criteria for inclusion as a service.

1. **Safe**

The service is designed to minimise the risk to third parties on the ground, other airspace users, and passengers. It is supported by appropriate safety management systems and processes.

2. **Reusable**

The service can be used in a multiple of operational scenarios and (where appropriate) by other U-space services.

3. **Autonomous units of business functionality**

The service provides a business function that may be independent of other services.

4. **Contract-based**

The interface and policies are strictly described by a standardised interface service contracts.

5. **Loosely coupled**

[4] The list does not imply any weighting of importance for the architecture.

The service contract is designed to be as independent of the service implementation as possible.

6. Platform-independent

Both the consuming and service systems can be on any platform that supports the service transport and interface requirements.

7. Discoverable and location independent

The service is located through a discoverable service registry/catalogue and accessed via universal resource locators, and therefore may move over time without disruption to consuming systems.

8. Accessible

The service is publicly accessible (with authentication or not as appropriate) for direct use. Public/semi-public interfaces (with registration or not) exist for use by third party applications.

Access to the service is open to all (except in case of security breach, level of security being defined by regulation and/or standards).

9. Interoperable with ATC

U-space data sent to ATC complies to ATC requirements (including cyber-security and certification of the information as requested by the ATC systems) in order to minimise the impact on ATM due to the emergence of U-space.

10. Auditable

Recordings and real-time data are preserved and made available for investigation purposes if requested. Service performance can be monitored and audited at national/European level by authorized agencies. Authorities may make recorded data available for research, training and system development - with an appropriate anonymization / obfuscation.

11. Liable

The service design allows the determination of who is responsible for any service failure or incorrect-untruthful data sharing.

12. Data validity

The service ensures data are valid in the timeline they have to be valid. This covers, as well, the data integrity.

13. Performance based

The service to Service Providers complies with the level of performance required by the authority. The service to Service Providers offers a quality of service level secured by a Service Level Agreement. The service is robust, with the necessary in-build resilience from a safety and security perspective (e.g. no single point of failure and filtering to ensure subsystems only have to handle data that matters to them). The service has to be delivered according to the appropriate time constraints. Latency of a service response has to comply with the identified level of performance.

14. Automated

The service has a high degree of automation in order to enable rapid response and ensure low costs. Human intervention is at a minimum: humans implement policies, monitor limits/alerts provided by automation, and intervene upon exceptions or when unsafe or unlawful operations are reported by automation.

15. Standards-based

The service is designed, implemented and consumed using standards that are appropriate to the nature of the service being provided.

16. Secure

The service is cyber-resilient and assures strong authentication of all actors.

17. Sustainable

The service is designed to minimise, when and where relevant possible, the environmental impact, of unmanned aircraft operations, including noise, and to protect the privacy of citizens.

18. Scalable

The service is designed to scale in various dimensions, including (but not restricted to) the number of users or services, the number of concurrent flights, the number of business use cases supported, the geographical areas where U-space is deployed.

The more generic set-up the better. Anything that requires tailoring to specifics of national or regional nature should be configurable (parametrized) and certainly not hard-coded.

3 U-space Architecture Framework

As an extension of the European Air Traffic Management Architecture (EATMA) work, CORUS, in coordination with SJU and EATMA team, is developing the architecture description using EATMA methodology [10] and technologies. The structure of the EATMA model is based on a standardised description framework for architectures. Specifically, it is based on the NATO Architecture Framework (NAF) V3 [8], which was used as a foundation for EATMA.

CORUS, having the goal of delivering the ConOps for U-space, has to design a high-level architecture of the concept. In addition, CORUS also aims to integrate the architecture provided by different projects working on the U-space architecture. Therefore as part of the architecting process, it integrates and aligns the structuring and architecting work that is performed, into a consolidated architecture, the U-space Architecture.

Having inherited the methodologies and technologies of SESAR there is not a dedicated document to describe the "U-space Architecture Guidance Material" because of the one already available of EATMA. Nevertheless, this chapter provides information on what it is the architecture, how it is structured, created, configuration managed and how it is communicated inside and outside SESAR.

The EATMA framework also defines how the elements relate to each other. This makes it possible to create a model of the architecture that provides traceability from performance needs down to technical solutions.

3.1 Architecture Layers

The EATMA framework organises elements and viewpoints in six different layers as is illustrated in the following figure.

Figure 4: EATMA Layered Structure

The purpose of layers is to provide a natural division of the architecture in different views that together provide a complete view of the U-space enterprise. Each layer contains a different set of elements that can be used to describe the view of the enterprise.

Architecture Layer	Description
Programme Layer	The programme layer contains the Operational Improvement Steps and Enablers as elements used to describe the U-space implementation schedule (as in ATM Master Plan addendum). This layer provides a project management point of view with the description of Solutions and their development roadmap.
Capability Layer	The capability layer describes the U-space's abilities. It can be understood as the strategic layer.
Operational Layer	The operational layer contains the elements needed to describe the operational concepts. This includes process models and descriptions of how U-Space actors collaborate.
Service Layer	The service layer provides a link between the operational need and technical solution by describing services. This may also include the linkage to data elements.
System Layer	The system layer describes all human and technical resources of a U-Space system including its internal functional breakdown and its interactions with the surrounding systems.
Standards Layer	This layer is used to describe standards and regulations needs within the European ATM.

Table 3 Architecture layers

CORUS U-space architecture mainly focuses on 4 layers with the intention to provide elements to build the Conops: **Capability (Business), Operational, Service and System**.

3.2 Architecture Elements

This chapter is aimed at showing the NATO Architecture Framework (NAF) primary architecture elements which are used in the EATMA structure for CORUS architecture development.

Architecture Layer	Main Architecture Elements
Operational Layer	**Node.** A logical entity that performs Activities. **Role**. An aspect of a person or organisation that enables them to fulfil a particular function. **Activity**. A logical process, specified independently of how the process is carried out. **Information exchange.** An information exchange describes the need for actors to deliver and receive information and information products. **Information Element**. A formalized representation of information.
Service Layer	**Service**. The contractual provision of something (a non-physical object), by one, for the use of one or more others. Services involve interactions between providers and consumers, which may be performed in a digital form (data exchanges) or through voice communication or written processes and procedures.

Architecture Layer	Main Architecture Elements
	Service interface. The mechanism by which a service communicates. **Service Operation**. A function or procedure which enables programmatic communication with a Service via a Service Interface. **Data Element**. A formalised representation of data.
System Layer	**Capability configuration**. A Capability Configuration is a combination of Roles and Technical Systems configured to provide a Capability derived from operational and/or business need(s) of a stakeholder type. **Stakeholder**. A stakeholder is an individual, team, or organization (or classes thereof) with interest in, or concerns relative to, an enterprise [e.g. the European ATM]. Concerns are those interests, which pertain to the enterprise's development, its operation or any other aspect that is critical or otherwise important to one or more stakeholders. **Technical system**. A collection of Functional Blocks or Functions. **Functional Block**. A logical and cohesive grouping of automated Functions in a Technical System. **Role.** An aspect of a person or organisation that enables them to fulfil a particular function. **Function**. An activity which is specified in context of the resource (human or machine) that performs it **Resource interaction**. A Resource Interaction is a relationship specifying the need to exchange data between resources such as Capability Configurations and Technical Systems. **Data Element**. A formalised representation of data.
Standards Layer	**Standard**. A ratified and peer-reviewed specification that is used to guide or constrain the architecture.

Table 4 Architecture elements

3.3 Architecture Sub-Views

This chapter is aimed at showing the NAF primary sub-views which are used in the EATMA structure for CORUS architecture development. For each considered sub-view a brief rationale for its usage.

View	Description	Examples
NOV-2 **Operational Node Connectivity Description**	Defines the nodes and describe information exchanges and (services between nodes). Mapping capability and nodes. it is a high level communication material for CONOPS graphical representation.	NOV-2 consists of multiple graphics. involves restricting the nodes and needlines on any given graphic to those associated with a subset of operational activities. Use of nodes and needlines supports analysis and design by separating process modelling and information requirements from the materiel solutions that support them.

View	Description	Examples
NOV-5 **Operational Activity Model**	Describes the operations that are normally conducted in the course of achieving a mission or an operational objective. It describes operational activities (or operational tasks) and between activities.	e.g. UML Activity diagrams
NSOV-1 **Service Taxonomy**	The taxonomy represents the operational domain's knowledge, as described in the Operational View, in terms of services.	A taxonomy can be represented by a hierarchy, a tree, a network, or even a loose set of groups (such as an alphabetical listing). In the case of a hierarchy, generalization-specialization (inheritance) relations are included.
NSV-1 **System Interface Description**	Links together the Operational View and the System View by depicting which systems and system connections realize which information exchanges. It is based on the definition of Capability Configurations and describes the assets, both technical and human which are required in order to provide capability.	NSV-1 is best represented as a graphical diagram depicting how systems are collaborating through their interfaces to realize the information exchanges between operational nodes. The diagram must be accompanied by a textual specification of all the graphical elements included in the diagram.

Table 5 Architecture Sub-views

3.4 Architecture publishing

In order to have a common understanding of the U-space architecture, it becomes essential to have only one single point of truth accessible for the U-space architects. This assures completeness, consistency and coherency of the content developed by the different projects in the most efficient way. So having access to the architecture designed by CORUS becomes a critical milestone for the future work to be performed on U-space.

Therefore, CORUS team has decided to show the architecture in a web based portal. This portal will expose the content available in the U-space architecture repository (MEGA). The portal will be updated with a frequency enough for the U-space architects to be able to stay up-to-date, continue their work in a consistent way and to provide feedback.

The portal will include content from the different EATMA layers and the relationships between the elements, easing the verification of the traceability between the different levels of the architecture (business, operational, service and system).

4 Business Architecture

This section provides high-level description of the U-space Capability Model.

The capability layer describes the U-space's abilities and performance measures such as validation targets and validation results. It can be understood as the strategic layer describing the business services/capabilities.

The main element of the Capability Layer in the U-space architecture is the Capability, whose definition is the following:

- **Capability:**

Capability is the ability of one or more of the enterprise's resources to deliver a specified type of effect or a specified course of action to the enterprise stakeholders.

A Capability represents a high-level specification of the enterprise's ability. As such, the whole enterprise can be described via the set of Capabilities that it has.

A Capability is a statement of "what" is to be carried out and does not refer to "how" or "by whom" they are carried out. Consequently, capabilities are free from considerations of physical organisation or specific choices of technology.

'Capabilities' is an important business concept that describes the abilities or competencies of an organization. They are typically quite stable, and while business processes, functions and roles change quite frequently, capabilities change less frequently. When they do change, it is typically in response to a strategic driver or change. Capabilities can be mapped back to strategic goals and objectives.

They provide a useful starting point to derive lower level elements such as process and functions, applications and technology assets.

The Capability Model then describes the entire U-space enterprise in the form of a set of decomposed capabilities. A capability is the perceived outcome realised by the undertaking of activities by stakeholders.

Main inputs for the development of the Latest version of U-space Capability model have been the [6] and EATMA Capability Model. Starting from the description of the "U-space Services" and the "on-drone capabilities" available in the U-space roadmap document, the WP5 team generalised the capabilities and mapped them on the EATMA capability model, including the capabilities in the ICAO structure.

Following figure shows the level 3 capabilities and their relationship with ICAO.

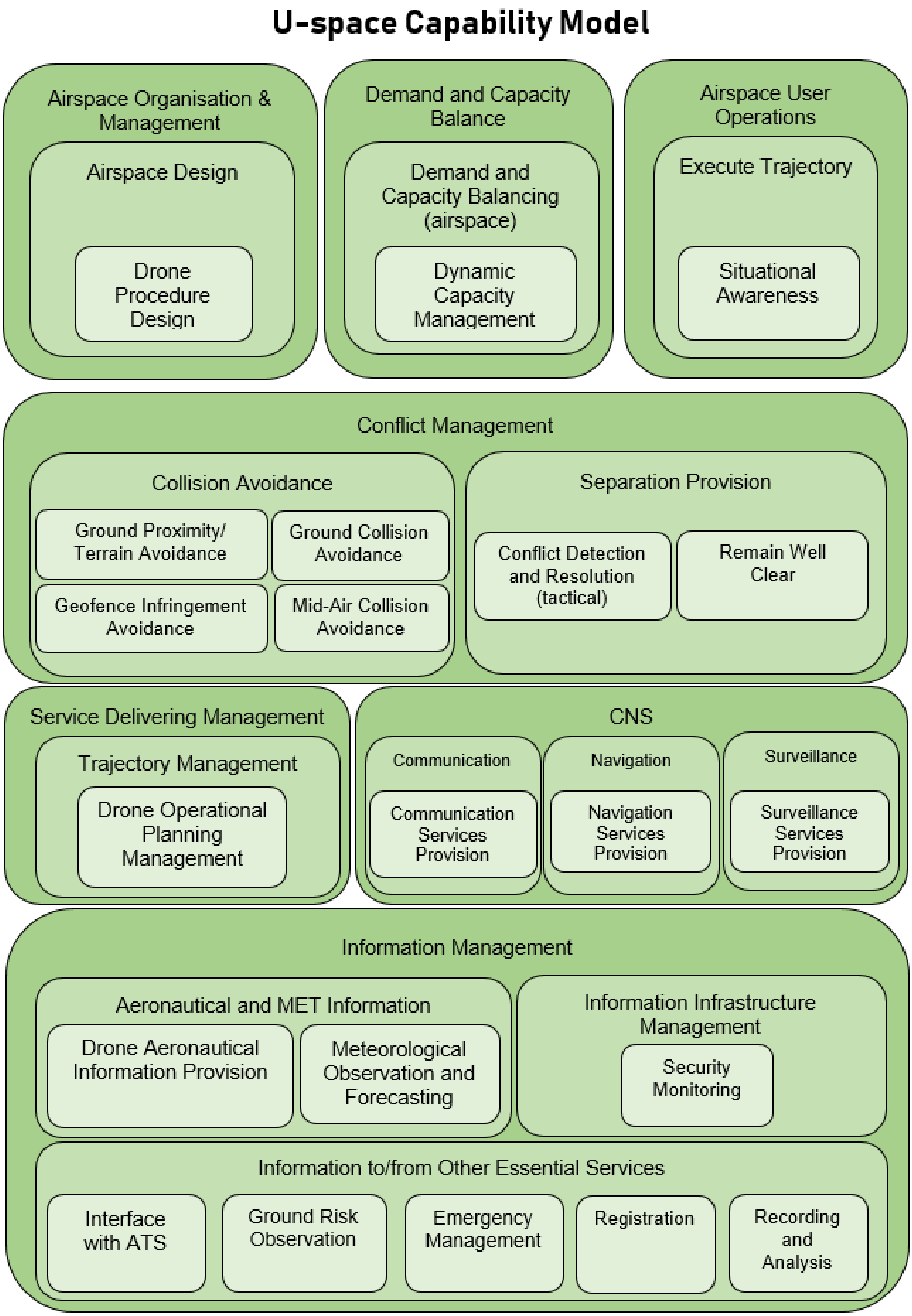


Figure 5 U-space Capability Model.

Capability Level 3 Name	Description
Drone Procedure Design	The ability to interface with ATC via a set of defined procedures for some mission types where there may be an impact on ATC; the procedures ensure clear and unambiguous drone operation, and provide an appropriate flow of information between the drone operators and ATC. Such procedures will allow drones to fly in controlled airspace and near airports with more flexibility and procedural approval/rejection based on agreed rules.
Dynamic Capacity Management	The ability to set the capacity and monitor demand for airspace, and to manage access to that airspace as new flight notifications are received, in nominal and non-nominal situation. .
Situational Awareness	The ability to provide traffic information for user situational awareness coming from any kind of monitoring.
Conflict Detection and Resolution (tactical)	The ability to detect and resolve conflicts during the tactical phase to ensure safe separation when flying.
Remain Well Clear[5]	The ability to keep a safe distance to other entities that otherwise will become a conflict.
Ground Collision Avoidance	Prevention of aircraft collision during taxi or push-back (including collisions with parked aircraft) or on the runway/landing spot or while one is on the ground and the other in the air close to the ground.
Ground Proximity / Terrain Avoidance	Prevention of aircraft collision with the terrain and obstacles while is in the air close to the ground. The avoidance of collision with the terrain by an airborne vehicle.
Geofence Infringement Avoidance	The avoidance of infringement into geofences by airborne vehicles not authorised or expected to enter the airspace The ability to stay in/out predefined volumes which constitute the drone aeronautical information.
Mid-Air Collision Avoidance	The avoidance of collision between mobile airborne vehicles.
Interface with ATS	The ability to interoperate with ATC with mechanisms which ensure proper effective coordination when drone operations using U-space services impact ATS.
Registration	The ability to provide the registration of the operator, drone and pilot with the appropriate information according to the Regulation.
Emergency Management	The ability to manage solutions for emergencies in U-space. It includes the exchange of information among the relevant actors and drone auto-diagnosis.
Ground Risk Observation	The ability to provide static and dynamic information about ground risks for drone operations (e.g. terrain and obstacle elevation, population density, other ground traffic such as trains, vessels, cars) at the scale of interest of small drones.
Recording and Analysis	The ability to record U-space such as relevant event and traffic scenes and to provide reports, statistics, playback. It encompasses e.g. logbooks, legal recordings, playback for incident and accident investigations.

[5] Considering the level of abstraction of the Capability, to be checked if better merged with Conflict detection and resolution (tactical)

Security Monitoring	Ability to protect vehicle and data (interaction with other vehicles and infrastructure) against attacks on information technology and communications systems.
Drone Aeronautical Information Provision	The ability to provide aeronautical and coherent information for manned and unmanned operators relevant to U-space. This includes predefined restricted areas or available aeronautical information.
Meteorological Observation and Forecasting	The ability to Identify weather phenomena (current, future) in the airspace which poses a risk to ATM and U-space
Surveillance Services Provision	The ability to facilitate the provision of ground and air surveillance data from different sources to track and fuse for determining the position of the aircraft.
Navigation Services Provision	The ability to facilitate (providing the link, coverage provided and monitoring) the planning, recording and controlling the movement of an aircraft from one place to another.
Communication Services Provision	The ability to facilitate (providing the link, coverage provided and monitoring) the air-air, air-ground and ground-ground communication.
Drone Operational Planning Management	The ability to manage the planning of drone missions taking into account all relevant information, such as meteorological information, aeronautical information, applicable rules and traffic information.

Table 6 Capability descriptions

4.1 Traceability

For the development of the Capability Model, the work started from the Services and Capabilities describing U-space and reported in following figure and table,

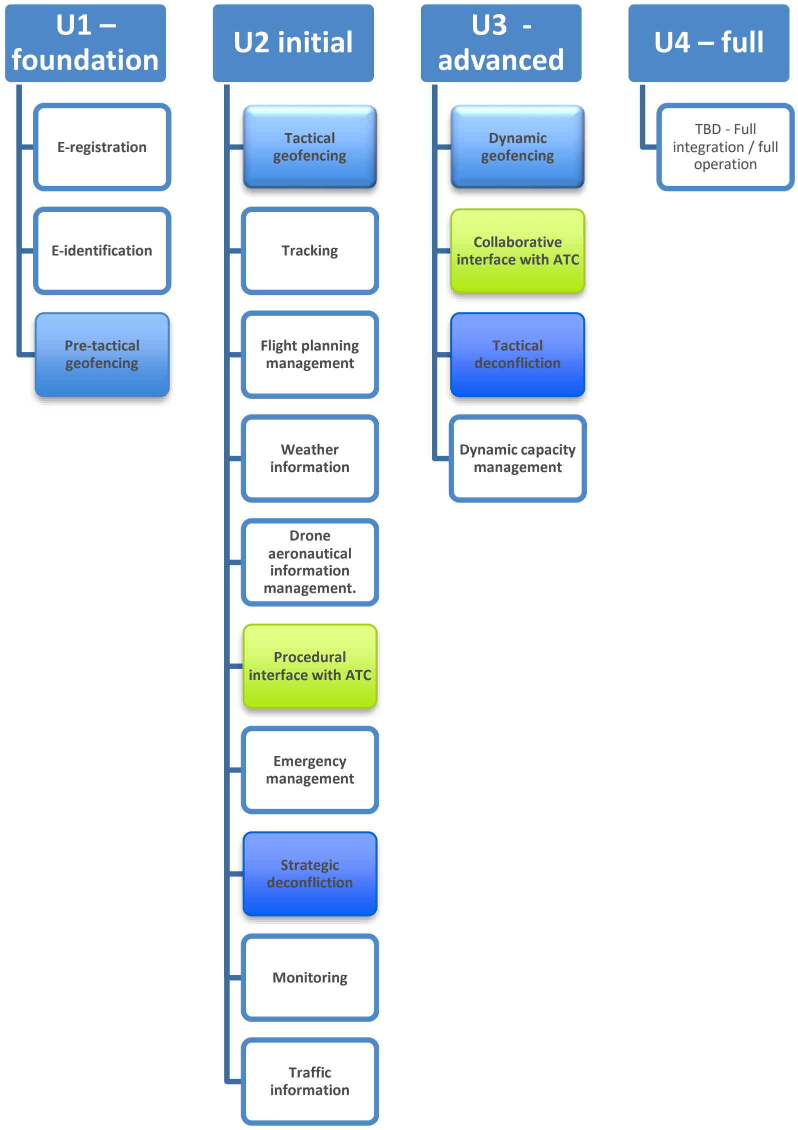


Figure 6 U-space services in the roadmap document towards U-space Capabilities

Capability	Actor	Description	Phase
e-Identification	Drone, drone operator, service provider	Ability to identify the drone and its operator in the U-space system	U1
Geofencing	Drone, drone operator, service provider	Ability to comply with geographical, altitude and time restrictions defined by the geofencing service. This capability covers the technology, processing and any required communication links, as well as management and use of geofencing information used in the provision of this service.	U1
Security	Drone, drone operator, service provider	Ability to protect vehicle and data (interaction with other vehicles and infrastructure) against attacks on information technology and communications systems.	U1
Telemetry	Drone	Ability to transmit measurement data from the drone-to-drone operator and/or service provider to meet the demands of relevant services.	U1
Tracking	Drone, drone operator, service provider	Ability of the drone to provide flight parameters including at least its position and height.	U1/U2
Vehicle to Vehicle communication (V2V)	Drone	Ability for drones to communicate information to each other. The nature of the information exchanged, and its performance requirements, will depend on the application.	U3
Vehicle to Infrastructure communication (V2I)	Drone, drone operator, service provider	Ability for drones to share information with infrastructure components.	U3
Communication, Navigation and Surveillance	Drone, drone operator, service provider	Ability for drones to meet the communication, navigation and surveillance performance requirements for the specific environment in which they will operate. This capability involves the combination of on-board sensors and equipment (e.g. data link, voice radio relay, transponder, laser, GNSS, cellular etc.) as means of achieving the required performance.	U1
Detect and Avoid	Drone	Ability for drones to detect cooperative and non-cooperative conflicting traffic, or other hazards, and take the appropriate action to comply with the applicable rules of flight. This includes the collision avoidance, situational awareness and "remain well clear functionalities, as well as the other hazards described in chapter 10.2.3 of the ICAO RPAS Manual: terrain and obstacles, hazardous meteorological conditions, ground operations and other airborne hazards.	U3
Emergency Recovery	Drone	Ability of drones to take account of failure modes, such as command and control (C2) link failure, and take measures to ensure the safety of the vehicle, other vehicles and people and property on the ground. This includes identification of possible problems (auto-diagnostic) and all equipment required to manage solutions.	U1/U2
Command and control	Drone, drone operator	Ability of drones to communicate with their ground control station to manage the conduct of the flight, normally via a specific data link.	U1
Operations management	Drone operator, service provider	Ability to plan and manage drone missions. This includes access to and use of all aeronautical, meteorological and other relevant information to plan, notify and operate a mission.	U1

Table 7 On drone capabilities towards U-space Capability

Next table maps the roadmap capabilities and services with U-space Capability Model.

Roadmap Capability/ Service Name	Capability Model / Capability Level 3 Name
e-Registration	Registration
e-Identification	Surveillance Services Provision
Tracking	Surveillance Services Provision
Pre-tactical geofencing	Drone Aeronautical Information Provision
Tactical geofencing	Drone Aeronautical Information Provision
Dynamic geofencing	Drone Aeronautical Information Provision

Drone aeronautical information management	Drone Aeronautical Information Provision
Emergency management	Emergency Management
emergency recovery	Emergency Management
Monitoring	Surveillance Services Provision
Traffic information	Situational Awareness
Strategic deconfliction	Drone Operational Planning Management
Tactical deconfliction	Conflict Detection and Resolution (tactical)
Detect & avoid	Remain Well Clear
	Collision Avoidance
Weather information	Meteorological Observation and Forecasting
Flight planning management	Drone Operational Planning Management
Operations management	Drone Operational Planning Management
Dynamic capacity management	Dynamic Capacity Management
Procedural interface with ATC	Drone Procedure Design
Collaborative interface with ATC	Interface with ATS
Security	Security Monitoring
Communication, navigation and surveillance	Surveillance Services Provision
	Navigation Services Provision
	Communication Services Provision
-	Recording and Analysis
-	Ground Risk Observation
V2I	Out of scope@ Capability Model– not business perspective
Telemetry	Out of scope @ Capability Model – not business perspective
V2V	Out of scope@ Capability Model – not business perspective
Command & control	Out of scope@ Capability Model– not business perspective

Table 8 Traceability Roadmap elements vs. Capabilities

5 Operational Architecture

The Operational layer contains the elements needed to describe the operational concepts and is independent from any physical implementation. It includes descriptions of how actors collaborate. Even if six different architectural elements compose this layer in the EATMA framework, five are used for the CORUS architecture so far.

- **Node:**

A logical entity that performs Activities. Note: nodes are specified independently of any physical realisation. They represent the actors in the operational layer. Nodes interact through Information Exchanges in which they exchange Information Elements.

- **Information Exchange:**

The collection of information elements that are exchanged between two nodes. An Information Exchange defines the types of Information Elements exchanged and which Nodes are involved in the Information Exchanges.

It is important to note that Information Exchanges are realised by Services. This means that the Services are identified from the Information Exchanges, which also represent the operational need for exchanging information.

- **Activity:**

A logical process, specified independently of how the process is carried out.

Activities represent WHAT has to be done to complete a Capability.

Activities are logically grouped within Nodes (and hence, associated to the Stakeholder that implements that node) Activities may be realized by people, or aspects may be automated and performed by functionality (Functions and Services) provided by Technical Systems.

- **Information Flow:**

A flow of information from one Activity to another.

An Information Flow defines the types of Information Elements sent from one Activity to another. It is always modelled as a one-way flow.

Information Flows may be aggregated into one or more Information Exchanges between Nodes, thus enabling the description of more complex two-way interactions

- **Information Element:**

A formalised representation of information. An Information Element is carried by one or more Information Exchanges (between Nodes).

5.1 Nodes and Information exchanges

Node	Description
USP Operations	Performs all the operational activities related to management of drone traffic. This includes the activities required at strategic level, in execution and post flight to ensure a safe execution of drone flights. It is as well encompassing activities to maintain/monitor physical condition of the supporting infrastructures, creating and maintaining a good relationship with local / national authorities, ATM and communities. It also includes assurance that the scale of equipment and facilities provided are adequate for the activities which are expected to take place, as well as provision of staff, where necessary, that are competent and, suitably qualified.
Drone operation	Represents all the activities undertaken by those organisations and individuals who have access to and operate in the airspace which is available for drone operations in accordance with international and national procedures. For the purpose of this document only those actors directly involved in Drone operations are described. The main types of Drone Operations are: · Civil Drone Operations /Organisation. The most extensive organization for Drone Operations is run by Legal Entities which uses drones for their business activities. The daily operations of these companies require a lot of flexibility. · Recreational Drone Operations. Another important segment of Drone Operations which are constituted by single individuals which are aimed to use drones for recreational purposes. · Special Drone Operations /Organisation. Organizations for Drone Operations which require special conditions to operate, such as military/law enforcement. The daily operations of these companies require special condition of privacy in respect to the other organisations.
Registration Operations	Performs all the operational activities related to the registration of drone ownership, drone pilot and drone operators licensing according to the law. It is as well encompassing activities to maintain registrations, to share them with interested parties, as well as provision of staff, where necessary, that are competent and, suitably qualified.
Law Enforcement Operations	Performs all the operational activities related to the law enforcement. Most of the activities relies on U-space services to provide required law enforcement actions (e.g. e-identification).
Public Users Operations	Performs all the operational activities related to public when wants to be informed about drone traffic. These activities are mainly derived from privacy and safety issues of an individual/community.
Insurance Management	Performs all the operational activities related to insurance management. Even if the process can be considered outside the scope, for registration purposes it is important to mention these activities especially for the required exchanges in the e-registration process.

Meteorological Service Provision	Performs all the operational activities related to the weather information provision. Provides at least the weather data and where necessary hyper local weather data to ensure safe drone operations. In most instances a weather provider will provide a wider scope of weather data relevant to the ATM stakeholders/ATM community.
Terrain and Obstacles Provider Operations	Performs all the operational activities related to the provision of Terrain and Obstacles information.
Surveillance Operations	Performs all the operational activities related to the provision of Surveillance information
Navigation Operations	Performs all the operational activities related to the provision of Navigation information
Communication Operations	Performs all the operational activities related to the provision of Communication information
ER/APP ATS (U-space)	Performs all the en-route and approach ATS operations.
Flight Deck	Performs all the on-board AU operations including flight execution/monitoring according to agreed trajectory, compliance with ATC clearances/instructions, etc.
AIM	Performs all the operational activities related to the provision of Aeronautical Information
Training School	Performs all the operational activities related to the training schools. Provides information required for the registration process.
Regulator Operations	Performs all the operational activities related to the regulator.

Table 9 Nodes

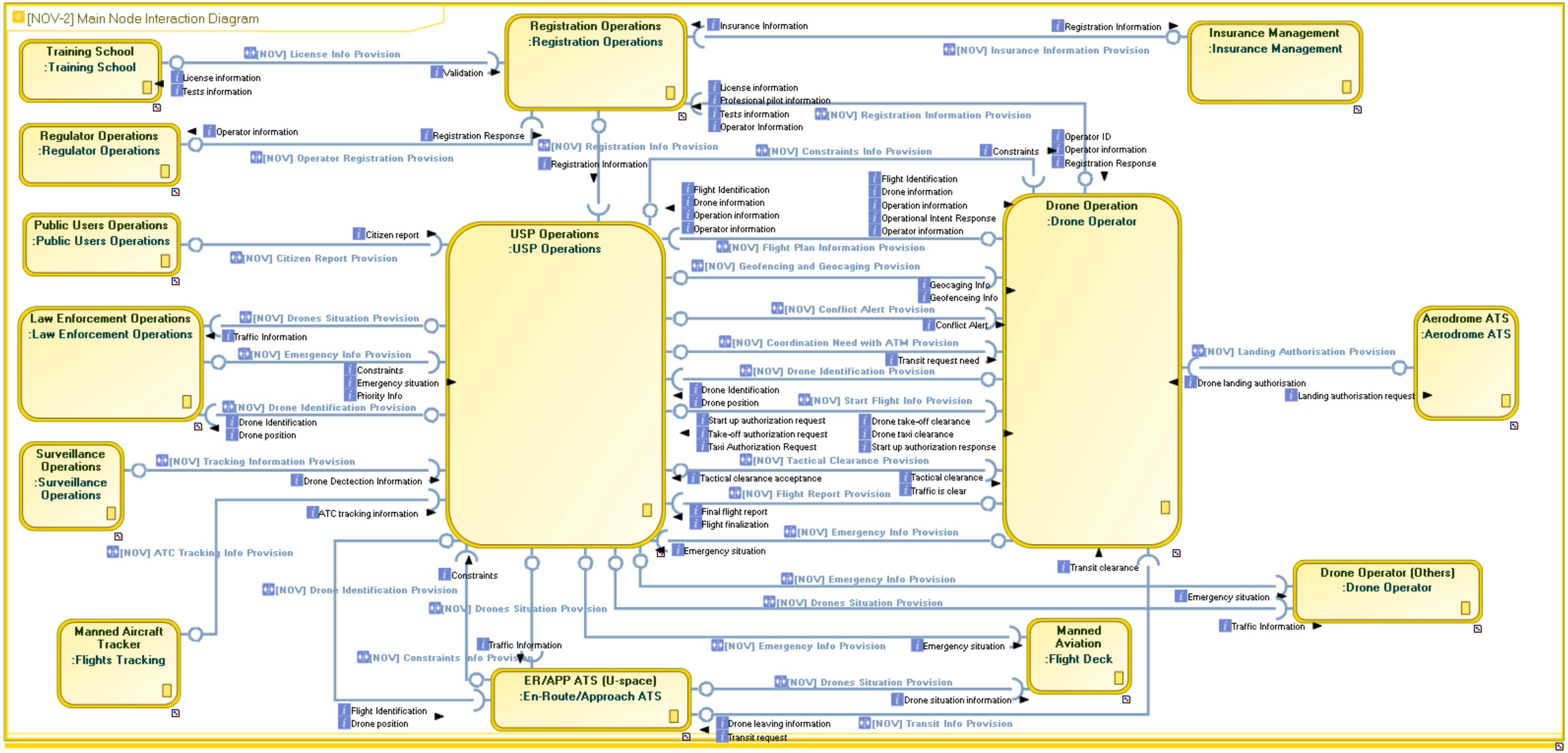


Figure 7: Main Node Interaction Diagram

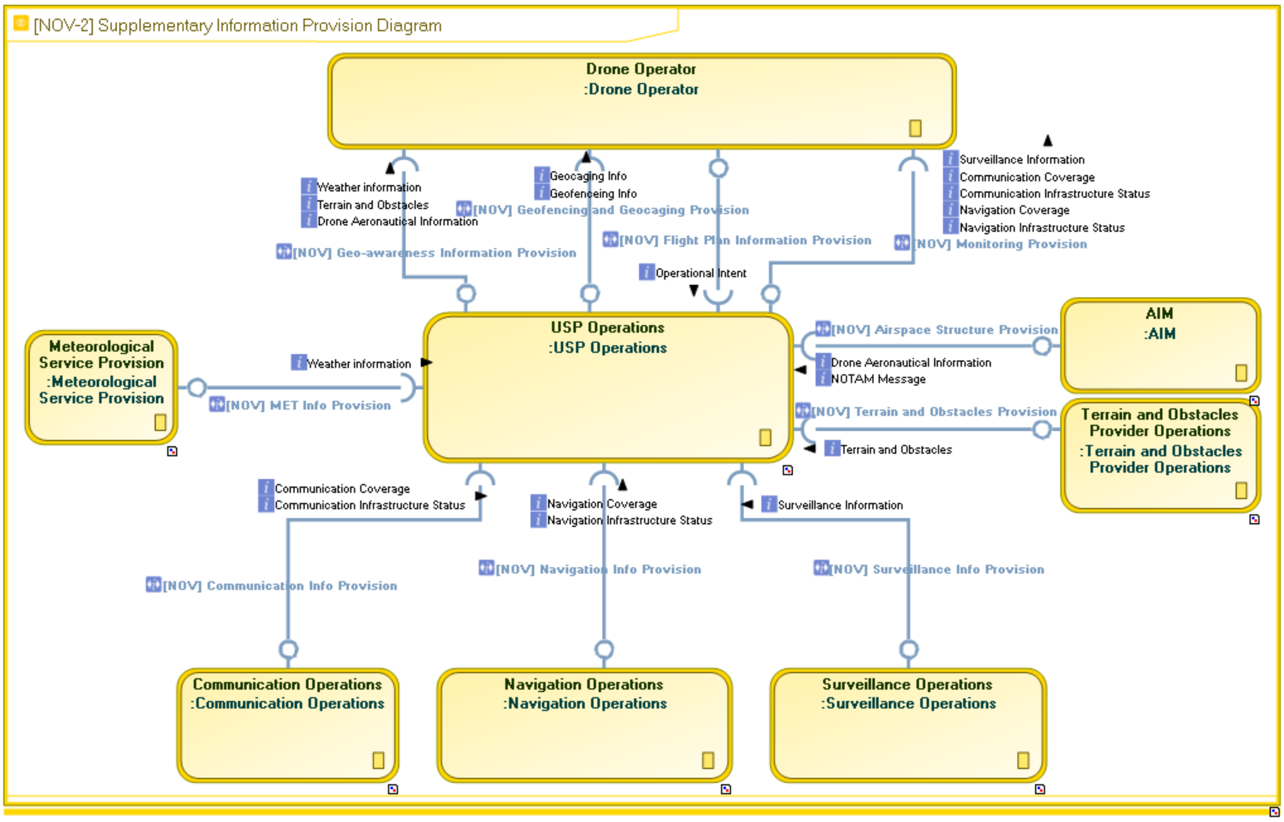


Figure 8: Supplementary Information Provision Diagram

At this level of abstraction and from an operational point of view the USP Operations is described as a single node, without entering in the technical possible variants of deployment.

Information Exchange	Description	From Node	To Node
Geo Fencing Info	Exchange of required information to operate on-drone geofencing capabilities.	Drone Traffic Management Ops	Drone Ops
Authorizations	Exchange of required information to forward ATM/USSP authorizations/clearances.	Drone Traffic Management Ops	Drone Ops
Constraints	Exchanges of specific constraints for the drone operation	Drone Traffic Management Ops	Drone Ops
Identification	Exchange of the e-identification of the drone	Drone Ops	Drone Traffic Management Ops
Positioning	Exchange of the localisation of the drone	Drone Ops	Drone Traffic Management Ops

Situational Awareness	Exchange of the required information to provide a situational awareness for the specific user (even if the exchange is called the same - different level of information may be provided to specific processes)	Drone Traffic Management Ops	Drone Ops Law Enforcement Ops Public User Ops Air Traffic Management
Conflict Alert/Warning	Exchange of Ground based detection of conflicts (strategic and tactical)	Drone Traffic Management Ops	Drone Ops
Mission/Flight Intent	Exchanges for Mission/Flight Intent or plan	Drone Ops	Drone Traffic Management Ops
NOTAM	Exchanges for NOTAM. It includes as well the requests for NOTAM from DTM to ATM.	Air Traffic Management	Drone Traffic Management Ops
Authorization/ Clearance	Exchanges (procedural/collaborative) of clearances and authorisation of specific drone operations	Air Traffic Management	Drone Traffic Management Ops
Surveillance	Exchanges of Air and ground surveillance which can be fused with drones to improve situational awareness	Air Traffic Management	Drone Traffic Management Ops
Flight Info	Exchanges of Flight info to enrich surveillance where necessary	Air Traffic Management	Drone Traffic Management Ops
Aeronautical Info	Exchanges of aeronautical information for drone aeronautical information and geofencing services	Air Traffic Management	Drone Traffic Management Ops
Privacy Feedback	Exchanges to signal privacy issues	Public User Ops	Drone Traffic Management Ops
Priority	Exchanges to signal a request to rise priority	Law Enforcement Ops	Drone Traffic Management Ops
Constraints	Exchanges to signal a request to protect some area, introducing specific constraints	Law Enforcement Ops	Drone Traffic Management Ops
Drone (and Ownership) Registration	Exchanges of drone and its ownership registration information	Registration	Drone Traffic Management Ops Drone Ops

	Exchanges can be tailored to provide right information to right user.		Insurance Management
Drone Pilot Registration	Exchanges of drone pilot registration information Exchanges can be tailored to provide right information to right user.	Registration	Drone Traffic Management Ops Drone Ops Insurance Management
Drone Owner Registration	Exchanges of drone owner registration information Exchanges can be tailored to provide right information to right user.	Registration	Drone Traffic Management Ops Drone Ops Insurance Management
Drone Operator Registration	Exchanges of drone operator registration information Exchanges can be tailored to provide right information to right user.	Registration	Drone Traffic Management Ops Drone Ops Insurance Management
*** Registration requests**	Exchanges of registration requests to obtain registration of drone, ownership of drone , pilot and operator.	Drone Ops	Registration
Insurance	Exchange of insurance information to be integrated in the registry where required.	Insurance Management	Registration

Table 10 Information exchanges

5.2 Use Cases

In EATMA, the Use Cases as represented in the Operational Layer as NAF Operational Views – 5 (NOV-5). They represent the dynamic behaviour of the Nodes (swim lines) showing in a sequenced way what Activities (yellow boxes) they perform and so when the Information Elements are sent between them.

Up to now, ten different views have been designed representing the use cases explained in the CORUS CONOPS. They represent one possible way of proceeding, but not constraining the process to these procedures.

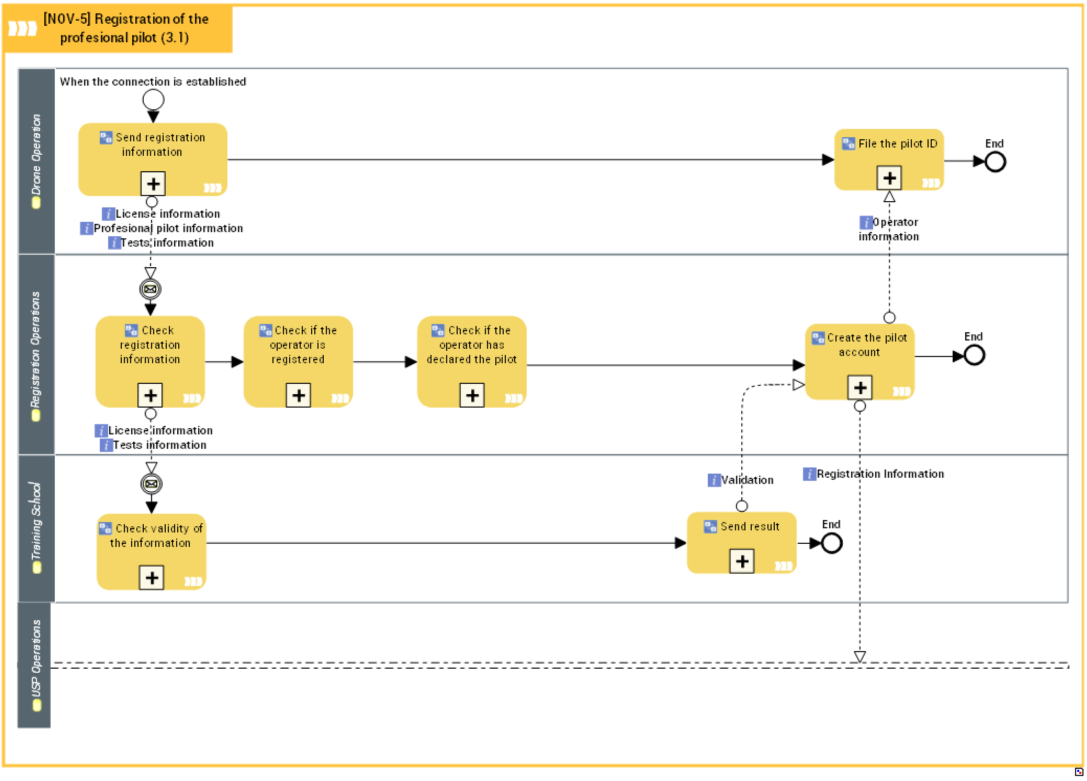


Figure 9: Registration of the Professional Pilot

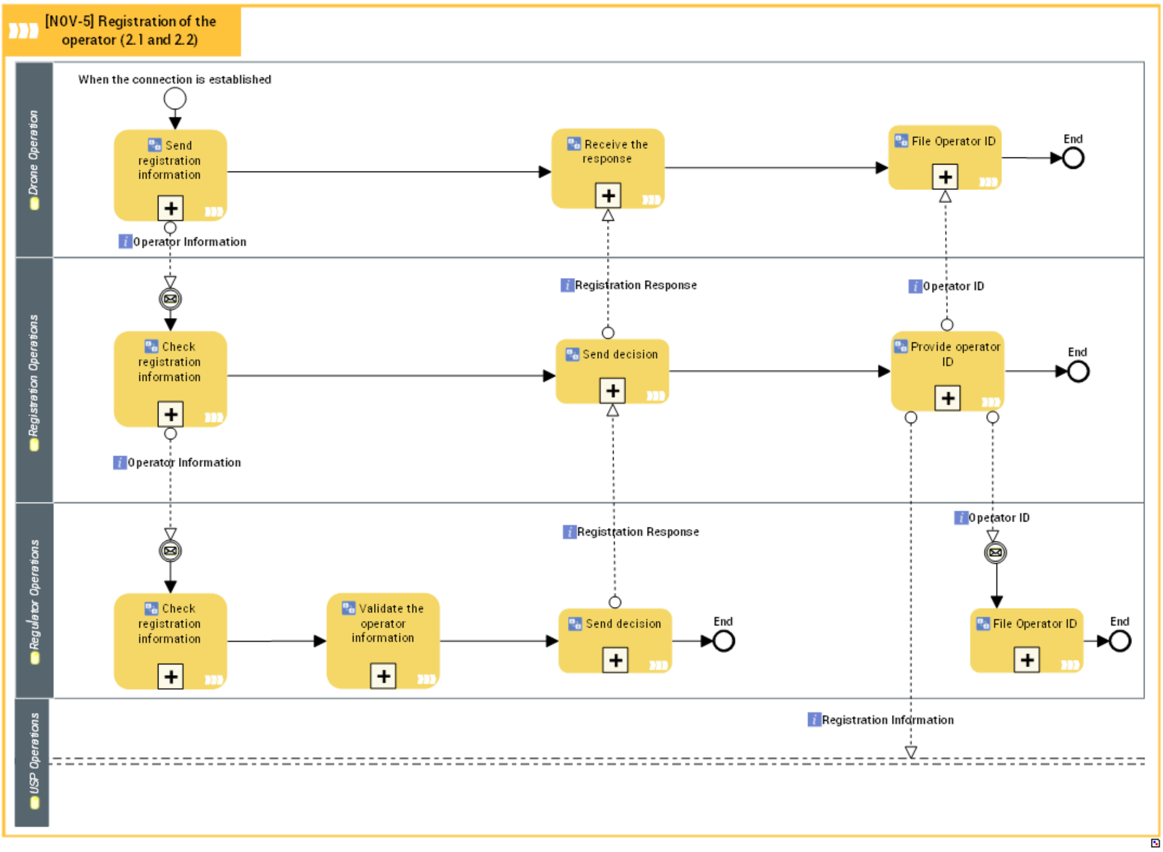


Figure 10 Registration of the Drone Operator

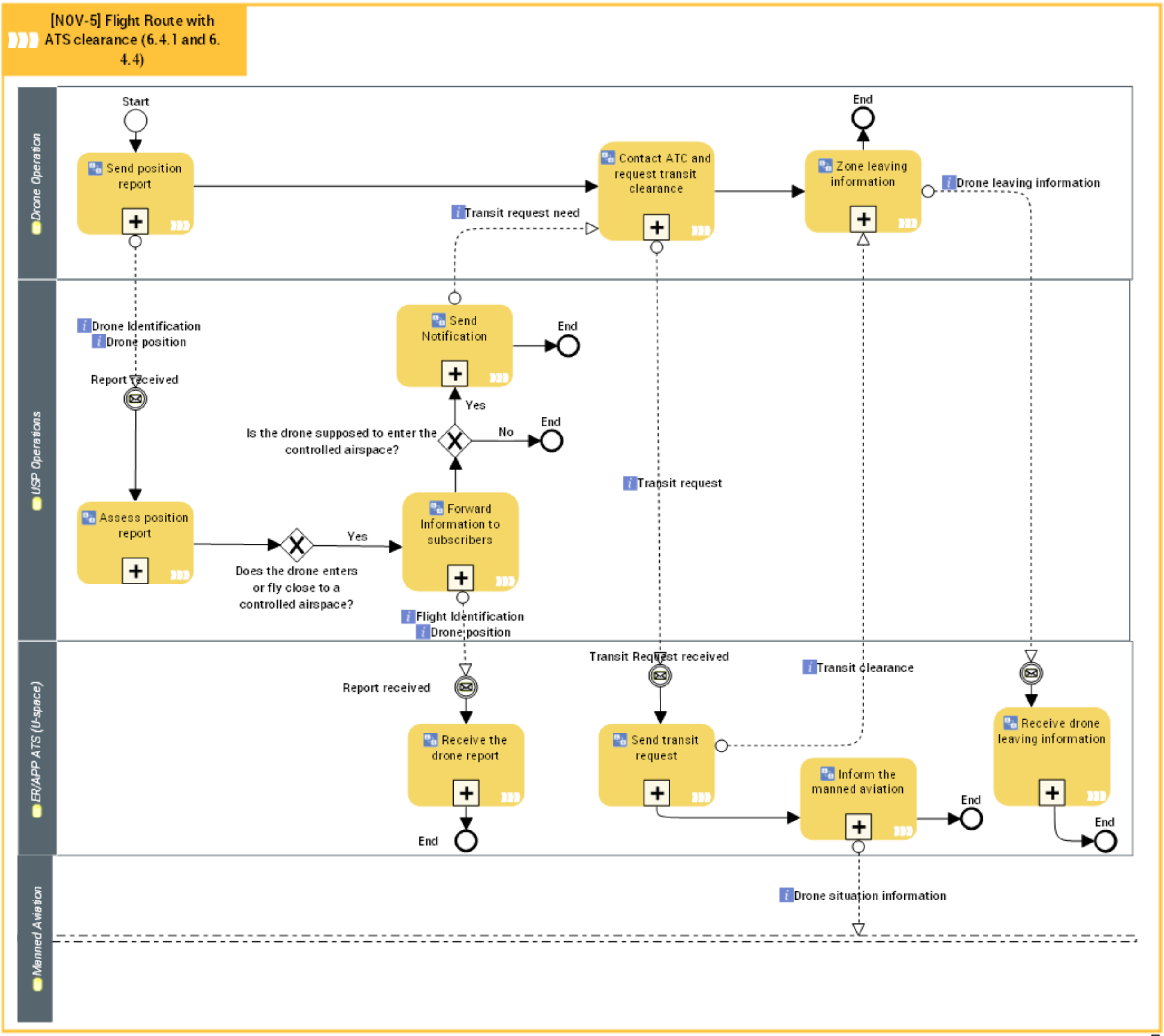


Figure 11 Flight Route

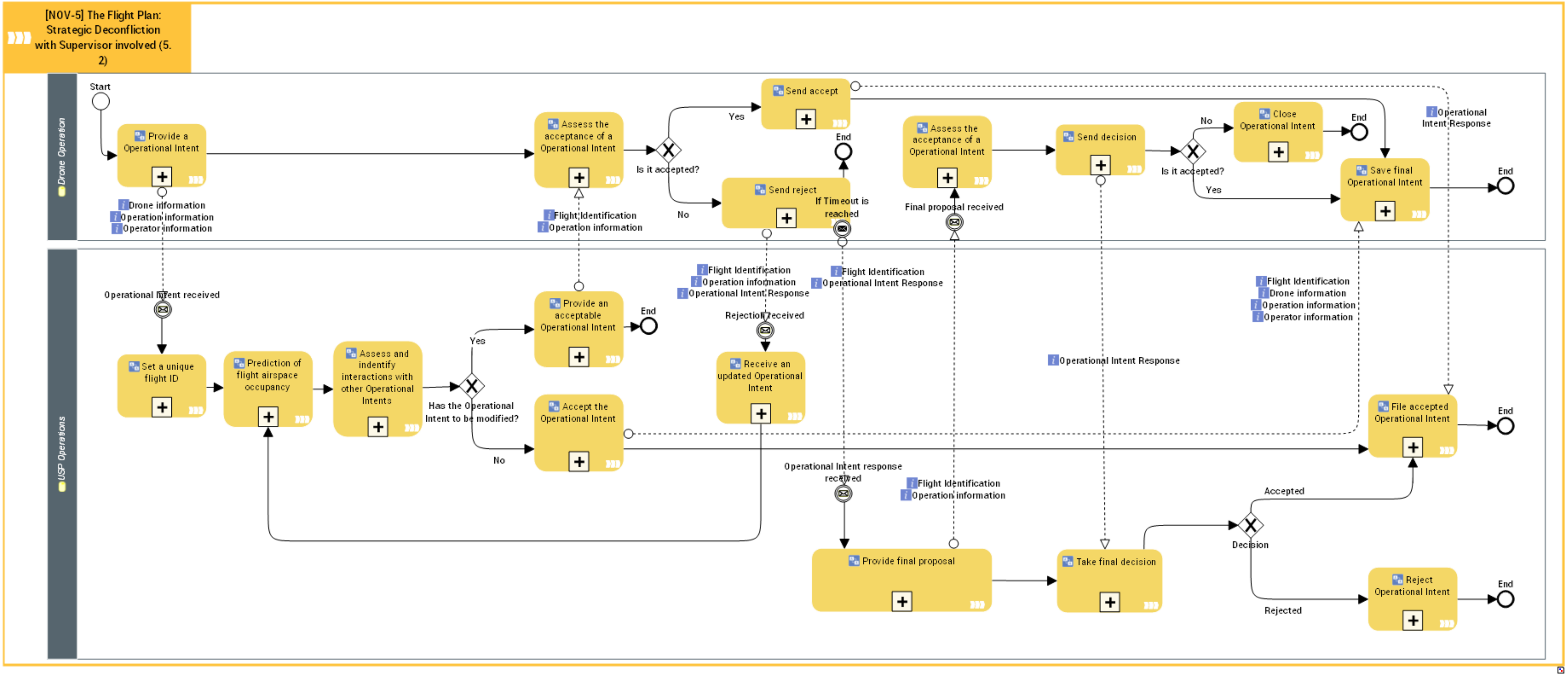


Figure 12 The Flight Plan with Strategic Deconfliction

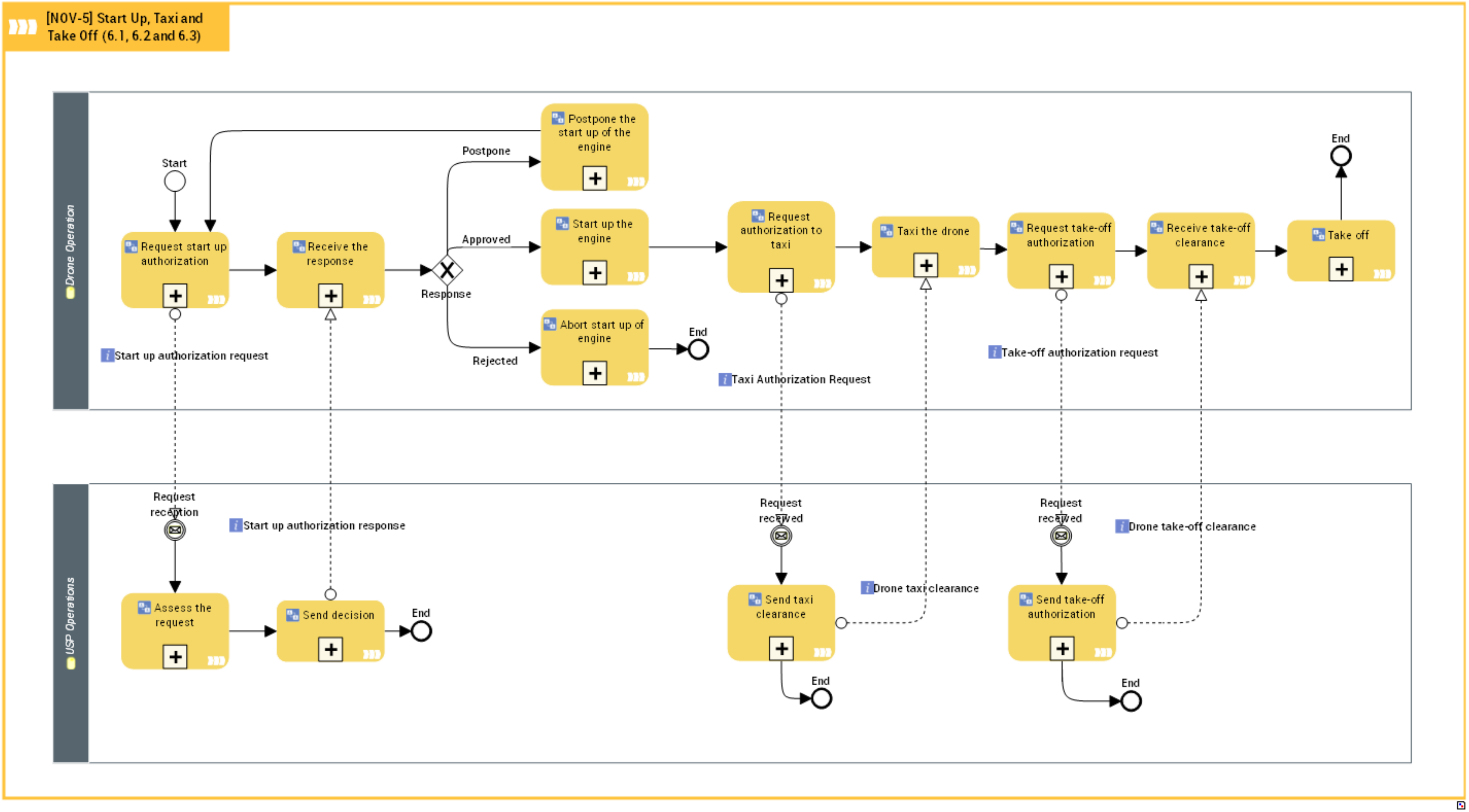


Figure 13 Start Up, Taxi and Take Off

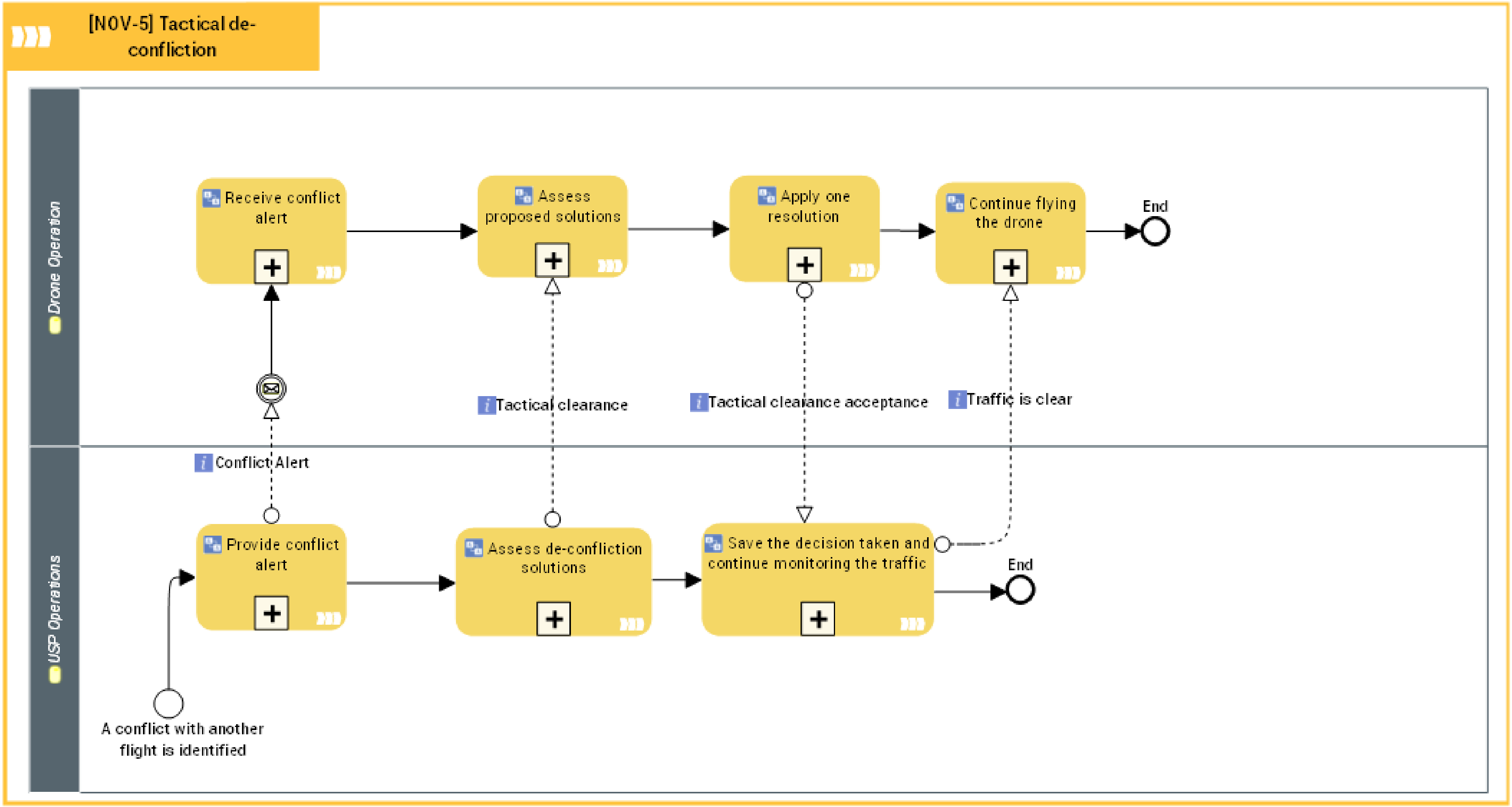


Figure 14: Tactical de-confliction

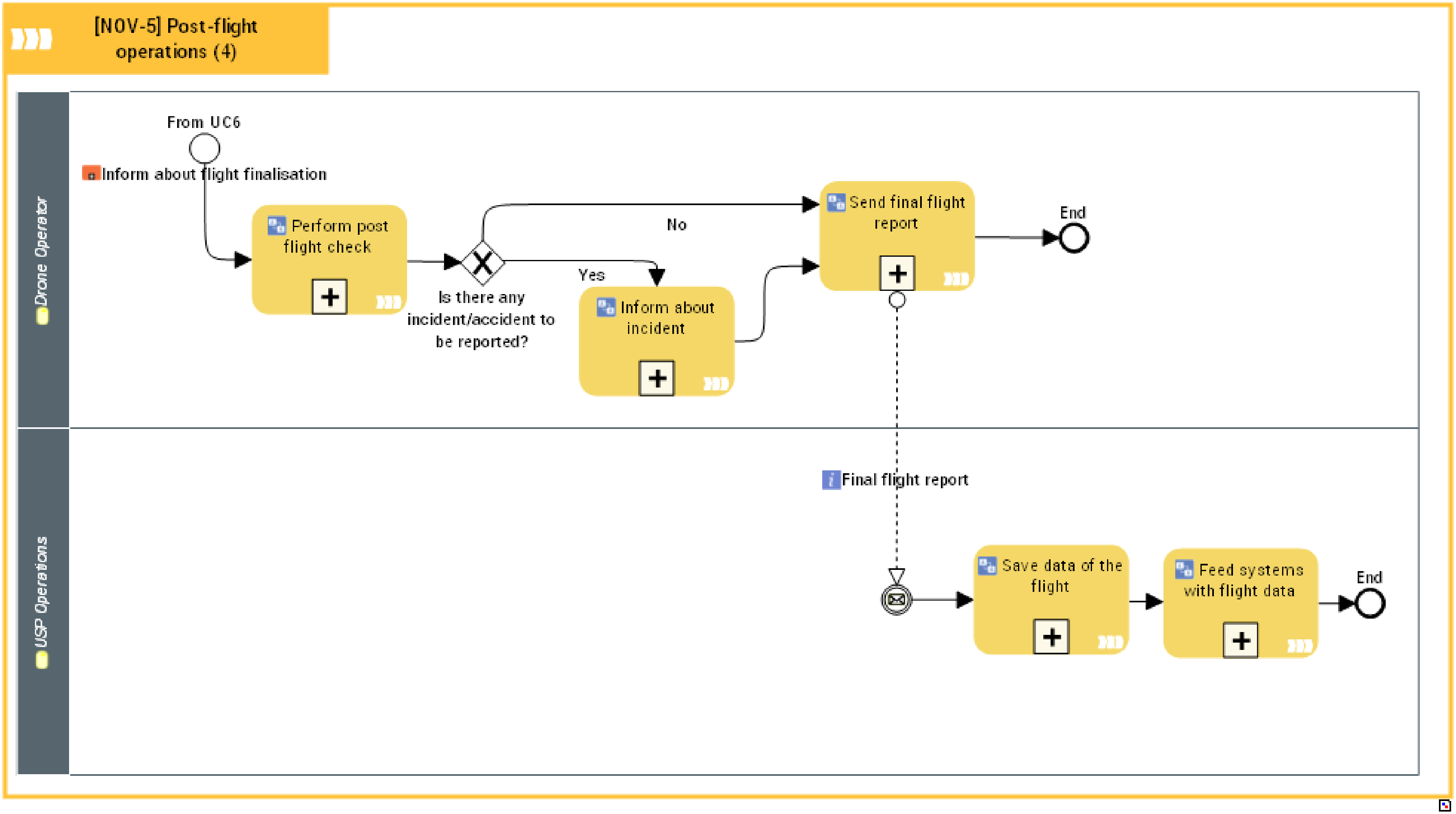


Figure 15: Post-flight Operations

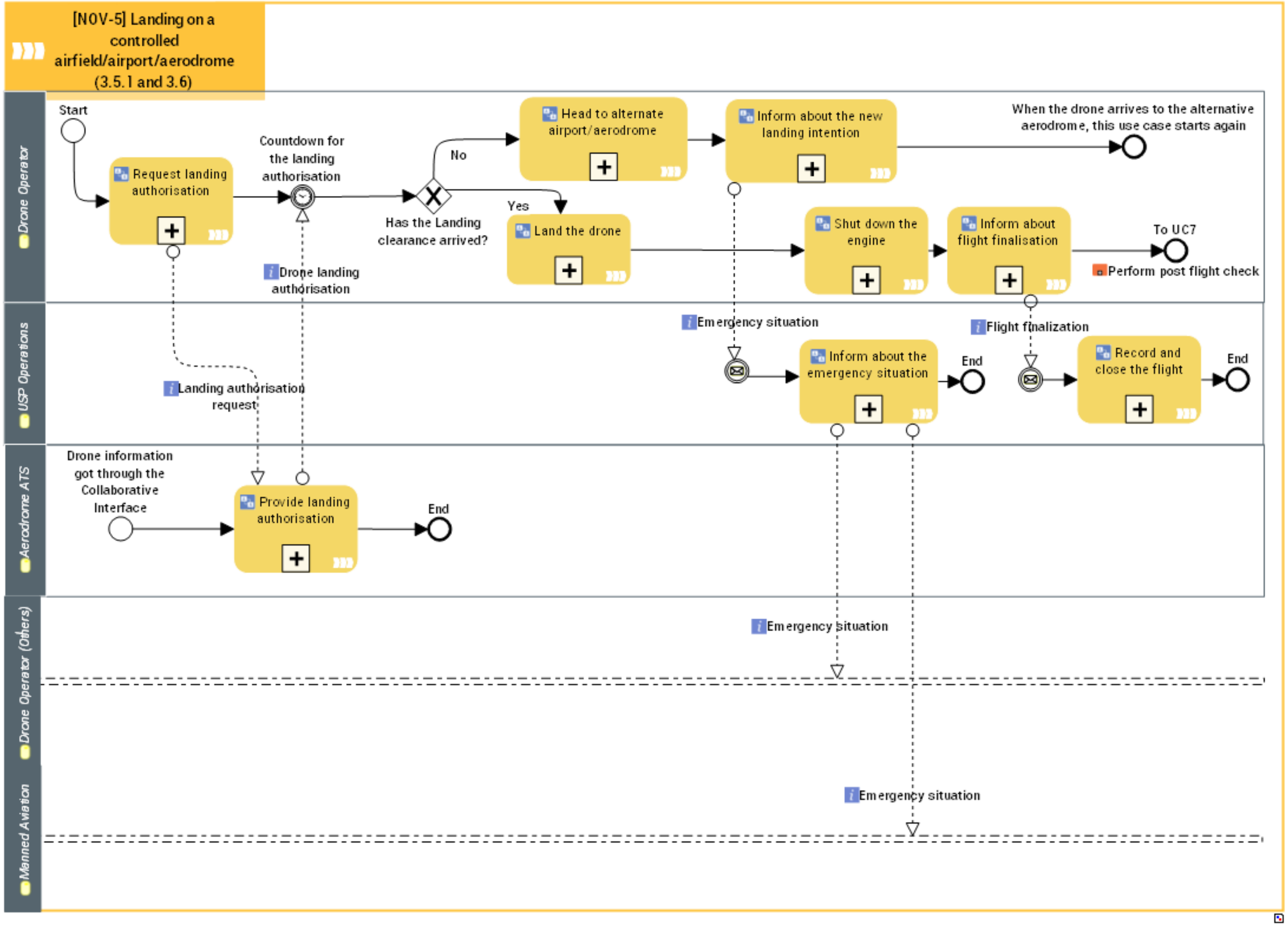


Figure 16: Landing on a controlled airfield/airport/aerodrome

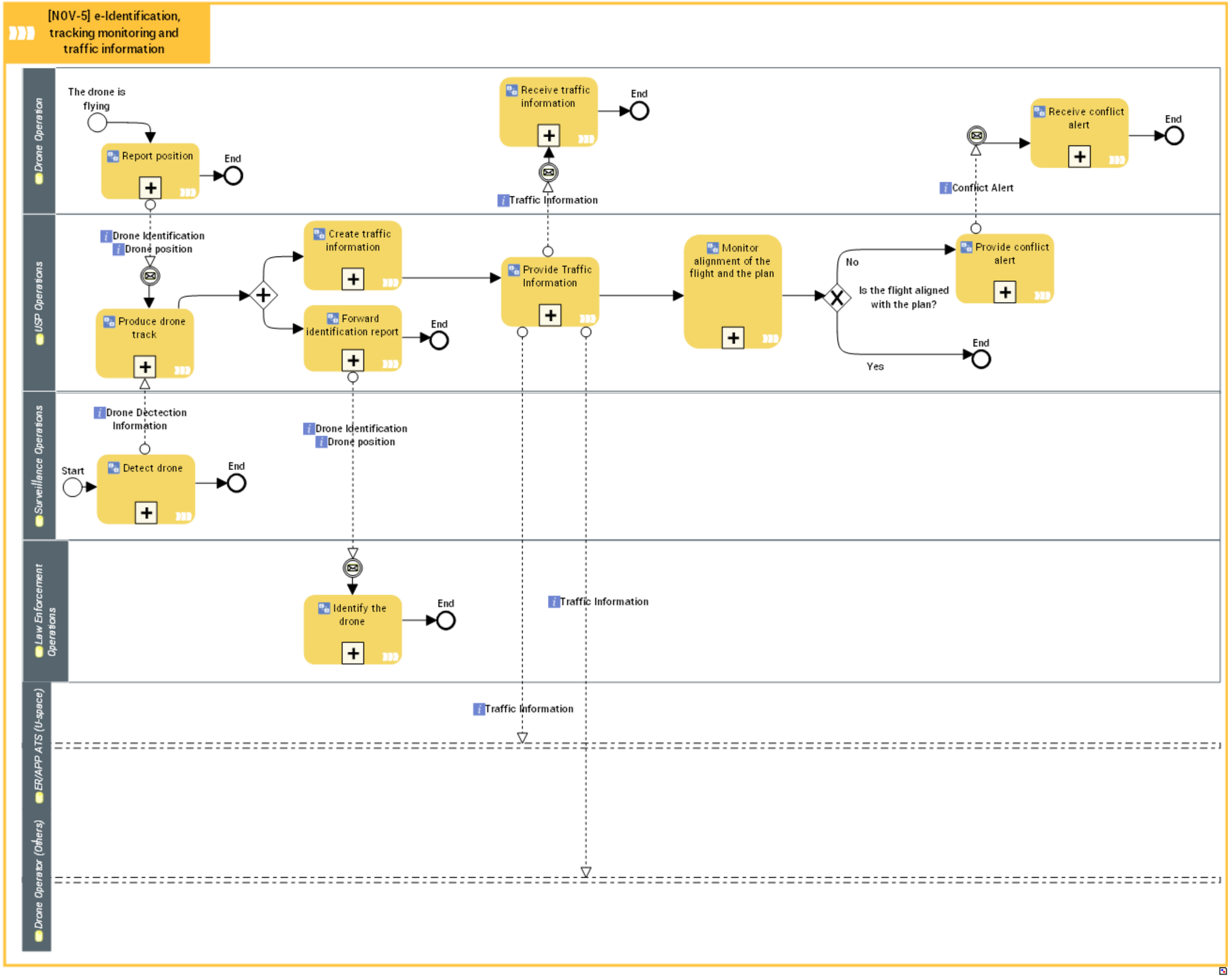


Figure 17: e-Identification, tracking monitoring and traffic information

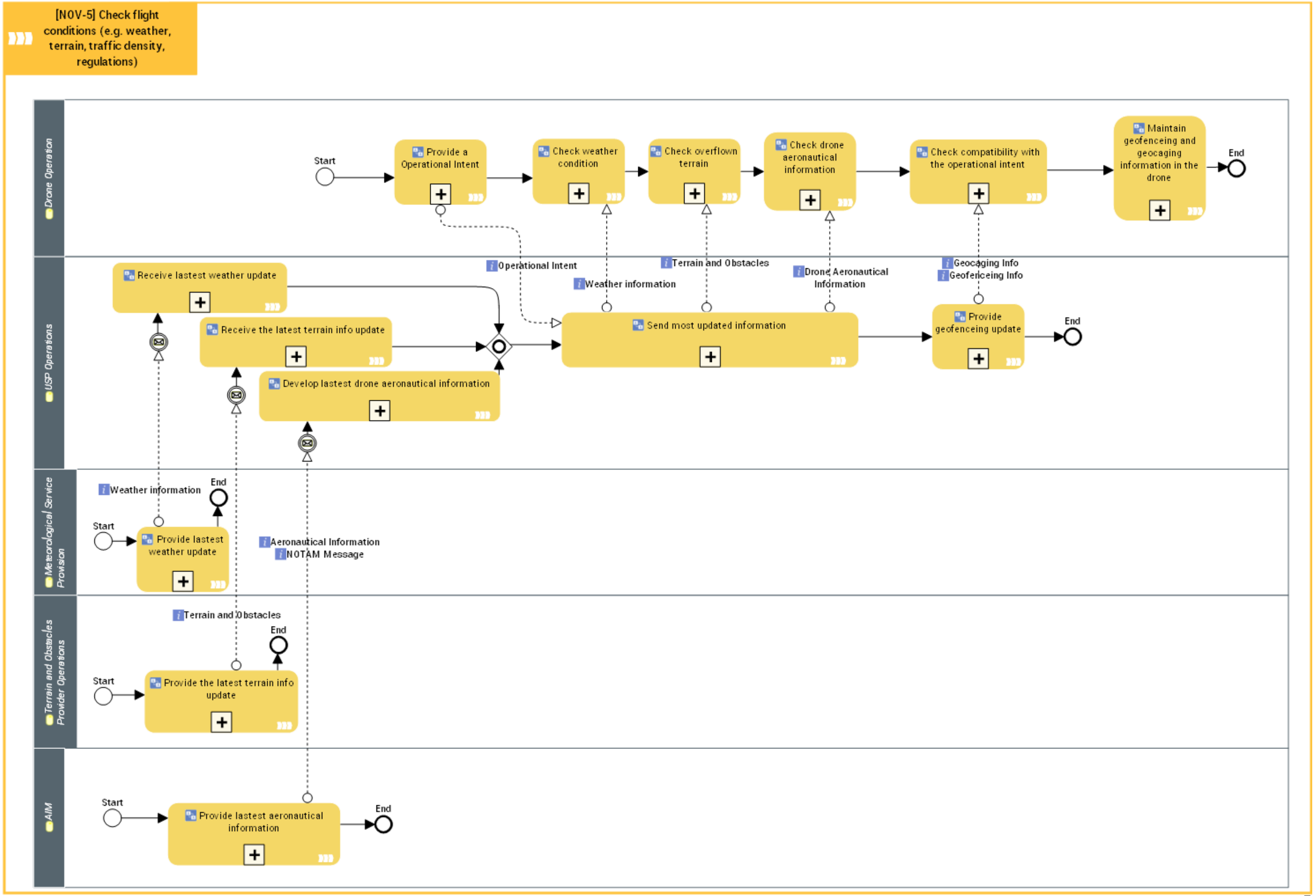


Figure 18: Check flight conditions (e.g. weather, terrain, traffic density, regulations)

5.3 From Needs to Services

As stated previously, the operational layer describes at a conceptual level (independent from any physical implementation) how the Nodes interact between them. These interactions, named Information Exchanges, describe then the operational needs that have to be covered at the System layer (implementation) with the technical systems. The service layer provides this link between the operational and technical layer. Once the Operational/Logical needs are described, the services shall be identified. Consequently, there is a direct relationship between the Information Exchanges and the Services. Examples of these links, for CORUS, are shown in the following table.

Information Exchange	Service
Registration Info Provision	Registration *and* Registration Assistance
Insurance Information Provision	
License Info Provision	
Registration Information Provision	
Operator Registration Provision	
Drone Identification Provision	e-Identification
Flight Plan Information Provision	Drone Operational Plan processing
	Drone Operational plan preparation assistance
	Strategic Conflict Management
	Dynamic Capacity Management
Conflict Alert Provision	Monitoring
Monitoring Provision	
Geofencing and Geocaging Info Provision	Geofencing and Geocaging
Geo-awareness Information Provision	Geo-awareness
Emergency Info Provision	Emergency Management
Airspace Structure Provision	Drone Aeronautical Information Publication
Drone Identification Provision	Automatic Flight Plan Validation
Start Flight Info Provision	Tactical Conflict Resolution
Tactical Clearance Provision	
MET Info Provision	Weather information
Constraints Info Provision	Interface with ATC
Transit Info Provision	
Coordination Need with ATM Provision	
Landing Authorisation Provision	
Drones Situation Provision	Traffic Information
ATC Tracking Info Provision	Tracking
Tracking Information Provision	
Flight Report Provision	Accident / Incident reporting
Citizen Report Provision	Citizen Report Service
Communication Info Provision	Communication Coverage information *and* Communication Infrastructure Monitoring
Navigation Info Provision	Navigation Coverage information *and* Navigation Infrastructure Monitoring
Surveillance Info Provision	Surveillance Data
Terrain and Obstacles Provision	Geospatial information service
	Risk analysis assistance
	Digital Logbook
	Legal Recording
	Population density Information
	Electromagnetic information

Table 11 Mapping of Information Exchanges to Services

6 Service Architecture

The service layer provides a link between the operational need and technical solution by describing services. This also includes the linkage to data elements.

Only one element from this layer is used in this iteration of the architecture document.

- **Service:** S

The contractual provision of something (a non-physical object), by one, for the use of one or more others. Services involve interactions between providers and consumers, which may be performed in a digital form (data exchanges) or through voice communication or written processes and procedures.

Services are key to describe the relationships between the different aspects (business, operational and solution) of the Architecture.

Based on the intermediate works, following table reports list of identified services. Other breakdowns are feasible, and the following is not aiming to prevent others at this stage. The identification of services is the first step towards their full specification.

Services have been grouped in order to manage their complexity:

- U-space services, which can be further classified in Principal and Operator U-space services according to the split of responsibilities in the deployment architecture. They are services strongly linked to U-space domain among USSPs and for the end-users.
- U-space Supporting services, which encompass Infrastructure and Supplemental Data services. They are services providing additional data to other services from different sources. They are typical services that are not specific to U-space and can be consumed in other domain as well (e.g. terrain, weather, surveillance, obstacle, cellular coverage)

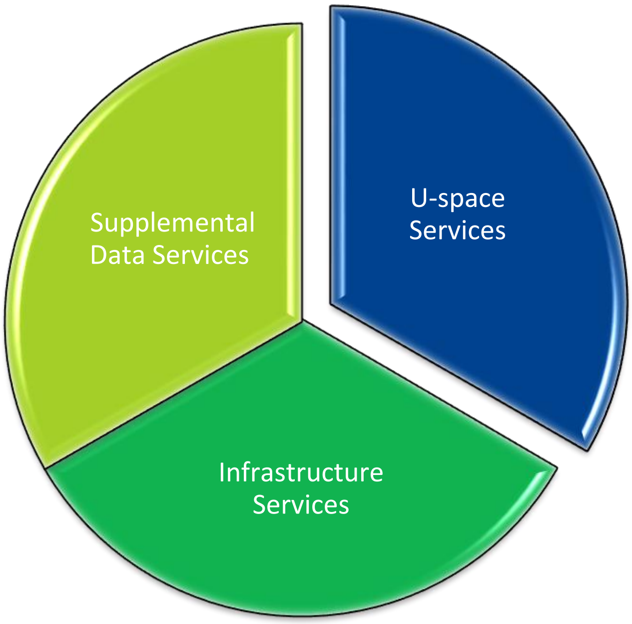


Figure 19 Service portfolio classification

In the service layer, the service portfolio includes an initial set of service identified form the experts taking into consideration the Operational process Model of the Operational View and the traceability with the U-space Capability model.

It should be noted that the activity performed in CORUS is not providing details about the signature of the services (out of scope in this iteration) and that specification activity may result in optimisation to merge/split services or introduce other services.

U-space Service	
Registration *Drone Registration* *Drone Pilot Registration* *Drone Owner Registration* *Drone Operator Registration*	The service (one service or many for the specific registration entrytype) to interact with the registrar in order to obtain registration. It mainly includes service operations to request a registration, maintain registration information and cancel an entry.
e-Identification	The identification provides access to the information, where necessary complemented by the one stored in the registry, based on an identifier emitted electronically by the drone. The identification service includes the localisation of the drones (position and time stamp).
Tracking	The service to receive location reporting and to fuse and provide tracking information about drone movements
Drone Aeronautical Information Publication	The service to access to drone aeronautical information (whole or its subparts -e.g. geographical subsection)
Geo-Awareness	The service to provide awareness of airspace limitations depending on the privileges of the drone operator. It is as well providing detected potential breach of airspace limitations and alerts.
Geo-Fencing provision	The service to support geofencing ondrone capability, which shows where it is possible to fly or not according to the authorisation of the drone, operator and latest drone aeronautical information.
Drone operational plan processing	The service to access to the flight plans, to submit new plan and modify/cancel alread existing ones. The service to manage authorisations workflows where necessary and the permissions with relevant authorities.
Strategic Conflict Management	The service to check for possible conflicts in strategic phase for a specific flight/mission plan/intent. It as well provides resolution advisories.
Tactical Conflict Management	The service to check possible tactical conflicts for flights including the provision of resolution advisories.
Monitoring	The service to provide monitoring alerts/warding about the progress of a flight (e.g. Conformance monitoring, Weather compliance monitoring, Ground risk compliance monitoring, Electromagnetic monitoring)
Traffic Information	The service to provide whole set of information required to obain a situation awareness.
Interface with ATC	Even if identified services are already providing means to achieve the interoperability with involved ATSUs or ANSPs as well e.g. to exchange tracking/traffic information, drone operational plans, emergency information, the interface with ATC service is to realize the collaboration with ATSUs in managed airspace for establishing the contact with the drone, e.g. asking/forwarding clearances (similarly to the Controller Pilot Datalink Communication for drones).
Emergency Management	The service to detect, to notify and to alert about emergency and to activate mitigation scenarios/actions.

Legal Recording	The service to record legal information for incident/accident investigation or suitable for statistics.
Dynamic Capacity Management	The service to balance traffic demand and capacity constraints.
Registration Assistance	The service to support the registration process to aid the submission of registration information.
Drone operational plan preparation assistance	The service to support the operator to guide the fileing of a flight /mission intent/plan.
Risk analysis assistance	This is a supporting service to elaborate specific operation risk analysis. Escalation to Supervisor for exceptions.
Accident / Incident reporting	The service to prepare and submit an accident/incident report and to mange its lifecicle.
Citizen reporting	The service to be used by the citizen to inform the law enforcement about not cooperative drone traffic or other suspicious event to be reported.
Digital Logbook	The service to create and keep up-todate the digital logbook

Table 12 U-space Services and their description.

Supplemental Data Services	
Weather information	The service to collect and present relevant weather information for the drone operation. This include hyperlocal weaher information when available/required.
Geospatial information service • **Terrain map** • **Buildings Obstacles**	The service to collect and provide relevant Terrain map, buildings, obstacles for the drone operation.
Population density Information	The service to collect and present relevant density map for the drone operation.
Electromagnetic information	The service to collect and present relevant electromagnetic information for the drone operation.

Table 13 Supplemental Data Services and their description.

Infrastructure Services	
Navigation Coverage information	The service to provide information about the navigation coverage. It can be specialised depending on the navigation infrastructure available (e.g. ground or satellite based). This service is used to plan relying on required coverage.
Navigation Infrastructure Monitoring	The service to provide status information about navigation infrastructure. This service is used during operations.
Communication Coverage information	The service to provide information about the communication coverage. It can be specialised depending on the communication infrastructure available (e.g. ground or satellite based). This service is used to plan relying on required coverage.
Communication Infrastructure Monitoring	The service to provide status information about communication infrastructure. This service is used during operations.
Surveillance Data	The service to detect traffic and to provide relevant tracks. (e.g. antidrone or telecom service provider by triangulation).

Table 14 Infrastructure Services and their description.

6.1.1 Services aim to achieve Capabilities

According to EATMA, a Service is a mean to achieve a Capability. Therefore, there is a need to trace the identified Services to the Capabilities composing the Capability Model.

	Surveillance Services Provision	Navigation Services Provision	Communication Services Provision	Drone Operational Planning	Drone Procedures Design	Dynamic Capacity Management	Conflict Detection and Resolution	Remain Well Clear	Ground Collision Avoidance	Ground Proximity Terrain Avoidance	Geofence Infringement	Mid-air Collision Avoidance	Registration	Emergency Management	Interface with ATS	Security Monitoring*	Meteorological Observation and	Drone Aeronautical Information	Situational Awareness	Recording and analysis
Registration													X							X
e-Identification	X																			X
Tracking	X																			
Geofencing provision					X						X							X		X
Geo-Awareness					X						X							X		X
Emergency management														X						X
Strategic Conflict Management				X		X														X
Tactical Conflict Management							X													X
Interface with ATC															X					
Weather information																	X			X
Drone operational plan processing				X																X
Monitoring	X							X	X	X	X	X								X
Traffic information																			X	X
Drone aeronautical information publication																		X		X
Dynamic capacity management						X														X
Legal Recording																				X
Accident / Incident reporting																				X
Citizen reporting																				X
Registration Assistance													X							X
Drone operational plan preparation assistance				X																X
Risk analysis assistance																				X
Digital Logbook																				X
Geospatial Information									X											X
Population density Information																				X
Electromagnetic Information																				X
Navigation Coverage Information		X																		X
Navigation Infrastructure Monitoring		X																		X
Communication Coverage Information			X																	X
Communication Infrastructure Monitoring			X																	X
Surveillance Data	X																			X

Table 15 Mapping of Services to Capabilities

7 System Architecture

The system layer describes all human and technical resources of a SESAR system including its internal functional breakdown and its interactions with the surrounding systems.

- **Capability Configuration:** 

A Capability Configuration is a combination of Roles and Technical Systems configured to provide a Capability derived from operational and/or business need(s) of a stakeholder type.

- **Role:** 

An aspect of a person or organisation that enables them to fulfil a particular function.

Roles can be expressed in both the operational and system layers of the architecture.

In the operational layer, they represent a need for a Role to perform a particular function while in the system layer they represent the use of a human resource (person or organisation) in a Capability Configuration.

As such, Roles are part of Capability Configurations in order to describe the human resources needed.

- **Technical System:** 

Technical Systems are artefacts that represent the technical part of Capability Configurations and contain Functional Blocks. Interaction between Technical Systems can be described via Services.

- **Functional Block:** 

A logical and cohesive grouping of automated Functions in a Technical System.

7.1 Stakeholders and Roles

At higher level the following diagram shows stakeholders roles using the U-space services

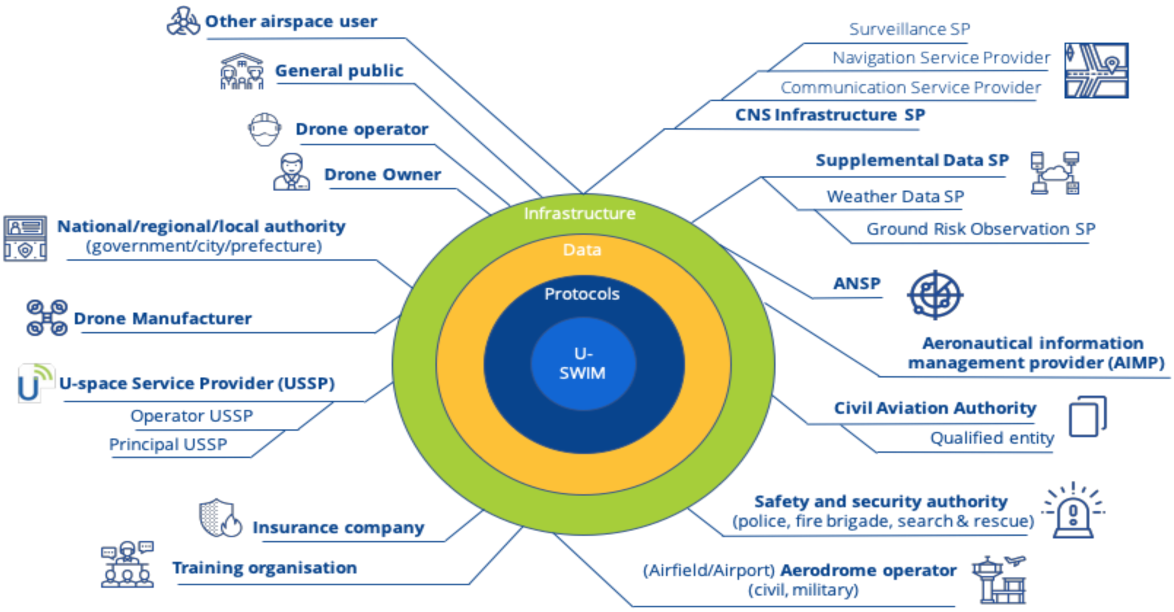


Figure 20 Stakeholder roles using U-space services

Stakeholder	Why it matters to stakeholder / what they expect
Drone operator	It is the legal entity, which can be a natural person, accountable for all the drone operations it performs. It is the equivalent of the airline for the pilot in manned aviation. It could be civil, military, an authority (special) or a flight club. It obtains fair, flexible & open access to the airspace. It is accountable for safe and secure operations. It expects that U-space further develops drone operations safe and socially acceptable which enables the development of new business models, spur jobs & market growth. It expects that U-space services protects privacy and confidentiality of competitive information (e.g. customer identity).
Drone Owner	It is the legal entity, which can be a natural person, owning the drone. It may be different from the Drone Operator legal entity (e.g. leasing rental mechanisms).
Drone manufacturer[6]	It produces drones and ensures their compatibility with U-space (technical feasibility, interoperability).
U-space Service Provider (USSP)	Generic stakeholder who provides one of the U-space services. The entity that provides U-space service access to drone operators, to pilots and/or to drones, to other operators visiting non-controlled very-low-level airspace. Depending on the architecture deployment options: • multiple services could be provided by different U-space Service Providers. • It is possible to distinguish between the providers of centralised services (i.e. **Principal USSP**) and concurrent service providers (**Operator USSP**)
Supplemental Data SP (SDSP)	An entity that provides access to supplemental data to support U-space Services. Multiple services could be provided by different Supplemental Data Service Providers.
Weather Data SP	It provides weather information data (hyper local weather data, solar flare information and TAFs and METARs) and ensures that these are reliable, accurate, correct, up-to-date and available.
Ground Risk Observation SP	It provides supplemental data which contribute to the knowledge/observation of the ground. It encompass: • ground and terrain data modelling (building heights, digital elevation model) and ensures that these are reliable, accurate, correct, up-to-date and available. • population density

[6] Economic operator, as introduced by EASA Opinion, generalise the stakeholder in case manufacturer is not in Europe. Economic operator means the drone manufacturer, the authorised representative of the drone manufacturer, the importer, and the distributor of the drone.

CNS Infrastructure SP	CNS infrastructures are constituting important U-space supporting systems. CNS Infrastructure SPs in general provide the availability of the CNS service and, where applicable, relevant monitoring and coverage services.
Communication Service Provider	It is responsible for the provision of a reliable and safe communication link between systems. It may contract different SLA to several Communication Service Providers, depending on the drone operations requirement and provide services to check coverage and monitor the status. For C2 Link it is aka C2-Link Service provider
Navigation Service Provider	It is responsible for the provision of a reliable navigation infrastructure to allow safe drone operations. It may contract different SLA to several Navigation Service Providers, depending on the drone operations requirement and access to airspace and provide services to check coverage and monitor the status. E.g. Satellite Nav Service providers.
Surveillance SP	It is responsible for the provision of surveillance services with different technologies/methodologies and SLA. It encompasses anti-drone surveillance for non cooperative traffic. It provides services to check coverage and monitor the status of the surveillance service offered. Drone neutralisation is out of scope of the architecture,
Air Navigation Service Provider (ANSP)	Provides services to Airspace Users that may be operating in airspace where U-space services are also being provided
Aeronautical Information Management Provider (AIMP)	Existing ATM provides sources of some data consumed by U-space service providers and users. It is typically the ANSP.
(Airfield/Airport) Aerodrome operator (civil, Military)	Support the definition of operating procedures and interoperability requirements It expects that U-space ensures safe integration of drones in airspace, especially in airport vicinity
Civil Aviation Authority	Generic term to encompass national or local aviation authority. It expects that U-space ensures aviation law is followed, ensures safe and secure operation of all aircraft, promotes the minimisation of environmental impact and anticipates deployment challenges
Authority for safety and security (police, fire brigade, search and rescue orgs)	Publish danger areas in real time – relating to medical evacuation, police helicopter or similar (Police only) Develop law enforcement methods related to illegal drone use.
Local authorities (government/city / prefecture)	It supports the definition of operating procedures and rules. It explores applications of U-space to urban needs – for example active measures limit noise “dose” in any one place It expects U-space develops methods to support among the others: - privacy assurance - enforcement of drone regulations - publishing VLL hazards as they arise – cranes, building work, …

	- derive added value from data generated by routine drone operations
Insurance companies	Collect statistics about drone accident rates in U-space. Propose more affordable insurance for drones that use enabling factors that lowers the risk of incident. Offer per operation insurance based on the specific operational plan. Providers supplemental data related to the insurance related to the U-space services. In that case it is an Insurance Data Service Provider.
Training Organisation	Remote pilot schools & Training centres Responsible for Pilot and operators training.
Aviation User	Users of the airspace other than drone operators / pilots. Includes those concerned with manned aircraft, parachuting and similar
The general public	Those who may hear, see or otherwise be concerned by a drone

Table 16 Operational Stakeholders

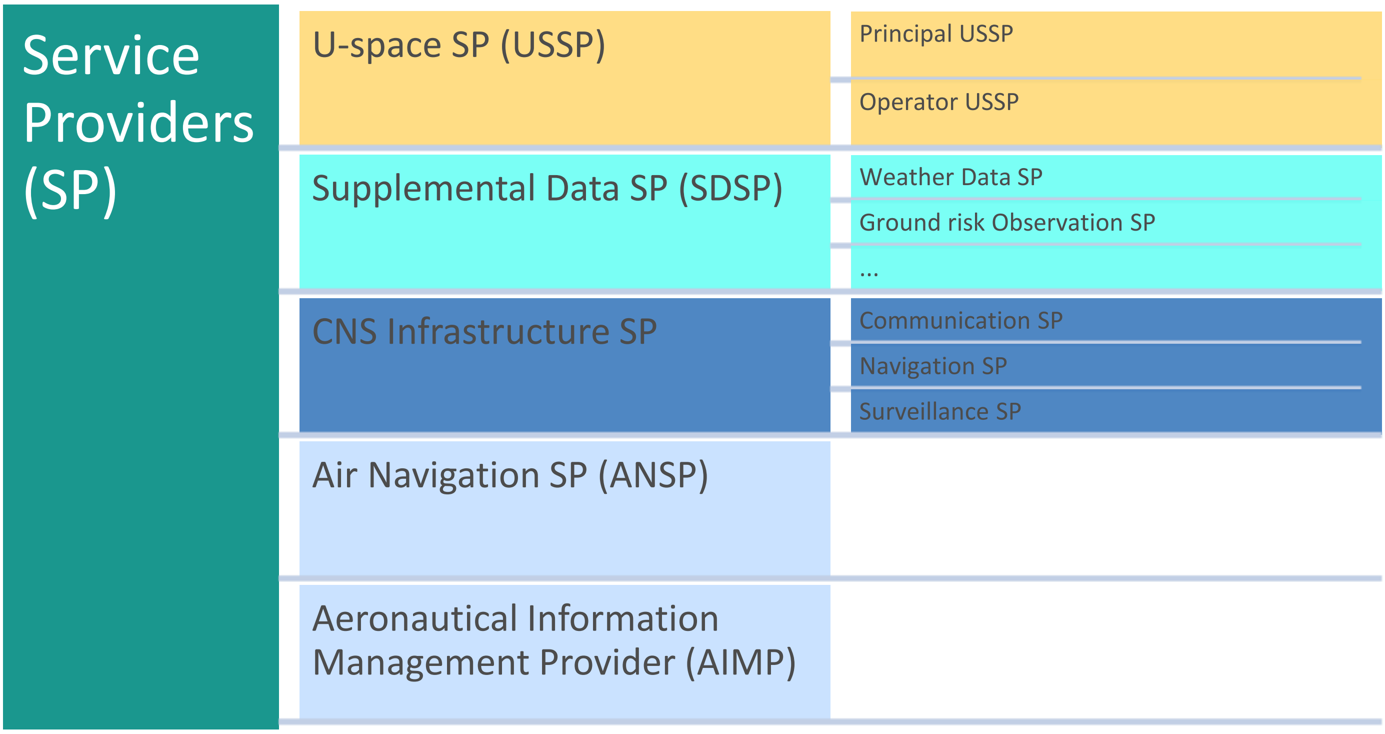


Figure 21 Service providers Stakeholders classification in U-space

Stakeholder	Why it matters to stakeholder / what they expect
Operation Customer	It is the final stakeholder of the drone operation who may have some roles in the authorisation of the mission itself.

U-space Service industry	It develops sw/hw products to realise U-space services. It expects that standards are issued for ensuring U-space interoperability. It provides a range of services implementation from basic to advanced solutions.
National Supervisory Authority	It will ensure aviation law is followed, ensure safe and secure operation of all aircraft, promote the minimisation of environmental impact and anticipate deployment challenges.
EASA/JARUS	Validate the assumptions underpinning Opinion 01/2018 and provide inputs contributing to - implement an operation-centric, proportionate, risk- and performance-based regulatory framework for all UAS operations conducted in the 'open' and 'specific' categories; - ensure a high and uniform level of safety for UAS; - foster the development of the UAS market; and - contribute to addressing citizens' concerns regarding security, privacy, data protection, and environmental protection
European institutions (European Commission, SJU, Directorate General for Mobility & Transport (DG MOVE), Directorate General for Internal Market, Industry, Entrepreneurship & SMEs (DG GROW), EUROCONTROL, European Defence Agency (EDA)	Promotion of economic activity related to drone use They expect that U-space ensures protection of privacy, EU consumer rules conformance and safety with regards to protected sites (geofencing)
Universities and academic institutions and research projects (e.g. CLASS, CORUS, SECOPS) **+ Industrial research projects + test range**	Feedback, outcomes, results on current research issues, recommendations for additional industrial / research needs
Drone association (manufacturers & operators)	It represents Drone Pilots/Operators/Manufacturers and provide them assistance. They expect that U-space services realise an important enabling factor for the safe growth of the drone marker.
Flight Model Club	It represents modellers which needs to be distinguished from drone operators in the U-space access considering peculiarity of their activities.
Specialized press	It is responsible for communicating and disseminating information/news about this drone market.

Table 17 Other Stakeholders

Role	Explanation
Drone pilot	aka UAS Pilot, Pilot in Command (PIC) or Remote Pilot, It is responsible for the safe execution of the flight according to the U-space rules, whatever it is recreational or professional with one of the different license levels, according to the typology of the drone used. (Recreational Drone Pilot, Professional Drone Pilot)

	It expects: • more efficient flight preparation, including getting permission (easier, quicker and more efficient); • safer and more efficient flight execution due to improved situational awareness in all operations – VLOS and BVLOS The person being registered in the pilot registry. A pilot is a human being, currently. The registry should be able to record some information about the pilot's qualification; mentions different levels of qualification. The drone pilot should be able to update some parts of his/her registry entry, such as changing his/her address and he/she may be allowed to create the record initially. How he/she interacts: User of geo-fence definitions during flight; User of situation awareness computed from the dynamic online traffic situation based on maintained tracks; User of weather nowcast to assist him in the in-flight phase; the person receiving warning and alerts from the monitoring service.
Drone crew	The drone pilot or any person following the drone's progress during flight. This term generalises the pilot, any kind of dispatcher, any mission specialist. Additional recipient of messages about flights. Drone Pilot Assistant. It is assisting the piloting in its duty. Observer. It is assisting the piloting in its duty, e.g. during EVLOS operations.
Drone operator representative	Aka UAS Operator, the operator being registered in operator registry. An operator representative is a legal entity; meaning a natural person or a business. An operator representative has contact details. How he/she interacts: User of geo-fence definitions during flight planning, User of situation awareness computed from the dynamic online traffic situation based on maintained tracks, Generalised actor that submits a flight plan, the person receiving warning and alerts from the monitoring service
Drone owner representative	When any drone is registered, it will have a registered owner. An owner is a legal entity; meaning a natural or a business. An owner representative has contact details. How he/she interacts: User of drone registration.
ATS Operator	ATS should have access to the air-situation generated from e-identification reports, with the usual controller-working-position tools to filter out those of no interest, give conflict alerts and so on. Main roles: AT Controller, Tower Supervisor, Tower Runway controller, Tower Ground controller, (A)FIS and RIS Operator. How he/she interacts: User involved to achieve the interface with ATS.
Police or security agent	Security actors would be interested in the air situation, to identify operators and to apply relevant procedures. Law enforcement Unit, responsible to develop law enforcement methods related to illegal drone use.

	How he/she interacts: User of registration, e-identification and interested in the situational awareness and monitoring alerts.
Pilot	It is the pilot of glider, parachutist, paraglider, balloon, GA, military flight which share the airspace (even if occasionally) in VLL operations. How he/she interacts: In some environments, user of situational awareness and monitoring alerts.
Citizen	Generic person who wants to be aware of drone operations impacting its privacy. How he/she interacts: a kind of authorised viewer of air situation.
Registrar	A registrar has a legal duty to operate a registry securely, reliably and adequately. The registrar will be a legal person, probably with staff. How he/she interacts: who may intervene in case of problems in the registration
Accredited registry updater	This category groups together pilot training schools, LUC issuers, nominated agents of the courts and any others who have the power to create, read, update or delete registry entries in any way – which may be very restricted for some. How he/she interacts: User of (operator/school/pilot) registrations.
Accredited registry reader	This category groups the police, accident investigators, other agents of the authorities or anyone else who might need – and be given permission - to look into the registry. (or registries). How he/she interacts: Who may query registration information.
Drone Aeronautical Information Manager	A body that is independent of the Aeronautical Information Office and allows drone specific aeronautical information to be registered, combines the information, assesses it and then published the result.
Drone specific aeronautical information originator	The person or representative of the organisation that creates drone specific aeronautical information. This actor is accredited and trained in the processes of creating, updating or deleting drone specific aeronautical information. This is reflecting the possibility to have a different originator of “constraints” for drones.
Authorised viewer of air situation	This groups actors like U-space operators, city authorities and some others such as researchers who can be trusted with the commercially sensitivities of the overall air-situation. How he/she interacts: Who may be allowed to have a situational awareness according to privileges and privacy.
USSP Supervisor	Being the level of automation high, it is not envisaged the role of “Controller”. Nevertheless, it has been envisaged a person who will arbitrate or impose a solution in some cases (in case of escalation required) who may intervene manually imposing ad-hoc solutions or taking over other USSP roles.
Authorization Workflow Representative	A person having the rights to participate in the authorization workflow (e.g. when local authority/USP/NAA must express the approval or does not object).

Capacity Authority	A person receiving warning and alerts from the monitoring service Responsible for setting the minimum safe operating conditions that determine the capacity of an airspace or an aerodrome due to safety Responsible for setting noise level limits that limit capacity due to noise footprint and "dose"
Drone Manufacturer Representative	It is responsible for drone registration and using the system for all other obligations the drone manufacturer must comply (e.g. drone model/characteristics/performance publication).
Airport Operator Representative	It is responsible for interacting with the system to protect airport perimeter (anti drone) to contribute to the safe integration of drones in airspace, especially in airport vicinity. It will responsible to establish proper coordination with other relevant stakeholders.

Table 18 Stakeholder Roles

7.2 Possible Systems breakdown

Even if a preliminary list of functional blocks have been identified, the following Technical Systems are representing a possible grouping of functional blocks.

Based on the initial works, following table reports list of Technical Systems. Being an architecture service-oriented other breakdowns are feasible and the following is not aiming to prevent others.

System	Description
Drone system	Aka Unmanned Aerial System (UAS), represents the Drone operating from the end to end, on the airport surface, from a field and in the air. The main groupings of functionalities are the ones dealing with traffic management: • Communication (air ground data link, information domain); • Navigation (Flight management, flight control, position determination); • Surveillance (traffic, weather, terrain); • Other functions (remote displays and controls, alerts, recording, databases, sensors and antennas, information domain display).
Drone Operating System	Where available it supports the drone operations in their activities assisting the human actor in the fleet management, drone preparation, the assistance to interface with Drone Traffic Management.
USSP system	Is a generic system which provides U-space services. It can be unique per volume of airspace or possibly broken down in several instances sharing responsibilities and interoperable. One of the possible breakdown is between Registration and Drone Traffic Management services (i.e. Registration system and DTM system) according to the services provided. A further breakdown is considering the deployment options where the boundary between Principal and Operator USSPs is determined; then it results in a Principal

	USSP system and several Operator USSP systems in case of federated deployments.
Drone Traffic Management system	Aka USSP system which supports the Drone operators in their activities related to traffic management. It provides the following main functionalities: e-identification, drone aeronautical information and geofencing, flight planning management, de-confliction, demand capacity balancing, weather data presentation. This system may provide graphical interfaces to the public, the law enforcement units (e.g. police, security agent) and drone operators/pilots, other airspace users. In some deployment options several instances of Drone Traffic Management systems may exists. Each of them realises completely or partially (a subset of service provision) a DTM system.
Registration system	Aka USSP system which supports with automation the Registration process.
Communication Infrastructure	U-space support infrastructure for Communication. It encompasses technologies and services that will provide communication among U-space actors. It includes: - ground-ground communications among systems and any other stakeholder: Drone Operator/Pilot, ATM, Law Enforcement, Aviation Authority - air-ground communications with the drone itself.
Navigation Infrastructure	U-space support infrastructure for Navigation. It encompasses technologies that could provide signals in space to allow drone positioning and navigation (e.g. satellite-based or ground-based).
Surveillance Infrastructure	U-space support infrastructure for Surveillance. It encompasses technologies and sensors to support cooperative and non-cooperative surveillance of drones
Supplemental Data system	It is a system which is able to elaborate/provide supplemental data for U-space services such as a weather system or terrain data model system.
Weather system	U-space support infrastructure for (hyper local) weather data. It encompasses the technologies and sensors and the evolution of the models for data elaborations.
Terrain Data Model system	U-space support infrastructure for terrain and obstacles data. It encompasses the technologies and the models for data acquisition, elaborations and provisioning.
ATM (Aerodrome ATC) system	Collaboration with ATM requires an evolution of the Air Traffic Service Unit systems such as the Aerodrome ATC system

Table 19 Possible breakdown in systems.

7.3 Candidate Functional blocks for DTM/USSP system

Following diagram shows possible breakdown in functional blocks of a DTM system. Each candidate functional block is briefly described in this section as well.

There is no indication of mandatory/optional functional blocks for this system.

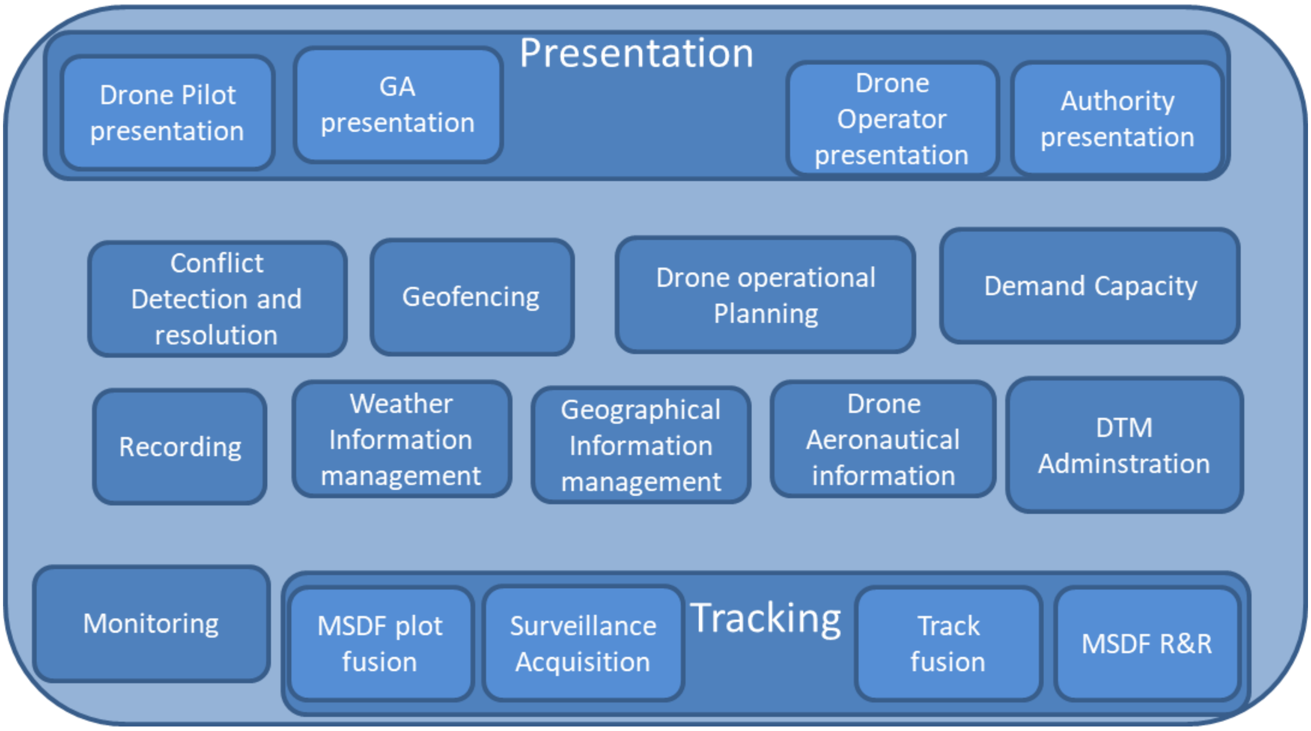


Figure 22 Possible breakdown in functional blocks for DTM System

Functional Block	Brief description

Drone Operator and Pilot Presentation	Assists the Drone Operator/Pilot in all phases of a drone flight. It provides the graphical representation and the mechanisms to access to the following functionalities:
	• Define and visualize the intended flight zone for his operation with the applicable drone aeronautical information;
	• Validate a planned flight against the local regulation, which can be used as a guidance to assist pilots in their planning phase;
	• Autocomplete required documents such as approval requests.
	• Monitor the position of surrounding drones in real-time;
	• Manage drones from the extensive database of drones;
	• Document management:
	  ○ Keep track of all licenses and certificates,
	  ○ Central place to store all documents such as operational manuals and maintenance documents;
	• Have an overview of all historic, planned and ongoing flights in the same company;
	• Incident reporting

GA presentation	General Aviation are using tools such as an Electronic Flight Bags (EFB) to assist them in their flight. Having a connection between the DTM and these EFB can be of benefit to the manned aviation pilots to be informed about surrounding drone operations.
Authority presentation	The DTM supervisor authority graphical presentation can be customized per stakeholder (Police, ANSP, Airports, etc.). The following functionalities can be provided to authorities:

	• Registration: every drone, drone pilot and drone operator willing to operate might need to be registered to be identified; • Realtime monitoring of drone operations: Simultaneous drone operations and tracks can be monitored (history, ongoing and future); • Permission management: A customized approval process to operate can be deployed according the local requirements; • Manage dynamic or static no-drone zones: it might be that some locations are no-drone zones (such as a runway for manned aircraft), these can be managed dynamically. Another example might be the dynamically creation of no-drone zones because of a car accidents or mass events; • Etc.
Drone operational planning	It encompasses the drone operational planning preparation, validation and permission management. Before performing an actual drone flight, the drone operator or his representative needs to define a flight plan. This flight plan will describe a detailed drone operation. A drone operation is a logical collection of one or more drone flight(s) flown to execute successfully the objective of an operation. An example: the operation of surveying a site might require several flights to make sure sufficient data is collected for building an accurate 3D site model. The operation definition would typically collect following data: • The operator accountable for the operation. • The drone pilot(s) responsible for performing the drone flight(s) in the operation. o the pilot-in-command, observer, … • Type of rule: recreational or commercial rules • The type of operation: VLOS, EVLOS or BVLOS • The time frame (date, time, duration) during which the operation will be performed. • The drone that will be used to perform the operation including operation specific details such as the estimated take-off weight of the drone and all other technical specifications. • The intended drone flight zone expressed as one of the following (e.g. cylinder, 3D volume, 4D flight path implying a safety zone around) It checks the compatibility of the operation(s) defined in the operation definition phase with both applicable (inter)national and local rules. If a proposed drone operation is incompatible with the applicable (inter)national and/or local rules the validation result is negative, and the proposed operation will have to be redefined and resubmitted for re-evaluation. The actual approval of the proposed drone operation will confirm if the drone operation is allowed or not.

	Two approaches can be implemented: • A fully automated approval process in which human intervention is not needed. The validation process will automatically approve drone operations compatible with the applicable national and local rules and procedures. • A manual approval process in which human intervention is integrated in the approval workflow. This would allow a DTM service provider representative to remain in control of the approval decisions for at least of a subclass of operations.
Geofencing	Geofencing and geocaging (aka geofencing stay-in) are two functions supported by the DTM system that allow the DTM Service Provider to restrict the flight path of drones. The two techniques are related: • In geofencing a 3D zone is defined in the DTM system in which a drone is not allowed to fly – a virtual fence is defined around the no-drone zone and the drone pilot and/or drone is warned not to cross that fence into the prohibited zone. • In geocaging a drone is not allowed to leave a 3D zone as defined in the DTM system – a virtual cage is built; the drone takes off in the cage and the drone pilot and/or drone is alerted when it attempts to fly outside of the virtual cage. The DTM system allows for the definition of the geofences and geocages. This information can be exchanged with the drones. The enforcement of the active geofences and/or geocages can be done in two, non-exclusive ways: • Manual notification in which case the drone pilot is informed by the DTM system via alerting of the fact that he must take action to avoid the drone leaving the cage or to avoid the drone from crossing the fence. • Automated enforcement in which case the DTM system will communicate directly with the drone to prevent the drone from leaving the cage or to avoid the drone from crossing the fence. (DTM communication support, autonomous, embedded autopilot etc.).
Conflict detection and resolution	Conflict detection is another functionality offered by the DTM system which will send alerts to the drone pilots whenever the DTM system detects a possible conflict before the flight is started and during the flight on basis of the real-time flight path data sent to the DTM system. Two different conflict types have been identified: 1. A potential conflict between a drone and a manned aircraft 2. A potential conflict between drones NB. Conflicts between drones and known obstacles could be part of a DTM system or of the drone-specific flight planning software.

	Once the conflict is detected the conflict can be resolved according priority rules specified by the authorities, both before as during the flight.
Monitoring	Real-time monitoring is an integral and important part of the DTM system. This functionality supports the monitoring of both drones and manned aircraft. Additional information concerning real-time specifications such as the identity of the pilot, drone and any other related known information and status can be displayed on an interactive map. Real-time tracking allows for the monitoring of a drone operation and can be used for example to verify if the operation is carried out in compliance with the approval given by the DTM service provider. Drone flight compliance monitoring allows the DTM system to verify if an actual drone flight is complying with the agreed upon flight rules or approved flight path. Compliance monitoring is also at the basis of the alerting system linked to the implementation of geofencing and geocaging. A DTM track/plot can have different states such as rogue, intruder, etc. This analysis will describe if the drone is known in the system or not, or if the drone is compliant with the rules.
Demand Capacity	Optimisation mechanisms are based on the prioritisation of drone traffic in the drone-available airspace. The system evaluates if the number of drones should be restricted for a certain area based on fair access to airspace rules. The DTM system provides slot management functions to reserve certain zones where the capacity is important to manage for reasons such as safety, privacy, security and noise. An example of such an area is an airport, where slots might be required to guarantee a controlled way of allowing drone operations.
Drone Aeronautical information	A DTM system has to support flexible management of zones in which drones are not allowed to fly. No-drone zone management is often used in the same context as airspace management. The output of this information is used for the Flight Plan Validation and Geofencing/Geocaging functionality.
Weather Information Management	The DTM system shall provide weather information and shall only share the applicable data with the drone operator. This data is limited to the intended drone flight zone which is prepared in the flight plan preparation functionality.
Recording	Real-time tracks can be archived to create a historical log of flights executed with drones supporting real-time tracking. These historical track logs can be used for post flight analysis by the DTM authority and can also be made available to the drone operator/pilot if needed and/or wanted. Not only real-time tracks are recorded, but also a full historical log of all transactions performed on the DTM system's data. This log fully describes the history of the system including all transactions and provides all information necessary for performing audits or trend analysis for example. The extensive data available on the use of the DTM system can also be used for billing purposes.
DTM Administration	It encompasses access management/authentication, billing and messaging, technical supervision functionalities

Table 20 Possible breakdown in functional block of a DTM system.

7.3.1 An example of realization of DTM system

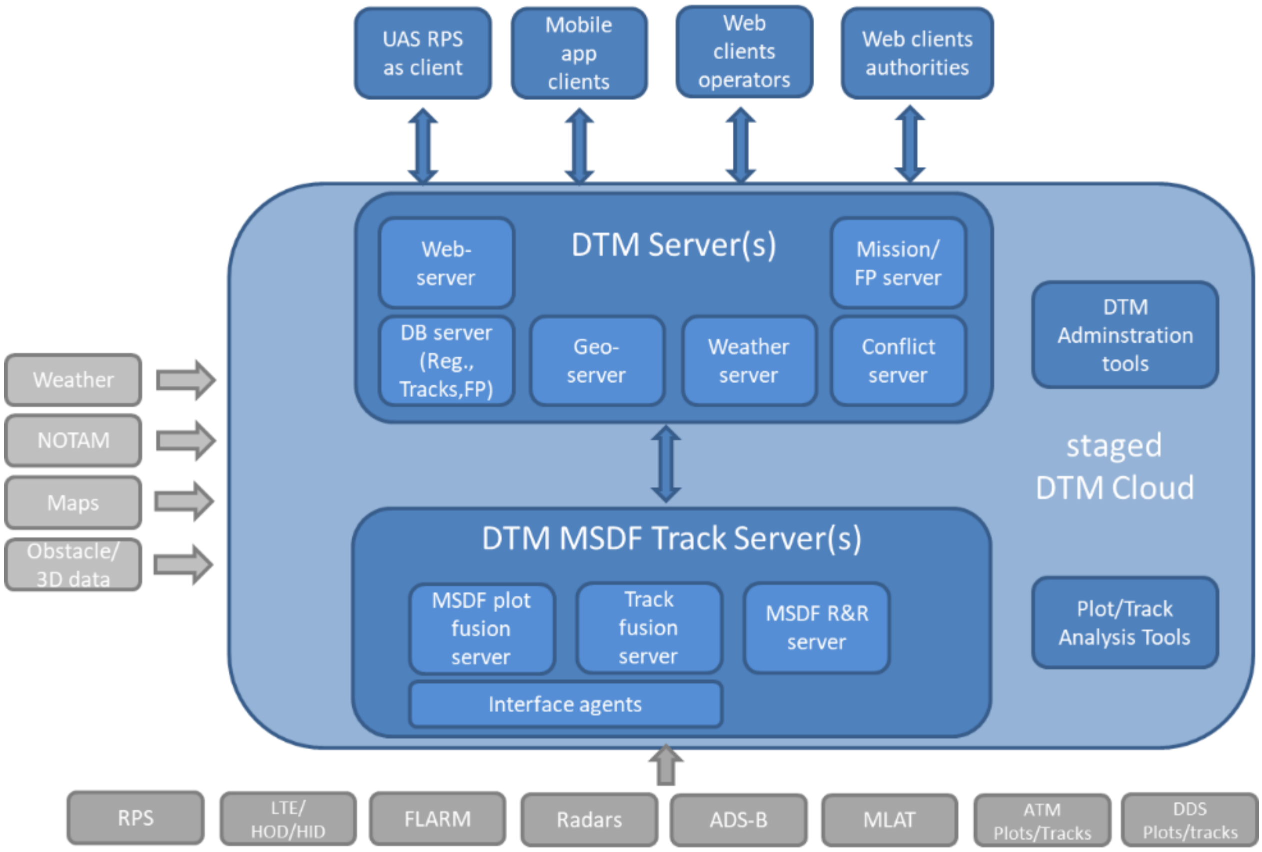


Figure 23 An example of realization of a DTM System

Component	Purpose	Type	Links
Staged DTM cloud	Cloud container with test and public instance for staging	n/a	n/a
DTM Servers	Set of DTM server processes providing the services to DTM clients	Set of Servers	IP
Webserver	Webserver to provide scalable number of client connections (web, apps)	Server	IP
DB Server	Database server to provide registration, e-Identification on UAS, operators, pilots and their data and documents	Server	IP
Geo Server	Geographic server to provide map background tiles and overlay maps incl. Obstacles and 3D	Server	IP
Weather server	Server to provide weather measurement data and weather images	Server	IP

DTM adminstration tools	Toolset for DB maintenance, configuration, updating, monitoring	Clients	IP
DTM MSDF Track Server	Set of DTM MSDF track server processes	Set of Servers	IP
MSDF plot fusion server	Tracker process performing the MSDF tracking on plot fusion	Server	IP
Track fusion server	Tracker process performing track fusion of pre-tracked UAS inputs like DDS or ATM	Server	IP
MSDF R&R	Recording and Replay processes for legal recording and analysis	Server and client	IP
Interface agents	Data format and evtl. transport layer transformers	Daemons	IP
Plot/track analysis tools	Tracking quality analysis tools	Clients	IP
UAS RPS as clients	3rd party RPS for drone remote control	Clients	IP
Mobile apps	Clients for UAS and VFR pilots	Clients	IP
Web clients operators	Web-based operator working positions	Clients	IP
Web clients authorities	Web-based working positions for authorities	Clients	IP

Table 21 A possible realisation of a DTM system.

7.4 Candidate Functional blocks for Drone system

The goal of this schema is to propose a basic functional representation of an unmanned aerial system.

The system is composed of the vehicle, the remote pilot station(RPS), and a communication module.

In the unmanned aircraft vehicle, two very important units are the power management function, which provides power to each device, and the Flight management function, which could provide instructions to each device.

The communication module allows the UAV to communicate with every external unit essential for the flight, and to receive instructions from the pilot in the RPS. This is the command and control link, or C2 link.

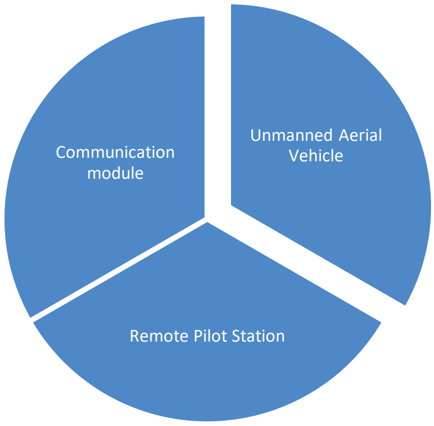


Figure 24 Drone system breakdown in subsystems

Functions such as geofencing/geocaging, Detect and Avoidance (Remain well clear and Collision Avoidance) depending on the implementation can be deployed on board on ground subsystem.

In the following breakdown in functions of the Drone system, there is no specifically indicated which subsystem the function is part of.

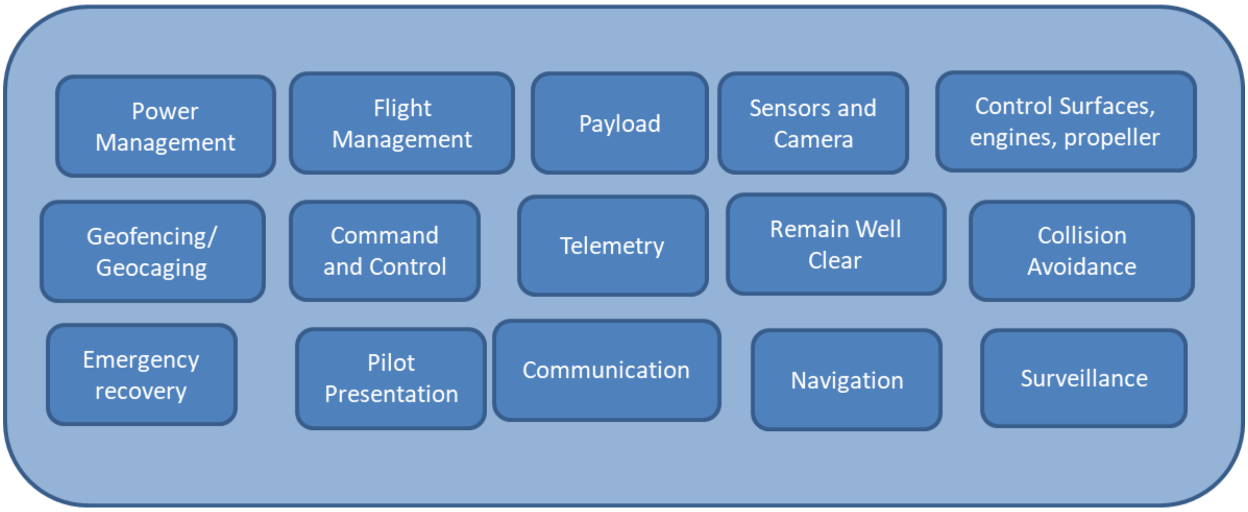


Figure 25 Possible breakdown in functional blocks for Drone System

7.5 Deployment Architecture

Being service oriented and having recognised different business models possible, a range of deployment architectures can be imagined for U-space.

The main arguments are around the deployment of U-space services and the possibility to have distributed responsibility among several USSPs and then interoperability among Drone Traffic Management system. The trivial solution is the monolithic deployment of all system functions in a unique solution managed by a unique provider in a certain volume of airspace (e.g. Member State, City). Alternative deployment solutions envisage the possibility of delivering more instances of DTM systems to provide a subset of services and interoperate each other to ensure consistency; the resulting federated architecture foresees the orchestration of services provided by more than one supplier in the same portion of airspace.

Before addressing at high level the two deployment architecture options it is important:

- to address the principles that may drive the selection of an implementable solution.
- to analyse service-by-service what it is important to be performed centrally or possible federated, in terms of final responsibility of service providers.
- It is recommended to balance the complexity of having more Drone Traffic Management service providers in same geographical airspace volumes with the impact to safety, security, privacy and access and equity. E.g. In many case Member state responsibility or complexity in ensuring a distributed model of the service realisation may lead with the centralised approach for the service deployment.
- It is recommended to have a deployment architecture economically sustainable. E.g. In some countries the decision to compensate the costs of realisation of U-space supporting infrastructure may lead in the decision of the centralisation of some services and the competition of the market for other.
- It is important not confusing Drone Traffic Management system with Drone or Drone Operating Systems which may realise service to the operator consuming DTM services. Then it is not necessary to compete on the services related to provision of traffic management when it is provided the possibility to build added value services upon them (e.g. assistance services).

There are likely to be two types of services, those that, for a specific volume of airspace, can run in parallel and those that are likely to work best if unique, or requiring close synchronisation across instances if not unique. Further there are likely to be services that are of interest to the user that they are willing to fund and services that are mandated by the state (typically for safety or law enforcement) that shall be funded by some state means – e.g. a levy, the taxpayer.

The basic idea is that it is not possible to approach the discussion of federated vs monolithic architecture with U-space as a whole, but considering service by service.

This document does not push any position on what shall be centralised and what can be executed.

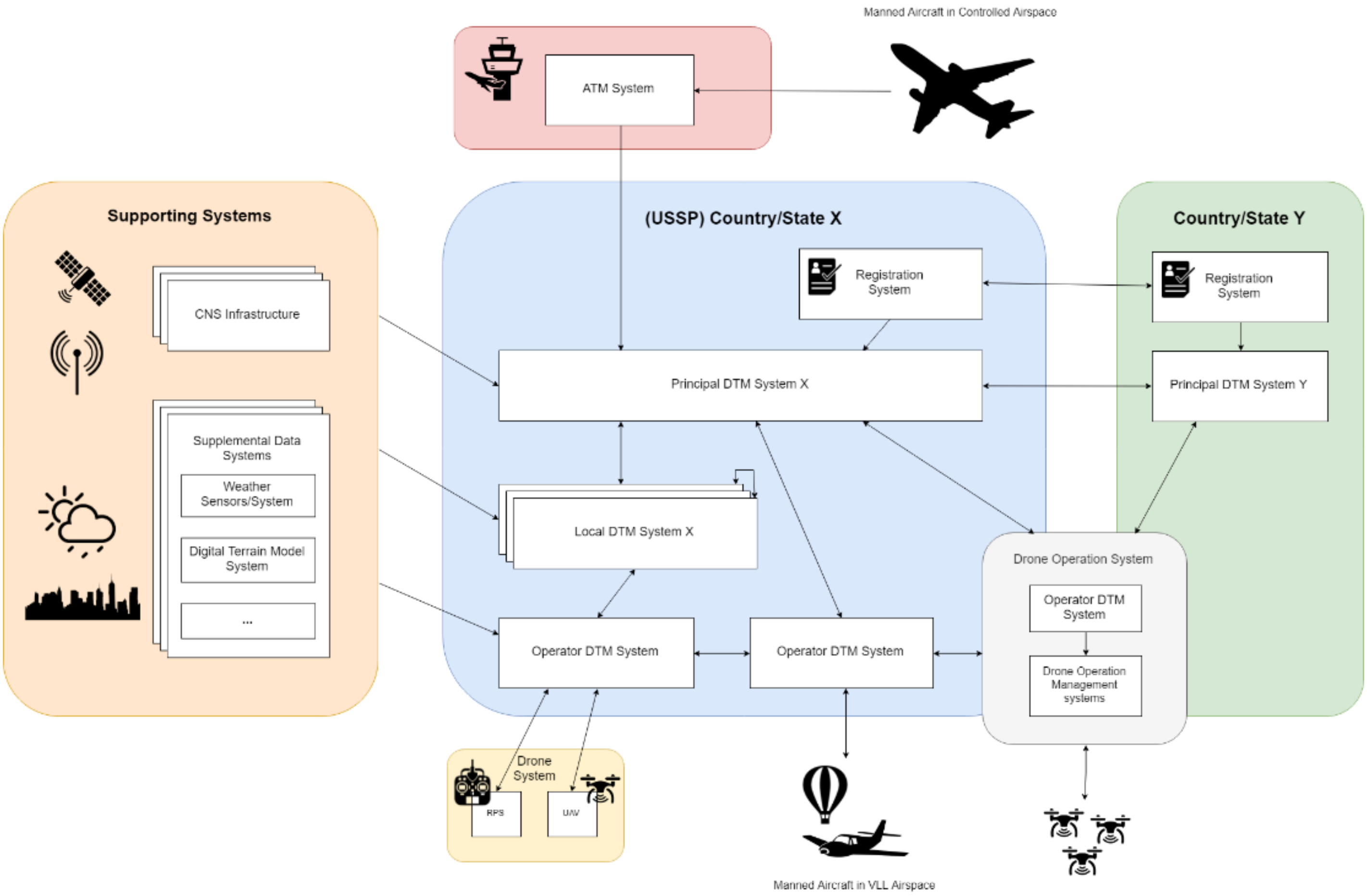


Figure 26 Deployment overview

The figure above aims providing an overview of possible interfaces among systems for both monolithic and federated options.

Validation and demonstration activities will provide evidences of these architecture options.

7.5.1 Federated

Base on the analysis performed, the architecture examples described in demonstration projects, and experts review, there is always a system which realise and provide a set of principal U-space services. It has been noted that the set of principal services and the responsibilities of the Principal USP system/USSP vary between the different alternative architectures.

Then, independently of the set of U-space services which will be centralised and then the architecture would have in any case a state-mandated core (i.e. Principal DTM system /USSP and where necessary supported by Local/Sub-regional DTM instances – in most of the case a terminal of this central system). The drone operators would then contract directly with this provider or with accredited service providers (i.e. Operator DTM system/ USSP) to consume U-space services.

7.5.2 Monolithic

The Monolithic deployment of traffic management services envisage a unique USSP.

This solution is based mainly on the fact that boundary between Principal and Operator USSPs is set enlarging the scope of the principal on all drone traffic management services (not envisaging indeed the interoperability among Operator USSPs to provide drone traffic management services in the same volume of airspace). It happens when:

- there is a national mandate to a specific provider,
- services to manage the traffic constituting the main set, and their interoperable implementation requires validation/demonstrations/standards which may delay their deployment.
- there are needs for compensation of costs to put in place required supporting infrastructure.
- There are need to put in place services as soon as possible, even before the publication of interoperability standards (quick wins/early deployments).

In this example of deployment, there are still possibilities for the open market (even if no competition on the drone traffic management service provision): Drone and Drone Operating systems can develop B2B with the unique USSP with same standards to integrate/consume traffic management services.

8 Reference

The following are referred to in the text.

[1] CORUS PMP

[2] CORUS ConOps intermediate version

[3] European Drones Outlook Study, Unlocking the value for Europe http://www.sesarju.eu/sites/default/files/documents/reports/European_Drones_Outlook_Study_2016.pdf

[4] EUROCONTROL RPAS ConOps. Version 4 https://www.eurocontrol.int/sites/default/files/publication/files/rpas-atm-cocept-of-operations-2017.pdf (An update is being prepared currently. The CORUS project expects to align itself with that update.)

[5] U-space Blueprint https://www.sesarju.eu/sites/default/files/documents/reports/U-space%20Blueprint.pdf

[6] European ATM Master Plan Drone roadmap, https://www.sesarju.eu/sites/default/files/documents/reports/European%20ATM%20Master%20Plan%20Drone%20roadmap.pdf

[7] ATM Lexicon https://ext.eurocontrol.int/lexicon/index.php/Main_Page

[8] NATO Architecture Framework V3 AC/322-D (2007)0048

[9] EATMA Community wiki: https://ost.eurocontrol.int/sites/eatmac

[10] EATMA Guidance Material, SESAR Extranet Programme Library

Beneficiary's logos

DFS Deutsche Flugsicherung	DLR
dgac DSNA	enav
EUROCONTROL	HEMAV
NATS	UNIFLY
UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH	