ORUS

U-space

Concept of Operations

Enhanced Overview

Founding Members

EUROPEAN UNION EUROCONTROL

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Enhanced Overview

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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.

What is a Concept of Operations?

A Concept of Operations (ConOps) is a document that describes the characteristics for a proposed system from a user's perspective. It gives qualitative and quantitative details of how the system should be used and how it should behave.

This ConOps describes how very low-level (VLL) airspace should be organised and what rules and regulations should be put in place to enable the safe integration of drones with other users of this airspace, and what U-space services should be available to help the drone user achieve this.

Following the principles laid out in this ConOps will enable drones to 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 rather than visuals.

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.

Unpiloted 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 150m/500ft above any obstacle within a radius of 150m/500ft, except with permission, or when taking off or landing. Over a populated area, it must not fly less than 300m/1000ft above the highest fixed object within 600m/2000ft 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

Training and passing a 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.

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	-	-	-	-	-	-	-

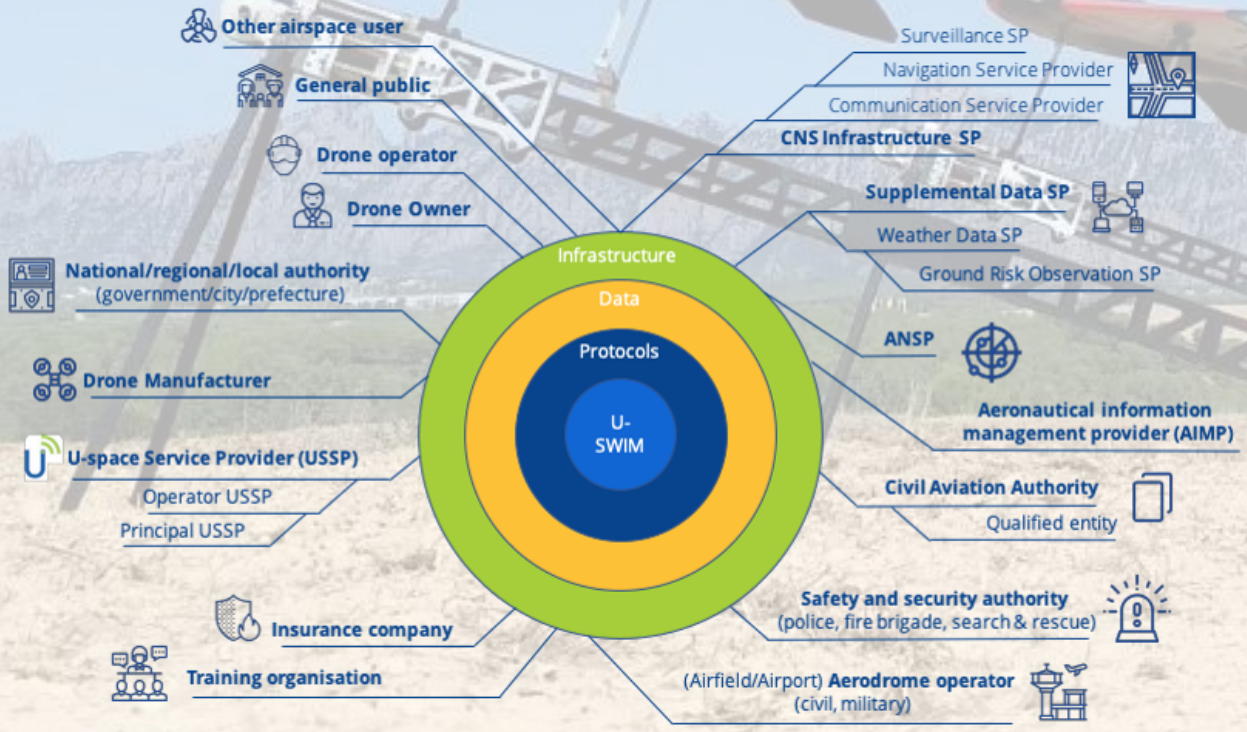
U-Space

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 (SP) 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.

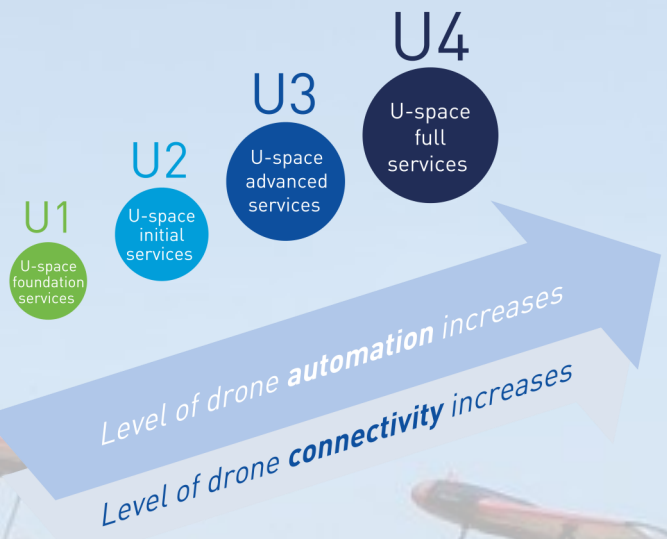
U-space is capable of ensuring the smooth operation of drones in all operating environments, and in all types of airspace, in particular but not limited to very low-level (VLL) airspace. It addresses the needs to support all types of missions and may concern all drone users and categories of drone.

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.



The delivery of U-space relies upon the following key principles:

- To ensure the safety of all airspace users operating in the U-space framework, as well as people on the ground.
- To provide a scalable, flexible and adaptable system that can respond to changes in demand, volume, technology, business models and applications, while managing the interface with manned aviation.
- To enable high-density operations with multiple automated drones under the supervision of fleet operators.
- To guarantee equitable and fair access to airspace for all users.
- To enable competitive and cost-effective service provision at all times, supporting the business models of drone operators.
- To minimise deployment and operating costs by building upon, as much as possible, existing aeronautical services and infrastructure, including GNSS, as well as those from other sectors such as mobile communication services.
- To accelerate deployment by adopting technologies and standards from other sectors where they meet the needs of U-space.
- To follow a risk-based and performance-driven approach when setting up appropriate requirements for safety, security (including cyber-security) and resilience (including failure mode management), while minimising environmental impact and respecting the privacy of citizens, including data protection.



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.

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 when available *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:

Operation		X	Y	Z
Drone	VLOS	Yes	Yes	Yes
	Follow-me	Yes	Only be undertaken with reasonable assessment of the risk involved.	
	Open	Yes	Yes, provided access requirements are met	
	Specific	Yes. However, the risk of unknown drone operations must be considered, evaluated and mitigated appropriately.	Yes	Yes
	Certified		Yes	Yes
	BVLOS		Yes	Yes
	Automated		As for X	Yes in Zu
Crewed	VFR		Yes, but the use of U-space services by VFR flights is strongly recommended	Yes. However, type Za is controlled airspace. Crewed flights in Za will need to behave as such.
	IFR	No	No	

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.

Restricted 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.

Controlled areas all exist inside class A to E airspace and cannot contain types X, Y or Z, except Za. 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 dangerous areas, a system of privileges will be implemented for authorised drones. U-space 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

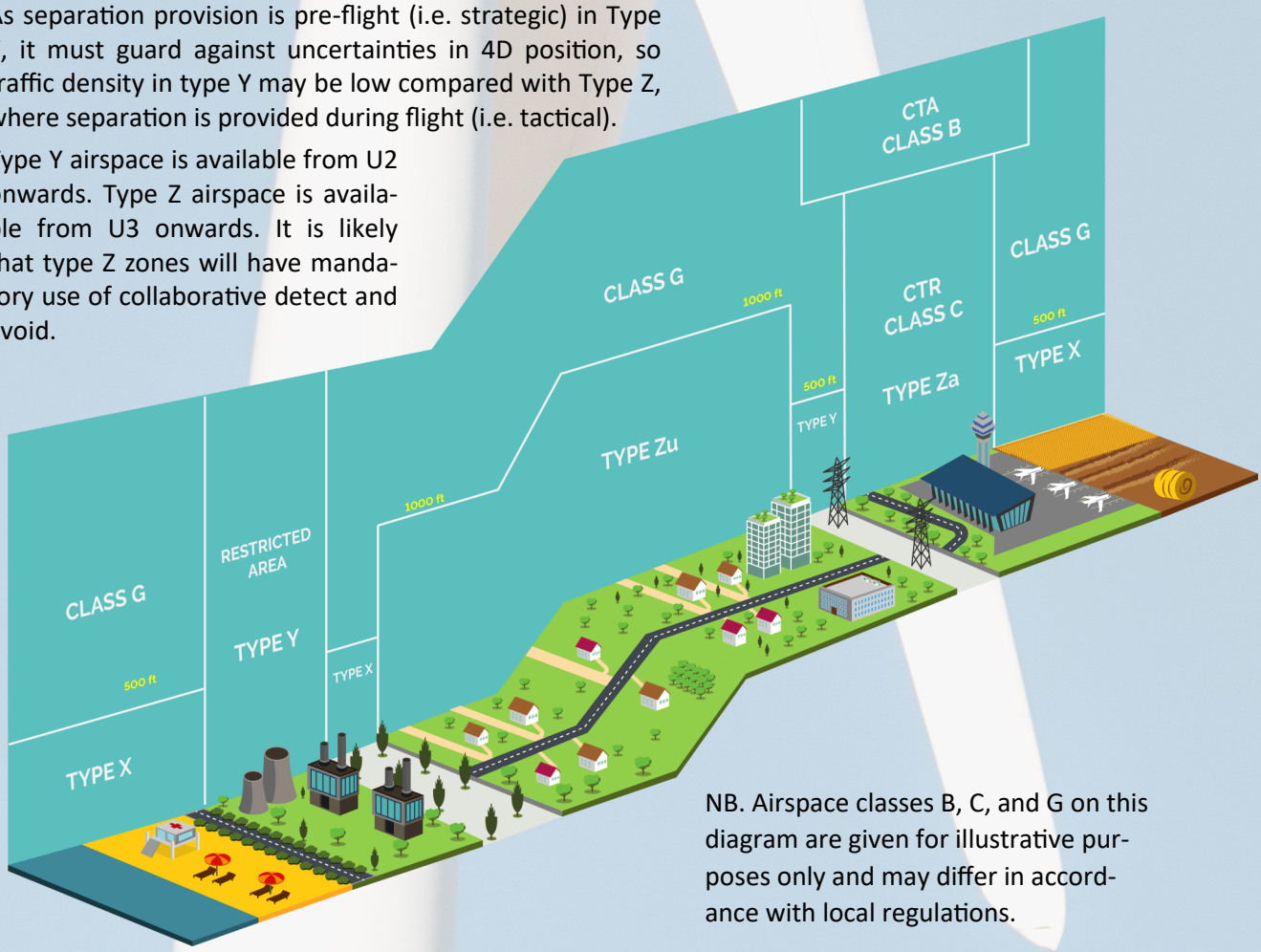
"Specific" operations can occur in airspace types X, Y and Z (and in ICAO classes A-G with prior coordination and depending on the local regulation and approval). Some type Y or Z airspaces may mandate the use of "Certified" drones for ground risk mitigation or similar reasons.

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.



NB. Airspace classes B, C, and G on this diagram are given for illustrative purposes only and may differ in accordance with local regulations.

Mandatory requirements for use		Type Y	Type Z
UAS Flights	VLOS or BVLOS	Y	Y
	Aautomated	N	Y
U-Space services	Operation declaration	Y	Y
	Strategic conflict resolution	Y	Y
	Position reporting	When available	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 type Z and where available in type Y.
- 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.

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/	Operation plan processing	Risk Analysis Assistance	Dynamic Capacity Management
Conflict Management		Strategic Conflict Resolution			Tactical Conflict Resolution
Emergency Management		Emergency Management	Incident / Accident reporting		
Monitoring	Monitoring	Traffic Information	Navigation infrastructure monitoring	Communication infrastructure monitoring	Digital Logbook Legal Recording
Environment	Weather Information	Geospatial information Population density map	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
Weather information	Mandated	Mandated	Mandated
Position report submission sub-service	Recommended	Mandated*	Mandated
Tracking	Optional	Mandated*	Mandated
Drone operation plan processing	Optional	Mandated	Mandated
Emergency management	Optional*	Mandated*	Mandated
Monitoring	Optional	Mandated*	Mandated
Procedural interface with ATC	Optional+	Mandated+	Mandated
Strategic conflict resolution	No	Mandated	Mandated
Legal recording	Optional+	Mandated*	Mandated
Digital logbook	Optional+	Mandated*	Mandated
Traffic information	Optional	Mandated	Offered
Geospatial information service	Optional	Optional	Mandated*
Population density map	Optional	Optional	Mandated*
Electromagnetic interference information	Optional	Optional	Mandated*
Navigation coverage information	Optional	Optional	Mandated*
Communication coverage information	Optional	Optional	Mandated*
Collaborative interface with ATC	Optional+	Mandated+	Mandated
Dynamic capacity management	No	Mandated*	Mandated
Tactical conflict resolution	No	No	Mandated
U-space Phase	U1	U2	U3

+ when needed * where available

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.
Operation plan preparation/ optimisation	Provides assistance to the operator in filing of a operation plan. This service functions as the inerface between the drone operator and the operation plan processing service
Operation plan processing	A safety-critical, access-controlled service that manages live operation plans submitted via the operation 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 operation 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 similar citizen-access service is possible.

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.

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, depending on the flight rules that the aircraft adhere to and the class of airspace. In uncontrolled airspace, and for aircraft in controlled airspace for which separation is not provided by ATC, 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 operation 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 for the open category and in the standard scenario for the specific category. 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 300m/1000ft over urban areas could also be envisaged, where justified.

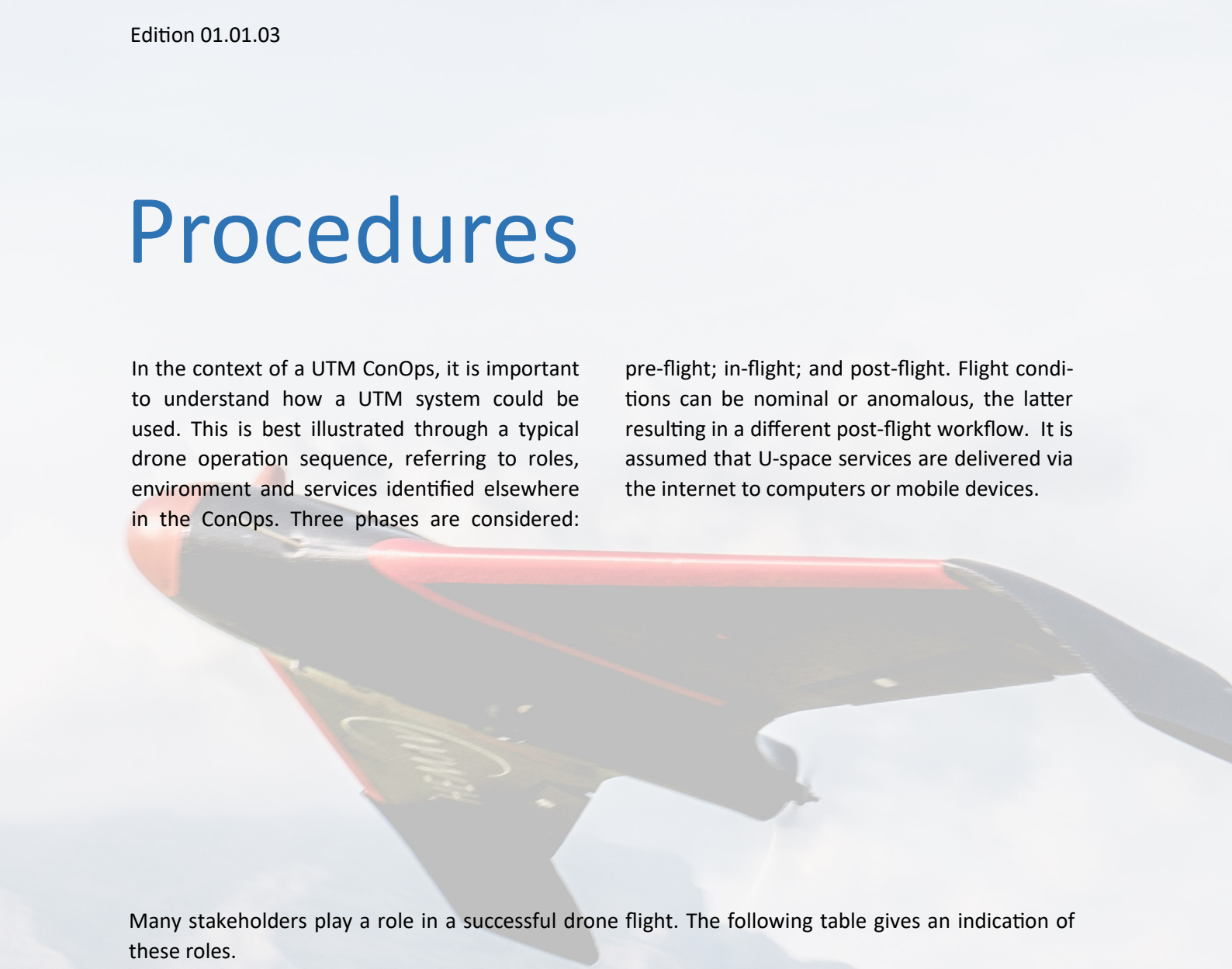
Geo-fences

Geo-fences are a new mechanism that provides 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 Employer of pilots and other staff for drone operations
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

Initial 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 (unless flying in type X volumes)
-

Strategic 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)

Tactical in-flight pilot procedures

- 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

Post-flight procedures

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

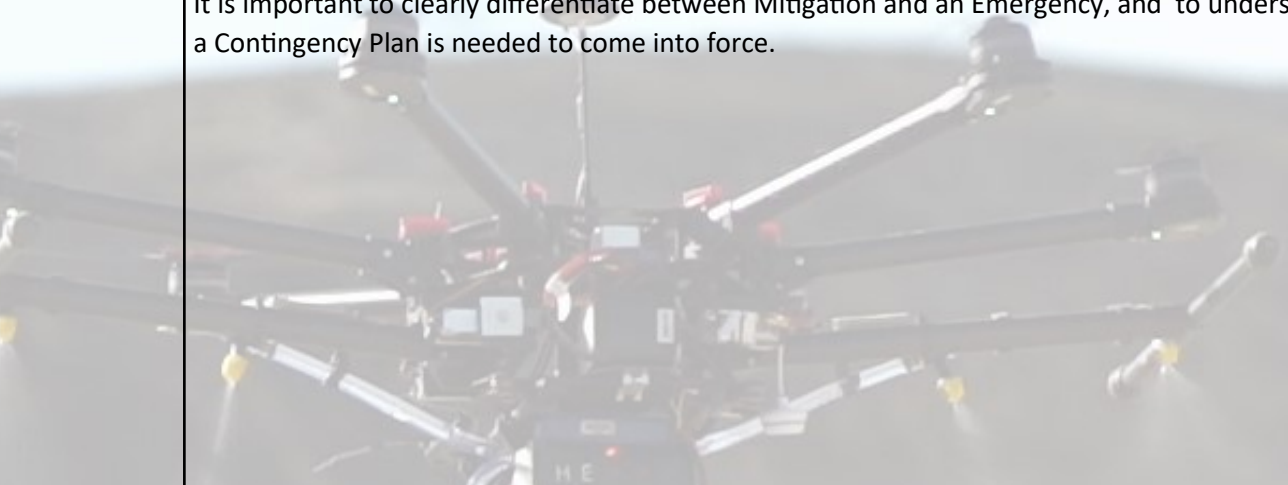
If the flight should experience any irregularities, incidents or accidents, these must be noted and an ad-hoc analysis made. The corrective action or mission modification to be taken immediately should be decided upon and taken. Such irregularities should be fully analysed and reported as part of the 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.

U-space supplies an Emergency management Service that provides assistance to a drone pilot experiencing an emergency with their drone, and communicates emerging information to interested parties

Contingency Plan:

Plan B. A contingency plan describes procedures to follow in a possible incident or emergency. 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:

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