U-space ConOps (edition 3.10)

Deliverable ID:	D4.1
Dissemination Level:	Pu
Project Acronym:	CORUS-XUAM
Grant:	101017682
Call:	SESAR-VLD2-03-2020
Topic:	U-space capabilities and services to enable Urban Air Mobility
Consortium Coordinator:	EUROCONTROL
Edition Date:	13 July 2022
Edition:	01.00.00
Template Edition:	02.00.03

Founding Members

EUROPEAN UNION EUROCONTROL

SESAR JOINT UNDERTAKING

CORUS-XUAM

CORUS-XUAM

This Concept of Operations is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 101017682 under European Union's Horizon 2020 research and innovation programme.

Abstract

U-space is Europe's traffic management system for Uncrewed Aerial Systems, also called drones. The CORUS project, 2017 to 2019, produced three editions of the U-space Concept of Operations or ConOps. The third [1] was produced in October 2019. The ConOps explains how U-space works from a user's point of view. This edition of the ConOps is named 3.10 and differs for three reasons. This edition attempts to meet the needs of Urban Air Mobility, including both goods and passenger air transport in urban areas. The European Union has passed various regulations relating to U-space which have to be taken into account. Research projects have completed details missing in the previous editions which are incorporated.

Meeting the needs of UAM focuses on processes at the vertiport, airspace structure and flight rules, particularly as initial passenger carrying operations with "electric vertical take-off and landing" (EVTOL) vehicles are expected to have a pilot on board.

The European Union regulations, primarily 2021/664, 665 and 666 define U-space in terms of seven services, six functional plus "common information." This ConOps supports that view.

Some research projects bring more precise descriptions of services or processes already mentioned, for example dynamic capacity balancing (DACUS), and some projects bring new services like altitude conversion services (ICARUS).

This "3.10" edition of the U-space ConOps aims to be more succinct than previous editions.

This version of the ConOps is available for comment and those comments will feed the production of Edition 4 of the ConOps to be released in 2023.

Table of Contents

List of Tables

List of Figures

1 Introduction

The opinions expressed herein reflect the author's view only. Under no circumstances shall the SESAR Joint Undertaking be responsible for any use that may be made of the information contained herein.

1.1 What is a ConOps

A concept of operations (abbreviated CONOPS, or ConOps) is a document describing the characteristics of a proposed system from the viewpoint of an individual who will use that system. It is used to communicate the quantitative and qualitative system characteristics to all stakeholders.

This ConOps tries to answer the basic question "how does U-space work" and in doing so provides a common basis for discussion of details. The ConOps provides terminology and a general model of the overall system of U-space. Ideally the ConOps expresses a set of ideas and assumptions that the reader absorbs, applies and is not conscious of. Until that is achieved this document aims to be a reference manual for, or an encyclopaedia of U-space.

1.2 Why this is the U-space Concept of Operations edition 3.10

The CORUS project ran from September 2017 to November 2019 and produced three editions of the U-space ConOps in an iterative process involving collaboration with a large number of stakeholders including other research projects. (The CORUS project received funding from the SESAR Joint Undertaking under grant agreement No 763551 under European Union's Horizon 2020 research and innovation programme.) The CORUS project seems to have achieved its goal. Since the third edition of the U-space ConOps [1] was published in October 2019, it has been downloaded more than 3000 times. Discussions in the stakeholder community now are very different from those in 2019, collectively we have moved on.

This edition of the U-space ConOps is numbered 3.10 and builds on the 3rd edition, preparing the release of a 4th Edition. It is needed as the third edition is rapidly becoming out of date. Specifically, this edition aims to address the following.

- The presentation should be concise and easy to read. The 3rd edition [1] is very long and contains a great deal of discussion.
- Several European regulations have been published that need to be fully embraced in the ConOps.
- The specific aim of this project, which is to study how the needs of Urban Air Mobility impact U-space.
- Many developments, research & demonstration projects have occurred, standards and legislation have been written that have moved the state of the art, rendering the third edition of the U-space ConOps less useful.

1.3 What is in the scope of this ConOps

1.3.1 U-space

U-space is based on a set of services [2] [8]. These services are provided from the ground (generally) and concern safety, security and efficient flight. This ConOps describes these services, how they are used and the environment in which they are used.

There are many other closely related services that may be supplied to U-space stakeholders, for business or other reasons, which are not considered to be in the scope of this ConOps. They may be mentioned in passing.

1.3.2 Urban Air Mobility

Urban Air Mobility in this document is defined as air operations which are:

- above urban areas, at least for part of the flight,
- in 'U-space airspace,' – see Section 2
- performed by a mix of traffic which includes aircraft,
    - incapable of flying IFR or VFR,
    - with very limited range,
- in traffic dense enough that tactical separation is needed to ensure safe operations.

The operations include but are not limited to air-taxi operations with remotely piloted electrically powered vehicles. (Initial operations may have pilot on board.) Urban Air Mobility includes any flights meeting the conditions above.

That the operations are above urban areas implies that there are limited opportunities for safe emergency landing which impacts the planning of operations.

The increased risk of Urban Air Mobility compared to other U-space operations, both in terms of ground risk and in the air risk, will influence the performance requirements on the operations and procedures, but may not impact the procedures themselves.

1.3.3 In scope

- Management of remotely piloted aviation of any level of autonomy
- Management of Pilot-on-board aviation
- Use of U-space in flight scenarios by different stakeholders
- Ground infrastructure such as Vertiports
- Contingency scenarios
- Safety
- Security including cyber-security
- Risk assessment and mitigation
- Social acceptability
- Flight rules
- Traffic management

- Optimisation of flight or traffic or airspace use according to key performance areas

1.3.4 Not in scope

- Whether or not there should be UAS flight and UAS applications[1]
- Business viability of drone uses, or of U-space service provision
- The environmental impact of UAS flight.
- Aircraft design, aircraft performance, aircraft certification
- Avionics, on board systems, detect and avoid, remote piloting stations
- Batteries, recharging, fuel cells, hydrogen production and storage
- Specific technologies (as far as possible)
- C2 links, navigation systems, surveillance technologies
- Human performance, HMI design
- Licencing and certification of U-space service providers or their suppliers

1.4 Expected evolution of U-space

At the time of writing, the number of UAS flights on an average day in Europe is small. The need for what is described in this document may not be apparent. It is anticipated that the number of UAS flights will rise and that urban air mobility will become more common. To help simplify discussion of the problems this rise will cause and the solutions that U-space should bring, this project groups the expected traffic evolution into five eras, considering the following assumptions.

1.4.1 Assumptions:

- While passenger carrying operations have higher risk than non-passenger carrying operations, the procedures they use will be the same. Hence the concept of operations for U-space can and should be extended to cover "Urban Air Mobility." It may be that some service providers are considered qualified to provide services to passenger carrying operations and others not, but the operational processes they are involved in will be the same for both.
- The services won't all be available at the same time, and the most complicated will arrive last (e.g., tactical conflict resolution).
- Technologies improvements and evolutions will allow UAS to fly more and more autonomously.
- Required equipment costs will decrease with the time so that the cost for a manned aircraft shall be increasingly acceptable. Hence it is not a question of whether there will be passenger operations, it is a question of when.
- As time progresses the proportion of operations that are unmanned grows to exceed manned operations.
- U-space airspace will become more common with the different volume types eventually being recognized as ICAO airspace classes.
- UAM infrastructure will be built incrementally to support operational needs.

[1] This document should be read as "if there is to be UAS flight then it should be as described here."

- Airspace design will change to accommodate all operations.
- There is a balance between commercial secrecy and providing a common picture of operations. As this ConOps is written that balance is that small UAS operators would prefer that their operations are not generally known. The balance may shift.
- U-space service provision will be a competitive commercial activity. There will be multiple simultaneous service providers and they will have to cooperate. That said, this ConOps should be applicable to situations with one or more service providers.

The "U levels" or "U blocks" as defined in the U-space Blueprint [2] are assumed, as shown in Figure 1.

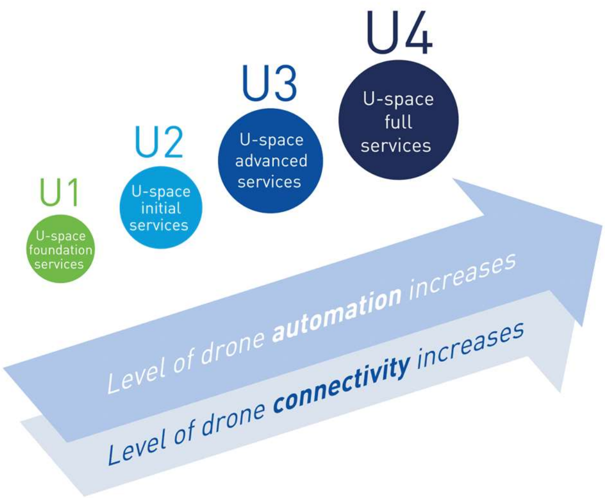


Figure 1: U-space levels, from U-space Blueprint

Airbus UTM Blueprint [20] proposes a timeframe of the automation level. CORUS XUAM would like to propose a vision with a kind of calendar for U-space implementation. The topics that need to be considered are the following.

- Availability of the U-space services
- Availability of the required technologies (CNS) and ground infrastructure for drone operations
- Availability of the "drones effective enough" to perform specific operations (e.g., carry heavy payload, long haul trip)
- Evolution of the airspace design and structure
- Interactions with manned aviation in controlled and uncontrolled airspace
- Rules of the air

In the following five subsections, the different considered implementation phases are outlined.

1.4.2 Before 2023: the foundations of U-space

States are setting up registries and defining geographic areas in accordance with the "Drone regulations" [4], [5], [6] & [7], but drones fly without U-space services. Manual coordination with and authorizations from the involved authorities are usually required. The current procedures make VLOS flights possible, though sometimes requiring some effort. BVLOS flights are limited, time consuming and expensive to set up.

1.4.3 Initial U-space implementation (2023-2030)

The "U-space regulations" [8], [9], [10] & [11] come into force on the 26th of January 2023. In line with these, a limited number of services are available, providing a digital assistance to the authorities in charge of authorizing the operations, and a digital assistance to the operators to plan and declare their operations. When required, airspace structures are defined, temporarily or permanently, to allow drone operations (e.g., corridors for point-to-point goods or passenger carriage).

- Few U-space airspaces are defined:
  - In controlled airspace, these airspace structures are temporarily activated on request, by the USSP (U-space Service Provider) to the ATC.
  - In uncontrolled airspace, permanent structures boundaries are published in the AIP to manned aviation.
  - Temporarily structures, boundaries and activation slots are also published in the AIP to manned aviation.
- In U-space airspace conflict resolution is strategic, that is, the plans are free of conflicts.
- Within U-space airspace, BVLOS operations are significantly easier to organise than has been possible before.
- Traffic densities are expected to be relatively low. In the initial period flights are expected to be widely spaced.

The majority of surveillance is expected to be dependent – the UAS report the position of the aircraft. Initial operations are expected to occur before the performance of U-space surveillance is well understood. Plans will initially be subject to wide separations in time and/or distance.

The U-space regulations [8], [9], [10] have chosen that strategic conflict resolutions will prioritise "first to file." This ConOps expects that another prioritisation scheme will be adopted quite soon.

As experience grows, U-space and UAS evolve rapidly. Standards and best practice will emerge in a number of fields. It is expected that during this period the level of performance achievable in communications, navigation and surveillance will improve. Confidence in the CNS performance will lead to the safe provision of U-space tactical services.

1.4.4 General U-space (2030-2040)

In view of rising UAS traffic and as experience grows, many U-space airspace volumes have been defined, in what was previously controlled or uncontrolled airspace. In uncontrolled airspace, as most drone operations are performed in the VLL, U-space airspace is defined from ground to 500 feet AGL. For some UAS operations which require to fly higher, such as inter-cities passengers or cargo transportation, corridors are in place and published in the AIP.

In more densely occupied U-space airspaces tactical conflict resolution is routinely offered. UAS traffic in ATC controlled areas is routinely controlled by ATC through U-space; that is using U-space means of CNS. In order to avoid exceeding the capabilities of the tactical conflict resolution service, a dynamic capacity management service will be needed to match the capacity and traffic demand.

Some U-space airspaces with tactical services will accommodate remotely piloted flight according to a new flight rule, UFR (see Section 4)

1.4.5 Advanced U-space (2035-2045)

UAS operations are now very common, as are U-space volumes. U-space services and volumes are increasingly used by crewed aircraft. U-space volumes are commonly defined above 500ft AGL, up to a few thousand feet as traffic necessitates. Tactical U-space services are in common use as is UFR.

1.4.6 Full U-space Integration

U4 is deployed. The vast majority of professional aerial operations are un-crewed. Un-crewed and crewed operations use U-space services and fly UFR. U-space airspace is defined widely. Un-crewed aircraft are capable to autonomously avoid any other aircraft, even if remote pilot of VLOS operations remains capable to avoid collision manually.

The timing of Full U-space Integration is hard to gauge. While U-space may have followed the trajectory mentioned above, full integration requires that the majority of aircraft used for professional purposes are uncrewed. If that requires new aircraft then the time taken may be a function of the useful life of the final generation of crewed aircraft. Currently aircraft are expected to have a working life of 25 to 30 years on average, see [33] and [34].

1.5 How to read this ConOps

Sections 2, 3 and 4 are a reference manual for the elements of U-space. There is no correct order to read them as (unfortunately) understanding any section requires some knowledge of the others. These sections present the bare minimum of information. Note that Sections 2, 3 and 4 are highly 'compartmentalised' and contain many levels of sub-heading to aid navigation.

Section 5 contains examples of how the elements in Sections 2, 3 and 4 are combined in operations. The needs of different users are addressed in different subsections

Sections 6, 7, 8 and 9 provide the usage guides for what is presented in Sections 2, 3 and 4.

Section 10 gives references, explains terms and expands acronyms and abbreviations.

The appendices provide more details on some topics.

2 Operating environment

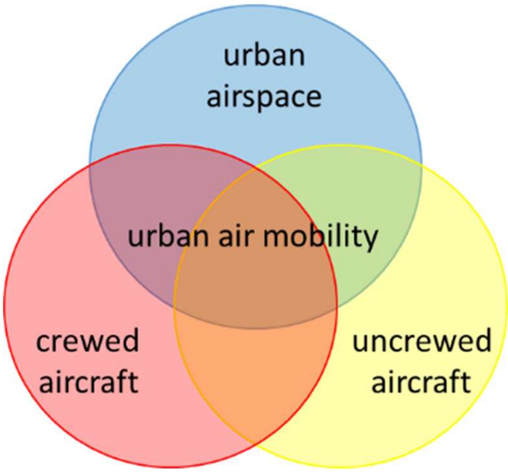
This chapter aims to give the context(s) in which the U-space services are used. Highlighting a significant difference with the previous version of the ConOps, [1], Urban Air Mobility is explained. The section then explains the lifecycle of a flight, the nature of the airspace and the ground infrastructure of relevance to U-space.

2.1 Urban Air Mobility

"Urban Air Mobility" or UAM can be parsed thus:

- Mobility: someone or something is made able to move
- Air: above the ground
- Urban: over/near a town or city

Urban mobility refers to commonly used transport means such as train, bus, car/taxi, bicycle, walking or boat. "Air" in UAM distinguishes mobility involving aircraft. The aircraft may have a crew on board or might not. The following diagram shows this relationship.



As so much urban mobility involves people going to/from work, the OECD definition of "functional urban area" is used, see [22], "A functional urban area consists of a city and its commuting zone. Functional urban areas therefore consist of a densely inhabited city and a less densely populated commuting zone whose labour market is highly integrated with the city."

Urban air mobility flights by crewed aircraft are likely to involve current Air Traffic Control providing services via radio. The expectation is that U-Space services will increasingly be used.

Figure 2 Urban Air Mobility Venn diagram

2.2 Phases of flight

The following phases are identified. Flight is highlighted to emphasise how much is pre-flight. Flight is further broken down in Section 2.2.4

Phase	Typical activities
Strategic – long term	Capacity planning, provision of services, airspace design, acquisition of aircraft, obtaining an operator's licence
Strategic – pre-flight	Developing a plan for a flight, Specific Operational Risk Assessment, seeking permission to enter airspace / overfly (if needed), selecting & configuring vehicle & crew, contingency planning.

Pre-tactical	Demand capacity balancing and pre-flight de-confliction
Tactical	Activation, **flight**, termination
Post-flight	Logging, reporting (as required), maintenance, performance assessment.

Table 1: Phases of flight

The descriptions that follow focus on activities involving U-space services. The plan for an operation in U-space is referred to as a U-plan. This diagram gives an overview of the life of a typical U-plan.

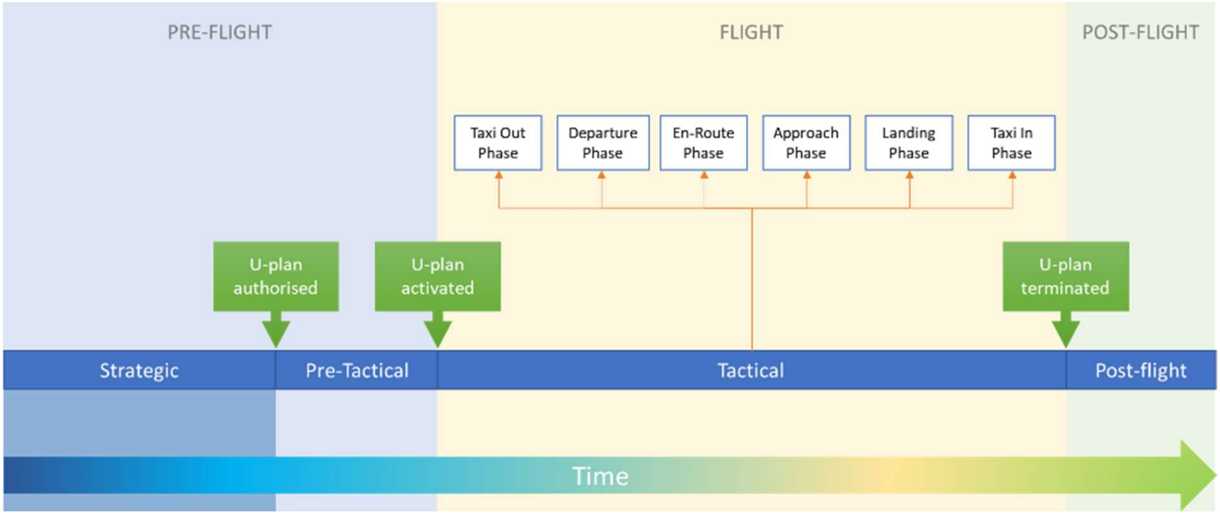


Figure 3: Timeline schema of the lifecycle of a U-plan

2.2.1 Strategic – long term

Many activities must take place to prepare for flight. These relate to the operator of an aircraft, the aircraft and to the operating environment.

2.2.1.1 Airspace design & redesign

The competent authority, see 8.3, establishes the airspace structure including which airspaces require U-space services and any technical constraints associated with them, in view of the expected risks, in line with EU regulation 2021/664 – see [8][11]. These technical constraints will include factors that set the capacity of the airspace. The competent authority is also required to review these requirements periodically in function of the expected UAS traffic.

2.2.1.2 UAS operator registration

The UAS operator shall be registered according to EU regulation 2019/947 – see [4][6]. In some situations the aircraft may also need to be registered.

2.2.1.3 UAS (type) approval

Depending on the flight category or risk level UAS may need a certificate of airworthiness, or “design approval.” Obtaining either is generally considered outside the scope of an individual flight and hence in the “long term” region of strategic.

2.2.2 Strategic – pre-flight

During the strategic pre-flight phase, the flight goes from being an idea to a concrete plan for one or more specific instances of flight. The process is likely to be iterative and balance business needs (or the equivalent for a leisure flight) with constraints of regulations and cost.

2.2.2.1 Operational category

The operational category of the flight may lead to approval being needed. The regulations embody requirements of safety and public acceptability.

EU regulation 2019/947 – see [4][6] – describes different circumstances in which a flight may occur, summarised below. Operations are categorised according to risk by combining aspects of the aircraft such as mass with how, where & when it is flown.

- Open category operations must meet various criteria that all limit risk to people and property. A flight not compatible with Open might be possible as Specific or Certified.
- There are different ways a Specific category flight can be permitted; by following an approved specific operational risk assessment (SORA), by conforming to a standard scenario or as a result of the operator holding an LUC (Light UAS operator's Certificate), or by following a process defined in an accepted alternate means of compliance.
- Flights that do not meet the Open or Specific category conditions may be possible as Certified category.

The determination of the operation category and then obtaining any necessary approval is a pre-flight process that has some support from U-space. During this process the UAS operator may refine the operation plan iteratively supported by U-space services, for example by routing the flight through areas of lower "ground risk" and so on. The relevant services are:

- Geo-awareness, see Section 3.4
- Risk Analysis Assistance, see Section 3.5.1.5

Specific Operational Risk Assessment is described in the SORA package of documents published by JARUS [21]. The process aids the identification of risks associated with the flight and their mitigation, including by use of U-space services. SORA approval may be for one flight or for a set of flights that meet the same criteria. It is expected that U-space service providers will supply services and tools that help the UAS operator optimise operation plans, including with the aim of conducting and optimising SORA. Edition 3 of the ConOps mentioned the "Operation plan preparation / optimisation" service, with a vague description. While such services are assumed to exist, they are not described in this edition of the ConOps.

2.2.2.2 Flight priority

EU regulation 2021/664 [8] article 10, paragraph 8 defines two levels of priority for flights which we might refer to as Normal and Priority. It states:

> *When processing UAS flight authorisation requests, the U-space service providers shall give priority to UAS conducting special operations as referred to in Article 4 of Implementing Regulation (EU) No 923/2012.*

EU regulation 2012/923 is SERA [12], the Standard European Rules of the Air. SERA Article 4 lists special operations that may be granted exemptions:

(a) police and customs missions;

(b) traffic surveillance and pursuit missions;

(c) environmental control missions conducted by, or on behalf of public authorities;

(d) search and rescue;

(e) medical flights;

(f) evacuations;

(g) fire fighting;

(h) exemptions required to ensure the security of flights by heads of State, Ministers and comparable State functionaries.

2.2.2.3 Vertiport constraints

An operation plan for a flight may include taking off from or landing at a vertiport. That ground movement may be constrained by a number of factors that must be taken into account in the operation plan.

- There must be an agreement that the flight can use the vertiport. This has different aspects. The aircraft should be compatible with the vertiport, which could include flight characteristics, size, noise, charging or refuelling requirements, ground handling needs,… As there are likely to be fees for using the vertiport, the vertiport operator may require some contractual arrangements to be set up before the aircraft operator can plan operations. (Or not, a vertiport may be open to all.) The net result is that the flight planning may be limited to a subset of the total number of vertiports.
- A vertiport is likely to have a limited number of FATO (Final Approach and Take-Off areas.) The vertiport operator is likely to be optimising the use of the vertiport and may constrain the time slot available for take-off or landing for any flight. Hence the operation planning will have to fit into these time slots.

There are (at least) three possible approaches to including the vertiport in the strategic phase of operation planning.

1. The vertiport is "mostly available" and in terms of deconfliction it can be treated like airspace; it is a resource at which there may be a conflict between operations. The allocation of the vertiport as a resource can be achieved in the same way as flights are strategically deconflicted.
2. The vertiport is "busy" and has its own planning process which imposes time-slot constraints on the take-off and landing. These time slots balance the need for vertiport efficiency while allowing enough margin that strategic uncertainties can be accommodated. Strategic operation planning can usually respect these time slots, hence vertiport planning and operation planning are loosely coupled.
3. The vertiport is "extremely busy" and is the most constraining resource of the entire network. Hence time slots are as brief as operations allow and all aspects of operation planning are in function of these slots. Operation planning cannot be decoupled from vertiport planning in case the needs of in-flight strategic deconfliction trigger a change to

vertiport planning. This model can be dealt with in two ways: as a static construction or by dynamically updating the planning continuously.

The three approaches are touched on below.

2.2.2.4 U-plan optimisation & authorisation

It is assumed that during the strategic phase the U-plan is created including any necessary permissions being obtained. The closing of the strategic phase is when the U-plan is filed. In 2021/664 terms this is the “flight authorisation request.” Filing the plan makes use of the Flight Authorisation service , see 3.5.2. The filed U-plan might be authorised or rejected. In case the U-plan is rejected, an explanation will be given and there may be a suggestion for how to construct a valid U-plan similar to that which was rejected. Following rejection, the UAS operator might refile a modified U-plan which addresses the reason for rejection. Successive filings may form part of the iterative process of planning.

The strategic phase ends when the U-plan is authorised.

Authorisation logic depends on the era. In the Initial U-space implementation (2023-2030) era, the U-plan is only authorised if it is free of conflict with other U-plans of the same or higher priority. In the later eras, it is likely that strategic conflict resolution cannot be completed at the time of filing, hence authorisation might not indicate an absence of conflicts. Such conflicts would be resolved in the pre-tactical phase, as is explained below.

2.2.3 Pre-tactical

Once the U-plan has been authorised the pre-tactical phase begins. The pre-tactical phase ends with activation of the U-plan, which triggers the start of the tactical phase.

During the pre-tactical phase the U-plan may have its authorisation removed or a warning may be issued, for any of three reasons:

1 Due to a conflict with another U-plan
2 Due to traffic demand exceeding airspace capacity
3 Due to a change in the airspace structure

Each is explained below. Each can occur at any moment. The logic depends on the operating environment and the prioritisation scheme in conflict resolution.

2.2.3.1 The pre-tactical phase during the Initial U-space implementation (2023-2030)

The U-space regulations [8], [9], [10], [11] refer to a flight authorisation request which is considered to be equivalent to a U-plan. The regulations require that a U-plan can only be authorised if it is free of conflicts and that U-plans are prioritised by filing time. Hence the filing of a new U-plan in conflict with an already approved U-plan of the same priority leads to that new U-plan being rejected and the already authorised U-plan not being impacted. However, if a new U-plan of higher priority is filed and is in conflict with any authorised U-plan(s), that/those U-plans have their authorisation withdrawn. As the U-space regulations do not describe a change process, the lower priority U-plan is in effect rejected.

The U-space regulations [8], [9], [10] & [11] describe an environment without demand-capacity balancing, hence the second reason for pre-tactical permission removal, above, does not apply.

U-space regulation 2021/664 Annex iv [8] proposes a "flight authorisation request" format which lacks any means to indicate that a flight has permission to enter any airspace. For this reason, any airspace boundary crossing can only result in a warning. Hence changes that result in an already approved operation plan crossing an airspace boundary where none was before can only result in a warning to the UAS operator.

2.2.3.2 Conflict resolution & dynamic capacity management & RTTA

In eras after that described in 2.2.3.1, there is expected to be dynamic capacity management and the following model is expected to apply. The details are currently the subject of research [29] and may change.

2.2.3.2.1 Reasonable Time To Act

It is assumed that U-plans will be filed at different times in advance of activation, depending on the business process of the UAS operator. Some UAS operators would like to file their U-plans very shortly before activation.

It is also expected that U-plans will be subject to revision to meet the needs of the UAS operator. These changes can also appear at any time before activation.

Hence any process that is going to impact plans in order to balance demand and capacity will only have a "complete" picture of the demand very close to activation. Whatever the balancing process is, the impact it has (for example delaying activation, hence take-off) needs to be absorbed by the UAS operator. There may be operators whose businesses cannot accommodate impacts on their U-plans very shortly before activation.

Hence a compromise is reached. An agreed time is used as the moment to determine what is the demand and which if any U-plans are impacted if the demand exceeds the capacity. This agreed time is the "reasonable time to act," (RTTA.) It is an agreed amount of time before the activation.

RTTA might be 5 minutes, or perhaps 1 minute, or even more or less. It may be that in different airspaces different RTTA are used. The principle remains the same.

2.2.3.2.2 Demand Capacity Balancing and RTTA

As explained above at RTTA there should be an acceptably complete picture of the traffic, hence the balance can be made between demand and capacity. The description that follows may be subject to refinement as it is tested experimentally.

The process of DCB with RTTA proceeds continuously but is best understood in terms of four cohorts of U-plans. Those which have passed RTTA, those at RTTA, those not yet at RTTA and "late filers", U-plans that are either filed or changed after RTTA.

U-plans that have passed RTTA are "frozen" and no longer subject to change. They form part of the demand picture but cannot be impacted in order to match that demand to the capacity.

U-plans that are "at RTTA", whatever that means, form part of the demand picture. They are fitted into the available capacity and impacted if necessary. In this process they "freeze" and the impacts are revealed to the operators. The DCB process acts on the "pool" of U-plans at RTTA and will optimise for some metric, for example fewest flights impacted, minimum total impact (minutes of delay) or whatever is agreed.

U-plans that are not yet at RTTA form part of the demand picture. They are tentatively fitted into the available capacity but may be subject to revised impacts later.

Late filers are added to the frozen set as well as can be achieved after the "at RTTA" cohort has been optimally served.

There may be sudden changes in capacity, for example the closure of an airspace or vertiport, that impact U-plans that are past RTTA. It is expected that this situation is infrequent.

2.2.3.2.3 Applying RTTA to Strategic Conflict Resolution

In the absence of schemes like auctions, applying RTTA to strategic conflict resolution can avoid the systematic disadvantage imposed by "first to file" prioritisation on businesses that cannot file far in advance such as on-demand delivery or air-taxis. The scheme is similar to that for DCB

- Until the RTTA a U-plan is not deconflicted. It is counted as part of the expected traffic but not acted upon.
- During the period a flight is considered to be at RTTA, the flight is subject to a conflict resolution process and subject to measures to balance demand and capacity. These processes do not change flights which have passed RTTA, and for those flights at RTTA, seek to find an optimal deconfliction. It is at this time that the flight authorisation may be withdrawn and the operator may have to file a modified plan.
- After the required time to act, the flight is left alone unless:
    - It is in conflict with a higher priority flight
    - There are other circumstances that prevent flight, such as a closed vertiport

2.2.3.2.4 On the management of uncertainty

In the execution of any plan there is some uncertainty of the outcome. The sources of the uncertainty may be considered at the level of an individual operation to be exceptional (the head-wind was strong and the flight took longer than planned) while at the macro level these may be normal events (a few days a year there are very strong winds). In a mature operating environment, uncertainty can be characterised by previous experience. (3% of flights take more than 110% of the planned time due to strong headwinds.)

Control theory shows that precision can be improved by the application of negative feedback, for example by varying the speed of the flight to achieve a precise arrival time, but doing so sacrifices another optimisation, for example fly so as to maximise battery life. Negative feedback also sets the "normal" performance much worse than the "best" – the flight always takes as long to arrive as it would on the most windy day. (Analogous to the difference between open-loop and closed-loop gain.)

These uncertainties limit the precision of the plans and hence the optimisations of the system. There will need to be trade-offs in U-space between different optimisations, including at least three: the optimisation of each flight, optimisation of vertiport utilisation and optimisation of airspace capacity. This ConOps cannot quantify these imprecisions nor propose how to trade-off between these optimisations but highlights that planning precision should be considered and quantified at all phases of the operation. The RTTA value and precise process are likely to impact this trade-off.

2.2.3.3 Pre-tactical overall, in the later eras

At the beginning of the pre-tactical phase, the flight is authorised.

During the pre-tactical phase this authorisation may be withdrawn at any time due to a change in the airspace structure, due to an unresolvable change in capacity (e.g. vertiport closure) or due to a conflict with a higher priority flight. The 2.2.3.3 authorisation might be withdrawn at RTTA due to an excess of demand or a conflict with one or more flights of the same priority.

Any withdrawal *might* be resolved by a change in the operation plan.

The pre-tactical phase ends when the flight is activated.

2.2.4 Tactical

The tactical phase starts when the U-plan is successfully activated. The tactical phase continues until the aircraft operator, which could be the pilot, indicates that the U-plan has ended.

2.2.4.1 Activation Request & Activation.

There is not a distinct activation service. Activation is a function of the operation plan processing service. The UAS operator, which could be the pilot, requests the activation of an existing authorised U-plan. The operation plan processing service makes a final check of the flight conditions and responds (promptly) either that the U-plan is activated or that the U-plan authorisation is withdrawn.

The activation request must be made during the period specified in the U-plan. Once the planned activation period is over, if the operation has not been activated its authorisation is withdrawn.

2.2.4.2 Commencement of tactical U-space services

U-space tactical services only operate for an active U-plan. These could include:

- Network identification, hence Tracking and Surveillance Data Exchange
- Conformance Monitoring service
- Traffic Information service
- Tactical Conflict Prediction and Tactical Conflict Resolution, if relevant
- Emergency Management
- Other monitoring services

These services all require connections to U-space. The activation will include a "logging on" process that "creates an active flight session" which links the sources/sinks of the services and data with a planned operation and the UAS operator / pilot.

2.2.4.3 Flight phases, conformance with the operation plan.

From the activation of the U-plan, the U-plan should be followed. Non-conformance with the U-plan can occur at any time. The flight phases depend on the operation type, for example an air taxi or a delivery with a small UAS and could include:

- Pre-flight operations that follow activation, for example confirmation that network identification is operating
- Taxi-out phase:
    - Pushback / towing if appropriate, involving ground handling processes and equipment.
    - Taxiing, if needed.

- Departure phase:
    - (probably) a check that everyone / everything is clear
    - Take-off.
    - Initial climb. The initial part of the flight may have the aim of “getting clear of the take-off site.” There may be restrictions on the procedure due to obstacles, noise abatement or ground risk.

- En-route. Once the aircraft is clear of the departure region, it can achieve the purpose of the flight, for example go to the destination.
- Approach. Safety / noise / environmental concerns may dictate that there is a particular way this type of aircraft needs to descend into the landing site in the current weather conditions. The approach phase involves getting the aircraft into position to start such a descent and then descending as required.
- Landing including final descent, flaring, touch down. These are likely to follow a check that everyone / everything is clear.
- Taxi in, if needed, meaning ground movement under aircraft power, possibly followed by towing in, if needed, meaning ground movement by means of ground handling equipment. Then parking.

Other events may occur depending on the nature of the operation. The operation should follow its plan.

The en-route section of the flight may be planned in such a way as to optimise a number of factors such as cost, ground risk, noise abatement and/or airspace limits – for example the flight may be constrained to remain within some height band relative to the ground immediately below. As a result of these optimisations, the flight path of an urban air mobility may not resemble the “straight and level” flight familiar in stratospheric flight.

The tactical phase can be viewed as a continuous sequence of challenges that the aircraft must overcome in order to follow the plan, for example completing checks in the planned time, or correcting course deviations due to gusts of wind. The plan represents a best guess as to what the prevailing conditions will be and how well the aircraft can meet these challenges. The aircraft follows the plan within agreed limits, or in control-system terms, acceptable error.

If the flight does not follow the plan within the agreed limits then it is initially “non-conforming” and can be expected to make every effort to return to the operation plan. If the non-conformance persists then the aircraft is in a contingency situation and should invoke a/the previously filed contingency plan.

2.2.4.4 Non-conformance with the operation plan

There are many reasons that an aircraft might not follow the operation plan.

- Failure:
    - The plan is unachievable. This aircraft just can’t fly that fast, that far, that high, that precisely.
    - The conditions have changed. For example, the wind is stronger than was allowed for in the plan.

  - Something has happened to or gone wrong with the aircraft. For example, a rotor snapped.
  - Something has gone wrong with the communications, navigation or surveillance. The aircraft is unable to communicate its position, does not know its position, does not know where it is supposed to go, …

- ‘External’ event:

  - A manoeuvre associated with Tactical conflict resolution is unusually large and requires the aircraft to fly outside the planned volume(s), for example a manned or other aircraft is in an emergency close to the aircraft and avoiding action must be taken.
  - The airspace has been “reconfigured dynamically.” The aircraft has to evacuate the region where it is currently.

In each case a previously announced contingency plan should be followed. These plans may be precise, for example fly directly to a predetermined location, or imprecise; land as quickly and safely as reasonable possible.

2.2.4.5 Contingencies

Contingencies are dealt with in more detail in Section 6, this is an overview.

The UAS operator should be cognisant of the contingency plans the aircraft will follow autonomously and their probable triggers. Possible triggers for contingency plans may include lost C2 link, low battery, loss of GNSS, mechanical or electrical failure. An autonomous contingency plan might be “fly straight back to take-off point.”

The UAS operator should also prepare contingency plans for hazards that risk assessment indicates are worthy of anticipating. Examples might include planning alternate landings or fitting a parachute.

When an aircraft is following a contingency plan, it is no longer “strategically deconflicted.” All conflicts must be dealt with tactically. An example of when this is likely to occur is as a result of dynamic airspace reconfiguration in which case the aircraft is required to exit the airspace.

Contingency plan activation in some cases lead to a state that can be strategically deconflicted by updating the U-plan during the active phase.

2.2.4.6 Updates to the operation plan during the active phase.

If the USSP’s agreement with the UAS operator allows it, then the UAS operator may update the U-plan during flight. The following guidelines seem likely:

- A flight which is following contingency plan, particularly in the case of a change, above, may be given priority over non-active flights in the strategic deconfliction, including those that have passed RTTA
- A flight which is active but not currently in contingency may not considered a priority, but rather a “late filer.” Rejection of the change would imply that the current operation plan remains authorised.

2.2.4.7 Termination of the flight & Ending of tactical U-space services

There is not a distinct flight termination service. The aircraft operator, which could be the pilot, signals to the operation plan processing service that the operation has ended. This triggers the ending of tactical U-space services that are running.

2.2.5 Post flight

The operation plan and records of how it was flown should be archived by the "legal recording service" but remain available for authorised use for as long as necessary. Uses include:

- Accident and incident investigation
- Criminal investigation other than aviation accident/incident
- Assessment of performance by or for the competent authority of UAS, UAS operators, U-space design, U-space services, Social impact and so on
- Research.

2.3 Airspace

This section describes different aspects of the airspace of interest to U-space.

2.3.1 Urban airspace

"Urban Airspace" is not currently much used by aviation for reasons of risk and nuisance, especially noise. The general expectation is that urban air mobility will make use of airspace which is currently mostly unused.

2.3.2 ICAO airspace classes

ICAO Annex 11 [14] Section 2.6 defines seven airspace classes, A to G, in terms of VFR and IFR flight rules, and the services offered. Only subsets of flight rules { VFR, Special VFR, IFR } are permitted in classes A to G. ICAO Annex 2 [13] defines Prohibited and Restricted areas as being something other than classes A to G. Restricted areas can enable air use which is neither IFR nor VFR.

2.3.3 U-space Airspace

EU regulation 2019/947 [4] Article 15 allows for the creation of Geographic Zones for the management of UAS traffic. EU regulations 2021/664 [8] and 2021/665 [9] allow for a Geographic Zone to be designated a U-space airspace. U-space airspaces are, in effect, Restricted Areas in the terms of ICAO airspace.

EU regulation 2021/664 [8] and [11] defines a means of operating in U-space airspace which does not include a Tactical conflict resolution service.

EU regulation 2021/664 [8] and [11] state that the geographic bounds of U-space airspaces are assembled and published by the CIS (Common Information Service). The same service part of what is referred to as Drone Aeronautical Information in the Edition 3 ConOps [1].

2.3.4 Geodetic Altitude Mandatory Zones

The ICARUS project [28] proposes a common altitude reference system. Within zones where there is a risk of altitude confusion, the competent authority may declare a "Geodetic Altitude Mandatory Zone." In a GAMZ, when aircraft exchange altitude information, it shall be exchanged in the form of geodetic height, that is referenced to the WGS84 ellipsoid. To support this expression, a vertical conversion series is foreseen, see 3.19 GAMZ-ness is independent of other properties of the airspace.

In total, ICARUS proposes four services, some of which map onto services identified in Edition 3 of the ConOps [1].

ICARUS	ConOps Edition 4	remarks
Vertical conversion service	Vertical Conversion Service, 3.19	
GNSS service	Navigation Infrastructure Monitoring, 3.15.1	Navigation Infrastructure Monitoring Service has more general scope.
Real-time geographic information service	Vertical Alert and Information Service, 3.20 Geographical Information Service, 3.9 Geo-awareness, 3.4	Scope of Icarus service is split between three services in this ConOps.
Vertical Alert Service	Monitoring, 3.10 Vertical Alert and Information Service, 3.20	The provision of height warnings to GA in the ICARUS service is distinct from Monitoring

2.3.5 CORUS volumes

The U-space ConOps edition 3 [1] describes some U-space "Volumes" in which different services should be used. The whole airspace is either X, Y or Z. The aim was a simple scheme for easy comprehension.

- X: No conflict resolution service is offered.
- Y: Pre-flight ("strategic") conflict resolution is mandatory
- Z: Pre-flight ("strategic") conflict resolution and in-flight ("tactical") conflict resolution are mandatory

For Y and Z an approved plan is required. In both Y and Z the pilot / UAS should be connected to U-space during flight to allow sending of position information and receipt of warnings, traffic information and so on.

The descriptions below are for a flight wholly in that airspace. For flights penetrating multiple airspaces, the conditions for each must be applied for that portion of the flight.

2.3.5.1 X volume

In X volumes flights need no plan and receive no separation service.

2.3.5.1.1 X, Pre-flight

The UAS operator should in some circumstances be registered, see 3.1. The UAS operator should make use of the geo-awareness service before flight, to load relevant data into the UAS, if appropriate and to confirm that the volume is X, see 3.4. The operator may make use of other services as appropriate (or as mentioned in the SORA for the flight, if there is one), for example: weather, see 3.8, geographic information, see 3.9.

2.3.5.1.2 X, In flight

No “tactical” separation service is available. The UAS operator remains responsible at all times for ensuring safe operation.

The UAS needs to be identifiable and will either have to direct remote identification, see EU regulations 2019/947 [4] and 2019/945 [5], or make use of a network identification service, see 3.2.1.

The operator may make use of services as they are available and needed by the circumstances, for example vertical conversion service (3.19), vertical alert and information service (3.20), emergency management (3.12)

2.3.5.1.3 X, Post flight

An accident and incident reporting service is available, see Section 3.13.

2.3.5.2 Y volume

Y volumes fulfil two roles. In the edition 3 ConOps [1] these were mentioned. UAS flight in a Y volume requires an approved plan. In Y volumes the plans are deconflicted before flight. The two purposes of Y are:

- The Y volume can exist primarily to limit access
- The Y volume can exist to enable flight with strategic deconfliction

2.3.5.2.1 Y, Pre-flight

The UAS operator should in some circumstances be registered, see 3.1. The UAS operator should make use of the geo-awareness service before flight, to load relevant data into the UAS, if appropriate and to confirm that the volume is Y, see 3.4.

Every flight must have an approved U-plan, see 3.5.2. Approved U-plans do not conflict due to the strategic conflict prediction, see 3.5.2.1, and resolution services, see 3.5.2.2.

2.3.5.2.2 Y, In flight

The U-plan shall be activated to commence flight, see 3.5.2.5

The flight shall make use of the following services unless their use is waived for the specific airspace:

- Network identification service, see 3.2.1
- Traffic Information service, see 3.14
- Emergency Management service, see 3.12
- Monitoring service, see 3.10, including Conformance Monitoring service, see 3.10.1
- Infrastructure monitoring services, see 3.15
- Vertical Alert and Information Service, see 3.20

2.3.5.2.3 Y, Post flight

The U-plan shall be ended by the operator, see 3.5.2.5. An accident and incident reporting service, see 3.13, is available. The operator may consult the digital logbook, see 3.16

2.3.5.3 Z volume

A Z volume is a volume in which there is a tactical conflict resolution service. Three versions of Z exist:

- Za in which Air Traffic Control manage all the traffic. Such airspaces may exist at an airport. The expectation is that ATC will communicate with UAS through U-space services.
- Zu in which U-space will provide a tactical conflict resolution service
- Zz in which U-space will provide a tactical conflict advisory service

Za is an existing controlled airspace. This 'Za' label is for the UAS community only.

2.3.5.3.1 Za, Pre-flight

The UAS operator should in some circumstances be registered, see 3.1. The UAS operator should make use of the geo-awareness service before flight, to load relevant data into the UAS, if appropriate and to confirm that the volume is Za, see 3.4.

Every flight must have an approved U-plan 3.5.2. The plan will need to be approved by ATC by means of the procedural interface with ATC, see 3.17. That procedural interface may result in various conditions being specified.

2.3.5.3.2 Zu & Zz, Pre-flight

The UAS operator should in some circumstances be registered, see 3.1. The UAS operator should make use of the geo-awareness service before flight, to load relevant data into the UAS, if appropriate and to confirm that the volume is Zu or Zz, see 3.4.

Every flight must have an approved U-plan, see 3.5.2. Approved U-plans do not conflict due to the strategic conflict prediction, see 3.5.2.1, and resolution services, see 3.5.2.2. The U-plan will be subject to dynamic capacity management, see 3.5.2.4

Strategic conflict resolution in Zu and Zz *may* operate with a higher residual risk of conflict than in Y, as there is a tactical process afterwards.

2.3.5.3.3 Za, In flight

The flight shall be activated to commence flight, see 3.5.2.5

The flight shall make use of the following services unless their use is waived for the specific airspace:

- network identification service, see 3.2.1. Other surveillance may be mandated.
- collaborative interface with ATC, see 3.18

2.3.5.3.4 Zu, Zz, In flight

The U-plan shall be activated to commence flight, see 3.5.2.5

The flight shall make use of the following services unless their use is waived for the specific airspace:

- Network identification service, see 3.2.1

- Tactical Conflict Prediction, see 3.6, and Tactical Conflict Resolution, see 3.7
- Traffic Information service, see 3.14
- Emergency Management service, see 3.12
- Monitoring service, see 3.10, including Conformance Monitoring service, see 3.10.1
- Infrastructure monitoring services, see 3.15
- Vertical Alert and Information Service, see 3.20

In Zu, the Tactical Conflict Resolution service issues instructions that the UAS must follow. In Zz the Tactical Conflict Resolution service issues advice. Because of the different likelihood of resulting action, the tactical conflict resolution advice in Zz may be issued earlier than would be the case for the tactical conflict resolution instructions in Zu.

2.3.5.3.5 Za, Zu, Zz, Post flight

The U-plan shall be ended by the operator, see 3.5.2.5. An accident and incident reporting service, see 3.13, is available. The operator may consult the digital logbook, see 3.16

2.3.6 Synthesis

The following table explains the relationship of the different U-space volumes to EU regulations and ICAO airspaces. Note below SVFR is a form of VFR and is usually not mentioned as a separate flight rule.

The U-space Volumes

ICAO	2019/947 UAS Geographical Zone	2021/664 U-space airspace	CORUS-XUAM	Flight rules	Remarks
G above VLL, ABCDEF	No	No	Not U-space	IFR (3,4) & VFR	For U-space users such airspace would probably be marked a Y volume and any U-space operation plan penetrating this airspace will either not be approved or will be subject to conditions or warnings.
ABCDE	No	No	Za	IFR (3) & VFR	Za if and only if the flight's entry into the airspace is enabled by a U-space planning process that includes ATC approval.
G VLL	No	No	X	VFR & IFR (4)	Conditions apply UAS fly below VFR limits but in effect conform to VFR
Restricted Area	Yes (1)	No	X	VFR	Restrictions may apply: Geo-zones can exist to manage which UAS flights are allowed
Restricted Area	Yes (1)	No	Y	Dependent on the restriction	Potentially a no fly zone for UAS

ICAO	2019/947 UAS Geographical Zone	2021/664 U-space airspace	CORUS-XUAM	Flight rules	Remarks
Restricted Area	Yes (1)	Yes	Y	See 5 & 6, below	No tactical separation service supplied by U-space
Restricted Area	Yes (1)	Yes (2)	Zu	UFR See 5, below	Tactical separation service supplied by U-space.
Restricted Area	Yes (1)	Yes (2)	Zz	See 5 & 7, below	Tactical separation **advice** supplied by U-space

Table 2: Volumes

Notes:

1) 2019/947 [4] article 15 does not state that geographic zones are restricted areas. U-space airspaces created as a result of 2021/664, 665, 666 are expected to be restricted areas due to the obligation on manned traffic to be conspicuous.

2) 2021/664 describes something approximating Y. Zu and Zz are considered as extending Y

3) IFR only in A.

4) IFR unlikely in G in many countries

5) UFR is defined as how to fly in Zu. In Zu there is U-space tactical conflict resolution, hence UFR includes obeying U-space tactical conflict resolution. It is expected that Zu only supports UFR and all aircraft in Zu must follow UFR.

6) An airspace which is a U-space airspace according to EU 2021/664 [8] & [11], most closely matching the CORUS volume Y, is one aimed at supporting BVLOS operations by means of strategic conflict resolution. Hence flights in the airspace do not follow UFR as flown in Zu, as tactical support is limited to traffic information. EU 2021/664 foresees entry of VFR or IFR traffic into U-space airspace as being an emergency procedure in which U-space traffic “take appropriate measures.” Hence it should be noted IFR and VFR traffic are not catered for in Y volumes.

7) The flight rule in Zz is not UFR as flown in Zu.

2.4 Ground Infrastructure

The term vertiport is used here to mean the aerodromes of urban-air-mobility. Two forms are presented, first the vertiport for passenger operations and then the vertiport for cargo operations by small UAS.

2.4.1 The Vertiport predominantly for passenger operations

2.4.1.1 Overview

Vertiports are landing and take-off sites for passenger carrying VTOLs and will be equipped with a number of facilities, including charging facilities for electrically operated vertical take-off and landing (eVTOL) vehicles as well as passenger boarding, de-boarding, and waiting areas. Non passenger carrying drones, for example for cargo operations, are expected to operate from other sites since decentral locations are preferable for such operations and infrastructure and safety requirements differ, though they may occasionally visit “passenger” vertiports.

A number of companies are presently developing vertiport concepts and infrastructure and these are largely inspired by heliports, including the touchdown and lift-off (TLOF) area, the final approach and take-off (FATO) area, the safety area around the FATO and stands as applicable. Additionally, while the aircraft is moved between TLOF and stand without depending on its power and wheels, ground movement equipment (GME) needs to be accommodated in the vertiports. GME serves as towing equipment in the form of a wheeled vehicle to move the aircraft horizontally on the vertiport surface, which can be either manually operated or remotely controlled or supervised by a member of the technical ground crew.

Vertiports may be located in any area, but realistically predominantly in urban areas and close to airports, permitting air taxi operations within cities and between cities and airports. An important consideration and requirement is the integration into the existing airspace; this concerns the airspace category in and around the area the vertiport is located and the safety of drone operations to and from the vertiport which may need to be separated or segregated from piloted aircraft. Operations at vertiports will be managed through U-space, a largely automatic system that will perform the necessary control tasks (sequence building, landing clearances, hold instructions, taxi clearances, etc.).

2.4.1.2 Vehicles

Whilst a number of vehicle types will undoubtedly be used in urban air mobility, we make the assumption that vertiports will be used by and designed for eVTOL and hybrid VTOL aircraft. Noise and local air quality considerations as well as the non-availability of landing sites for vehicles taking off in any other way than vertically have informed this assumption. Since eVTOL vehicles require charging facilities and have very limited endurance (so that holdings are not a desirable feature) this has a number of repercussions for the vertiport layout.

2.4.1.3 Vertiport facilities

The present design concept of vertiports, which is based on the EASA Guidance Material for Design of VFR vertiports [35][35] and largely inspired by current standards and recommendations for heliport design (e.g., ICAO Annex 14, Volume 2), provides the following facilities:

- Touchdown and Lift-off (TLOF) area(s);
- Final Approach and Take-off (FATO) area(s);
- Safety Area(s) around the FATO(s);
- Stands
- Facilities for re-energizing of aircraft batteries;
- Areas for taxiing (under own power) and ground movement (not under own power) of VTOL aircraft between the FATO and TLOF; and
- Passenger embarking, disembarking, and waiting areas.

For capacity and contingency reasons, it is desirable to provide more than one TLOF/FATO since the TLOF/FATO will be occupied by the incoming or outgoing flight for a specified period of time. FATO and safety area are always placed together within vertiport environment, but TLOF and stand can be placed elsewhere. Different options are expressed in Figure 4 for:

- Air taxiing, with TLOF being at the same place as the stand, where vehicle moves hovering over the vertiport surface on its own power, i.e. the vehicle does not lift-off or touch down at the FATO.

- Ground movement, where TLOF and FATO being at the same place with a stand in a different location and where ground movement of the vehicle is needed e.g., for longer distances. A VTOL aircraft can be moved under own power or by a vertiport movement system.

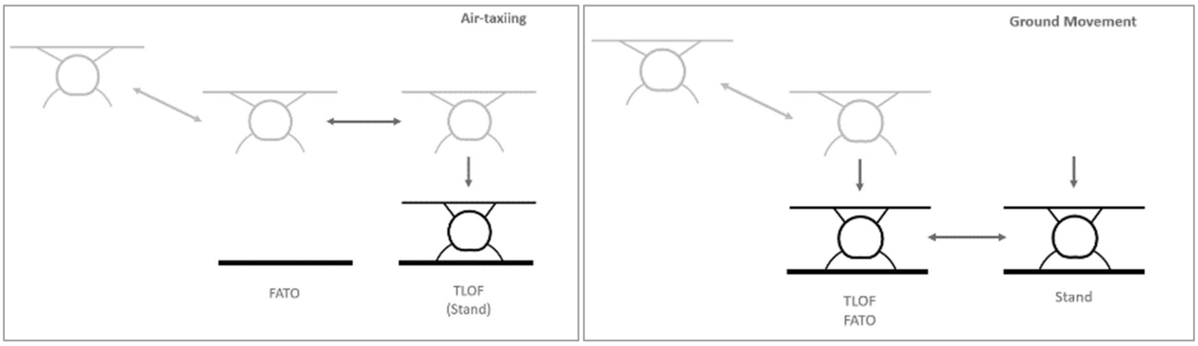


Figure 4: Air taxiing and Ground movement vertiport configuration

2.4.1.4 Vertiport access and operations

Operations are performed under the authority of the vertiport operator. Whilst detailed responsibilities are yet to be defined and agreed, the vertiport operator can be expected to

- specify the minimum operational and equipage requirements for vehicles using the vertiport and ensuring compliance;
- indicate the operational status of the vertiport and the availability of landing / departure / parking capacity;
- provide information and services, e.g. provide ground obstacle maps and/or landing/departure routes, potentially also local meteorological information.

Vertiports will probably have defined procedures including arrival, departure, holding, diversion, ground operations (charging, ground movement).

Vehicles in the U-space surrounding the vertiport will be under responsibility of one or various U-space service providers. The presently favoured view is that the USSP(s) also authorize landing and take-off operations at the vertiport, based on the availability of slots and infrastructure indicated by the vertiport operator. Note that different concepts are imaginable, for example a vertiport authority which clears vehicles for take-off and landing similarly to tower control. Yet the interface with USSP(s) in the surrounding airspace in terms of control authority would become complex to manage. (Due to a number of possible setups and solutions as presented above, the concept of traffic management at the vertiport should be further investigated and could be subject to following research projects.)

When considering vertiports for passenger VTOL aircraft operations, EASA is distinguishing different kinds of vertiports (see Figure 5: Vertiport Classification from Operations Perspective [23]).

As per EASA SC VTOL, VTOL aircrafts certified in the category enhanced, need to satisfy the requirement of and hence be able to continue to the original intended destination or a suitable alternate vertiport after a critical failure for performance [24]. This enhanced category of VTOLs covers those aircraft which will carry passenger on-board.

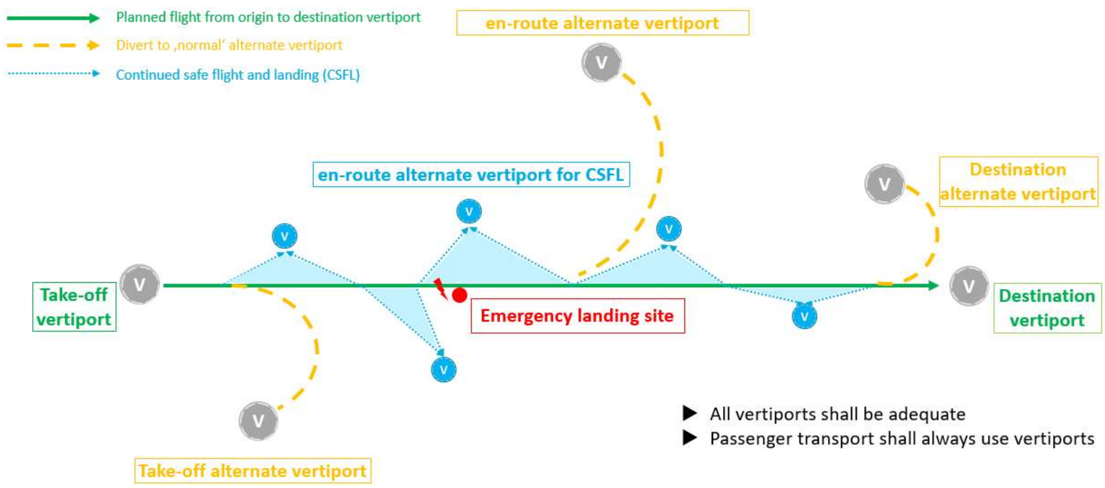


Figure 5: Vertiport Classification from Operations Perspective [23]

The grey circles are normal aerodromes, heliports or vertiports, with the full range of facilities and services required for the operation, so that the VTOL vehicle can take-off from. The blue circles are aerodromes for continued safe flight and landing (CSFL) which may be heliports or vertiports, that only have a minimum set of facilities and services (to be specified), from which the VTOLs may not be able to take off.

- **Take off and destination vertiport**: Each flight originates from a take-off vertiport and is planned and conducted to the destination vertiport.

- **Alternate vertiport**: This can be either an alternate take-off vertiport, where the VTOL aircraft would be able to land should this become necessary shortly after take-off, or an alternate en-route vertiport, where the VTOL aircraft would be able to land in the event that a diversion becomes necessary with normal aircraft performance while en-route, or an alternate destination vertiport, where the VTOL aircraft would be able to land should it become either impossible or inadvisable to land at the intended destination vertiport.

- **Alternate en-route vertiports for CSFL**: The alternate en-route vertiport for CSFL complies with the same minimum design requirements as the alternate en-route vertiport. But it only has to fulfil a minimum set of services with respect to the aircraft and CSFL operations.

- **Emergency landing site** is excluded from these considerations as emergency landing may be carried out at any possible location, not necessarily at an aerodrome/operating site.

The procedures to manage the availability of alternate vertiports are yet to be defined and will be informed by the, presently unknown, occurrence rates of technical failures and other causes lead to the need for alternate vertiports. The presently favoured view is that vertiports will not nominally operate at maximum capacity and thus leave some availability to accommodate unforeseen operations on an ad-hoc basis.

2.4.1.5 Vertiport location, airspace, and flight rules

Whilst vertiports with lower traffic demand may not have a designated area of airspace assigned/attached, we assume that the majority of vertiports is surrounded by a Vertiport Traffic Zone (V-TZ); the Vertiport Traffic Zone is U-space airspace, having an adequate approach area which is a protected one and in possession of the set of rules defined. V-TZ is part of the U-space airspace.

Flight planning and authorisation are performed by the USSP providing service to the UAS operator wishing to land at the vertiports. This includes booking of vertiport access. Details have yet to be defined but it may well be that *InterUSS* will be used not only for booking access to the airspace but also to the vertiport resources (ASTM standard F3548-21).

Vertiport access booking is part of the U-space flight plan (U-Plan) but does not authorise the vehicle to take-off or land. For this, the take-off/landing clearance is required which will be obtained shortly prior to the actual operations. The exact concept of clearance provision in U-space has yet to be defined; however, suffice it to say that stepwise clearances, with clearance limits similar to traditional aviation, seem to have a number of advantages when compared to clearing the whole mission at take-off; these advantages concern the ability to better accommodate uncertainty, capacity aspects, lost-link procedures, and other contingencies.

For the initial concept and use cases, we assume vertiports to be located in airspace surrounded by class G (uncontrolled) airspace. This would cover some vertiports located in urban areas but exclude vertiports in the vicinity of airports which are surrounded by class D airspace. In an evolution vertiports could be imagined in the premises or the vicinity of an airport (i.e., airspace class C or D). In this case, air taxi operations will require some form of interaction with ATM, which may be through the U-space service Collaborative interface with ATC, see 3.18. VTOL aircraft need then to be clearly displayed for ATC on the HMI for ATCOs situational awareness. This integration with ATM needs to be further researched.

2.4.2 Vertiports predominantly for cargo operations

Much of the description of the passenger vertiport applies to vertiports for cargo flights, but there are some simplifications other than the absence of passengers.

2.4.2.1 Optimisation

There may be cases where a vertiport is used by only one aircraft operator or by a small number of aircraft operators working in close cooperation with the vertiport operator. Examples might include “business to customer delivery” or if a number of hospitals/medical facilities have set up an air delivery service between themselves. The close linkage between the vertiport operator and the aircraft operator(s) may influence the way flights are scheduled at the vertiport, allowing emphasis of “network” optimisation.

‘General’ use of vertiport by aircraft operators without shared business interests diminishes the opportunities for such over-arching optimisations. We can expect each aircraft operator to optimise their own flights with the vertiport operator optimising vertiport operations.

2.4.2.2 Location

Two modes of cargo flight can be identified linked to the type of operation which impact vertiport location.

- The flight takes off and lands with the cargo on board. The cargo vertiport is at a source/sink of cargo, such as a warehouse, logistics centre, "fulfilment centre" or "dark store." The location of the vertiport is determined by the location of the source/sink of cargo.
- The cargo is collected and then delivered during the flight. Aircraft leave and return to the vertiport without cargo. The vertiport is only concerned with flight operations. The vertiport position can be optimised for flight efficiency, safety and social acceptance

2.4.3 The impacts of vertiport in U-space

Vertiports are often going to be a limited resource and hence will constrain flight planning, both for normal operations and in contingency planning. A service will be needed to share the current and planned availability. Other services will need to take this availability into account.

Processes at the vertiport may inject uncertainty into operations. For example, a flight may take off when the FATO is clear, but any number of improbable events can result in the FATO not being clear at the planned take-off time and hence the take-off is delayed.

3 U-space services

This section draws on the ConOps edition 3 [1] but seeks to align the material with EU regulation. The following table lists the U-space services which are then described each in its own section. Note that 2019/947 [4] & [6] does not refer to U-space services. 2021/664 [8] & [11] does refer to U-space services, but only describes a small number used by the operator. ConOps edition 3 broke the services down into their different functions.

Edition 4 service	section	Edition 3 Service	U-level	2019/947 & 945	2021/664, 665 & 666
Registration	3.1	Registration (e-registration)	U1	947 Article 14	
		Registration Assistance	U1		
Network identification	3.2.1	e-identification	U1	Partial match with remote identification	664 Article 8 Network Identification
		Position report submission subservice	U2		664 Article 8 Network Identification
Tracking	3.2.2	Tracking	U2		Not mentioned but might be inferred in the description of the Traffic Information Service in 664
Surveillance Data Exchange	3.2.3	Surveillance Data Exchange	U2		664 Article 8 Network Identification Reception of ATM surveillance data by U-space is part of the Traffic Information Service
Drone Aeronautical Information Management	3.3	Drone Aeronautical Information Management	U1	947 Article 15	
Geo-awareness	3.4	Geo-awareness	U1	Partially: 947 Article 15	664 Article 9 Geo-awareness service
		Geo-Fence provision (includes Dynamic Geo-Fencing)	U2		

Edition 4 service	section	Edition 3 Service	U-level	2019/947 & 945	2021/664, 665 & 666
Operation Plan Preparation / Optimisation service		Operation plan preparation / optimisation	U2		
Risk Analysis Assistance		Risk Analysis Assistance	U2		
Flight Authorisation service	3.5.2	Operation Plan processing	U2		Partly covered in Article 10 UAS flight authorisation service
Strategic Conflict Prediction	3.5.2.1	Strategic Conflict Resolution	U2		Article 10 UAS flight authorisation service
Strategic Conflict Resolution	3.5.2.2				Article 10 UAS flight authorisation service
Dynamic Capacity Management	3.5.2.4	Dynamic Capacity Management	U3		
Tactical Conflict Prediction	3.6	Tactical Conflict Resolution	U3		
Tactical Conflict Resolution	3.7				
Monitoring	3.10	Monitoring	U2		Partially covered by Article 13 Conformance monitoring service
Legal Recording	3.11	Legal Recording	U2		Article 15(g)
Emergency Management	3.12	Emergency Management	U2		Article 13 Conformance monitoring service
Incident / Accident reporting	3.13	Incident / Accident reporting	U2		Partially covered by Article 15(d)
		Citizen Reporting service	U2		
Traffic Information	3.14	Traffic Information	U2		Article 11 Traffic information service
Navigation Infrastructure Monitoring	3.15.1	Navigation Infrastructure Monitoring	U2		
Communication Infrastructure Monitoring	3.15.2	Communication Infrastructure Monitoring	U2		

Edition 4 service	section	Edition 3 Service	U-level	2019/947 & 945	2021/664, 665 & 666
Digital Logbook	3.16	Digital Logbook	U2		
Weather Information	3.8	Weather Information	U2		Article 12 Weather information service
Geographical Information Service	3.9	Geospatial information service	U2		
Population density map	3.5.1.1	Population density map	U2		
Electromagnetic interference information	3.5.1.2	Electromagnetic interference information	U2		
Navigation Coverage information	3.5.1.3	Navigation Coverage information	U2		
Communication Coverage information	3.5.1.4	Communication Coverage information	U2		
Procedural interface with ATC	3.17	Procedural interface with ATC	U2		
Collaborative interface with ATC	3.18	Collaborative interface with ATC	U3		
Vertical Conversion Service	3.19		U3		
Vertical Alert and Information Service	3.20**Error ! Reference source not found.**		U3		

Table 3: U-space Services cross reference

3.1 Registration

EU regulation 2019/947 [4] article 14 states that operators of many UAS shall be registered and that some UAS shall be registered. Hence there needs to be a registry and a registrar (the operator of the registry) who is approved by the competent authority.

EU 2019/947 [4] article 14 lists what information is expected in the registry. The registry should generate unique registration numbers associated with registry entries. The registry should form part of a multi-national network which is coordinated to ensure registration numbers are unique.

Registry entries will need to be able to be created, read, updated and deleted. There will need to be search functions. Some data consistency rules will need to be enforced, such as avoiding multiple registrations of the same information. There will need to be agreed processes to determine who is permitted to query and change the contents of the registry. Registration information may also change with time (e.g. lapse) in some cases. There will need to be means to carry out less frequent processes such as the registrar removing or changing a record following a court order.

The U-space Blueprint [2] and Roadmap [3] mention an 'e-registration' service to emphasise the digital implementation of the registry.

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/check/remove their own data or (when permitted) query the contents of the registry. The Registry will also need to be connected to other systems so as to validate names of people, businesses, addresses and other information given as inputs. The registry will probably need to be able to send emails to take part in the usual multi factor authentication and support processes for "forgotten password" and similar to an appropriate degree of security.

The registrations will be accessed by authorised officials (for example law enforcement) in combination with the Network Identifcation service. Hence the registry implementation must be capable of rapid response. The multi-national network of registries should be interconnected to allow network identification queries to function in any collaborating state for any registration known in any collaborating state.

Registration Assistance was identified as a U-space service in the U-space ConOps edition 3 [1]. This was foreseen as a service that might support something like a legal requirement for businesses selling UAS to ensure that the owners are registered. Services may be offered to assist routine registrations, presenting a user interface that is simplified and/or partly filled in with standard information.

3.2 Surveillance in U-space

EU 2021/664 [8] and [11] article 8 describes the Network Identification service as a way of U-space being informed of where UAS are. This service is complemented by the requirement for Electronic Conspicuity in EU2021/666 [10]. These two provisions require that all aircraft flying in U-space airspace shall regularly communicate their current position to U-space. This is done in three ways:

- UAS communicate with their contracted U-space Service Supplier via the Network Identification service – 2021/664 article 8
- Manned aircraft in receipt of an ATC service have their surveillance communicated from ATC to U-space, following 2021/666
- Manned aircraft not in receipt of an ATC service must make themselves conspicuous to U-space, following 2021/666

Hence the Network identification service is the basis of drone surveillance in the U-space airspace.

Surveillance in U-space is the basis for the following services:

- The Network Identification service
- Monitoring
- Traffic Information

- Tactical Conflict Prediction
- Surveillance data exchange

The performance of the system and the services consuming surveillance data, especially separation can be quantified if position reports contain an indication of the uncertainties in the reported figures and tracks have known quality. U-space airspaces will have associated with them minimum performance for surveillance.

3.2.1 Network identification

EU 2021/664 [8] and [11] article 8 describes the Network Identification service as having two distinct aspects. A service is described whose function requires the position of all UAS to be known. Based on that there is a requirement for the position of all UAS to be supplied to U-space.

These two aspects are explained separately below.

3.2.1.1 The Network Identification service as an Identification service

EU 2021/664 [8] and [11] article 8 describes a service by which authorised users and systems can obtain information about a currently active UAS. The amount of information depends on the user or system but the list of what should be output includes:

1. the UAS operator registration number,
2. the unique serial number of the unmanned aircraft or, if the unmanned aircraft is privately built, the unique serial number of the add-on,
3. the geographical position of the UAS, its altitude above mean sea level and its height above the surface or take-off point,
4. the route course measured clockwise from true north and the ground speed of the UAS
5. the geographical position of the remote pilot or, if not available, the take-off point,
6. the emergency status of the UAS.

The rate of update is determined by the competent authority, as may be other performance criteria for surveillance.

In addition to the Surveillance uses mentioned in Section 3.2 and that the data is to be shared with other U-space service providers (see [11],) the use of this service to substitute for the "Direct Remote Identification" provision of UAS in Open operations – see EU 2019/947 [4]. That is, it allows a person to identify a UAS that he/she is aware of, for example a policeman to identify a UAS that he/she can see.

3.2.1.2 Position report submission as part of Network Identification

EU 2021/664 [8] and [11] article 8 requires UAS in U-space to regularly inform U-space of enough information to supply the Network Identification service. The rate is determined by the competent authority.

Examining the list of elements that must be supplied in Section 3.2.1.1:

- Some elements might not be known to the aircraft, such as the geographical position of the remote pilot. Hence the position report information sent form the UAS to U-space may combine elements with different sources; the vehicle, the remote piloting station.

- Some elements are not likely to change during flight, such as the UAS operator registration number and the take-off point.
- The messages sent from the UAS to U-space may vary over time. In particular there is Item 4, ‘the route course measured clockwise from true north and the ground speed of the UAS,’ can come from three different means
    - The U-space service receiving reported positions from the UAS could perform Tracking and infer the motion vector
    - The UAS can send its own measurements of heading and velocity. The velocity is likely to come from examination of previous positions.
    - The UAS can sent its intended (planned) heading and ground speed

Neither the regulation [8] nor the draft acceptable means of compliance [11] indicate how the information is to be sent to U-space. It is assumed that “within the UAS” the vehicle will be in almost continuous contact with the remote piloting station and that the pilot will be informed of (at least) the position of the aircraft. Hence the position reports could be sent to U-space from either the vehicle, the remote piloting station or a combination of elements from each.

The position report submission aspect of Network Identification will require particular processes to start and end the submission. The submission process should be secure. Start of submission will involve secure identification of the operator and vehicle. Start of submission and should follow very shortly after activation of the flight – see 2.2.4.2. The ending of submission precedes the Termination of the flight – see 2.2.4.7.

3.2.2 Tracking

EU 2021/664 [8] and [11] does not mention Tracking, though it might be inferred.

Tracking is a statistical process that uses the observations of where the object has been (the position reports) and builds a model of where the object is most likely to be now, and how it is most likely to be moving, hence where it is most likely to be in the near future. Tracking can be made to work with multiple sources of observations for the same object, known as Multi Sensor Fusion Tracking.

Tracking implies a computing cost. Experience in current air traffic control is that Tracking aids human cognition. Some services such as Tactical Conflict Prediction require tracks to work correctly. Any source of uncorrelated reports, such as a drone detection system, will require tracking in order to correlate the tracks with the other surveillance and/or flight plans.

There appear to be at four (or more) ways tracking can feature in U-space.

- As a service performed by the U-space Service Provider receiving the reported positions and motions of the UAS. (by the producer)
- As a ‘shared’ service at some point within the interconnected U-space service providers as they exchange surveillance data. (centrally)
- As a service performed by the U-space Service Provider making use of the reported positions and motions of the UAS. (by the consumer)
- As a process applied in the Remote Piloting Station, if at all (downstream of U-space).

It is assumed that the Monitoring (3.10) and Tactical Conflict Prediction (3.6) services require tracks rather than observations. Traffic Information (3.14) benefits from being supplied tracks rather than observations. Tracking is also needed to allow cooperation between U-space and drone detection systems.

3.2.3 Surveillance Data Exchange

EU 2021/664 [8] and [11] article 8(4) requires U-space service providers to share surveillance data [Network Identification] with

- other U-space service providers in order to ensure the safety of operations in the U-space airspace
- the air traffic services providers concerned
- when designated, the single common information service provider

EU 2021/664 article 11(2) requires U-space to be able to display

- information about manned aircraft and UAS traffic shared by other U-space service providers and relevant air traffic service units

Hence U-space service providers must share surveillance data and accept surveillance data shared with them.

3.3 Drone Aeronautical Information Management

The Drone aeronautical information management service is the drone equivalent of the Aeronautical information management service. It is concerned with bringing together temporary and permanent changes to the drone "flying map." A (fictitious) example might be a prohibition of drones flying over schools. If such a prohibition exists, the education ministry, or the local (e.g. city) authority may use the drone aeronautical information service to publish the geographic bounds of schools.
Operating the service will involve:

- Collecting input 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 (perhaps certified) to upload or publish changes;
- Vetting and training (and certification) 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, etc.;
- Updating and synthesising the overall situation, and making it continuously available.

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

EU 2021/664 article 5 describes the Common Information Service. This service allows drone aeronautical information to be made available to U-space service providers.

The publication of this drone aeronautical information is by the geo-awareness service. See Section 3.4

The publication of environmental data - Weather Information, Geospatial Information, Population Density, Electro-magnetic Interference, and Navigation and Communication Coverage services - is associated with the Drone aeronautical information management service.

3.4 Geo-awareness

EU 2021/664 article 9 requires a geo-awareness service that provides the following information to UAS operators concerning the U-space airspace:

- applicable operational conditions and airspace constraints;
- UAS geographical zones;
- temporary restrictions applicable to airspace use.

It further states that U-space service providers must provide this information in a timely manner so that contingencies and emergencies can be addressed by UAS operators. The information must include the time at which it was updated through a version number and/or a valid timestamp

3.4.1 Geo-Fence provision

The Geo-fencing provision service is the part of the Geo-awareness service that provides UAS/UAM with 4-D coordinates of, and information about, geo-fences. As stated above, such geo-fences can be static or dynamic. The Geo-fencing service can be used during flight if the UAS / UAM vehicle has the technical capability to request, receive and use the geo-fencing data. All geo-fences until will be checked by the Operation plan processing service until the Pre-tactical phase. The Geo-awareness service uses existing aeronautical information, such as restricted areas, danger areas, CTRs, AIPs, and so on and adds information from national and local drone legislation. Temporary and drone-specific restrictions are added from the national airspace authority (CAA), NOTAMs, and the Drone Aeronautical Information Management service, to produce an overall picture of where drones may operate. All restrictions on airspace access are included in this service.

Short-term restrictions can define geo-fences with immediate effect, for example to protect HEMS and similar unplanned manned operations in VLL but they may also be used for other purposes. Such restrictions must be communicated very quickly as they can impact operation plans already known to the Drone operational plan processing service, including for drones that are already airborne.

The data delivered by this service will either be generated by the service or integrated into an operation planning management tool or service. The information delivered by this service will most likely be presented to the operator or pilot on a map, on a web site, app, etc. and must also be available in an electronic form for uses such as configuring a UAS / UAM vehicle to perform geo-fencing (see 3.9).

In operation planning, the data delivered by this service may be used by the operator to check that U-plans are compliant, and may be loaded into the flight management system of the drone.

3.5 Flight authorisation

The UAS flight authorisation service is mandated under EU Regulation 2021/664 Article 10 [8] [11]. Flight authorisation in 2021/664 only has very limited scope. The Flight Authorisation service described here was referred to as the Operation Plan Processing service in Edition 3 [1] and has a larger scope.

Action	EU Regulation 2021/664	Edition 4
Specific Operational Risk Assessment	No	Some support

Action	EU Regulation 2021/664	Edition 4
Obtaining permission to fly	No	No
Checking the operator is registered	?	Yes
Listing geo-zones penetrated by the flight	Yes	Yes
Obtaining permission to enter a geo-zone	No	In some cases
Confirming the flight has permission to enter a geo-zone / confirming the flight conforms to geographic bounds	No	In some cases
Uniquely identifying each flight	Yes	Yes
Storing and making available the flight intent for use by other services before, during and after the active phase	Yes	Yes
Strategic Conflict Resolution	Yes	Yes
Dynamic Capacity Management	No	Yes, when appropriate
If the flight penetrates a region controlled by ATC, coordinating the flight with the ATC for that region	No	Yes

Table 4 Relative scopes of the Flight Authorisation Service of 2021/664 and this ConOps

3.5.1 Operation Plan Preparation / Optimisation service

It is assumed that many UAS operators will have a tool to develop plans for flights and send those plans for authorisation. This tool is likely to be a service provided by a USSP and is referred to as the Operation Plan Preparation / Optimisation Service. Different versions of this service could be imagined for different business sectors. These tools are expected to be very valuable to UAS operators, however the details of how they work is out of the scope of this ConOps.

Supporting the Operation Plan Preparation / Optimisation service, various services providing geographic data used in planning may be offered:

3.5.1.1 Population density map

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

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

3.5.1.2 Electromagnetic interference information

The service collects and presents relevant electromagnetic interference information for the drone operation. The service shows where there may be a risk to the C2 link or other aspects of drone function due to radio frequency emissions.

3.5.1.3 Navigation Coverage information

The service to provide information about navigation coverage. This can be specialised depending on the navigation infrastructure available (e.g. ground or satellite based). This service is used to plan operations that rely such coverage. It may show regions with known issues or regions in which augmentation is available.

3.5.1.4 Communication Coverage information

This service provides 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 operations that rely such coverage. For example, this might be a map of the calculated or measured signal strength of mobile internet based on mobile telephony standards such as 3G, LTE 4G, 5G and so on.

3.5.1.5 Risk Analysis Assistance

Preparation of Specific operations involves SORA (see Annex I to EASA ED Decision 2019/021/R - Acceptable Means of Compliance (AMC) and guidance material (GM) to Commission Implementing Regulation 2019/947 [3]) which requires analysing risks associated with the operation. It is expected that a service will be offered to support this analysis using the draft operation plan as well as information coming from the Drone Aeronautical Information Management service (Section 3.3), various Environment services and the Traffic Information service (Section 3.14)

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

3.5.2 Flight Authorisation service

Edition 3 of the ConOps [1] referred to this as the Operation plan processing. To follow EU regulation 2021/664 [8], the name Flight Authorisation service is used.

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

The description of operations presented here is as if the system providing the flight authorisation service is a single integrated instance. This is the operational view. The implementation may be otherwise – that choice is out of the scope of this ConOps.

The Flight Authorisation service maintains a pool of data containing the histories of all submitted U-plans that have not yet been archived. Archiving occurs at some time after the U-plan is ended (after flight) or is cancelled (without ever flying). The U-plans in this pool are considered to be commercially sensitive and may additionally be restricted for other reasons – such as for state operations. Hence access to this pool is controlled.

The role that submits a U-plan to the Flight authorisation service is the drone operator representative. To do this they probably use an Operation plan preparation / optimisation service or tool. The submission will be by some secure means.

The sum of all the U-plans known in the Flight authorisation service is “the traffic.” The impact of a U-plan being submitted is to an extent felt by all other drone operators as a change in the traffic. To maintain commercial secrecy while multiple instances of the flight authorisation service collectively build a pool, the pool might only contain the minimum information, as proposed in ASTM F3548-21 Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability [18].

The Flight authorisation 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 Flight authorisation service when an operation plan is received.

- Syntax check. Does whatever has arrived resemble a U-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 U-plan.
- Authorisation-check using the Registration service, see 3.1. Is there some reason this operator or this pilot or this drone should not be flying?
- Check the 4D trajectory supplied in the U-plan is credible. (e.g. no gaps)
- 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 4D 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 4D trajectory then the procedural interface with ATC is triggered for each.
- The Strategic conflict-management service is invoked. See Sections 3.5.2.1 and 3.5.2.2
- If appropriate, the Dynamic capacity management service is invoked. See Section 3.5.2.4

The response from the processing should be a copy of the accepted U-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 flight authorisation service will also offer a validation mode in which the U-plan is checked, but not submitted (i.e. not added to the set of operations.) This mode supports risk 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 a U-plan has been accepted by the Flight authorisation service, the operator may send further messages to

- Cancel the U-plan,
- Change the U-plan,
- Ask for the current status of the U-plan.

Further an operator can query the service to get a list of all the U-plans known that have been submitted by that operator and their status.

The status of a U-plan can change after the U-plan is accepted, see Section 2.2.3.3, due to

- A change in the airspace structure,
- A conflict with another U-plan,
- Capacity being exceeded and this plan being subject to a measure to reduce demand.

The operator should be notified directly by the Flight authorisation service if such an event occurs and it changes the status of the U-plan.

The status of a U-plan also changes when it is activated. A further status change occurs on receipt of end-of-flight.

The following table summarises the different interactions that involve the Flight authorisation service

Role / Node	Action	notes
Drone operator representative	Submits U-plans, changes, cancellations Activates and terminates U-plans Receives positive or negative acknowledgements Queries U-plans or status Receives status change warnings	May use an Operation plan preparation / optimisation service or tool.
Aeronautical Information Service (may be supplied via Common Information Service)	Supplies aeronautical publications Supplies NOTAMs	This service and these publications already exist for the benefit of existing aviation.
Drone Aeronautical Information Service (Common Information Service)	Supplies X, Y , Z volumes and other drone specific information	
Registration service	Confirms the validity of the operator, any pilot training, the type of drone mentioned in any plan	
Weather Information service	Supplies weather forecasts and warnings	
Procedural interface with ATC	Triggers a coordination for a flight to penetrate a controlled area.	
Strategic Conflict Prediction service Strategic Conflict Resolution service	Detects and resolves conflicts before flight May trigger a state change	
Dynamic Capacity Management service	Detects and resolves demand and capacity imbalances May trigger a state change	
Network identification service	Queries U-plans, U-plan identifiers and U-plan states Creates / feeds / destroys flight surveillance session(s) associated with a U-plan	
Monitoring service Including Conformance Monitoring service	Retrieves a plans Updates the current position of a plan Signals non-conformance, which may change the state of a plan	

Table 9: Flight Authorisation service Roles and Actions

Drone surveillance systems, for example drone detection systems, benefit accessing U-plan data.

3.5.2.1 Strategic Conflict Prediction

The Strategic conflict prediction service may be invoked by the Flight authorisation service, before the flight takes place, because a new operation plan has been submitted or because a previously submitted operation plan has changed.

Currently UAS operators consider flight details commercially sensitive. ASTM F3548-21 [18] is a "Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability" and describes how different USSP can discover conflicts between flights while revealing the minimum information. The standard describes the use of a "discovery and synchronisation service" DSS, for which there is a reference implantation, the Inter-USS [19], published by the Linux foundation and available on Github. In very simple term the DSS maintains a four-dimensional grid of cells and USSP express an interest in cells. When a USSP expresses an interest in a cell they are informed the contact details of any other party having an interest in that cell. The DSS can be replicated across multiple instances.

Strategic conflict prediction within one USSP is a simpler version of the same activity. The trajectory is expressed as the probability of occupying 4D cells and conflict is detected as significant probability of intersection.

EU regulation 2021/664 article 10(2)(b) requires flights authorisations to be "free of intersection."

The intersection of two operation plans may be interpreted in different ways. The desired trajectory of a flight can be expressed as a time-ordered series of points in four dimensions. To allow for uncertainties this series of points has to be inflated and at least two approaches can be considered.

1. Each point of the desired trajectory becomes a four-dimensional volume.
2. Each point of the desired trajectory is surrounded in four dimensions by a field of probability that the aircraft is present.

Intersection of the volumes in the first is simple to calculate. For the second the calculation results in a probability of collision. Considering how the volumes in the first case are generated, for example the volume that represents a 95% probability that the aircraft is within, it can be seen that these two approaches are very similar.

For a more thorough study of the topic see deliverables 4.1 [25] and 4.2 [26] of the BUBBLES project.

3.5.2.2 Strategic Conflict Resolution

Strategic conflict resolution is undertaken by changing one of the pair of conflicting trajectories so that there is no longer "intersection." It is expected that the strategic conflict resolution service will search for non-conflicting alternatives by applying automatically generated changes from a standard set of "recipes" to the filed plan(s) and testing the result. (E.g. take off delay) Those that resolve the problem (and do not cause another problem) will be proposed to the operator who will refine the plan further before resubmitting or changing it.

ASTM F3548-21 [18] proposes that when it is found that two USSP have an interest in the same 4D cell, they contact each other and negotiate.

EU regulation 2021/664 article 10 proposes a simple approach: the first filed plan reserves the airspace in which it flies. This is qualified by there being two priorities of flight and a higher priority will take precedence over the lower, but within the same priority, the earliest to file is accepted and others are rejected. This rejection can be understood as signalling to the UAS operator that the plan needs to be changed.

3.5.2.3 Fairness in strategic conflict resolution

In case of a conflict between two flight plans, the conflict is usually resolved by changing one of the plans. This change may be viewed as a penalty. UAS operators are expected to file plans that are in their best interest, that best optimise their business. Any change will move the plan away from that optimisation - to some degree.

The “first to file” prioritisation of EU regulation 2021/664 systematically penalises types of operations that cannot file long in advance, such as “on demand” services like food delivery.

There is a desire to achieve fairness in strategic conflict resolution. What exactly fairness means is currently the subject of research, as is how it might be achieved, such as RTTA: see 2.2.3.2.3. Many other approaches could also be imagined, see “Market Design for Drone Traffic Management” [27] for an overview.

3.5.2.4 Dynamic Capacity Management

Dynamic Capacity Management aims to match demand with capacity and has two threads. Demand may be regulated to match capacity, or capacity may be changed to match demand.

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.

3.5.2.4.1 Inner working

This section condenses the work done by the DACUS project. See the Drone DCB concept and process [29].

There will be a process to predict times in the future when an airspace will be “full” or “saturated”. 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, or that some social acceptability metric (e.g. noise) has reached its limit. 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), and considerations of priority – see Section 2.2.3.2.

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

- All high-priority operations continue unhindered, as far as possible.
- Apart from high priority operations, all operations for which an operation plan was submitted after the RTTA for the 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. If the above will not solve the problem, lower-priority operations are examined to find those causing the greatest risk of conflict, hence whose removal would cause the largest overall reduction in risk to the airspace.
- If the above will not solve the problem, all operation plans take part in a process that proposes changes to those with the lowest priority, working upward until the problem is solved.

3.5.2.4.2 Invocation

The Dynamic capacity management service is expected to appear in U3. It is invoked by the Flight authorisation 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 Flight authorisation service.

3.5.2.4.3 Modulating capacity in response to demand

A number of approaches can be followed that will change capacity in response to demand.

- There may be a traffic organisation scheme in which traffic is collected into certain regions while others are generally not used, for example for noise abatement reasons. There could be traffic level triggers that allow the unused regions to come into use.
- Similarly, prediction of or experience of 'hotspots' may trigger a revision of any traffic organisation scheme; for example measures that produce more homogenous traffic such as one way systems or speed-controlled zones.

- Longer-term trends might lead to changes in the technical requirements for the volumes concerned. For example, higher-precision tracking and navigation may allow closer spacing between aircraft and may be mandated for a volume that is frequently subject to demand regulation measures.

This ConOps does not include any study of traffic organisation. The exploration of methods to increase capacity in response to demand is left for future research.

3.5.2.5 Flight authorisation states

The operation plan has a number of distinct phases in its life. This topic is quite large and needs proper discussion. This is just an introduction.

1 Draft. There is a business need, and a plan is being developed.
2 Approved. The plan has been filed, strategically deconflicted and so on. Resources (e.g., airspace, vertiport) are now committed to this flight.
3 Active. The services used in flight are operating. Tracking, emergency management, etc.
4 Ended. The flight is over.

There are a few other states that can usefully be added to that set. Flights may have been approved but then due to changes in circumstances might not be able to be activated. Flights might be already activated and then the same change in circumstances make them activated but not safe. Flights may invoke contingency procedures which means that they are flying but not following the original plan.

3.6 Tactical Conflict Prediction

Tactical conflict prediction and resolution is the process of resolving conflicts that occur during the flight by changing the flight while it happens. These can be implemented as advisory services or as systems giving instructions. The descriptions here assume that the services are implemented on the ground and not as a function distributed among the aircraft.

The Tactical conflict prediction service requires that the positions of all aircraft be known and frequently updated in the airspace volume being served, and further that the precision with which these positions are known can be reliably determined. The Tactical conflict prediction service is highly linked with the Tracking service (see 3.2.2) and the Vertical Alert and Information Service (see 3.20) to provide common-reference altitudes of all aircraft. The service may also take intent into account, as obtained from the U-plans in the Flight authorisation service (see 3.5) Based on current motion and possibly intent, the service predicts conflicts and provides alerts to the operators/pilots and to the USSP.

3.7 Tactical Conflict Resolution

On receiving a conflict alert from the Tactical conflict prediction service, the Tactical conflict resolution service issues advice or instructions to aircraft to change their speed, level or heading as needed to resolve these conflicts. These instructions should reach the pilot (or piloting system) rapidly and reliably.

The Tactical conflict resolution service can work more effectively if it makes use of 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 (see 3.2.2), the Flight authorisation service (see 3.5.2) and the Drone aeronautical information management service (see 3.3).

3.8 Weather Information

Article 12 of Reg. 2021/664 mandates the provision of a weather information service. This service will collect and present relevant weather information for the drone operation. This includes hyperlocal weather information when available/required.

3.9 Geographical Information Service

The Geographical Information Service (GIS) provides a 3D model of terrain and obstacles for use during planning, updated continuously for use during flight. GIS extends the Geospatial Information (GI) service referred to in Edition 3 [1].

Sources of data could include digital surface models combined with a ground obstacle database, or from direct mapping of the obstacles. The map data quality will be announced and assured by the service provider.

3.10 Monitoring

Subject to appropriate data-quality requirements, this broad service retrieves data from the tracking service and combines it with information related to:

- the flight plan, from the Flight authorisation service, in order to achieve the Conformance Monitoring service (see 3.10.1),
- obstacles, from the Geographical Information Service, in order to provide the Vertical Alert and Information Service (see 3.20),
- other air vehicles from the Traffic Information service in order to provide an air situation status report for authorities, service providers, and operators, including pilots,

- geo-fences from the Geo-awareness service in order to provide geo-awareness compliance monitoring and warnings (see 3.4.1),
- weather information from the Weather Information service in order to provide weather limit compliance 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 the Tracking and Drone aeronautical information management services and of the different environmental services.

3.10.1 Conformance Monitoring service

Article 13 of Reg. 2021/664 requires that a Conformance monitoring service be in place to "enable UAS operators to verify whether they comply with the requirements set out in article 6(1) of the same regulation [referring to the obligations of UAS operators] and the terms of the UAS flight authorisation." Furthermore, article 15(g) of Reg. 2021/664 mandates legal recording of flights and article 15(d) requires incident and accident reporting. All of these requirements are discussed in this section.

The monitoring service supplies conformance monitoring.

3.11 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.

3.12 Emergency Management

The Emergency management service of U-space has two aspects:

- assistance to a drone pilot experiencing an emergency with their drone
- communication of emergency information to those who may be interested:
    - pilots whose drones may be affected;
    - manned aviation, air traffic services;
    - police, military and similar

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 or emergency response plans.

The Emergency management service needs to be configured for the “current operation.” The pilot will need to identify their 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 ‘log-on’. Emergencies communicated to the drone pilot are those likely to come near their operation and hence pose a risk to it.

The Emergency-management communication channel 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 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. If the flight has an operation plan, the Emergency management service will warn the pilot when a geo-fence-with-immediate-effect has been created which affects the current flight.

3.13 Incident / Accident reporting

An Incident/accident reporting service is a requirement of Article 15(d) of Reg. 2021/664. This service allows drone operators and others to report incidents and accidents. It allows these reports to mention drone identifiers and operation plan identifiers to help later investigation.

The service maintains the reports for their whole life-cycle. The system is secure and only gives access to authorised persons.

The Accident and Incident reporting service is a client of the Legal Recording service (see 3.11) 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.

U-space should also 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.

3.14 Traffic Information

A traffic information service is mandated in Reg. 2021/664, article 11. 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.” There is some commercial sensitivity to drone flight information and an air situation display may be restricted. Note that an air situation display presents an image to the user; it is foreseen that tracks will be shared between U-space and ATM through the Surveillance data service – see 3.2.3. The traffic information should be subject to Vertical Conversion Service (see 3.19) when it is available in order to present information that is meaningful to the recipient.

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.

3.15 Infrastructure monitoring

Services exist to report the current state of critical infrastructure.

3.15.1 Navigation Infrastructure Monitoring

The service to provide up to date status information about navigation infrastructure. This service is used before and during operations. The service should give warnings of loss of navigation accuracy. Specifically, the GNSS service retrieves data from EDAS (the EGNOS Data Access Service), from the Reference Stations database and, through the USSP API, from the U-Space Tracking and Monitoring service (see Section 3.2.2) provided by the USSP. Once all the necessary data have been obtained, the service can provide GNSS signal monitoring, Position Velocity and Time (PVT) and Integrity calculation.

This service may also distribute correction information coming from augmentation services, and even RTK (real time kinematic) augmentation as appropriate.

3.15.2 Communication Infrastructure Monitoring

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

3.16 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.

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

3.17 Procedural interface with ATC

The procedural interface with ATC is a mechanism for coordinating the entry of a flight into controlled airspace. The interface works before the flight takes place. 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.

3.18 Collaborative interface with ATC

The collaborative interface with ATC is introduced in U3 and is a service offering communication between ATC and the appropriate representative of a drone flight, which could be the remote pilot, the drone itself in case of automated flight or in some cases the USSP. The collaborative interface with ATC is expected to used while a drone is close to or in a controlled area. The communication may be verbal or textual / graphical. The Collaborative interface allows flights to receive instructions and clearances in a standard and efficient manner, replacing the ad-hoc solutions used prior to this service's being used.

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

In addition to communications, the Collaborative Interface with ATC provides for safe operation by giving ATC access to U-space surveillance data.

3.19 Vertical Conversion Service

The Vertical Conversion Service (VCS) and the Vertical Alert and Information Service (see Section 3.20) are both elements of the proposed ICARUS suite of services not mentioned in Edition 3 [1]. The VCS ensures the conversion of altitudes between barometric and geodetic reference systems to both manned and unmanned aircraft in Geodetic Altitude Mandatory Zones (GAMZ). It uses other services and ICARUS sub-services to calculate the geometric height a manned plane is flying at, and the barometric height of a drone and shares these with other aircraft in the vicinity.

The Vertical Conversion Service retrieves weather data from weather service providers, from the USSP (Weather information service) and from the Weather Reference Station database. It also obtains GNSS data and barometric data etc. about GA, through interfaces with ATM.

3.20 Vertical Alert and Information Service

The ICARUS project [28] has defined the Vertical Alert and Information service (VALS) which alerts GA pilots and UAS / UAS pilots in any Geodetic Altitude Mandatory Zones (GAMZ) to any risk of collision with ground obstacles, using APIs (Application Programming Interfaces) from the ANSP and the USSP respectively. This is done through using the GIS (Section 3.9), Navigation Infrastructure Monitoring (Section 3.15.1), and VCS (Section 3.19) services that provide it with the position of the manned aircraft and the drone, and their barometric and geometric heights. For UAS the service is part of the monitoring service. For GA is requires separate provision – or monitoring of GA aircraft.

4 Flight rules

This section briefly introduces the topic of the rules of the air for flights receiving U-space services. This topic is the subject of ongoing work as this edition of the ConOps is being prepared and this section will be enlarged in the next edition.

4.1 Rules of the Air

ICAO Rules of the Air date back to October 1945 when the first international recommendations for Standards, Practices and Procedures for the Rules of the Air were established and ultimately amended into Annex 2 [13]. The Standardised European Rules of the Air (SERA) [12] includes the transposition of Annex 2 into European law. The legislative framework for SERA includes Regulations (EU) 923/2012, amendment Regulations (EU) 2016/1185 and the Aviation Safety (Amendment) Regulations 2021 applies to all European Union states and the United Kingdom (as per the EU Withdrawal Act 2018). Additional flight rules are also applied at the state-level (for example the UK's Air Navigation Order), which are designed to align with SERA and ICAO standardisation.

There are two distinct flight rule categories defined in Annex 2 [13] and SERA [12] :

- Visual Flight Rules (VFR); flown in Visual Meteorological Conditions (VMC),
- Instrument Flight Rules (IFR); flown in either Visual or Instrument Meteorological Conditions (IMC).

Special VFR is more of an exception-based rule set, for VFR flights that do not meet the requirements for VFR (typically VFR minima) when operating in controlled airspace.

4.1.1 Avoidance of collisions

Annex 2 [13] Section 3.2 explains the rules of the air related to avoiding collisions.

- Section 3.2.1 requires that aircraft not come too close to other aircraft
- Section 3.2.2 on right of way describes decisions and actions based on assessments of the relative positions and motions of other aircraft

In Visual flight rules, there is the expectation that the pilot of each aircraft is aware of what is around his/her aircraft by means of sight.

Annex 2 [13] chapter 5 describes instrument flight rules. In essence the flight either benefits from a separation service or traffic information.

4.2 UFR

U-Space Flight Rules (UFR) shall apply uniquely to airspace users in receipt of U-Space services within U-Space airspace. Aircraft and pilots that adhere to standardised U-Space equipment interfaces, and operate within U-Space Airspace Volumes, shall operate under UFR.

The aim of UFR is to be a flight rule that works for remotely piloted aircraft, without the pilot being able to look out of the window. Instead the pilot should be informed about the relative positions of aircraft by other means.

The principle behind UFR is to enable aircraft operations that cannot conform to either VFR, SVFR or IFR in all operational conditions. Whilst in some operating cases it is possible for UAM to operate under VFR if piloted as visual line of sight (VLOS), however, more advanced UAM use cases may not be capable of “see and avoid” procedures if the aircraft are uncrewed. Likewise, UAM may be accommodated by IFR in some instances, however, their separation minima may not be suitable for effective operations in more congested airspace, such as the CTR. The aircraft participating under UFR are therefore required to be supported by a set of U-Space services for a particular airspace volume. The required U-Space services and their interface with other ATS depends on the airspace classification.

UFR is for operations in U-Space volumes for airspace users that are consuming U-Space services. UFR is based on deconfliction service(s) for separation provision (safety layer 1) and on-board technologies (DAA/SAA) for collision avoidance (safety layer 2).

It shall be expected that aircraft conforming to UFR are required to:

- be Electronically Conspicuous to the ground system(s) and to other aircraft within the U-Space Airspace,
- be in receipt of a traffic information service(s), as required, with respect to other aircraft,
- adhere to any [Digital] ATS clearance/instruction deemed necessary by the controlling authority,
- have any air traffic separation service managed by a U-Space service.

Aircraft operating under UFR are not expected to receive voice communications from ATS units.

U-Space Mandatory Zone: aircraft operating in a U-Space Mandatory Zone (UMZ) shall be required to make their position known to U-Space through a defined procedure. States shall be responsible for defining the required process for making aircraft Electronically Conspicuous to U-Space.

5 Examples of using U-space services

Five flights are expanded here to show how the Operating Environment, Services and Flight Rules apply. The DACUS project's deliverable on the Drone DCB Concept and Process [29] has identified three general types of operations with different characteristics:

> ***Surveillance operations*** *are distinguished by mostly larger trajectory patterns and possibly repeating schemes to effectively monitor larger areas or points of interest. It is expected that most of these operations will not be performed in close range of any structures and therefore will be deployed in higher altitudes within very low-level airspace. Typical examples for this type are aerial mapping, traffic monitoring or applications in public safety and security;*
>
> ***Inspection operations****. They refer to all business models that practically require a close approach to the point of interest and for the whole execution of the mission task, e.g., the automated recognition of structural damage to a surface with optical methods. Contrary to surveillance operations, this type of mission can be expected to stay inside a defined and foreseeable containment area that is comparably small and near the observed structure. Further examples for this case are the inspections of solar power, cell towers or target-oriented photography;*
>
> ***Transport operations****. They are characterized by a point-to-point flight scheme and the actual transport of goods or persons. The cruise flight in this type is mostly distant to structures but straight forward and optimised on efficiency to reach a certain destination. It is likely that loading and unloading requires an approach to the ground and/or solid structures. Besides the industrial and private transportation of goods, this operation type also covers medical transport (e.g., medication or first responder equipment) or the carriage of persons in personal air vehicles.*

Five examples will consist of:

- Architectural photography, an example of Inspection, VLOS
- Aerial mapping, an example of Surveillance
- Power line inspection, an example of Inspection, BVLOS
- Pharmaceutical delivery, an example of Transport
- Air taxi, remotely piloted, an example of Transport

These five examples build in complexity.

5.1 Architectural photography

The photography mission is VLOS. The building to be photographed stands in an area that is enclosed by a fence, hence people can be excluded. The ground around the building is approximately the same altitude all over with respect to mean sea level. The missions are flown "by hand" by a pilot / photographer wearing first-person-view goggles. An observer stands beside the pilot and scans the sky visually. The flight is planned because it takes place in a Y volume (see 2.3.5.2) an airspace for which planning is mandatory.

The plan consists of a single 4D volume, from ground level to 50m above ground, covering a square on the ground of side 200m with the building at the centre, lasting from 7pm to 8pm local time. The operation will involve what appears to be unpredictable flight within the volume including periods when the aircraft is on the ground for battery changes.

5.1.1 Pre-flight

The drone-photographer is asked if she can take pictures of a hotel which stands in its own gardens. The photographer studies the location using the Geo-awareness service 3.4, considers the customer's wishes and decides the work can be done as an "open" category mission.

The photographer uses a relatively simple Operation Plan Preparation / Optimisation service 3.5.1 to prepare and submit the plan mentioned above; an hour long period in a "box" around the hotel during the 'golden hour.' The plan is sent the day before flight.

The plan is received by the Flight Authorisation service, 3.5.2. An acknowledgement comes back confirming the conditions applicable to the flight, notably which services should be used (see 2.3.5.2.2), what the technical requirements are. These same conditions are published per airspace but the acknowledgement serves as a reminder and makes the conditions contractual.

On the day of flight, the photographer and her assistant drive to the hotel. They check the status of the plan and if it has passed RTTA with no conflicts see 2.2.3.2.3.

5.1.2 In flight

Using the Flight Authorisation service, 3.5.2, the photographer activates her flight and commences the tactical services required for the airspace, in this case

- network identification service, 3.2.1
- traffic information service, 3.14
- emergency management, 3.12
- monitoring, 3.10

With the assistant, the pilot flies the drone and takes pictures.

In this example flight there are no unexpected events.

5.1.3 Post flight

Using the Flight Authorisation service, 3.5.2, the photographer ends her flight. The tactical services end.

The photographer and her assistant pack up and leave.

Later the photographer checks the details of the flight from the digital logbook.

5.2 Aerial mapping

The drone operator has received an order from a regular customer to collect the data to enable the production of an aerial map of a region of about 1km x 1km. The work consists of taking a large number of photographs of the specified region from different angles ensuring that every point on surface has been photographed from three angles[2]. The precise location at which each photograph is taken must be recorded. The work involves a drone carrying quite a lot of equipment for positioning and image recording.

The flight is flown following a pre-programmed trajectory that scans over the region of interest. It is flown as a BVLOS flight, within an area, even though the aircraft may be visible to the operator much of the time. The interventions available to the operator are to deviate following a tactical separation instruction, to return to base and to restart the mission from the last 'good' point.

The airspace in which the flight occurs is Zu.

5.2.1 Pre-flight

The operator uses a relatively sophisticated Operation Plan Preparation / Optimisation service, 3.5.1, to develop a U-plan (or series of U-plans) that meet the needs of the mapping task. That tool makes use of the Geo-awareness service, 3.4, a Population density map service, 3.5.1.1, and a Risk Analysis Assistance service, 3.5.1.5, to minimise the risks associated with the operation. The Operator has a LUC (light UAS operator certificate), see EU regulation 2019/947 [4]. The Operation Plan Preparation / Optimisation service also checks for risks to the flight by making use of services providing Electromagnetic interference information, 3.5.1.2, Navigation Coverage information, 3.5.1.3 and Communication Coverage information, 3.5.1.4.

Once the U-plan seems optimal from a business and risk consideration, the Operation Plan Preparation / Optimisation service submits the U-plan to the Flight Authorisation service, 3.5.2. The U-plan describes large blocks of airspace being occupied in sequence. The operator is informed that the U-plan is accepted.

At RTTA the operator is informed that the flight is involved in a demand-capacity imbalance at one point and has been suspended. The system proposes several solutions. The operator prefers to change the sequence of scanning the area of interest and submits a revised plan which is accepted.

5.2.2 In flight

Using the Flight Authorisation service, 3.5.2, the operator activates the U-plan and commences the tactical services required for the airspace, in this case

- network identification service, 3.2.1
- monitoring, 3.10, including conformance monitoring service, 3.10.1
- tactical conflict prediction service, 3.6

[2] Detail invented for the sake of the story.

- tactical conflict resolution service, 3.7
- traffic information service, 3.14
- emergency management, 3.12
- weather information, 3.8
- navigation infrastructure monitoring, 3.15.1
- communication infrastructure monitoring, 3.15.2
- vertical alert and information service, 3.20

The pilot prepares the UAS and starts the flight.

During the flight the pilot monitors the flight operations and the achievement of business objectives while U-space information is overlaid on the flight display. The pilot receives tactical separation instructions form U-space in a form that can be directly uploaded to the aircraft.

The pilot's flight management system records which business objectives have been met and collects any which have not been met due to tactical interventions to allow the generation of a new U-plan to "fill the gaps."

5.2.3 Post flight

Using the Flight Authorisation service, 3.5.2, the pilot ends the flight. The tactical services (listed above) end.

After the aircraft has been powered off and made secure the pilot checks the digital logbook, 3.16, to confirm the details.

5.3 Power line inspection

The operator has a contract to inspect a number of power lines periodically. Following the schedule in the contract as well as the weather and any reports of exceptional situations, the operator plans a line inspection flight. The flight is BVLOS consisting of three parts. The aircraft flies to the start point of the inspection. The flight then follows the powerline while cameras and other sensors relay information back to the operator. When the operator's attention is drawn, the flight may linger at a point on the line. Finally the aircraft flies to a landing site. The airspace is all Y volume. The operation is specific category. The operator has an existing SORA approved for this flight.

5.3.1 Pre-flight

The operator has flown this inspection before. The operator uses an Operation Plan Preparation / Optimisation service, 3.5.1, to recheck and if necessary update the U-plan for the inspection. That tool makes use of the Geo-awareness service, 3.4, the Weather Information service, 3.8, and a Risk Analysis Assistance service, 3.5.1.5, which helps the operator check that the SORA is still applicable.

The Operation Plan Preparation / Optimisation service submits the U-plan to the Flight Authorisation service, 3.5.2. The U-plan describes a sequence of tubes of airspace being occupied in sequence, with growing uncertainty in the entry and exit time as the flight continues. The operator is informed that the U-plan is accepted.

At RTTA the operator is informed that the flight is in conflict with more than one other flight and has been suspended. The system proposes several solutions including a delayed start. The operator updates the U-plan to match the proposed delayed start and it is accepted.

5.3.2 In flight

Using the Flight Authorisation service, 3.5.2, the operator activates the U-plan and commences the tactical services required for the airspace, in this case

- network identification service, 3.2.1
- monitoring, 3.10, including conformance monitoring service, 3.10.1
- traffic information service, 3.14
- emergency management, 3.12
- weather information, 3.8
- navigation infrastructure monitoring, 3.15.1
- communication infrastructure monitoring, 3.15.2
- vertical alert and information service, 3.20

The pilot prepares the UAS and starts the flight.

During the flight the pilot monitors the flight operations and inspects the power line while U-space information is overlaid on the flight display. At times the operator pauses to record additional details.

5.3.3 Post flight

Using the Flight Authorisation service, 3.5.2, the pilot ends the flight. The tactical services (listed above) end.

After the aircraft has been powered off and made secure the pilot checks the digital logbook, 3.16, to confirm the details.

5.4 Pharmaceutical delivery

The drone operator has a contract with a number of hospitals, medical laboratories, clinics and a few pharmacies in a city. Each location has a vertiport suitable for the small UAS used by the operator. The operator has developed a network of routes between these vertiports. In some cases there are multiple routes between the vertiports. These routes follow regions of lower ground risk.

The operations are a mix of planned in advance and on demand services, always over known routes between known end points. The flights are certified category operations. The airspace is a mix of Zu and Y.

5.4.1 Pre-flight

The operator receives a request for an urgent delivery of pharmaceuticals from a pharmacy to a clinic. There happens to be a suitable UAS sitting waiting at the pharmacy. A pharmacist is collecting the pharmaceuticals as the operator prepares the U-plan. The expected activation time of the flight is in three minutes. The operator uses an Operation Plan Preparation / Optimisation service, 3.5.1, which is programmed with the vertiport and route-network. That tool makes checks the possible routes using the Geo-awareness service, 3.4 and the Weather Information service, 3.8. To choose the fastest route, the Operation Plan Preparation / Optimisation service calls the Flight Authorisation service in "test" mode for each route with different start times to find the fastest. A suitable combination of start time and route is identified and submitted to the Flight Authorisation service, 3.5.2. At RTTA the operator is informed that the flight is conflict free. The pharmaceuticals are loaded on board and the UAS checked. The destination is advised of the arrival time.

5.4.2 In flight

Using the Flight Authorisation service, 3.5.2, the operator activates the U-plan and commences the tactical services required for the airspace, in this case

- network identification service, 3.2.1
- monitoring, 3.10, including conformance monitoring service, 3.10.1
- tactical conflict prediction service, 3.6
- tactical conflict resolution service, 3.7
- traffic information service, 3.14
- emergency management, 3.12
- weather information, 3.8
- navigation infrastructure monitoring, 3.15.1
- communication infrastructure monitoring, 3.15.2
- vertical alert and information service, 3.20

The pilot starts the flight. During the flight the pilot monitors the flight operations while U-space information is overlaid on the flight display. In the Y volumes the pilot monitors traffic information, in Zu, the pilot receives tactical separation instructions form U-space in a form that can be directly uploaded to the aircraft.

As the UAS approaches the clinic, the flight management system warns the clinic of the imminent arrival. A member of staff is standing by as the UAS lands.

5.4.3 Post flight

Using the Flight Authorisation service, 3.5.2, the pilot ends the flight. The tactical services (listed above) end.

The aircraft has been powered off and made secure and then the pharmaceuticals are unloaded.

5.5 Passenger carrying, remotely piloted, scheduled

In the first of two passenger carrying operations, a scheduled services is considered.

A UAS operator focusing operations on making the best use of the vertiport may adopt the approach of operating flights according to a schedule. (See 2.2.2.3, third case.) Flights follow a predetermined route network visiting known vertiports. The air operations are carefully planned to turn around quickly so as to maximise the utility of the vertiport. Passengers buy tickets to occupy seats on scheduled flights.

The planning is made long in advance. The operations are certified. The airspace is a Zu volume. Vertiports will have associated arrival and departure routes which will be determined by the needs of safety and social acceptability.

5.5.1 Pre-flight

The operator plans an entire day at a time, fitting together all the flights so as to optimise vertiport use. Each flight is planned with some margin for tactical changes but that margin is limited in the interest of maximising the optimisation. The operator uses an Operation Plan Preparation / Optimisation service, 3.5.1, of great sophistication which models the vertiport operations and multiple flights by the whole fleet of aircraft.

So as to minimise the risk of conflict, flights are planned using four dimensional volumes of the minimum size.

The Operation Plan Preparation / Optimisation service submits plans to the Flight Authorisation service, 3.5.2. At RTTA for each flight the operator is usually informed that the flight is conflict free. In cases where there is a conflict, strategic conflicts are generally solved by speed and route changes, attempting to keep take-off and landing times undisturbed. When this is not possible, the Operation Plan Preparation / Optimisation service, 3.5.1, may update many flights to coordinate the overall schedule.

The pre-flight phase will include the boarding of passengers. Systems or an agent at the vertiport will signal to the remote pilot that the passengers are on board, the doors are closed.

5.5.2 In flight

Using the Flight Authorisation service, 3.5.2, the operator activates the U-plan and commences the tactical services required for the airspace, in this case

- network identification service, 3.2.1
- monitoring, 3.10, including conformance monitoring service, 3.10.1
- tactical conflict prediction service, 3.6
- tactical conflict resolution service, 3.7
- traffic information service, 3.14
- emergency management, 3.12
- weather information, 3.8
- navigation infrastructure monitoring, 3.15.1
- communication infrastructure monitoring, 3.15.2
- vertical alert and information service, 3.20

The pilot starts the flight. During the flight the pilot monitors the flight operations while U-space information is overlaid on the flight display. The pilot may communicate with the passengers, either directly or via a staff member dedicated to passenger relations.

In Zu, the pilot receives tactical separation instructions form U-space in a form that can be directly uploaded to the aircraft. The pilot strives to maintain the planned arrival time. When the planned arrival time is in jeopardy, the operator may update the plan to operate at higher speed. When tactical manoeuvres delay the flight beyond the planned margin, the operator will replan the operations at the arrival vertiport and perhaps beyond.

The pilot constantly monitors the state of the vehicle and the status of both the nearest vertiport and the destination vertiport. The pilot maintains contingency plans throughout the journey to allow safe landing with different degrees of urgency.

As the UAS approaches the arrival vertiport, the pilot checks the availability of the destination. The aircraft follows a standard arrival path and touches down.

5.5.3 Post flight

Using the Flight Authorisation service, 3.5.2, the pilot ends the flight. The tactical services (listed above) end. The aircraft is made secure. A member of the ground staff opens the doors of the aircraft and those passengers who have reached their destination exit the vehicle.

5.6 Passenger carrying, remotely piloted, on demand

In the second of two passenger carrying operations, an on demand services is considered.

It may be that passengers might use a phone app or web page to investigate and then order air-taxi journeys. The process would probably resemble current ride-hailing apps where the customer requests a start point and a destination and in return is offered a price, an estimated departure time and an estimated arrival time. In this example the start and end points are vertiports of which we assume there are many.

The operations are certified. The airspace is a Zu volume. Vertiports will have associated arrival and departure routes which will be determined by the needs of safety and social acceptability.

5.6.1 Pre-flight

On receiving a request, the ride hailing app will investigate availability of the vertiports and the candidate vehicle(s). Optimisations involving multiple passengers may be possible but are out of the scope of this simple example. The ride-hailing app is likely to interface with the UAS operator's Operation Plan Preparation / Optimisation service, 3.5.1, which is programmed with the vertiport and route-network and is likely to call the Flight Authorisation service in "test" mode for possible each route to find the best trade-off between speed, cost and so on.

Once the passenger has converted the enquiry into an order, the U-plan can be submitted to the Flight Authorisation service, 3.5.1. If the flight is in conflict then the business logic of the app / operator will determine what solution to follow – one involving more time or more cost.

The plan is simultaneously submitted to the departure and arrival vertiports.

At RTTA, which is presumably very soon after the U-plan is submitted, the operator is usually informed that the flight is conflict free. In cases where there is a conflict, strategic conflicts are solved as previously described using the business logic of the operator to balance cost vs time while meeting the constraints agreed with the vertiports. On occasions this whole process will fail to meet the expectations of the customer and a process of apology may be needed.

The customer finds his/her way to the vertiport and is guided on to the airacrft. Systems or an agent at the vertiport will signal to the remote pilot that the customer is on board, the doors are closed.

5.6.2 In flight

Using the Flight Authorisation service, 3.5.2, the operator activates the U-plan and commences the tactical services required for the airspace, in this case

- network identification service, 3.2.1
- monitoring, 3.10, including conformance monitoring service, 3.10.1
- tactical conflict prediction service, 3.6
- tactical conflict resolution service, 3.7
- traffic information service, 3.14
- emergency management, 3.12
- weather information, 3.8
- navigation infrastructure monitoring, 3.15.1
- communication infrastructure monitoring, 3.15.2
- vertical alert and information service, 3.20

The pilot starts the flight. During the flight the pilot monitors the flight operations while U-space information is overlaid on the flight display. The pilot may communicate with the passenger(s), either directly or via a staff member dedicated to passenger relations.

In Zu, the pilot receives tactical separation instructions form U-space in a form that can be directly uploaded to the aircraft. The pilot strives to maintain the planned arrival time. When the planned arrival time is in jeopardy, the operator may update the plan to operate at higher speed. When tactical manoeuvres delay the flight beyond the planned margin, the operator will replan the operations at the arrival vertiport and perhaps beyond.

The pilot constantly monitors the state of the vehicle and the status of both the nearest vertiport and the destination vertiport. The pilot maintains contingency plans throughout the journey to allow safe landing with different degrees of urgency.

As the UAS approaches the arrival vertiport, the pilot checks the availability of the destination. The aircraft follows a standard arrival path and touches down.

5.6.3 Post flight

Using the Flight Authorisation service, 3.5.2, the pilot ends the flight. The tactical services (listed above) end. The aircraft is made secure. A member of the ground staff opens the doors of the aircraft and those passengers who have reached their destination exit the vehicle.

6 Contingency and Safety

<empty in this version>

7 Social acceptability

Social acceptance of Urban Air Mobility is a key requirement for the economic growth foreseen in the European drones outlook study to happen [30]. For this reason the "General public" is considered a stakeholder of U-space (see **Error! Reference source not found.**) Figure 6) and has a role as authorised viewer of the air situation. In addition to this role, citizens are also the final destination of the drones flights, as UAS delivery client, as UAM passenger. The roles "UAS delivery client" and "UAM passenger" are also direct stakeholders of U-space, and their acceptability are economical. Still people are indirect users of the UAM for HEMS flights. These are performed by law enforcement or emergency responders, but the final goal are always the society.

Numerous surveys have been performed during the last years to assess the opinion of public. While some years ago these surveys focus on the people as "General public", the more recent ones are also evaluating the acceptance in terms of potential market. The results of these surveys are diverse, showing that not all the countries have same expectations or concerns about drones and about urban air mobility. Also gender, age, early/late adopters, education and especially the mission of the drone are aspects that provide different responses to similar questions. Most relevant survey of CORUS-XAUM is the EASA survey published in May 2021 [31]. This survey is recent, addresses European countries and gives insights into the concerns of the "General public", but also on the potential of UAM business growth. Acceptance is directly related with the knowledge of the technology. The survey shows that "Experts" responses are statistically different of General public's responses. When more knowledge has a person about drones, highest is the probability of their acceptance. The survey shows that the early adopters of other technologies are the most potential clients to demand drone services.

On the opposite, General public concerns remain the same since the former surveys. Public concerns are safety (including security and cyber-security), privacy and the potential impact of drones in the environment. Safety is still the number one concern, but its relative weight compared with other concerns is decreasing over the years. The consolidation of the technology and the legislation in place can explain the improvement on safety perception. On the other hand, security and cyber-security are increasing their weight as concerns raised in the survey. Privacy concerns are not so relevant for the public when people are questioned about urban air mobility. As long as the drone is moving to deliver cargo or to transport passengers and does not stop, the privacy is not seen as compromised. By far, the environmental aspects are the option of the concerns that General public mostly selects. And in particular noise. The EASA survey includes a short study about the personal perception of a set of persons subjected to diverse audio inputs. Results show that the volume is not the only factor considered by respondents, but also the knowledge of the source of the noise. Again, more knowledge implies higher acceptance.

As a final remark, European citizens responding the survey reflected high interest on the natural life in the cities, in particular in birds. How drones can affect birds and natural life in the cities is a study that needs to be done and shared with the public. Further actions to improve the societal acceptance of urban air mobility include public campaigns addressed to the general public, transparency and inclusion. Public/private funds are needed to put these actions in place. As per CORUS-XUAM, the ConOps proposes to keep citizens as primary actor of the U-space, with (probably limited) access to the airspace information. In addition, a list of mitigations has been proposed to improve the acceptability of the VLDs [32].

After an analysis of the impact of potential actions and their efficiency and their cost we proposed the following Top ten mitigations:

1. Limit the minimum altitude
2. Establish no-fly zones for drones
3. Identify strategic location for vertiports
4. Public knowledge about drone technology and operations
5. Avoid/limit hovering drone flights
6. Promote the use of renewable energy to recharge batteries. Use of SAF for hybrid drones
7. Ensure proper maintenance processes and controls for batteries to extend their life cycle
8. Work with eco-friendly drones (re-cycling parts)
9. Ensure that the cost of drone services commensurate with the value of the activity
10. Develop a risk and safety culture in drone industry

The proposed mitigations apply mainly to the competent, local and specific authorities, but also to UAM/UAS operators and drone industry. Clearly the design of the urban airspace is a challenging task that will have to be done with the societal concerns in mind.

8 Architecture

This section is used to give to the reader an overview of U-space architecture and required evolutions for UAM. It is not aiming to provide details but the high-level elements and views which are supporting the concept development and understanding with a focus on UAM.

This section contains the following:

- Architecture principles
- Architecture Framework
- Stakeholders and Roles
- Operational processes and Information Exchanges
- A generic system breakdown
- An explanation of the U-space Portal

8.1 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 of information, 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 UAS 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 implementation options.

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.

8.2 Architecture Framework

Architecting has become a decisive process for the successful development of projects aiming to capture all the relevant information from different facets to end-up with a complete, consistent and coherent content. Starting from CORUS project achievements, CORUS-XUAM team has worked to provide U-space stakeholders with a reference architecture from which to build up a realizable U-space for UAM and that will support the future decision making.

Every architecting approach needs an architecture framework, which has a common set of principles and practices for structuring and describing the enterprise/concept, in this case the U-space for UAM.

As for CORUS project, the European Air Traffic Management Architecture (EATMA[3]) was selected to drive the CORUS-XUAM architecture development work. This choice consolidates previous projects achievements and facilitate the integration of the ATM and U-space architecture since EATMA is also the framework used for the research and development activities of ATM and other U-space related projects.

8.3 Stakeholders and Roles

The architecture of a complex system such as that of U-space, brings together different elements and requires operating procedures that involve numerous "players". For this reason, the U-space 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 mainly looking at safety and performance. For this reason, this commitment covers various types of organisations, regardless of their size, ownership model, operational model, or geographical distribution. It includes people, information, processes, and different technologies.

[3] EATMA Guidance Material
https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5b2deab5c&appId=PPGMS

In these paragraph two terms are distinguished which help the reader to easily understand the U-space system. These terms are Stakeholders and Roles. In particular:

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. Therefore, the role element is the means in EATMA to represent the human being.

The mapping from stakeholder to role can be many depending on the scenario to which it refers. In the following table the stakeholders identified in the overall architecture are mapped with the correspondence of roles as indicated in the Operational Framework document:

Stakeholder
UAS operator: is the legal entity, performing one or more UAS operations and is accountable for them.
UAM operator: is the legal entity, performing one or more UAM operations and is accountable for them. A UAM operation is an air transportation operation that carries passenger and/or goods. UAM is a safe, secure and sustainable air transportation system for passengers and cargo in urban environments, enabled by new technologies and integrated into multimodal transportation systems. The transportation is performed by electric aircraft taking off and landing vertically, remotely piloted (in such a case it is a specialisation of **UAS operator**) or with a pilot on board. One of the responsibilities is the booking and potentially it can be considered a new stakeholder to highlight business choices for UAM Booking, in that case it supplies the booking services. Specialisations are envisaged for the urban air transport such as Air taxi booking service provider (allowing the general public to book a journey in an air taxi. It offers mobility as a service (MaaS) and Air delivery booking service provider (allowing anyone who wants to, to book a delivery by air).
UAS manufacturer: has an interest in vehicle and equipment certification processes. The UAS manufacturer or representative may have a role in U-space registration, for example as the provider of UAS characteristics and serial numbers.
U-space Service Provider (USSP): This stakeholder provides one or more of the U-space services as listed in the U-space regulation [8] chapter iv.
Common Information Service Provider: where applicable, provides the services mentioned in the the U-space regulation [8] article 5. The CIS is concerned with the provision of the necessary information for the well-functioning of the ecosystem. Its objective is to ensure that the information comes from trusted sources and that it is of sufficient quality, integrity and accuracy as well as security so that the USSPs and other users such as ASNPs can use this information with full reliability when providing their services.
Supplemental Data Service Provider (SDSP): provides access to supplemental data to support U-space services. E.g., Weather Data Service Provider, Ground risk observation service provider.
CNS Service Providers (CNS): a provider of Communication, Navigation or Surveillance services.

Stakeholder
Air Traffic Service provider: is a provider of air traffic services to airspace users. It can be ATS Aerodrome or ATS Approach service provider.
Aeronautical Information Service Provider (AISP): The provider of a service established within the defined area of coverage responsible for the provision of aeronautical information/data necessary for the safety, regularity and efficiency of air navigation. It has the task of producing the Aeronautical Information Publication, a collection of data describing the geography and procedures of for flying in a given country.
(Airfield/Airport) Aerodrome operator (civil, Military): The aerodrome operator is distinct from the ANSP and has business concerns and legal responsibilities which make them interested in / concerned by UAS flight and U-space procedures.
Vertiport operator: will provide services at a vertiport. Service provision might vary between vertiport for private use and public use. It encompasses passenger and Cargo transport This one operates the facility in a safe and efficient manner including the scheduling of arrivals and departures as well as supplying U-space with information about the aerodrome's status and capacity to accommodate incoming aircraft.
Competent Authority: Generic term to encompass national or local civil aviation authority, or some entity delegated by them. • *Roles:* Registrar, Authorised viewer of air situation, Airspace access authorization Workflow Representative, Capacity Authority
Authority for safety and security (police, fire brigade, search and rescue orgs): Authorities involved in preparation and supervision of the operations of law enforcement such as police, security, military, homeland security that are responsible for law enforcement methods. *Roles:* Police or security agent, UAS specific aeronautical information originator
Emergency Responders: Organisations involved in preparation and execution of emergency operations such as fire brigade, emergency, first aid, Search and Rescue (SAR).
Local and specific authorities: city / region / prefecture / county / canton / state - support the definition of operating procedures and rules.
UAS delivery client: The clients of the delivery service
UAM passenger: Generic beneficiary of safe, secure and sustainable air transportation system for living being e.g. the air-taxi passenger rides in an air taxi UAM operation.
Airspace User (other than UAS/UAM): include scheduled airlines, charter companies, cargo and air freight service providers, the business and leisure aviation sectors and all forms of non-military air travel, from hot air balloons through police helicopters to general aviation pilots. *Roles*: Pilot, Authorised viewer of air situation
General Public: representing those who may hear, see or otherwise be concerned by a UAS • *Roles*: Citizen, Authorised viewer of air situation

Table 5: Stakeholder

Figure 6 shows as a whole the stakeholders identified in the previous table, aggregating those with "similar" characteristics together with those who are involved in the U-space, but in an "indirect" way, such as UAS delivery clients and air taxi passengers.

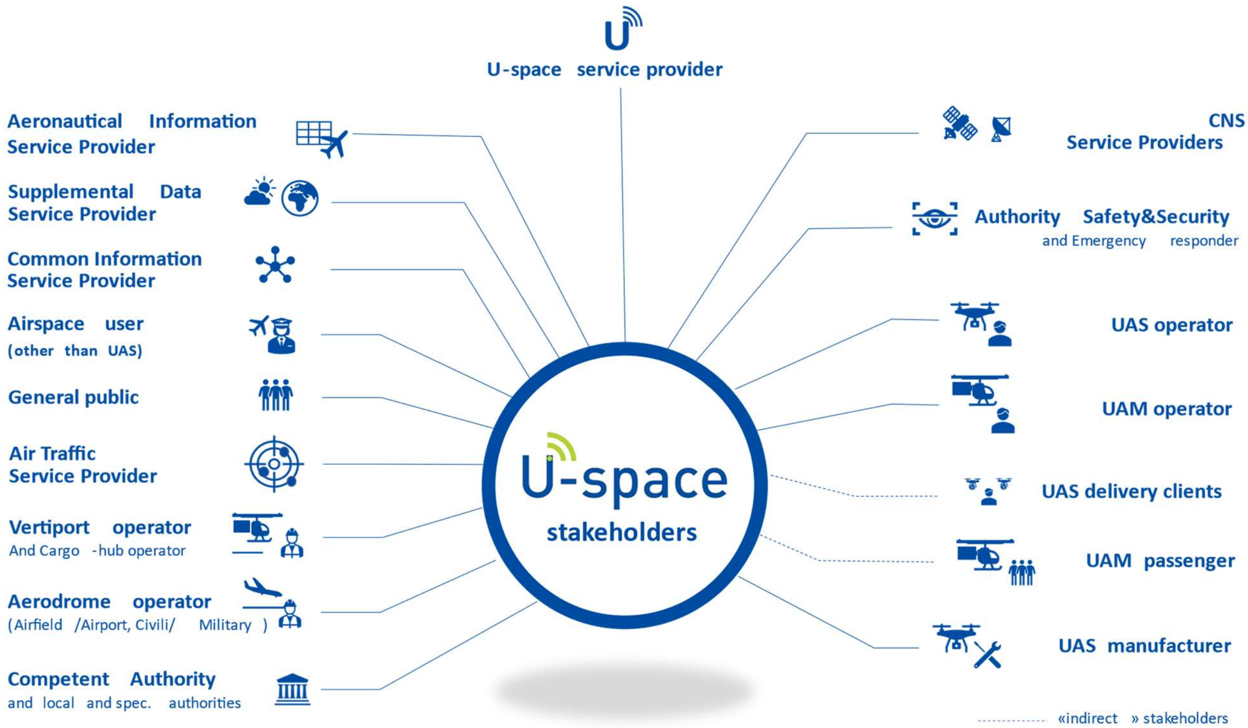


Figure 6: Stakeholders

8.4 Operational processes and Information Exchanges

From an operational point of view, Figure 7, below shows, independently of any physical realisation, high level operational processes (the blocks which represent the stakeholder and relevant activities) and information exchanges among these processes (the arrows between blocks). Figure 7 mainly focuses on U-space traffic management operations.

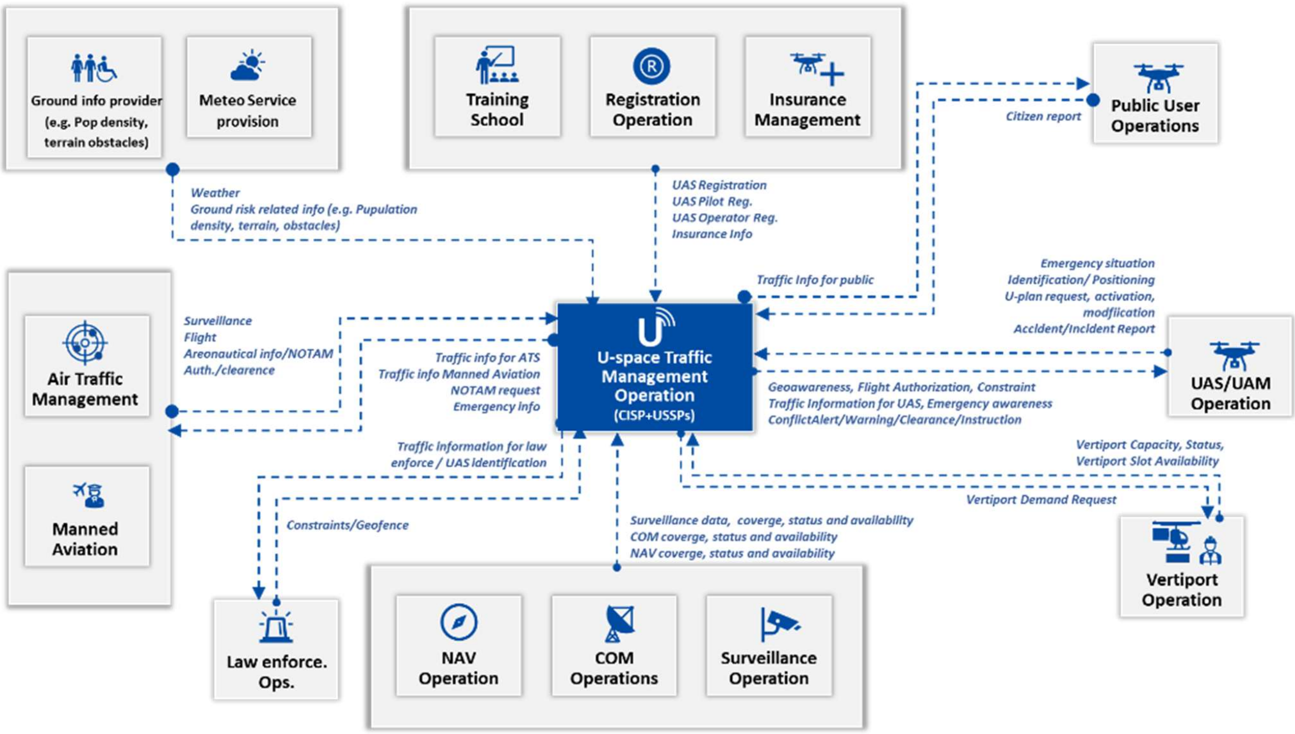


Figure 7: information exchanges, informal presentation

Information exchanges will be focused in order to provide the right information at right people and time, in order to comply with safety, security and privacy requirements. These interactions, named Information Exchanges, describe then the operational needs that are required to be covered in implementation with the provision and consumption of data by technical systems through U-space services.

8.4.1 An example of an operational process

In addition to the static information diagram shown in Figure 7, it is crucial to understand the sequence of activities that have to be performed by the stakeholders in a specific scenario. Like this, the responsibilities of each stakeholder would be defined.

So far 12 business process models or operational processes have been developed in the context of CORUS-XUAM. Several of them continue the work presented in the U-space ConOps Ed.3, but others have been newly defined due to the entrance of the UAM, whose vertiports would play an important role in the U-space. All these business process models can be consulted in the Section 8.6 U-space Portal.

Figure 8 illustrates an example of the process defined for the departure from a vertiport is shown.

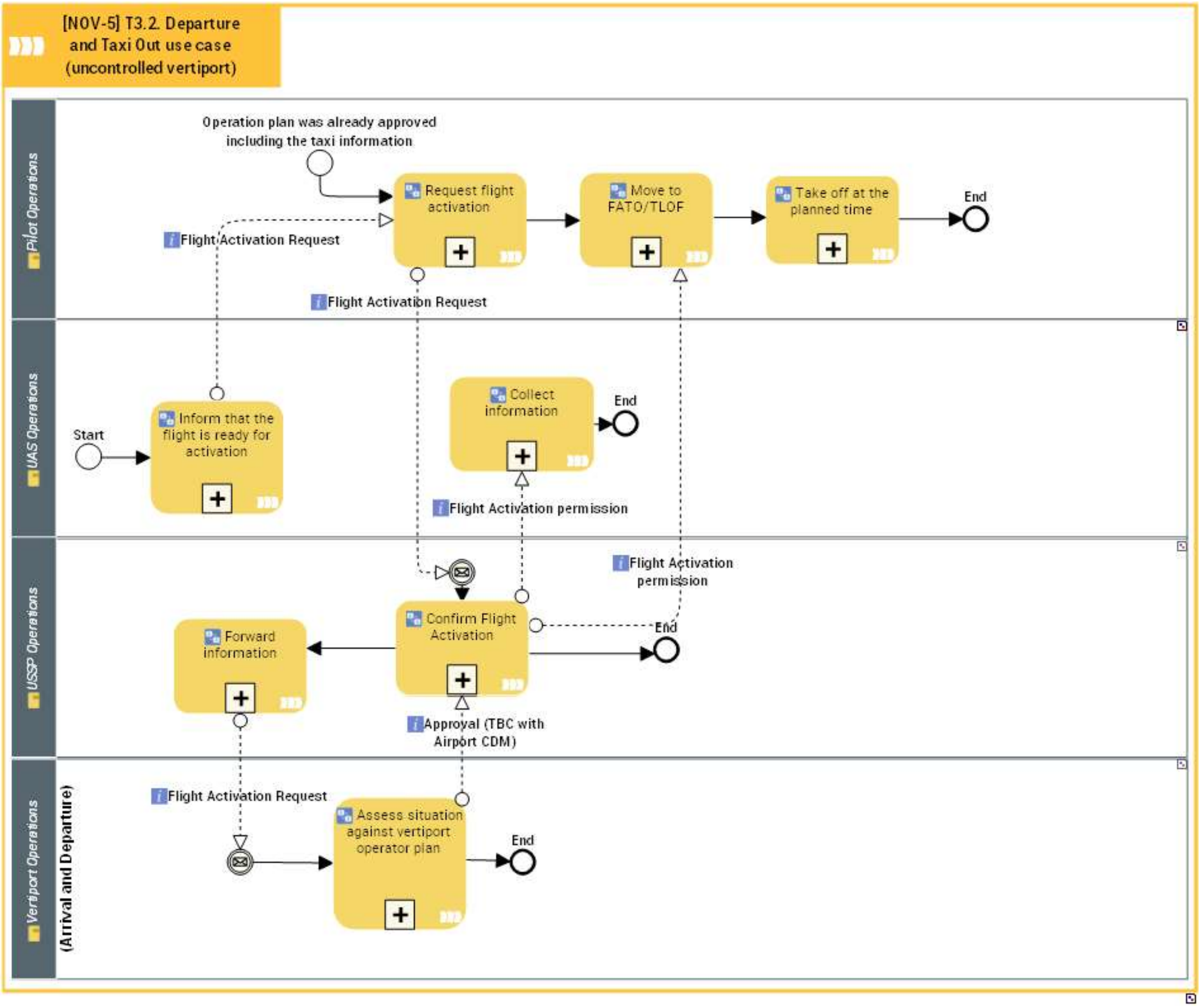


Figure 8: Operational use case for the departure from a vertiport

8.5A generic system breakdown

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 or centralised responsibilities for Common Information services and the interoperability among several USSPs. Deployment solutions envisage the possibility of centralised or distributed alternatives. This document does not push any position on what shall be centralised and what can be executed in distributed way.

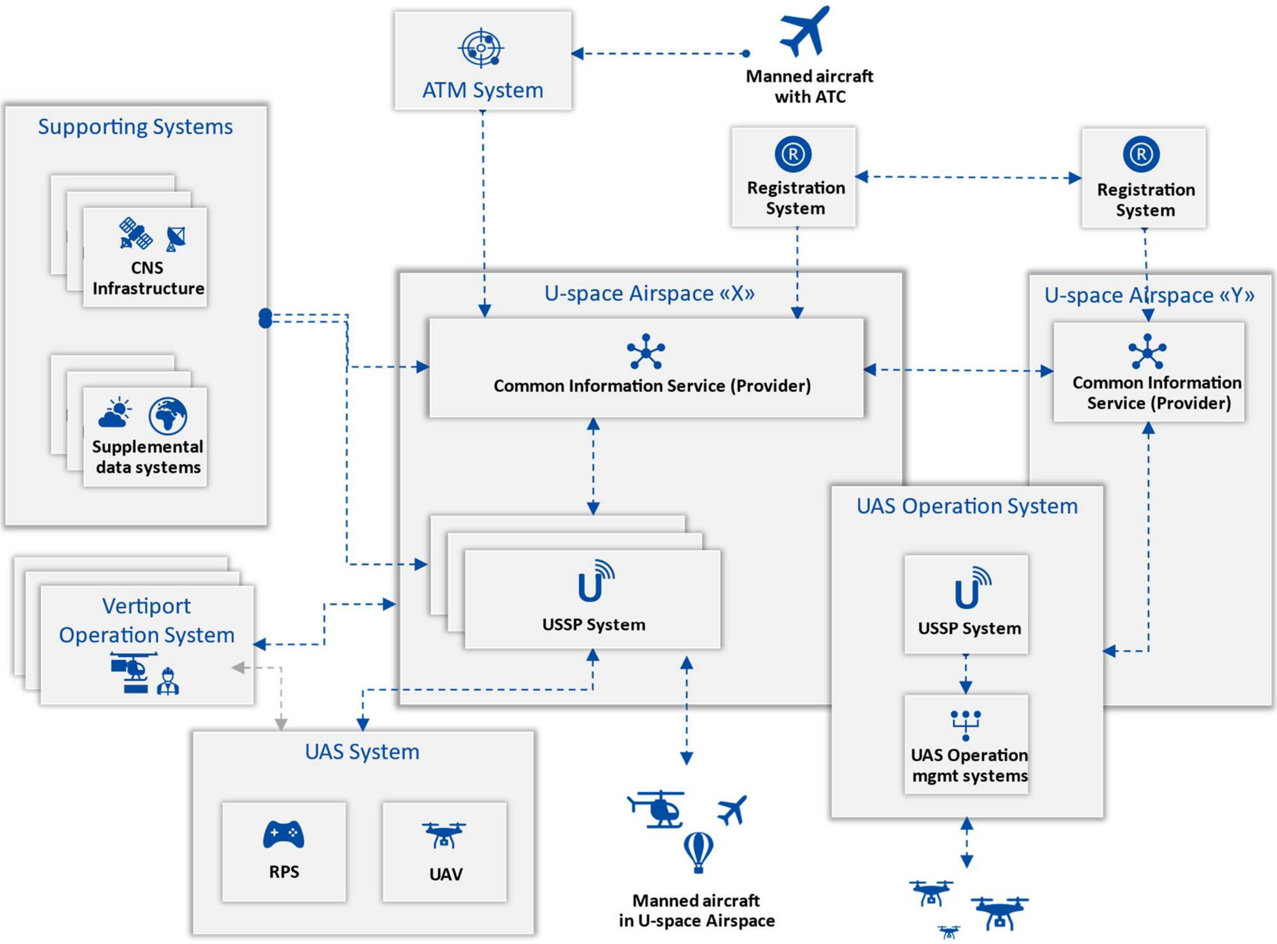


Figure 9: Generic U-space system breakdown

Figure 9 provides an overview of possible interfaces among systems for both monolithic and federated options.

Supplemental data system is encompassing the MET, Terrain and Obstacles ones. CNS Infrastructure represents the physical systems for Communication, Navigation and Surveillance including the services providing information about status and coverage. ATM System includes mainly the AIM system and Air Traffic service unit systems. More details on the EATMA portal.

Validation and demonstration activities will provide evidence of these architecture options.

8.6 U-space Portal

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-XUAM becomes a critical milestone for the future work to be performed on U-space.

Therefore, in continuation with CORUS work, CORUS-XUAM team has decided to show the architecture in a web based portal (https://www.eatmportal.eu/working/signin). This portal shows the CORUS-

XUAM U-space architecture. Therefore, it will allow the future U-space architects to easily access the reference material to continuously enhance and develop in a consistent way the future U-space.

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).

9 Regulatory context

The European regulatory context for "Uncrewed" aviation at the time this document is written is described here as it influences the contents of this document.

Aviation is subject to national law. National law for aviation is greatly shaped by international treaties.

All European states except Liechtenstein have ratified the Chicago Convention on International Civil Aviation, the founding document of ICAO. Some national exemptions exist to specific ICAO regulations.

All European Union member states, as well as some European countries, follow the regulations developed by EASA, the European Aviation Safety Agency.

"Crewed" aviation is well described in the regulations issued by the two (see references [12], [13], [14], [15], for example) and corresponding national law. "Uncrewed" aviation is partly covered by these aviation regulations. Specific regulations for "uncrewed" aviation have been developed by EASA. These are:

- 2019/947[4] [4] *on the rules and procedures for the operation of unmanned aircraft* and its corresponding acceptable means of compliance and guidance material (AMC-GM) [6]
- 2019/945 [5] *on unmanned aircraft systems and on third-country operators of unmanned aircraft systems* and its corresponding AMC-GM [7]
- 2021/664 [8] *on a regulatory framework for the U-space.*
- 2021/665 [9] *amending Implementing Regulation (EU) 2017/373 as regards requirements for providers of air traffic management/air navigation services and other air traffic management network functions in the U-space airspace designated in controlled airspace*
- 2021/666 [10] *amending Regulation (EU) No 923/2012 as regards requirements for manned aviation operating in U-space airspace*
- As the time of writing a draft AMC-GM for 2021/664, 5, 6 has been circulated for comment [11]. The final AMC-GM is not yet available.

Key points of these European regulations are:

Flights are categorised by risk. The lowest risk are known as Open category, then Specific, then Certified. There are requirements on the aircraft in order for a flight to be in a given category.

Geographic zones may be created to manage (limit or enable) drone flight. These resemble Restricted Areas.

Some geographic zones will require the use of U-space services by UAS operators. These zones are referred to as U-space airspaces, see 2.3.3. Four U-space services are always mandated: Network Identification, Geo-awareness, Flight authorisation and Traffic information. The competent authority may also mandate either of two others; Weather information and Conformance monitoring. A

[4] European regulations are named for the year they are issued and a sequence number. Either the year or sequence number may be written first. 2019/947 may be referred to as 947/2019

mapping of the services described in EU regulation 2021/664 to those described in this ConOps can be found in Table 3.

Current EU regulation seems to cover initial U-space operations with “low” traffic. The expected evolution of U-space is described in Section 1.4.

10 References, Terms, Acronyms

[1] U-space ConOps, 3rd Edition, CORUS Consortium https://www.eurocontrol.int/project/concept-operations-european-utm-systems

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

[3] 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

[4] Commission Implementing Regulation (EU) 2019/947 of 24 May 2019 on the rules and procedures for the operation of unmanned aircraft (Text with EEA relevance.) https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1560259925294&uri=CELEX:32019R0947

[5] Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1560259925294&uri=CELEX:32019R0945

[6] Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Commission Implementing Regulation (EU) 2019/947 https://www.easa.europa.eu/sites/default/files/dfu/AMC%20%26%20GM%20to%20Commission%20Implementing%20Regulation%20%28EU%29%202019-947%20%E2%80%94%20Issue%201.pdf

[7] Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Part-UAS UAS operations in the 'open' and 'specific' categories https://www.easa.europa.eu/sites/default/files/dfu/AMC%20%26%20GM%20to%20Part-UAS%20—%20Issue%201.pdf

[8] Commission Implementing Regulation (EU) 2021/664 - https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R0664

[9] Commission Implementing Regulation (EU) 2021/665 - https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R0665

[10] Commission Implementing Regulation (EU) 2021/666 - https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R0666

[11] Proposed acceptable means of compliance and guidance material for EU regulations 2021/664, 2021/665 and 2021/666 as Notice of Proposed Amendment 2021-14 https://www.easa.europa.eu/document-library/notices-of-proposed-amendment/npa-2021-14

[12] EU Regulation 2012/923, SERA, Standard European Rules of the Air - https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012R0923

[13]ICAO Annex 2 - Rules Of The Air Annex 2 - Rules Of The Air | ICAO Store

[14]ICAO Annex 11 - Air Traffic Services https://store.icao.int/en/annex-11-air-traffic-services

[15]ICAO Annex 14, Aerodromes. https://store.icao.int/en/annex-14-aerodromes

[16]ICAO Heliport Manual – Doc 9261 https://store.icao.int/en/heliport-manual-doc-9261

[17]ICAO Global Air Traffic Management Operational Concept – Doc 9854 https://store.icao.int/en/global-air-traffic-management-operational-concept-doc-9854

[18]ASTM F3548-21 Standard Specification for UAS Traffic Management (UTM) UAS Service Supplier (USS) Interoperability – see https://www.astm.org/f3548-21.html

[19]Inter-USS: https://github.com/interuss

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

[21]JARUS SORA package. http://jarus-rpas.org/content/jar-doc-06-sora-package

[22]OECD Definition of Functional Urban Areas (FUA) for the OECD metropolitan database September 2013 https://www.oecd.org/cfe/regionaldevelopment/Definition-of-Functional-Urban-Areas-for-the-OECD-metropolitan-database.pdf

[23]Volocopter's internal presentation prepared based on discussions in EASA RMT.0230 Working group on Vertiports design

[24]European Union Aviation Safety Agency, 'Special Condition Vertical Take-Off and Landing (VTOL) Aircraft'. Jul. 02, 2019. Accessed: Oct. 22, 2020. [Online]. Available: https://www.easa.europa.eu/sites/default/files/dfu/SC-VTOL-01.pdf

[25]BUBBLES project deliverable 4.1, "Algorithm for analysing the collision risk". https://www.bubbles-project.eu/wp-content/themes/bubbles/Deliverables/BUBBLES_D4.1_Algorithms%20for%20analysing%20the%20collision%20risk_Ed_01.01.00.pdf

[26]BUBBLES project deliverable 4.2, "Guidelines to implement separation minima & methods", https://www.bubbles-project.eu/wp-content/themes/bubbles/Deliverables/BUBBLES_D4.2_Guidelines%20to%20implement%20separation%20minima%20and%20methods_Ed_01.00.00.pdf

[27] "Market Design for Drone Traffic Management", Seuken, Friedrich, Dierks, https://www.aaai.org/AAAI22Papers/SMT-00225-SeukenS.pdf

[28] ICARUS project https://www.u-spaceicarus.eu/

[29]DACUS deliverable D1.1, Drone DCB concept and process https://dacus-research.eu/wp-content/uploads/2021/03/DACUS-D1.1-Drone-DCB-concept-and-process_01.00.00.pdf

[30] SESAR JU, "European Drones Outlook Study. Unlocking the value for Europe", Nov 2016.

[31] EASA, "Study on the societal acceptance of Urban Air Mobility in Europe", May 2021.

[32] Çetin E. et al, "Implementing Mitigations for Improving Societal Acceptance of Urban Air Mobility", MDPI Drones 2021.

[33] https://www.airbus.com/en/products-services/commercial-aircraft/the-life-cycle-of-an-aircraft/operating-life

[34]https://www.boeing.com/assets/pdf/commercial/aircraft_economic_life_whitepaper.pdf

[35]EASA Guidance Material for Design of VFR Vertiports - https://www.easa.europa.eu/document-library/general-publications/prototype-technical-design-specifications-vertiports

The following acronyms appear in the text

Acronym	Expansion	remarks
AGL	Above Ground Level	Height measured relative to the ground directly below.
AIP	Aeronautical Information Publication	A publication issued by or with the authority of a State and containing aeronautical information of a lasting character essential to air navigation (ICAO Annex 15).
AMC-GM	Acceptable Means of Compliance – Guidance Material	AMCs are non-binding standards adopted by EASA to illustrate means to establish compliance with the Basic Regulation and its Implementing Rules. Guidance Material provides solutions to reach that goal.
API	Application Programming Interface	Software solution which allows two applications to communicate.
ASTM	American Society for Testing and Materials	
ATC	Air Traffic Control	Used to inform that the control service is provided by an ATC unit.
ATS	Air Traffic Services	Three services are provided by Air Traffic Controller, depending on the airspace class and his knowledge of the traffic: control, information and alert.
BVLOS	Beyond Visual Line Of Sight	UAS operation where the aircraft is beyond visual line of remote pilot's sight.
C2 link	Command and Control Link	Radio or satellite link between the remote pilot station and the aircraft.
CIS	Common Information Service	Common information service is a service consisting in the dissemination of static and dynamic data to enable the provision of U-space services for the management of traffic of unmanned aircraft.
CNS	Communication Navigation Surveillance	Are the foundation of the aviation operational performance, enabling airspace capacity.

Acronym	Expansion	remarks
CSFL	Continued Safe Flight and Landing	Continued safe flight and landing means an airplane is capable of continued controlled flight and landing, possibly using emergency procedures, without requiring exceptional pilot skill or strength.
CTR	Controlled Traffic Region	Volume of controlled airspace set for protecting departures and arrivals to or from an aerodrome.
DCB	Demand and Capacity Balancing	Process used to minimise disruption and optimises operations using powerful, accurate forecasting that balances demand with capacity allowing to anticipate and mitigate disruption.
DFR	Digital flight rule	A term used in what is currently research at NASA See https://ntrs.nasa.gov/citations/20205008308
EASA	European Aviation Safety Agency	The European Union Aviation Safety Agency (EASA) is an agency of the European Union (EU) with responsibility for civil aviation safety.
EATMA	European ATM Architecture	EATMA is the European ATM architecture reference.
EDAS	EGNOS Data Access Service	The EGNOS Data Access Service (EDAS) offers ground-based access to EGNOS data through the Internet on a controlled access basis. EDAS is the single point of access for the data collected and generated by the EGNOS ground infrastructure - mainly Ranging and Integrity Monitoring Stations (RIMS) and Navigation Land Earth Stations (NLES) - distributed over Europe and North Africa. See https://egnos-user-support.essp-sas.eu/new_egnos_ops/services/about-edas
EGNOS	European Geostationary Navigation Overlay Service	Europe's regional satellite-based augmentation system (SBAS). It is used to improve the performance of global navigation satellite systems (GNSSs), such as GPS and Galileo in the future. EGNOS was deployed to provide safety of life navigation services to aviation, maritime and land-based users. See https://egnos-user-support.essp-sas.eu/new_egnos_ops/egnos-system/about-egnos
EU	European Union	The European Union (EU) is a political and economic union of member states that are located on the European Continent.
EVTOL	Electric Vertical Take Off and Landing	Electric powered aircraft capable of vertical take-off and landing.
FATO	Final Approach and Take-off	Area designed to allow take-off and landing of VTOL aircraft.
GAMZ	Geodetic Altitude Mandatory Zones	A region of airspace in which Geodetic Altitudes should be used. See 2.3.4
GCS	Ground Control Station	Part of a UAS. Synonymous with Remote Piloting Station

Acronym	Expansion	remarks
GME	Ground Movement Equipment	
GNSS	Global Navigation Satellite System	With a global coverage, the system allows satellite navigation everywhere on earth.
HEMS	Helicopter Emergency Medical Service	Helicopter in charge of moving patients from an area to another. It could be from an accident scene to a healthcare facility such as hospital or between two hospitals for instance.
HMI	Human Machine Interface	The Human Machine Interface allows interactions between a machine and a human in charge of using it.
ICAO	International Civil Aviation Organization	A United Nations agency in charge of proposing and recommending principles and techniques in order to foster and harmonize aeronautical practices in the world.
IFR	Instrument Flight Rules	Defined in ICAO Annex 2 [13]
JARUS	Joint Authorities for Rulemaking on Unmanned Systems	Group of experts from the National Aviation Authorities (NAAs) and regional aviation safety organizations. Its purpose is to recommend a single set of technical, safety and operational requirements for the certification and safe integration of Unmanned Aircraft Systems (UAS) into airspace and at aerodromes (source JARUS LinkedIn page).
LUC	Light UAS operator Certificate	Certificate issued to a UAS operator by a competent authority (see COMMISSION IMPLEMENTING REGULATION (EU) 2019/947 of 24 May 2019 on the rules and procedures for the operation of unmanned aircraft, part C).
Maas	Mobility as a service	A shift from personally owned transport to mobility consumed as a service
MET	METeorology	What is related to meteorological data and information.
MSL	Mean Sea Level	Heights above Mean Sea Level have equal gravitational potential.
OECD	Organisation for Economic Co-operation and Development	Intergovernmental organization which goal is to stimulate economic progress and world trade.
PVT	Position Velocity Time	Third mode of motion, position-velocity-time (PVT) mode, allows the same ease of coordination as contour mode, but removes velocity discontinuities.
RPS	Remote Pilot Station	Part of the UAS or RPAS, such as the RP (remote pilot) or the RPA (remotely piloted aircraft). RPS encompasses, at least, the functionalities allowing the remote pilot to steer and navigate the remotely piloted aircraft.
RPS	Remote Piloting Station	Part of a UAS. Sometimes also called Ground Control Station
RTTA	Reasonable Time To Act	RTTA is an agreed amount of time before the activation of the U-plan.

Acronym	Expansion	remarks
SAR	Search And Rescue	Organisation and operations of localisation and rescue of people in distress.
SDSP	Supplemental Data Service Provider	Provides access to supplemental data to support U-space services. E.g., Weather Data Service Provider, Ground risk observation service provider.
SERA	Standardised European Rules of the Air	SERA is the transposition into law of ICAO Annex 2 (Rules of the Air) and parts of ICAO Annex 3 (Meteorology), Annex 10 (Communication Procedures), Annex 11 (Air Traffic Services) and Doc 4444 (PANS-ATM). (Source https://www.caa.co.uk/).
SESAR (JU)	Single European Sky ATM Research (Join Undertaking)	The SESAR Joint Undertaking is an institutionalised European partnership between private and public sector partners set up to accelerate through research and innovation the delivery of the Digital European Sky (source sesarju.eu).
SORA	Specific Operation Risk Assessment	Methodology to assess the safety risk of a UAS operation in the specific category.
SVFR	Special Visual Flight Rules	Special VFR flight' means a VFR flight cleared by air traffic control to operate within a control zone in meteorological conditions below VMC (Source SERA).
TLOF	Touchdown and Lift-Off	A load bearing area on which a helicopter may touch down or lift off (Annex 6 Part III).
UAS	Uncrewed Aerial System	Also expanded as 'Unmanned Aerial System.' A UAS may carry passengers but in normal operations is being piloted remotely or autonomously. The term "system" denotes a combination of the vehicle and other parts needed to make it work such as the remote piloting station
UFR	U-space Flight Rules	Flight rules to be followed by any aircraft flying in a U-space airspace.
UFR	U-space flight rule	Defined in this document. See section 4 May be the same as DFR.
UMZ	U-space Mandatory Zone	Zone in which aircraft shall be required to make their position known to U-Space through a defined procedure.
USSP	U-space Service Provider	This stakeholder provides one or more of the U-space services as listed in the U-space regulation[8]
UTM	UAS Traffic Management	UTM is a traffic management ecosystem for UAS operation.
VALS	Vertical ALert and information Service	Alerts GA pilots, drones and their pilots in any Geodetic Altitude Mandatory Zones (GAMZ) to any risk of collision with ground obstacles.
VCS	Vertical Conversion Service	Ensures the conversion of altitudes between barometric and geodetic reference systems to both manned and unmanned aircraft in Geodetic Altitude Mandatory Zones.

Acronym	Expansion	remarks
VFR	Visual Flight Rules	Defined in ICAO Annex 2 [13]
VLL	Very Low level	Part of airspace from ground to 500 feet above the ground.
VLOS	Visual Line Of Sight	UAS operation where the aircraft is in sight the remote pilot.
VTOL	Vertical Take-Off and Landing	Aircraft capable of vertical take-off and landing (e.g., helicopter).
V-TZ	Vertiport Traffic Zone	Is a zone around a vertiport designed for protecting vertiport arrivals and departures. This zone is a U-space airspace.

Table 6 Acronyms

The following terms appear in the text

Term	Meaning	Source / remarks
Aircraft	Vehicle that derives lift from the air	May have the pilot / aircrew on board or not.
Below	In the direction towards the gravitational centre of the earth	
Crewed aircraft	Aircraft with a human pilot (air crew) on board	May also be written as 'manned aircraft'
Drone	Aircraft without a human pilot (air crew) on board	May be any size. Synonym of Un-crewed aircraft and UA
Uncrewed aircraft	Aircraft without a human pilot (air crew) on board	Synonym of Drone. Sometimes shortened to UA.
U-plan	A plan for a flight in U-space	

Table 7 Terminology

CRIDA I+D+i - ATM	nais NEXTANT APPLICATIONS AND INNOVATIVE SOLUTIONS	m3 systems
IBG Independent Business Group	DTA DISTRETTO TECNOLOGICO AEROSPAZIALE	CITYMESH