UAS ATM Integration

Operational Concept

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This document has been developed by EUROCONTROL in partnership with the European Aviation Safety Agency (EASA).

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EXECUTIVE SUMMARY

The safe and efficient integration of unmanned aircraft systems (UAS) into air traffic management (ATM) is one of the major challenges in aviation in the first half of the 21st century. UAS – including Remotely Piloted Aircraft Systems (RPAS) and automated air vehicles, including driverless personal air vehicles (DPAV) - are increasingly becoming a part of our day-to-day lives. The vast range of their possible uses has created a new industry with a large economic potential. Technological developments are arriving at a much faster pace than for manned aviation.

Much of the current body of UAS regulation has been written as a reaction to market developments and emerging risks. Harmonisation has not been achieved, therefore, and this affects the ATM perspective. The volume of operations has expanded and has to co-exist with manned aviation on a larger scale, creating the need for this UAS ATM Operational Concept that describes operations in European Airspace of UAS capable of meeting the requirements set for each airspace classification. This includes operations below 500ft and above FL600. It is presented from a high-level ATM perspective and is fully complementary to the EASA Opinion and the detailed CONOPS being defined by the SESAR/H2020 CORUS project.

ICAO has specified four main requirements for UAS-ATM integration:

- The integration of UAS shall not imply a significant impact on current users of the airspace;
- UAS shall comply with the existing and future regulations and procedures laid out for manned aviation;
- UAS integration shall not compromise existing aviation safety levels nor increase risk more than an equivalent increase in manned aviation would.
- UAS operations shall be conducted in the same way as those of manned aircraft and shall be seen as equivalent by ATC and other airspace users.

This operational concept defines two new sets of flight rule-based operation: low-level flight rules (LFR), below the normal minimum VRF height of 500ft in what is termed very low-level airspace (VLL), and high-level flight rules (HFR), above FL600.

The concept is primarily based on traffic classes, not UAS categories or airspace classes, within these types of operation.

- ➔ Type of operation - based on flight rules: LFR, IFR/VFR, HFR
  - ➔ Class of traffic: Class I, II, III, etc.
    - ➔ Class of airspace: Class A-G
      - ➔ Category of UAS - Open, Specific, and Certified (from EASA Opinion [EASA, 2018])

A two-step approach is defined for integrating IFR-capable UAS into controlled airspace, with accommodation mostly possible through FUA/AFUA techniques during ASBU Block 1 (until 2025), then full integration with the necessary SARPS from ASBU Block 2 (from 2025). In Europe the accommodation phase can easily be maintained due to the relatively low number of UAS operations.

VFR operations pose additional challenges compared with IFR. The “see and avoid” principle used for separation and collision avoidance in uncontrolled airspace must be replaced by a technical “detect and avoid system” (DAA) of the same level of confidence as, and compatible with, current “see and avoid". Despite promising results towards finalising such a system and operationally validating it, it is unlikely that full integration into VFR airspace can occur before around 2030 (ASBU Block 3).

Due to the limited use of airspace above FL600, both by manned aviation (mostly military) and prospective UAS, UAS operations in this airspace may be accommodated for the near future.

LFR operations are linked to the implementation of services under U-Space, with accommodation up to around 2021 (U-space U1) through national rules and regulations, and integration from 2021 onwards (U-space U2), with harmonised rules and standards, and the deployment of the adequate infrastructure and capabilities.

This UAS ATM operational concept is published in conjunction with three discussion documents on subjects vital to its implementation: flight rules, airspace assessment, and a common altitude reference system.

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FOREWORD

The UAS air traffic management (ATM) operational concept aims to describe the operational ATM environment in which manned and unmanned aircraft must co-exist safely, including the airspace below 500ft. The planning horizon is up to and beyond 2025. The baseline against which the significance of the changes proposed in the operational concept may be measured is the present European ATM environment in 2018.

While the operational concept is visionary and even challenging, many of the current practices and processes will continue to exist through the planning horizon. In this sense, this operational concept document should be seen as evolutionary.

A key point to note is that the operational concept is, to the greatest extent possible, independent of technology; that is, it recognises that within a planning horizon of more than ten years, much of the technology that exists or is in development today may change or may cease to exist and be replaced by new, as yet unknown, technologies.

An operational concept is a statement of “what” is envisaged. It asks and answers the question of what outcomes are required for UAS integration into the ATM system of the future. It is a vision statement. It is not a technical manual or blueprint; nor does it specify “how” things will be enabled; that lies in lower documents in the hierarchy, which may include concepts of operation or use, technical standards and strategic plans.

1 INTRODUCTION

Unmanned Aircraft Systems (UAS)[1] - Remotely Piloted Aircraft Systems (RPAS) and automated air vehicles, including driverless personal air vehicles (DPAV) (Volocopter, Kittyhawk, Vahana, etc.) - are increasingly becoming a part of our day-to-day lives. The vast range of their possible uses has created a new industry with a large economic potential. Technological developments are arriving at a much faster pace than for manned aviation. The worlds of manned and unmanned aircraft must be integrated in a safe and efficient way since both types of aircraft will use the same airspace.

As much of the current body of UAS regulation has been written as a reaction to market developments and emerging risks, harmonisation has not been achieved and this affects the Air Traffic Management (ATM) perspective. As the volume of operations has expanded and has to co-exist with manned aviation on a larger scale[2], the need for a UAS ATM Operational Concept has become a necessity.

This document describes the operations in European Airspace of UAS that are capable of meeting the requirements set per airspace classification, including operations below 500ft and above FL 600[3]. In anticipation of both an expansion of UAS traffic and its interaction with current manned traffic, this operational concept is presented from an ATM perspective and is fully complementary to the EASA Opinion and CORUS CONOPS.

Full implementation of this operational concept is expected to begin after 2023, when the necessary documents, rules and technologies will be available to enable seamless and safe integration of UAS into ATM. Some, perhaps extensive, safe operations could be foreseen in the near future (as early as 2019) as some low-altitude services become progressively available.

There are several reasons for changing the name of the original RPAS CONOPS to "UAS ATM Operational Concept": the use of the abbreviation RPAS by ICAO to cover only international IFR; the use of the abbreviation sUAS for smaller UAS; and the change of scope of this document in the light of other UAS-ATM CONOPS being developed by, for example, the CORUS project. This operational concept will use the term UAS (and UA for the air vehicle part of the unmanned aircraft system) throughout, to the exclusion of sUAS, RPAS, drone, etc. It will cover all types of operation from remotely piloted to fully automated ones.

The UAS ATM Operational Concept is a "living document" that will be updated when required. It describes the “what” and as such must be seen as a visionary perspective. The “how” will have to be validated through R&D. This, together with lessons learnt during deployment and implementation, will lead to improvements in the maturity of the operational concept.

[1] All Unmanned Aircraft Systems (UAS), including Remotely Piloted Aircraft Systems (RPAS)

[2] UAS operations are already disturbing the local traffic in some terminal airspaces.

[3] This level may differ depending on local regulation. In this operational concept it is set at 60,000ft purely as an example.

1.1 PROBLEM STATEMENT

The rapid growth in civil and military UAS has increased the demand for access to non-segregated airspace. The absence of a pilot on-board the aircraft means that technical solutions and procedures will have to be developed to integrate the aircraft into non-segregated airspace. Manned-aviation is expected to manage dangerous situations such as potential collisions with other airspace users, clouds and severe weather conditions, obstacles and ground operations at aerodromes through the ability of a pilot to "see and avoid" these hazards. The absence of a pilot on-board also brings the challenge, therefore, of replicating this ability on the UAS, a concept known as "detect and avoid (DAA)".

The use of small UAS at lower altitudes is now a driving force for economic development. Many of these operate at altitudes below 500ft above ground level (AGL). According to the Standardised European Rules of the Air (SERA) [EU, 2016], 150m/500ft is the lowest available VFR altitude (300m/1,000ft above towns), and thus creates a possible boundary between smaller UAS and manned aircraft. However, many VFR flights that have a good justification are authorised below 500ft AGL by competent authorities. Large numbers of small, undetectable UAS coexisting with manned operations below this altitude poses a safety challenge. Additionally, considering that the justification for setting the general minimum flying height of aircraft flying VFR at 500ft AGL is related to the protection of persons and property on the ground, the risk associated with UAS operating below 500ft AGL should be carefully considered.

For now, no restrictions have been put in place regarding the maximum number of small UAS allowed to operate in a certain area.

Integration of UAS into the airspace between 500ft and 60,000ft as either IFR or VFR is challenging due to the fact that UAS will have to fit into the ATM environment and adapt accordingly. Many UAS aspects such as latency and see and avoid have never been addressed before within this environment for manned aviation, simply because a pilot is on-board the aircraft, capable of handling these issues in a safe and timely manner. Also, these human capabilities have never been fully translated into system performance as they were placed under “good airmanship” for see and avoid, or simply not addressed at all.

Unmanned aircraft will not only be encountered at low altitudes but also in the higher altitudes bands (i.e. above FL 600), normally used for specific military aircraft.[4]

Manned aviation is considered acceptably safe due to the contributions of many factors such as initial airworthiness (design, manufacturing quality), continuing airworthiness (maintenance) and operational approvals, the ATC system, safety nets, cockpit automation, etc., together with many years of experience and the diligent application of lessons learned from safety events. These factors are now challenged by the introduction of a new type of airspace user, with a large number of flights, of different types and sizes, and with performance envelopes greatly different from those for which today's air traffic procedures were designed. This challenge lies in the quantification of these safety

[4] Private companies such as Facebook, Google and others are looking at the use of high-altitude unmanned aircraft to provide a pan-European 4G network in remote areas around the world. Such operations will take place above FL600 for weeks on end, but they will have to use the lower airspace volumes to reach or return from their operational environment. This can impact traffic flows and the ATC system. Facebook intends to use 6000 solar powered aircraft and Google, 12000 unmanned balloons to achieve this.

attributes, due to the introduction of new aspects such as latency of communications[5], automation and contingency[6]. It also shows up potential areas where improvements are required in manned aviation (e.g. for a more efficient "See and Avoid" rule).

1.2 SCOPE

This operational concept aims to describe the operational ATM environment, including the airspace below 500ft, of manned and unmanned aircraft, thereby ensuring a common understanding of the challenges, and aims to create a level playing field for all the ATM players involved.

It considers all types of unmanned operation and makes no distinction between civil or military operations, as the integration challenges are identical. This operational concept is aligned as closely as possible with the ICAO Global Air Navigation Plan (GANP) [ICAO, 2016a], supports the EASA opinion [EASA, 2018] and addresses all phases of flight.

This operational concept does not describe or address different detailed scenarios, but provides an operational ATM perspective based on areas of operation;

- Ground to the lowest VFR altitude (generally 500ft AGL)
- From the general minimum VFR flying height (generally 500ft AGL) up to FL600[7] (including aerodromes)
- Above FL600 (depending on the state).

The transition from the present time-frame until full establishment of this UAS ATM operational concept is described in the Appendixes.

1.3 INTENDED AUDIENCE

This is a high-level document and as such may be read by anyone needing to understand the general operational concept behind integrating UAS into the airspace. This includes manufacturers, pilots, and operators of UAS; ANSPs and national airspace regulators; manufacturers of UTM equipment and apps; etc.

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[5] Delay experienced in the communication between the remote pilot and the air traffic controller and between the remote pilot and the UAS could be substantial.

[6] In case of loss of communication between the pilot and the RPA, or other technical failure, the RPA shall have the capability of engaging a programmed contingency procedure.

[7] Refer to footnote 3

2 GENERAL CONSIDERATIONS

This operational concept assumes that the required technology, standards, procedures and regulations will be available as foreseen [ICAO, 2016b] in the 2018 to 2024 time-frame.

Current flight rules are described in ICAO Annex 2 [ICAO, 2005], subsumed into the SERA [EU, 2016] and are made up of general flight rules supplemented by the more specific VFR or IFR. These rules apply to the totality of the airspace. For safety reasons it is stated that general flight rules apply regardless of type of aircraft and airspace class. In order to meet one of the integrating principles i.e. not negatively affecting existing aviation, it is not foreseen to modify VFR and IFR.

Considering that a significant number of UAS operations could occur below 500ft AGL, the use of airspace between the ground and 500ft AGL needs to be organised in a manner that guarantees that the current levels of safety are maintained. This could be done using specific flight rules that would apply on top of the existing rules, including for contingency aspects.

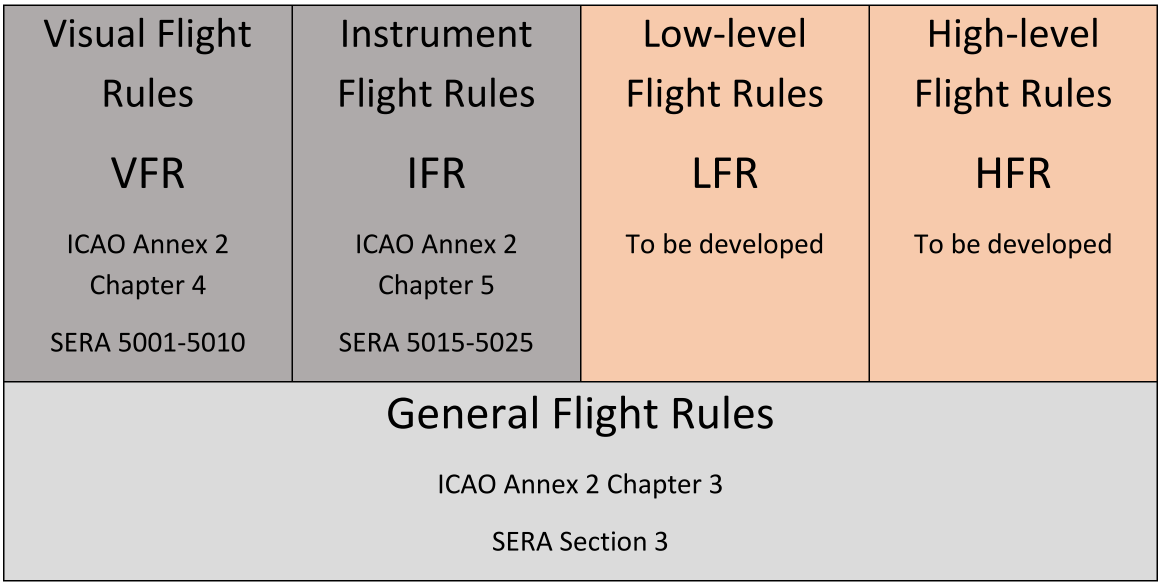

Figure 1 Application of Flight Rules

2.1 ACCESS TO SPECIFIC AIRSPACE VOLUMES

The term Very Low Level (VLL) operations is used to make a clear distinction for operations below the lowest VFR altitude – see Figure 2. It describes an airspace volume between the ground and the lowest VFR altitude (generally 500ft AGL)[8] where specific rules are required for the safe coexistence of manned and unmanned operations. CTRs are not a part of VLL.

As nearly all states have filed exemptions to operate below 500ft and there is no harmonisation of this, the case for additional flight rules in VLL is very strong. EASA is developing harmonised rules for UAS in the EU [EASA, 2018] including specific rules for small UAS. Supporting EASA-proposed rules

[8] Other principles may apply, however, such as the "glide free" principle (SERA.5005(f)(b)) or state decision to require higher minimum height for security purpose (SERA.3105) [EU, 2016].

with specific rules for VLL will improve European standardisation and facilitate the development of UAS operations. If these rules are not supported by harmonised rules of the air, it will become very difficult to implement them in environments where the airspace is not organised in a standard way to take all users and all needs (including, for example, emergencies) into account.

The airspace above FL600[9] is uncontrolled in many states. Very High Level (VHL) operations, above FL600, have mostly been conducted by the Military. With the development of remote balloons and solar powered high-altitude aircraft, this environment is expected to become increasingly busy and flights in this airspace will need to be organised in the near future, taking many differences in performance into account. (See also section 3.2.4.)

2.2 LOW LEVEL FLIGHT RULES (LFR)

These will be applicable to operations below the lowest VFR altitude covering subcategories for VLOS and BVLOS operations. The LFR will define the rules of the air for UAS and will have to be compatible with VFR since VFR traffic uses this airspace. Due to the difficulty of manned aviation to see and avoid small UAS, in the cases when they are not separated by airspace design the latter will have to be responsible for remaining clear of the former. Similarly, BVLOS, when not kept apart from VLOS, will need to have right of way over VLOS.

2.3 HIGH LEVEL FLIGHT RULES (HFR)

These will apply to operations above FL600[9] and cover all operations on manned and unmanned aircraft operating in this airspace. These rules must be compatible with IFR but may warrant additional requirements.

2.4 IFR/VFR AIRSPACE REQUIREMENTS

It is assumed that all UAS operating as IFR/VFR traffic within airspace classes A-G will comply with the relevant airspace requirements in the same manner as manned aircraft. Operations in the airspace where commercial transport aircraft normally operate could demand additional operational performance requirements covering speed, reaction time, turn performance, and climb/descent performance.

The general principle for the integration of UAS into airspace where VFR/IFR traffic is operating is that capabilities should be available that prevent collisions between UAs and other UAs or between UAs and manned aircraft. In cases where such capabilities are not available or are degraded, the airspace should be organised and allocated in order to guarantee that there is no risk of collision. ASM/FUA-AFUA concepts and airspace structures defined by ICAO would be the primary means of achieving such an airspace organisation.

[9] There is no common boundary for flights above IFR and VHL operations. FL600 has been taken to be soft boundary to this airspace volume and any other upper UIR limit may be taken depending on state-specific regulations.

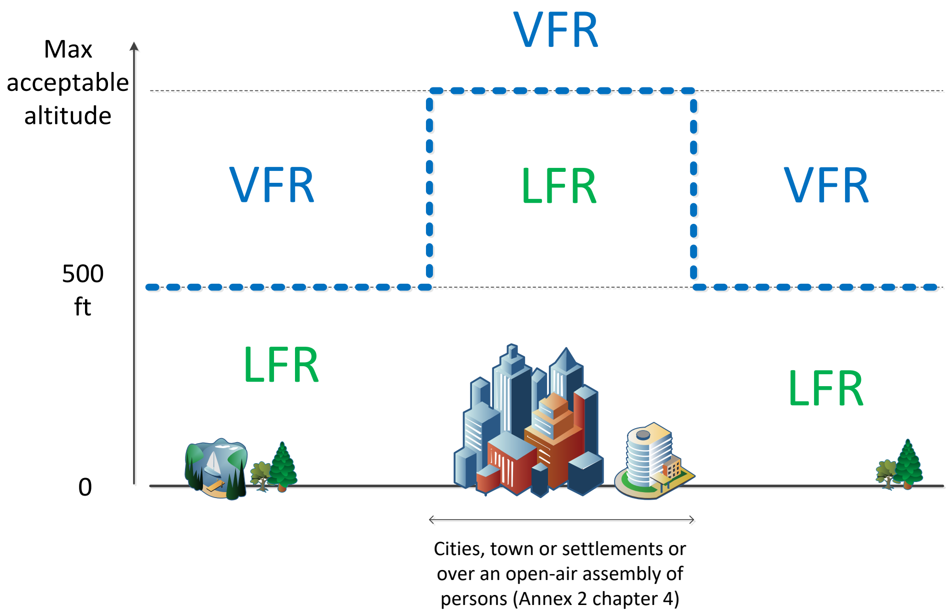

Figure 2 Limits of VFR

Note: lowest VFR altitude above urban areas is 1000ft above the highest obstacle in the area [EU, 2016].

2.5 OPERATIONS AT AERODROMES OTHER THAN DEPARTURE AND ARRIVAL

There are two types of operation at aerodromes:

- Those similar to the ones performed by manned aviation (VFR/IFR).
- Operations executed by small UAS in support of
    - ATC (runway inspections, weather, ground operations, etc.)
    - airlines (fuselage inspections, etc.)
    - additional services to aerodromes (security, perimeters checking, car park, etc.)

These types of operation will be conducted as VLOS or BVLOS. The compatibility of this mix of operations in relationship to the rules of the air is crucial for efficient and safe operations within the CTR.

3 OPERATIONAL APPROACH

To address the variety of UAS operations, this operational concept is primarily based on traffic classes, not UAS categories or airspace classes. These last two typologies are used as secondary typologies. In this operational concept, the traffic classes will therefore be defined throughout the document for each type of operation (see section 5) and are as follows:

- ➔ Type of operation: based on flight rules: LFR, IFR/VFR, HFR
  - ➔ Class of traffic: Class I, II, III, etc.
    - ➔ Class of airspace: Class A-G
      - ➔ Category of UAS - Open, Specific, and Certified (from EASA Opinion [EASA, 2018])

An example of this type of organisation is given in Appendix 1.

3.1 GENERAL INTEGRATION REQUIREMENTS

There are 4 main integration requirements [ICAO, 2015]:

- The integration of UAS shall not imply a significant impact on current users of the airspace;
- UAS shall comply with the existing and future regulations and procedures laid out for manned aviation;
- UAS integration shall not compromise existing aviation safety levels nor increase risk more than an equivalent increase in manned aviation would.
- UAS operations shall be conducted in the same way as those of manned aircraft and shall be seen as equivalent by ATC and other airspace users[10].

3.2 A TWO-STEP APPROACH: ACCOMMODATION THEN FULL INTEGRATION:

Presently, UAS can benefit mostly from the latest FUA/AFUA techniques, and operate under protection either through dedicated corridors (as is currently done over the Mediterranean) or through creating “a dynamic segregation bubble” around the UA, which places fewer restrictions on airspace usage. This allows for early UAS flights before the required technology, standards and regulations are in place. To fully integrate UAS as any other airspace user, a two steps approach is proposed: accommodation then integration in line with the ICAO GANP Aviation System Block Upgrades (ASBU) [ICAO, 2016b] (see Appendix 2).

3.2.1 IFR OPERATIONS

1. Accommodation during ASBU Block 1 (until 2025)

   Due to the current absence of regulation and industry standards, accommodation of IFR-capable UAS in controlled airspace is, for the time being, mostly possible through FUA/AFUA

[10] Specifically for contingency procedures (due to loss of data link) ATC will not be able to handle many different recovery procedures.

techniques. In Europe this phase of accommodation can easily be maintained due to the relatively low number of UAS operations.

2. Integration from ASBU Block 2 (2025 onwards)

   It is expected that the essential SARPS, which will enable civil and military UAS to fly in non-segregated airspace, will be in place by 2023 (ASBU Block 2) [ICAO, 2013]. With the availability of regulations, standards and relevant supporting technology UAS will, if necessary, be able to integrate as any other airspace user, when meeting the specific airspace requirements based on the principles explained above.

3.2.2 VFR OPERATIONS

VFR operations pose additional challenges compared with IFR. The "see and avoid" principle is the primary means of separation and collision avoidance in uncontrolled airspace today. It is also the primary means of avoiding collisions between VFR and IFR in uncontrolled airspace, or in airspace classes where separation between VFR and IFR is not provided. A technical detect and avoid system (DAA) of the same level of confidence as, and compatible with, current "see and avoid" has yet to be finalised and operationally validated. Despite promising results towards resolving this issue, it is not considered realistic to accommodate UAS into VFR operations in controlled or uncontrolled airspace at present, or to anticipate full integration before around 2030 (ASBU Block 3) in this context.

3.2.3 LFR OPERATIONS

1. Accommodation up to around 2021 (U-space U1) [SJU, 2018]

   Current VLL operations are accommodated through national rules and regulations, and require harmonisation. In this timeframe, the first U-Space services will be implemented to support accommodation.

2. Integration around 2021 onwards (U-space U2)

   With the implementation of harmonised rules and standards, and the deployment of the adequate infrastructure and capabilities, small UAS will be fully integrated into VLL airspace, safely coexisting with all other airspace users.

3.2.4 HFR OPERATIONS

Since the use of airspace above FL600 by manned aviation is currently limited to certain military operations, and since only a few UAS operators have so far expressed an interest in using this airspace, it is considered that these UAS operations may be accommodated for the near future.

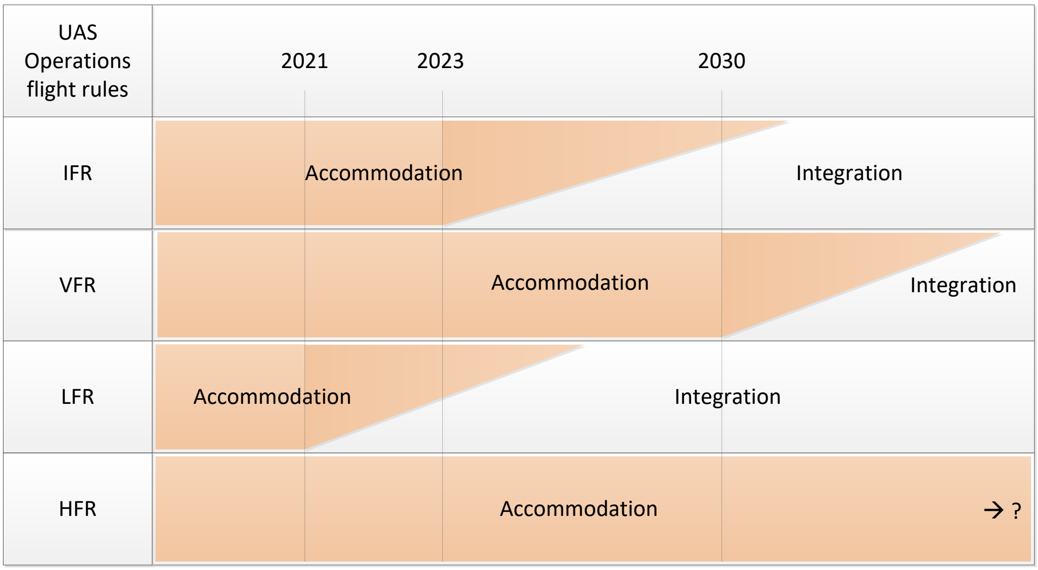

Figure 3 Timeline for accommodation and integration of UAS into flight rules

3.3 OPERATIONAL ENVIRONMENT ASSESSMENT

Operations in VLL airspace are not consistently organised at present. They are addressed state-by-state as an exemption to the SERA/ICAO Annex 2.

So far, the SERA have not recognised VLOS or BVLOS as legitimate operations, although ICAO Annex 2 was amended with an appendix on RPAS in 2012. The EASA Opinion [EASA, 2018] is an initial step towards resolving this. Therefore, these types of operation can only be accommodated locally. Although local accommodation does not mean a reduction in safety levels, with the increase in the number of operations of small UAS, there is an increasing need to organise their safe coexistence with manned operations, and each other.

In manned aviation, airspace design has been the cornerstone in organising airspace to meet the safety demands for aircraft operations. The relatively small volume of UAS traffic today does not yet require a similar approach, although solutions must be developed before this volume reaches the level where they become a critical necessity. The present environment therefore needs to at least be considered through the development of a reference benchmark that identifies the positive and negative aspects of integrating UAS into today's airspace. Drivers for this are:

- the spread and increase in operations, combined with the co-existence of VLOS and BVLOS operations, and manned traffic;
- a rise in urban operations that create environmental and privacy issues, including nuisance (non-)acceptance;
- an improvement in UAS performance (speed, range, propulsion, altitude, etc.);
- the performance of UAS CNS infrastructure or UTM/U-Space [SJU, 2018] coverage.

An airspace assessment approach should adapt the organisation of the airspace, including the selection and designation of airspace classifications, to meet the increasing demand of UAS operations, while ensuring that safety levels are maintained. Such an approach should consider the following aspects:

- Existing airspace classification
- CNS infrastructure or UTM/U-Space availability/performance
- Traffic complexity, forecast and density
- Zoning areas (hospitals, heliports, schools, etc.)
- Geographic situation (mountains, urban areas)
- Traffic flows
- Noise
- Privacy
- Security
- High-frequency radio transmissions (interference).

3.3.1 UAS AIRSPACE STRUCTURES

Based on the outcome of the airspace assessment, specific or dynamic UAS structures can be used to organise traffic. Such specific UAS structures could easily be created under the legal umbrella of airspace restrictions existing in the ICAO framework (danger, restricted, prohibited). The general term used to define these areas is "drone[11] zones". These include, but are not limited to:

- No drone zones (NDZ): UAS are totally prohibited in this volume unless granted special authorisation (e.g. government UAS)
- Limited drone zones (LDZ): UAS are allowed if they meet specific requirements and/or do not exceed a defined number in this volume
- Exclusive drone zones for unplanned drone operations (EDZu): all other traffic is excluded from these volumes, which are reserved for unplanned UAS VLOS operations.
- Exclusive drone zones for planned drone operations (EDZp): all other traffic is excluded from these volumes, which are reserved for planned UAS operations.
- Exclusive drone zones for passenger operations (EDZm): all other traffic is excluded from these volumes, which are reserved for urban mobility UAS operations (DPAVs).
- Dedicated UAS routes: Waypoints dedicated to UAS traffic create a pan-European network of UAS routes designed to support segregation of manned traffic from unmanned traffic, thus increasing the level of safety in the airspace for heavy traffic.

3.3.2 GEO-AWARENESS

Geo-awareness is a function that can detect a potential breach of airspace limits and provides the remote pilot with sufficient information and an appropriate alert to allow them to take effective action to prevent that breach, much in line in what happens today with manned aircraft. It defines how information on the airspace restrictions mentioned in section 3.3.1 is managed and shared with UAS and manned operators in a specific airspace volume.

[11] Notwithstanding the statement in section 1 that only the terms "UAS" or "UA" would be used, this term, and the following initialisations are already widespread and so the term "drone" is admitted here to mean any type of UA.

Geo-awareness complements airspace design by offering additional and dynamic protection to infrastructure, people, and other traffic. It generically aims to prevent a UA from crossing a geographically and temporally designated airspace limit. It comprises, but it is not limited to:

- Geo-caging: aims to prevent an RPAS from flying outside of a predetermined volume (e.g. a hangar at an aerodrome when doing a fuselage inspection)
- Geo-exclusion: aims to prevent a particular UA or a set of UAs from flying into a predetermined volume (e.g. protection bubble around electromagnetic source to avoid interference due to masking or damage to the UAS due to electrical overload)

Note: a geo-fence is defined by geographical coordinates and a time slot (4D definition), e.g.:

- A circle of radius 2NM centred on 50.9439N, 6.9627E.
- Upper limit: 2000ft. Lower limit: SFC
- Permanent

Geo-caging would confine a UA to within this shape; geo-exclusion would prohibit a UA from entering it.

In future, geo-awareness could be built into the UAS, especially for geo-exclusion related to the most sensitive areas. It would add an additional protection by removing the risk of human error or non-cooperative behaviours.

3.3.3 COMMON ALTITUDE REFERENCE SYSTEM

To avoid collision in a scenario where two UAS, or a UAS and a manned aircraft, are approaching each other and signalling their relative 3D (or 4D) positions, there must be no confusion about any aspect – temporal, horizontal, vertical. This requires a scheme that gives a common value for altitude above any given ground position, no matter where a UAS flight started or what other conditions pertain. The figure should be absolute and derived directly by the aircraft, without reference to any external datum such as the ground level at take-off, nor to any calibration process that an operator could inadvertently carry out incorrectly. The scheme should also work after a system reboot etc.

If the vertical separation of UAS is going to be small enough to allow them to pass while maintaining a reasonable clearance above the ground to minimise nuisance, the uncertainty of this absolute measurement needs to be quite small – to within a few metres.

A common altitude reference system must be compatible with (future) mapping systems that detail the height of the ground, and buildings, trees and other ground-referenced objects, so that these may be avoided. Similarly, it must be compatible with the coordinate system used to define geo-fencing volumes.

3.4 OPERATIONAL RISK ASSESSMENTS FOR UAS/ATM INTEGRATION

In order for UAS to operate as non-certified aircraft in VLL, an operational risk assessment such as defined in the SORA must be executed to ensure that the intended operations do not compromise the level of safety in ATM. The implementation of this non-standard safety assessment process requires that the operator be provided with information enabling them to run the risk assessment processes.

This assessment must be backed by reliable and validated data, i.e. with high integrity. This is essential to allow operations of non-certified UAS in mixed traffic environments with certified aircraft.

3.4.1 DATA SETS

The required data for the risk assessment will be divided into Traffic Static Data (TSD) and Traffic Dynamic Data (TDD).

- TSD will support a generic risk assessment accessible to registered operators to prepare for their operation, which will have to be subsequently complemented by TDD to fine tune the risk assessment.
- The TSD dataset is composed of the information necessary for such a generic risk assessment, with a stability of information at least equal to a week. A cycle, similar to AIRAC, will have to be organised to update the TSD dataset.
- The TDD dataset is composed of all the information necessary for this assessment, but whose stability is less than a week and with a refresh rate no greater than 6 hours.
- The TSD and the TDD datasets are timestamped.

The risk assessments will be performed at a strategic and tactical level.

The TSD will feed the strategic risk assessment (SRA) submitted to the aviation authority. The SRA ensures that, according to the information available at the time of the request, the operation is expected to be safe. A local SRA or part of a local SRA can be automatically generated by one of the services provided by the UTM (Generic Risk Assessment – GRA).

The Tactical Risk Assessment (TRA) includes TDD to refine the SRA/GRA. It addresses risks that cannot be known when the SRA/GRA was performed and submitted. The operator must perform the TRA and transmit the results to the competent authority.

The outcome of the combined risk assessment is expected to lead to defining specific and dynamic UAS airspace structures complemented by the implementation of geo-exclusion zones. The TSD and the TDD datasets will reflect these zones.

4 UNMANNED TRAFFIC MANAGEMENT – UTM/U-SPACE

4.1 UAS MANAGEMENT IN VLL

Many initiatives and actual deployments are underway to develop and implement UAS management systems. Unmanned Traffic Management (UTM) as developed by NASA or U-Space as described by the EC are only two examples. Both strive to have a UAS management system in place supporting unmanned operations in urban and non-urban-areas. A UAS management system is essential to ensure safe integration of large amounts of UAS and manned traffic in VLL.

The system will be built on high levels of automation, as it will not be possible to provide ATC-like services due to the expected numbers of UAS and the challenging environments concerning tracking.

4.1.1 UTM BUILDING BLOCKS

In principle, a UAS management system provides three main building blocks or services:

- Data management:
    - Geo-fencing-based protection of airspace zones;
    - NOTAMs;
    - Weather;
- Situational awareness:
    - Flight planning;
    - Surveillance;
    - Air situation display and conflict alerting;
- Small UAS Traffic Management:
    - Flight approvals;
    - Air traffic flow management;
    - Airspace management;
    - Infrastructure service levels (CNS).

4.1.2 UTM AREA

The UTM area is expected to be below 500ft AGL, or 1000ft[12] above the highest obstacle in urban areas - excluding areas under the responsibility of ATS - or higher if authorised.

4.1.3 UTM RELATIONSHIP WITH ATM

UTM provides services in its area of responsibility. Some of these services are similar to ATM services. Such services must have a high-level of coordination with ATM. Therefore, for these services, UTM is part of ATM.

[12] Some cities – such as Paris – have a higher minimum altitude for flying, hence a higher top of VLL.

The other services provided by UTM are specific and can be separately handled by UTM[13]. These can include such things as:

- flight registration to enable regulatory authorities to manage where UAs fly, including management of NDZs and LDZs;
- linking flight registration of all UAs, or specific categories of UA, to an authorisation management system based on the applicable regulation;
- dynamic real-time processing of authorisations and restrictions through smartphone apps;
- supply of geo-fencing data directly to the UA if a standard interface is available;
- providing access to the appropriate authorities for legal verification etc.

4.1.4 UTM RELATIONSHIP WITH RISK ASSESSMENTS

When UTM is deployed, the air and ground risk assessments will use information provided by the UTM system, as the system has details of both the air and ground situations. UTM will provide a reflection of manned aviation and ATM by ensuring efficient and safe integration or segregation of all types of airspace user in VLL. Other functions will manage the risks associated with flight crew licencing and airworthiness.

[13] Several such UTM systems, e.g. Airmap, Altitude Angel, Colibrex, Unifly, are already available on the market.

5 FLIGHT RULES

It is envisaged that UAS will operate in a mixed environment adhering to the requirements of the specified airspace it is operating in. UAS will be able to operate as follows:

- High-level Flight Rules (HFR) for stratospheric operations ,above currently controlled airspace FL6009;
- Instrument Flight Rules (IFR) or Visual Flight Rules (VFR) following the same rules that apply to manned aircraft. These can be conducted in RLOS or B-RLOS conditions;
- Low-level Flight Rules (LFR) in addition to existing rules of the air for operations in VLL airspace.

As yet, only IFR and VFR rules exist.

5.1 VERY HIGH-LEVEL OPERATIONS (VHL): HFR RULES APPLY

Stratospheric unmanned flights operating at altitudes above FL600[9] are expected to grow in numbers.[14] Apart from military High-Altitude Long Endurance (HALE) UAS, several other vehicles (i.e. weather balloons, space rockets, Virgin Galactic) operate through or in this block of airspace. At this moment, no management of this traffic is foreseen in most parts of the world. Particular attention should be given to the entry and exit to/from this high-altitude volume as its traffic will need to interact with the airspaces below.

5.2 IFR/VFR OPERATIONS

For UAS to fly in either IFR or VFR they must meet the airspace requirements set for manned aviation. These operations include: aerodromes, TMA and en-route. For IFR-capable UAS, additional requirements can be set for flying in the volumes of airspace where manned transport aircraft operate. As such it is envisaged to have minimum performance standards for elements such as speed, climb/descent speed, turn performance and latency.

Due to the technical and regulatory challenges it is not foreseen to have VFR operations in the near future (as defined in Appendix I) as they will require a major investment in technology (detect & avoid) and must also take non-corporative traffic into account.

5.3 VERY LOW-LEVEL OPERATIONS (VLL): LFR RULES APPLY

Operations performed at altitudes below 500ft are not new to manned aviation as many operators - police, armed forces, balloons, gliders, trainings, fire-fighting, ultra-light aircraft etc. - are allowed to operate in this environment. Currently VFR traffic may operate here, under specific conditions prescribed by the national competent authorities, conditions that can differ from state to state.

UAS operating in this volume of airspace do not conform to either IFR or VFR as defined in the SERA [EU, 2016], and this safety problem must be addressed.

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[14] As already described in section 1.1, private companies such as GOOGLE and FACEBOOK foresee the extensive use of unmanned aircraft and balloons to ensure a global 4G/5G network supporting their internet business model.

LFR should include priority and avoidance rules that are yet to be defined, e.g. between UAS and manned aircraft, BVLOS and BVLOS, VLOS and BVLOS. Until capabilities and/or services guaranteeing collision-avoidance become available, LFR will require airspace to be organised in a way to ensure that collisions are avoided by segregation and that safety levels are maintained. These new flight rules will cater for additional equipage requirements and thereby enable the right of way rules for VFR, VLOS and BVLOS operations. They will also enable the definition of zones in this airspace such as those described in section 3.3.1.

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APPENDIX 1 POTENTIAL OPERATIONAL CONCEPT IMPLEMENTATION

As UAS are very difficult to categorise due to the large variety of shapes, sizes and performance, this operational concept proposes organising UAS traffic into classes (see section 3). A "class of UAS traffic" is a set of flying rules, operational procedures and system capabilities applicable to the UAS and to the operator when operating the UAS in a portion of the airspace.

Different traffic classes have been developed to support the management of large numbers of UAS operations. Each proposed class of UAS traffic shall be implemented with all elements and requirements, as described. Implementation of individual elements will not be able to support safe integration of UAS into ATM.

A1.1 VERY LOW-LEVEL UAS OPERATIONS

This part of the operational concept addresses operations of UAS between ground level and 500ft[15] AGL. It assumes that the current rules of the air will not be adapted to take low-level UAS operations in this layer into account; a new set of rules - LFR - will be developed to complement existing rules of the air. These rules will include appropriate airspace segregation for cases where collision avoidance cannot be guaranteed.

A1.1.1 SPECIAL REQUIREMENTS FOR URBAN OPERATIONS

Urban operations will require additional requirements from UAS due to the complexity of the airspace, interaction with manned aircraft, and a higher risk to people and properties. All urban operations (manned and unmanned) will require prior authorisation and tracking. BVLOS operations will require a detect-and-avoid (DAA) system that not only avoids collision with other airspace users but also with obstacles. An airspace assessment will be required to determine CNS and UTM/U-Space coverage, and risk to people, property and the environment.

A1.1.2 VERY LOW LEVEL INFRASTRUCTURE: UTM/U-SPACE

In order to accommodate the expected growth of traffic in this airspace and to ensure an acceptable level of safety, a supporting infrastructure is required. This system is called U-Space or UTM. UTM is complementary to ATM as it expands the logic of services to airspace users in volumes of airspace where ANSPs currently provide no services. These services must interact and exchange information, but there must be no overlap of conflicting services or areas of responsibility.

UTM or U-Space has three basic elements;

- Data management;
- Situational awareness;
- Traffic management.

[15] Different boundary altitudes can be applied by the authorising state

This system will provide a series of location and information services, aiming to provide information to UAS pilots and manned traffic. Such a system could be based on existing technologies, such as the pan-European mobile phone network. Specific UAS route planning, reporting systems, authorisation and information systems are already in use in several states.

UTM/U-Space will have to cater to the following aspects:

- UAS registration;
- UAS identification;
- UAS flight planning;
- UAS flight authorisation;
- Real time UAS tracking capability;
- Provision of actual weather and aeronautical information.

As previously mentioned, until any liability aspects are addressed, this infrastructure will be unlikely to support the active controlling of UAS at lower altitudes. The large number of UAS will also mean that such systems are likely to be highly automated. The system will therefore support operations and will be able to provide sufficient data to enable the remote pilot to safely execute a UAS flight, based on the information made available to them. Data required could include, but are not limited to:

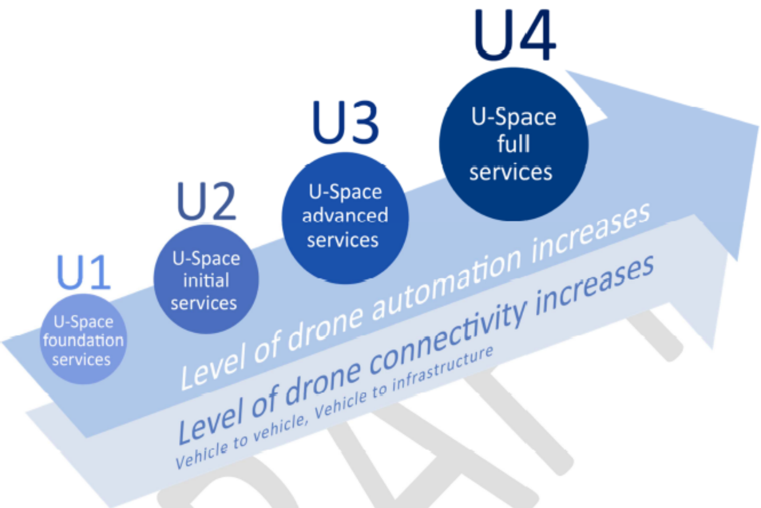
- Filed flight plans;
- Active UAS flight plans;
- Airspace data;
- NOTAMs;
- Weather;
- Infrastructure availability;
- Geo-fencing.

The following assumptions have been made:

- The state has executed an airspace assessment and a safety assessment;
- Geo-fencing is in place;
- Where a surveillance capability is required, it is similar to, in terms of performance, and compatible with that of manned aircraft (but will probably not use 1090Mhz16);
- At least one C2 service is available for BVLOS operations;
- VLOS operations are tracked;
- UTM/U-Space infrastructure is in place.

[16] The use of 1090 Mhz has not been intended to cater for UAS and can, if overloaded, negatively impact manned aviation and ATC system tracking capability.

The EC has public-shed a blueprint which has an implementation schedule as follows:



- **U1 - U-Space foundation services** provide e-registration, e-identification and geofencing.
- **U2 - U-Space initial services** support the management of drone operations and may include flight planning, flight approval, tracking, airspace dynamic information, and procedural interfaces with air traffic control.
- **U3 - U-Space advanced services** support more complex operations in dense areas and may include capacity management and assistance for conflict detection. Indeed, the availability of automated DAA functionalities, in addition to more reliable means of communication, will lead to a significant increase of operations in all environments and may require a more robust framework.
- **U4 - U-Space full services**, particularly services offering integrated interfaces with manned aviation, support the full operational capability of U-Space and will rely on very high level of automation, connectivity and digitalisation for both the drone and the U-Space system.

Figure 4 EC U-Space Blueprint implementation timeline

A1.1.3 AIRSPACE ASSESSMENT

An airspace assessment has to be undertaken to determine where UAS are able or allowed to fly. This is wider than just aviation specific. For the aviation perspective, the following aspects have to be taken into account:

- existing airspace structures;
- airspace density – based on filed flight plans, and forecasts;
- CNS infrastructure;
- risk to third parties on the ground;
- environmental consideration;
- military activities.

Apart from the actual airspace assessment in collaboration with all the known entities operating in the manned aviation world, data on areas where drones are not allowed could also be provided by police, hospitals, prisons, local authorities (municipal or regional councils, port-authorities, etc.) and industry.

The actual assessment should be undertaken in 3D airspace blocks. These blocks could have an accessibility level taking into account the following high-level parameters:

- communications - availability of C2;

- navigation - ability to navigate;
- surveillance - capable of being tracked;
- risk - level risk to other airspace users or people or structures on the ground.
- nuisance - level of nuisance to people on the ground

Depending on the accessibility levels defined for each of the five parameters, certain of the traffic classes will be able to operate in that specific airspace block. Some accessibility levels will require specific equipage or pilot qualification.

Lastly, zones where interference from outside sources could impact the safe flight of a UAS should be taken into account, as should zones where UA operation will impact safe or effective operation of the ground facility. These include airspace volumes around:

- solar panels;
- satellite transmissions;
- wind energy parks;
- military radar installations;
- GPS Receiver Autonomous Integrity Monitoring (RAIM);
- severe weather ;
- high-intensity radio transmission.

A1.1.4 VLL TRAFFIC CLASSES

The traffic classes for VLL traffic that can operate from ground up to 500ft[15] are defined as follows:

Class I - "open" category VLOS:

- Reserved for EASA "open" category [EASA, 2018];
- VLOS only;
- Class I has 3 sub-classes as defined in the EASA Opinion [EASA, 2018]
  - Subcategory A1 is the light-weight buy-and-fly category (vehicle classes C0 and C1 [EASA, 2017]) that will be able to fly up to 50m altitude in low-risk environments, in areas of low traffic density, and remain clear of no-drone zones such as aerodromes;
  - Subcategory A2 is for operations with vehicle class C2 up to 120m altitude, away from people, flown by pilots who have passed an on-line test ;
  - Subcategory A3 is for operations with vehicle classes C2, C3 and C4, and home-built UAS up to 25kg MTOM up to 120m AGL altitude, which do not endanger uninvolved people, flown by pilots who have passed a theoretical and practical exam.
- A geo-fencing capability that ensures that this category remains outside NDZs is required for UAs in classes C1, C2 and C3. [EASA, 2018]

Class II - free flight:

- "specific" or "certified" category [EASA, 2018];
- VLOS and BVLOS;
- This class operates in free flight due to the nature of their operations such as surveys, filming, search and rescue, and other operations that have no fixed route structure.
- Class II flights and are subject to the following requirements:

- Flight planning if required by the standard scenario [EASA 2018, UAS.SPEC.025] and the operator is not exempt [EASA 2018, UAS.SPEC.030, 035];
- Mandatory authorisation for operation if required by the standard scenario [EASA 2018, UAS.SPEC.025] and the operator is not exempt [EASA 2018, UAS.SPEC.030, 035];
- Surveillance capability;
- Free-flight capability;
- Must be capable of self-separating in 3D;
- Common altitude reference system.

Class III - medium/long haul traffic:

- "specific" or "certified" category;
- BVLOS operations only;
- For transport, at higher altitude and speed, or surveillance at lower speed and altitude (power-line, railway line, gas pipe, , etc.);
- This traffic can operate as free flight or on a structured commercial route depending on the requirements set by the airspace assessment:
  - Flight planning;
  - Mandatory authorisation for operation;
  - Surveillance capability;
  - Free flight or route structure;
  - When outside segregated airspace:
    - Must be capable of self-separating in 3D;
    - Common altitude reference system.

Class IV - special operations:

- "specific" or "certified" category;
- VLOS and BVLOS operations;
- Very specific types of operation that will be assessed on a case-by-case basis, for example flying in areas that are otherwise not permitted (NDZ) or in ways that are otherwise not permitted (high wind, high MTOM, above crowds, etc.)
- Can be civil, state or military operations and as such require special authorisation;
- Can operate in urban areas, aerodromes and other specific locations;
- This class is designed for highly specialised operations and as such not many of these types of UAS are expected.

A1.1.5 CONCEPTUAL OPERATIONAL OPTIONS

There are three possible ways that UAS operations can evolve and these three options can be part of a phased approach. This largely depends on the specificities that were identified in the airspace assessment.

- Present Situation

  Operations are conducted as at present because, for example, there are a relatively low number of UAS operations. No airspace assessment is required since most no-drone zones (NDZ) or limited drone zones (LDZ) are already identified, for example:
  - Aerodromes

- Nuclear power stations
- Hospitals, etc.

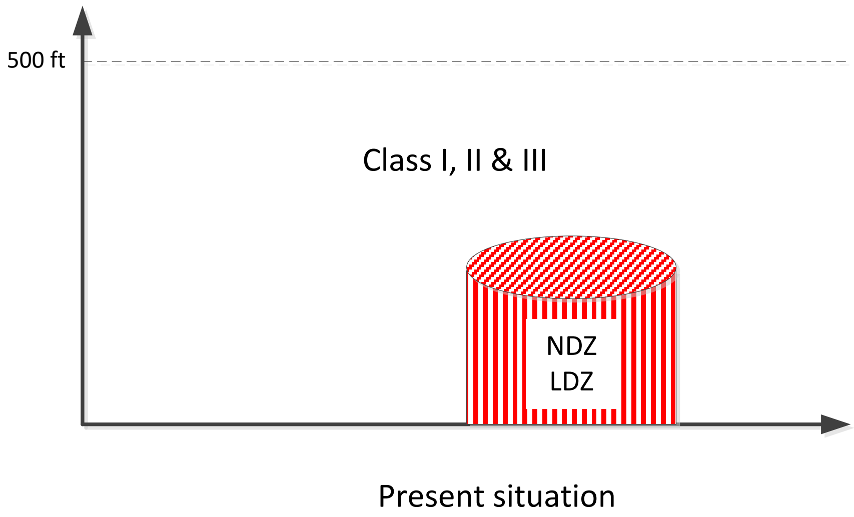


Figure 5 Present situation

- Free Flight

In this option, UAS traffic has increased to a level requiring a more specific structure to be in place. The complexity and density of the traffic can still allow free flight for both classes II & III. However, the risk associated with mixing unplanned class I traffic, which is unknown to U-space, with the other classes that are being strategically separated by U-space could require these class 1 operations to be restricted in altitude and to particular geographical areas - geo-caging.
Detect and avoid, based on a cooperative means could allow a conceptual and inviolable bubble to be created around each UAS , although the requirements for such a system will be high due to the possible high rates of conflict that are linked to free flight.
The airspace assessment that is required will also identify the general UAS traffic density in support of defining the geographical areas where class I traffic will be restricted.

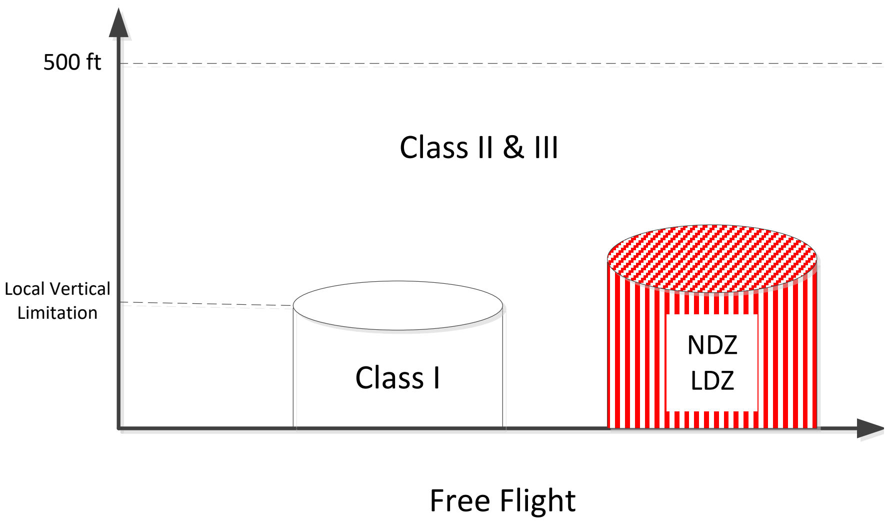


Figure 6 Free flight

- Route Structure

The third option is designed to cover for higher traffic demands, specifically in areas where high volume flight routes occur or there are needs to manage routing to cater for safety, security, noise and privacy issues. The airspace assessment will identify areas of minimal impact and as such, the identification and promulgation of route structures could be undertaken. The route structure could follow rivers, railway lines or other geographical areas where there is minimal impact on people on the ground.

To enable this option, it is essential that a common altitude reference system be adopted (see section 3.3.3).

Depending on the route structure, the requirements for the DAA system might be adjusted to account for the specific risk aspects of the location, environment, complexity, etc.

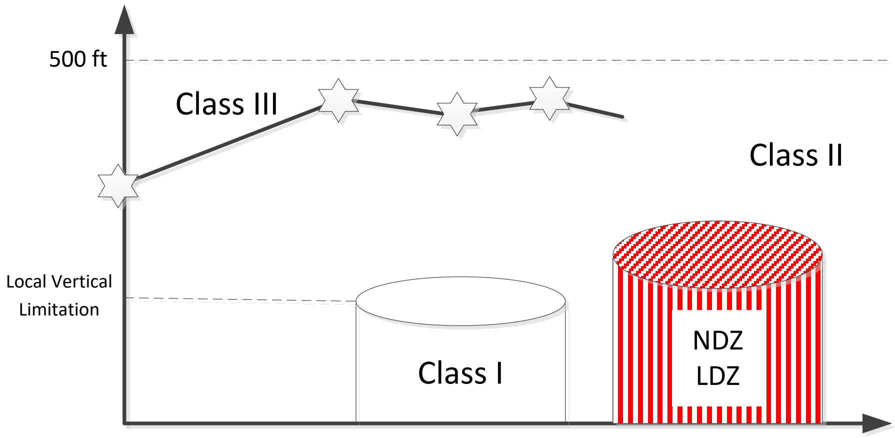


Figure 7 Structured routes

- Structured airspace

In a fourth possibility, similar to the Amazon concept [Amazon, 2015], class III traffic flies above class II flights in a dedicated and segregated higher-level airspace. No route network is needed. In this option, class III will still have to cross through the airspace reserved for class II, but will be in its reserved layer for long-distance flights.

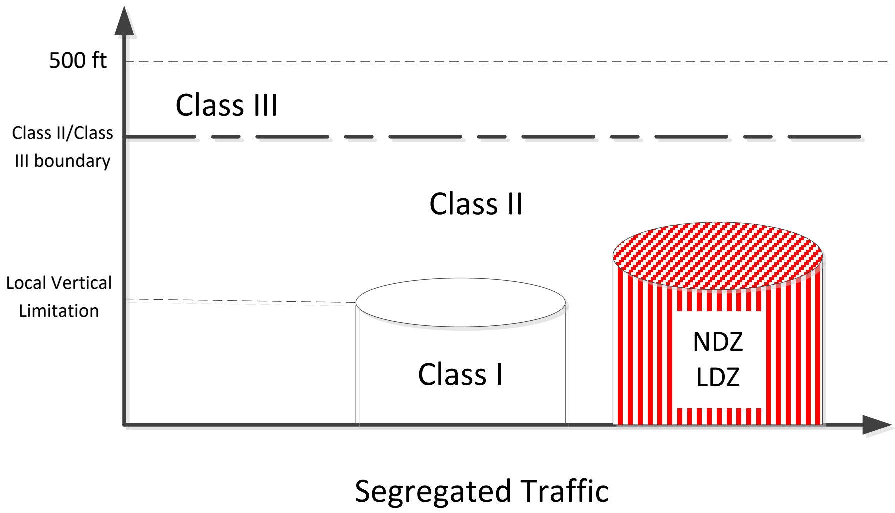


Figure 8 Segregated traffic

A1.2 IFR/VFR OPERATIONS

This section is concerned with traffic in a volume of impact from 500ft[15] AGL up to FL600[9], and including aerodromes.

A1.2.1 TRAFFIC CLASSES

Based on the area and type of operation, two traffic classes that can operate in all airspace classes are foreseen:

Class V - IFR/VFR operations outside the pan-European network, and not flying SIDs and STARs.

- UAS that do not meet pan-European airspace network performance requirements will be able to operate without negatively affecting manned aviation;
- Operations at aerodromes will be accommodated through segregation of launch and recovery;
- Ground operations can be accommodated through either towing or wing walking;
- Operations from uncontrolled aerodromes or dedicated launch and recovery sites are to be conducted initially under VLOS/VFR until radio communication is established with ATC;
- No additional performance requirements will be set in this environment above those for manned aviation;
- General requirements:

  UAS operating in the environment will file an ICAO flight plan including information such as:
  - Type of UAS;
  - Planned operations (navigation, route of flight/operational area, flight level etc.);
  - Contingency procedure;
  - Contact phone number;

  UAS will meet CNS airspace requirements;
  UAS will be able to establish two-way communication with ATC if required;
  UAS will remain clear of manned aircraft or must be capable of self-separating in 3D;
  UAS operator must be able to contact ATC (if required) concerning special conditions such as:
  - data link loss;

- emergency;
- controlled termination of flight;

UAS D&A capability will be compatible and cooperative with existing ACAS systems.

Class VI - IFR operations, including pan-European network, TMA and aerodrome operations with UAS capable of flying SIDs and STARs as designed for manned operations.

- Either manned transport aircraft (civilian air carriers) enabled to fly unmanned with similar capabilities or new types able to meet the set performance requirements for the pan-European network, TMA and aerodromes;
- General requirements:

  UAS operating in this environment will file an ICAO flight plan including:
  - Type of UAS;
  - Contingency procedure;
  - Planned operations (navigation, route of flight/operational area, flight level, etc.);
  - Contact phone number;

  UAS will meet CNS airspace requirements;
  UAS will be able to establish two-way communication with ATC;
  UAS will remain clear of manned aircraft or must be capable of self-separating in 3D;
  UAS operator must be able to contact ATC (if required) concerning special conditions such as:
  - data link loss;
  - emergency;
  - controlled termination of flight;

  The interoperability of UAS D&A between existing ACAS systems will have to be addressed.

<u>Note: Operations of Small UAS above 500ft AGL</u>

In particular, for operations above 500ft AGL outside segregated airspace, where the numbers of VFR and IFR flights are higher, UAS must meet the IFR/VFR airspace requirements and have a solution for being conspicuous to manned traffic, while having the ability to avoid mid-air collisions. Other aspects such as wake turbulence and separation standards also have to be addressed. However states can accommodate UAS above 500ft AGL, based on a decision by the competent authority, on a case-by-case basis and based on a safety assessment.

A1.3 VHL OPERATIONS

VHL operations are expected to be performed from FL600[9] and above.

Based on the area and type of operations, the traffic class that can operate in VHL airspace classes is foreseen as follows:

Class VII - stratospheric IFR operations that transit non-segregated airspace:

- These types of UAS are solely designed for operation at very high altitudes.
- The launch and recovery of fixed-wing UAS can be from dedicated aerodromes, unless Class VI requirements are met.
- This airspace will be shared with many different UAS. Although their operations will not directly impact the lower airspace, they will have to pass through either segregated or non-segregated

airspace to enter or exit the airspace above FL600. For such cases, temporary segregated airspace should be considered.

- Transition phases in segregated or non-segregated airspace below FL600 will be very limited since they will be focusing on long missions (up to several months).
- In Europe, the airspace in which these types of operation take place is mostly seen as uncontrolled. It requires no management of this traffic, but it does require the airspace to be managed. However, due to the expected numbers - estimated to be around 12,000 just for Google - it will become necessary to manage this type of operation. Launch and recovery of unmanned balloons or aircraft, together with emergencies, will also require a set of procedures and pre-arranged coordination capabilities to ensure the safety of traffic below this altitude.
- General Requirements:

  UAS operating in this environment will file a flight plan including:

  - Type of UAS
  - Contingency procedure
  - Planned operation (navigation, route, level, etc.)
  - Contact phone number

  UAS will meet CNS airspace requirements.
  UAS must inform the responsible ATC unit in case of emergency re-entry into controlled airspace.
  UAS must inform ATC about the type of contingency procedures to be used (balloon deflating or orbiting descent).
  A regional centralised system should have an overview of the ongoing operations.
  UAS must be able to remain clear of manned aircraft if operating outside segregated airspace;
  Departure and arrival procedures should be developed.

The Global Air Navigation Plan (GANP) [ICAO, 2016a] is ICAO's strategy for achieving a global, interoperable, air navigation system. It is a worldwide reference for an evolutionary transformation of the world's air navigation systems. This evolution is managed through Aviation System Block Upgrades (ASBUs) [ICAO, 2016b], numbered 0 (baseline) to 3, each lasting 6 years. At present, ICAO is only concerned with IFR0-capable RPAS.

A2.1 ASBU FRAMEWORK

A2.1.1 ASBU 1 TIMEFRAME (1 JAN 2013 – 31 DEC 2018)

In this timeframe VLOS UAS operations will have become a regular occurrence. These types of UAS operation could also be conducted above urban and highly populated areas by civil, military and governmental non-military operators with higher safety requirements.

Further progress will have been made to integrate UAS into class A-C airspace, though probably not in the standard arrival and departure operations in major Terminal Airspace, aerodromes or busy en-route environments.

UAS will also operate at altitudes above FL600 to provide internet in remote areas and for other purposes.

It is assumed that the essential Standards and Recommended Practices (SARPs), Minimum Aviation System Performance Standards (MASPS) and Minimum Operational Performance Specification (MOPS) will not have been finalised in this time frame and will not yet allow full integration of UAS into ATM.

BVLOS operations will be further developed.

A low-level UAS ATM support system will be developed in this timeframe.

IFR operations and/or demonstrations will be allowed under certain conditions. No regular VFR operations are expected in this timeframe, though some demonstration/validation VFR flights might take place.

Impact of UAS operations on performance requirements:

- The foreseen performance requirements for ASBU-1 will not be affected by the envisaged operational scenarios. It is possible that DAA solutions could contribute to enhancing safety for manned aviation.
- The following operating environments / phases of flight will be included:
    - Aerodrome (taxi, take-off and landing); segregated from other traffic;
    - Terminal (arrival and departure); segregated from the existing SIDs and STARs;
    - En-route, taking into consideration that the trajectories for aerial work may be significantly different from the routes used by commercial air transport flights from point A to B.

The following operational scenarios are envisaged in the timeframe of ASBU-1;

1. VLOS scenario

Visual line of sight UAS operations will already be conducted in all airspace classes and initial operations will take place from aerodromes and urban areas.

Restrictions could still be applied above urban areas and environments with a permanently or temporarily high population density, or large crowds.

2. IFR operations

In this time frame it is assumed that there will be more IFR UAS operations, though still under certain restricted conditions using a detect and avoid solution to enhance safety. It is expected that the first DAA systems will be validated. The types of UAS operation in this timeframe will include civil operations.

This type of UAS operation will encompass all phases of flight, keeping in mind that the arrival, departure and aerodrome operations will possibly be integrated with manned aviation at this time on a small scale.

IFR UAS operations will mostly be of a loitering nature with some initial point-to-point flights for cargo or dangerous goods. It is not expected that UAS will be able to integrate busy and complex environments.

3. VFR operations

Initial VFR UAS operations will start in this timeframe, mostly with military UAS. Due to the absence of standards and suitable, acceptable/approved DAA solutions, it is not foreseen that VFR operations will be conducted on a regular basis. There are likely to be demonstration and validation flights, however.

4. BVLOS operations

Further investigation into the BVLOS type of operation will be developed and it is expected that more trials and initial regular operation will be conducted. Due to the similarities with VFR operations and the additional requirements for terrain & obstacle avoidance, it is not expected that there will be many operations in this timeframe

- Demonstration flights
- Scientific research flights
- Inspection flights
- Search and rescue

A2.1.2 ASBU 2 TIMEFRAME (1 JAN 2019 – 31 DEC 2024)

In this timeframe all the required documentation will be available to allow certified and operationally approved UAS to operate IFR in all airspace classes based on the traffic classes as described in the operational concept. It is expected that based on the performance requirements some areas will still be out-of-bounds to UAS. These will include major aerodromes and terminal airspace, and some areas in Europe that are bottlenecks for all airspace users. It is not, for example, foreseen to have IFR UAS operations at Heathrow or in the London TMA.

Initial VFR UAS operations will start, pending the maturity of the D&A system and expected simplification of airspace classification for all airspace users.

Low-level operations will be fully supported by the UAS ATM system.

VLOS and UAS operations will be fully integrated into day-to-day life by all airspace users.

BVLOS operations will be further expanded and possibly enter populated areas. These types of operation will also cater for cargo flights.

UAS will be SESAR-compatible and will be connected as part of SWIM.

Impact of UAS operations on performance requirements:

- The foreseen performance requirements for ASBU-2 are to be met by UAS operations and must not negatively impact operations. It is possible that a DAA solution could contribute to enhancing safety for manned aviation; for example, UAS could contribute to enhancing the weather information broadcast through SWIM by downloading crucial flight data.
- UAS will have to be able to exchange 3D/4D trajectories where required.
- The following operating environments / phases of flight are included:
    - Aerodrome (taxi, take-off and landing);
    - Terminal (arrival and departure);
    - En-route, taking into consideration that the trajectories for aerial work may be significantly different from the routes used by commercial air transport flights from point A to B;
    - Oceanic.

The following operational scenarios are envisaged in the timeframe of ASBU-2.

1. VLOS scenario

   Visual line of sight operations will be fully integrated in day-to-day operations.
2. IFR operations

   In this timeframe, it is expected to have IFR partially integrated, by using approved DAA solutions. This type of operation will include civil operations in all phases of flight. It is not expected that UAS will be integrated into all environments due to operational and economic restrictions.
   IFR UAS operations will be point-to-point and of a loitering nature, in mixed civil/military environments. Aerodrome operations will start initial UAS integration with manned aviation.
3. VFR operations

   VFR UAS operations could start in this timeframe, mostly in areas remote from other airspace users. As DAA solutions are put in place, it is expected that VFR operations will expand.
4. BVLOS operations

   BVLOS UAS will initially start operating in remote areas. These types of operation can be conducted from an aerodrome or remote launching station, starting the operation in VLOS and later continuing as BVLOS.

The Unmanned Aircraft System (UAS) typically consists of three main components: the Unmanned Aircraft (UA), the Remote Pilot Station (RPS) - sometimes called the Ground Control Station (GCS) - and the Command and Control Link (C2 Link). It is assumed here that there is always a possibility for a pilot to be in the loop.

A3.1.1 REMOTELY PILOTED AIRCRAFT (RPA)

The UA is the actual airborne vehicle, and one of the essential parts of the whole UAS. It can have the same physical structure as an airplane without the cockpit part. The UA can have different shapes and sizes, ranging from a small craft that fits in your hand to a normal passenger jet such as the Boeing 737 or Airbus 320. They also have different flight endurance, performances and capabilities.

A3.1.2 REMOTE PILOT STATION (RPS)

The RPS is the component of the UAS that is located outside of the aircraft and is used by a remote pilot to monitor and fly the UA. The RPS can range from a hand-held device up to a multi-console station. It may be located inside or outside of a building, and be stationary or mobile (installed in a vehicle/ship/aircraft).

A3.1.3 C2 LINK

The command and control (C2) link connects the RPS and the UA for managing the flight. It may operate in direct radio line-of-sight (RLOS) or beyond radio line-of-sight (BRLOS).

RLOS refers to the situation in which the transmitter(s) and receiver(s) are within mutual radio link coverage (using direct radio frequency line); and

BRLOS refers to any configuration when the transmitters and receivers are not in RLOS, and in order to communicate other relays, such as satellite systems and terrestrial network, are used.

The distinction between RLOS and BRLOS mainly considers variable delay in communications between the remote pilot and the UA.

A "Lost C2 Link" is an operational event where the UAS is in a state in which the remote pilot is no longer able to actively manage the flight in a safe and timely manner, appropriate to the airspace and operational conditions, and the UA is performing pre-programmed, pre-coordinated and predictable manoeuvres.

The C2 link critical component since a lost link changes the operational condition of the UAS in respect to the other airspace users and ATC.

A3.1.4 ASSOCIATED COMPONENTS

UAs are piloted from a Remote Pilot Station (RPS) via a command and control (C2) link. Other components such as launch and recovery equipment may also be integrated into the full UAS.

APPENDIX 4 INTEGRATION ASPECTS TO BE ADDRESSED

Time-frame	Types of Operation	Integration aspects to be addressed						
		Airspace access	**Comms C2 datalink**	**D&A**	**Human factors**	**SESAR compatibility**	**Contingency**	**Security**
ASBU 1 2013 - 2018	**IFR** (instrument flight rules) IFR operations 2013-2018 Class A-C airspace Integrating UAS into Class A-C airspace has the biggest potential of success IFR operations include all phases of flight including aerodrome operations	ATM impact assessment Impact on pan-European network operations Aerodrome operations Minimum Performance requirements for IFR operations CNS requirements Flight planning	Integrity Availability Continuity of service Lost link Latency Spectrum requirements Satcom	Minimum requirements Conspicuous-ness issues Interoperability Ground-based solutions	Human-machine interface Impact on ATC ops Mixed operations	MAP ATM Master Plan requirements Trajectory management for UAS Initial 4D operations SWIM Delegated separation	Transparent contingency procedures	Ground station Jamming GPS vulnerability Hijacking
	VFR (visual flight rules) Integrating UAS VFR is the most challenging aspect. This encompasses all airspace classes	ATM impact assessment Impact on GA operations	Integrity Availability	Minimum requirements Conspicuous-ness issues	Impact on ATC operations Impact on GA operations	MAP ATM Master Plan requirements	Transparent contingency procedures	Ground station Jamming

Time-frame	Types of Operation	Integration aspects to be addressed						
		Airspace access	Comms C2 datalink	D&A	Human factors	SESAR compatibility	Contingency	Security
	where VFR flights are allowed including all types of aerodrome operation (controlled, uncontrolled, civil/mil etc.)	CNS requirements Flight planning	Continuity of service Lost link Latency Spectrum requirements Satcom Secure comms	Interoperability Ground-based solutions	Mixed operations	Trajectory management for UAS SWIM		GPS vulnerability Hijacking
	B-VLOS (very low level) To enable B-VLOS operations the following aspects need to be addressed; • Airspace assessment • Performance requirements • Types of flight rule applied • Terrain database • C2 requirements • Security • D&A (B-VLOS specs) • Contingency Met Urban specific	Infrastructure requirements Flight Planning	Integrity Availability Continuity of service Lost link Latency Spectrum requirements Satcom Secure comms	Minimum requirements Conspicuous-ness issues Interoperability Ground-based solutions	General impact assessment	n/a	Transparent contingency procedures	Ground station Jamming GPS vulnerability Hijacking

Time-frame	Types of Operation	Integration aspects to be addressed						
		Airspace access	**Comms C2 datalink**	**D&A**	**Human factors**	**SESAR compatibility**	**Contingency**	**Security**
ASBU 2 2018 - 2023	**IFR** (instrument flight rules)	ATM impact assessment Impact on pan-European network operations Minimum performance requirements for IFR operations in core area CNS Integrated aerodrome operations	Integrity Availability Continuity of service Lost link Latency Spectrum requirements Satcom	Minimum requirements Conspicuous-ness issues Interoperability Ground-based solutions Link to possible manned solutions	Human-machine interface Impact on ATC ops Mixed operations	MAP ATM Master Plan requirements Trajectory management for UAS Initial 4D operations SWIM	Development of transparent contingency procedures	Ground station Jamming GPS vulnerability Hijacking
	VFR (visual flight rules)	ATM impact assessment Impact on GA operations CNS requirements Flight planning	Integrity Availability Continuity of service Lost link Latency	Minimum requirements Conspicuous-ness issues Interoperability Ground-based solutions	Human-machine interface Impact on ATC ops Mixed operations	MAP ATM Master Plan requirements Trajectory management for UAS	Development of transparent contingency procedures	Ground station Jamming

Time-frame	Types of Operation	Integration aspects to be addressed						
		Airspace access	**Comms C2 datalink**	**D&A**	**Human factors**	**SESAR compatibility**	**Contingency**	**Security**
		CNS Integrated aerodrome operations	Spectrum requirements Satcom	Link to possible manned solutions		Initial 4D operations SWIM		
	B-VLOS (very low level)	ATM impact assessment Impact on pan-European network operations Minimum performance requirements for IFR operations in core area CNS Integrated aerodrome operations	Integrity Availability Continuity of service Lost link Latency Spectrum requirements Satcom	Minimum requirements Conspicuous-ness issues Interoperability Ground-based solutions Link to possible manned solutions	Human-machine interface Impact on ATC ops Mixed operations	MAP ATM Master Plan requirements Trajectory management for UAS Initial 4D operations SWIM	Development of transparent contingency procedures	Ground station Jamming

APPENDIX 5 UAS TRAFFIC CLASSES

	CLASS	EASA MAPPING	TRAFFIC TYPE	AIRSPACE	OPERATIONS	PURPOSE	SPECIFICITY
VLL	I	Open Category	Buy and Fly primarily	From ground to 120m/400ft AGL In low traffic density areas UAS ONLY	VLOS	Recreational	• Mandatory declaration of operation • UAS must self-separate in 3D • Geofencing ensures that this category remains separated from no-drone zones
	II	Specific Operation/ Certified Category (possible operations)	Specific/Certified Category	From ground to 500 FT	VLOS/ BVLOS	Surveys, filming, search and rescue and other	• Has surveillance capability (4G chip or other means) • Free flight Capability • UAS must self-separate in 3D • BVLOS shall have barometric measurement equipage
	III	Specific Operation / Certified Category (possible operations)	Medium/Long haul traffic	From ground to 500 FT	BVLOS Free Flight or Route structure	Mainly transport purposes	• Mandatory authorisation for operation • Has surveillance capability • Shall have barometric measurement equipage
	IV	Specific Category/ Certified Category	Special operations	From ground to 500 FT	VLOS/ BVLOS	Highly specialised operations (civil, state or military, etc.)	• Addressed on case by case basis • Require special authorisation • Could require surveillance capability, depends on the mission requirements

	CLASS	EASA MAPPING	TRAFFIC TYPE	AIRSPACE	OPERATIONS	PURPOSE	SPECIFICITY
IFR/ VFR	**V**	Certified Operations	UAS not meeting pan-European network Performance requirements	From 500 FT AGL up to FL 600, including uncontrolled aerodromes	IFR/VFR Operating outside of the pan-European network Not flying SIDs and STARs	Mainly transport or military	• UAS operating in the environment will file a flight plan including information such as type of UAS, planned Contingency procedure and a contact phone number • UAS will meet CNS airspace requirements • UAS will be able to establish two-way communication with ATC if required • UAS will remain clear of manned aircraft • UAS operator must be able to contact ATC (if required) in regard to special conditions such as data link loss, emergency or controlled termination of flight • UAS D&A capability will be compatible with existing ACAS systems
	VI	Certified Operations	UAS meeting pan-European network performance requirements	From 500 FT AGL up to FL 600, including aerodromes	IFR/VFR According to airspace classes requirements Operating in the pan-European network, including SIDs and STARs	Any	• UAS operating in the environment will file a flight plan including information such as type of UAS, planned Contingency procedure and a contact phone number • UAS will meet CNS airspace requirements • UAS will be able to establish two way communication with ATC • UAS operator must be able to contact ATC (if required) in regard to special conditions such as data link loss, emergency or controlled termination of flight • UAS D&A capability will be compatible with existing ACAS systems

	CLASS	EASA MAPPING	TRAFFIC TYPE	AIRSPACE	OPERATIONS	PURPOSE	SPECIFICITY
VHL	**VII**	Certified Operations	Very high level IFR operations transiting non-segregated airspace	Above FL600, transition through lower airspace	IFR/VFR	Stratospheric commercial operations (unmanned aircraft and balloons)	• UAS must file a flight plan • UAS will meet CNS airspace requirements • UAS must inform the responsible ATC unit in case of emergency re-entry into controlled airspace • UAS must inform ATC about the type of contingency procedures to be used (balloons deflating or orbiting descent) • A regional centralised system should have an overview of the ongoing operations • Departure and arrival procedures should be developed

APPENDIX 6 UAS AIRPORT CONOPS

A6.1 INTRODUCTION

The Unmanned Aircraft System (UAS) Airport CONOPS describes the operational perspective of UAS operations at airports. Airport stakeholders are recognising the potential for UAS in a multitude of airport operations from commercial, ATM, aircraft inspection, airport infrastructure, maintenance and security related activities. UAS are welcome enablers providing new business opportunities.

The operation of UAS should be equitable, benefiting all stakeholders with unfettered access in and around an airport subject to having a clearly defined role and remaining within an agreed regulatory context that ensures the safety and security of all actors.

Different types of UAS operation will occur, operated by craft ranging from small Unmanned Aircraft Systems (sUAS) to Remotely-Piloted Aircraft System (RPAS), which can be certified for IFR operations.

Considering the different types of UAS operation, the generic abbreviation UAS will be used unless the specific operation referred to requires a more focused definition.

It is assumed that all UAS operations in and around the vicinity of an aerodrome or its control zone (CTR) will participate in a U-Space service via pre-registration and will be known to the Airport local control authority.

A6.1.1 OPPORTUNITY

UAS operations at airports create new opportunities compared with historical manned aircraft and ground-vehicle operations and it is important that UAS be afforded the same growth opportunities as traditional mobiles. However, the European Rules of the Air (SERA) do not yet recognise UAS Airport operations. The UAS Airport CONOPS provides a view of an airport operating environment that incorporates UAS.

ATC management of movements at airports and authorisation of non-ATC managed operations should necessarily and equitably integrate UAS, whilst ensuring unrestricted operation for existing stakeholders, providing a common situational awareness and safe operations for all.

UAS will operate airside and landside as well as in other areas in support of security and services not directly involved in the operation of the airport. All operations should be defined together with the areas within which UAS can operate, and with the regulations and procedures to be followed.

The UAS operations, operating areas, associated regulations and procedures will necessarily be facilitated through U-space[17] in such a manner as to enable UAS to undertake current day airport tasks and to be able to expand into new business opportunities.

[17] U-space. Blueprint.© SESAR Joint Undertaking, 2017

A6.1.2 SCOPE

The UAS Airport CONOPS aims to describe the operational ATM environment of UAS operations at or in the vicinity of an airport and within the aerodrome control zone (CTR).

The CONOPS adheres to UAS integration principles[18] ensuring equity and access for both manned and UAS aviation, supporting the development of this new industry. It considers all types of UAS operation, making no distinction between civil or military operations.

The ICAO Global Air Navigation Plan (GANP) provides the top-level framework for this, while the EASA opinion ensures technical compliance.

The CONOPS provides a generic view, applicable to all airports and although it does not describe or address detailed scenarios, it provides an operational ATM perspective based on UAS areas of operation.

A6.1.3 GENERAL ASSUMPTIONS

This concept of operations assumes that the required technology, standards, procedures, processes and regulations will be available and that the Rules of the Air for UAS are in place.

In addition, the following are assumed:

- The airport in question is a controlled airport;
- An airspace assessment of the CTR has been performed;
- Detect & avoid capabilities are in place as well as;
- UAS are tracked and distinguishable from manned vehicles;
- Geo-fencing technology is in place;
- Harmonised UAS contingency procedures are in place.

A U-space operation provides for pre-registration that will guide the UAS operator to the procedures and regulations applicable and will ensure that the local control authority is aware of the nature of the operation and its obligations towards the UAS.

It is assumed that UAS operators will comply with the procedures and regulations set out in U-Space and communicated at registration in accordance with the UAS operation to be undertaken.

Unmanned Traffic Management (UTM) systems, client-server apps and associated database systems designed to assist the UAS operator and pilot in the procedures requires for notification and authorisation of a UAS flight, are used. Several such systems are available on the market.

A6.2 UAS AERODROME INTEGRATION

A6.2.1 AUTHORITY, EQUITY AND ACCESS

The local control authority responsible for agreeing UAS operations at or in the vicinity of an aerodrome may be a national authority, airport operator or air navigation service provider (ANSP).

[18] UAV integration essentially involves three elements: reliable systems; tracking; and a rapid command response capability with other aircraft or AT

This “authority” will be responsible for providing the U-Space capability and agreeing the procedures, regulations and standards that all operators, including UAS, should abide by when operating at or in the vicinity of an aerodrome, its traffic zone (ATZ) and its control zone (CTR), hereinafter called the “aerodrome”.

The objective of the control authority is to ensure equitable access to the aerodrome for all operators and in the context of UAS as a new “entrant,” to facilitate the various UAS business models, in a safe, efficient and expeditious manner, ensuring a common situational awareness of all the players involved such that they can optimise their individual business needs.

Operations at an aerodrome will be subject to key performance indicators (KPI) for safety, efficiency, resilience, equity, access and environmental aspects. UAV operations will participate in driving these KPIs as with other players at the aerodrome.

The core model for UAS integration will be through a U-Space-compliant UTM, which will hold the local procedures, regulations and standards by which UAS will operate at an aerodrome.

Regulations will include any necessary training and certification required to support operations. Latest information on aerodrome operations will normally be promulgated to UAS operators through U-Space ensuring a common understanding of the aerodrome’s operational situation for all stakeholders.

A6.2.2 U-SPACE COMPLIANCE

Whilst aerodromes and U-Space have their own respective areas of responsibility, their operation can be concurrent. The local control authority and UAS operators should use a U-Space-compliant UTM as the single point of registration and authorisation for UAS aerodrome operations. U-Space in this context should be interoperable with the local control authority aerodrome and ATC systems

The relevant information exchanged between the local control authority and UTM operators will ensure a safe and efficient integration of UAS into aerodrome operations, ensuring continuity of aerodrome operations for all aerodrome users.

Depending on the nature of the UAS operation requested, authorisation may be automatic, requiring only compliance with the applicable procedures, regulations and standards. Where positive control is required, the authorisation will detail the additional procedures, regulations and standards applicable.

A6.3 GEO-FENCING

Technologies are being developed that will enable restrictions of the movement of UAS based on geographical and temporal coordinates, available from a dynamic database that can be uploaded to the UA via a UTM, for example. This technology will support several types of restriction. A selection of these relevant to UAS activities at or near airports is given below:

- Geo-fencing - supports collaborative dynamic security alerts and the means to prevent surface and aerial intrusion into or out of a defined area;
- Geo-fence (see Figure 9) – describes geographical and temporal airspace barriers that UAs should/may not cross, to reduce nuisance and ensure operational safeguards.

Figure 9 Geo-fence

- Geo-limitation – the act of restricting the movement of a UA by the use of geo-fences – notably through exclusion or caging (see below);
- Geo-exclusion (see Figure 10) - prevents unauthorised UAS from flying inside a pre-determined sensitive area whilst authorised UA can freely operate in accordance with their agreed mission;

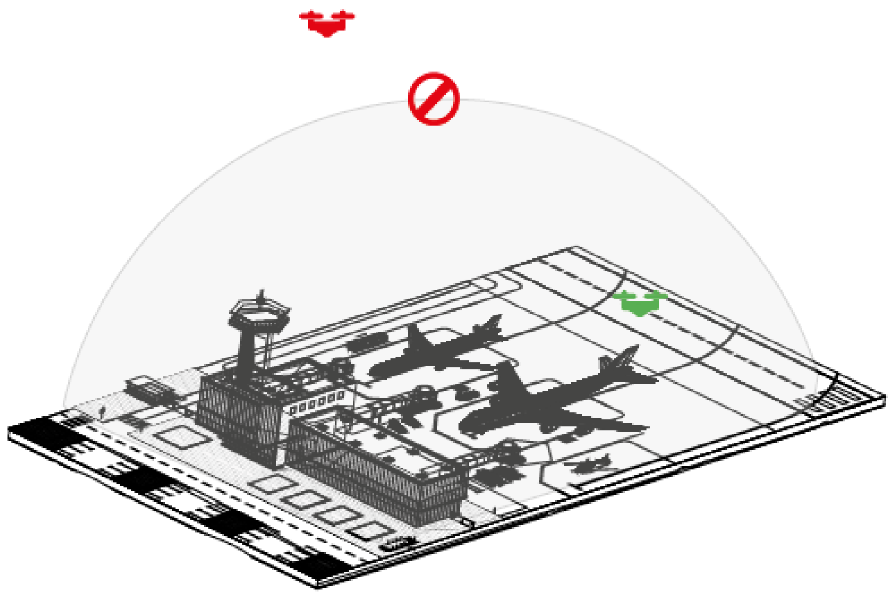


Figure 10 Geo-exclusion

- Geo-caging (see Figure 11) - prevents a UA from flying outside of a pre-determined volume;

Figure 11 Geo-caging

A6.4 AIRSPACE CONSIDERATIONS

Airspace design may require adjustment to facilitate safe and efficient UAS operations at aerodromes.

UAS bring new operational models that can provide an impetus for wider changes to aerodrome and ATM operations. This opportunity should be exploited such that “safety shall be enhanced or at least maintained by the design of any airspace structure”[19].

In the context of UAS operations at or near aerodromes, two airspace structures are likely to be concerned:

- Control zones (CTR) containing the paths of IFR flights arriving at and departing from aerodromes, and
- Aerodrome Traffic Zone (ATZ)20 which may be controlled or uncontrolled.

The geographical nature and dimensions of these airspace structures should incorporate all airspace users in an equitable manner. Access by UAS should be facilitated, as for other users, in a safe and efficient way ensuring optimum operations for all users.

Special needs such as UAS access corridors and operating zones should be clearly defined to facilitate UAS operations. The different UAS operations and application of geo-fencing to specific areas should be described and promulgated to all airspace users to ensure a common understanding of airspace use and access requirements.

[19] ERNIP. Part 1 – EAD Methodology Guidelines – *General principles for airspace design. 2.1.2,* Principles 1 – Safety (pg 20)

[20] Definition used in ICAO Annex 2 “Rules of the air” and Regulation (EU) No.923/2012 “Standardised European Rules of the Air (SERA)

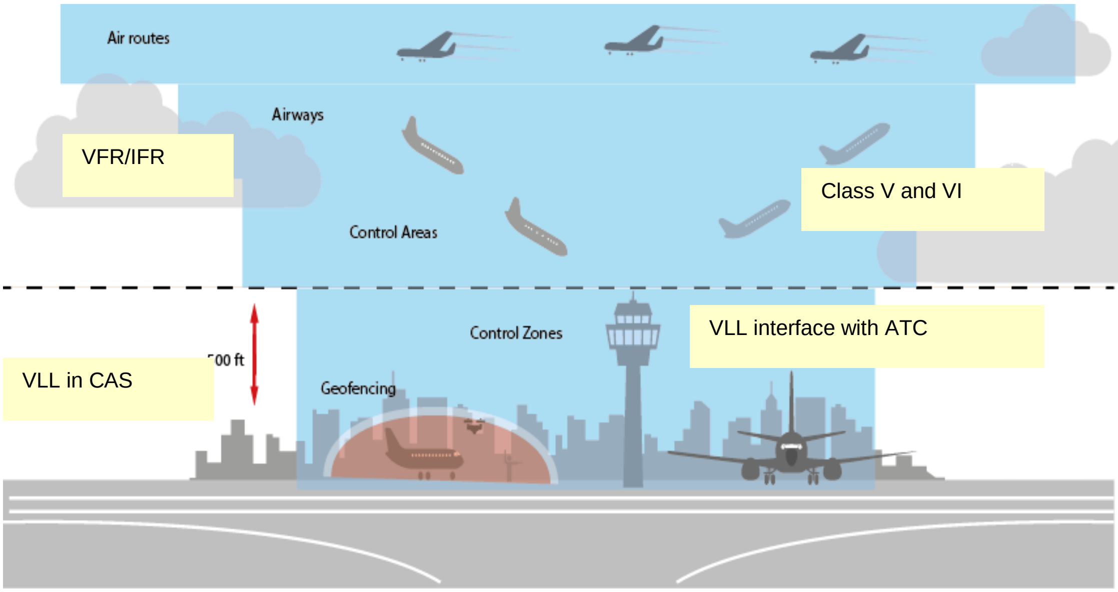


Figure 12 Airport airspace organisation

A6.5 UAS OPERATIONS

To address the variety of UAS operations at airports, the CONOPS refers to the type and area of UAS operations to provide clarity on the applicable procedures, regulations and standards.

UAS operations will be conducted under VLOS and BVLOS. Although most UAS applications will be carried out in Visual Line of Sight (VLOS) missions, BVLOS might facilitate operations in areas where access is difficult, dangerous, time consuming or expensive yet suited to UAS.

Larger UAS such as RPAS may operate under IFR/VFR rules and avail of an ATC service.

The CONOPS describes three types of UAS operation:

- Sensitive Operations;
- General Operations; and
- External Operations.

These different operations are described in the following sections.

A6.5.1 SENSITIVE UAS OPERATIONS

Sensitive UAS operations involve all aspects of runway operations and areas around navigation aids such as ILS that can affect flight safety assurance.

In such areas, positive control of all vehicles is required to ensure safety through procedures and common situational awareness.

Typically, this may involve utilising UAS for existing tasks such as runway inspection, weather observations, visual landing aid calibration (PAPI), Navaid inspection and other similar tasks.

It could include UAS operating in close vicinity to a sensitive area such as wild life; operations near to a runway; security operations and emergency operations carried out by security and police forces that could involve a runway crossing; or UAS operating in close proximity to the airfield under a final approach path.

Requirements to be considered

Such operations will require pre-authorisation and should be carried out under the supervision of the local control authority. Typically, they will be covered by local procedures and regulations supporting VLOS and BVLOS with an enabling safety case and clearly defined failure procedure.

Other enabling requirements to be considered include:

- The operator being in continuous two way communication with the local control authority;
- Remaining visible to the local control authority, and if appropriate, with lighting to improve detectability and/or have a transponder capability;
- In dense operations, be equipped with detect and avoid capabilities;
- Operator situation awareness, and
- Geo-fencing to ensure regulated geographical operations by authorised UAS.

Technical recommendations:

In addition to typical vehicles (aircraft and ground support equipment - GSE), sensitive areas should be exclusive to authorised UAS operating in accordance with the requirements described above.

However, due to the safety and security aspects of sensitive areas, other more stringent technical requirements should be considered to provide enhanced protection including geo-fencing and geo-exclusion.

A6.5.2 GENERAL UAS OPERATIONS

General UAS operations are normally pre-authorised by the local control authority and operate under geo-caging (see Figure 11), geo-limitation that prevents the UAS from operating outside the authorised area.

General UAS operations are generally carried out airside over apron, taxiway and perimeter areas but clear of sensitive areas, in support of a number of stakeholder tasks. UAS that transition into a sensitive area are subject to the requirements for Sensitive UAS operations.

Typically, General UAS operations may involve tasks such as infrastructure and maintenance inspections, pavement inspections, aircraft inspections, airfield and incident surveillance, and perimeter security patrols. Airports are also considering authorising general operations that involve transporting of aircraft spares or high value freight between apron, parking and store areas.

Requirements to be considered

General operations will require pre-authorisation by the local control authority but might not be required to be under direct supervision. They will be covered by local procedures and regulations supporting VLOS and BVLOS with an enabling safety case and clearly defined failure procedure adapted to their geographical operation.

Other enabling requirements to be considered include:

- The operator complying with any local requirements:
    - to be in continuous two way communication with the local control authority;

  - to remain visible to the local control authority, and if appropriate, with lighting to improve detectability and/or have a transponder capability;
  - to have detect and avoid capabilities;
- Operator situation awareness, and
- Geo-fencing to ensure regulated geographical operations by authorised UAS.

Technical recommendations:

In addition to typical authorised vehicles (aircraft and GSE), UAS operating in accordance with the requirements described above may have additional requirements to adhere to for safety and security aspects of landside operations.

This protects UAS and other vehicles from infringement of sensitive areas and unauthorised areas of operation. Such technical requirements may be prescribed by the local control authority and include geo-fencing, geo-limitation and geo-exclusion.

A6.5.3 EXTERNAL UAS OPERATIONS

External UAS operations cover most other operations that are executed outside the direct operational environment of landside and sensitive areas but within the vicinity of an aerodrome and its CTR.

It is assumed that positive control of a UAS is not required although safety and security is enabled through pre-registration and observation of the locally defined procedures applicable at the time of operation, agreed through pre-registration or promulgated by the local control authority.

Typically, this may involve use of UAV for inspections, farming, filming and media, sport or commercial purposes, and local or national security.

Requirements to be considered

External operations will require pre-registration with the local control authority under the rules of U-Space although such operations are unlikely to be under direct supervision. They will be covered by local procedures and regulations supporting VLOS and BVLOS with defined geographical limits and failure procedures adapted to their geographical operation.

Other enabling requirements to be considered include:

- The operator complying with any local requirements deemed relevant to the nature of the operation:
  - to be in two way communication with the local control authority (e.g. operations outside of a boundary fence yet close to runway operations);
  - to remain visible to the local control authority, and if appropriate, with lighting to improve detectability and/or have a transponder capability;
  - Detect and avoid capabilities;
- Operator situation awareness, and
- Geo-fencing to ensure regulated geographical operations by authorised UAS.

The local control authority should be aware of UAS operations within the vicinity of an aerodrome and its CTR through pre-registration or based on local agreements such as pre-defined corridors and zones used by known UAS operators for their own purposes e.g. busy freight/parcel/medical/operations accessing designated non-sensitive areas.

Corridors, zones and other similar operations may be designated as not requiring communication with the local control authority or may have simple requirements such as advising the local control authority of being active or in active, or subject to pre-defined opening hours.

Technical recommendations:

Some technical requirements for External UAS operations may be defined through a U-Space-compliant UTM at registration to ensure safety, security and common situational awareness. Such technical requirements may include one or more of the following: geo-fencing, geo-limitation, geo-exclusion, and geo-caging.

DEFINITIONS, ACRONYMS AND ABBREVIATIONS

Term	Definition
ACAS	Airborne Collision Avoidance System
ADS-B	Automatic Dependent Surveillance-Broadcast
AFUA	Advanced Flexible Use of Airspace
AGL	Above Ground Level
AIM	Aeronautical Information Management
AIRAC	Aeronautical Information Regulation And Control
AIS	Aeronautical Information Service
AMC	Airspace Management Cell
ANS	Air Navigation Service
ANSP	Air Navigation Service Provider
ASBU	Aviation Systems Block Upgrades
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
ATZ	Aerodrome Traffic Zone
BRLOS	Beyond Radio Line of Sight
BVLOS	Beyond Visual Line of Sight
C2	Command and Control Link
CAA	Civil Aviation Authority
CEF	Connecting Europe Facility
CFR	Code of Federal Regulations
CNS	Communications, Navigation, Surveillance
COM	Communications Technology
CONOPS	Concept of Operations
CPDLC	Controller Pilot Datalink Communication
CTR	Control Zone
D&A / DAA	Detect and Avoid
DTM	Drone Traffic Management
EAD	European Aviation Database
EASA	European Aviation Safety Agency
EC	European Commission
ECAC	European Civil Aviation Conference
EDZ	Exclusive drone zone
EOC	Essential Operational Change
eIDAS	electronic Identification and Trust Services
EU	European Union
EVLOS	Extended Visual Line Of Sight
FCC	Flight Control Computer
FIS	Flight Information Service
FL	Flight Level
FLARM	Flight Alarm
FOC	Full Operational Capability
FPL	Flight Plan
FUA	Flexible Use of Airspace
GA	General Aviation
GANP	Global Air Navigation Plan
GIS	Geographic Information System
GRA	Generic risk assessment
HALE	High-altitude long endurance

HIRAT	High Intensity Radio Transmissions
HFR	High-evel flight rules
IBAF	Integrated Briefing Automated Facility
ICAO	International Civil Aviation Organisation
IFR	Instrument flight rules
JARUS	Joint Authority on Rulemaking for Unmanned Systems
LDZ	Limited drone zone
LFR	Low-level flight rules
LSSIP	Local Single Sky ImPlementation
MASPS	Minimum aviation system performance standards
MATZ	Military Aerodrome Traffic Zones
MET	Meteorological
MOPS	Minimum operational performance specification
MoT	Ministry of Transport
NDZ	No drone zone
NOTAM	Notice to Airmen
RCC	Rescue Coordination Centre
RLOS	Radio line-of-sight
RPA	Remotely Piloted Aircraft
RPAS	Remote Piloted Aircraft System
SERA	Standard European Rules of the Air
SESAR	Single European Sky ATM Research
SID	Standard instrument departure
SIM	Subscriber Identification Module
SJU	SESAR Joint Undertaking
SORA	JARUS Standard Operational Risk Assessment
SRA	Strategic risk assessment
STAR	Standard Terminal Arrival Route
sUAS	Small Unmanned Aircraft System
TDD	Traffic dynamic data
TMA	Terminal Area
TRA	Tactical risk assessment
TSD	Traffic static data
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
UIR	Upper information region
UTM	Unmanned Traffic Management
UTMS	Unmanned Traffic Management System
VFR	Visual flight rules
VHL	Very high level
VLL	Very Low Level
VLOS	Visual Line Of Sight

Table 1 - Definitions, acronyms, and abbreviations