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DRONES4SAFETY

Drones4Safety

Research & Innovation Action (RIA)

Inspection Drones for Ensuring Safety in Transport Infrastructures

Regulatory Gap/Barriers Analysis (initial)
D2.2

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1 Executive Summary

This deliverable aims at providing an initial analysis of Regulatory Gaps and Barriers for the drone operations foreseen by the Drones4Safety concept of operations. The main recipients of this document are the technical Work Packages of Drones4Safety. In particular, the activities involving the design and validation of the use cases (T2.4, T7.1, T7.2 and T7.3) and the Work Packages dedicated to the actual drone platform design and development (Work Packages 3, 5 and 6) should take into consideration the regulatory aspects highlighted by this document.

Albeit a more detailed analysis of how the regulation may impact the use cases will be provided in D2.4, this document already draws some conclusions and recommendations about the main high-level gaps and barriers identified so far. Important aspects about the nature of the foreseen operations need to be defined by the Consortium as soon as possible in order to understand the next steps needed to get authorisations to carry out the demonstration flights. These aspects include, among the others:

- Exact place of the operation (including the nature of the surrounding airspace);
- Operation duration;
- Number and type of drones used for the operation;
- Volume of operations (distance from the infrastructure and from the pilot/operator, altitude, etc.);
- VLOS/B-VLOS.

Some attention should be paid on the most innovative concepts introduced by Drones4Safety in its use cases: autonomous flights and the use of swarms of drones. Both these aspects are not yet fully defined in the regulation, so an exploratory approach will be adopted with the authorities. This means that an experimental plan and a set of tests should be agreed to get a permission to perform such "special" operations. On one hand, this may mean spending additional coordination effort, but on the other side, should the work done in Drones4Safety demonstrate the feasibility and safety of such kind of operations, this would substantially contribute to both the technological advancement and the regulatory developments in the field.

Contents

Acronyms

Acronym	Description
ACP	Aeronautical Communications Panel
ADS-B	Automatic Dependent Surveillance – Broadcast
AIP	Aeronautical Information Publication
AMC	Acceptable Means of Compliance
ANS	Air Navigation Service
ATC	Air Traffic Control
B-RLOS	Beyond Radio Line-of-Sight
B-VLOS	Beyond Visual Line-of-Sight
C2L	Command and Control Link
EASA	European Aviation Safety Agency
EU	European Union
E-VLOS	Extended Visual Line -of -Sight
FSS	Fixed Satellite Service
GM	Guidance Material
ICAO	International Civil Aviation Organization
ITU	International Telecommunication Union
JU	Joint Undertaking
LUC	Light Drone Operator Certificate
MTOM	Maximum Take-Off Mass
NAA	National Aviation Authority
NOTAM	Notices to Airman
PDRA	Predefined Risk Assessment
PIC	Pilot in Command
QE	Qualified Entity
RLOS	Radio Line-of-Sight
RPA	Remotely Piloted Aircraft
RPS	Remote Pilot Station
RPAS	Remotely Piloted Aircraft System
SORA	Specific Operations Risk Assessment
SS	Standard Scenario
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
UTM	Unmanned Traffic Management
VLOS	Visual Line-of-Sight
VO	Visual Observers

References

[RD1] ICAO Manual on Remotely Piloted Aircraft Systems (RPAS) (Doc 10019)
[RD2] ICAO Remotely Piloted Aircraft System (Rpas) Concept of Operations (Conops) for International IFR Operations
[RD3] EASA Concept of Operations for Drones, https://www.easa.europa.eu/sites/default/files/dfu/204696_EASA_concept_drone_brochure_web.pdf
[RD4] European Commission Implementing Regulation (EU) 2019/947 "on the rules and procedures for the operation of unmanned aircraft" published on 24 May 2019
[RD5] European Commission Delegated Regulation (EU) 2019/945 "on unmanned aircraft systems and on third-country operators of unmanned aircraft systems" published on 12 March 2019
[RD6] Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Commission Implementing Regulation (EU) 2019/947
[RD7] EASA Opinion 01/2020 High-level regulatory framework for the U-space, https://www.easa.europa.eu/document-library/opinions/opinion-012020
[RD8] ICAO Annex II: Rules of the Air
[RD9] Easy Access Rules for Standardised European Rules of the Air (SERA)

2 Introduction

2.1 Scope of the document

This deliverable collects and presents the outcome of the regulatory analysis and identification of potential gaps and issues in the Concept of Operations and in the system validation campaigns proposed by Drones4Safety. This document is meant to be used as input for guiding the development of the technical WPs and to support the Request of Authorization and/or Permission by the competent Civil Aviation Authorities in the countries in which the flights will be carried out. This is an initial version of the Regulatory Gap/Barriers Analysis, the final findings will be collected in D8.6, foreseen for the end of the project, at month 36.

3 Drones Regulatory framework

This Section is meant to give the reader with information about the current regulatory framework for drone operations. This review is not meant to be exhaustive, as the topic is very wide and an in-depth investigation is out of the scope of the Drones4Safety project. Nonetheless, the objective of this Section is to provide the reader with a level of understanding of the drone regulation state-of-the-art in Europe that is sufficient to understand the potential impact of the regulation on the Drones4Safety concept of operations and use cases.

3.1 Definitions

Aircraft that are not controlled (during the all flight or parts of it) by a pilot on-board are called *Unmanned Aircraft*. The inherently distributed nature of such configuration includes several components, so the international community has agreed to refer them as *Unmanned Aircraft Systems* (UAS). A sub-category of UAS is composed by the configurations where the remote pilot (typically on the ground) has a direct control of the flight during all its phases. They are called Remotely Piloted Aircraft Systems (RPAS). UAS with the ability to perform an autonomous flight (or part of it) are not included in the category of RPAS.

An in-depth analysis of all the subsystems and technologies composing an UAS is out of the scope of this document, but a preliminary overview of its functioning and structure, together with some definitions, has a certain importance for understanding the following sections. Different definitions and descriptions of UAS and their component have been provided in the past years, and the terminology itself may slightly differ from a source to another (e.g. military and civil terminologies are not always aligned). In order to provide the Drones4Safety consortium and the readers with a common understanding and a uniform terminology, the following definitions adhere as strictly as possible to International Civil Aviation Authority (ICAO) taxonomy [RD1] [RD2].

3.1.1 Main components of an UAS

The remotely-piloted aircraft system comprises a set of configurable elements including a Remotely Piloted Aircraft (RPA, the flying part), its associated remote pilot station(s), the required C2 Link and any other system elements as may be required, at any point during flight operation. Other features might include, inter alia, software, health monitoring, ATC communications equipment, a flight termination system, launch and recovery elements, and/or other elements.

3.1.1.1 Unmanned Aircraft (UA) or Remotely Piloted Aircraft (RPA)

The RPA is the flying part of the system. It is properly considered as an "aircraft" by ICAO, so all the definitions, rules and general provisions about aircraft are applicable. The table below reports the categorization of aircraft, following ICAO Annex 7.

<table>
<tr><td rowspan="13">Aircraft</td><td rowspan="3">Lighter than air</td><td rowspan="2">Non power driven</td><td colspan="2">Free balloon</td></tr>
<tr><td colspan="2">Captive balloon</td></tr>
<tr><td>Power-driven</td><td colspan="2">Airship</td></tr>
<tr><td rowspan="10">Heavier than air</td><td rowspan="2">Non power driven</td><td colspan="2">Glider</td></tr>
<tr><td colspan="2">Kite</td></tr>
<tr><td rowspan="6">Power-driven</td><td rowspan="3">Aeroplane</td><td>Landplane</td></tr>
<tr><td>Seaplane</td></tr>
<tr><td>Amphibian</td></tr>
<tr><td rowspan="2">Rotorcraft</td><td>Gyroplane</td></tr>
<tr><td>Helicopter</td></tr>
<tr><td colspan="2">Ornithopter</td></tr>
</table>

Table 1: Categorization of aircraft in ICAO

All the classes of aircraft mentioned in the table may have their own unmanned (remotely piloted) version. In the ICAO classification, the category of *multi-copters* falls under the definition of helicopters *("a heavier-than-air aircraft supported ... by ... one or more power-driven rotors on substantially vertical axes"*).

3.1.1.2 Remote pilot station

The Remote Pilot Station (RPS) is defined as *"…the component of the remotely piloted aircraft system containing the equipment used to pilot the remotely piloted aircraft."* As a general principle, the RPS behaves, or functions, in the same manner as the cockpit/flight deck of a manned aircraft and should, therefore, offer the remote pilot with an equivalent capability to command/manage the flight.

There are no common standards for the design of RPS and they may vary significantly in terms of size, functionalities, Human Machine Interface (e.g. joystick, knobs, touch screen), flight control modalities (e.g. fully manual vs. partly automated flight). In general, complexity of the ground station is proportionate to the size and weight of the RPAS and the type of operations to be conducted.

3.1.1.3 Command and Control link

The Command and Control Link (C2L) is the data link between the RPA and the RPS for the purposes of managing the flight. Accordingly, the C2L has two main functions:

- to allow the pilot to modify the behaviour of the RPA:
  - Control the RPA's flight (Aerodynamics, Propulsion, etc.);
  - Control Detect and Avoid systems on the RPA (execute manoeuvres);
  - Control on-board tools and equipment (Transponder, ADS-B[1], Radar, etc.);
- to allow the pilot to retrieve info about the RPA status:

[1] Automatic Dependent Surveillance – Broadcast is a surveillance technology in which an aircraft determines its position via satellite navigation and periodically broadcasts it

- RPA health and status (Speed, Attitude, Warnings, etc.);
- Monitor Detect and Avoid system on RPA (Target tracks, Advisories etc.);
- Monitor Flight Data Recording and other data sources.

No international standards have been currently defined on frequencies and channels for RPAS C2L. This led to a situation where different countries adopt different rules on the topic, so the manufacturers and operators do not have unambiguous references to follow. International Telecommunication Union (ITU), the United Nations specialized agency for information and communication technologies, is in charge to define and promote a worldwide uniform allocation of communication bands. In current ITU Radio Regulation (2012) following bands are candidates for C2 Link:

- 960 - 1164 MHz for RLOS
- 1545 – 1555 / 1646.5 – 1656.5 MHz and 1610 - 1626.5 MHz for BRLOS
- 5030 – 5091 MHz for RLOS and BRLOS

Other frequency bands, with suitable technical and regulatory provisions, are under consideration.

Work is underway in Aeronautical Communications Panel (ACP) WG-F to develop a band plan to allow sharing between the terrestrial and satellite RPAS users of the 5030 – 5091 MHz allocation.

Significant interest has been shown in using 12/14 GHz and 20/30 GHz Fixed Satellite Service (FSS) bands.

3.1.2 UAS/RPAS Operations

In remote piloted operations, the pilot (and the crew in general) is not "co-located" with the aircraft, so it emerged the necessity to define new categories of operations, with regard to the respective position of the pilot (at his/her RPS) and the RPA (the aircraft).

3.1.2.1 VLOS

Operating within VLOS (Visual Line-Of-Sight) means that the Remote Pilot is able to maintain direct, unaided (other than corrective lenses) visual contact with the RPA, and is able to monitor the whole flight in relation persons, other airspace users and/or fixed obstacles, including ground. Following the above definition, it is not easy to determine precise boundaries or a definite volume for VLOS operations: it strongly depends on the size, colour and shape of the RPA, weather and light conditions, orography, presence of obstacles. As a general provision, ICAO [RD1] outlined some maximum limitations to VLOS operations:

- Max RPA distance from the pilot: 500 m;
- Max altitude: 500 ft Above Ground Level.

Most recently, in [RD4], the European Commission provided another definition of VLOS:
"V*isual line of sight operation' ('VLOS') means a type of UAS operation in which, the remote pilot is able to maintain continuous unaided visual contact with the unmanned aircraft, allowing the remote pilot to control the flight path of the unmanned aircraft in relation to other aircraft, people and obstacles for the purpose of avoiding collisions*". This is the definition that is assumed in this document.

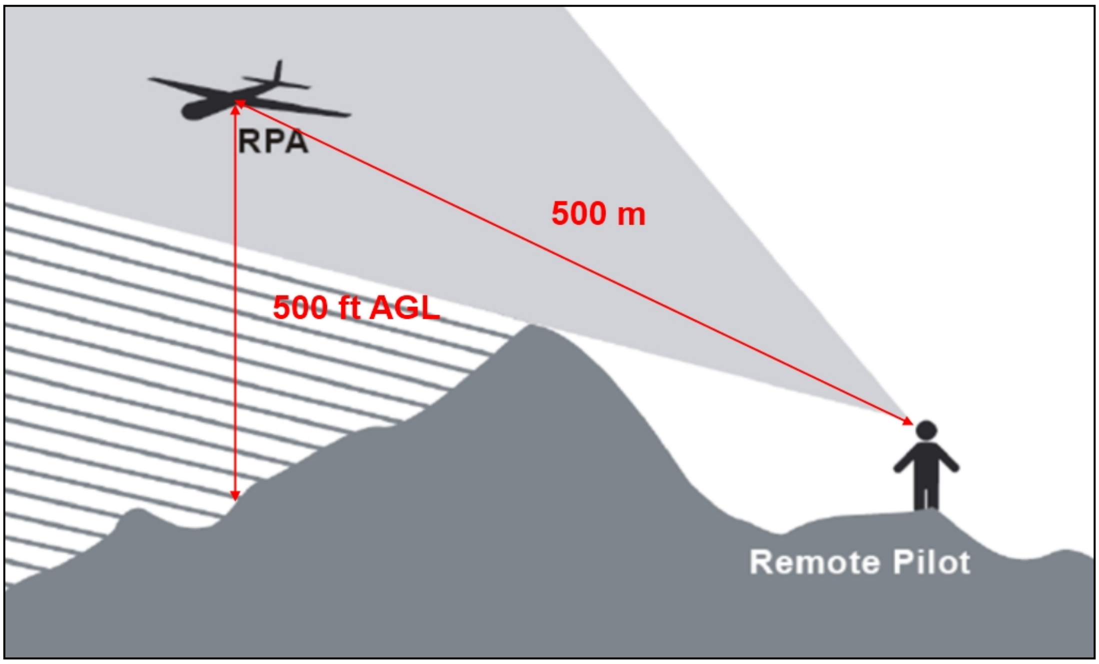


Figure 1: VLOS Operations (Courtesy ICAO)

3.1.2.2 E-VLOS

Extended Visual Line-of-Sight (E-VLOS) relates to the operations whereby the Remote Pilot in Command (PIC) relies on one or more Remote Observers to keep the unmanned aircraft in visual sight at all times, relaying critical flight information via radio and assisting the Remote Pilot in maintaining safe separation from other airspace users and/or fixed obstacles, including ground.

3.1.2.3 B-VLOS

Beyond Visual Line of Sight (B-VLOS) operations are the ones conducted in conditions where the VLOS between pilot and RPA is not maintained [RD1][RD4].

3.1.3 UAS vs. RPAS vs. Drone

In Section 3.1 we introduced the acronyms UAS and RPAS, which are the most correct and formal terms to use in the aviation domain. Nonetheless, the term drone emerged in the press and in the public as an informal, popular and generic substitute for an RPAS or a UAS. The European Union Aviation Safety Agency (EASA) and the European Union (EU) use the term “drone” [RD3]: ”…*RPAS are a sub-set of UAS. These terms that are coming from the ICAO circular328-AN/190 are replaced in the common language by the word drone and this document will accordingly use drones to speak of UAS and RPAS*”. The Drones4Safety project (and the authors of this document) decided to adopt the same approach and use the term “drone” as an easy to understand substitute for RPAS or UAS. In our vision, the use of the word “drone” makes the project outcomes easier to reach and understand even by non-technical or non-aviation related public. Wherever autonomous operations are foreseen, this will be made clear, so to the reader will be easily understand whether we will be talking about RPAS or (autonomous) UAS operations.

3.2 Europena Union Regulatory Framework and Initiatives

On September the 11th, 2018 the European Parliament adopted updated aviation safety rules for Europe including a new mandate for EASA that redefines the Agency’s competences. Regulation (EU) 2018/1139 empowers the Agency to propose to the European Commission the technical expertise to regulate drones of all sizes, including the small ones (Maximum Take-Off Mass (MTOM) below 150kg) that were originally out of the mandate of EASA. This decision paves the way for a progressive application of the EASA safety rules on a global European scale.

European Commission Implementing Regulation (EU) 2019/947 “on the rules and procedures for the operation of unmanned aircraft” was published on 24 May 2019. The Regulation lays down detailed provisions for the operation of unmanned aircraft systems as well as for personnel, including remote pilots and organisations involved in those operations. The document introduces three categories of operations based on the associated level of risk: Open, Specific and Certified category.

European Commission Delegated Regulation (EU) 2019/945 “on unmanned aircraft systems and on third-country operators of unmanned aircraft systems” was published on 12 March 2019. This Regulation lays down the requirements for the design and manufacture of unmanned aircraft systems (UAS) intended to be operated under the rules and conditions defined in Implementing Regulation (EU) 2019/947 and of remote identification add-ons. It also defines the type of UAS whose design, production and maintenance shall be subject to certification. It also establishes rules on making UAS intended for use in the ‘open’ category and remote identification add-ons available on the market and on their free movement in the Union. It also lays down rules for third-country UAS operators, when they conduct a UAS operation pursuant to Implementing Regulation (EU) 2019/947 within the single European sky airspace.

Both Regulations (EU) 2019/945 and (EU) 2019/947 came into force on 1st July 2019. Member States originally had a transaction period of maximum two years to adapt their National regulation to the common regulatory framework and by that time all the **National authorisations, certificates, declarations will be fully converted to the new EU system.** Due to the COVID-19 crisis, the applicability date of EU regulation 2019/947 has been delayed from the 1st July 2020 to the **31st December 2020**, meaning:

- as of 31st December 2020, registration of drone operators and certified drones becomes mandatory;
- as of 31st December 2020, operations in the “Specific” category may be conducted after authorisation given by the national authority;
- between 31st December 2020 and 1st January 2023 drones’ users operating drones without CE class markings can continue to operate, in the limited category under article 22 EU regulation 2019/947;
- as of January 2022, national authorisations, certificates, declarations must be fully converted to the new EU System;
- from 1st January 2022, EASA Member States must make available information on geographical zones for geo awareness in a digital format harmonised among EU countries;
- as of January 2023, all operations in the “Open” category and all drones’ operators must fully comply with EU regulation 2019/947 and EU regulation 2019/945.

In October 2019, the European Commission published the Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Commission Implementing Regulation (EU) 2019/947. These provisions contain the description of measures to comply with the regulation. They include:

- a revised version of the draft AMC and GM that were published with Opinion 01/2018
- the description of the risk assessment methodology called SORA (Specific Operation Risk Assessment) that is required in the “specific category”
- the first pre-defined risk assessment to assist operators when applying for an authorisation in the specific category for an operation:
    - Over Sparsely Populated Areas
    - In Uncontrolled Airspace
    - At Very Low Levels
    - B-VLOS with Visual Air Risk Mitigation
    - Using UA up to 3 m characteristic dimension

In other words, the AMC and GM give a legal background for the use of SORA methodology for the risk assessment of specific category operations in Europe.

3.2.1 Open, Specific and Certified Category

The European regulation establishes three categories of operation, as follows:

- 'Open' category (low risk): Safety is ensured through compliance with operational limitations, mass limitations as a proxy of energy, product safety requirements, and a minimum set of operational rules.
- 'Specific' category (medium risk): Authorisation by an aviation authority, possibly assisted by a qualified entity (QE[2]), following a risk assessment performed by the operator. A manual of operations lists the risk mitigation measures.
- 'Certified' category (higher risk): Requirements comparable to those for manned aviation. Oversight by NAA (issue of licences and approval of maintenance, operations, training, ATM/ANS and aerodromes organisations) and by EASA (design and approval of foreign organisations).

A drone can be operated in the "Open "category when it:

- bears one of the CE class marks 0, 1, 2, 3 and 4; or
- is privately built and with a weight less than 25 kg; or
- it is purchased before the 1st of January 2023, with no CE class marking as above;
- will be operated not directly over people, unless it bears a CE class mark or is lighter than 250 g;
- will be maintained in Visual Line of Sight (VLOS) or be assisted by a UA observer;
- is flown at no more than 120 m high;
- will not carry dangerous goods and not drop any material.

In all other cases it must be operated in the **Specific or Certified category**. UAS operations in the 'open' category are not subject to any prior operational authorization, nor to an operational declaration by the UAS operator before the operation takes place.

For the operations in the Specific Category, **Standard Scenario (SS)** are defined in the regulation. These scenarios define the conditions when UAS operators can start an operation after having submitted a declaration to the competent aviation authority, instead of applying for an authorization. The EU Regulation Commission Implementing Regulation (EU) 2020/639 introduces two Standard scenarios:

- **STS-01 "Urban VLOS":** Operations in the **Visual Line of Sight** at a maximum height of **120 m**, at a ground speed of **less than 5 m/s** in the case of untethered UAS, **over controlled ground areas** that can be in populated (e.g. urban) environments, using UAS with **maximum** take-off masses (*MTOMs*) of **up to 25 kg.** As defined in Article 2(21) of the Implementing Regulation, a controlled ground area is "the ground area where the UAS is operated and within which the UAS operator can ensure that only involved persons are present". So, the operator must at least be familiar with the intended area of operations. The drone must have a CE mark class 5.
- **STS-02 "Rural B-VLOS":** Operations **Beyond Visual Line of Sight** with the UAS at **not more than 2 km from the remote pilot**, if visual observers (*VOs*) are used, at a **maximum height of 120 m**, over **controlled ground areas** in sparsely populated environments, using UAS with MTOMs of **up to 25kg**. The launch and the recovery of the UAS is, in any case, required to be performed in VLOS. The main mitigation means are provided by the VOs who assist the remote pilot in scanning the airspace for the presence of other airspace users. Without the assistance of VOs, the range can be up to 1 km,

[2] The "Basic Regulation" for EASA defines a qualified entity as follows: 'qualified entity' shall mean a body which may be allocated a specific certification task by, and under the control and the responsibility of, the Agency or a national aviation authority.

if the UAS flies a pre-programmed flight, allowing it to scan the airspace itself. With VOs the range can be extended up to 2 km. The drone must have a CE mark class 6.

When the foreseen operation cannot be categorised as a standard-scenario, there are other means to get an operational authorisation under the "Specific" category, depending on the level of risk the operation poses. EASA published on its website some FAQ[3] to help operators understanding the regulation. The following indications are given to the drone operator wishing to operate in the Specific category, that can apply for:

1. ***An Operational Authorisation via conducting a risk assessment of the intended operation*** *using a methodology for the risk assessment, one possible is the SORA (specific operation risk assessment) that is included in AMC1 to Article 11 to Regulation (EU) 2019/947. This methodology helps to identify the risk level of the operation and to identify the mitigations and operational safety objectives needed to make the operation safe. When the drone operator believes it has put in place satisfactory measures to ensure the safety of the operation, she/he sends all information to the national Civil Aviation Authority and apply for an* ***Operational Authorisation****. When the national civil aviation authority is satisfied it provides the drone operator with the authorisation and the operation can be started.*
2. ***An Operation Authorisation through a predefined risk assessment' (PDRA)****: as a simplification of conducting a risk assessment by the drone operator. For those operations that will be the most common in Europe, EASA will carry out the risk assessment and will publish, as an acceptable means of compliance to the drone regulation, the list of actions that the drone operator needs to put in place in order to conduct the operation safely. Still the application for an authorisation to the national civil aviation authority is needed, however both the drone operator and the national aviation authority will benefit from the standardised measures defined in the PDRA. The PDRAs are published by EASA as AMC to Art 11 to Regulation (EU) 2019/947, more are already under development.*
3. ***Light drone operator certificate (LUC)****: this is a voluntary certification after which the national civil aviation authority may recognise some privileges to the drone operator. Drone operators may ask to the national civil aviation authority to have their organisation assessed such that they demonstrate to be capable to assess the risk of an operation themselves. The requirements to be demonstrated by drone operators are defined in the Part C of the Regulation (EU) 2019/947. When the national civil aviation authority is satisfied, they will issue a light drone operator certificate (LUC) and they will recognise privileges to drone operators based on their level of maturity. The privileges may be one or more of the following: conduct operations covered by standard scenario without submitting the declaration; self-authorise operations conducted by the drone operator and covered by a PDRA without applying for an authorisation; self-authorise all operations conducted by the drone operator without applying for an authorisation.*

3.2.2 Unmanned Traffic Management (UTM) and U-Space

In recent years, the need for traffic management focused on unmanned aircraft systems (UAS) emerged in many parts of the world. This UAS traffic management system (UTM) would ensure safe operation of a large number of drones at low-altitude (especially in urban areas). As traditional air traffic management (ATM) ensures the safety of aircraft operations at high altitude, so does UTM at a lower altitude. The Commission mandated the SESAR JU to lead the development of a UTM concept for Europe, called U-Space. A blueprint[4] was released in June 2017 with a preliminary vision for the U-space. It consists of a set of services enabling complex drone operations in all types of operational environments.

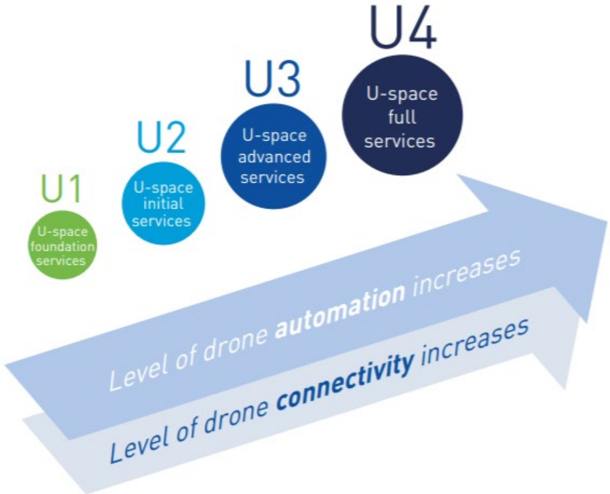
The progressive deployment of U-space is linked to the increasing availability of blocks of services and enabling technologies. Over time, U-space services will evolve as the level of automation of the drone

[3] https://www.easa.europa.eu/the-agency/faqs/drones-uas (Accessed: 14/09/2020)

[4] https://www.sesarju.eu/sites/default/files/documents/reports/U-space%20Blueprint.pdf (Accessed: 14/09/2020)

increases, and advanced forms of interaction with the environment are enabled (including manned and unmanned aircraft) mainly through digital information and data exchange.

The U-space services defined so far are here listed:



U1: U-space foundation services covering e-registration, e-identification and geofencing.

U2: U-space initial services for drone operations management, including flight planning, flight approval, tracking, and interfacing with conventional air traffic control.

U3: U-space advanced services supporting more complex operations in dense areas such as assistance for conflict detection and automated detect and avoid functionalities.

U4: U-space full services, offering very high levels of automation, connectivity and digitalisation for both the drone and the U-space system.

EASA has recently published its *Option 01/2020 on High-level regulatory framework for the U-space[RD7]*. The objective of this Opinion is to create and harmonise the necessary conditions for manned and unmanned aircraft to operate safely in the U-space airspace, to prevent collisions between aircraft and to mitigate the air and ground risks. Therefore, the U-space regulatory framework, supported by clear and simple rules, should permit safe aircraft operations in all areas and for all types of unmanned operations. The Opinion proposes an effective and enforceable regulatory framework to support and enable operational, technical and business developments, and provide fair access to all airspace users, so that the market can drive the delivery of the U-space services to cater for airspace users' needs. The Opinion is, therefore, a first regulatory step to allow immediate implementation of the U-space after the entry into force of the Regulation and to let the unmanned aircraft systems and U-space technologies evolve.

3.3 National Regulations

According to the European regulatory provisions described in the above section, as from December 31, 2020, national rules in EU Member States will be replaced by a common EU drone regulation. This basically means that once an operator has received a valid authorization from their state of registry, they will be allowed to freely operate within the European Union. From December 2020 onward it will be still possible to use previously obtained permits and exemptions for a period of two years up to December 2022. From then on only the EU regulations will apply. The demonstrations campaigns of Drones4Safety will be held in this interim period so, although the main reference regulatory framework for the project remains the EU common regulation, all the needed considerations about specific provisions made by the Civil Aviation Authorities of the member States where the flights will be taken into account and then included in the requests of Authorization or Declarations for the operations.

3.4 Industrial Standards for Small RPAS

The definition of a set of industry standards for drones is a fundamental cornerstone for a safe, reliable and cost-effective development of the sector. In the last years, the development of a regulatory framework for drones is being complemented by a growing number of standards for all the categories of drone operations, covering airworthiness, operations, equipment, software, and other important factors. A clear understanding of the current state-of-the-art of industry standards for drones is important for the Drones4Safety project, as the design and development of the proposed and solutions will necessarily take into account the existence of those standards. The adoption of adequate standards for safety of design and operations will also enable an easier path towards the achievement of authorizations by the competent aviation authorities for the foreseen validation campaigns.

The AW-Drones[5] project, funded by the European Commission, publishes and maintains an open online repository with a collection of technical and operational standards for drones. In particular, the objectives of AW-Drones are the following ones:

- **Collect information** on on-going and planned work with regards to technical and operational **standards** developed for drones worldwide, with a focus on SORA, U-Space and autonomous UAS operations
- Carry out a **critical assessment/benchmarking** of all collected data to identify best practices, gaps, bottlenecks and applicability
- **Propose** and **validate** a well-reasoned set of standards for each category of drone operations (published on the open repository)
- **Engage** with key stakeholders and end-users, i.e. representatives of the whole drone value chain.

In order to avoid duplications in the work of the two projects, it assumed that the main source of information in Drones4Safety for what concerns technical and procedural standards for the operation of drones will be the AW-Drones open repository. A strong link between the two actions is guaranteed by the fact that the responsible for the regulatory assessment of the operations in Drones4Safety is beneficiary Deep Blue, that also coordinates the AW-Drones project. AW-Drones will end up in December 2021, nonetheless the open repository will be kept available, maintained and updated after the end of the project, so it will remain available for Drones4Safety for all the time needed.

[5] https://www.aw-drones.eu (Accessed: 14/09/2020)

4 Potential Regulatory Gaps and barriers in Drones4Safety

One of the objectives of Work Package 2 of the Drones4Safety project is the identification of potential regulatory gaps and barriers for the proposed concept of operations. In addition, WP 2 will conduct a more detailed regulatory analysis of the proposed use cases for the demonstrations' exercises, with the objective to identify obstacles and/or difficulties for their execution, and potential strategies to overcome those issues. This detailed assessment of the use cases will be included in Deliverable 2.4, that is explicitly dedicated to the development and validation of the use cases.

The following sub-sections, instead, present the main general remarks about the potential regulatory gaps and barriers that should be kept in consideration during the design, development and validation of the Drones4Safety solutions, regardless of the nature of the specific use cases for the demonstration campaigns.

4.1 Drones4Safety overall concept of operations

The Drones4Safety system consists of a set of drones that have a self-charging capability to harvest energy from overhead power line cables (transmission lines/railways power lines). The drones are working autonomously in a swarm and apply local image processing utilizing edge computing to decrease the inspection time. The drones run onboard AI algorithms that are trained to detect faults on the transportation infrastructure (railways/bridges). Once the fault is detected, the drone reports it to the drone operator via its cloud service system that offers inspection services such as inspection mission control, fault detection reports, and swarm fleet management.

The D4S project is built upon two highly compelling use cases that address a large part of the European transportation infrastructure. A constructive design methodology is applied where use cases become key drivers for system requirements, prototype design aiming at lowering risk barriers in implementation as well as verification and validation to ensure and quantify the aimed project impacts. The identified use cases are:

- Use case 1: Railway inspection;
- Use case 2: Bridge inspection.

At this stage, the Use cases are not yet fully defined and detailed, so an extensive analysis of the potential regulatory gaps and barriers cannot be carried out. Nonetheless, it is possible to identify some high-level issues and strategies to address them. This activity will feed the design and definition of the use cases, in order to mitigate and minimize the risk of producing a final ConOps and use cases which are not aligned with the current (and evolving) regulatory framework for drone operations in Europe.

4.2 Open, Specific or Certified Category?

A first step in the high-level regulatory assessment is understanding the category under which the foreseen Drones4Safety drone operations may fall (see Section 3.2.1).

Due to the nature of the operations, that exclude flights over populated urban areas and/or gatherings of people, and due to the size and weight of the used drone that will never exceed 25 kg of Maximum Take-Off Mass (MTOM), we can reasonably exclude the Certified Category from the discussion.

The following subsection will give a picture of where open or specific category may apply to the foreseen operations.

4.2.1 VLOS operations

Flying **VLOS is currently compulsory in the Open Category operations**. It means that only VLOS Drones4Safety use cases may fall under this category. In addition, the following table[6] shows the main restrictions and provisions for VLOS operations under the European Regulation:

UAS		Operation		Drone Operator/pilot		
Class	MTOM	Subcategory	Operational restrictions	Drone Operator registration	Remote pilot competence	Remote pilot minimum age
Privately built	< 250 g	A1 (can also fly in subcategory A3)	- may fly over uninvolved people (should be avoided when possible) - no fly over assemblies of people	No, unless camera / sensor on board **and** a drone is not a toy	- no training needed	No minimum age
0					- read user's manual	16*, no minimum age if drone is a toy
Legacy drones (art. 20)						16*
1	< 900 g		- No expected fly over uninvolved people (if happens, should be reduced) - no fly over assemblies of people	Yes	- read user's manual - complete online training - pass online theoretical exam	16*
2	< 4 kg	A2 (can also fly in subcategory A3)	- no fly over uninvolved people - keep horizontal distance of 30 m from uninvolved people (it can be reduced to 5 m if low speed function is activated)	Yes	- read user's manual - complete online training - pass online theoretical exam - conduct and declare a self-practical training - pass a written exam at the CAA (or at recognized entity)	16*
3	< 25 kg	A3	- fly away from people - fly outside of urban area (150 m distance)	Yes	- read user's manual - complete online training - pass online theoretical exam	16*
4						
Privately built						
Legacy drones (art. 20)						

Table 2: VLOS condition under the European Regulation (Class column stands for CE mark class, from C0 to C4).

With reference to the table, the innovative drone platform designed and developed in Drones4Safety (privately build) falls under the A3 Subcategory (at least until it will get a CE mark). This means that **operational restrictions** (no fly over people, outside of urban area) **need to be met in all the flight phases**. If the operator decides to use a C1 or C2 marked drone (not yet available on the market and with important limitations in weight) those operational bounding restrictions may be relaxed. VLOS operations different from the ones described in the table must me classifies the specific or certified category.

4.2.2 B-VLOS operations

BVLOS operations can be operated only in the specific and certified category. In particular, in order to be flown under the specific category, the operation must fall in one of the defined standard scenarios or must

[6] Taken from https://www.easa.europa.eu/faq/116452 (Accessed: 14/09/2020)

undergo a risk assessment, with the modalities already introduced in section 3.2.1 and further explained in section 4.3.3.

As regarding the drone platform, drones in the specific category do not need a CE class mark, but their airworthiness and safety requirements are investigated through the holistic risk assessment (SORA or Predefined Risk Assessment). Drones flying in the only currently available B-VLOS standard scenario (STS-02) must have a CE mark class 6.

4.2.3 Autonomous operations and swarms

The Drones4Safety concept of operations include the possibility to carry-out autonomous drone operations to monitor transportation infrastructures. First of all, a brief clarification of what is an "autonomous" operation and what is an "automatic" one. EASA[7] gives the following definitions:

"*An **autonomous** drone is able to conduct a safe flight without the intervention of a pilot. It does so with the help of artificial intelligence enabling it to cope with all kinds of unforeseen and unpredictable emergency situations. This is different from **automatic** operations where the drone flies pre-determined routes defined by the drone operator before starting the flight. For this type of drones, it is essential for the remote pilot to take control of the drone to intervene in unforeseen events for which the drone has not been programmed.*"

Based these definitions, we can derive that, in the current Drones4Safety concept of operations, some operations (or part of them) will be automatic ones, while other will be autonomous. D2.4 will describe more in details for which use cases one approach or the other will be preferred.

For automatic operations no special considerations are needed (except for the ability of the pilot to promptly intervene in case of need) and most of the flight control systems for commercial and own built drones offer the automatic flight mode. On the other hand, autonomous operations need to be addressed with a specific approach, to the point that EASA in its FAQ states that "*Autonomous drones need a level of verification of compliance with the technical requirements that is not compatible with the system put in place for the open category. Autonomous operations are instead allowed in the specific category, where the regulation includes a tool flexible enough to verify requirements with the appropriate level of robustness.*". This translates in a number of robustness (and safety) requirements that need to be derived with an extensive risk assessment when designing the use cases.

Similar considerations maybe made about flying swarms of drones. Currently, the European and most of National Regulations for drones assume a one-to-one association between the drone and the pilot (one pilot flies one drone), at least for the open category and in the standard scenarios. This does not exclude the possibility to conduct operations where one pilot is in charge of more than one drone, but currently there is no "predefined" way to deal with this situation (and definitely excludes this kind of operations from the open category). The specific risk assessment must therefore include enough considerations about safety and reliability to convince the Competent Authorities about the feasibility of the operations. The "swarm" topic is still exploratory and not yet consolidated, with lack of clear data and standards to support an extensive safety risk assessment. Therefore, it is likely that the Competent Authority would require the design and execution of a number of test and a proper experimental plan. The complexity and completeness of such set of test and experiments will strongly depend on the level of risk associated to the operation (distance from people and infrastructures, nature of the airspace, proximity to aerodromes, mission duration, elevation, etc.) so this element should be taken into account when designing the uses cases, in order to fully understand their impact in terms of time and resources needed to get authorisations from the authorities.

[7] https://www.easa.europa.eu/faq/116449 (Accessed: 14/09/2020)

4.3 Authorisation process

4.3.1 Registration

Registration is mandatory for any kind of drone operation. The European Regulation (and almost the totality of European national regulations) impose the registration of the drone in association with the name of the operator (and in some countries with the drone pilot). Currently, the registration is demanded to the States, with slightly different approaches in the modes and procedures to register for operations. In general, the registration is not a time-consuming process, but the operator must pay attention to the local procedures and approach the authorities in due time.

For instance, let us assume operations to be conducted in Italy (where most of the use cases will be likely located). To operate a drone in Italy, the registration to the D-Flight system[8] (early stage U-Space platform) is mandatory, after the payment of a fee, for every operator wishing to carry out operations in Italy. D-Flight offers useful services like maps and charts with all the useful information about airspace, weather conditions and special prescriptions.

After the registration, the operator may apply for a declaration (in the case of open category operations) or authorisations (for the specific category).

4.3.2 Declaration (open category)

As said before, to fly a drone in an Open Category operation, a prior authorization from the competent authority is not needed. Instead, only the drone's registration and pilot's competence are requested.

As regarding the pilot, in the "Open" category all remote pilots flying in Subcategory A1, A2 and A3 are required to:

- be familiar with the Manufacturers manual;
- complete a training course (typically online) provided by the national Civil Aviation Authority; and
- successfully complete an online theoretical knowledge examination (provided at the end of the training) before they can fly.

4.3.3 Authorisation (specific category)

An operator willing to fly in the Specific Category, needs to file a request for authorization to the competent authority (the Civil Aviation Authority of the State where the operations are conducted). An exemption to this rule is when the foreseen operation can be accommodated within a Standard Scenario. In such a case, the process is close to the one for Open Category operations, with the operator declaring that the standard scenario will be followed in all its prescriptions and limitations. Currently, the EASA Standard Scenarios are not yet fully implemented and therefore the ones defined by the National Authorities apply (EASA Standard Scenarios will come into force at the end of 2021).

For the Drones4Safety consortium, this means that the reference standard scenarios are the ones defined by the Member State where operations are foreseen. For instance, in Italy, seven standard scenarios for VLOS are defined[9], while no BVLOS standard scenario is currently available. The Italian CAA is working on the publication of new standard scenarios (including BVLOS) and will release some of them before the end of 2020.

[8] https://www.d-flight.it/ (Accessed: 14/09/2020)

[9] https://www.enac.gov.it/la-normativa/normativa-enac/note-informative/ni-2017-007 (Accessed: 14/09/2020)

Where the foreseen operation is not included in the standard scenarios, a risk assessment must be conducted and included in the request for authorisation. This can be done through three different approaches (see details in Section 3.2.1):

1. **An Operational Authorisation via conducting a risk assessment of the intended operation** using, SORA;
2. **An Operation Authorisation through a predefined risk assessment' (PDRA)**: as a simplification of conducting a risk assessment by the drone operator (in other words the SORA assessment has already been done by the authority for a specific type operation and the operator needs only to demonstrate its compliance with the derived requirwements);
3. **Light drone operator certificate (LUC)**: this is a voluntary certification after which the national civil aviation authority may recognise some privileges to the drone operator.

Currently, the PDRAs are under development by both EASA and the National Aviation Authorities. EASA published PDRA-01 [RD6] that is of interest for Drones4Safety, although it includes important operational limitations (no autonomous operations, one pilot for each drone, 1 km maximum distance for BVLOS with no Visual Observer).

Monitoring the evolution of standard scenarios and PDRAs definition is an important activity as they may have an impact on the authorisation process for the Drones4Safety flying campaigns, so it is included in the plan for the integration and update of this document (see Section 5.1).

As regarding the pilot qualification, if the operation falls under the Specific category, the training depends on the level of risk associated to the operation. So, after the risk assessment, the operator needs to propose to the National Civil Aviation Authority a possible training plan.

4.3.4 Access to the airspace

Whatever kind of operations are being conducted, the pilot has the responsibility to minimize the risk of conflicts with other traffic and obstacles on the ground and in the air [RD8] [RD9]. Therefore, the pilot must ensure to be always flying in a portion of the airspace where the conducted operations are allowed. The operational limitations indicated in the operations manual must be respected, and they must include the restrictions for the category in which the operation is conducted (e.g. max elevation 120 meters for the open category, as stated by the European Regulation). In addition, the pilot must be sure not to infringe at any time restricted or prohibited areas of the airspace, that are defined and communicated by the Aviation Authorities and may be permanent ones (reported in the Aeronautical Information Publication, AIP) or temporary ones (issued with Notices to Airman, NOTAM). The airspace requirements (rules, procedures, equipment) have to be met.

If the operations are carried out in controlled airspace, the operator must request for an access to the airspace and the pilot must file a valid flight plan before starting the operation.

The provisions about airspace and the procedures to request access to it may vary from State to State, so the operator and the pilot must plan the operation with enough time to check them and adhere to the requested rules and procedures.

5 Conclusions and Recommendations

5.1 Monitoring the evolving regulatory and standardization framework

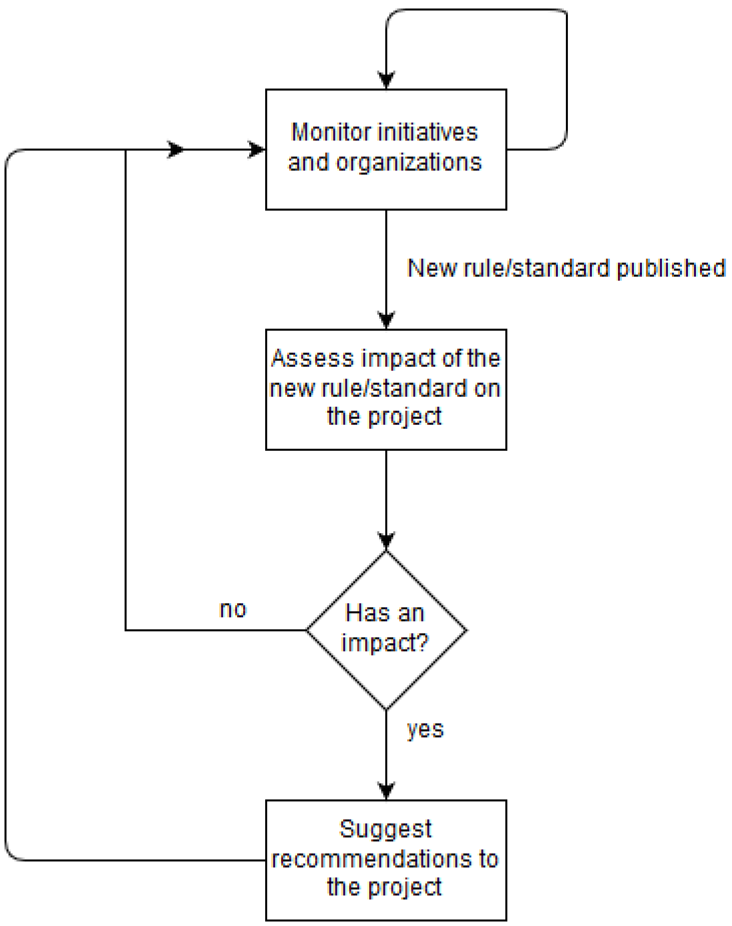
The Drones4Safety consortium has defined a process to deal with the evolution of regulatory and standardization framework.

First of all, a preliminary list of institutions, working groups and initiative worthy of being monitored has been defined. The list is not meant to be fully exhaustive and fixed for the whole project duration, rather it is an alive document to be amended, refined and integrated by the consortium to keep it in-line with the current situation.

Institution/Group/Initiative	Activity - Expected date	Relevance for the project
ICAO	Completion of ICAO SARPs on RPAS –	Relevant
ICAO	Publication of other material (e.g. 2nd version of the RPAS Manual) – Non-predictable	Maybe relevant
NAAs	Amendment of national rules in the countries of interest – Non-predictable	Very relevant (anyway they will not deviate so much from European common regulation)
ITU	Provision of standards about C2L frequencies – Non-predictable	Relevant
JARUS	Publication of new deliverables- Non-predictable	Relevant
EU, EASA	New EASA Regulations – New Airworthiness rules foreseen in 2021 (Special Condition Light UAS) – New standard scenarios and Predefined Risk Assessments	Very Relevant
EUROCAE	Deliverables of WG-105	Relevant
RTCA, ISO, ASTM	New Standards – Non-predictable	Maybe relevant

The process is made of three main activities:

1. To monitor all the items in the list, mainly by means of:
   - official websites and social network accounts of the reference organizations;
   - specialized newsgroups and newsletters.
2. To assess and evaluate the impact of new (or amended) provisions, rules or standards on Drones4Safety operations, using the same approach proposed in Section 4;
3. To propose new (or amended) guidelines and recommendation to the project, that will be part of deliverable D8.6 - Regulatory Gap/Barriers Analysis (final).



At the same time, further development and refinement of the use cases may be needed to ensure their alignment with the regulatory framework

5.2 Recommendations for the next steps

This document is meant to feed the technical Work Packages of Drones4Safety. In particular, the activities involving the design and validation of the use cases (T2.4, T7.1, T7.2 and T7.3) and the Work Packages dedicated to the actual drone platform designed and development (Work Packages 3, 5 and 6) should take into consideration the regulatory aspects highlighted by this document. A validation campaign with real-world flights is foreseen in Work Package 7, so authorisations from (or declarations to) the local Aviation Authorities need to be collected. Considerations about the complexity of the authorisation (or declaration) process, together with estimations of the spent effort and resources to get them, may also contribute to the definition of the Cost Model, that will be produced by Task T8.5.

Albeit a more detailed analysis of how the regulation may impact the use cases will be provided in D2.4, we may already draw some conclusions and recommendations about the main high-level gaps and barriers identified so far.

First of all, the description of the use cases will need to clarify important aspects about the nature of the foreseen operations, among the others:

- Exact place of the operation (including the nature of the surrounding airspace);
- Operation duration;
- Number and type of drones used for the operation;

- Volume of operations (distance from the infrastructure and from the pilot/operator, altitude, etc.).
- VLOS/B-VLOS.

As seen in the previous section, these information are fundamental to understand whether the operation falls in the Open or in the Specific Category and, if needed, to feed the risk assessment of the operations. Nonetheless, this preliminary assessment is needed to understand the competence and the training needed for the pilot(s).

It is strongly recommended to start the collection of the abovementioned information in the early phases of the design of the use cases, as it will help to understand the regulatory impact and to correctly address potential barriers.

An early choose of the location of the use cases execution is also fundamental to understand the correct regulatory framework to apply, that still partly depends on the national rules issued by the States, as described in the previous Sections.

The design and development of the drone platform (WP5 and WP6) are also fed by the considerations here reported, as they are impacted by the applicable rules about safety and airworthiness of the UAS, and the related applicable industry standards. It is therefore strongly recommended that WP5 and WP6 take onboard regulatory and legal requirements (reported in this document and in D2.4) and develop the platform in accordance with them. This will facilitate the authorisation process when the use cases demonstration operation will be planned.

Finally, as regarding the aspects of fully autonomy and swarms, it is recommended to start as soon as possible a dialogue with the National Aviation Authorities of the States where use cases demonstrations are foreseen. As already explained in this document (see Section 4.2.3), these aspects are not yet fully defined in the regulation, so an exploratory approach will most likely be adopted by the authorities. This means that an experimental plan and a set of tests should be agreed with the authority in order to get permissions to perform such “special” operations. On one hand, this may mean spending additional coordination effort, but on the other side should the work done in Drones4Safety demonstrate the feasibility and safety of such kind of operations, this would substantially contribute to both the technological advancement and the regulatory developments in the field.