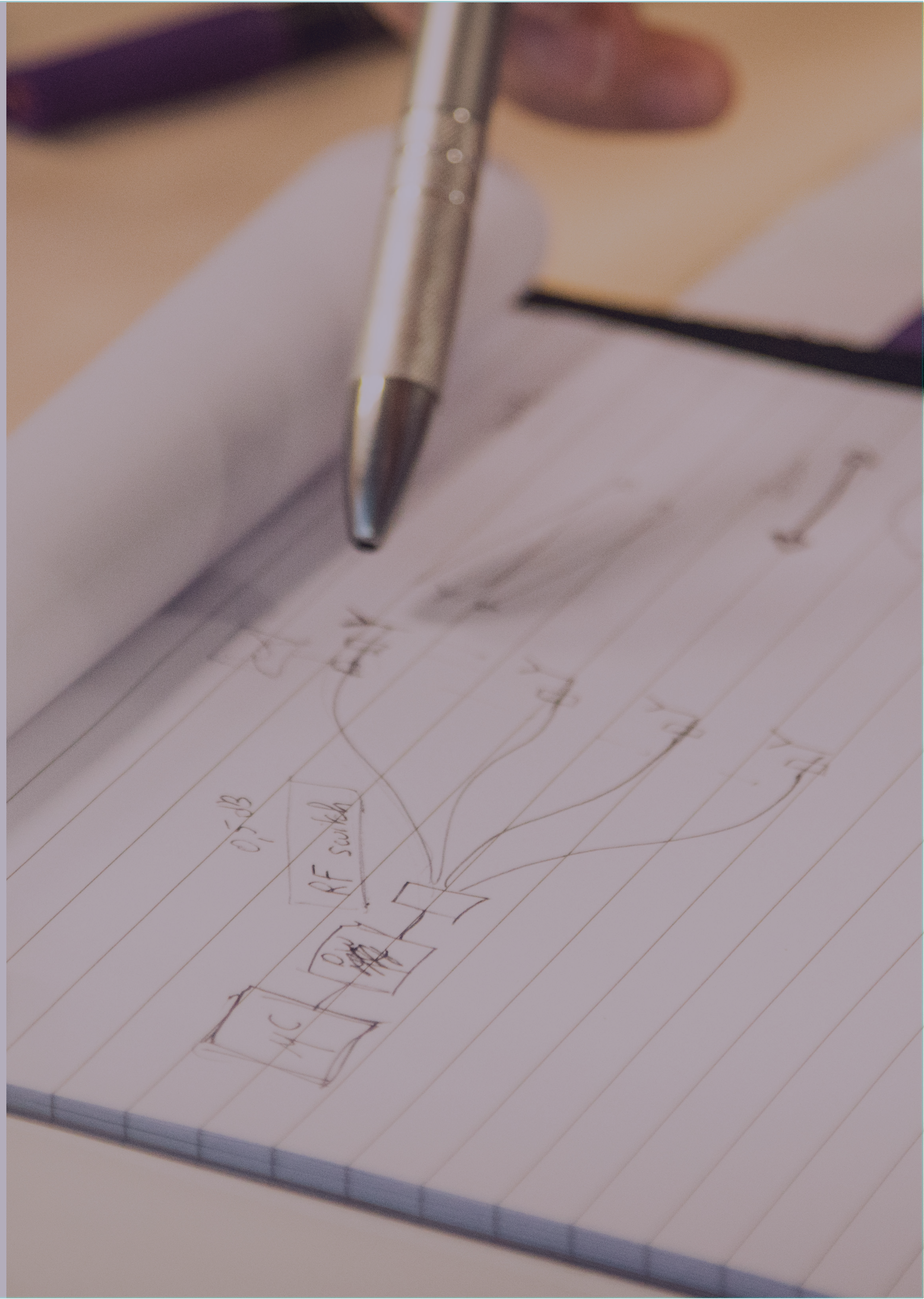

# D2.2
DELIVERABLE

# ETHICAL, SECURITY and SAFETY issues concerning RPAS use in confined spaces

AiRT


RF switch

**Coordinator** María de Miguel (Universitat Politècnica de València)

**Author** María de Miguel, Virginia Santamarina, Stephan Kröner and María Ángeles Carabal (Universitat Politècnica de València); Miguel Rosa (AeroTools); Jade Snyper and Greta Zabulyte (Clearhead)

**Design and layout** Virginia Santamarina

**Images** Virginia Santamarina

**Photography** Clearhead

**WP nº** 2

**Work package title** Analysis of CIs needs, ethical/security issues and risk analysis

**Deliverable relative nº** D2.2

**Deliverable nº** D5

**Deliverable name** Ethical, Security and Safety issues concerning RPAS use in confined spaces

**Delivery date** 28th February 2017

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement nº 732433



# Table of contents

# 1. EXECUTIVE SUMMARY

The use of RPAS (Remotely Piloted Aircraft Systems) or drones, as they are mostly known, has become very popular in recent years, for commercial and recreational use, with millions of devices sold and new users adopting the technology every year. An important pedagogical work must be carried out, to educate people in this new technology, making everyone aware of the impact in privacy, security or safety they can cause if they are not used in a responsible way.

The AiRT Project will put efforts in making this educative work, developing standards for a safe and ethical correct use of RPAS flying indoor for the Creative Industries. Seeking support in current RPAS regulations that cover outdoor airspace, this document will provide references and technical means to design and implement safe RPAS operations.





# 2. DELIVERABLE DESCRIPTION

The aim of this deliverable is to highlight the ethics/ security, privacy and safety issues that are related to use of drones in confined spaces.

Ethics play a crucial role in any project and are extremely important when designing a drone or gathering audio visual material within confined spaces.

In order to maintain high ethical standards, considerations of ethical research should be part of the project from the very beginning as ethics are relevant at all stages.

Regarding safety, in the European Union the responsibility for civil drones over 150 kg is left to the European Aviation Safety Agency (EASA), under the Regulation (EC) No 216/2008, that mandates the Agency to regulate Unmanned Aircraft Systems (UAS) and in particular Remotely Piloted Aircraft Systems (RPAS), when used for civil applications and with an operating mass of 150 Kg or more.

So, up to now, there is a legal framework that covers the operation of drones and gives proper references on how to operate a drone within given safety standards.

But for civil drones with an operating mass of 150 kg or less, the current regulatory system in the European Union (EU) is based on fragmented rules, with many Member States having already regulated or planning to regulate the use of drones in civil applications. Despite of this fragmented approach, most of the regulations are setting similar standards in drone operations, as for instance:

- Mass weight limits for VLOS (Visual Line Of Sight) and BVLOS (Beyond Visual Line of Sight) flying modes.
- Technical requirements for special operations.
- Training and qualification requirements for pilots.
- Registration of operators' procedures.

Given the increasing number of drones and operators that intend to fly drones in civil airspace, the European Commission decided to work on harmonization of national regulations. Thus, the Commission adopted a strategy for opening the aviation market to the civil use of drones in a safe and sustainable manner. It focuses upon how to enable the development of drones while at the same time addressing their societal impact.

The Commission noted its intention to take a step-by-step approach, by firstly regulating drone operations with mature technologies. More complex operations would be permitted progressively.

EASA was tasked by the European Commission, following the Riga Declaration on Remotely Piloted Aircraft, "Framing the Future of Aviation" (which was adopted on March 6, 2015, by Commission representatives, civil aviation officials, data protection national authorities, and representatives from the manufacturing industry), to develop a regulatory framework for drone operations as well as concrete proposals for the regulation of low-risk drone operations.

The Riga Declaration came to recognize the necessity of harmonized guiding principles, that will be key to be taken under consideration in the future regulation of drones:

- Drones must be dealt with as a new type of aircraft and any safety rules imposed must be proportional to the risk of each operation.
- There is a critical need for the EU to establish safety rules immediately and also to lay down technologies and standards for the integration of drones within civil aviation.
- The protection of privacy of individuals will lead to greater public acceptance.
- The operator of a drone bears responsibility for its use.

In 2016, this task has been showed in a "'Prototype' Commission Regulation on Unmanned Aircraft Operations" by EASA, but this draft has not been approved yet.

However, it is important to notice that the scenario in which the AiRT project is developed for, flying indoor, it is not specifically regulated either by EASA or any national Aviation Authorities (i.e. CAA in UK, Mobilité in Belgium, AESA in Spain, or FAA in USA). As a general rule, these bodies regulate operation of aircrafts only in open airspace, paying no attention to aircrafts flying under a ceiling (indoor). This could mean that a drone operator could fly a drone into a roofed facility with no restriction, provided the owner of the space has given permission.

But this possibility is hard to be considered if additional operational issues are taken in account, as the civil liability of the operator or the owner in case of an incident or accident.

The definition of what is considered an "indoor space" in terms of regulated operation by civil aviation bodies, is not so explicit, but it is generally accepted that indoor is any airspace under a fixed roof or ceiling that could prevent an aircraft to gain altitude beyond this point. It is no relevant if this space has vertical walls or not.





In terms of safety, the indoor operation offers some positive aspects:

- Short range of flight.
- Always flying VLOS (although obstacle can generate shade areas).
- Short time of flight.
- Lack of meteorological agents inducing restriction to operation.
- Enough resources at hand to provide an easy operation (plugs, electrical power, short distances, easy communication…).

On the other hand, concern about invasion of privacy, in particular when it comes to private property, has long been an issue tied in gathering geographic information, whether it's gathering images via satellite, airplanes, or drones. Thus, in order to maintain high ethical standards, considerations of ethical research conduct should be part of the project from the very beginning as ethics are relevant at all stages.

Guidelines issued by independent bodies with a large expertise and knowledge in the filming sector, as UK´s ICO (Information Commissioner´s Office), can help to address standards for respecting people´s privacy when using RPAS:

- Let people know before starting RPAS operation and recording.
- Consider surroundings and the influence on images to be recorded.
- Get to know performance of the camera.
- Plan carefully flights and operation.
- Think before sharing images.
- Keep the images safe.

By virtue of the European Convention on Human Rights and the Human Rights Act 1998, everybody has a right to a respect for their private and family life, their home and their correspondence. The Court has held that "wrongful disclosure of private information" and "misuse of private information" would breach an individual's right to respect for their private life, and, in certain circumstances, publication of an image of the relevant individual would amount to the misuse of private information.

Though it is unlikely that publication of an image of a person carrying out an ordinary task in a public place (i.e. shopping) would amount to misuse of private information, the key question is whether the person in question had a reasonable expectation of privacy in respect of the image. This needs to be considered on a case-by-case basis as the assessment will vary depending on what the person is doing and who they are. A different threshold applies to a politician or other public figure than to a person who does not work in the public eye. A much higher threshold applies to children, so that it will rarely be appropriate to publish any image of a child without the consent of the child and/or its parents.

So, as it can be deduced from the above, having a reference or a standard for indoor operation of drones is crucial for consolidating their commercial use. And setting the standard for an appropriate use of drone indoor is what this document is all about.

# 3. CONCEPT AND APPROACH

As mentioned above, this deliverable is dedicated to evaluate security, ethical and safety issues related to the use of drones in confined spaces. The overall approach was to the analysis of three different sources (triangulation data method) in order to a meaningful document which can be consulted by any person, who is interested in using drones/ RPAS for filming purposes indoor.

These three sources consulted are as follows:

**a) Official and freely available European documents**

**b) Data from literature review of scientific publications**

**c) Results of focus groups activities held in UK, Belgium and Spain (Deliverable D2.1)**

Sources a) and b) are considered as secondary source since they are based on evidences not directly experienced by the authors of the documents. Since both are of secondary nature the analysis has been grouped together. On the other hand, focus group activities (Participatory action research – PAR, see also D2.1) are considered as primary sources because drone pilots/ operators tell/ explain their point of view about security, ethical and safety issues from their personal experiences.

Finally, an Aeronautic Study on Safety, Risk Analysis and Mitigation proposal has been developed in the case of the use of drones indoor. This proposal synthetises methodologies of different European countries in order to create a basis for aeronautic studies to be taken in consideration while using RPAS in confined spaces.





## 3.1 Secondary sources analysis

This chapter summarises the research undertaken by AiRT project consortium to analyse security, ethical and safety issues related to the use of drones. This includes the review of found literature in scientific publications about these issues and the revision of existing material published by the European Commission.

From the literature review, 59 publications from conferences and journals at Scopus database (Elsevier) can be found and have been taken into consideration, related to the topics: drones, security, privacy and safety.

Moreover, this chapter includes statistics on issues about these topics from Statista database.

### Security and privacy

RPAS are not fully secure. A number of research trials and practical cases (though less than broadcasted) have demonstrated that there is still a way to run till a completely secure RPAS is available. The areas where RPAS show more weaknesses are summarized as follows:

- GPS Signal: Spoofing GPS signal to take control of the RPAS has proved to be difficult and challenging though possible.
- Communication: Hacking RF signals that operate flying controls and datalink, as well as video signal, is also a concern, as it could allow taking control of the RPAS or contributing to a misuse of data or images recorded.
- Jamming RF signals is another threat, that can prevent the normal operation of the RPAS (making safety procedures to start, as the Return to Home or forced landing) or even cause electronic systems failure if the jamming signal is strong enough.
- Physical interaction with the RPAS by non-authorized persons to change configuration or other misuses could be another issue to be considered.

Thus, information security deals with measures designed to protect information and information systems from unauthorized access, use, disclosure, disruption, modification, perusal, inspection, recording or destruction (Braun et al. 2015). Some concerns of security include hacking, hijacking, cyber-attack, or other types of vulnerabilities. Therefore, from the point of view of manufacturers, it is necessary the encryption of communications among all the devices to permit secure computer-RPAS communication and avoid unauthorized access by third-parties.

To reduce exposure to these threats, recommendations are made to be implemented by RPAS operators:

- Security Controls to be implemented within the organization to limit access to RPAS and other key systems. Only authorized staff can be in contact with RPAS prior and after flying operations.

- ☐ Integrate encryption modules to the RF (both control communication and datalink) and video signals.
- ☐ Use GNSS systems that allow data from different satellite constellation (GPS, Glonass, Galileo…) as well as other positioning systems based on different technologies (computer vision, Ultra-Wide Band, previous mapping…), to provide redundancy in positioning.
- ☐ Use radiofrequency scanners to detect potentially disturbing frequencies on the surroundings of the flying area.

On the other hand, privacy concerns relate to recording and processing several personal data such as images, geolocalization or electromagnetic signals, because in a drone the camera can be fixed to record data and later process it.

At present, the Directive 95/46/EC of the European Parliament and of the Council, of 24 October 1995, "on the protection of individuals with regard to the processing of personal data and on the free movement of such data", applies to any person or company 'processing' anything within the definition of 'personal data'. Storing, developing and printing photographs amounts to 'processing', so by extension recording and exploiting video footage is also likely to fall within the definition. 'Personal data' is defined as anything relating to living individuals who can be identified from either that data itself or from that data and other information which the data processor holds or could have access to.

These definitions are very wide and it is likely that even a simple image of a person could amount to 'personal data' if that person was or could be identifiable, even if there was no other data included with the image. In this case the data controller, which is likely to be the producer or broadcaster, would then need to comply with the regulation.

New regulation on Data Protection that would replace the existing regime are:

> Directive (EU) 2016/680 of the European Parliament and of the Council, of 27 April 2016, on the protection of natural persons with regard to the processing of personal data by competent authorities for the purposes of the prevention, investigation, detection or prosecution of criminal offences or the execution of criminal penalties, and on the free movement of such data, and repealing Council Framework (Decision 2008/977/JHA).

From 5 May 2018, it would be directly binding on data controllers in all member states immediately upon coming into force without the need for implementation by the member states.

> And Regulation (EU) 2016/679 of the European Parliament and of the Council, of 27 April 2016, on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation). This Regulation contains measures that would harmonize data protection procedures and enforcement across the EU and should be applied from 24 May 2018.

From the side of the operators and the firms that could contract with them, the current European Directive guarantees rights of access, rectification, erasure and blocking. And the new Directive and Regulation on Data Protection include the same standards. But, to apply for them, it is essential to inform the subjects.



This could be done easier indoors by different forms, such as tickets, posters or individual authorizations. Besides, the necessary storage measures should be applied when processing, according to the European Union Directive.

In these cases, both security and privacy, design by default could be also a solution for a more ethical use of drones. For example, there is the possibility of anonymize data (such as pixels to avoid facial recognition).

### Safety

When operating a RPAS or drone, no matter if it is for recreational use or intending to carry out a commercial work, safety shall be placed in first place.

The definition of safety in the operation of drones is related to the desired optimum state in which the flight that is executed in specific circumstances can be carried out and controlled with acceptable risk for the surroundings means and persons.

The risk of operating with drones is tightly linked with:

- ☐ Design and features of the drone and auxiliary equipment.
- ☐ Planning of the whole operation: logistics, flight…
- ☐ Hazards on the area where the operation to be performed.
- ☐ External agents that can affect operation, such as interferences.
- ☐ Maintenance and full operation of the drone (which includes not only piloting but management of everything related to the RPAS as well), based on skilled and experienced staff.
- ☐ Skills and experience of pilot and supporting staff.

According to Clarke (2014b), especially in the mini-drones segment, there is the risk of manufacture and operation with very little regard for safety. Drone costs have fallen, particularly for micro-drones for the consumer market, and the competition among producers or operators can result on unethical behaviours. Drones manufacturers have to comply with different standards (Clarke 2016). For example, all the drones have to include a drone identification. And requiring operators be licensed and have insurance can impose standards and ensure safety (Luppicini and So, 2016).

It is important to collect and identify operational drone safety hazards, which can be addressed to different levels: "active failures" and "latent conditions", both of which might occur during the flight operations, so turning on a threat to safety:

Active failures are considered as actions (including errors or rules violations) that have an immediate effect on the RPAS´s attitude. Generally, they are viewed as unsafe acts, and are associated with front-line personnel (pilots, supporting personnel, engineers, and so on).

Latent conditions are those that exist in the RPAS system (equipment) well before a damaging outcome is experienced. Initially, these latent conditions are not perceived as harmful, but could become evident once the system defences are breached.

Key Safety Issues when operating indoor RPAS that shall be kept in mind to prepare safe operations are the following. They can be divided in several areas, but they must be considered and assessed both separately and jointly:

**RPAS and auxiliary equipment:**

Positioning (2D, height).

Attitude & Navigation (influence of magnetic Fields in IMU´s).

Power plant (batteries, motors, ESC, propellers, wiring…).

**Communications:**

Loss of communication.

Frequency Jamming.

Interferences (deliberated or unintended).

**Protections and passive safety elements.**

**Personnel:**

Skills and knowledge.

Training.

Roles & coordinated work: pilot, camera operator.

Certification.

**Environment:**

Surrounding Obstacles (fixed or moveable).

Staff & Persons not directly related to the operation.

**Operation:**

False sensation of safety (being comfortable can relax controls).

Emergency situations and contingency plans.

External interferences (unintended or deliberated).

The identification of safety hazards must be performed considering different levels:

**Reactive:** involving analysis of past outcomes or events, hazards are identified through investigation of safety occurrences. Incidents and accidents are clear indicators of system deficiencies; therefore, they can be used to determine the hazards that contributed either to the event or to the latent.

**Proactive:** involving an analysis of existing or real-time situations during drone operation.





**Predictive:** involving data gathering is used to identify possible negative future outcomes or events during drone operation, analyzing system processes and the environment, to identify potential future hazards, and to initiate mitigating actions.

The following methods are examples that can be used to identify safety hazards:

- ☐ Flight Operations Data Analysis (FODA).
- ☐ Flight Reports.
- ☐ Maintenance Reports.
- ☐ Safety (& Quality) Audits / Assessments.
- ☐ Voluntary reporting of Incident/accidents/near misses.
- ☐ Mandatory accident reporting to the competent authority.
- ☐ Brainstorm acc. to Failure Mode Effects Analysis (FMEA.)
- ☐ Surveys.

Finally, safety measures can be divided in two types: active or passive. Active are related to the measures that can avoid risks, for example crashes, and passive regard to measures that reduce the impacts, such as airbags.

**Results**

As we can observe in Figure 1, the number of publications related to these issues has increased a lot during the last years, that shows it is a trend topic (keep in mind drop in 2017 is not "real" since report is released in month 2; February 2017).

However, the majority of studies are based on the USA while, in the European Union, Germany and United Kingdom are the countries that are working more on these topics (Figure 2).

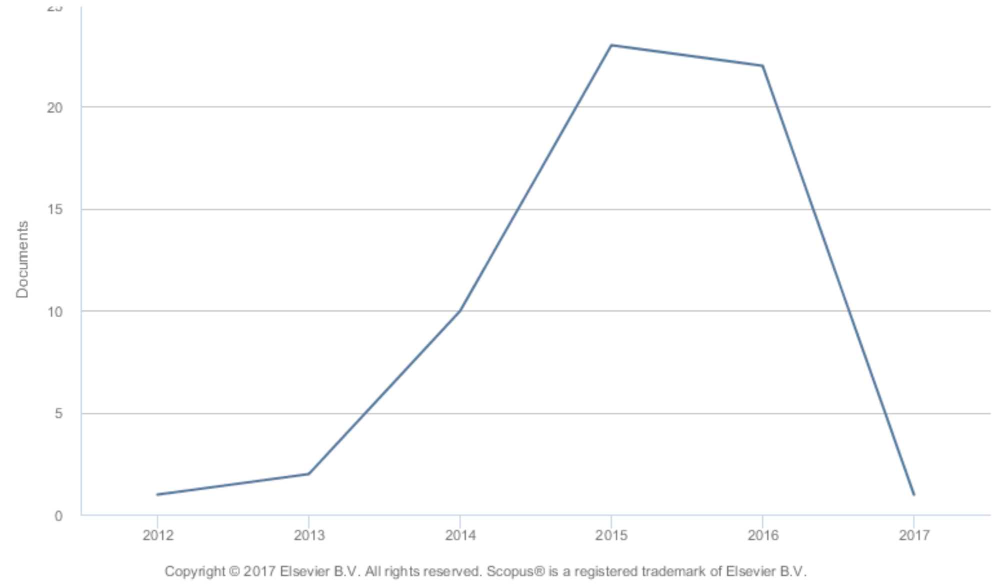



Figure 1. Analysis by years with Scopus database (Elsevier).

In relation to the field of study, even if Computer Science plus Engineering cover around the 76% of the papers (alone or with other fields), we can observe that Social Sciences plus Business integrate around 61%. That is, it is also a relevant topic from the point of view of the firms and stakeholders (Figure 3).

The second source of data analysed has been from the European Union database Statista. In this database, different statistics from the United Kingdom developed by ComRes on May 2016 (2,043 Respondents from 18 years and older) can be found.

The first one is about the safety of drones and conventional aircrafts in the United Kingdom (Figure 4). The following question was asked: "To what extent,

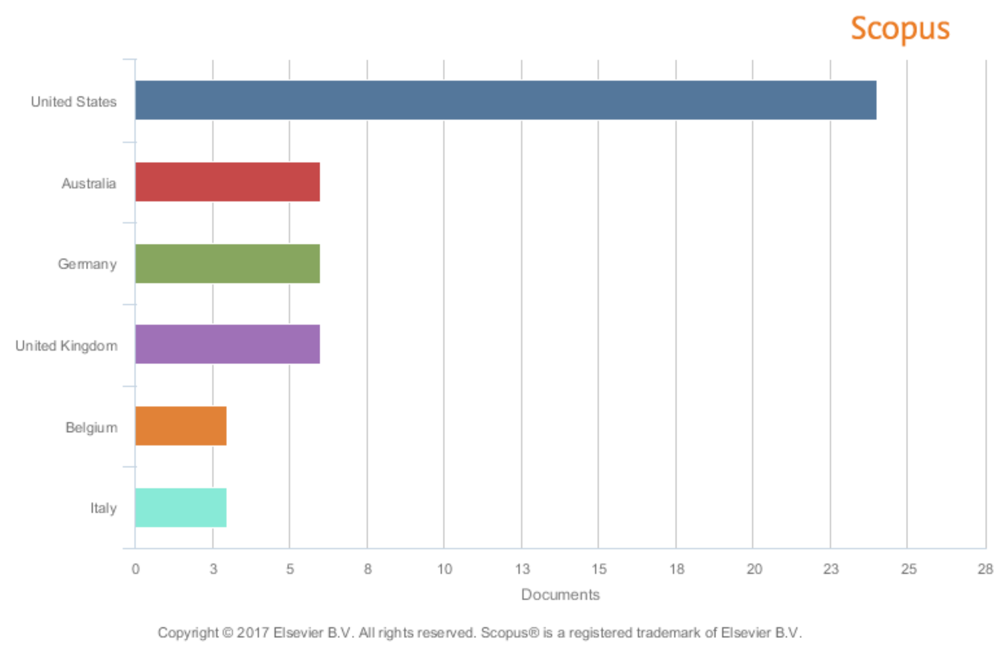



Figure 2. Analysis by countries with Scopus database (Elsevier).

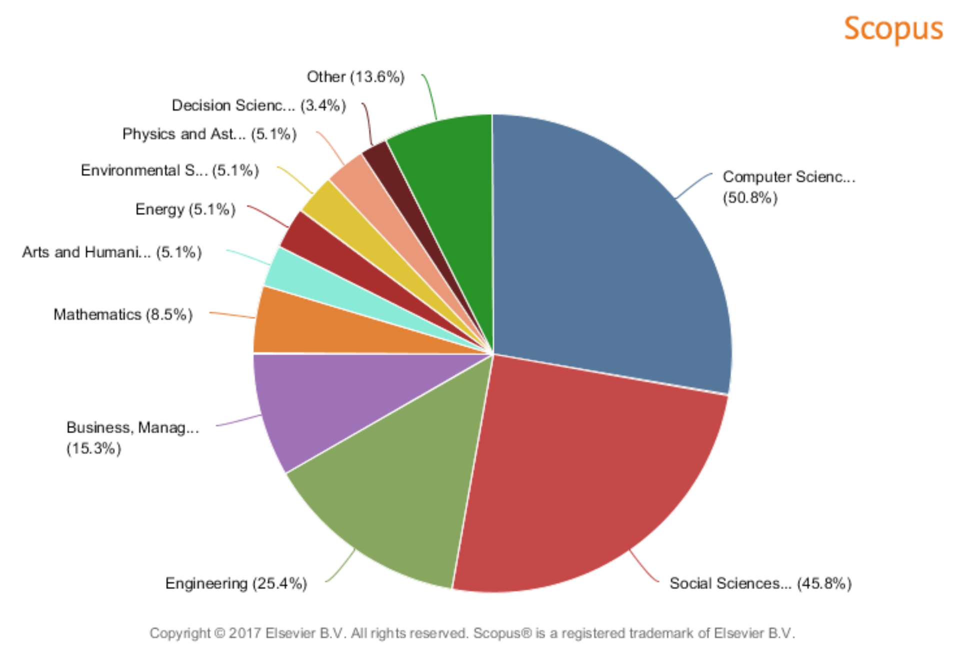



Figure 3. Analysis by field of study with Scopus database (Elsevier).





if at all, do you agree or disagree with each of the following statements? Drones pose more of a safety risk than radio-controlled aircraft which have been around for years." 58 percent of the respondents tended to agree or strongly agree that drones posed a greater safety risks than conventional aircrafts. Consequently, more ethical measures plus clear regulation could improve people's trust.

In the case of privacy, the next diagram shows the share of respondents who are concerned about privacy matters because of the use of drones in the United Kingdom (Figure 5). This question was phrased by the source as follows: "Thinking of all the potential uses of drones previously mentioned, to what extent, if at all, are you concerned or otherwise about their usage for any of the following reasons? Privacy (e.g. being spied on at home)". 42 percent of the respondents stated that they were very concerned about their privacy.

Once more, the lack of information and clear solutions can affect people's perception about their privacy when someone uses a drone.

The last one, shows the evaluation of the respondents in terms of the commercial and private use of drones in the United Kingdom (Figure 6). The corresponding question was: "To what extent, if at all, do you agree or disagree with each of the following statements? I am less worried about the commercial use of drones than private use of drones." 48 percent of the respondent tended to agree that they are less worried about commercial application of drones than of private usage. Additional 14 percent agreed strongly with this statement. That is, people have more confidence on the professionals using drones than on the general public.

In addition, the information from the focus groups lets us to explore deeper the concerns that operators could have when flying an indoor drone, even if regulation does not apply. We separate safety and security concerns.

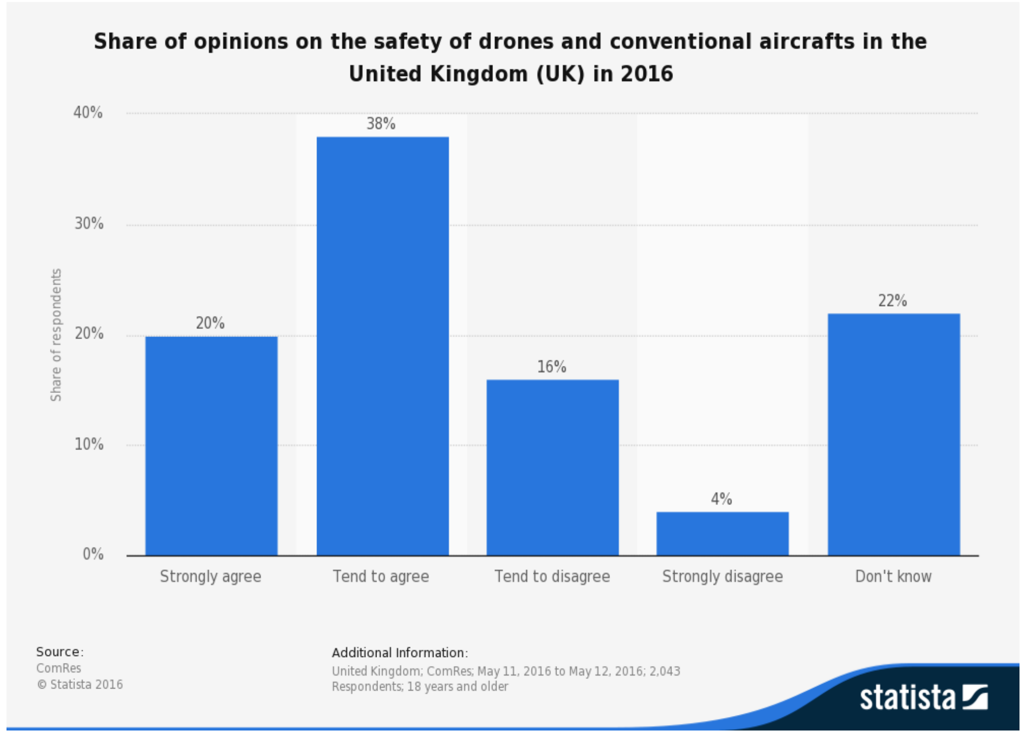



Figure 4. Drones pose more of a safety risk than radio-controlled aircraft which have been around for years?

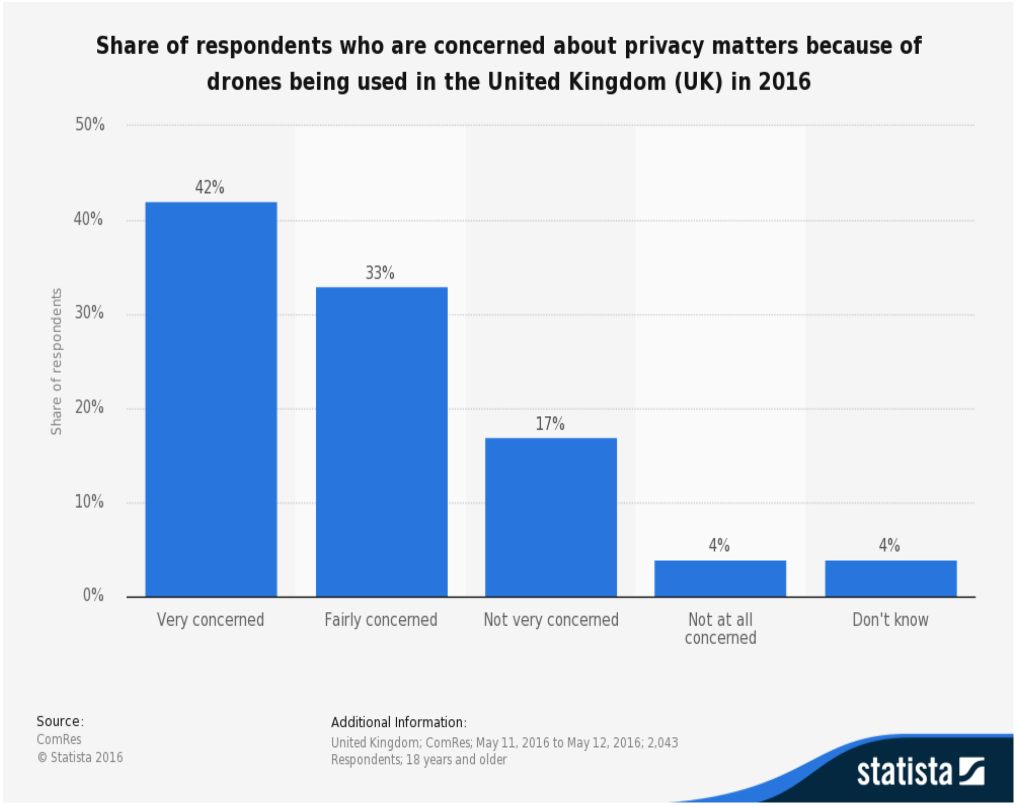



Figure 5. To what extent, if at all, are you concerned or otherwise about their usage for any of the following reasons? Privacy (e.g. being spied on at home).

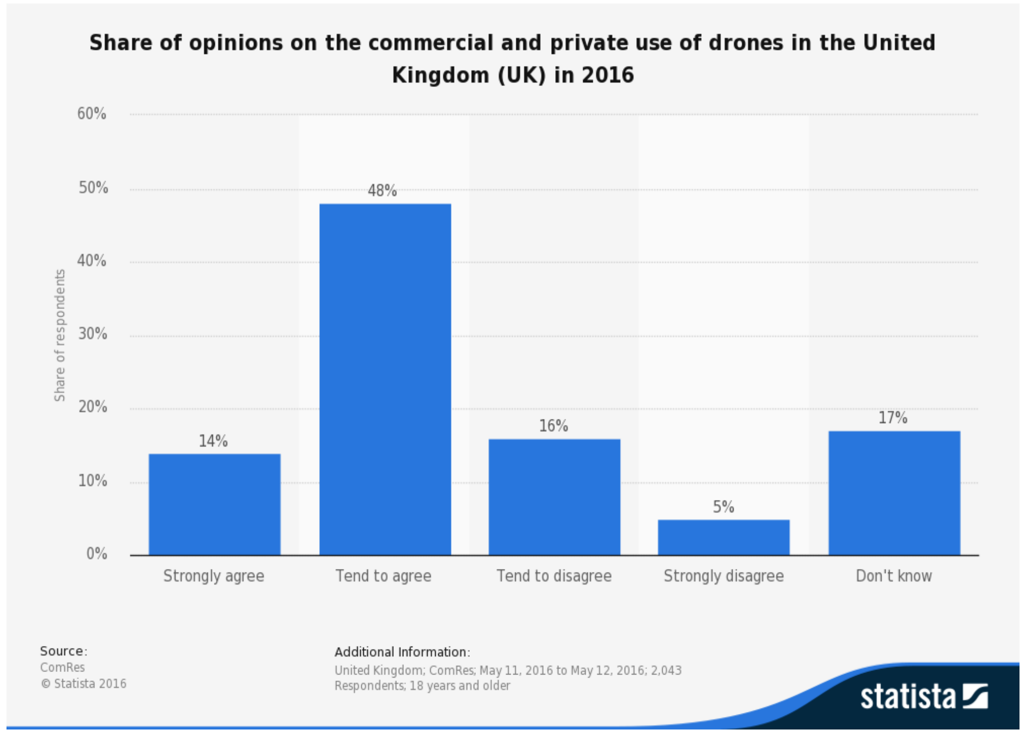



Figure 6. To what extent, if at all, do you agree or disagree with each of the following statements? I am less worried about the commercial use of drones than private use of drones.





# 3.2 Primary source analysis

This analysis, in order to evaluate security, ethics and safety issues, is based on the analysis of primary sources obtained by the Participatory action research (PAR) of the focus groups, which have been formed in the three different participating countries in order to evaluate the needs of the Creative Industry (CI) when using drones for their creative activities. Apart from the "need analysis" (what do they expect the product should look like, features etc.; see in detail D2.1) the participants have been also asked about their security, ethics and safety concerns while using drones for film footage.

## Brief description of focus group activities

(Further information can be found in D2.1, which is also public).

In Ghent (Belgium), Luton (UK) and Valencia (Spain) three focus groups have been created, and each of those was made up of six or seven informants (experts) from different CI sectors, whereas 45% of them were drone pilots (Table 1). Based on literature review a script was elaborated with questions related to the use of drones by CIs. The groups were led by experts in PAR and focus group activities from the UPV, which acted as facilitator to guide the discussions of the participants to key topics. Each activity lasted about 2 hours (three groups, thus in total 6 hours) and was recorded both video and audio. Transcription of discussions, and later the activities yielded in 49,266 words, which have been analysed.

| Informant | CI sector profile | Drone pilot | Country | Date (focus group) |
|---|---|---|---|---|
| 1 | TV / MUSIC / MOVIES / PERFORMING ARTS / PUBLISHING | NO | Spain | 9/02/2017 |
| 2 | MOVIES / PERFORMING ARTS / PHOTO | YES | Belgium | 13/02/2017 |
| 3 | ADVERTISING / ARTS / TV | NO | Belgium | 13/02/2017 |
| 4 | ARCHITECTURE / PHOTO / ADVERTISING | YES | UK | 3/02/2017 |
| 5 | MOVIES / MUSIC / PHOTO / ADVERTISING | NO | UK | 3/02/2017 |
| 6 | DESIGN / ARCHITECTURE | NO | Spain | 9/02/2017 |
| 7 | MOVIES / PHOTO / ADVERTISING | YES | UK | 3/02/2017 |
| 8 | ANTIQUES AND MUSEUMS / ARTS &CRAFTS | NO | Spain | 9/02/2017 |
| 9 | ADVERTISING | NO | Belgium | 13/02/2017 |
| 10 | MOVIES / PHOTO | YES | Belgium | 13/02/2017 |
| 11 | ADVERTISING | NO | Belgium | 13/02/2017 |
| 12 | MOVIES / PHOTO / SOFTWARE | YES | UK | 3/02/2017 |
| 13 | ADVERTISING / ARCHITECTURE / PHOTO | YES | Spain | 9/02/2017 |
| 14 | MUSEUMS / ARCHITECTURE | NO | Spain | 9/02/2017 |
| 15 | TV / MOVIES / PHOTO | YES | UK | 3/02/2017 |
| 16 | MOVIES / PHOTO | YES | Belgium | 13/02/2017 |
| 17 | ADVERTISING / PHOTO | YES | Belgium | 13/02/2017 |
| 18 | TV / MOVIES / FASHION | NO | UK | 3/02/2017 |
| 19 | MOVIES / ADVERTISING | NO | Spain | 9/02/2017 |
| 20 | PHOTO / FASHION / ADVERTISING / MUSIC | NO | Spain | 9/02/20170 |

Table 1. Participants in the focus groups and CI sector. Note: all informants have been encoded in order to guarantee anonymity.

### Security and privacy

All the Informants agree that security/privacy by default can prevent risks. For example, device authentication can prevent unauthorized connections. A key measure for security is to protect the Wi-Fi connection, as "A big, massive Wi-Fi booster in a big exhibition hall would come across and… that has the potential to knock out your remote-control link" (Informant 15).

About privacy, concerns are related in the case a camera is fixed at the drone: "Privacy issues… always have to do, are related to the camera you use. It's not to the use of the drone. It's just a camera use" (Informant 16). A first measure will be to identify who is the drone operator "especially when they're unethical on it and that's trouble" (Informant 15).

Moreover, asking for permission or at least give the necessary information can prevent troubles or hours of editing. "If in your record there are people, or they sign or you delete their faces" (Informant 13).

During the collection of audio-visual data, the use of consent forms is an essential part of ethical practice. Consent forms allow respondents to decide how captured material can be used for what purposes, and whether they require anonymity.

Consent forms should be kept confidential in paper and electronic format and it is strongly recommended that participants receive a copy of the consent form and a project summary. The use of consent forms is especially important for dissemination and for further use of the data by third parties or archiving.

### Safety

Safety by design (manufacturer) and safety during the flight (operator) can be analysed separately.

Besides, the design of the drone has to take into account active and passive measures, as more active measures can reduce the necessity of passive ones. Regarding the manufacture of the drone, Informants agree that design by default can reduce incidents. As Informant 2 said, "something that is 'uncrashable' because it detects everything". From indoor drone, "safety first in this case. And it has to be as easy to use as possible. And small. So, interchangeable" (Informant 9).

For example, in the case of outdoor drones, DJI shut down when approaching to an airport, "that's built in to the drone by the manufacturer or firmware update" (Informant 4).

The key elements that should have that design by default in an indoor drone, according to the Informants, are the following:

#### a) Active measures:

"Much larger batteries that last longer" (Informant 4).

Control speed: "flying very smoothly, slowly indoors because twitchiness and things like that can be… pain" (Informant 15).





"Flying home…the drone works… and then returns" (Informant 13).

"Not to lose the connection with the pilot…it should be necessary to fix antennas to maintain the communication" (Informant 1).

Positioning system: sensors ("infrared … and also sound… sonar") to avoid crashes (Informant 2). "A security margin, a security border, no physical, with sensors, to avoid the drone to approach very much to the works" (Informant 1). "Indoors your margin for error is even smaller" (Informant 15), so "Safety is a main thing. When you put a camera from fifty-sixty thousand euro in the air you want to get on the ground in one piece, you know? and that's the main thing, … you have sensors everywhere" (Informant 10). "Sensors… seem the most practical to me and easiest solution for collision avoidance indoors. A visual system that you have to look at to see how far you are distracts you from the position of the drone. See that you can't rely on the valid, sorry inaccurate, indoor positioning system such as the GPS that you use outdoors" (Informant 15). "Drone development is also already making more sensors around the drone, in the drone, inside the drone" … "sudden obstacles are still a weak point" (Informant 2). Informant 17: "then you could fly really, really close to anything and as soon as you touch something with the things they can do a small correction and back off a little bit".

#### b) Passive measures:

"Prop guards can be really handy" (Informant 15).

"Weight also influences, as the lighter the drone the better in case it will crash on something" (Informant 14).

"Maybe when it like hits something, something props like an airbag" (Informant 11).

From the side of the operators, Informants think that for a professional "reputation is everything" (Informant 5) and "loyalty is a huge thing" (Informant 4), so they avoid to take risks with a wick product or flying a drone without experience. But they worry about the unprepared competence: "Think of all the other people that say they can do it. Uh probably illegally" (Informant 4). "I think there are lot of people who say 'I am a drone operator' and they may well go with an old one, and they may have read the manual, but actually they don't know fully what they're doing. There is a lot of… a lot of amateurs out there and one I worry about the safety of it" (Informant 18).

"I think only one thing that doesn't exist is the reliability and the safety of the drone because now the market is like everybody buy a drone but not everybody can fly so when is really easy to use that would be a work point for it" (Informant 10). To avoid professional intromissions, "I will… ask for a license and total control…you can't have a risk…license and training…to ask for the portfolio of the pilot because you're going to have him/her in a very special place" (Informant 14). Also "The obvious first thing you would ask for is proof of license, proof of insurance, uh the insurance indemnity that you have, etc. Then you would ask for… to see the portfolio of the pilot" (Informant 4).

Experience gives trust because, even if the regulation does not require a license indoors, "qualified drone pilot with civil aviation authority… when… you get your approval or license … the course objective is not to teach you how to fly… The main focus is safety, navigation, rules, regulations, where you can fly or can't fly, how far you need to be away from… extras, personnel. So, anyone who's got the license… approvals, their number one priority … certainly should be safety" (Informant 4).

Professionals pay attention on more things such as make the operator visible, request for authorizations or have insurance coverage. "I worry about the insurance side of risks: you know, the equipment getting broken, somebody getting hurt…" (Informant 18). Even if you automatize the flight, "Now you need two people, … and then you could be one people" (Informant 17). "In an indoor sense, you're far more capable of delivering what your vision is", "someone's always got their eye on the drone while someone else might be monitoring" (Informant 18). But… "always something else can happen. You have to anticipate; you have to be able to anticipate. That's when the creativity also kicks in and if everything is too much automated, you're limited on that" (Informant 2).

Moreover, producers could give advice and instructions. For example, "YouTube videos of five minutes each, or some random software, without putting money into it" (Informant 4).

### Results of focus group activities

In general, all the Informants agree that a proper design by default, including active safety and security, is the best solution for all the issues, because, e.g. "If it's very accurate and it works very well then it will be more ethical" (Informant 11). Anyway, active safety is the issue most valued: "Maybe if there's a point when, without doubts, the sensors work perfectly, we know there's no error margin, it's very easy to use and in case of any problem it lands without crashing on anything… if all of these will be very very tested, it could arrive a point when anyone could use it" (Informant 13).

As we have observed, in relation to security and privacy, the main concerns of the informants were two: the possibility of hijacking a Wi-Fi signal and the need of asking for people's permission while recording images. That is in accordance to Deliverable 2.1 results.

Additionally, indoor drone "do not need a pilot or a license, anyway it's convenient for the owner the insurance", that is to give confidence to the client even if "the regulation doesn't apply". However, this situation creates sometimes an unsafe environment: "The main problem is always regulation vacuum, depending where you fly you're afraid and sometimes we are stopped when we're recording something" (Informant 6).

The European Union (2015) recommends that manufacturers can help giving some advice in their packaging and using codes of conduct in order to self-regulate the industry. Other tools, as Impact assessment or the participation of a Data Protection Officer, could improve clients' reliability. Industry could react in a proactive way in case regulation is not enough.

Some associations of manufacturers and operators of drones in the EU have developed codes of good behaviour. What these codes do is provide guidance to regulators of in-place legal standards and practices





(Freeman and Freeland 2014). For example, ARPAS-UK (https://www.arpas.uk/mem-code-of-conduct/). As drones' technology changes fast, news organizations' adoption of drone technologies must be paired with clear articulations of their ethical use and full transparency with the public (Culver 2014).

But critics argue that these codes have the limitations of any industry's attempt of self-regulation: there are no significant consequences when the code is broken. Therefore, some authors add the necessity of co-regulation with public administration (Clarke 2014a) as well as additional training for the users (Clarke 2016).

Consequently, interaction among stakeholders may produce a consensus of a public policy approach in an area where there is considerable uncertainty (Freeman and Freeland 2014).

# 04. CONCLUSIONS

Based on the analysis of the data triangulation of primary and secondary sources conclusions can be subdivided in two categories:

a) Recommendations: RPAS characteristics, design of operation, pilot(ing) requirements

b) Aeronautic Study of Safety recommendations, including risk analysis and mitigation actions.

## 4.1 Recommendations: RPAS characteristics, design of operation, pilot(ing) requirements

When planning the use of RPAS in indoor operations for creative industries, the following issues should be taken in account, either to choose the correct equipment or to plan how to operate and manage the RPAS within the creative industry:

**1)** Design and technical features of the RPAS and auxiliary equipment:

- Dimensions according to expected use.
- External soft covering.
- Propeller protection.
- Rounded edges in external components that could cause harm in a collision.
- Retractable camera gimbal.





- Easy-to-connect battery system that includes an electronic control and management software.
- Transportable, with adequate packaging devices.
- Appropriate assembly procedures that:
  - Avoid failures in assembly of propellers, batteries.
  - Allow adequate starting of electronic systems on-board.
  - Provide Checklist for a safe function of the RPAS.

**2)** Functionalities provided by the RPAS:

- Flying controls with automatic flight modes.
- Safety measures and procedures embedded (RTH, Course Lock...).
- Navigation related to specific environments, capable to position and navigate supported by environment.
- Positioning system working correctly indoor.
- Sensors of proximity that detect obstacles nearby.

**3)** Design of Operation for implementation:

- Registration as RPAS Operators complying with national requirements in every country where RPAS will be operated.
- Elaboration of technical and procedures documents:
  - Technical RPAS documents: User Manual, Maintenance Manual.
  - Safety Study for all different environments and scenarios where the RPAS will be flying.
  - Operations Manual where all the procedures and necessary Works has to be detailed and assigned.
  - Protocols for regular use and emergency procedures:
    - Regular operations.
    - Means to avoid external interferences.
    - Emergency.

**4)** Pilots and supporting staff to be certified according to national requirements but checking also additional requirements in other countries:

- Extensive Training to get to know the equipment and functionalities.
- Be aware of firmware actualizations and new functionalities to be incorporated by manufacturers.

☐ Specific work to be performed on coordination of Pilot and Camera Operator, for appropriate movements and flight control.

**5)** Insurances, both Civil Liability and covering of RPAS damages in case of accident, to be contracted in every country where the operations will be carried out.

**6)** Developing contacts with national or local ATM (Air Traffic Management) or RPAS management organizations to be aware of possible NOTAM´s or cases that could affect the operation.

The indoor RPAS which will be developed during the AiRT Project will try to keep all these recommendations in mind, providing innovative solutions that meet most of the requirements for a safe use for creative industries.

## 4.2 Aeronautic Study of Safety recommendations

This Safety Risk Assessment is based on methodology widely applied in several European countries. The work to assess the risks has to be carefully developed and applied by people in charge of RPAS´s operation, following a methodology that can help to take in account every factor. There are a number of methodologies already in use in the aeronautical sector that have been adapted to the use of RPAS. Once the operation is analysed under the safety-first mode, an iterative approach is highly recommended, in order to refine the process and get information from the experience and real cases. The following diagram (Figure 7) shows the analysis to be performed, which can be described in 6 phases:

**Phase 1.** Flight planning. What is the purpose of the flight? What is intended to be filmed, and why?

**Phase 2.** Hazard identification. Collects and identifies operational RPAS safety hazards.

**Phase 3.** Safety risk assessment. Measures the projected probability and severity of the consequences (very low, low, medium, high and very high)

**Phase 4.** Mitigation strategies, how accidents might be avoided or consequences reduced. Mitigation actions can be subdivided into two groups: Corrective actions (e.g. software response avoiding accident, or protectors mitigating damage) and preventive actions (e.g. regular maintenance measures of RPAS, routine check before take of etc.)

**Phase 5.** Safety Study – Safety document. Finally, before flight, the risk management process will be documented

**Phase 6.** Operation (flight).

Under this approach, planning off flights according to user needs (scene to be filmed) should be preliminary made, in order to identify hazards in the operation





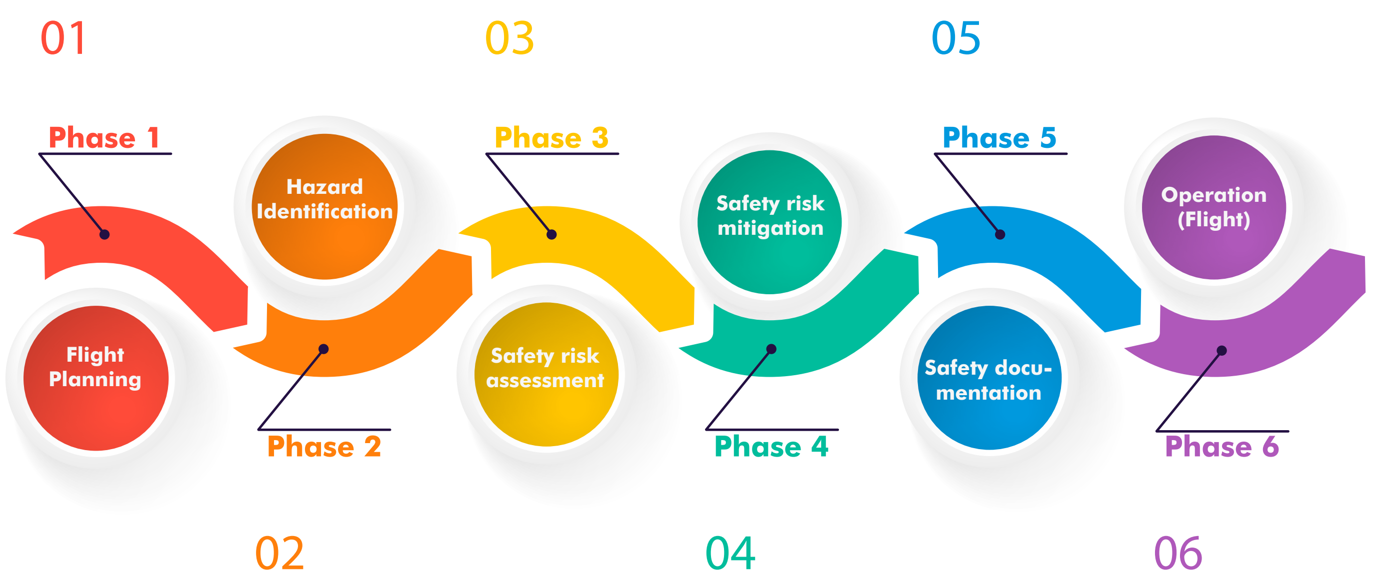



Figure 7. Approach for safety analysis.

environment, and then the process of assessing risks and defining action to mitigate their effects will end in the safety study that will allow performing the flights and getting more info on re-planning the flights with safer procedures.

This document presents a sample of a Safety Risk Assessment based on methodology widely applied in several European countries, that could be used by new users as a reference. This study shall be kept permanently open to modifications, updating and improvements based the RPAS operator´s own experience.

The present section is intended to be used as a guide for a safe operation of drones in confined environments, especially directed to the Creative Industries while using drones (RPAS) for filming. The Aeronautic Study of Safety performed will help the future operators to assess hazards and scenarios in order to fly drones indoor in safe manner.

The presented results are based on several methodologies that are commonly used in European Countries.

As mentioned above, the safety risk assessment is an instrument used to identify and assess active and latent safety hazards for RPAS operation. This safety risk assessment includes mitigation actions, predicted probability and severity of the consequences or outcomes of each operational risk. This approach makes safety risks measurable and so that risks can be better controlled.

### Pre-Flight Checklist

Previously to operate a drone, there are a number of checkpoints that must be carefully verified.

In this first phase of the study, safety hazards have to be identified and collected separately into "active failures" and "latent conditions", as explained above, both of which occur or might occur during the flight operations. The methodology has also been explained for a concise analysis, showing different hazards modes as "Reactive", "Proactive" or "Predictive", and ways of identifying them.

The issues listed below are given as an example, and a complete review and modification for specific drones and environments shall be made as a general rule:

- ☐ Verify correct assembly of the drone and configuration of the flight controls.
- ☐ Batteries are fully loaded for all the devices (drone, ground station, camera…).
- ☐ Review all connections and wiring are in good shape.
- ☐ Start drone and ground station.
- ☐ Check correct functioning of motors before take-off.
- ☐ Check adequate positioning signal and functioning of positioning system.

### Risk Analysis and Mitigation Chart

The identified safety hazards must be run through a root cause analysis to identify the causes and their potential consequences. The potential outcome shall be assessed according to their risks in the following phase, the risk assessment, that provides a measuring of the probability and severity of the consequences of the identified safety hazards.

The risk is the evolution of a hazard when an action is exposed and it has a probability to occur, which is defined as the likelihood or frequency that the consequence of the hazard might occur. This probability can be categorized in levels that can receive a number as a value reflecting frequency of occurring:

**P = Probability, going from Extremely Improbable with a value of just 1, to Frequently with a value of 5.**

The extent of harm that might reasonably occur as an outcome of the hazard is named as Severity, which can be assessed through economic impact of the consequences or having also in mind possible injuries to persons.

**The scale of S = Severity is going from Negligible 1, to High Impact 5.**

The last factor is called Exposure, which is related to the frequency the activity is carried out so the risk is exposed to happen.

**Value going from -3 (rarely) to 3 (frequent).**

The combined application of Probability, Severity and Exposure gives a value of the Risk, named the RISK INDEX:

**P = Probability / S = Severity / E = Exposure**

**RISK INDEX = P * S + E**

In case Risk Index is beyond 7, mitigating actions shall be applied, and the Index to be calculated again for the Residual Risk Index. Parameters used in assessing level of risk or Risk Index and how they are mitigated by correcting actions are those regularly used in most European countries. This safety study should be performed for each one of the expected operating scenarios. The following chart shows a reference list of risks and mitigating actions that can be applied to keep risk at acceptable levels, mandatory condition to perform a RPAS operation. But in every case, a complete analysis should be taken in account.





Table 2. Risk Analysis and Mitigation Chart

| HAZARD IDENTIFICATION | P | S | E | RISK INDEX | RISK MITIGATING ACTIONS | P | S | E | RESIDUAL RISK LEVEL |
|---|---|---|---|---|---|---|---|---|---|
| **INDOOR ENVIRONMENT** | | | | | | | | | |
| Interference of obstacles (film set constructions, equipment, inner structures…) when flying in the flying area | 2 | 3 | 1 | 7 | Indoor Environment has to be inspected before starting flights to reduce this chance. Mapping the environment to design accurate flying routes shall be performed in advance. A geo-fencing or flying limits have to be set for the drone to fly with a separation. | 1 | 3 | 1 | 4 |
| Interference of obstacles (film set constructions, equipment, inner structures …) in nearby areas that could be used as ESCAPE or APPROACHING ROUTES | 3 | 3 | 1 | 10 | Indoor Environment and flying area has to be inspected before starting flights, identifying those risky zones and the safer zones to plan the escape or approaching routes. | 1 | 3 | 1 | 4 |

| HAZARD IDENTIFICATION | P | S | E | RISK INDEX | RISK MITIGATING ACTIONS | P | S | E | RESIDUAL RISK LEVEL |
|---|---|---|---|---|---|---|---|---|---|
| **PERSONS** | | | | | | | | | |
| Unexpected adverse situations for the pilot | 2 | 3 | 1 | 7 | A detailed Flight Plan is elaborated with feasible options for the pilot in case of unexpected events. | 1 | 3 | 1 | 4 |
| Interference of unaware persons in the operation | 2 | 4 | 1 | 9 | A tight control of persons is set to access the flying zone, and a safety perimeter around the pilot and dedicated zones. Access to this perimeter is only allowed to technical staff. | 1 | 1 | 1 | 2 |
| Drone or auxiliary systems could have been manipulated by unauthorized person. | 3 | 3 | 1 | 7 | Instructions set in the User Guide related to measures to avoid illicit interferences shall be complied at all time. | 2 | 1 | 1 | 3 |
| An incident with damages or accident affecting persons is occurred. | 1 | 4 | 1 | 5 | First Aid team and instructions for the Staff shall be designed, with urgent evacuation procedures. Location of nearby medical centres shall be made. | 1 | 2 | 1 | 3 |

| HAZARD IDENTIFICATION | P | S | E | RISK INDEX | RISK MITIGATING ACTIONS | P | S | E | RESIDUAL RISK LEVEL |
|---|---|---|---|---|---|---|---|---|---|
| **MEANS** | | | | | | | | | |
| Loss of radio frequency link between drone and ground station. | 2 | 3 | 1 | 7 | Automatic activation of functionality RETURN TO HOME (RTH) to allow the drone to fly back to original or designated position and soft landing. | 1 | 3 | 1 | 4 |
| Loss of positioning signal or reference during flight. | 3 | 3 | 1 | 10 | Pre-check of every system functioning correctly shall be performed before flight. In case of failure, manual piloting and mission abortion shall be performed. | 1 | 3 | 1 | 4 |
| Loss of datalink transmission between drone and ground station. | 2 | 3 | 1 | 7 | Mission shall be aborted and automatic RTH functionality shall be activated. | 1 | 3 | 1 | 4 |
| Loss of visual contact with the drone as flying behind an obstacle. | 2 | 3 | 1 | 7 | Observers shall be positioned to provide information to the pilot. | 1 | 3 | 1 | 4 |
| Interferences in communication due to nearby facilities or devices | 2 | 3 | 1 | 7 | Most of the communication links between drone and pilot are based on "frequency hopping spread spectrum", what prevent from interferences when a number of transmitters are working simultaneously. Indoor environment can help to control sources of radiofrequency signals, most of them in the range of Wi-Fi working frequencies. | 1 | 3 | 1 | 4 |
| Several drones flying in same airspace. | 2 | 4 | 1 | 9 | If this case arises when a number of drones and pilots are operating in coordination and previous agreement, then the procedure for regular flying and emergencies must be set in advance. If there is an unexpected invasion of the operating airspace by external agents, then an emergency procedure for immediate landing has to be devised and applied. | 1 | 4 | 0 | 4 |
| Fly away out of the planned airspace | 2 | 4 | 2 | 10 | Inner-fencing methods must devise within the flying planner software or the mapping functionality, what prevent the drone to fly beyond the limits established. | 2 | 2 | 1 | 5 |
| Failure in electronic systems | 3 | 3 | 2 | 11 | Check lists are devised and the procedure implies checking the correct function of this factor before flying. Design will reinforce the need of no-failure in this system. | 2 | 2 | 2 | 6 |
| Structural failure of the aircraft | 2 | 4 | 1 | 9 | Check lists are devised and the procedure implies checking the correct function of this factor before flying. Appropriate structural design will reduce the possibility of failure. | 1 | 3 | 1 | 4 |
| One or more motors failure while flying | 2 | 3 | 2 | 8 | Check lists are devised and the procedure implies checking the correct function of this factor before flying. Having an 8-motors drone, as it is the designed case, will provide some kind of redundancy in this area and will allow a soft landing. | 2 | 2 | 1 | 5 |
| Loss of power in the Ground Station | 3 | 3 | 2 | 11 | Battery level will be checked before flying. Check lists are devised and the procedure implies checking the correct function of this factor before flying. In case of activation of low level alarm, drone will be landed as soon as possible. | 2 | 1 | 2 | 4 |
| Failure in aircraft control software or hardware | 3 | 3 | 2 | 11 | Both control software and hardware are based on COTS products (Commercial Off-The-Shelf), what reduces probability of failure. If still happens then manual piloting will be performed for a soft landing. | 2 | 2 | 2 | 6 |





# REFERENCES


- Braun, S., Friedewald, M., & Valkenburg, G. (2015). Civilizing drones: Military discourses going civil? Science and Technology Studies, 28(2).
- Clarke, R. (2014a). The regulation of civilian drones' impacts on behavioural privacy. Computer Law and Security Review, 30(3).
- Clarke, R. (2014b). Understanding the drone epidemic. Computer Law and Security Review, 30(3).
- Clarke, R. (2016). Appropriate regulatory responses to the drone epidemic. Computer Law and Security Review, 32(1).
- Culver, K.B. (2014). From Battlefield to Newsroom: Ethical Implications of Drone Technology in Journalism. Journal of Mass Media Ethics: Exploring Questions of Media Morality, 29(1).
- EASA (European Aviation Safety Agency). A-NPA 2015-10. Introduction of a regulatory framework for the operation of drones. 31 July 2015.
- European Commission (2015). Riga Declaration on Remotely Piloted Aircraft (drones) 'Framing the Future of Aviation', Riga, 6 March 2015.
- European Union (2015). Opinion 01/2015 on Privacy and Data Protection Issues relating to the Utilisation of Drones, 16 June. Article 29 Data Protection Working Party, 01673/15/EN WP 231.
- Freeman, P.K., & Freeland, R.S. (2014). Politics & technology: U.S. polices restricting unmanned aerial systems in agriculture. Food Policy, 49(P1).
- Luppicini, R., & So, A. (2016). A technoethical review of commercial drone use in the context of governance, ethics, and privacy. Technology in Society, 46.

# GLOSSARY

**AESA** Agencia Estatal de Seguridad Aérea (Spain, Spanish aviation safety agency)

**BVLOS** Beyond Visual Line Of Sight

**CAA** Civil Aviation Authority (UK)

**EASA** European Aviation Safety Agency

**ESC** Electronic Speed Control

**FAA** Federal Aviation Administration (USA)

**GNSS** Global Navigation Satellite System

**GPS** Global Positioning System

**ICO** Information Commissioner´s Office (UK)

**IMU** Inertial Measurement Unit

**RF** Radio-frequency

**RPAS** Remotely Piloted Aircraft System

**RTH** Return To Home

**UAS** Unmanned Aircraft Systems

**UPV** Universitat Politècnica de València

**VLOS** Visual Line Of Sight