

COMPARATIVE STUDY OF EUROPEAN RPAS REGULATIONS

Cristina Cuerno-Rejado

Polytechnic University of Madrid (UPM), Department of Aircraft and Spacecraft. ETSIAE

Professor of Aircraft Design

Plaza Cardenal Cisneros 3, 28040, Madrid, Spain

cristina.cuerno@upm.es

Alejandro Sánchez-Carmona (UPM, ETSIAE), Paula Álvarez-Llorián (UPM, ETSIAE) and Luis García-Hernández (UPM, ETSIAE)

ABSTRACT

This study struggles with the regulatory framework in the EU for RPAS lighter than 150 kg. The regulation responsibility is competence of each state member; hence a harmonization of the regulation is far from being reached. In this context, this paper is a first step for achieving this objective. A deep analysis of the regulations in force has been developed in order to compare one to each other. The comparative study has been carried on from the standpoint of six main sections: Categorization, Unmanned Aircraft, Pilots, Operators, Design and Maintenance and Operations. The majority of the National Authorities focuses on regulating the operations, because it is the easiest way to control RPAS uses. However, many other countries establish norms related to the other sections indicated previously in order to be more restrictive and nearer to manned aircraft regulations. The main conclusion of this work is that the regulatory framework is heterogeneous enough than EASA may need to extend its competence to all the RPAS for allowing harmonization and growing of this field.

NOMENCLATURE

AGL	Above Ground Level	ILT	Human Environment and Transport Inspectorate
ANSP	Air Navigation Service Provider	KE	Kinetic Energy
ATC	Air Traffic Control	MOA	Maintenance Organization Approval
BVLOS	Beyond Visual Line of Sight	MTOW	Maximum Take-Off Weight
CGS	Control Ground Station	NAAs	National Aviation Authorities
DOA	Design Organization Approval	POA	Production Organization Approval
EASA	European Aviation Safety Agency	RPA	Remotely Piloted Aircraft
EC	European Commission	RPAS	Remotely Piloted Aircraft System
EVLOS	Extended Visual Line of Sight	SSR	Secondary Surveillance Radar
FAA	Federal Aviation Administration	UA	Unmanned Aircraft
FRTOL	Flight Radio Telephony Operators' License	UAS	Unmanned Aircraft System
IAA	Irish Aviation Authority	VFR	Visual Flight Rules
ICAO	International Civil Aviation Organization	VLL	Very Low Level
IFR	Instrumental Flight Rules		

1 INTRODUCTION

Recently, there has been a very noticeable increment in the use of unmanned aircraft and remotely piloted aircraft systems (RPAS). In the beginning, these vehicles were designed for military use; however, there are currently a large number of civil and commercial activities that can be performed using these platforms. This interest has led to the growing development that these platforms are experiencing, with a wide variety of designs, sizes and capabilities. Actually, this flexibility is considered one of the reasons of the actual growth and one of its main advantages. The opening of the European market for remotely piloted aerial systems therefore, is an important step for the aviation market of the future [1, 2]. Nevertheless, despite being in increasing demand and have been proven useful for many types of missions, there is yet no definitive regulatory framework to fully incorporate them into airspace. Due to the diversity of sizes and shapes previously mentioned, the design of rules to cover all possible types of aircraft seems significantly complex [3]. Many resources and efforts to develop rules governing the use and certification of these platforms and their equipment are being followed at international level [4].

The European civil RPAS community has grown substantially and has come a long way in a relatively short period of time, and is currently taking decisive steps towards the incremental integration into European airspace [5]. In the same way, out of Europe, the FAA is working for reaching this final objective of fully integration of RPAS into airspace [6]. Besides, the US authority has taken a further step on developing and implementing standards for certification of UAS, preparing a Draft Advisory Circular focused mainly on design standards and assumptions for Type Design Approval under 14 CFR 21.17(b) of Fixed Wing UAS. Also, the International Civil Aviation Organization (ICAO) [4] has set the objective of establishing the principles and rules for the RPAS to operate in airspace mixed with manned aircraft, under Instrumental Flight Rules (IFR) and Visual Flight Rules (VFR) adhering to the requirements of the specific airspace in which they are operating [7, 8, 9].

In the European Union, the aviation safety regulator is the European Aviation Safety Agency (EASA) and, by the moment and until the actual regulations does not change, the RPAS responsibilities are divided between the very light aircraft (MTOW under 150 kg), owned by the National Authorities, and the heavy RPAS (MTOW over 150 kg), competence of EASA [10]. While the moment when the previous division finishes (envisioned more or less by 2017 according to [1] and [5]) there are several European national authorities who are establishing their own regulations in order to facilitate the commercial expansion of the small RPAS business in their territories. This multiplicity of legislations is generating a confusing regulatory map across Europe which is hindering the natural expansion of small RPAS manufacturers and operators through the common market.

The comparative analysis of the European regulations embraces the challenges of facilitating the integration of RPAS into the non-segregated airspace, acting in a dual role to satisfy both the regulators and the industry. As of this, to ensure that RPAS companies have an easier access to what shall be complied to develop their intended activities and also to assist as possible the National Aviation Authorities are among the main objectives. Even though numerous of the members of EASA have already set in force their RPAS regulation, harmonization is yet far from being achieved. A comparative research of what already exists may help those countries with no regulation in force to properly approve theirs while may lead to improvements on the existing. In order to comply with those objectives, the regulations shall be deeply analyzed and, after setting a regulatory structure, considerations classified in sections according to diverse topics.

2 NATIONAL REGULATIONS CLASSIFICATION

A growing number of national aviation authorities from countries members of EASA have already approved regulations on the operation of civil RPAS with a MTOW of less than 150 kg. Austria, Czech Republic, Denmark, France, Germany, Ireland, Italy, Malta, Netherlands, Poland, Spain, Sweden, Switzerland and United Kingdom are those countries that have a proper regulation in force, while Belgium, Finland, Lithuania, Norway and Romania are about to pass theirs.

Although these regulations are not harmonized and differ from one to another, it may be possible to establish a comparison framework according to the common regulatory topics considered. The FAA's *Roadmap for Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS)* [6] addresses the myriad challenges associated with this effort. A regulatory structure may be developed following the FAA's Roadmap together with what each European authority considers in its regulation. To this end, six main sections are differentiated: Categorization, Unmanned Aircraft, Pilots, Operators, Design and Maintenance and Operations. In addition, some of these have been further subdivided according to the regulatory considerations. Unmanned Aircraft includes five subsections: ID marking, devices, payload, registration and authorization; Pilots include considerations about minimum age, requirements and responsibilities; Operators include requirements, responsibilities and other personnel; and, finally, under Operations four subsections may be found: use of airspace, control, Air Navigation Service Providers, and safety aspects and insurance. In spite of not having been considered as a proper topic, applicability of regulations may also be an important aspect. It is fundamental to know which aircraft are affected by these regulations and, consequently, by this study.

Scope of application		
	MTOW (kg)	Model a/c
Austria	≤150	
Czech Republic	≤150	>20kg
Denmark	≤150	X
France	≤150	X
Germany	≤25	
Ireland	≤150 (conditions for < 20)	
Italy	≤150	X
Malta	≤150	
Netherlands	≤150	Annex
Poland	≤150	X
Spain	≤150	X
Sweden	≤150	
Switzerland	RPA ≤30, model a/c rules	X
United Kingdom	≤150	CAP 658

Table 1: Scope of application of the national regulations.

Currently, as already mentioned, the regulatory responsibilities in the European Union for civil remotely piloted aircraft with a maximum take-off mass of up to 150 kg lay within the relevant national aviation authorities. Nevertheless, the scope of the initiatives of these authorities does not always cover all RPA below 150 kg and varies upon each other. Although the majority of the national regulations in force apply to those unmanned vehicles not covered by EASA, Germany only regulates unmanned aircraft weighing up to 25 kg while Ireland just appoints specific rules for those weighing less than 20 kg. Besides, Switzerland RPA weighing up to 30 kg share those rules approved for model aircraft. Meanwhile, the main difference among the regulations is whether or not they include guides on model aircraft. In order to better explanation, the information about applicability of each national regulation has been summarized in Table 1; where the cells left in blank indicate that the RPAS regulation does not include aspects on model aircraft, those with a cross do include them in the regulation itself, and the others appoint their specific applicability.

3 CATEGORIZATION

Noteworthy differences exist among how national authorities categorize RPAS. Although categories differ, every authority, except for the Dutch, has established a classification in order to facilitate developing the regulatory framework. The basic parameter on which authorities lean for the categorization is the maximum take-off mass of the RPAS, although limits significantly differ and other specifications may also be appointed.

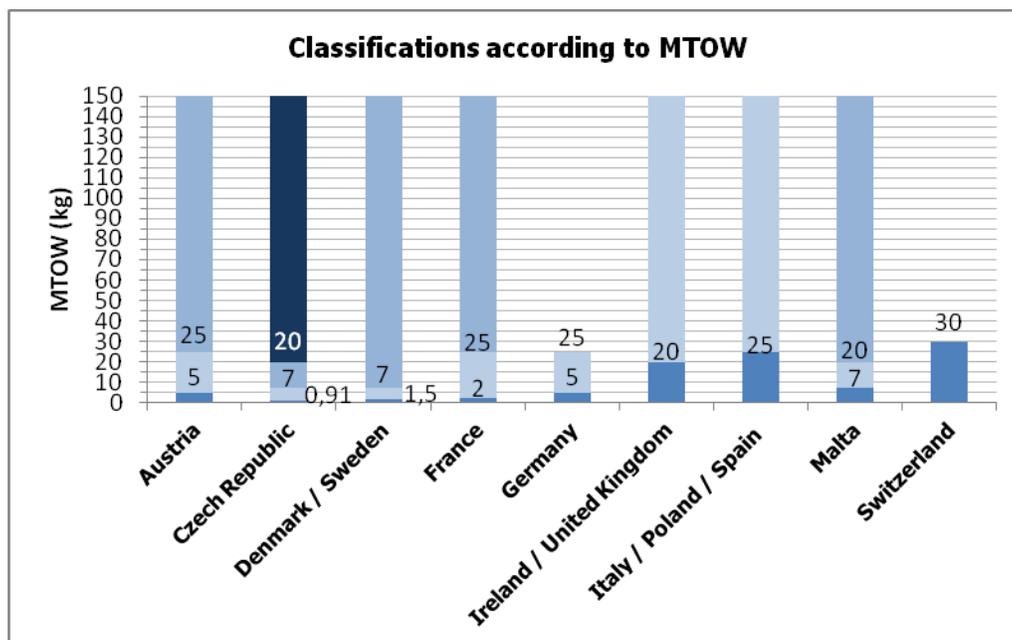


Figure 1: Classifications by countries according to MTOW (kg).

Denmark and Sweden, on one side, have divided RPAS into four categories (1A, 1B, 2, and 3) according to the type of operation and maximum kinetic energy along with the MTOW. While category 3 is reserved just for RPAS operating BVLOS, the limiting values of the other categories would be associated to the following velocities, in the case of a loss of control event:

- Category 1A: $m = 1.5\text{kg}$; $KE = 150\text{J} \rightarrow V = 14 \text{ m/s}$.
- Category 1B: $m = 1.5\text{kg}$; $KE = 1000\text{J} \rightarrow V = 37 \text{ m/s}$.

- Category 2: $m = 7\text{kg}$; $\text{KE} = 1000\text{J} \rightarrow V = 17\text{ m/s}$.

These figures can be compared with the worldwide record in baseball, in which a 150gr ball is thrown away at $V = 45\text{ m/s}$. In this same example, a $\text{KE} = 66\text{J}$ is associated to a high-school boy throwing with $V = 30\text{ m/s}$. This non-lethality level (66 J) is the one chosen by the NATO for its STANAG 4703, intended for the airworthiness certification of fixed-wing RPAS with MTOW under 150 kg. So, the values established by Denmark and Sweden are clearly above this non-lethality level. Nevertheless these countries are the only ones in including KE values as categorization criteria, which is slowly disappearing worldwide.

Although also included in Figure 1, classification encountered in regulation from Austria may be also far from the aforementioned, being significantly more complex. Austria differentiates two classes of RPAS regarding whether the operation is within visual line of sight, class 1, or beyond, class 2. In addition, there are four categories within class 1 established depending on the mass of the aircraft ($\leq 5\text{ kg}$; $\leq 25\text{kg}$; $\leq 150\text{kg}$) and the operational area (undeveloped, unsettled, settled and densely populated).

Once the diverse methods of classification have been exposed for every national regulations, regular patterns are observed among them and some countries retain certain degree of parallelism. Two or three are more commonly the groups in which RPAS are divided, leaning all the regulations on the maximum take-off mass of the aircraft. According to where the boundaries are set, several are the authorities with a division around 20 or 30 kg. Others also distinguish lighter aircraft, appointing a category for less than around 5 kg. Nevertheless, it is remarkable that there are no categorization limits between 30 and 150 kg in any regulation.

4 UNMANNED AIRCRAFT

When intending to establish a regulatory framework for the unmanned aircraft itself, several areas shall be analyzed. National authorities seem to have agreed on what fields shall in particular be controlled. Consequently, requirements regarding identification, equipment, airworthiness and communications or data link of the unmanned aircraft have been appointed.

4.1 ID Marking

Numerous are the authorities requiring an attached identification on the RPA, being Italy, Netherlands, Spain and Sweden the strictest, extending this requirement to the Control Ground Station (CGS). In Czech Republic and United Kingdom it is only mandatory when the maximum take-off mass of the aircraft is over 0.91kg or 20kg respectively, while Sweden appoints an additional requirement in the case of BVLOS operations. To operate in Denmark, France, Italy, Netherlands, Spain or Sweden, the operator's data are also required to be included. Regulations mainly differ in how the ID marking shall be affixed and in what it shall contain.

4.2 Equipment

Authorities from different countries enjoin the aircraft to be equipped with a fail-safe system to allow the safe terminating of the flight if necessary. Although definitions differ from one to other, Czech Republic ($>0.91\text{kg}$), Denmark (categories 1B and 2), France, Italy, Malta, Spain, Sweden and United Kingdom are those agreeing on that matter.

A sense and avoid system is properly mandatory to comply with regulations in Ireland and United Kingdom. Besides, Ireland appoints some minimum capabilities that the system shall develop, while both are slightly flexible as demand it just for BVLOS operations within non-segregated airspace.

A serviceable transponder shall be carried for flight operating outside the *Bubble*¹ in Malta, while unmanned aircraft intending to operate BVLOS in controlled airspace in Italy, Spain or United Kingdom shall have a mode S transponder. In Spain this shall also apply to those with a maximum take-off weight of more than 25 kg. A SSR Transponder may be mandatory in Czech Republic upon own discretion of ATC Unit.

In addition, Austria, France, Ireland, Italy, Spain and Sweden establish further guides relevant to the equipment that must be onboard. Specific comments on the requirements may also be included in the regulations.

4.3 Payload

Regulations have not yet established significant requirements or specifications regarding payload. By the moment, transport of dangerous substances or devices is properly prohibited in Czech Republic, France, Italy, Malta and Spain. Furthermore, Czech Republic does not allow dropping objects, while France, Malta and United Kingdom state that any carried load must be securely fixed under the operator's responsibility. In Sweden, extending requirements applying to manned aviation, specific authorization shall be issued for the transport of goods and passengers.

4.4 Registration and authorization

Unmanned aircraft have to be registered in order to operate in Czech Republic, Denmark, Italy, Malta, Netherlands, Poland, Spain, Sweden or United Kingdom. Although specifications differ among these countries, regulations from Denmark and Netherlands apply to any UA, while the others aforementioned apply pursuant to their characteristics.

Further agreement seems to be achieved when requiring the issuing of an authorization to operate, which is only not compulsory in Denmark and Ireland. Nevertheless, requisites yet significantly differ. The Information Bulletin applied to RPAS in Netherlands may be the most restrictive and simple, under which all unmanned aircraft must hold a certificate of airworthiness in order to operate. A certificate of airworthiness must also be issued to UA to operate in France, Italy, Spain or United Kingdom, though with specifications. Other authorities may be considered more flexible requiring the UA to be issued a permit, license or any specific authorization to operate. The division of UA needing or not authorization is in many cases set by meanings of its weight, being the barrier located between 20 and 30 kg.

4.5 Data-link

Even though Data Link forms a key subsystem of the entire Unmanned Aircraft System, national authorities have not yet set significant requirements regarding such issue. Use of specific frequencies is one of the aspects that regulations commonly have in account, requiring them to be somehow approved by the authorities. Regulations from Italy and Spain have a specific article on Data Link: *"must ensure the execution of the functions of Command and Control with the necessary continuity and reliability, and must use frequencies authorized and suitably selected so as to minimize interferences"*. Minimizing

¹ Block of airspace of defined dimensions around the launch and recovery site reserved for operating either in a visual line-of-sight mode or by means of a remote ground station.

interferences is also fundamental for the well-functioning and safety of the subsystem; in Germany operations must cease in case of any interferences.

Once analyzed what national regulations establish regarding the platform, only Italy, Spain, Sweden and United Kingdom have developed the most complete regulations according to this matter, establishing specifications to each of the exposed subjects (ID marking, devices, payload, registration, authorization and Data Link).

Although included in almost every regulation, it shall also be pointed out the disparity of opinions towards ID Marking and the devices that shall be carried onboard UAV. Meanwhile, payload and Data Link are less regulated by the countries and neither so deeply treated. Lastly, with regards to registration and authorization to operate UAV, only few countries have nothing to appoint, being harmonization however still far from being achieved.

5 PILOTS AND OPERATORS

Pilots and operators make up that personnel more directly involved in RPAS operations. ICAO Circular 328 [8] defines an operator as "...a person, organization or enterprise engaged in or offering to engage in an aircraft operation..." Except for the IAA that considers pilots as the operators of the RPAS, they are separately regulated by NAAs, which establish different requirements and responsibilities to be fulfilled by both.

In addition, sometimes pilots must be a minimum age. Denmark, Italy and Spain require the pilot to be at least eighteen for operating RPAS and Austria lower the limit to sixteen. Sweden is the other country establishing a certain limit, demanding the pilot to be at least eighteen when operating in VLOS aircraft with a maximum take-off mass of more than 7kg, and between twenty one and sixty seven when intending to operate BVLOS.

5.1 Requirements

Remote pilots are generally required to hold a medical certificate and a pilot license, and to follow a training program; periodical practical and theoretical checks may have to be passed and the pilot may have to be registered or hold a certificate of qualification, which shall be by some means ensured depending both in the country and the type of RPA intended to be operated. Each country establishes various requirements for the pilot, although regulations in Italy, Poland, Spain and Sweden may be the most detailed and restrictive.

Requirements for pilots	Countries
Authorization	Austria, Czech Republic, Denmark, France, Ireland, Italy, Malta, Netherlands, Spain, Sweden, United Kingdom
Medical Certificate	Austria, Italy, Netherlands, Spain, Sweden
Training Program	Denmark, France, Ireland, Italy, Malta, Sweden, United Kingdom
FRTOL ²	Ireland, Malta, United Kingdom

Table 2: Requirements for pilots.

² Flight Radio Telephony Operators' License.

A valid or adequate level of insurance is the most common feature among the requirements set for operators. Besides, authorization may be also demanded, while in some countries operators shall appoint additional managers for the operations.

Requirements for operators	Countries
Insurance	Austria, Denmark, France, Malta, Spain, Sweden and United Kingdom
Appoint additional managers	Netherlands: commander and observer. Spain: operation and airworthiness managers. Sweden: accountable, operations and technical managers

Table 3: Requirements for operators.

Along with these, France, Spain and Sweden establish further considerations to be fulfilled to operate within their territories.

5.2 Responsibilities

The remote pilot and the operator shall also comply with several responsibilities. Pilots must assure the safe conduct of the flight, keep the flight information in a logbook or equivalent, and monitor the RPA's position and height/altitude. Besides, the safety of third parties, whether on ground or in flight, may also be their responsibility.

Responsibilities for pilots	Countries
Safe conduct of flight or operation	Czech Republic, Italy, Malta, Sweden, UK
Keeping a logbook	Czech Republic, Netherlands, Sweden, Malta
Flight safety of third parties	France

Table 4: Responsibilities for pilots.

Regarding the responsibilities associated to operators, regulations again differ rather than concur. Operators are responsible of monitoring or establishing a data record of the operation. In several countries, operators shall also prepare and follow an Operations Manual which generally includes a risk analysis for operations, responsibilities, or the types of RPAS operated by the company. The responsibility of reporting incidents and accidents may be explicitly assigned³, and occasionally, maintenance also relies on the operators. Further specifications are stated in the regulatory frameworks from Italy, Malta, or Netherlands. These, along with France, Spain and the United Kingdom, might be the strictest countries and their regulations set thus numerous conditions when regulating UAS operators.

Responsibilities for operators	Countries
Record flight information	Austria, France, Italy ($\geq 25\text{kg}$), Malta, Netherlands, Spain and United Kingdom
Operations Manual	Czech Rep., France, Malta, Netherlands and Spain
Reporting incidents and accidents	Austria, Italy and Netherlands

³ Irrespectively of the compulsory nature of reporting any aircraft accident or incident.

Maintenance	France, Denmark, Netherlands, and Sweden
Maintenance program	Italy ($\geq 25\text{kg}$) and Malta
Aircraft and flight	Spain
Establish safety areas	Spain and Sweden

Table 5: Responsibilities for operators.

6 DESIGN, MANUFACTURING AND MAINTENANCE

The design, manufacturing or maintenance of UAS has not yet carried significant concerns to national authorities and no widely agreed standards regarding these matters have been established. Furthermore, opinions range from establishing standards equivalent to conventional aviation across the board, to tailoring requirements to the size and mission of the UAS.

The more restrictive regulations require approval to organizations intending to conduct design or manufacturing of RPAS; i.e. holding a DOA or a POA respectively. Meanwhile, it seems that national authorities aim to take a further step into setting a framework around RPAS maintenance. To this end, diverse requirements are laid down according to the need of an approval (MOA), the establishment of a program or to who is deemed to conduct the work.

In general, authorities from France, Italy, Spain, United Kingdom and specially Sweden present a more complete regulation as of these matters. Italy and Spain rather agree upon the required standards, while Sweden and United Kingdom do likewise intending to extrapolate manned aircraft requirements.

6.1 Design

Design shall generally be supervised by the national authorities. To that end, Czech Republic ($>20\text{kg}$), France (for series production), Italy, Netherlands, Spain, Sweden and United Kingdom require holding a certificate or approval (DOA). Besides, in United Kingdom designers are subject to the same requirements as those of manned aircraft.

6.2 Manufacturing

Manufacturers will be required to hold organization approvals (POA) in Czech Republic ($>20\text{kg}$), France, Italy (for series production), Netherlands, Spain, Sweden and United Kingdom. Besides, in Spain manufacturers shall develop operation, maintenance and inspection manuals; while in Sweden these manuals can be subcontracted, and in France they shall monitor all in-service events related to the fleet of aircraft type that are notified by operators.

6.3 Maintenance

When regulating RPAS maintenance, the majority of the regulations state that a maintenance program or manual shall be established in line with the manufacturer's recommendations; Denmark, France, Ireland, Italy, Spain and Sweden require such compliance, while in Austria it must be performed according to a check-list. In Sweden and United Kingdom maintenance will be in accordance with the requirements that currently apply to manned aircraft.

Additionally, Sweden and United Kingdom require personnel to be qualified and to hold approval for maintenance (MOA), and in Netherlands it is also mandatory when intending to achieve exemption for some operations. In Italy and Spain, manufacturers or authorized organizations are designated to carry out maintenance, although in Italy the operator may also be authorized to conduct routine maintenance if

qualified. In Sweden, maintenance responsibilities can be held by subcontracted organizations or a technical manager from the operating company. Sweden is thus the most restrictive country regarding RPAS maintenance, establishing also requirements concerning facilities, equipment and working methods. Documentation of all maintenance work carried out shall be recorded and a quality control system should be applied.

7 OPERATIONS

7.1 Use of airspace

Notwithstanding the importance of how RPAS are to be operated, operating procedures that have to be followed still widely diverge among countries, not only regarding the aspects to be considered, but also in the way that those shall be regulated. Unmanned aerial operations involve a broad range of aspects that shall be appropriately and clearly treated, e.g. weather and light conditions, height and distance limitations, or use of airspace classes.

Regulations from Austria, Czech Republic, Denmark, Malta, Netherlands, Spain and Sweden state that when operating UAS, weather conditions shall be controlled. As a minimum requirement, weather shall be such as to permit a safe conduct of the flight. Concerning when operations are enabled to be developed, authorities may limit the use of unmanned aircraft to daylight hours from sunrise to sunset, while some others are more permissive and allow night operations under permission.

A significant aspect that shall be controlled is where RPAS operations are allowed to be conducted. Limits regarding height and distances to obstacles or areas are thus nominated. RPAS should usually avoid congested areas, persons, airports or other obstacles in order to exclude any possible dangers. The minimum distance required to congested areas is 150 meters and is usually 50 meters to persons or others such as buildings. The most common distance to airports seems to be 8 km, as agreed by Denmark, Ireland, Italy and Spain.

Generally, operation over built-up areas and assemblies of persons shall be avoided and is prohibited regardless the weight of the aircraft unless permission from the respective authority. Among the regulations that set height limits for unmanned operations, Austria, Switzerland and France (in spite of its 50 m limit for BVLOS operations) appear to be the less restrictive, allowing operations up to 150 m (492,13 ft.). Ireland, Malta, Netherlands, Spain, Sweden and United Kingdom agree on setting the flying limit in 120 m. This height approximately equals to 400 ft. which coincides the limit set by the FAA for small types of unmanned aircraft [11].

Further considerations regarding where unmanned aircraft are to be flown deal with the airspace to be used. Although the majority of the general operations with RPAS shall be conducted within segregated airspace, operating in controlled airspace may also be allowed upon authorities. Moreover, each National Authority appears to have its own considerations on this matter. These aircraft shall generally give way to manned aircraft or others, being expected to interfere the least with general aviation and thus considered the least priorities.

To conclude with the analysis of operational limitations, regulations from Czech Republic, France, Italy, Spain, Sweden and United Kingdom are those establishing a more complete and developed framework, appropriately considering those factors that unmanned flights entail. Meanwhile, regulation from Poland is that appearing to be rather incomplete as to this matter.

7.2 Control and ANSP

Considering the broad range of operations and possibilities that UAS entail, numerous factors shall be dealt with when establishing an operational regulatory framework for this type of aviation. Authorities shall thus appoint how, where or when operations are permitted, and what shall be done in case of an accident or non-expected event.

As RPAS do not fly over 500 ft. AGL, operations conducted by them are considered to be very low level (VLL). Within that frame, three types of operations may be further distinguished: visual line of sight (VLOS), extended visual line of sight (E-VLOS) and beyond visual line of sight (BVLOS). These three operations will be or not contemplated by NAA's based on the level of development of their respective regulations. Austria, Czech Republic, Denmark, Germany, Ireland, Sweden and Switzerland allow only VLOS operations. Meanwhile, Italy (≥ 25 kg) and Netherlands may also authorize EVLOS operations for short phases of flight. The most permissive authorities regarding this matter are those from France, Malta, Poland, Spain and United Kingdom, where BVLOS operations are allowed to be conducted although subject to some restrictions and usually within segregated airspace.

To avoid interferences with conventional aircraft, diverse measures must be followed when operating RPAS in airspace. Even so, several authorities have not yet appointed any considerations to air navigation service providers (ANSP). Regulations from Ireland, Sweden and United Kingdom are the strictest and most complete. They demand unmanned aircraft flights to:

- Respond to ATC within same period of time as manned aircraft.
- Ensure that ATCs are aware that it is a RPAS flight.
- Monitor all communications when operating within non-segregated airspace.

7.3 Safety and insurances

In order to conduct safe operations, several measures have to be adopted in case of an unexpected event or accident. Coincidences among regulations may seem to appear when explicitly remarking reporting accidents and there is neither slight doubt among authorities that insurance requirements must be appointed if pursuing the well development of RPAS operations.

Meanwhile, no harmonized regime for liability for damage to third parties caused by RPAS lighter than 150kg exists at the EU level. However, an international legal framework [12], clearly defining responsibilities and establishing thus a civil liability regime for third party damage, which is applicable to RPAS in a few countries (Spain, for example) if there is not any other specific regulation. Following this, an appropriate insurance cover to guarantee compensation for victims or damage, is indeed needed. National authorities agree that the remotely-piloted aircraft operator shall hold an adequate level of insurance in order to meet any liabilities in the event of an accident and third party damages, but it is necessary regulate previously the liability to fix an amount of compulsory insurance. Several regulations refer to that approved by the European Parliament (EC Regulation 785/2004), which defines insurance requirements for manned aircraft operators, based on the maximum take-off mass; while others appoint certain particularities. France and Poland do not mention requirements regarding insurances, though in the application for operating in France a copy of the insurance is said to be enclosed [13].

Together with those common aspects above analyzed related to accidents and insurances, some countries state further measures to the end of facilitating the safe conduct of flights such as the definition of a safety zone to ensure a safety distance to persons, animals, craft and other property. In Italy and Spain the operator must also take appropriate measures to protect the RPAS from unlawful acts during

operations, to prevent deliberate interference of the radio link, and establish procedures to prevent access by unauthorized personnel to the area of operations.

8 LATEST UPDATES ON NATIONAL REGULATIONS

Among European authorities, which are the principle targets of this analysis, the ILT from Netherlands is currently working on relaxing its respective regulation on UAV. As of May 2015, the Infrastructure Minister announced that is working on new rules which will enable what it calls “commercial companies” to use small UAS weighing a maximum of 4 kg without having to apply for permits. Actually, on April 23rd, 2015, a Decree amending licenses for aviation and rules on remotely piloted aircraft was already approved to enter into force on July 1st.

The current regulation has thus been admitted to be slightly practical as it holds up the development of commercial UAS operations. The change, due to come into effect on October 1st, means the same rules will apply to both commercial and private users, and was published on April 30th, 2015, as a proposal regulatory policy in order to allow a smooth transition to the future European regulation.

9 SUMMARY/CONCLUSIONS

Over the last years the world has been witnessing the rapid development and use of Unmanned Aerial Systems. Ensuring that UAS operate safely in the airspace is a new and complex challenge for the aviation authorities and understanding the issues, trends, and influences of UAS will be critical in strategically planning for the future airspace system. The International Civil Aviation Organization, the Federal Aviation Administration (USA) and the European Aviation Safety Agency are three of the organization more actively commanding the regulation of UAS. Coming to a solution towards the integration of unmanned aircraft into non-segregated airspace will thus allow unblocking a multitude of projects and initiatives.

At first, the integration of RPAS into the aviation system should be based on the principle that safety must not be compromised. RPAS operations should exhibit an equivalent level of safety as manned aviation, although the adoption of a proportionate approach with regards to airworthiness and operational regulations may be more appropriate than simple equivalence to manned aircraft.

In Europe, EASA regulates those systems not weighing less than 150 kilograms, leaving the ruling of those underneath for the respective National Aviation Authorities, which extends the already existing international lack of harmonization to European territories. The comparison among European regulatory frameworks on RPAS has led to several conclusions already exposed throughout the analysis of each of the topics:

- **Categorization:** RPAS are usually categorized depending on their weight. Some countries also separate RPAS operated BVLOS under a different category.
- **Unmanned aircraft:** the platform, sometimes together with the CGS, shall have an identification mark attached. Besides, it can be required to be registered and, commonly, it shall be required to hold authorization.
- **Pilots:** few are the countries setting a minimum age for piloting RPAS but the majority does appoint requirements and responsibilities for them. Pilots are usually required to hold license, medical certificate and to ensure the safe of the operation and keep flying information.
- **Operators:** generally responsible of the operation and maintenance, shall report accidents and hold insurance.

- **Design, manufacturing and maintenance:** slightly considered on regulations, though several countries establish that organizations developing these must hold DOA, POA and MOA respectively. Maintenance programs have also been created.
- **Operations:** most of the regulatory frameworks only consider VLOS operations, although some already contemplate those conducted BVLOS, which allow broadening the operational utility of RPAS. Operations are generally limited to segregated airspace, although each NAA appoints its respective specifications and exemptions. Besides, flying limits and distances are specified and accidents shall always be reported. Insurances and reporting accidents or incidents are explicitly regulated by the majority of the authorities, as considered key to the safe development of operations, leaning several authorities on EU Regulation 785/2004.

Some regulations seem to extend equal rules of manned aviation leading to perhaps too strict aspects that may hold up the conduct of operations. As a fact, Netherlands has already proposed relaxing rules on sUAS. Also, NAAs issuing new regulations lean on those already existing and there are countries sharing numerous analogous considerations: Denmark and Sweden; Spain and Italy; or Malta, Ireland and United Kingdom. Furthermore, France, Italy, Spain, Sweden and United Kingdom appear to have developed the most complete regulations.

The broad range of considerations when ruling RPAS in Europe lead to difficult the growth of unmanned aerial industry as well as avoid the exploitation of the advantage it appears to offer. Recent steps taken by EASA suggest that the Agency will in an unknown future take control of RPAS of less than 150 kilograms; either lowering the current limit to 20-30 kilograms or even avoiding such limit [14,15]. Besides, an ideal framework should take into account the already existing national rules while shall also ensure that future EU rules will be compatible with international arrangements in other countries.

Future works towards integrating unmanned aviation within the airspace systems shall not only embrace the harmonization of regulations, but also help creating awareness among society about the hazards that RPAS operations entail at the same time that enabling growth in the industry and development of technology for the near future.

9.1 Future works

Once the comparative study has been concluded and conclusions of the regulatory frameworks ruling in Europe have been extracted, other activities could be developed. A case study of an RPAS intended to be operated within an EU country could be addressed, and other possible line of work could consist on building a decision tree diagram in order to use it as a guide for the considerations that shall be complied when operating, although it would depend on the standpoint of the final user of the regulation (i.e. operator, pilot, designer, authorities).

Additionally, this comparative analysis could be further extended to the rules on software and hardware relevant to UAS that are expected to be issued and which could be also be linked to the already existing regulations.

From the analysis on, a new regulation result of a combination of those analyzed could also be developed, leaning in addition on the interests and opinions from the unmanned aerial industry.

REFERENCES

- [1] European Commission. Communication from the Commission to the European Parliament and the Council. *"A new era for aviation. Opening the aviation market to the civil use of remotely piloted aircraft systems in a safe and sustainable manner"*. COM (2014) 207.
- [2] European Commission. *"Flightpath 2050"*, 2011.
- [3] Ramalingam, K., Kalawsky, R. and Noonan, C. *"Integration of Unmanned Aircraft System (UAS) in Non-segregated Airspace: A Complex System of Systems Problem"*. *Systems Conference (SysCon), 2011 IEEE International*. Montreal, QC. 4-7 April 2011
- [4] International Civil Aviation Organization (ICAO), *"Manual on Remotely Piloted Aircraft Systems (RPAS)"*, March 2015.
- [5] European RPAS Steering Group. *"Roadmap for the integration of civil Remotely- Piloted Aircraft Systems into the European Aviation System. Final Report"*. 2013.
- [6] U.S. Department of Transportation, *"Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS)"*, Federal Aviation Administration (FAA). First Edition 2013.
- [7] International Civil Aviation Organization (ICAO), *"Annex 2 - Rules of the Air"*, Tenth Edition. July 2005.
- [8] International Civil Aviation Organization (ICAO), *"Circular 328 Unmanned Aircraft Systems (UAS)"*, 2011.
- [9] International Civil Aviation Organization (ICAO), *"Amendment 43 to the International Standards Rules of the Air (Annex 2)"*, March 2012.
- [10] Regulation (EC) n° 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency.
- [11] Federal Aviation Administration, FAA, *"Overview of Small UAS Notice of Proposed Rulemaking"*, February 2015.
- [12] International Civil Aviation Organization (ICAO), *"Rome Convention. Damage on third parties on surface"*, Doc. 7364. October 1952.
- [13] Guerrero Lebrón, María Jesús, *"La regulación transitoria de los operadores de aeronaves civiles pilotadas por control remoto (1)"*, LA LEY mercantil, Ed. LA LEY. 31-July-2014.
- [14] *"Riga declaration on remotely piloted aircraft (drones): framing the future of aviation"*, 6-March-2015.
- [15] European Aviation Safety Agency, *"Concept of Operations for Drones"*, EASA report. March 2015.