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EASA's "Open" Category for Military UAS: Opportunities and Limitations in the Field of Airworthiness

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Abstract: The European Aviation Safety Agency (EASA) plans to establish a sole risk-based set of regulations for drones to grant access to European airspace, thus opening a multibillion-euro market. One part of this new regulation set is the so-called "open" category, imposing only a minimum set of regulations. The EASA's approach presents a strong converse to traditional and prescriptive airworthiness regulations. For decades, unmanned aircraft systems (UAS) have been state-of-the-art assets in military forces. Aiming at the fulfilment of complex missions in extreme environments, in different theatres of operation, and with different partners, military UAS need to be reliable, safe, and interoperable. Therefore, NATO established internationally accepted airworthiness standards. However, these standards might be too severe to be adhered to by small, commercial, off-the-shelf UAS in the up-to-25 kg category, preventing the military from benefiting from the now fast-growing civil drone market. Based on a sound literature review, the paper presents the EASA's upcoming regulations for civil UAS and discusses if they are applicable to military UAS. Possible opportunities, challenges, and limitations of applying the approach for the military are shown.

Keywords: UAS; airworthiness; military; EASA; "open" category

1. Introduction

Unmanned aircraft systems (UAS), remotely piloted aircraft systems (RPAS), or just "drones" have emerged from being a purely military asset to being a sophisticated tool for professional civil applications and model aircraft enthusiasts. The range of UAS is nearly infinite regarding design and performance. Manufacturers already produce millions of UAS for the private sector, causing market prices to drop and therefore making UAS achievable for the broad public. The steady progressive development of the field of UAS, and especially in the field of small UAS, has enabled people with no experience in aviation to fly an aircraft [1,2].

Of course, every person who purchases a UAS wants to fly it, regardless of whether it was bought just for leisure purposes or for professional usage. Flying these machines requires operators and manufacturers to enter the aviation system and the related regulatory framework. The regulatory framework of the aviation system is a highly controlled system in which operational and technical aspects are regulated in every detail in order to ensure the utmost safety of all people involved. UAS are prohibited from endangering existing manned aviation, therefore, they must be integrated into the aviation system in a seamless and appropriate way [3,4].

This development was also acknowledged by the European Union (EU), and therefore, the European Commission tasked the European Aviation Safety Agency (EASA) to facilitate the integration of UAS into the European Airspace in a safe manner and in order to open the market for UAS [4,5].

One of the latest results of this task was the publication of a draft regulation for making UAS available on the EU market [6] as well as the publication of a draft regulation for operating UAS in the EU, including an Annex document which specifies the operational regulation [7,8]. In addition to the publication of these draft documents, EASA published the related Annex Acceptable Means of Compliance (AMC) and Guidance Material (GM) [9]. In contrast to traditional airworthiness codes, as for example CS-25 or CS-29 [10,11], the UAS regulation approach of EASA is operation and risk based instead of purely product based. The risk to people and property based upon the operation of UAS has been put into focus. In conclusion, one can say that the higher the risk of UAS operation, the more the competent aviation authority must be involved [6–9].

This new regulatory approach is a significant step within European aviation regulations. Up to now, UAS with a maximum take-off mass (MTOM, including fuel, batteries, payload, etc.) below 150 kg are under the authority of the Member States of the EU [12]. Obviously, putting all UAS under one regulatory framework will overcome the difficulty of different UAS airworthiness and operational regulations in the EU Member States and will greatly advance the harmonization and subsequent operations of UAS in the EU.

Harmonization is also key for interoperability within the regime of military UAS if they are used in allied operations like those of NATO. This fact was recognized by NATO years ago. Consequently, NATO has already published harmonized standards regarding airworthiness and operations of UAS (for example [13–16]). While within the military community, airworthiness standards for UAS comparable to the Certified Category of EASA are now quite common, the military community struggled and still struggles with the harmonization of UAS comparable to the "open" category which do not fulfill traditional airworthiness requirements but are already in use across military nations. To overcome this issue in Europe, the European Defence Agency (EDA) has been ordered to create a harmonized set of regulations similar to the upcoming civil regulations [17].

However, one core question remains: are the upcoming European civil UAS regulations entirely applicable to military UAS? Military UAS are operated quite differently compared to the envisaged usage of civil UAS. Moreover, it must be taken into account that the European civil UAS regulation approach is not limited to UAS operations. The approach also encompasses aspects of the UAS itself and the manufacturing industry as well as requirements of UAS pilots. Additionally, it should be considered that, for the time being, military aviation is always under the sovereignty of the individual state, unlike civil aviation in Europe, which is under the supervision of one authority. Several publications have already shown the applicability of military UAS regulations on civil UAS. However, it is not so obvious that this is also valid vice versa [18–20].

By providing sound insight into the proposed new civil regulations and comparing the different aspects of them to military unmanned aviation, the present paper discusses the core question outlined above. The discussion will show possible impacts and challenges for military unmanned aviation, if those regulations would be applied in exact the same way, and if such an approach is feasible at all. Furthermore, the possible opportunities for aligning civil and military regulations for UAS are shown.

2. The European UAS Regulation Approach

At the moment, the European UAS regulation approach consists of four central draft documents. The titles are quoted as written within the draft documents.

- "Draft Delegated Commission Regulation (EU) . . . / . . . of XXX on making available on the market of unmanned aircraft intended for use in the 'open' category and on third-country UAS operators" [6]. For the purpose of this paper, this regulation will be called "UAS Market Regulation".
- "Draft Commission Regulation laying down rules and procedures (EU) . . . / . . . of XXX for the operation of unmanned aircraft" [7]. For the purpose of this paper, this regulation will be called "UAS Operations Regulation".

- "Annex UAS operations in the 'open' and 'specific' categories [PART-UAS]" [8]. For the purpose of this paper, the annex will be called "Part UAS".
- "Draft acceptable means of compliance (AMC) and guidance material (GM) to Regulation ... / ... [IR] laying down rules and procedures for the operation of unmanned aircraft and to the Annex (Part-UAS—UAS operations in the 'open' and 'specific' categories)" [9]. For the purpose of this paper, the document will be called "UAS AMC GM".

The next subsections outline the content of each draft document. In the last subsection, a conclusive overview in relation to traditional airworthiness regulations is provided.

2.1. UAS Market Regulation

The UAS Market Regulation [6] is going to become a law of the EU. Member States have to adopt the regulation and to include it into their national laws [21]. The regulation is divided as shown in Table 1.

Table 1. Content of the UAS Market Regulation [6].

Section	Content
	Preamble
1	General Provisions
2	Obligations of economic operators
3	Conformity of the product
4	Notification of conformity assessment bodies
5	Union market surveillance, control of products entering the Union market and Union safeguard procedure
6	Third-country UAS operators
7	Final and transitional provisions
Appendix 1	Product requirements for a class C0 UAS
Appendix 2	Product requirements for a class C1 UAS
Appendix 3	Product requirements for a class C2 UAS
Appendix 4	Product requirements for a class C3 UAS
Appendix 5	Product requirements for a class C4 UAS
Appendix 6	Electronic identification system
Appendix 7	Conformity assessment Module A—Internal production control as per Annex II to Decision No 768/2008/EC
Appendix 8	Conformity assessment Modules B and C—EU-type examination and conformity to type based on internal production control as per Annex II to Decision No 768/2008/EC
Appendix 9	Conformity assessment Module H—Conformity based on full quality assurance as per Annex II to Decision No 768/2008/EC
Appendix 10	Contents of technical documentation
Appendix 11	EU declaration of conformity
Appendix 12	Simplified EU declaration of conformity

2.2. UAS Operations Regulation

Not only will the UAS Market Regulation [6] become EU law, so will the UAS Operations Regulation [7,21].

Table 2 presents the articles and content of the UAS Operations Regulation. In contrast to the UAS Market Regulation, the UAS Operations Regulation is not further divided into sections and appendices.

Table 2. Content of the UAS Operations Regulation [7].

Article	Content
	Preamble
1	Subject matter and scope
2	Definitions
3	Principles applicable to all UAS operations
4	The 'open' category of UAS operations
5	The 'specific' category of UAS operations
6	UAS operations conducted in the framework of model clubs and associations
7	Registration of UAS operators and their UA
8	Designation of the competent authority
9	Tasks of the competent authority
10	Means of compliance
11	Airspace conditions for UAS operations
12	Safety information
13	Derogations and limitations
14	Conversion of authorisations, declarations and certificates
15	Entry into force and application

2.3. Part UAS

The Part UAS [8] contains specific and detailed requirements on the UAS Operations Regulation [7]. The main content is shown in Table 3. It will become an annex to the UAS Operations Regulation and therefore a law of the EU. A similar structure with regulation and annex can be seen for example in the Implementing Regulation 748/2012 and the included annex Part 21 [22].

Table 3. Content of the Part UAS [8].

Subpart	Content
A	UAS operations in the "open" category
B	UAS operations in the "specific" category
C	Light UAS Operator Certificate (LUC)

2.4. UAS AMC GM

The UAS AMC GM [9] contains the Acceptable Means of Compliance and Guidance Material to the UAS Operations Regulation and the Part UAS [7,8]. AMC and GM are the recommended means to show compliance to the requirements in the regulation. For the sake of completeness, it is noteworthy that in contrast to regulations, which become law, the AMC and GM are not mandatory. Therefore, a UAS manufacturer might use alternative means of compliance but only if they are well justified [9,23].

2.5. Conclusion

Unlike traditional airworthiness regulations which put the aircraft, the "technical product", in focus, the upcoming UAS regulations put the UAS operation in the centre of all further considerations. However, to reduce the approach only to the UAS Operations Regulation would be a shortfall. Without the UAS Market Regulation, the Part UAS, and the UAS AMC GM, the approach would not work and would not be as comprehensive as it is now [6–9,19].

The UAS Market Regulation, the UAS Operations Regulation, Part UAS, and the UAS AMC GM take into account the special characteristics of UAS. Especially within the "open" category, this can be seen very well. However, because of the necessary interconnections between the documents, the whole set of regulations is complex. These interconnections and other details will be discussed in the next section, in which the "open" category is outlined.

3. The "Open" UAS Category

3.1. Manned versus Unmanned Aviation Safety

The technical airworthiness of manned aircraft is achieved by strict regulations on the aircraft and the design and manufacturing organisations. Technical airworthiness regulations may be either product based or performance based, but always with clear expectations of what the machine shall do and/or shall not do.

Besides an airworthy aircraft, the professional on-board human pilot and the environment in which the aircraft is operated (e.g., aerodromes, maintenance facilities, air traffic control and air navigation services, weather forecast services) must guarantee flight safety to the utmost extent. Consequently, this stringent approach primarily protects flight crews, passengers, and ground personnel but also reduces the risk to overflown third parties as far as possible [24–26].

UAS do not have a pilot on-board and do not transport crew and/or passengers yet. On the one hand, this allows a great amount of freedom in designing such vehicles, but on the other hand, it also puts the protection of third parties in the environment where the UAS is operated upfront. In contrast to manned aviation, in which a controlled environment is assumed, UAS in general, but in particular UAS of the "open" category, may be operated in any environment without an airport infrastructure or air traffic control. Furthermore, pilots of "open" category UAS do not need extensive training comparable to pilots of maned aircraft [2,24,27]. Therefore, their influence on the environment might be more intense than that of manned aircraft.

Another aspect in this context is the fact that presently available UAS of the "open" category have usually not been built against a solid airworthiness standard. Subsequently, airworthiness of such systems can hardly be verified [19]. Enforcing a strict airworthiness standard now and only allowing UAS that have been built and certified against such a standard to ensure safety to third parties would probably lead to an immense protest from the UAS industry.

Therefore, the focus change from the mainly technical product-certification-driven approach to an operation-driven approach is quite obvious. Nevertheless, this still represents a stark contrast to manned aviation, in which one key driver to achieve safe flight operations is an airworthy aircraft [24]. UAS of the "open" category are seen as a class of UAS operations that pose an acceptably low risk to the public if they are operated in accordance with the UAS Operations Regulation. Because of this fundamental assumption, UAS in the "open" category should not be put under prescriptive airworthiness regulations and procedures comparable to manned aviation [6,7].

However, if the technical product is no longer the primary driver to ensure safety, some apparent questions come up: In which way are the other interacting aspects for ensuring safe UAS flight operations taken into account? How do the upcoming UAS regulations [6–9] encompass the human pilot, the design and/or manufacturing organisation, and the environment?

Figure 1 shows the basic interaction of aspects that influence safe UAS operation. The design/production organisation with its production processes directly influences the quality of the UAS operated by the pilot. Furthermore, it influences the pilot by the quality of the associated operation manuals. The pilot can only operate a UAS safely if the UAS is of good and safe design and if he or she has the appropriate manuals and sufficient expertise. Both the UAS and the pilot affect the environment directly with their operation, especially in case UA crashes, whereas the designer/producer does this only indirectly but foremost also if the UA crashes because of bad design. The supervision and creation of regulations that enable the safe operation of UAS that are not deemed airworthy but safe enough to fly are obliged to the competent authorities, as was done by EASA and proposed in [6–9]. The entire regulation approach can be summarized into four central requirement aspects:

- UAS operation requirements
- Requirements of the remote pilot
- Requirements of the product
- Requirements of the organisations

Together, these aspects guarantee safe UAS operations in the "open" and "specific" categories. All four central aspects are highlighted in the next subsections, with the focus on the "open" category because of the scope the present paper.

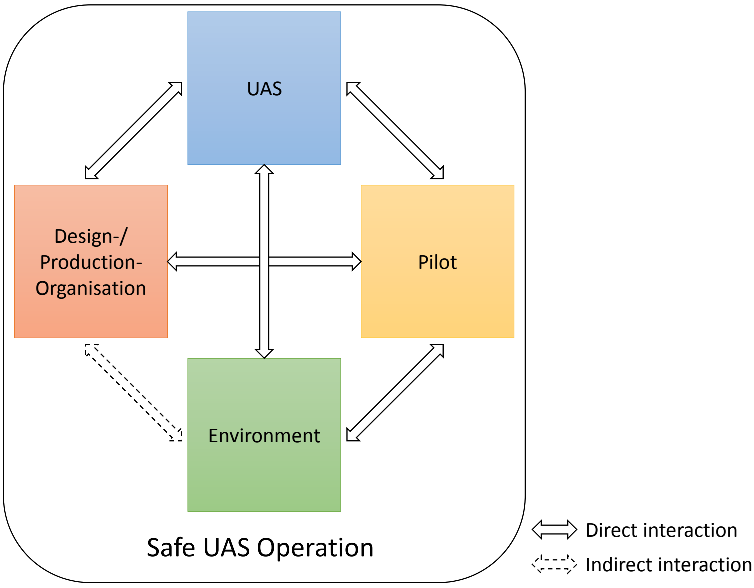

Figure 1. Aspects and their interactions affecting safe UAS operation.

3.2. UAS Operation Requirements

The core of the regulation approach is the allowed UAS operations, which are recorded in the UAS Operation Regulation [7] and the Part UAS [8]. These two documents are accompanied by the UAS AMC GM [9], providing guidance and AMC (cf. Section 2.4).

It is proposed by the regulation approach that there are three types of operation: A1, A2, and A3. All operations have the aim to reduce the risk for third parties to the greatest extent possible. Because of this aim and because the "open" category is made especially for UAS which are not airworthy (cf. Section 3.1), the operational limitations are very strict. The fundamental requirements on all three types of operation are [7]:

- All UAS operations must be conducted in the visual line of sight (VLOS) of the remote pilot. VLOS is defined as an entire unaided and unhindered view on the UA by the remote pilot.
- The UA shall not fly higher than 120 m above the ground, except in close proximity to a fixed object that is higher than 120 m. In this case, the height may be increased up to 50 m above this object.

These two general limitations are intended to protect other airspace users as well as persons or property on the ground. Besides these general limitations, the operational requirements can be categorized into three further groups:

- Protection of people on the ground
- Required pilot competence
- Required UAS class

In fact, the UAS operation requirements of [7,8] encompass all the central aspects that were outlined in general in Section 3.1 and Figure 1, which affect safe UAS operation. This makes it obvious why the UAS regulation approach of EASA cannot be reduced only to operational limitations. The requirements of each group are summarized in Sections 3.2.1–3.2.3.

3.2.1. Protection of People on the Ground

Regarding protection of people on the ground, the distinctions between the three types of operation are presented in Table 4.

Table 4. Protection of people on the ground [8].

Operation	Requirement
A1	The UA shall not be flown over an open-air assembly of persons (UAS.OPEN.020).
A2	The UA shall not be flown over and only in a safe distance to uninvolved persons (UAS.OPEN.030).
A3	The UA shall only be flown above an area where it can be reasonably expected that during the entire operation no uninvolved person will be endangered. A safe distance to congested areas must be maintained (UAS.OPEN.040).

Looking at Table 4 and at the general limitations makes it obvious that, in fact, only three operational requirements must be fulfilled by an operator who wants to conduct a UAS mission in the "open" category. Although these few requirements per type of operation seem to be clear at first sight, they leave room for interpretation. For example, is it allowed to fly a UA over individual persons in an A1 operation, or what are uninvolved persons with respect to A2 and A3 operations? Such questions can be clarified by the UAS AMC GM [9].

To discuss every single AMC in detail would be out of scope this paper. Therefore, three core aspects will be discussed:

- Open-air assembly of persons vs. individual persons
- Uninvolved persons
- Safe distance

EASA states within the AMC to the requirement UAS.OPEN.020 that the overflight of individual persons is allowed, and also that the overflight of groups is allowed. However, this should be minimized, and the UA should not fly less than 3 m above ground level. This is remarkable if one takes into account that the "open" category encompasses UA with MTOM up to 25 kg, which could kill people if it crashes on them [28]. Nonetheless, such an interpretation is not correct, as is shown in Sections 3.2.3 and 3.3.

With respect to "uninvolved persons", only guidance is provided and no AMC is provided by the UAS AMC GM because of the vast possibilities for the definition of "uninvolved persons" [9]. In conclusion, the GM to UAS.OPEN030 and UAS.OPEN.040 defines "uninvolved person" as a person who does not occur especially for the UAS operation. An "involved person" is defined as "someone who can reasonably be expected to follow directions and safety precautions given by the person controlling the operation" (GM1 UAS.OPEN.030(1) and UAS.OPEN.040(1) [9]). This definition excludes, for example, spectators who are watching a car race which is filmed by a camera drone. To become an "involved person", the UAS operator should ask each person for an overflight permission. This guidance regarding "uninvolved person" is of special interest for military UAS operations and will be discussed in Section 4.

Regarding the required "safe distance" for A2 and A3 operations, the UAS AMC GM makes the clear statement that this distance is highly dependent upon the design of the UAS. In case of doubt, the remote pilot has the full responsibility to ensure that a distance is kept which avoids hitting uninvolved persons by a crashing UA. Nevertheless, it is suggested that during an operation, a horizontal distance equal to the altitude of the UA above ground should be maintained. As minima, the AMC defines 5 m for UA capable of limiting the speed down to 3 m/s, including balloons and airships, and 50 m for all other cases (AMC1 UAS.OPEN.30(2) [9]). For example, a fixed-wing UA that flies 100 m above the ground must maintain a safe distance of 50 m to uninvolved people on the ground, but it should maintain 100 m distance to uninvolved people on the ground.

The brief outline on the "safe distance" showed again an important factor in order to ensure safe operation—the human pilot in the loop, who must guarantee the protection of the people on the ground affected by the UAS operation. This brings up the question, what are the necessary requirements of the remote pilot? The will be analysed in the next subsection.

3.2.2. Required Pilot Competence

It is stated in [7] that, besides the operator of the UAS ensuring the safety of the UAS operation, it is the remote pilot's mandatory duty to conduct every flight of a UA in such a UAS operation safely. As can be seen in Table 5, the required pilot competence is again dependent upon the UAS operation, but there is already dependency to the design of the UA with respect to the MTOM in the A1 operation.

Table 5. Required pilot competence [8].

Operation	Requirement
A1	UA MTOM < 0.25 kg: UAS familiarization is sufficient (UAS.OPEN.020(3)(a)). UA MTOM ≥ 0.25 kg: Remote pilot competence must be demonstrated via an online training and online test in a format to be defined by EASA, provided by an entity, recognized by the competent authority (UAS.OPEN.020(3)(b)).
A2	Remote pilot competence must be shown by obtaining a certificate of remote pilot competency, by passing a theoretical test to be defined by EASA at an entity recognized by the competent authority (UAS.OPEN.030(3)).
A3	Remote pilot competence must be demonstrated via an online training and online test in a format to be defined by EASA, provided by an entity, recognized by the competent authority (UAS.OPEN.040(2)).

Table 5 shows that the required remote pilot competencies range from a simple familiarization up to a course including an examination. More details can be found in the related AMC to UAS.OPEN.020(3)(b), UAS.OPEN.030(3), UAS.OPEN.040(2), and GM to UAS.OPEN.030(2).

In conclusion, it is envisaged that the remote pilot who conducts A1 operations with a UA that has an MTOM ≥ 0.25 kg or who conducts A3 operations must demonstrate adequate knowledge in the following fields (AMC1 UAS.OPEN.020(3)(b) and UAS.OPEN.040(2) [9]):

- Responsible behaviour, safety measures, basic knowledge of dangerous goods
- Maintaining VLOS, safe distance, and height above the ground
- Awareness regarding recognizing assemblies of persons and air traffic encounters
- Consciousness regarding the environment where the UAS operation takes place, including operational conditions, low airspace structure, prohibited areas, etc. of the Member State
- Profound knowledge of emergency procedures and the UAS operational manual
- Background knowledge with respect to types of UAS operations, related restrictions, as well as privacy and security risks.

The demonstration of these points shall be verified by the competent authority in accordance with specifications to be set up by EASA. In contrast to this, for an A1 operation with a UA of less than 0.25 kg MTOM, self-study of the UAS and the instructions is seen as appropriate because of the very low risk of such an operation.

Regarding the A2 operation, which poses a higher risk because it is possible to fly above involved persons, it is foreseen that the pilot must prove a deeper knowledge of the points mentioned above plus sufficient flying practice in order to obtain the certificate of remote pilot competency (AMC1 UAS.OPEN.030(3) [9]).

After this quick look at the required pilot competencies, the "required UAS" will be discussed. This completes all aspects that affect safe UAS operation with respect to the UAS Operations Regulation [7].

3.2.3. Required UAS Class

As it has already been seen in the section before, the "open" category includes more than one generic class of UAS. In fact, the UAS Operations Regulation defines five classes of UAS and aligns them to the three types of operation. One could say that, with a specific class of UAS, only certain operations are allowed. In particular, specific equipment which must be part of the UAS is also required to conduct an operation. Table 6 presents the allocation of operation type to UAS class in accordance with [7].

The technical requirements of each class of UAS are discussed in Section 3.3 because they are not as extensive as traditional airworthiness codices, although they do require a more detailed review.

Table 6. Required UAS [8].

Operation	Requirement
A1	C0 UAS C1 UAS with active electronic identification and updated geo-awareness systemsPrivately build UA < 0.25 kg MTOM (UAS.OPEN.020)
A2	C2 UAS with active electronic identification and updated geo-awareness systems (UAS.OPEN.030)
A3	C2 UAS with active electronic identification and updated geo-awareness systems C3 UAS with active electronic identification and updated geo-awareness systems C4 UAS Privately build UA < 25 kg MTOM (UAS.OPEN.040)

To summarize the section on UAS operation requirements, the Table 7 provides three theoretical examples for UAS applications and the related operations allowed.

Table 7. Theoretical examples for UAS operations.

Application	Environment	Operation	UAS Class	Remarks
Movie shoot	Old city town	A1	C0, C1	The area where the movie shoot takes places is cordoned off. Uninvolved persons cannot enter the area. An A3 operation is not possible because the requirement to maintain a safe distance to congested areas cannot be fulfilled.
		A2	C2	
Cell phone tower inspection	Open field	A3	all	Only persons who are involved with the operation are in the area where the UA is flown. No congested areas are close to the operation.
Traffic analysis	Close to motorway	A2	C2	In order to not endanger the drivers, the UA is operated at a safe distance from the motorway. Privacy and data protection rights are maintained.

3.3. *Requirements of the Product*

Despite UAS in the "open" category not being subject to traditional airworthiness requirements, they still have to fulfil certain product or build requirements. This fact became quite obvious when analysing the UAS Operations Regulation [7] in detail. One could expect to find the technical requirements of the five UAS classes, shown in Tables 8–10, also in the UAS Operations Regulation or in the PART UAS, but this expectation is misleading. The five UAS classes and the technical requirements are part of the UAS Market Regulation [6]. Besides the definition of the UAS classes and the related requirements, the technical requirements for the necessary electronic identification and geo-awareness systems are also defined.

The technical requirements can be found in appendices 1–6 of the UAS Market Regulation [6]. All requirements are written in a performance-based style by clearly outlining what shall be achieved but not outlining how it shall be achieved [29].

Furthermore, the requirements can be split roughly into the following groups:

- Physical characteristics
- Functional characteristics
- Documentation and marking

The number of technical requirements between the UAS classes differs. This variation can be related to the resulting risk of operation combined with UAS class:

- C0—11 Requirements
- C1—20 Requirements
- C2—21 Requirements
- C3—16 Requirements
- C4—6 Requirements

Even though the number of requirements varies among the five UAS classes, many requirements are identical or almost identical. To get an overview and to compare the requirements of the five classes directly, excerpts have been taken from appendices 1–5 of [6] and are summarized in Tables 8–10.

Table 8. UAS physical characteristics requirements excerpt [6].

UAS Physical Requirement	C0	C1	C2	C3	C4
MTOM (kg)	<0.25	<0.9	<4	<25	<25
Impact Energy (J)	-	<80	-	-	-
v_{Max} (m/s)	≤19	≤19	-	-	-
Voltage (V)	≤24	≤24	≤48	≤48	-
Sound pressure (dB(A))	-	<60	<60	-	-

Table 9. UAS functional characteristics requirements excerpt [6].

UAS Functional Requirement	C0	C1	C2	C3	C4
Safely controllable	X	X	X	X	-
Safe flight design	X	X	X	X	X
Safe work design	-	X	X	X	-
Attainable height	X	X	X	X	-
C2Link loss procedure	-	X	X	X	-
Electronic identification system	-	X	X	X	-
Geo-awareness system	-	X	X	X	-

Table 10. UAS documentation and marking requirements excerpt [6].

UAS Documentation Requirement	C0	C1	C2	C3	C4
Manual	X	X	X	X	X
Class identification label	X	X	X	X	X
Serial number on UA	-	X	X	X	-

A sound description on the origin and development of the five UAS classes can be found in [4,30–34]. The present paper takes the classes as given and highlights only some noteworthy aspects.

As can be seen in Table 8, despite the fact that the UAS regulation approach focuses on the operation, the first denominator in the appendices to differentiate the UA classes is the MTOM. A urther primary parameter is the allowed speed. By limiting C0 and C1 UAS to these low masses and respectively low velocities, the risk to people overflown is reduced immensely. In contrast to this, the C2, C3, and C4 classes do not have limitations regarding velocity. The resulting higher risk is mitigated by very prescriptive operational requirements of A3.

The C2 class has no speed limit but does have an MTOM of 4 kg. Such a UA may fly above involved persons and at a safe distance from uninvolved persons in accordance with an A2 type of operation. Therefore, the C2 class includes the most requirements, and a certified remote pilot is required for an operation in order to compensate the resulting highest risk throughout all combinations of UAS and types of operation [4].

With respect to functional, documentation, and marking requirements, the C1, C2, and C3 classes are obliged to fulfil the same requirements entirely. Furthermore, all UAS classes fall under the essential functional requirement of “safe flight design”—the UAS must be designed and produced to fly safely. Additionally, fundamental requirements, such as the “safe work design” (a UAS obliged to this requirement can be operated safely if the user follows the instructions) or mandatory lost link procedures, reduce the operational risk by technical requirements [6].

One question might arise with respect to the C4 class, which is treated hereafter. The C4 class has, at first sight, the fewest technical requirements but the same freedom regarding MTOM and velocity as the C3 class. The resolution can be found in one unique technical requirement to this class. For C4, no automatic control modes are allowed [6]. Thus, this class must be seen as a model aircraft and not as a UAS in the common sense.

Even if the technical requirements of [6] are basically not treated as “traditional” prescriptive UAS airworthiness requirements, they ensure a high level of safety. In addition to this, similar technical requirements, for example, on the safety and correct functioning of the UAS on lost link loss procedures, or also on the controllability of the UAS can also be found in common UAS airworthiness standards (e.g., [13]).

Nevertheless, the technical requirements laid down in [6] grant a great amount of flexibility to the designers, manufacturers, distributors, or in other words, the economic operators. Consequently, the question arises of how these organisations, e.g., the economic operators, will be controlled and which processes will be applied. These significant points are the content of the next section.

3.4. Requirements on Organisations

It has been shown that the combination and interconnection of the driving aspects to ensure safe UAS operations can grant a sufficient level of safety. Therefore, it is not necessary to put UAS of the ”open” category under prescriptive airworthiness requirements. It also allows much flexibility and freedom for the design and/or manufacturing organisations, e.g., the economic operators, because the processes for designing and manufacturing to be applied are not as strict as those in civil manned aviation [22].

However, there are also requirements for the economic operators and their processes in order to ensure that the requirements to grant safe UAS operations in the “open” category can be achieved. They are laid down in UAS Market Regulation [6] and are subdivided into requirements for the manufacturers, importers, and distributors. It can be said that this division will ensure that the UAS to be sold on the European market will comply with the requirements laid down in the market regulation throughout the entire economic chain.

At first, the manufacturer must ensure that the appropriate product complies with the applicable technical requirements and have in place appropriate procedures to prove this (Article 5, [6]).

Second, the importer must take all necessary actions to ensure that the imported product complies with the market regulation (Article 7 [6]). In fact, the importer verifies that the manufacturer has built the product in the right way.

Third, the distributor must recheck again that the UAS obtained from the importer still is in conformity with the market regulation (Article 8 [6]).

This chain of control is obviously dependent upon how many bodies are involved in the distribution of a UAS. There must not always be the chain manufacturer–importer–distributor. It is reasonably possible that all three entities are encompassed in one company.

Besides this interdependent quality assurance between the different industrial actors, the market regulation foresees a mandatory conformity assessment of the manufacturer by so-called notified authorities and notified bodies to ensure the conformity of the UAS to the regulations already at the production origin in order to guarantee independent quality assurance (preamble, (11), [6]).

Notified authorities shall be designated by each Member State. Notified authorities are obliged to be independent but must not be a governmental body. It is also possible that the Member States designate a national accreditation body (Articles 18 and 19, [6]).

The notified authorities will entitle competent bodies as so-called "notified bodies" after a successful assessment of them with respect to the relevant requirements (Article 21, [6]). Further on, notified authorities shall monitor the notified bodies (Article 18, [6]). The main task of notified bodies is to perform the conformity assessment of the manufacturer regarding the product. If the notified body finds that a manufacturer's product is produced in conformity with the UAS Market Regulation, an EU-type examination will be issued to the manufacturer for the specific product. The individual products shall be built identical to this type. The manufacturer shall document that the product fulfils the applicable requirements in the EU declaration of conformity.

The responsible notified authority must inform the European Commission and the other Member States about the notified bodies, who may raise an objection against the notification (Article 25, [6]). A noteworthy aspect within the system of notified authority and notified body is the fact that both may subcontract other entities to perform the assessment task, although the responsibility remains with the notified authority/body (Articles 18 and 23, [6]). Figure 2 shows the interaction and related articles of the UAS Market Regulation between the European Commission, Member States, notifying authority, notified body, and manufacturer.

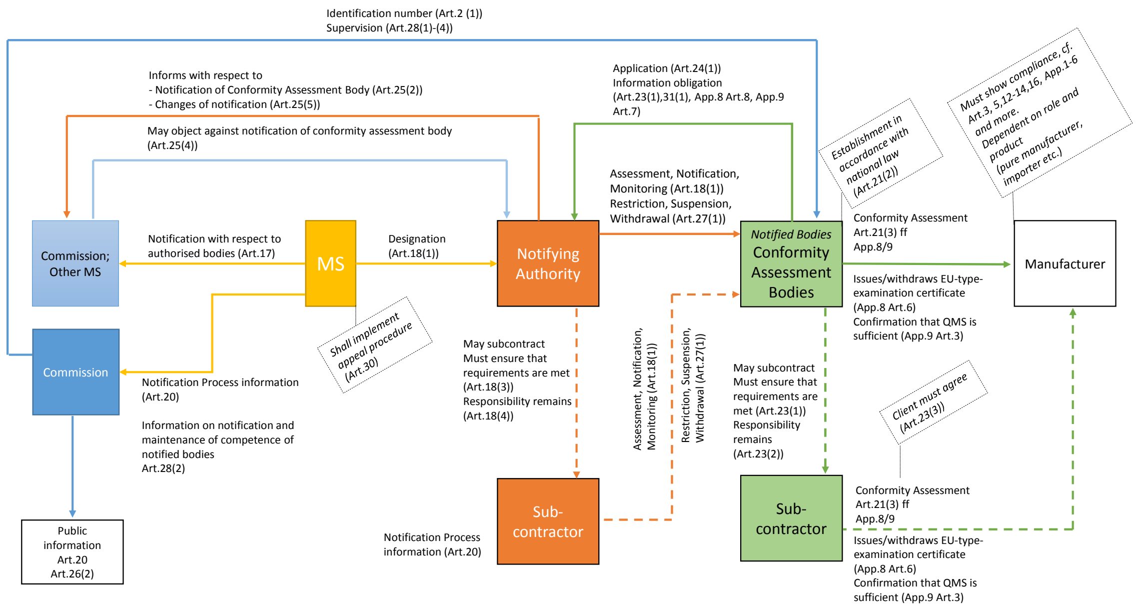

Figure 2. Interaction between stakeholders in accordance with the UAS Market Regulation [6].

At the moment, it cannot be said if the proposed system to control the economic operators in order to ensure the safety of UAS products will work as expected. The designation of the first notified bodies is especially crucial. A pure "industry controls industry" situation without any governmental oversight and control should be avoided.

4. Applicability of the "Open" UAS Category to Military UAS Operations

The proposed regulatory framework for civil UAS operations of the "open" category seems to be very promising and has the potential to ease the usage of UAS in Europe immensely. If the regulations come into force as suggested by EASA, harmonization of UAS operations in Europe would be significantly advanced.

As stated in Section 1, harmonization across military forces is one essential factor. Therefore, it is very reasonable to discuss if such an approach would also be feasible for military forces. Before reviewing military UAS operations itself and if they could be compared, the paper briefly outlines some key differences between civil and military regulations in the field of aviation and airworthiness.

4.1. Civil vs. Military Aviation

While civil aviation is organized under the leadership of EASA as the focal point, the military aviation community in Europe does not have a single focal point. Furthermore, military aviation is usually excluded from the fundamental civil aviation agreements and laws, as for example, in the Chicago Convention of the International Civil Aviation Organization (Article 3, [35]) or the Basic Regulation of EASA (Article 2, [12]). In addition to this, military aircraft always need a special permit to fly into a foreign airspace by the state which has sovereignty over that airspace (Article 3, [35]).

Military aviation always has to achieve a balance between safety and mission accomplishment. This is related to the fact that since military aircraft are intended to fly over enemy territory in hostile airspaces, they carry weapons or operate from airfields with no infrastructure. In summary, military aircraft must be as reliable as possible in the worst environmental conditions. Taking these aspects into account, it becomes quite clear that airworthiness certification for military aircraft cannot work in the same manner as civil airworthiness does.

Furthermore, because military aircraft may carry weapons, electronic warfare items, or similar equipment, as well as the fact that these aircraft usually represent the cutting edge of aviation technology, they will probably always remain under the sovereignty of a state. Consequently, airworthiness certification bases are driven usually by the design usage spectrum of the military aircraft and therefore might differ greatly among the states of a military alliance, e.g., NATO. With respect to the above mentioned Article 3 of the Chicago Convention, this might cause many obstacles, especially within the field of UAS in which almost no limitations regarding design exist because of the absence of a human on-board [17,18,36].

In order to overcome these issues and to enable harmonization in the field of military aviation on a broad, international basis, both NATO and EDA have launched several groups, for example, the NATO Flight In Non-Segregated Air Space Group (FINAS) for UAS, the NATO Aviation Committee for or at the EDA, and the so-called Military Airworthiness Authorities Forum (MAWA) for any kind of military aviation among the allies [37–39].

Today, the working groups have made several steps forward. For example, NATO was able to publish and establish harmonized airworthiness standards for UAS several years ago and continues to develop them further [13–15]. MAWA on the European side published the European Military Airworthiness Requirements 21 (EMAR 21) [40], which represents a military version of the civil Part 21 [22]. However, the latest developments have shown that those standards probably are too prescriptive for small military UAS comparable to the new civil UAS classes [17,41].

As it was outlined, the civil European regulatory approach encompasses all aspects that affect the safe operation of UAS. To ensure that this principle is kept, the military community would have to apply the same principles. The next subsections take the four areas outlined in the Sections 3.2, 3.2.2, 3.3, and 3.4 and apply them to the military context.

4.2. Military UAS Operation Requirements

One of the biggest obstacles is probably the fact that military UAS operations cannot be limited to VLOS. For example, the UAS "ALADIN" of the German Army could be classified as C2 UAS with respect to the MTOM of 3.5 kg. However, the usage quite differs: ALADIN is capable of flying up to 5 km away from the remote pilot at heights up to 150 m. Such a usage is obviously not in accordance with VLOS as defined by [7]. While in military controlled airspaces this is not an issue, it would not be applicable in the regime of the new civil UAS regulations. ALADIN would automatically fall into the "specific" category, making the advantages of the "open" category obsolete [42,43].

Similar issues would probably arise if the UAS Operations Regulation were applied on the small UAS program of the German Navy. The German Navy intends to purchase several UAS of the type "PUMA AE II". The UA will be flown by the Special Forces of the German Navy at day and night. Even if this UAS is in conformity with the comparable C3 UAS class, the capability of flying up to 20 km in relation to the tasks of the Special Forces, for example, obtaining intelligence or observe critical evacuations, rejects the application of any of the three types of operation [44,45].

These have been only two examples of military UAS usage. Reality shows that military UAS operations are always of a complex nature, including gathering intelligence, reconnaissance, and surveillance of targets, in all kinds of environments. This also makes flying over individual persons or assemblies indispensable. Persons who are the target of such military UAS missions can probably not be counted as involved persons because they obviously will not be asked for an overflight permission. Furthermore, military forces need to take advantage of the entire capabilities of the UAS regarding range and endurance in particular [27].

4.3. Competence of Military Remote Pilots

Military remote pilots are required to obtain an adequate licence. This might range from remote operator certificates for small UAS up to a pilot licence if manned aviation is necessary. Furthermore, military remote pilots are required to obtain a sufficient amount of flight hours per year in order to keep their licence. An example of a national military authority that has the responsibility of oversight regarding military remote pilot licences is the German Military Aviation Authority (GMAA).

To have well-trained remote pilots is also one goal of NATO. Thus, it is not surprising that NATO has also published a standard with respect to the training of UAS operators [16,46,47].

4.4. Military Requirements of the Product

The aspect "requirements on the product" does not need to be discussed in detail, because as written in the abstract as well as in the introduction, the military UAS community does not have a similar set of requirements for UAS as those foreseen by EASA for the "open" category and the related UAS classes [6,7].

4.5. Requirements of Military Forces for Organisations

National military forces might put requirements on the qualification of the contracting companies. In Europe, for example, this could be EMAR 21. However, at the moment, this also falls under the responsibility of the competent national military authorities. Furthermore, because there is not a military EASA, the national MAAs must recognize each other as competent authorities. This process is slowly on its way, but there is no guarantee that if, for example, the Spanish MAA certifies a company in accordance with EMAR 21, that this company would get the same privileges from the MAA of France. A comparable system of notified authorities, notified bodies, and economic operators, as shown in Figure 2, is not available in the military communities yet [40,48].

5. Results and Discussion

Applying the four key areas—UAS operation requirements, requirements for the remote pilot, requirements for the product, requirements for the organisations—has resulted in the major finding that a complete application of EASA's UAS regulation approach on military UAS is not seen as feasible. In order to be consistent with EASA's regulation approach, the same strict operational limitations must be applied also on military UAS operations. It is quite questionable if such restricted operations would enable military forces to reach their mission aims, in particular, for missions abroad or missions of

Special Forces. Nevertheless, there might be areas where it would be sufficient to perform a military operation in accordance with the civil operational regulations. For example, in training operations in the home country.

Furthermore, it cannot be said that the military community would be able to introduce an international system with respect to the oversight and control of designers, manufactures, etc. as it was described in Section 3.4. It is quite doubtful that the European nations would, for example, establish a military EASA with the power to enact standards, etc. as one single point because this would mean giving up national sovereignty over military aviation.

Regarding the competence of military remote pilots, it can reasonably be said that military remote pilots have a very high level of competence. Based on experience in flying all types of UAS, defined standards and procedures for the training of remote pilots, and the continuing growth of both of these aspects in the military UAS community, one could also say that the military remote pilots are far in advance of the civil world regarding professionalism.

Finally, with respect to the requirements of UAS products, there are already common standards in the field of airworthiness. In the context of airworthiness standards for UAS that receive a type certificate and the related certificates for airworthiness, the community of military aviation authorities was able to create mutually accepted standards. Having this in mind, this community should also be able to create a set of technical requirements for UAS that are in a similar range as the civil C0–C4 UAS classes are. While the requirements could become slightly more prescriptive because of the more complex and risky military operations, it should be feasible to create such a harmonized set of adequate technical requirements that provide enough product safety. In this context, it is worth considering if risk assessment tools for UAS operations could be included in a beneficial way. This topic will be discussed in an upcoming paper by the corresponding author.

In conclusion, if military aviation authorities would generate a UAS standard that carefully takes into account the proposed civil UAS regulation framework as well as the given facts regarding experience and professionalism of military UAS operators and pilots, such a standard would probably ensure an equivalent level of safety as the proposed civil European regulations for UAS.

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