

State-of-the-art of mass-market drones standards

D3.2

AW-Drones

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AW-Drones

Abstract

This document summarizes the data collection and structuring work that was performed as a part of work package 3 of the AW-Drones project. The purpose for the data collection effort and the overall approach is presented. Furthermore, the structure of the data collection document and its content relating to drone standards is explained. It will give an overview of what kind of data is being collected, how the data is categorized and how it is mapped to the ongoing regulatory process for UAS. This document concludes with an outlook to the further work of the project on the state of the art of standards documents.

The initial version of this document (D3.1) presented the first data collection and a 'mapping' of the standards to airworthiness requirements. This 2nd iteration of the document describes the updated status of the data collection, including the feedback of assessment data and the approach to include U-Space requirements.



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1. Introduction

The lack of clear standards is holding back the development of drone-related business, both at a global level and in Europe. Several studies and surveys identify a reliable regulatory and standardization framework as one of the main potential boosters for the drone business. Therefore, to foster the growth of a safe drone usage, there is a need to implement coherent and interoperable global standards and regulations for drones in the EU. The European Union's Horizon 2020 Research and Innovation Program funded AW-Drones to tackle these issues and guide future EU drone regulation.

AW-Drones contributes to harmonize the EU drone regulation and standards, supporting the rulemaking process for the definition of rules, technical standards and procedures for civilian drones to enable safe, environmentally sound and reliable operations in the European Union. In order to achieve this, one of the sub-goals of the project, is to propose and validate a well-reasoned set of technical standards for operations, appropriate for all relevant categories of drones.

A work plan has been formulated to collect and assess existing and planned standards. The effort is split into three work packages (WP):

- WP2 - Development of a methodology for categorization and assessment
- WP3 - Collection and categorization of standards that might be applicable for UAS
- WP4 - Assessment of these standards to evaluate their feasibility to support this process in order to derive a set of standards that are validated and found applicable

This deliverable will give an overview about the second aforementioned point (WP3). It refers directly to a document called 'Collection of UAS standards' which contains the actual data and will be explained in the next section.

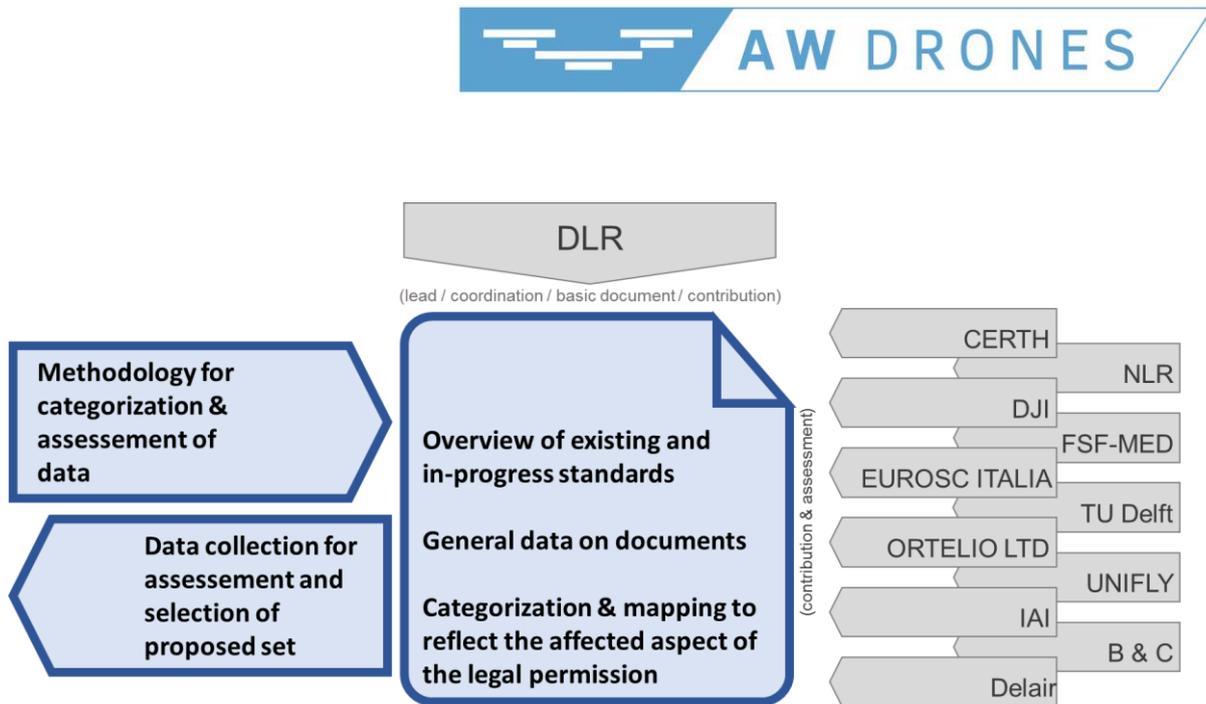


Figure 1-1: data collection input and involved partners

The figure above gives an overview about how the data collection work is linked to other parts of the project. The work package is led by DLR with strong contributions by all partners. They provided:

- Expertise and background knowledge on collecting UAS related standards
- Support on the categorization and assessment of the standards

During the project kick-off meeting it was discussed and decided that the focal point of the project should be to support the ongoing process in EU and EASA as best as possible [1]. It was agreed that the data collection should have a high bandwidth and especially cover specific category drones as this class of drones is applicable to many use-cases. The regulatory process is ongoing and there should be numerous standards which might be applicable to act as an Acceptable Means of Compliance (AMC) in the later process.

As the JARUS Specific Operations Risk Assessment (SORA) process is now adapted into a regulatory framework with ED2019/947 [2] it was decided [1] that the categorization shall be made in accordance with the SORA process with focus on the Specific category up to SAIL 4 for the first iteration of the data collection. More specifically, the standards shall be linked to the OSOs and ground/air risk mitigations that are proposed by SORA. This will be a first step for the assessment of a standard as a possible AMC to this OSO/mitigation and the input to WP 4. Furthermore from the number and general data of the standards a first impression of gaps will be visible.

For its second iteration the document and the relation to U-Space it was decided to refer to the recently published EASA opinion on U-Space structure [11] and its appendixes [12]. As the progress of defining the U-Space structure is still ongoing the requirements given are high level requirements and may not be appropriate for the assessment of the standards. However for the mapping of standards to the relevant requirements / topics this input may be used. The identified requirements are described in section 4.

The starting point for the collection of data shall be the EUSCG Rolling Development Plan [6] as stated in the Grant Agreement [4] and in the KOM [1]. It provides an overview of a large number of UAS standards related to UAS. However this source will be complemented with other data, e.g. ANSI





roadmap and own literature studies. There is special importance placed on the collection of UAS related standards from ANSI [7] and ASTM [8], as they cover a huge amount of documents and are obviously very much complete about the standards by these Standards Design Organizations (SDOs). From the first to the second iteration of the document the data was updated from the SDOs databases for all documents (04/2020). Additionally documents derived from the two EASA workshops and the workshops at EUROCONTROL were added.



2. Collection of UAS standards

The format of the data collection of UAS standards is an Excel file that contains the standards line wise. The format was chosen as it provides the most flexibility between functionality (e.g. filtering) and a format that can be edited by all partners.

The header of the file contains several sections that are presented in the schematic below. It contains four sections.

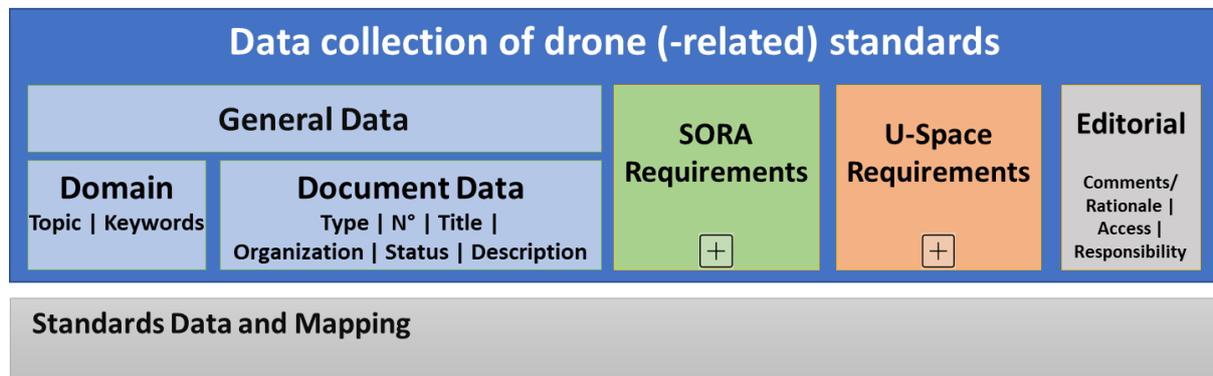


Figure 2-1: Header of Data Collection Document

The first section 'General Data' (blue) contains general data on the document, such as document reference number, responsible SDO and title. Also a short description is included here, if there is any abstract or similar accessible. Furthermore a categorization into a domains and keyword system is made. This is helpful to 'scan' the document for standards in a specific topic, which might be a common use-case for the document. In the first iteration of the data collection a domain and subdomain system was used. From workshop input this was changed to a domain and keywords system. Each standard is assigned to the domain that is most appropriate. Each domain is associated with different keywords that represent subtopics within this domain. A standard can have up to three keywords to characterize its content. For the keyword 'systems and equipment' there are again second level keywords to further detail if necessary. The categorization structure is an input from WP 2 and part of the methodology (as described in D2.1 [9]). It is also included on the second work sheet of the data collection document and in the Annex of this document. The topics that are relevant for UAS regulation are split into domains and keywords.





The second section 'SORA Requirements' (green) contains all the OSOs and mitigations that are identified from the SORA process [10]. The details about this section are given in chapter 3.

The third section 'U-Space Requirements' (red) contain the requirements identified from EASA opinion on U-Space structure [11], [12]. The details about this section are given in chapter 4.

The last section 'Editing' (grey) contains information which is necessary to do the mapping to the SORA step. The work is distributed among the partners. The partner in charge is recognized as 'responsible' and within the columns for 'mapped it is indicated, if the mapping to SORA or U-Space requirements was performed. Each standard can be complemented with a comment or a short rationale for the mapping. Finally the assessment performed in WP4 is also marked here.

As described before, the basis for data collection is the EUSCG Rolling Development Plan. A first structure of the overview was also derived from this collection. However, the Domains were changed in a later process to the ones derived by WP2.1 Methodology and later updated to the keyword system established by the workshops and included in WP2 updated. The additional data sources are explained above.

The first iteration of the data collection table contained one more section to divide the standards into applicable drone categories open, specific, certified as accepted by EASA with 2019/945 [3] and 2019/947 [2]. As this was found to be redundant with information from SORA requirements and not relevant for U-Space requirements it was removed for the second iteration.

3. Mapping to SORA requirements

As mentioned in the previous chapter the second section of the header represents the Operational Safety Objectives and Mitigations for Ground and Air Risk that are addressed from the current version 2.0 of SORA. A schematic with a detailed view on the subsections of the SORA requirements is shown in Figure 3-1.

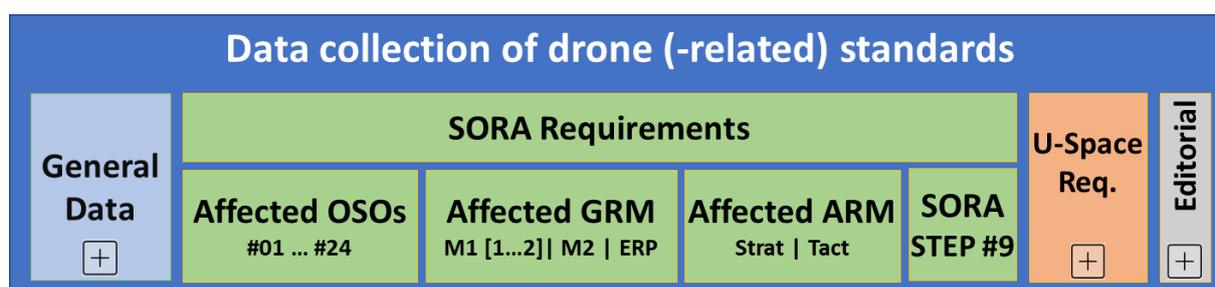


Figure 3-1: Header of data collection with detailed SORA requirements

The OSOs included in the header are shown in Table 1.

Table 1: Operational Safety Objectives considered from JARUS SORA process

Technical OSOs	#01	Ensure the operator is competent and/or proven
	#02	UAS manufactured by competent and/or proven entity
	#03	UAS maintained by competent and/or proven entity
	#04	UAS developed to authority recognized design standards
	#05	UAS is designed considering system safety and reliability
	#06	C3 link characteristics (e.g. performance, spectrum use) are appropriate for the operation
	#07	Inspection of the UAS (product inspection) to ensure consistency to the ConOps
Operational	#08	Operational procedures are defined, validated and adhered to (to address technical issues with the UAS)
	#11	Procedures are in-place to handle the deterioration of external systems supporting UAS operation
	#14	Operational procedures are defined, validated and adhered to (to address human errors)
	#21	Operational procedures are defined, validated and adhered to (to address Adverse Operating Conditions)
Remote crew	#09	Remote crew trained and current and able to control the abnormal

training		and emergency situations (i.e. Technical issue with the UAS)
	#15	Remote crew trained and current and able to control the abnormal and emergency situations (i.e. Human Error)
	#22	The remote crew is trained to identify critical environmental conditions and to avoid them
Safe design	#10	Safe recovery from technical issue
	#12	The UAS is designed to manage the deterioration of external systems supporting UAS operation
Deterioration of external systems supporting UAS operation	#13	External services supporting UAS operations are adequate to the operation
Human Error	#16	Multi crew coordination
	#17	Remote crew is fit to operate
	#18	Automatic protection of the flight envelope from human errors
	#19	Safe recovery from Human Error
	#20	A Human Factors evaluation has been performed and the Human-Machine Interface (HMI) found appropriate for the mission
Adverse Operating Conditions	#23	Environmental conditions for safe operations defined, measurable and adhered to
	#24	UAS designed and qualified for adverse environmental conditions (e.g. adequate sensors, DO-160 qualification)

Table 2 provides an overview about the mitigations for ground and air risk extracted from the SORA process. An additional point which is included is step N°9 from the SORA methodology. The reason for this additional point is, that step 9 must be shown by AMCs and is not represented by any of the OSOs or mitigations.

Table 2: Ground and Air Risk Mitigations considered from JARUS SORA process

Ground Risk Mitigations	M1 (Generic)	Strategic M.	M1 S#1	Definition of the ground risk buffer
			M1 S#2	Evaluation of people at risk
		Tethered operation	M1 T#1	Technical Design of tether
			M1 T#2	Procedures for tether installation & control
	M2 (Effects of ground impact)	M2 #1	Technical Design for ground impact	
		M2 #2	Procedures for equipment installation	
		M2 #3	Training for ground impact measures	
ERP	M3 #1	Emergency Response Plan		
Collision Risk (Air Risk)	Strategic Mitigation	Operational Restrictions	Boundary	Mitigations that bound the geographical volume in which the UAS operates
			Chronology	Mitigations that bound the operational time frame
			Time of Exposure	Mitigations that bound the time of exposure
	Common Structures	Common Flight Rules	Mitigations by setting a common set of rules which all airspace users must	



		and Rules		comply with
			Common Airspace Structure	Mitigations by controlling the airspace infrastructure through, physical characteristics, procedures, and techniques
	Tactical Mitigation	VLOS	VLOS	Tactical mitigation with the remaining well clear and avoiding collisions requirements
		BVLOS	Detect	Define Detection with adequate precision for the avoidance manoeuvre (ARC-a to ARC-d)
			Decide	Define Decide with adequate precision for the avoidance manoeuvre (ARC-a to ARC-d)
			Command	Define Command with adequate precision for the avoidance manoeuvre (ARC-a to ARC-d)
Execute			Define Execute with adequate precision for the avoidance manoeuvre (ARC-a to ARC-d)	
Feedback loop	Define feedback loop with adequate precision for the avoidance manoeuvre (ARC-a to ARC-d)			
SORA Step #9			Containment	Containment requirements for adjacent airspace and area considered

The mapping to the SORA process is the second step after the collection of the data. It is the basis for further assessment of the standards. The mapping of the standards is distributed among the project partners and merged by DLR. For each standard a partner is in the role of the 'responsible' who does the mapping and includes a short rationale to explain the decisions. This is done on a very high level and based on available data on the documents, like abstracts/summaries, table of contents and, if available, the actual content of the standards.

After the first iteration 298 standards (approximately 47%) were mapped to the requirements.

The current status is that 524 standards (approximately 80%) of the documents are mapped.

Validation with EASA experts

The data collection work was presented to EASA experts during a two day workshop [5] during the first iteration of the document and a second workshop during the second iteration. However for the second workshop the focus was on the assessment data. The overall approach was shown during the plenary of the workshop and the data collection document was reviewed during group activities.





The structure and the approach of WP3 and WP4 were reviewed as well as feedback was given (to WP3) to the domains (resulting in the update to the presented keyword system), the completeness of the data (and standards were added) and the mapping.

4. Mapping to U-Space requirements

The second iteration of the data collection is supposed to include requirements coming from U-Space implementation and to connect the data collection to these requirements. In March 2020 EASA published its Opinion 01/2020 ‘High-level regulatory framework for the U-space’ [11] focusing on the possible architecture of U-Space and connected services. This document gives intended guidelines on a very high level and therefor only high level requirements may be identified. As Annex to this opinion a draft for the implanting regulation of U-Space structure was published following the same approach and going one step further to a ‘technical’ description. Figure 4-1 summarizes the documents used as input.

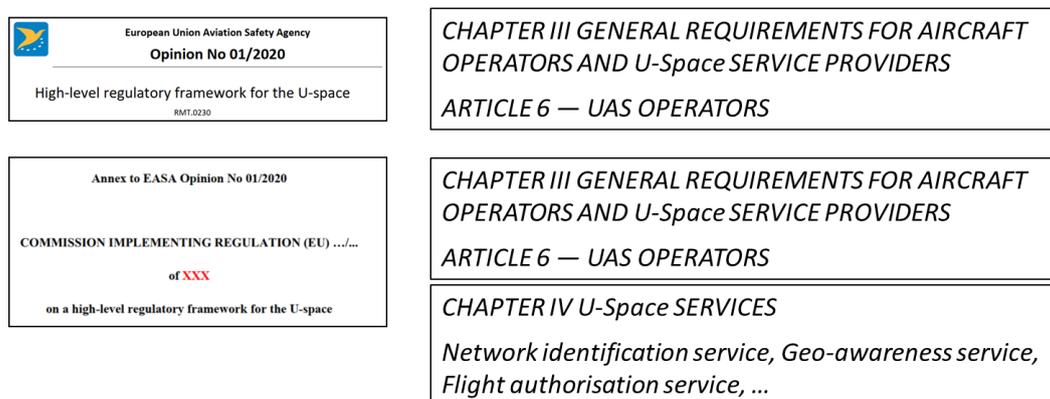


Figure 4-1: Identification of U-Space requirements

In both documents chapters can be found giving requirements towards UAS operators as well as service providers. The requirements from the Annex were found to be more topic-like and closer to technical matters and were therefor primarily considered and expanded by requirements from the opinion itself. A large part of the requirements is directly connected to the planned U-Space services and gives content that shall be related to each service. Additionally there are few high-level requirements e.g. occurrence reporting.

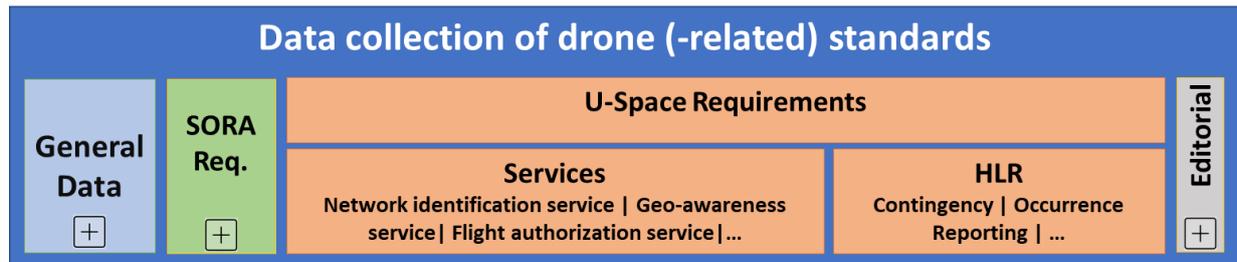


Figure 4-2: Header of data collection with detailed U-Space requirements

The requirements found for the services were grouped and, together with the high level requirements added to the data collection document. A schematic with a detailed view on the subsections of the U-Space requirements is shown in Figure 4-2.

The requirements included in the table are shown in more detail in Table 3.

Table 3: U-Space Service and General Requirements considered from EASA Opinion

U-Space Service Requirements	Network Identification Service	RemoteID, Message Publication, Traffic Information
	Geo-awareness Service	Operational Data, CIS, Airspace Information
	Flight authorisation service	Flight authorisation, Restrictions & De-confliction, Priorities
	Traffic information service	Enroute Traffic (Position, Time, Speed, Course, Status), Update Frequency
	Tracking service	Telemetry, Ground based surveillance, Reporting, Recording, Alerting
	Weather information service	Weather Information Data (Wind, Visibility, Clouds, Temp.), Forecast
	Conformance monitoring service	Conformance Monitoring, Alertion
	Common Information Service	
General U-Space Requirements	Occurrence Reporting	
	Contingency & Emergency Management	
	Communication Service	

All standards connected to the U-Space and Aerodromes domains were mapped to the identified requirements and can act as an input for a more detailed view in WP4 context.



5. Incorporation of Assessment Data

After the assessment on the standards was performed in WP4 to further study the fulfillment of SOEA requirements by the standards it was identified that it will be crucial to align the data from WP4 and WP3 and feedback the relevant information into the data collection document. It was therefore decided during project meetings, that the ‘effectiveness to fulfill SORA req.’ established in WP4 shall be included into the data collection table.

Two sheets were added into the data collection document. The header of these sheets resemble the structure for assessment details in D4.1 and include each OSO for the first sheet and each mitigation and SORA step9 for the second sheet. The data below this header are the standards with one standard per line, like in the first sheet of the table. The overall header is too large to be shown here, but Figure 5-1 shows a section containing OSO3 as an example.

OSO REQUIREMENTS P = Partial Coverage, F = Full Coverage, NS = No standard required, OS = Out of scope for SAIL up to IV				ASSESSED	OSO 03 – UAS maintained by competent and/or proven entity						
					Criterion 1			Criterion 2			Gaps/Comments
					Procedures			Training			
					L	M	H	L	M	H	
1	AS####	UAS Propulsion System Terminology	SAE E-39 Unmanned Aircraft Propulsion Committee								

Figure 5-1: Assessment data feedback to data collection

The feedback is included by all partners by entering the identified effectiveness in the table as partial, full, not required or out of scope. Additionally comments and identified gaps will be entered for each requirement. This process is currently ongoing and will be finalized in the third iteration.



6. Status and Outlook

The collection of standards and the general data has been the first step of the work done. Currently there are more than 600 standards in the document. These standards were also categorized in the domains and subtopics to allow a first structuring.

SORA requirements were identified and large parts of the data were mapped against those requirements. Additionally this approach was expanded to cover the currently available U-Space requirements based on the EASA opinion. The mapping of the standards towards these requirements is completed. It must be regarded that there are far less standards that are appropriate to be applicable to U-Space.

The ongoing work is the inclusion of the WP4 assessment data into the data collection. When this is finished the next step will be to align the mapping that was the prior step to the assessment with the assessment results.

It is not appropriate to print here all pages of the data collection document. The complete Microsoft Excel version of the file is available online at [this link](#).



7. References

- [1] AW-Drones: Kick Off Meeting, 25th – 26th January 2019, Brussels - Final minutes
- [2] EU Commission: Implementing Regulation (EU) 2019/947
- [3] EU Commission: Delegated Regulation (EU) 2019/945
- [4] AW-Drones: Grant Agreement
- [5] AW-Drones: 1st Experts Review meeting, 6th-7th June 2019 EASA HQ, Cologne - Final minutes
- [6] EUSCG (EUROCAE): European UAS Standardization Rolling Development Plan
(Available: https://www.eurocae.net/media/1514/version-10-rdp_17_02_2018.pdf)
- [7] ANSI: Standardization Roadmap – For Unmanned Aircraft Systems, Version 1.0
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- [8] ASTM: Unmanned Aircraft Systems – A comprehensive solution
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- [10] JARUS: Guidelines on Specific Operations Risk Assessment (SORA) – V2.0
- [11] EASA: Opinion No 01/2020 - High-level regulatory framework for the U-space, 13.03.2020
(Available: <https://www.easa.europa.eu/document-library/opinions/opinion-012020>)
- [12] EASA: Annex to EASA Opinion No 01/2020 - COMMISSION IMPLEMENTING REGULATION (EU) on a high-level regulatory framework for the U-space, (Available: <https://www.easa.europa.eu/document-library/opinions/opinion-012020>)



Annex

Table 4: Domains and keywords used for categorization

Domains	Keywords Level 1	Keywords Level 2		
General	Definitions			
	Classification of UAS operations			
	Classification of drones			
	Manuals			
Initial Airworthiness (at UAS level)	Flight performance			
	Limitations			
	Structures			
	Design & Construction			
	Propulsion			
	Electrical System			
	Noise & Environment			
	Level of Automation/Autonomy			
	Software Development Assurance			
	Airborne Electronic Hardware (AEH) Development Assurance			
	Remote Pilot Station			
	Systems safety assessment			
	Accident/Incident investigation			
	Systems & Equipment			Emergency capabilities & Health monitoring
				ATS Communication
				Detect and Avoid
				Navigation
				Lights
				Instruments
				Traffic surveillance (tracking)
				Command and Control (C2) Link
	Environmental qualification of Equipment (Ground and Airborne)			
Manuals				
			HMI	
		Human Factors		
		Cyber-security		



	Organization Electromagnetic Compatibility and Lightning Protection Flight Control System Fuel	
Continuing Airworthiness	Instructions for continued airworthiness Manuals Organization Human Factors UAS Maintenance personnel competence Cyber-security Maintenance & Inspection	
UAS Operations	Manuals Organization Level of Automation/Autonomy Physical Security Privacy and data protection UAS Operator C2 Link Service Provider RPS Service Provider Standard Scenarios Accident/Incident investigation Safety data collection and analysis UAS-ATM (IFR above VLL and below FL 600) Risk Assessment (Operations) Human Factors Take-off/Landing zones (urban vertiports) Marking and Registration E-Identification U-Space Service Providers Tracking Geo-awareness Cyber-security HMI	
Aerodromes	Manuals Organization Level of Automation/Autonomy Aerodrome operator Take-off/Landing zones (urban vertiports) Ground Handling Service	





U-Space/ATM	Manuals	
	Organization	
	Privacy and data protection	
	Level of Automation/Autonomy	
	C2 Link Service Provider	
	RPS Service Provider	
	Standard Scenarios	
	UAS-ATM (IFR above VLL and below FL 600)	
	Take-off/Landing zones (urban vertiports)	
	Ground Handling Service	
	Marking and Registration	
	E-Identification	
	U-Space Service Providers	
	Tracking	
	Geo-awareness	
Cyber-security		
HMI		
Environment	Aircraft Noise Emission	
	Aircraft gaseous emissions	
	Cumulative noise around vertiports	
Personnel	Manuals	
	Organization	
	Instructors	
	Examiners/Assessors	
	Training organizations	
	Human Factors	
	UAS Maintenance personnel competence	
	Remote Pilot competence	
Additional crew members competence (non-regulated professions)		
Oversight	Manuals	
	Organization	
	UAS Operator	
	C2 Link Service Provider	
	RPS Service Provider	
	U-Space Service Providers	
	Notified bodies and Qualified Entities	