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

D3.1

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.

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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 validating 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.

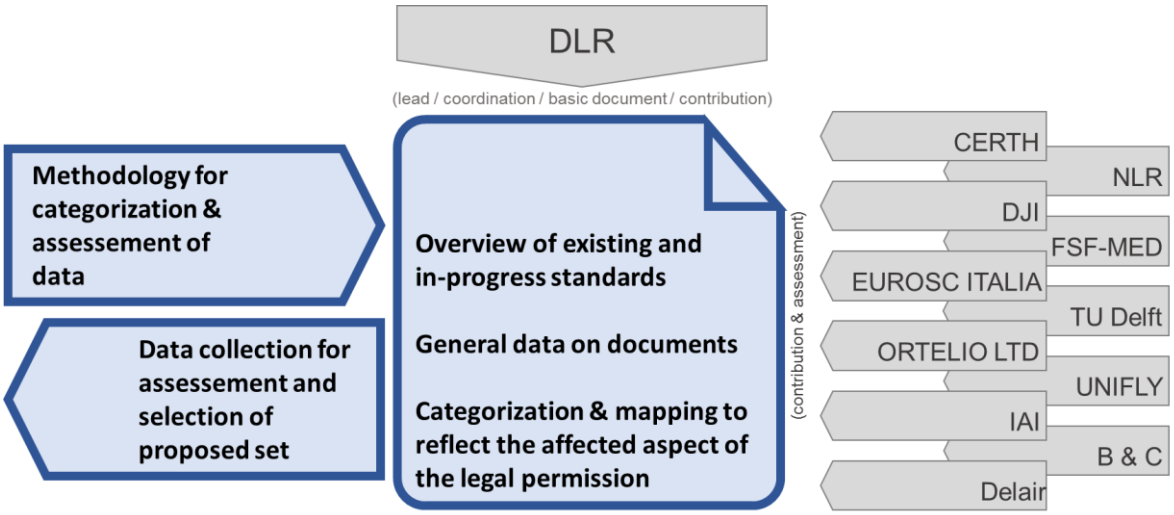

Figure 1: data collection input and involved partners

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. 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.

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).

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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.

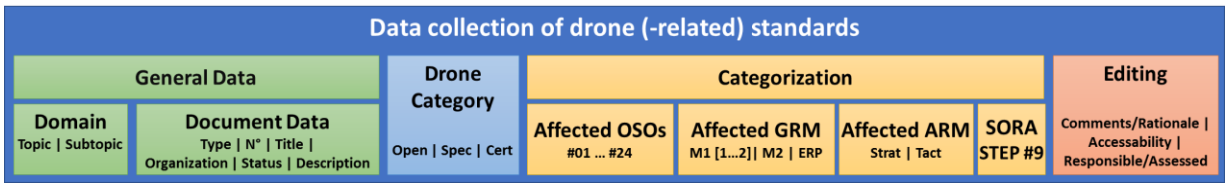

Figure 2: Header of Data Collection Document

The first section 'General Data' (green) 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. Also a categorization into domains and subtopics 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. 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 subtopics. Each of the standards is assigned to one domain and one subtopic within this domain. If the standard spans across several subtopics it is placed in a General subtopic (if possible) or classified into the most relevant subtopic.

The second section 'Drone Category' (blue) is divided into the drone categories open, specific, certified as accepted by EASA with 2019/945 [3] and 2019/947 [2]. For each category one column is included that is marked with an 'X' if the standard is applicable in general to the category of operation. The initial assumption was that each standard added to the document is applicable to all types of drone categories. During review and assessment of the standard the crosses are removed if a standard is found not applicable to certain types of operation.

The third section 'Categorization' (yellow) is handled in a similar way. It contains all the OSOs and mitigations that are identified from the SORA process [10]. The details about this section are given in the next chapter.

The last section 'Editing' (red) 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 column 'assessed' it is indicated, if the mapping was already performed. Each standard can be complemented with a comment or a short rationale for the mapping.

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. The additional data sources are explained above.

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3 Mapping to SORA requirements

As mentioned in the previous chapter the third 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.

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 training	#09	Remote crew trained and current and able to control the abnormal 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 and Rules	Common Flight Rules	Mitigations by setting a common set of rules which all airspace users must 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

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				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			Contain-ment	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. Currently there more 298 standards (approximately 47%) mapped to the requirements. The work will continue after the first iteration of the D3.1 documents.

4 Validation with EASA experts

The data collection work was presented to EASA experts during a two day workshop [5]. The overall approach was shown during the plenary of the workshop and the data collection document was reviewed during the group activities.

The group activities were structured by domains/topics. Each group reviewed the standards related to its topic and the mapping done until this point. The feedback from the groups was collected and merged to the main document. The overall approach was approved; some documents were added that were still missing and some removed as not important.

Inputs were also made to the domains and subtopics. These inputs were collected and resulted in a new proposed structuring with domains and keywords instead of domains and subtopics. Due to the timeline of the project and the iteration phase with EASA for the new proposal, it was decided that the new domains and keywords will be included in the next iteration of the data collection document (D3.2).

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5 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. The ongoing work is the mapping to the presented OSOs/mitigations. This work will be continuing after D3.1. The next step, which will be included in the second iteration in D3.2 will be a first assessment step. The methodology for the assessment is not part of this WP but will be presented in D2.2. The first assessment step will then be the basis of the detailed assessment performed in WP4.

The current version of the document (July 2019) with all the collected standards is attached in the Annex of this document. The Microsoft Excel version of the file is available online at this link.

6 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 (Available: https://www.surveymonkey.com/r/TJTGZS9)

[8] ASTM: Unmanned Aircraft Systems – A comprehensive solution (Available: https://www.astm.org/COMMIT/ASTM%20UAS%20Roadmap-1.pdf)

[9] AW-Drones: D2.1 Methodology for structuring of collected technical rules, standards and procedures – first release

[10] JARUS: Guidelines on Specific Operations Risk Assessment (SORA) – V2.0

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7 Annex

Table 3: Domains and subtopics used for categorization

Domain	Subtopic
General	Definitions
	Classification of UAS operations
	Manuals
	Classification of drones
Design & Airworthiness (at product level)	Manufacturer organization (design & production)
	Maintenance
	Design
	Production
	Systems safety assessment
	Electrical System
	Propulsion systems
	Fuel
	Noise & Environment
	Level of Automation/Autonomy
	Flight Control System
	Management of Continuous Airworthiness
	Electromagnetic Compatibility and Lightning Protection
	Software Development & Assurance
	Emergency capabilities & Health monitoring
	Structures
	Flight Handling
	Performance
	Ground Control Station
Avionics & Equipment	General
	Communication
	Detect and Avoid
	Navigation
	Lights
	Cyber-security
	Instruments
	Traffic surveillance (tracking)
	Command and Control (C2) Link

Operations	General
	Security (operator's responsibility)
	Marking and Registration
	Level of Automation/Autonomy
	Operator organization
	C2 Link Service Provider
	RPS Service Provider
	Ground Handling Service
	Standard Scenarios
	Accident/Incident investigation
	UAS-ATM (IFR above VLL and below FL 600)
	Take-off/Landing zones (urban vertiports)
	Risk Assessment (Operations)
Personnel	Remote Pilot competence
	UAS Maintenance personnel competence
	Additional crew members competence (non-regulated professions)
	Human Factors
	Instructors
	Examiners
	Assessors
	Training organizations
U-Space	General
	E-Identification
	Service Providers
	Tracking
	Geo-awareness
Oversight	Notified bodies and Qualified Entities

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