AW-Drones proposed standards – 3rd iteration (SC Light-UAS)

D4.3

AW-Drones

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AW-Drones

Table of Contents

1 Introduction

1.1 Assessment of SC Light UAS in the context of AW-Drones

The AW-Drones project supports the European Union's drone regulations by identifying standards that EASA may accept as AMC in the perspective of the 'Performance-Based Regulation' on UAS, enabling safe, environmentally sound and reliable operations of drones in the European Union.
This deliverable contains the assessment of standards that are mapped with the requirement of the Special Condition Light UAS. This assessment covers known updates in the activity of the SDOs, as assessed in 2021/Q4.

1.2 AW-drones Work Plan

In collaboration with EASA, AW-drones drafted a work plan to identify and assess standards addressing the requirements of the Special Condition Light-UAS. The work plan distinguishes three main technical work packages (WP):

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

The first step of the assessment process was to map the requirements of SC-Light UAS with the corresponding SORA Operational Safety Objectives. The assessment of standards supporting SORA was in fact used as the starting point to identify suitable Means of Compliance for SC-Light UAS.

1.3 Purpose and scope of this document

The assessments are based on the methodology [2] defined in work package (WP) 2. This methodology was then revised by removing the criterion "Effectiveness to fulfil the requirement" from the multi-criteria analysis to assess standards, and it is therefore not kept in consideration when evaluating a standard's score. As such, a standard scoring +5 is considered adequate and is therefore recommended. This was done to avoid standards with full coverage but limited scope to be penalised, such as, for example, standards fully covering a requirement, but for a specific configuration (e.g., only multicopters).

The score assigned to each standard is reported in the detailed evaluation that can be found here:

https://docs.google.com/spreadsheets/d/1ju3nHVLk7BavTeYNUzQIaFpIU9ui1kZ8/edit?usp=sharing&ouid=103547595748493215490&rtpof=true&sd=true

The assessment led to the identification of a number of gaps. In case of gaps preventing full coverage, or where no standards are identified to provide at least partial coverage SDO's could discuss in the European UAS Standard Coordination Group (EUSCG) how to fill them.

1.4 Structure of the document

The assessment is based on the Special Condition Light-UAS Medium Risk published by EASA in December 2020.

Chapter 2 provides the detailed results of the assessment with respect to each requirement. This section is structured as follows.

1.4.1 Summary table

For each requirement the full text is provided at the beginning of the respective sections. Then a summary table includes the identified standards that could be considered by EASA as candidates to be recognised by the Agency as possible MoC to the Special Condition. Such tables include following columns:

Table 1 Example of Summary Table

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale

Standard

The title of the document assessed, which can be a in a Planning, Drafting, Internal Consultation, External Consultation or Published phase.

Applicable section(s)

This column indicates which specific section of the standard can be considered as a MoC. In fact, standards sometimes address different aspects not all relevant for a given requirement.

SAIL

This column indicates whether the standard is suitable for SAIL III and/or SAIL IV. This evaluation is based on the mapping with the SORA OSOs and their level of robustness at SAIL III and IV. If the level of robustness for the corresponding OSO is the same for SAIL III and IV no difference is made.

Coverage

This column reports which specific sub-requirement is covered by the standard.

Gaps

This column reports gaps in the coverage of the requirement by the standard assessed.

Score

This is the score obtained by the standard according to the AW-Drones methodology. If the score is greater than 5 the standard is recommended as a preferred MoC.

Rationale

This is a short explanation of the main drivers behind the score assigned to the standard. For the full assessment the reader should refer to this document:

https://docs.google.com/spreadsheets/d/1ju3nHVLk7BavTeYNUzQIaFpIU9ui1kZ8/edit?usp=sharing&ouid=103547595748493215490&rtpof=true&sd=true

1.4.2 Summary and Conclusions

This section gives an overview of the current coverage of each requirement of the SC-Light UAS, providing a table with the best identified standards that cover the requirement at present, alongside any associated limitations and gaps.

Table 3 Example of Conclusions table

SC Requirements	Link SORA OSO(s)	Recommended standards for SAIL III	Gaps for SAIL III	Recommended standards for SAIL IV	Gaps for SAIL IV

1.5 List of acronyms

AMC	Acceptable Means of Compliance
ASTM	American Society for Testing and Materials International
ATM	Air Traffic Management
CD	Committee Draft
CISP	Common Information Service Provider

CMS	Conformance Monitoring Service
CU	Command Unit
DOC	Designated Operational Coverage
DRI	Direct Remote Identification
EASA	European Union Aviation Safety Agency
EDPS	European Data Protection Supervisor
EU	European Union
EUSCG	European UAS Standards Coordination Group
FAS	Flight Authorisation Service
FCS	Flight Clearance (alias authorisation) Service
GAW	Geo-Awareness service
MOPS	Minimum Operational Performance Specification
MS	Member State
NIS	Network Identification Service
SDO	Standard Development Organization
SORA	Specific Operations Risk Assessment
TIS	Traffic Information Service
ToR	Terms of Reference
TRS	Tracking Service
UAS	Unmanned Aircraft System
UCS	UTM Communication Service
USSP	U-space (alias UTM) service provider
UTM	UAS Traffic Management (equivalent to U-space)
WIS	Weather Information Service
WP	Work Package

2 Subpart B – Flight

2.1 Link with SORA OSOs

This Whole Subpart B is linked with the following Operational Safety Objective:

- OSO#4: UAS developed to authority recognised standards, that is required at Low Robustness for both SAIL III and IV.

2.2 Light-UAS.2100 Mass and centre of gravity

2.2.1 Requirement Description

(a) Limits for mass and centre of gravity that provide for the safe operation of the UA are to be determined.

b) The design must comply with each airworthiness standard of this Subpart at critical combinations of mass and centre of gravity within the aircraft's range of loading conditions using acceptable tolerances.

(c) The condition of the UA at the time of determining its empty mass and centre of gravity must be defined and repeatable.

2.2.2 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale

ASTM F3298 − 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS)	Sections 5, 7, 9, 13, 14 and 16	III IV	All points	None The standard refers to UAS up to 25kg, however it can be used to address all systems without limiting the maximum take-off weight.	6	The score is driven by the cost of compliance that is considered low for UAS employed in SAIL III and IV operations
ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	14	III IV	All points except (d) and (f)	Does not fully cover point (b) as verification methods are not provided	2	The score is driven by the cost of compliance that is considered high since verification methods are not provided and should be agreed on a case-by-case basis. The standard is approved by ISO and under publication, not yet published

ASTM F3298 − 19 provides an adequate coverage of the requirement in its Sections 5, 7, 9, 13, 14 and 16.

ISO 21384-2 standard requires the mass and CoG ensure balance in all operations. This is formulated only as a basic requirement. The standard is approved by ISO and under publication (60.00), not yet published

2.3 Light-UAS.2102 Approved Flight envelope and environmental conditions

2.3.1 Requirement Description

(a) The applicant needs to determine the normal and limit flight envelope for each flight configuration used in operations. The flight envelopes determination must account for the most adverse conditions for each flight configuration.

(b) In defining these limitations, environmental conditions are to be considered

(c) For adverse weather conditions for which the UAS is not approved to operate, appropriate operating limitations must prevent inadvertent operation within those adverse conditions or the UAS must have means to detect and avoid or safely exit those conditions.

Note:
The flight envelopes might be combined or adapted to the accepted MOC at project level. The MOC will specify the envelopes as applicable for the design and operation of the UA to ensure protection of limitations with appropriate margins such as structural design loads or controllability limits such as a minimum safe speed for each flight configuration and phases of flight;

Environmental conditions should include meteorological conditions such as wind, rain and icing as well as external factors that may interfere with the performance of systems such as HIRF

2.3.2 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for Design, Construction, and	6	III IV	All points	The standard only provides high level requirements and should be complemented with additional guidance to support the demonstration of compliance. The standard refers to UAS up to 25kg, however it can be used to address all	2	The score is driven by the cost of compliance that is considered high since verification methods are not provided and should be agreed on a case-by-case basis.

Verification of Lightweight Unmanned Aircraft Systems (UAS)				systems without limiting the maximum take-off weight.		
IEC 60529 – "Degrees of protection provided by enclosures (IP Code)"	All	III IV	All points except (a)	Although this standard is widely used by several UAS manufacturers and there are already products on the market which are compliant to its specifications, this is a general product standard, not specific for UAS. No coverage of sub-requirement a)	2	The score is driven by the cost of compliance that is considered high since verification methods are not provided and should be agreed on a case-by-case basis.

2.4 Light-UAS.2105 Performance data

2.4.1 Requirement Description

(a) The performance of the UA must be adequate to ensure the safety of the intended operation in the approved flight envelope.

(b) Sufficient data on the performance of the UA needs to be determined and scheduled in the aircraft flight manual

(1) to provide the remote crew with the necessary information and relevant operational parameters to ensure a safe minimum performance for the intended flight operation, and

(2) in order to ensure the UA performs as intended within the normal flight envelope and limitations for the ranges of mass, atmospheric conditions and any other operational variables for which the UA is to be certified.

(c) The UA must be able to meet the scheduled performance in still air and standard atmospheric conditions at sea level and up to the ambient atmospheric conditions for the normal flight envelope.

(d) The procedures used for determining performance are executable consistently in atmospheric conditions expected to be encountered in operation and by a remote crew of average skill.

(e) Losses due to atmospheric conditions, cooling needs, installation, downwash considerations, and other demands on power sources as applicable as well as system failure condition in accordance with LightUAS.2510 must be taken into account.

2.4.2 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 − 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS)	6	III IV	a), c), d)	The standard only provides high level requirements and should be complemented with additional guidance to support the demonstration of compliance. The standard refers to UAS up to 25kg, however it can be used to address all systems without limiting the maximum take-off weight.	2	The score is driven by the cost of compliance that is considered high since verification methods are not provided and should be agreed on a case-by-case basis.
ASTM F2908 – 18 Standard Specification for Unmanned Aircraft Flight Manual (UFM)	7.6	III IV	b)	No Gaps	6	The cost of compliance for this standard is considered low

for an Unmanned Aircraft System (UAS)				The standard refers to UAS up to 25kg, however it can be used to address all systems without limiting the maximum take-off weight.		
ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	14.2	III IV	b)	No Gaps	2	The cost of compliance for this standard is considered low The standard is approved by ISO and under publication, not yet published

2.5 Light-UAS.2135 Controllability, manoeuvrability and stability

2.5.1 Requirement Description

(a) The UA must be controllable and manoeuvrable, without requiring exceptional skill or alertness on the part of the remote crew, within the normal flight envelope

1. in all loading conditions for which certification is requested;

2. during all phases of flight;

3. with likely flight control or thrust/lift/power system failure; and

4. during configuration changes.

(b) Within its flight envelopes, the UA must show suitable stability by natural or artificial means, or a combination of both.

2.5.2 Coverage

Table 3 Requirement coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS)	5, 16	III IV	All	Covers the requirement at all points in the flight envelope The standard refers to UAS up to 25kg, however it can be used to address all systems without limiting the maximum take-off weight.	4	The score is driven by the cost of compliance that is considered high as verification is required through demonstration at all points of the flight envelope.
ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	6, 7, 10, 13	III IV	All It covers SAIL III and IV as it sets out the requirements for the UAS to maintain course, altitude, speed, and position for both rotor and fixed wing craft, with specific requirements for each where needed.	Verification methods are not provided	2	The standard is approved by ISO and under publication, not yet published

2.6 Light-UAS.2160 Vibration and Buffeting

2.6.1 Requirement Description

Within the limit flight envelope there must be no vibration or buffeting severe enough to interfere with normal control of the UA or the safety of the operation.

2.6.2 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS)	7, 16	III IV	All	Fully covers the requirement	6	The score is driven by the cost of compliance that is considered low as verification through flight tests is considered adequate for the scope.

2.7 Conclusions

SC Requirements	Link SORA OSO(s)	Recommended standards for SAIL III and IV	Gaps for SAIL III and IV
Light-UAS.2100	#4	ASTM F3298 – 19 Sections 5, 7, 9, 13, 14 and 16	None
Light-UAS.2102	#4	None	There is a gap
Light-UAS.2105 a), c), d)		None	

Light-UAS.2105 b)	#4	ASTM F2908 – 18 Section 7.6	There is a gap: ASTM F3298 – 19 should be complemented with additional guidance to support the demonstration of compliance for sub-requirements a), c), d).
Light-UAS.2135	#4	ASTM F3298 – 19 Sections 5, 16	No gap, but cost of compliance may be high for SAIL III and IV as verification is required through demonstration at all points of the flight envelope.
Light-UAS.2160	#4	ASTM F3298 – 19 Sections 7, 16	None

Subpart B requirements 2100, 2135 and 2160 have a full coverage by ASTM F3298 − 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems.

For the requirement Light-UAS.2102, ASTM F3298 − 19 would need to be used in conjunction with other standards to support the demonstration of compliance. IEC 60529 – "Degrees of protection provided by enclosures (IP Code)" is widely used by several UAS manufacturers and there are already products on the market which are compliant to its specifications, but this is a general product standard, not specific for UAS. Nonetheless, it does not cover sub requirement a).

For the requirement Light-UAS.2105, only only partially addresses the special condition and would need to be used in conjunction with other standards (e.g. ASTM F2908 – 18 Standard Specification for Unmanned Aircraft Flight Manual (UFM) for an Unmanned Aircraft System (UAS)).

3 Subpart C – Structures

3.1 Link with SORA OSOs

This Whole Subpart C is linked with the following Operational Safety Objective:

- OSO#4: UAS developed to authority recognised standards, that is required at Low Robustness for both SAIL III and IV.

3.2 Light-UAS.2235 Structural Strength and deformation

3.2.1 Requirement Description

The structure must support

(a) limit loads without:

(1) interference with the safe operation of the UA; and

(2) detrimental permanent deformation,

(b) ultimate loads without failures.

3.2.2 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 − 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS)	7, 9	III IV	All	No gaps The standard refers to UAS up to 25kg, however it can be used to address all systems without limiting the maximum take-off weight.	4	The score is driven by the cost of compliance that is considered high as the safety factor of 1.5 may be demanding for SAIL III and IV (low robustness).
ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	6	III IV	All	Verification methods are not provided	4	The test loads for structural strength and deformation are not defined, but are instead left to vary depending upon the UAS design and operational limitations. This leads to a low cost of compliance

3.3 Light-UAS.2240 Structural durability

3.3.1 Requirement Description

Effective inspections or other procedures that are designed to prevent structural failures due to foreseeable causes of strength degradation during the operational life of the UA must be developed.

Inspections and procedures must be recorded in the Instructions for Continued Airworthiness (ICA) as prepared in accordance with Light-UAS.2625.

3.3.2 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS)	8, 16	III IV	Fully covers the requirement (in combination with the following two)	No gaps The standards refer to UAS up to 25kg, however it can be used to address all systems without limiting the maximum take-off weight.	6	
ASTM F2909-19 Standard Practice for Maintenance and Continued Airworthiness of Small Unmanned Aircraft Systems (sUAS)		III IV	Needed to cover the second part of the requirement (ICA)			
ASTM F3366-19 Standard Specification for General Maintenance Manual (GMM) for a small Unmanned Aircraft System (sUAS)		III IV	Supporting standard for the Maintenance Manuals Needed to cover the second part of the requirement (ICA)			

ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	6	III IV	All	Verification methods are not provided	0	Requires fatigue testing, damage tolerance assessments, fatigue assessments, and also imposes a drop design requirement. These multiple requirements are more than similar standards and are considered demanding for low level of robustness

3.4 Light-UAS.2250 Design and construction principles

3.4.1 Requirement Description

(a) The design of each part or assembly must be suitable for the expected operating conditions of the UA.

(b) Design data must adequately define the part or assembly configuration, its design features, and any materials and processes used.

(c) The suitability of each design detail and part having an important bearing on safety in operations must be determined.

3.4.2 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 − 19 Standard Specification for	8, 14	III IV	a), b)	The standard requires the development and retention of data on the processes and materials used in the construction of the parts of the UAS. This does not fully	2	

Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS)				meet the requirements of the special condition and so would require use in conjunction with other standards.		
ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	5, 6	III IV	All	Verification methods are not provided	2	

3.5 Light-UAS.2260 Materials and Processes

3.5.1 Requirement Description

Materials and manufacturing process must be suitable for the intended use and must result in adequate and reproducible properties and performance.

3.5.2 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for	7.3, 16.2	III IV	All	No gaps The standard refers to UAS up to 25kg, however it can be	4	This specification requires the use of durable materials and reliable construction processes. It has reasonable verification requirements

Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS)				used to address all systems without limiting the maximum take-off weight.		and should not create excessive expense for compliance.
ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	14	III IV	All	Verification methods are not provided	2	

3.6 Conclusions

SC Requirements	Link SORA OSO(s)	Recommended standards for SAIL III and IV	Gaps for SAIL III and IV
Light-UAS.2235	#4	ASTM F3298 – 19 Sections 7 and 9	None
Light-UAS.2240	#4	ASTM F3298 – 19 Sections 8 and 16 + ASTM F2909-19 + ASTM F3366-19	None
Light-UAS.2250 a), b)	#4	ASTM F3298 – 19 Sections 8, 14	There is a gap for subrequirement c)
Light-UAS.2250 c)	#4	None	
Light-UAS.2260	#4	ASTM F3298-19 Section 7.3, 16.2	None

ASTM F3298 is a good candidate MoC for most the requirements in Subpart C for SAIL III and IV. For requirement 2240 the full coverage for SAIL III and IV is reached with the combination of with ASTM F3298, F2909 and F3366

A gap has been identified for *Light-UAS.2250 Design and construction principles.*

ISO CD 21384-2 is a good candidate and is potentially covering the identified gap for *Light-UAS.2250.*

In addition to the mentioned standards, “ASTM F3478-20 Standard Practice for Development of a Durability and Reliability Flight Demonstration Program for Low-Risk Unmanned Aircraft Systems (UAS) under FAA Oversight” for compliance by flight tests should be considered as useful for all the subparts, where flight tests are considered as adequate mean of verification.

4 Subpart D - Design and Construction

4.1 Light-UAS.2300 UA flight control systems

4.1.1 Requirement Description

The flight control systems must be designed to allow proper performance of their functions and protect against likely hazards.

4.1.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objective:

- OSO#4: UAS developed to authority recognised standards, that is required at Low Robustness for both SAIL III and IV

4.1.3 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for Design, Construction, and Verification of Lightweight	10, 16	III IV	All	No gaps The standards refers to UAS up to 25kg, however it can be	6	The standards have reasonable verification requirements and should not

Unmanned Aircraft Systems (UAS) + following two standards for the verification means				used to address all systems without limiting the maximum take-off weight.		create excessive expense for compliance.
ASTM F3002-14a: Standard Specification for Design of the Command and Control System for Small Unmanned Aircraft Systems (sUAS)	All					
ASTM F3003: Standard Specification for Quality Assurance of a Small Unmanned Aircraft System (sUAS)	All					
ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	10	III IV	All	Verification methods are not provided	2	

4.2 Light-UAS.2305 Landing gear systems

4.2.1 Requirement Description

(a) The landing gear system, if installed, must be designed to:

(1) provide stable support and control to the UA during surface operation; and

(2) account for probable system failures and the operation environment.

(b) The UA must be designed to absorb the kinetic energy of the landing performance.

(c) Adverse landing conditions must not cause damage to the essential systems of the UA, which could lead to a hazardous or catastrophic event if not detected

4.2.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objective:

- OSO#4: UAS developed to authority recognised standards, that is required at Low Robustness for both SAIL III and IV

4.2.3 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS)	7, 16	III IV	All	No gaps The standard refers to UAS up to 25kg, however it can be used to address all systems without limiting the maximum take-off weight.	6	

4.3 Light-UAS.2325 Fire protection

4.3.1 Requirement Description

The UA must be designed to minimize the risk of fire initiation and propagation such that ground hazards for people and infrastructure are properly mitigated.

4.3.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objective:

- OSO#4: UAS developed to authority recognised standards, that is required at Low Robustness for both SAIL III and IV

4.3.3 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS)	7, 16	III IV	All	Imposes design limitations on manufacturers that may increase UAV mass The standard refers to UAS up to 25kg, however it can be used to address all systems without limiting the maximum take-off weight.	4	The score is driven by the high cost of compliance caused by imposed design limitations on manufacturers that may increase UAV mass

4.4 Light-UAS.2335 Lightning protection

4.4.1 Requirement Description

(a) If the intended operation does not exclude exposure to lightning, the UAS must be protected against the catastrophic effects of lightning.

(b) If the intended operation excludes exposure to lightning, limitations must be developed to prohibit flight, including take-off and landing, into conditions where the exposure to lightning is likely.

4.4.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objective:

- OSO#24: Adverse operating conditions, that is required at medium robustness for SAIL III and high robustness for SAIL IV

4.4.3 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ED-113 Aircraft Lightning Direct Effects Certification	All	IV	All points	No gap but the processes defined by these standards can be demanding for small UAS.	2	The score is driven by the cost of compliance that is estimated to be High because these standards are intended for traditional aeroplanes although they could be used for UAS as well.
ARP5415B User's Manual for Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning	All	IV	All points		2	

ARP5412B Aircraft Lightning Environment and Related Test Waveforms	All	III and IV	Standards cover only test methods which could be sufficient for SAIL III	2	
ARP5416A Aircraft Lightning Test Methods	All	III and IV		2	
ARP5414B Aircraft Lightning Zoning	All	IV	No gap but the processes defined by these standards can be demanding for small UAS.	2	

4.5 Light-UAS.2340 Design and construction information

4.5.1 Requirement Description

The applicant needs to define the following design and construction information:

(a) operating limitations, procedures and instructions necessary for the safe operation of the UA;

(b) instrument markings and placards;

(c) any additional information necessary for the safe operation of the UA; and

(d) inspections or maintenance instructions to assure continued safe operation.

4.5.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objective:

- OSO#4: UAS developed to authority recognised standards, that is required at Low Robustness for both SAIL III and IV

4.5.3 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 − 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS) + ASTM F2909-19 Standard Practice for Maintenance and Continued Airworthiness of Small Unmanned Aircraft Systems (sUAS) + ASTM F3366-19 Standard Specification for General Maintenance Manual (GMM) for a small Unmanned Aircraft System (sUAS)	7, 16	III IV	All	No gaps The standard refers to UAS up to 25kg, however it can be used to address all systems without limiting the maximum take-off weight.	6	
ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	12	III IV	All	Verification methods are not provided	2	

4.6 Light-UAS.2350 Forced landing or a crash

4.6.1 Requirement Description

Where the emergency procedure contains a forced landing or a crash:

(a) the UA must be designed with sufficient self-containment features to minimise possible debris, fire or explosions extending beyond the forced landing or crash area; and

(b) the Flight Manual for the crew must contain the characteristics of the forced landing or crash area.

4.6.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objective:

- OSO#5: UAS is designed considering system safety and reliability, that is required at Low Robustness for SAIL III and Medium Robustness for SAIL IV.

4.6.3 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ED-280 Guidelines for UAS safety analysis for the Specific category (low and	All	III IV	Partial coverage of point (a)	It does not include a Common Cause analysis.	9	The score is driven by the cost of compliance which is estimated to be very low as

medium levels of robustness						these standards were explicitly developed for SAIL III and IV operations.
ED-279 Generic Functional Hazard Assessment (FHA) for UAS/RPAS	All	III IV	Partial coverage of point (a)	It only covers FHA process.	9	
ASTM F2908-18 Standard Specification for Unmanned Aircraft Flight Manual (UFM) for an Unmanned Aircraft System (UAS)	7	III IV	Coverage of point (b)	It only includes specifications for the landing area required at a normal recovery site using normal landing/recovery procedure	6	

4.7 Light-UAS.2370 Transportation, assembly, reconfiguration and storage

4.7.1 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objective:

- OSO#4: UAS developed to authority recognised standards, that is required at Low Robustness for both SAIL III and IV

4.7.2 Requirement Description

Where a UAS or part of the System is designed to be transportable, assembled and disassembled or reconfigured for transportation or storage:

(a) the conditions defined for the transportation and storage must not adversely affect the airworthiness of the UAS;

(b) incorrect assembly must be prevented by proper design provisions; and

(c) instructions for transportation, disassembling/assembling or reconfiguration and storage and the respective handling must be provided.

4.7.3 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS)	7	III IV	a), b)	No gaps The standard refers to UAS up to 25kg, however it can be used to address all systems without limiting the maximum take-off weight.	6	
F3366-19 Standard Specification for General Maintenance Manual (GMM) for a small Unmanned Aircraft System (sUAS)	7	III IV	c)	No gaps The standard refers to UAS up to 25kg, however it can be used to address all systems without limiting the maximum take-off weight.	6	
ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	14	III IV	All	Verification methods are not provided	2	

4.8 Light-UAS.2375 Payload Accommodation

4.8.1 Requirement Description

(a) The provisions for installation or accommodation of payload internal or external to the UA and for loading and releasing of payload must be designed to:

(1) minimize hazards to the UA or to third parties during normal operation, and

(2) in case of dangerous goods, not result in high risk for third parties in case of an accident.

(b) The applicant needs to provide limitations, procedures and instructions as required for the safe operation with payload.

4.8.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objective:

- OSO#5: UAS is designed considering system safety and reliability, that is required at Low Robustness for SAIL III and Medium Robustness for SAIL IV.

4.8.3 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 − 19 Standard Specification for Design, Construction, and Verification of Lightweight	12, 16	III IV	All	No gaps The standard refers to UAS up to 25kg, however it can be used to address all systems without limiting the maximum take-off weight.	6	

Unmanned Aircraft Systems (UAS)						

4.9 Light-UAS.2380 Ancillary Equipment not permanently installed on the UA

4.9.1 Requirement Description

Where the UA is intended to be used in combination with ancillary equipment not permanently installed on the UA that is required for the safe operation of the UA:

(a) the type design of the UA shall specify the performance and, when required, the design of the ancillary equipment;

(b) all necessary instructions, information and limitations for the safe and correct interface between the UA and such ancillary equipment needs to be provided in the Flight Manual or a Ground Handling Manual as appropriate; and

(c) the UA must be designed to operate safely using the ancillary equipment under the anticipated operating conditions.

4.9.2 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems (UAS)	11	III IV	a), c)	No gaps The standard refers to UAS up to 25kg, however it can be used to address all systems without	6	

				limiting the maximum take-off weight.		
ASTM F2908 – 18 Standard Specification for Unmanned Aircraft Flight Manual (UFM) for an Unmanned Aircraft System (UAS)	7	III IV	b)	No Gaps The standard refers to UAS up to 25kg, however it can be used to address all systems without limiting the maximum take-off weight.	6	The cost of compliance for this standard is considered low

4.10Summary and conclusions

SC Requirements	Link SORA OSO(s)	Recommended standards for SAIL III and IV	Gaps for SAIL III and IV
Light-UAS.2300	#4	ASTM F3298 – 19 Sections 10, 16 + ASTM F3002-14a + ASTM F3003	None
Light-UAS.2305	#4	ASTM F3298 – 19 Sections 7.10, 16	None
Light-UAS.2325	#4	ASTM F3298 – 19 Sections 7, 16	There is a gap: test on battery-induced fires are not included
Light-UAS.2335	#24	Several standards available but actual applicability must be further assessed after a technical evaluation.	
Light-UAS.2340	#4	ASTM F3298 – 19 Sections 7 and 16 + ASTM F2909-19 +	None

		ASTM F3366-19	
Light-UAS.2350 a)	#5	None	There is a gap
Light-UAS.2350 b)	#5	ASTM F2908-18 Section 7	There is a gap: standard only includes specifications for the landing area required at a normal recovery site using normal landing/recovery procedure
Light-UAS.2370 a), b)	#4	ASTM F3298 – 19	None
Light-UAS.2370 c)	#4	ASTM F3366 – 19	None
Light-UAS.2375	#5	ASTM F3298 – 19 Section 12, 16	None
Light-UAS.2380 (a), (c)	#4 #13	ASTM F3298 – 19 Section 11	None
Light-UAS.2380 (b)	#4 #13	ASTM F2908 – 18 Section 7	None

5 Subpart E - Lift/thrust/power system installation

5.1 Light-UAS.2400 Lift/Thrust/Power systems installation

5.1.1 Requirement Description

The Lift/Thrust/Power system installation includes each part of the UA that is necessary for lift/thrust/power generation and affects the control or the safety of the Lift/Thrust/Power systems.

(a) Each component of the Lift/Thrust/Power system installation must be designed, arranged, and installed in accordance with applicable airworthiness standards of Subparts C, D and F.
(b) Compliance needs to be substantiated via test, validated analysis, or a combination thereof or through evidence of certification of systems or components to acceptable specifications.
(c) The hazards in the event of a malfunction or failure of the Lift/Thrust/Power Control Systems and the Lift/Thrust/Power System Installation need to be assessed and mitigated in accordance with the airworthiness standards Light-UAS.2500 and Light-UAS.2510.
(d) The Lift/Thrust/Power system installation must take into account anticipated operating conditions and environmental conditions, for which the UA is certified, in addition to foreign object threats.
(e) The Lift/Thrust/Power system installation must take into account for
(1) anticipated operating and environmental conditions, including foreign object threats;
(2) sufficient clearance of moving parts to other unmanned aircraft parts and their surroundings; and
(3) likely hazards in operation, including hazards to ground personnel.
(f) All necessary instructions, information and limitations for the safe and correct interface between the lift/thrust/power system and the UA need to be available.

5.1.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objectives:

- OSO#4: UAS developed to authority recognised standards, that is required at Low Robustness for both SAIL III and IV.
- OSO#5: UAS is designed considering system safety and reliability, that is required at Low Robustness for SAIL III and Medium Robustness for SAIL IV.

5.1.3 Coverage

The standards assessed are divided into three categories:

- Standards at product level that include MoC for the Lift/Thrust/Power system installation
- Standards at system level that are specifically addressing this requirement
- Standards addressing the part of the requirement that is linked with OSO#5

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems	7.9	III IV	All points except (f)	None	6	The score is driven by the cost of compliance that is considered low for UAS employed in SAIL III and IV operations

ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	6	III IV	All points except (d) and (f)	Does not fully cover point (b) as verification methods are not provided	2	The score is driven by the cost of compliance that is considered high since verification methods are not provided and should be agreed on a case-by-case basis.

Table 1 Light-UAS.2400 Coverage – Standards at system level liked with OSO#4

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
F3062/F3062M-16 Standard Specification for Installation of Powerplant Systems	All	III IV	All points	It only covers the installation, not the design of the system. Only applicable to fixed-wing	5	The score is driven by the cost of compliance that is considered high since this standard is intended for small aeroplanes with a MTOM up to 19.000 lbs.
F3065/F3065M-18 Standard Specification for Aircraft Propeller System Installation	All	III IV	All points	It only covers the installation of propellers, not the design of the system. Only applicable to fixed-wing	5	The score is driven by the cost of compliance that is considered high since this standard is intended for small aeroplanes with a MTOM up to 19.000 lbs.
F3066/F3066M-18 Standard Specification for Aircraft Powerplant Installation Hazard Mitigation	All	III IV	Coverage of point (c)	Standard might need adaptation to specific UAS designs. Only applicable to fixed-wing	5	The score is driven by the cost of compliance that is considered high since this standard is intended for small aeroplanes with a MTOM up to 19.000 lbs.

Table 2: Light-UAS.2400 Coverage – Standards at system level liked with OSO#5

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3309 - Standard Practice for Simplified Safety Assessment of Systems and Equipment in Small Aircraft	All	IV	Coverage of point (c)	Might need adaptation for UAS.	9	The score is driven by the maturity since the standard is referenced in EASA CS-23.
ARP 4761 Guidelines And Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment	All	IV	Coverage of point (c)	Might need adaptation for UAS.	4	The score is driven by the cost of compliance that is considered high for small UAS.
ASTM F3230 Standard Practice for Safety Assessment of Systems and Equipment in Small Aircraft	All	IV	Coverage of point (c)	Might need adaptation for UAS.	4	The score is driven by the cost of compliance that is considered high for small UAS.
ED-280 Guidelines for UAS safety analysis for the Specific category (low and medium levels of robustness	All	III IV	Coverage of point (c)	It does not include a Common Cause analysis.	9	The score is driven by the cost of compliance which is estimated to be very low as these standards were explicitly developed for SAIL III and IV operations.
ED-279 Generic Functional Hazard Assessment (FHA) for UAS/RPAS	All	III IV	Coverage of point (c)	It only covers FHA process.	9	

The identified standards provide an adequate coverage of the requirement with the following exceptions:

- No standard is explicitly addressing the design of the engine itself. This is partly addressed by the ASMT and ISO standards at product level, but their guidance is considered too generic to be used. Further analysis is required to assess their suitability from a technical point of view to support the design of engines.
- No standard is explicitly covering point (f). ASTM standard F2909-19 "Standard Practice for Maintenance and Continued Airworthiness of Small Unmanned Aircraft Systems (sUAS)" and "F2908-18 Standard Specification for Aircraft Flight Manual (AFM) for a Small Unmanned Aircraft System (sUAS)" do not provide specific guidance on how to provide information on the interface between the Lift/Thrust/Power System and the UAS

In addition, for the standards identified to cover point (c) and that are linked to OSO #5 the following conclusions can be made:

- ED-280 and ED-279 are considered the preferred standards. However, they need to be complemented with a Common Mode Analysis following ASTM F3309 § 4.6 (with additional guidance from ARP 4761A App K)
- Design and installation appraisal aspects can be taken from ASTM F3309 §4.4.1 and 4.4.2

5.2 Light-UAS.2405 Lift/Thrust/Power System Integrity

5.2.1 Requirement Description

The integrity of the Lift/Thrust/Power system including mounting and accessory attachment must be demonstrated throughout the limit flight envelope of the UA.

5.2.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objectives:

- OSO#4: UAS developed to authority recognised standards, that is required at Low Robustness for both SAIL III and IV.

5.2.3 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems	16.3 16.4	III IV	Full	None	6	The score is driven by the cost of compliance that is considered low for UAS employed in SAIL III and IV operations

ASTM F3298 – 19 provides guidance on how to demonstrate the Lift/Thrust/Power system. However, additional technical analysis is needed to assess if the level of detail is sufficient to comply with Light-UAS.2405.

5.3 Light-UAS.2410 Lift/Thrust/Power Endurance and durability

5.3.1 Requirement Description

Each Lift/Thrust/Power System must be subject to

(a) an endurance demonstration of sufficient duration with respect to cycles and power settings in accordance with Light-UAS.2415;
(b) a durability demonstration to show that each part of the system has been designed and constructed to minimize the probability of failure of the system and sub-systems between overhaul periods, or between replacement intervals of parts; and
(c) an operational demonstration to verify the performance of the system throughout its declared operating range and operational limitations.

5.3.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objectives:

- OSO#4: UAS developed to authority recognised standards, that is required at Low Robustness for both SAIL III and IV.

5.3.3 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 − 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems	15 16.3 16.4	III IV	Full	None	6	The score is driven by the cost of compliance that is considered low for UAS employed in SAIL III and IV operations
ASTM F3478-20 Standard Practice for Development of a Durability and Reliability Flight Demonstration Program for Low-Risk Unmanned Aircraft Systems (UAS) under FAA Oversight	N.A.	III IV	Potentially fully covering the requirement	N.A.	N.A.	Standard not available to AW-Drones
WK58939 New Test Method for Evaluating AerialResponse RobotEnergy/Power: Endurance Range and Duration	N.A.	III IV	Potentially fully covering the requirement	N.A.	N.A.	Standard not available to AW-Drones

ASTM F3298 – 19 and 3478-20 should provide adequate guidance. However, ASTM F3478-20 could not be properly evaluated by AW-Drones as it was suggested for inclusion in the latest stages of the project and a copy could not be obtained in time for the assessment. It is recommended to further assess its suitability especially in relation to the EASA regulatory framework.

5.4 Light-UAS 2415 Lift/Thrust/Power Calibration, Ratings and Operational Limitation

5.4.1 Requirement Description

(a) Each Lift/Thrust/Power System must be subject to calibration tests as necessary to establish its power characteristics.
(b) The Lift/Thrust/Power System must produce, within its stated limits, the lift/thrust/power demanded at all required flight conditions, taking into account environmental effects and conditions.
(c) Ratings and operational limitations need to be established as required for the safety of the operation

5.4.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objectives:

- OSO#4: UAS developed to authority recognised standards, that is required at Low Robustness for both SAIL III and IV.

5.4.3 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems	15 16.3 16.4	III IV	Full	None	6	The score is driven by the cost of compliance that is considered low for UAS employed in SAIL III and IV operations
F3064 / F3064M - 21 Standard Specification for Aircraft Powerplant Control, Operation, and Indication	All	III IV	Potentially fully covering the requirement	Standard might need adaptation to specific UAS designs. Only applicable to fixed-wing.	5	The score is driven by the cost of compliance that is considered high for UAS employed in SAIL III and IV operations
ARP6971 Power and Torque Determination for UAS Engines	All	III IV	Only applicable to power and torque determination	Standard might need adaptation to specific UAS designs. Only	4	The score is driven by the cost of compliance that is considered high for UAS

Having Maximum Power Ratings at or Below 22.4 kW				applicable to fixed-wing.		employed in SAIL III and IV operations

5.5 Light-UAS.2430 Energy storage and distribution systems

5.5.1 Requirement Description

(a) Each system must:
  (1) provide compatible and uninterrupted energy as required with adequate margins to ensure safe functioning of the supported systems; and
  (2) provide information and warnings to the remote crew regarding normal and degraded modes and remaining energy as required to be available for the remote crew to safely operate the UA.

(b) Each storage system must be designed and installed to:
  (1) ensure that in normal operation or probable failure no explosive, toxic, or corrosive gases or fluids may accumulate in hazardous quantities or may damage structures or adjacent essential equipment or systems;
  (2) maintain safe operating temperatures, pressures, or any other identified parameter, during normal operation;
  (3) provide means of protection, or controlling to prevent hazardous conditions during normal operation or probable malfunction; and
  (4) minimize hazards during ground handling, refilling or recharging, storage and exchange of the storage device or its components if such a function is provided.

5.5.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objectives:

- OSO#4: UAS developed to authority recognised standards, that is required at Low Robustness for both SAIL III and IV.

- OSO#5: UAS is designed considering system safety and reliability, that is required at Low Robustness for SAIL III and Medium Robustness for SAIL IV.

5.5.3 Coverage

The standards assessed are divided into three categories:

- Standards at product level that include MoC for Energy storage and distribution
- Standards at system level that are specifically addressing this requirement

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems	7.9.5 10.5.7.2 10.5.7.3	III IV	All points	None	6	The score is driven by the cost of compliance that is considered low for UAS employed in SAIL III and IV operations
ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	9	III IV	Point (b)	Verification methods not provided. IEC 62133:2017 Suggested as the reference standard for verification methods.	4	The score is driven by the cost of compliance that is considered high since verification methods are not provided and should be agreed on a case-by-case basis.

Table 3 Light-UAS.2430 Coverage – Standards at system level

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
F3005 Standard Specification for Batteries for Use in Small Unmanned Aircraft Systems	All	III IV	Point (b)	None	6	The score is driven by the cost of compliance that is considered low for UAS employed in SAIL III and IV operations
IEC 62133:2017 Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications	All	III IV	Point (b)	None	6	The score is driven by the cost of compliance that is considered low as this standard is intended for COTS batteries
F3063/F3063M-18a Standard Specification for Aircraft Fuel and Energy Storage and Delivery	All	III IV	Point (b)	Standards might need adaptation to specific UAS designs. Only applicable to fixed-wing	2	Score is driven by the cost of compliance that is estimated to be high as all these standards are intended for manned aircraft.
AIR6464 Hydrogen Fuel Cells Aircraft Fuel Cell Safety Guidelines	All	III IV	Point (b)		2	
AIR6343 Design and Development of Rechargeable Aerospace Lithium Battery Systems	All	III IV	The two standards combined cover Point (b)		2	
AIR6897 Lithium Battery Systems – Prognostics and Health Management	All	III IV			2	

From the assessment the adequate combination of standard to fulfil Light-UAS.2430 is the following:

- ASTM F3298 – 19 sections 10.5.7.2 and 10.5.7.3 to fulfil point (a)
- ASTM F3298 – 19 section 7.9.5 or ISO 21384-2 section 9 for point (b).
- ASTM F3005 or IEC 62133:2017 if the energy storage system used is a battery.

5.5.4 Summary and conclusions

SC Requirements	Link SORA OSO(s)	Recommended standards for SAIL III	Gaps for SAIL III	Recommended standards for SAIL IV	Gaps for SAIL IV
Light-UAS.2400	#4	ASTM F3298 – 19 Section 7.9	Point (f) not addressed	ASTM F3298 – 19 Section 7.9	Point (f) not addressed
Light-UAS.2400(c)	#5	ED-280 and ED-279 complemented with a Common Mode Analysis following ASTM F3309 § 4.6. Design and installation appraisal from ASTM F3309 §4.4.1 and 4.4.2	None	Same as SAIL III	
Light-UAS.2405	#4	ASTM F3298 – 19 Sections 16.3 and 16.4	Only general guidance provided. Further technical assessment needed	Same as SAIL III	
Light-UAS.2410	#4	ASTM F3298-19 Section 15, 16.3 and 15.4 F3478-20	F3478-20 not fully assessed	Same as SAIL III	
Light-UAS.2415	#4	ASTM F3298-19 Section 15, 16.3 and 15.4	None	Same as SAIL III	
Light-UAS.2430(a)	#4 and #5	ASTM F3298-19 Sections 10.5.7.2 and 10.5.7.3	None	Same as SAIL III	
Light-UAS.2430(b)	#4	ASTM F3298-19 Section 7.9.5 ISO 21384-2 section 9	None	Same as SAIL III	

		ASTM F3005 or IEC 62133:2017 for batteries		

From the table above the following gaps are identified in relation to MoC that are not considered adequate to fulfil the requirements:

- Light-UAS.2400: there is no standard explicitly addressing point (f) “All necessary instructions, information and limitations for the safe and correct interface between the lift/thrust/power system and the UA need to be available”. Existing standards on Flight Manuals and maintenance Manual are assessed as too generic.
- Light-UAS.2405: existing standard only provides general guidance provided. Further technical assessment is needed to better evaluate the adequacy of the standard to be used as a MoC.


AW DRONES

6 Subpart F - Systems and Equipment

6.1 Light-UAS.2510 Equipment, Systems and Installation

6.1.1 Requirement Description

(a) The equipment and systems identified in CS-Light UAS.2500, considered separately and in relation to other systems, must be designed and installed such that:
  (1) hazards are minimized in the event of a probable failure;
  (2) it can be reasonably expected that a catastrophic failure condition will not result from any single failure; and
  (3) if the SAIL is IV, a means for detection, alerting and management of any failure or combination thereof, which would lead to a hazard, is available.

(b) Any hazard which may be caused by the operation of equipment and systems not covered by LightUAS.2500 must be minimized.

1. The term 'probable' needs to be understood in its qualitative interpretation, i.e. 'Anticipated to occur one or more times during the entire system/operational life of an item.'
2. The term 'failure' needs to be understood as an occurrence that affects the operation of a part, or element such that it can no longer function as intended (this includes both loss of function and malfunction). Errors may cause failures, but are not considered to be failures. Some structural or mechanical failures may be excluded from the criterion if it can be shown that these mechanical parts were designed according to aviation industry best practices;
3. The term "hazard" needs to be understood as a failure condition that relates to major, hazardous or catastrophic consequences.
4. MOC for Light-UAS.2510 (medium risk) will be defined by EASA at a later stage.
5. (a)2 is transposed from OSO 10/12 of EASA AMC and GM "when operating over populated areas or assemblies of people it can be reasonably expected that a fatality will not occur from any single failure of the UAS or any external system supporting the operation"

6.1.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objectives:

- OSO#5: UAS is designed considering system safety and reliability, that is required at Low Robustness for SAIL III and Medium Robustness for SAIL IV.
- OSO#10,12: OSOs related to Safe Design that are required at Medium Robustness for SAIL III and IV.
- OSO#19, Criterion 3: UAS is designed to ensure a safe recovery from Human Error, that is required at Low Robustness for SAIL III and Medium Robustness for SAIL IV.

6.1.3 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3309 - Standard Practice for Simplified Safety Assessment of Systems and Equipment in Small Aircraft	All	IV	No explicit coverage of point (a)(3).	None for the other points.	9	The score is driven by the maturity since the standard is referenced in EASA CS-23.
ARP 4761 Guidelines And Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment	All	IV	No explicit coverage of point (a)(3).	Might need adaptation for UAS.	4	The score is driven by the cost of compliance that is considered high for small UAS.
ASTM F3230 Standard Practice for Safety Assessment of Systems and Equipment in Small Aircraft	All	IV	No explicit coverage of point (a)(3).	Might need adaptation for UAS.	4	The score is driven by the cost of compliance that is considered high for small UAS.

ED-280 Guidelines for UAS safety analysis for the Specific category (low and medium levels of robustness	All	III IV	No explicit coverage of point (a)(3).	It does not include a Common Cause analysis.	9	The score is driven by the cost of compliance which is estimated to be very low as these standards were explicitly developed for SAIL III and IV operations.
ED-279 Generic Functional Hazard Assessment (FHA) for UAS/RPAS	All	III IV	It only covers FHA process.		9	

For the standards identified that are linked to OSO #5 the following conclusions can be made:

- ED-280 and ED-279 are considered the preferred standards. However, they need to be complemented with a Common Mode Analysis following ASTM F3309 § 4.6 (with additional guidance from ARP 4761A App K)
- Design and installation appraisal aspects can be taken from ASTM F3309 §4.4.1 and 4.4.2

Although Software and Hardware development assurance are not explicitly addressed by Light-UAS.2510, they are required by OSOs #10,12 at Medium Robustness. The following standards are therefore identified.

Table 4: Light-UAS.2510 Coverage – Standards linked with OSO#10,12

Standard	Applicable section(s)	SAIL	Gaps	Score	Rationale
ED-80 Design Assurance Guidance for Airborne Electronic Hardware	All	IV	None for AEH	6	The score is driven by the fact that this standard is recognised by EASA. The score may be increased depending on the actual cost of compliance which is a function of the required DAL.
ED-12C Software Considerations in Airborne Systems and Equipment Certification	All	III and IV	None for SW development assurance	6	
ASTM F3201 - 16 Standard Practice for Ensuring Dependability of	All	III and IV	None but applicable only to small UAS	9	Score is driven by cost of compliance that is estimated to be very low for small UAS.

Software Used in Unmanned Aircraft Systems (UAS)					
EUROCAE Software Considerations in Lower Risk Applications, Equipment Certifications and Approvals	All	III and IV	N.A	N.A.	Standard possibly applicable but not assessed as draft is not yet available.
EASA AMC 20-152A Development Assurance for Airborne Electronic Hardware (AEH)	All	III and IV	None for AEH	6	The score is driven by the fact that this AMC is developed by EASA. The score may be increased depending on the actual cost of compliance which is a function of the required DAL.
EASA AMC 20-115D "Airborne Software Development Assurance using EUROCAE-ED12 and RTCA DO-178	All	III and IV	None for SW development assurance	6	

For the standards identified that are linked to OSOs #10,12 the following conclusions can be made:

- For Software Development Assurance:
  - ASTM F3201 – 16 is the recommended standard for small UAS. EUROCAE Software Considerations in Lower Risk Applications, Equipment Certifications and Approvals should be assessed once ready as another option.
  - EUROCAE ED-12C and EASA AMC 20-152A are the recommended standards and guidance for all other UAS designs.
- For Hardware Development Assurance:
  - EUROCAE ED-80 and EASA AMC 20-115D are the recommended standards.

6.2 Light-UAS.2511 Containment

6.2.1 Requirement Description

(a) No probable failure of the UAS or of any external system supporting the operation must lead to operation outside the operational volume.

(b) When the risk associated with the adjacent areas on ground or adjacent airspace is significantly higher than the risk associated with the operational volume including the ground buffer:
  (1) the probability of leaving the operational volume must be demonstrated to be acceptable with respect to the risk posed by a loss of containment;
  (2) no single failure of the UAS or of any external system supporting the operation must lead to its operation outside the ground risk buffer; and
  (3) software and airborne electronic hardware whose development error(s) could directly lead to operations outside the ground risk buffer must be developed to a standard or methodology accepted by the Agency.

6.2.2 Link with SORA

This requirement is linked with SORA Step#9.

6.2.3 Coverage

Standard	Applicable section(s)	Coverage	Gaps	Score	Rationale
ED-270 Minimum Operational Performance Specification Geocaging	All	(b)(1) at 10-4 for Medium geocaging (b)(1) and (2) for High grade geocaging	None	7	The score is driven by the cost of compliance that is considered low for small UAS.
ED-269 Minimum Operational Performance Specification Geofencing	All	Point (b)(1)	No probability target is set	7	The score is driven by the cost of compliance that is considered low for small UAS.

ASTM F3309 - Standard Practice for Simplified Safety Assessment of Systems and Equipment in Small Aircraft	All	Point (a) and Point (b)(2)	None for the other points.	9	The score is driven by the maturity since the standard is referenced in EASA CS-23.
ARP 4761 Guidelines And Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment	All	Point (b)(2)	Might need adaptation for UAS.	4	The score is driven by the cost of compliance that is considered high for small UAS.
ED-280 Guidelines for UAS safety analysis for the Specific category (low and medium levels of robustness	All	Point (a) and Point (b)(2)	It does not include a Common Cause analysis.	9	The score is driven by the cost of compliance which is estimated to be very low as these standards were explicitly developed for SAIL III and IV operations.
ED-279 Generic Functional Hazard Assessment (FHA) for UAS/RPAS	All	Point (a) and Point (b)(2)	It only covers FHA process.	9	
ED-80 Design Assurance Guidance for Airborne Electronic Hardware	All	Point (b)(3)	None for AEH	6	The score is driven by the fact that this standard is recognised by EASA. The score may be increased depending on the actual cost of compliance which is a function of the required DAL.
ED-12C Software Considerations in Airborne Systems and Equipment Certification	All	Point (b)(3)	None for SW development assurance	6	
ASTM F3201 - 16 Standard Practice for Ensuring Dependability of Software Used in Unmanned Aircraft Systems (UAS)	All	Point (b)(3)	None but applicable only to small UAS	9	Score is driven by cost of compliance that is estimated to be very low for small UAS.
EUROCAE Software Considerations in Lower Risk Applications, Equipment Certifications and Approvals	All	Point (b)(3)	N.A	N.A.	Standard possibly applicable but not assessed as draft is not yet available.

EASA AMC 20-152A Development Assurance for Airborne Electronic Hardware (AEH)	All	Point (b)(3)	None for AEH	6	The score is driven by the fact that this AMC is developed by EASA. The score may be increased depending on the actual cost of compliance which is a function of the required DAL.
EASA AMC 20-115D "Airborne Software Development Assurance using EUROCAE-ED12 and RTCA DO-178	All	Point (b)(3)	None for SW development assurance	6	

In relation to requirements (a) and (b)(2) the following conclusions can be made:

- ED-280 and ED-279 are considered the preferred standards. However, they need to be complemented with a Common Mode Analysis following ASTM F3309 § 4.6 (with additional guidance from ARP 4761A App K)
- Design and installation appraisal aspects which are mentioned in SORA Step#9 can be addressed using ASTM F3309 §4.4.1 and 4.4.2.

Requirement (b)(1) can be supported by EUROCAE ED-269 and ED-270 depending on the required probability. For Requirement (b)(3) the following conclusions can be made:

- For Software Development Assurance:
  - ASTM F3201 – 16 is the recommended standard for small UAS. EUROCAE Software Considerations in Lower Risk Applications, Equipment Certifications and Approvals should be assessed once ready as another option.
  - EUROCAE ED-12C and EASA AMC 20-152A are the recommended standards and guidance for all other UAS designs.
- For Hardware Development Assurance:
  - EUROCAE ED-80 and EASA AMC 20-115D are the recommended standards.

6.3 Light-UAS.2512 Mitigation Means linked with Design

6.3.1 Requirement Description

Design features intended to be used as mitigation means must be demonstrated with the adequate level of performance.

Note: The level of performance will be determined considering integrity criteria for mitigation means expressed in the EASA AMC and GM For mitigation means linked to ground risk the performance demonstration will be covered by the TC (e.g. the integration of a parachute or a frangible design). For tactical mitigation means linked with air risk, as per CIR 947/2019 the performance justifying the mitigation may have to be agreed upon with a different Authority when an operational authorization is applied for (e.g. the use of ADS-B for air risk mitigation must be discussed and agreed with the competent Authority of the Member State responsible for the affected volume of airspace). In the second case, the TC will validate the integration of the equipment in the UAS configuration, not the claimed mitigation.

6.3.2 Link with SORA

This requirement is linked with Ground Risk Mitigation M1 (Tethered UAS – Criterion #1 Technical Design) and M2 (Criterion #1 Technical Design).

Table 5 Requirements' Description – M1 - Tethered Operations

Criterion	Robustness	Description
Criterion #1 technical design Integrity	Low	Does not meet the "Medium" level criteria
	Medium	1) The length of the line is adequate to contain the UA in the operational volume and reduce the number of people at risk. 2) Strength of the line is compatible with the ultimate loads expected during the operation. 3) Strength of attachment points is compatible with the ultimate loads expected during the operation. 4) The tether cannot be cut by rotating propellers.
	High	Same as Medium
	Low	Does not meet the "Medium" level criteria

Criterion #1 technical design Assurance	Medium	The applicant has supporting evidence (including the tether material specifications) to claim the required level of integrity is achieved. This is typically achieved through testing or operational experience. Tests can be based on simulations, however the validity of the target environment used in the simulation needs to be justified.
	High	The claimed level of integrity is validated by EASA.

Table 6 Requirements' Description – M2

Criterion	Robustness	Description
Criterion #1 (Technical Design) Integrity	Low	Does not meet the "Medium" level criterion
	Medium	Ground risk buffer takes into consideration: • Effects of impact dynamics and post impact hazards are significantly reduced although it can be assumed that a fatality may still occur. • When applicable, in case of malfunctions, failures or any combinations thereof that may lead to a crash, the UAS contains all elements required for the activation of the mitigation. • When applicable, any failure or malfunction of the proposed mitigation itself (e.g. inadvertent activation) does not adversely affect the safety of the operation.
	High	Same as medium. In addition: • When applicable, the activation of the mitigation, is automated. • The effects of impact dynamics and post impact hazards are reduced to a level where it can be reasonably assumed that a fatality will not occur.
Criterion #1 (Technical Design) Assurance	Low	The applicant declares that the required level of integrity has been achieved.
	Medium	The applicant has supporting evidence to claim the required level of integrity is achieved. This is typically done by means of testing, analysis, simulation, inspection, design review or through operational experience.
	High	The claimed level of integrity is validated by EASA against a standard considered adequate by EASA and/or in accordance with means of compliance acceptable to EASA (when applicable).

6.3.3 Coverage

Criterion	Robustness	Recommended standard	Coverage/Gaps	Score	Rationale
M1 Tethered operation - Criterion #1 technical design	Low	NO STANDARD REQUIRED	N.A.	N.A.	N.A.
	Medium	ISO/WD 24356 General requirements for tethered unmanned aircraft system	Still in planning phase, draft needs to be checked but it is expected to provide generic guidance	N.A.	N.A.
		ASD-STAN prEN 4709-01 Aerospace series — Unmanned Aircraft Systems — Product requirements and verification for the Open category	Section 7.6 possibly applicable but only for UAS manufactured according to the standard	4	Score is driven by the low maturity as this standard is not published yet.
	High	ISO/WD 24356 General requirements for tethered unmanned aircraft system	Still in planning phase, draft needs to be checked	N.A.	

For mitigation M1 - tethered, there is no standard already published that can adequately cover the requirements. The ISO planned standard "General requirements for tethered unmanned aircraft system" appear to be the best candidate to fill this gap. Currently the main reference could be prEN 4709-01 but this is only applicable to Open Category Drones.

Table 7: Light-UAS.2512 - Mitigation M2 - Coverage

Criterion	Robustness	Recommended standard	Coverage/Gaps	Score	Rationale
M2	Low	NO STANDARD REQUIRED	N.A.	N.A.	N.A.

Criterion #1 (Technical Design)	Medium	F3322-18: Standard Specification for Small Unmanned Aircraft System (sUAS) Parachutes	F3322-18 is a specification that defines design, manufacturing, and test requirements for the parachute system. It does not provide minimum requirements related to the ground impact effects as this will likely be dependent on the governing CAA. It does not cover the automatic activation required by High robustness.	6	Score is driven by cost of compliance that is estimated to be low for small UAS.
		ASTM F3389 Standard Test Method for Assessing the Safety of Small Unmanned Aircraft Impacts	This standard cover the evaluation of the effects of a ground impact when the UAS is equipped with the parachute. In includes test methods to demonstrate a 90% reduction of the risk of fatal injuries.	6	Score is driven by cost of compliance that is estimated to be low for small UAS.

Criterion #1 of M2 seems to be adequately covered for parachutes by standards that are published except for the requirement about the automatic activation of the system.

However, there is no standard covering other possible systems to reduce the impact energy working for example on the frangibility of the UAS.

6.4 Light-UAS.2515 Electrical and electronic system lightning protection

6.4.1 Requirement Description

For a UAS where exposure to lightning is likely, each electrical or electronic system that performs a function, the failure of which would prevent the continued safe flight and landing or emergency recovery of the UA, must be designed and installed such that:

(a) the function at the UAS level is not adversely affected during or after the time when the UAS is exposed to lightning; and

(b) the system recovers normal operation of that function in a timely manner after the UAS is exposed to lightning unless the system's recovery conflicts with other operational or functional requirements of the system.

6.4.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objectives:

- OSO#24: UAS is designed and qualified considering adverse environmental conditions, that is required at Medium Robustness for SAIL III and High Robustness for SAIL IV.

6.4.3 Coverage

<table>
<tr><th>Standard</th><th>Applicable section(s)</th><th>SAIL</th><th>Coverage</th><th>Gaps</th><th>Score</th><th>Rationale</th></tr>
<tr><td>ED-113 Aircraft Lightning Direct Effects Certification</td><td>All</td><td>IV</td><td>All points</td><td rowspan="2">No gap but the processes defined by these standards can be demanding for small UAS.</td><td>2</td><td rowspan="4">The score is driven by the cost of compliance that is estimated to be High because these standards are intended for traditional aeroplanes although they could be used for UAS as well.</td></tr>
<tr><td>ARP5415B
User's Manual for Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning</td><td>All</td><td>IV</td><td>All points</td><td>2</td></tr>
<tr><td>ARP5412B Aircraft Lightning Environment and Related Test Waveforms</td><td>All</td><td>III and IV</td><td colspan="2" rowspan="2">Standards cover only test methods which could be sufficient for SAIL III</td><td>2</td></tr>
<tr><td>ARP5416A Aircraft Lightning Test Methods</td><td>All</td><td>III and IV</td><td>2</td></tr>
</table>

ARP5414B Aircraft Lightning Zoning	All	IV	No gap but the processes defined by these standards can be demanding for small UAS.	2	

The standards identified are considered adequate to address Light.UAS.2515 but further technical analysis is required to confirm the cost of compliance that is currently set as high. However, no standards were identified to specifically address Lightning protection of the GCS, thus this is identified as a gap.

6.5 Light-UAS.2520 High-Intensity Radiated Fields (HIRF) Protection

6.5.1 Requirement Description

For a UAS where the exposure to HIRF is likely each electrical and electronic system that performs a function, the failure of which would prevent the continued safe flight and landing or emergency recovery of the UA, must be designed and installed such that:

(a) the function at the UAS level is not adversely affected during or after the time when the UAS is exposed to the HIRF environment; and

(b) the system recovers normal operation of that function in a timely manner after the UAS is exposed to the HIRF environment, unless the system's recovery conflicts with other operational or functional requirements of the system.

6.5.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objectives:

- OSO#24: UAS is designed and qualified considering adverse environmental conditions, that is required at Medium Robustness for SAIL III and High Robustness for SAIL IV.

6.5.3 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3367-21 Simplified High Intensity Radiated Field (HIRF) Protection in Level 1 and Level 2 Aircraft	All	III IV	All points	No gap but adaptation is required since the standard is primarily intended for manned aeroplanes. In addition this standard is currently not accepted by EASA for manned aircraft.	4	The score is driven by cost of compliance that is estimated as medium and the maturity which is decreased since the standard is not recognised by EASA.
ED-107 Guide to Certification of Aircraft in a High-Intensity Radiated Field (HIRF) Environment	All	IV	All points	No gap but the processes defined by these standards can be demanding for small UAS.	2	The score is driven by the cost of compliance that is estimated to be High because these standards are intended for traditional aeroplanes although they could be used for UAS as well.
F3236-17 Standard Specification for High Intensity Radiated Field (HIRF) Protection in Small Aircraft	All	III and IV	All points		2	

The standards identified are considered adequate to address Light.UAS.2520 but further technical analysis is required to confirm the cost of compliance that is currently set as high. ASTM F3367-21 should be further assessed to identify if the proposed methods are acceptable for UAS. Similarly, as Light.UAS.2515, no standards were identified to specifically address HIRF protection of the GCS, thus this is identified as a gap.

6.6 Light-UAS.2528 UAS Envelope protection Function

6.6.1 Requirement Description

(a) Where required for safe operation, the UAS must ensure that the UA remains within the limit flight envelope under foreseeable operating conditions, consistent with the system safety objectives of LightUAS.2510.
(b) Characteristics of any envelope protection feature and combinations thereof must be appropriate for the phase of flight and type of maneuver.
(c) Limit values of protected flight parameters must be compatible with:
    (1) structural limits;
    (2) required safe and controllable maneuvering of the UA under anticipated operating conditions with adequate margins on specified limits;
    (3) prevention of hazardous and catastrophic failure conditions;
    (4) applicable lift/thrust/power system limitations; and
    (5) dynamic effects due to maneuvering, lift/thrust/power system characteristics and external effects.

6.6.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objectives:

- OSO#18: Automatic protection of the flight envelope from human errors, that is required at Low Robustness for SAIL III and Medium Robustness for SAIL IV.

6.6.3 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
EUROCAE Guidelines on the Automatic protection of the flight envelope from human errors for UAS	All	III IV	Standard is planned but not yet developed		N.A.	N.A.

The standard under development by EUROCAE is expected to cover Light.UAS.2528 as it is being developed to explicitly address this requirement. However, no draft was available for the assessment.

6.7 Light-UAS.2529 UAS Navigation Function

6.7.1 Requirement Description

The UAS must ensure that the UA remains within the applicable spatial limitations or if applicable the intended flight path in all flight phases.

6.7.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objectives:

- OSO#4: UAS developed to authority recognised standards, that is required at Low Robustness for both SAIL III and IV.

6.7.3 Coverage

Table 8: Light-UAS.2529 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for	10.2.2	III IV	All	Performance requirements not provided	6	The score is driven by the cost of compliance that is considered low for UAS employed in SAIL III and IV operations

Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems						
ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	10.5	III IV	All	It provides requirements depending on the technology used (GNSS, RTK, IMU) but performance requirements and verification methods are not provided	4	The score is driven by the cost of compliance that is considered high since verification methods are not provided and should be agreed on a case-by-case basis.
EUROCAE guidelines for the use of multi-GNSS solutions for UAS	All	III IV	All	Appendix IV contains a procedure to determine GNSS performance level and reference values. No other elements are included.	3	The score is driven by the maturity which is low since the standard is not published yet.

The existing standards can be combined to provide an adequate set of MoC to Ligh.UAS.2529. EUROCAE Guidelines should be used to set the performance targets to be used for the design of the system according to the ASTM or ISO standard.

6.8 Light-UAS.2530 UA External lights

6.8.1 Requirement Description

When required by operational rules:

(a) lights required for conspicuity at night must have the intensities, colors, and other characteristics to allow an observer to distinguish the UA from a manned aircraft;

(b) any position lights and anti-collision lights, must have the intensities, flash rates, colors, fields of coverage, position and other characteristics to provide sufficient time for another aircraft to avoid a collision;

(c) any position lights, must include a red light on the port side of the UA, and a green light on the starboard side of the UA spaced as far laterally apart as practical and a white light facing aft as far to the rear of the UA as practicable;
(d) a strobe light must be installed; and
(e) Taxi and landing lights, if installed, must perform as expected.

Note: In (b) "sufficient time" should be intended as a function of ownship system latencies (decision time, processing time, communications latency, etc.), ownship dynamics and manoeuvring performance, and the relative velocity between the traffic pair. Strobe Light: UA with relatively small wingspans may lack the physical separation required to prevent the red and green position lights from appearing to converge into a single light source and this may limit their use for collision avoidance.

6.8.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objectives:

- OSO#4: UAS developed to authority recognised standards, that is required at Low Robustness for both SAIL III and IV.

6.8.3 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems	A2.4.2 and A2.4.3	III IV	All except point (d)	None	6	The score is driven by the cost of compliance that is considered low for UAS employed in SAIL III and IV operations

prEN 4709-004: Lighting requirements	All	III IV	All except point (d)	No gap but standard is intended for UAS with class mark up to C6 (i.e. up to 25kg). For larger UAS it might need adaptation	5	
F3234/F3234M-17 Standard Specification for Exterior Lighting in Small Aircraft	All	III IV	All except point (d)	None but lights positioning and colours to be adapted	5	The score is driven by the cost of compliance that is estimated as high due to the adaptations required for UAS.

ASTM F3298 – 19 and prEN 4709-004 are the standards recommended as MoC for Light.UAS.2530. However, since prEN 47009-004 is not published yet, F3298 should be recommended at this stage. However, none of the identified standard covers the requirement for a strobe light so this is identified as a gap.

6.9 Light-UAS.2575 Command, Control and Communication Contingency

6.9.1 Requirement Description

(a) Where the safe operation of the UA requires command, control and communication functionality, the UAS must initiate adequate contingency procedures following a command, control or communication function loss or a degraded status which no longer ensures safe operation of the UA by the remote crew.

(b) The contingency procedures must be specified in the Flight Manual for the remote crew for each operational situation.

Note: This airworthiness standard is linked with the C2 Link and has been kept under Subpart F as it relates not only with C2 Link but with how equipment and systems will manage the loss of command, control and communication.

6.9.2 Link with SORA OSOs

This requirement is linked with the following Operational Safety Objectives:

- OSO#5: UAS is designed considering system safety and reliability, that is required at Low Robustness for SAIL III and Medium Robustness for SAIL IV.

6.9.3 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	11	III IV	All	It only provides high level requirements and no verification methods	4	The score is driven by the cost of compliance that is considered high since verification methods are not provided and should be agreed on a case-by-case basis.
ASTM F3002 – 14 Standard Specification for Design of the Command and Control System for Small Unmanned Aircraft Systems (sUAS)	All	III IV	All	Standard applicable to small UAS below 25kg	6	The score is driven by the cost of compliance that is considered low for UAS employed in SAIL III and IV operations

F3002-14 is the preferred standard. It also includes generic specifications on contingency procedures in case of function loss or a degraded status. However:

- It only addresses UAS < 25kg
- Communication function is not covered

6.10 Summary and conclusions

SC Requirements	Link SORA OSO(s)	Recommended standards for SAIL III	Gaps for SAIL III	Recommended standards for SAIL IV	Gaps for SAIL IV
Light-UAS.2510	#5	ED-280 and ED-279 complemented with a Common Mode Analysis following ASTM F3309 § 4.6. Design and installation appraisal from ASTM F3309 §4.4.1 and 4.4.2	None	Same as SAIL III	Point (a)(3) not covered
	#10,12 (SW)	ASTM F3201 – 16	None	EUROCAE ED-12C and EASA AMC 20-152A	None
	#10,12 (HW)	EUROCAE ED-80 and EASA AMC 20-115D	None	Same as SAIL III	
Light-UAS.2511(a) and (b)(2)	Step #9	ED-280 and ED-279 complemented with a Common Mode Analysis following ASTM F3309 § 4.6. Design and installation appraisal from ASTM F3309 §4.4.1 and 4.4.2	None	N.A.	
Light-UAS.2511(b)(1)		EUROCAE ED-269 and ED-270 depending on the required probability	None	N.A.	
Light-UAS.2511(b)(3)		For SW: ASTM F3201 – 16 or EUROCAE ED-12C and EASA AMC 20-152A depending on containment reliability For HW: EUROCAE ED-80 and EASA AMC 20-115D	None	N.A.	

Light-UAS.2512	M1 and M2	Recommended standards depending on selected mitigation. See section 6.3.3		
Light-UAS.2515	#24	Several standards available but actual applicability must be further assessed after a technical evaluation. For details see section 6.4.3		
Light-UAS.2520	#24	ASTM F3367-21	Standard to be further assessed as it is not currently accepted by EASA for manned aircraft. No coverage for GCS	Same as SAIL III
Light-UAS.2528	#18	EUROCAE Guidelines on the Automatic protection of the flight envelope from human errors for UAS	Standard still under development	Same as SAIL III
Light-UAS.2529	#4	ASTM F3298 – 19 (10.2.2), ISO CD 21384-2 (10.5) and EUROCAE guidelines for the use of multi-GNSS solutions for UAS	No gap but EUROCAE guidelines not published yet	Same as SAIL III
Light-UAS.2530	#4	ASTM F3298 – 19 (A2.4.2 and A2.4.3)	Strobe lights not covered	Same as SAIL III
Light-UAS.2575	#5	ASTM F3002-14	It only addresses UAS < 25kg Communication function is not covered	Same as SAIL III

7 Subpart G - Remote Crew Interface and Other Information

7.1 Light-UAS.2600-2602

7.1.1 Requirement Description Light-UAS.2602 Command Unit Integration

(a) This subpart is applicable to the UA in combination with Command Units to remotely control the UA.
(b) The type design of the UA must specify the Command Unit design and identify all equipment and systems of the CU that are essential for the crew to operate the UA.
(c) Equipment and systems of the CU must be designed and installed in accordance with subpart F.
(d) The type design of the UA needs to specify the design of the CU to the level of detail required to ensure compliance with this special condition and the identified design assurance levels.
(e) All necessary instructions, information and requirements for the safe and correct interface between the CU and the UA must be available.
(f) The Flight Manual shall address all combinations of Command Unit models accepted to control the UA.
(g) Design provisions and procedures for safe transfer of control within and between command units, remote crew handovers, and control link switchovers as foreseen for the operation need to be developed.
(h) Design provisions and procedures for safe handling during operation and when applicable for configuration, storage and transportation of the CU need to be defined.
(i) Procedures for installation and maintaining the CU in a condition for safe operation need to be made available in the Instructions for Continued Airworthiness (ICA) as prepared in accordance with LightUAS.2625.
(j) The applicant needs to perform satisfactorily integration tests with all approved models of CU as necessary to verify the validity of the declared conditions and limitations and to ensure that the CU will operate satisfactorily and reliably using any C2 Link as specified under the anticipated operating conditions.

7.1.2 Requirement Description Light-UAS.2602 Command Unit

(a) The Command Unit must be adequate to support the command and control of the UA for the intended operations.
(b) The CU must provide an adequate work environment and human machine interface to allow for the safe execution of operations. The CU must allow the remote crew to perform their duties without excessive concentration, skill, alertness, or fatigue and its design shall consider human factors principles.
(c) The applicant needs to design the system controls and displays so that the remote crew can monitor and perform defined tasks associated with the intended functions of systems and equipment. The system and equipment must be designed to minimise the flight crew errors and must account for flight crew errors which could result in additional hazards

7.1.3 Link with SORA OSOs

The above requirements are linked with the following Operational Safety Objectives:

- OSO#4: UAS developed to authority recognised standards, that is required at Low Robustness for both SAIL III and IV.
- OSO#20: A Human Factors evaluation has been performed and the HMI found appropriate for the mission, that is required at Low Robustness for SAIL III and Medium Robustness for SAIL IV.

7.1.4 Coverage

Since most of the sub-requirements are covered other subparts or in the following requirements of subpart G, the following table only reports standards assessed in relation to sub-requirement (j).

For Light-UAS.2602 no standard covers adequately the human factors aspects. The same considerations made in the 2nd iteration for SORA OSO#20 still apply here: STANAG 4671 and 4703 in principle cover the requirement up to SAIL IV. Nonetheless, their approach is systems oriented (navigation, powerplant parameters…) and furthermore mainly focus on ergonomics and anthropometrics, but most of the human performance issues observed with modern systems and HMIs are related to cognitive ergonomics and usability matters. In addition, STANAG standards are too much complex and expensive for SAIL III and IV.

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
F3002-14a: Standard Specification for Design of the Command and Control System for Small Unmanned Aircraft Systems (sUAS)	9	III IV	Only covers integration of C2 link.	Verification methods not specifically provided. ASTM F3003 can be used as a reference.	6	

7.2 Light-UAS.2605-2610-2615

7.2.1 Requirement Description Light-UAS.2605 Command Unit Installation and operation information

(a) The minimum number of crew members or the acceptable UA to crew ratio for safe operation of the CU and UAS must be established.
(b) Each item of installed equipment related to the remote crew interface must be labelled, if applicable, as for its identification, function, or operating limitations, or any combination of these factors.
(c) There must be a discernible means of providing system operating parameters required to operate the UA including warnings, cautions, and normal indications, to the responsible remote crew.
(d) Information concerning an unsafe system operating condition must be provided in a timely manner to the crew member responsible for taking corrective action. The information must be clear enough to avoid likely crew member errors. (e) Information related to safety equipment must be easily identifiable and its method of operation must be clearly marked.

7.2.2 Requirement Description Light-UAS.2610 Instrument markings, control markings and placards

(a) The CU must display in a conspicuous manner any placard and instrument marking necessary for operation.
(b) The design must clearly indicate the function of each control, unless obvious.
(c) The applicant needs to include instrument marking and placard information in the Flight Manual.

7.2.3 Requirement Description Light-UAS.2615 Flight, navigation, and thrust/lift/power system instruments

Installed systems must provide the remote crew member, who sets or monitors parameters for the flight, navigation, and lift/thrust/power system the information necessary to do so during each phase of flight. This information must:

(a) be presented in a manner that the crew members can monitor the parameters and trends, as needed to operate the UA; and
(b) include limitations, unless the limitation cannot be exceeded in all intended operations.

7.2.4 Link with SORA OSOs

The above requirements are linked with the following Operational Safety Objectives:

- OSO#4: UAS developed to authority recognised standards, that is required at Low Robustness for both SAIL III and IV.
- OSO#20: A Human Factors evaluation has been performed and the HMI found appropriate for the mission, that is required at Low Robustness for SAIL III and Medium Robustness for SAIL IV.

7.2.5 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ED-272 Minimum Aviation Systems Performance Standard for Remote Pilot Stations supporting IFR operations into non-segregated airspace	All	IV	All	Not applicable for small UAS flying at VLL.	2	Score is driven by cost of compliance that is estimated to be high since most requirements are too demanding and/or not applicable

AMC to Certification Specification for Light Unmanned Aeroplane Systems (CS-LUAS)	Subpart I of Book 2	III IV	All	Verification methods are not included	4	Score is driven by cost of compliance that is estimated to be medium due to the lack of verification methods
F3298-19: Standard Specification for Design, Construction and Verification for Lightweight Unmanned Aircraft Systems (UAS)	10	III IV	All	None	6	Score is driven by cost of compliance that is estimated to be low
ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	12	III IV	All	Verification methods are not included	4	Score is driven by cost of compliance that is estimated to be medium due to the lack of verification methods

ASTM F3298-19 Section 10 is the preferred standard but its applicability to UAS above 25kg of MTOM should be further assessed.

7.3 Light-UAS.2620 Flight Manual

7.3.1 Requirement Description

The applicant needs to provide a Flight Manual containing the following information:

(a) operating limitations and procedures, for the intended operation;
(b) performance information;
(c) loading information;
(d) procedures and limitations for transportation, reconfiguration and storage;
(e) instrument marking and placard information; and

(f) any other information necessary for the safe operation of the UAS.

7.3.2 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
F2908-18 Standard Specification for Aircraft Flight Manual (AFM) for a Small Unmanned Aircraft System (sUAS)	All	III IV	Full coverage		6	The score is driven by the cost of compliance that is estimated to be low.

7.4 Light-UAS.2625 Instructions for Continued Airworthiness (ICA)

7.4.1 Requirement Description

(a) The applicant needs to prepare Instructions for Continued Airworthiness that are appropriate for the UAS design and intended operation.
(b) The Instructions for Continued Airworthiness must contain a Section titled 'Airworthiness limitations' that is segregated and clearly distinguishable from the rest of the document. This Section must contain a legible statement in a prominent location that reads: 'The Airworthiness limitations Section is approved and variations must also be approved'.

7.4.2 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
F2909-19 Standard Practice for Maintenance and Continued Airworthiness of	All	III IV	Full	In principle it is only applicable to UAS with MTOM up to 25kg, but	6	Score is driven by cost of compliance that is estimated to be Low since

Small Unmanned Aircraft Systems (sUAS)				applicability can be extended if approved by NAA		the standard is specifically developed for small UAS
F3366-19 Standard Specification for General Maintenance Manual (GMM) for a small Unmanned Aircraft System (sUAS)	All	III IV	Supporting standard for the above covering Maintenace Manuals		6	

7.5 Summary and conclusions

SC Requirements	Link SORA OSO(s)	Recommended standards for SAIL III	Gaps for SAIL III	Recommended standards for SAIL IV	Gaps for SAIL IV
Light-UAS.2600	#4	F3002-14a: Standard Specification for Design of the Command and Control System for Small Unmanned Aircraft Systems (sUAS)	Only covers integration of C2 Link. For verification methods refer to ASMT F3003	Same as SAIL III	
Light-UAS.2602	#20	No standard recommended			
Light-UAS.2605-2610-2615	#4 #20	F3298-19: Standard Specification for Design, Construction and Verification for Lightweight Unmanned Aircraft Systems (UAS)	Applicability for UAS with MTOM > 25kg to be assessed	Same as SAIL III	
Light-UAS.2620	N.A.	F2908-18 Standard Specification for Aircraft Flight Manual (AFM) for a Small Unmanned Aircraft System (sUAS)	None	Same as SAIL III	

Light-UAS.2625	N.A.	F2909-19 Standard Practice for Maintenance and Continued Airworthiness of Small Unmanned Aircraft Systems (sUAS) Complemented by F3366-19 Standard Specification for General Maintenance Manual (GMM) for a small Unmanned Aircraft System (sUAS)	None	Same as SAIL III

8 Subpart H - C2 Link

All the requirements in this subpart are linked with OSO#6: C3 link characteristics (e.g. performance, spectrum use) are appropriate for the operation.

8.1 Light-UAS.2710 General Requirements

8.1.1 Requirement Description

(a) This subpart is applicable for C2 Link command, control and communication function required for the safe operation of the UA.
(b) C2 link performances must be specified as part of the Type Design of the UA
(c) C2 Link Performance needs to be provided in the Flight Manual.

8.1.2 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
F2908-18 Standard Specification for Aircraft Flight Manual (AFM) for a Small Unmanned Aircraft System (sUAS)	7.5.4	III IV	Point (c)	The standard provides only a list of the information to be provided without additional details or guidance.	2	The score is driven by the Cost of compliance that is estimated as high since the standard does not provide additional guidance with respect to the requirement text.

No standards are identified for Light-UAS.2710 (a) and (b) but a standard might not be required to support the demonstration of compliance. For (b) the identified standard does not provide much additional guidance and it is therefore not recommended.

8.2 Light-UAS.2715 C2 Link Performances

8.2.1 Requirement Description

(a) The C2 link performance must be adequate to ensure safe operation and must be protected from external interference.
(b) The C2 Link system message sequencing must be such to preserve the safety of the operation.

8.2.2 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	11.7	III IV	All	The standard only provides generic guidance and does not provide sufficient detail.	2	Cost of compliance is estimated to be high due to the lack of details provided for the implementation.
ED-266 - Guidance on Spectrum Access, Use and Management for UAS	All	III IV	Only (a)	Only guidance on the selection of the appropriate spectrum is provided	7	Even if this document only provides guidance, cost of compliance is estimated to be low and there is a positive impact on the environment from the right selection of frequencies and power levels.
ED-265 Minimum Operational Performance Standard for RPAS	All	IV	All	No gap for C-band satellite Data Link	2	Cost of compliance is estimated as high and drives the score.

Command and Control Data Link (C-Band Satellite)						
DO-362 Command and Control (C2) Data Link Minimum Operational Performance Standards (MOPS) (Terrestrial)	All	IV	All	No gap for C-band terrestrial Data Link	2	Cost of compliance is estimated as high and drives the score.
IEEE 802.11-2020 WIFI technology (2.4 GHz + 5 GHz Band)	All	III IV	All	No gaps for the C2 technology selected	6	These standards have a low cost of compliance since they are based on well-established technologies for which COTS products exist.
IEEE 802.15.3c-2009 Bluetooth technology	All	III IV	All	No gaps for the C2 technology selected	6	
IEEE 802.22 Wireless regional area network (WRAN)	All	III IV	All	No gaps for the C2 technology selected	6	
EUROCAE LTE C2 MOPS	N.A.	III IV	No draft available. Assessment not performed.			

Standard ED-266 is recommended to select the appropriate spectrum. Then, depending on the selected frequency and system architecture different standards can be used. All the standards assessed are potentially suitable and can be recommended.

8.3 Light-UAS.2720 C2 Link Performance monitoring

8.3.1 Requirement Description

If required for safe operation:

(a) the UAS remote crew must have the means to continuously monitor C2 link performance and ensure that it continues to meet the identified required operational performance; and
(b) appropriate technical and procedural means must be provided to the remote crew to establish and maintain the C2 link, including, where applicable, the interaction with the Command & Control Communication Service (C2CSP). The Applicant needs to provide these means within the Flight Manual.

8.3.2 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ASTM F3298 – 19 Standard Specification for Design, Construction, and Verification of Lightweight Unmanned Aircraft Systems	10.6	III IV	Point (b) and focuses only on Lost-link procedures	It does not include interaction with C2CSP	4	Score is driven by cost of compliance that is estimated Medium since the level of detail is limited thus increasing the cost to comply with the requirement using this standard.
F3002-14 - Standard Specification for Design of the Command and Control System for Small Unmanned Aircraft Systems (sUAS)	9.2	III IV	All	It does not cover the reporting of the information into the Flight Manual	6	Score is driven by cost of compliance that is estimated Low since the standard is intended for small UAS and sufficiently detailed to allow an easy implementation.
ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	11	III IV	All	The standard only provides generic guidance and does not provide sufficient detail.		

F2908-18 Standard Specification for Aircraft Flight Manual (AFM) for a Small Unmanned Aircraft System (sUAS)	7.8.2.2	III IV	Point (b)	No detail provided on how to report the information. The standard only reserves a section for the information	4	Score is driven by cost of compliance that is estimated Medium since the level of detail is limited thus increasing the cost to comply with the requirement using this standard.

8.4 Light-UAS.2730 C2 Link Security

8.4.1 Requirement Description

(a) Information exchange between the Command Unit and the UA via the C2 Link must be secure to prevent unauthorized interference with the UA.
(b) The C2 Link system must enable the UA to unambiguously and at any time ensure that it is controlled by an authorized Command Unit.

8.4.2 Coverage

Standard	Applicable section(s)	SAIL	Coverage	Gaps	Score	Rationale
ED-265 Minimum Operational Performance Standard for RPAS Command and Control Data Link (C-Band Satellite)	3.1.7 and 3.1.8	IV	All	No gap for C-band satellite Data Link	2	Cost of compliance is estimated as high and drives the score.
DO-362 Command and Control (C2) Data Link Minimum	All	IV	All	No gap for C-band terrestrial Data Link	2	Cost of compliance is estimated as high and drives the score.

Operational Performance Standards (MOPS) (Terrestrial)						
IEEE 802.11-2020 WIFI technology (2.4 GHz + 5 GHz Band)	All	III IV	All	No gaps for the C2 technology selected	6	These standards have a low cost of compliance since they are based on well-established technologies for which COTS products exist.
IEEE 802.15.3c-2009 Bluetooth technology	All	III IV	All	No gaps for the C2 technology selected	6	
IEEE 802.22 Wireless regional area network (WRAN)	All	III IV	All	No gaps for the C2 technology selected	6	
ISO CD 21384-2 Unmanned aircraft systems — Part 2: UAS Components	11.8	III IV	All	The standard only provides generic guidance and does not provide sufficient detail.	2	Cost of compliance is estimated to be high due to the lack of details provided for the implementation.

8.5 Summary and conclusions

SC Requirements	Link SORA OSO(s)	Recommended standards for SAIL III	Gaps for SAIL III	Recommended standards for SAIL IV	Gaps for SAIL IV
Light-UAS.2710	#6	No standard recommended			
Light-UAS.2715		ED-266 - Guidance on Spectrum Access, Use and Management for UAS complemented by a technology-specific standard (see list in section 8.2.2)	no Gaps	Same as SAIL III	

Light-UAS.2720		F3002-14 - Standard Specification for Design of the Command and Control System for Small Unmanned Aircraft Systems (sUAS)	It does not cover the reporting of the information in the Flight Manual	Same as SAIL III
Light-UAS.2730		Recommended standard depends on the technology selected	No gaps	Same as SAIL III