Proposed Special Condition for Light UAS

Introductory note

The following Special Condition has been classified as an important Special Condition and as such shall be subject to public consultation, in accordance with EASA Management Board Decision 12/2007 dated 11 September 2007, Article 3 (2.) of which states:

"2. Deviations from the applicable airworthiness codes, environmental protection certification specifications and/or acceptable means of compliance with Part 21, as well as important special conditions and equivalent safety findings, shall be submitted to the panel of experts and be subject to a public consultation of at least 3 weeks, except if they have been previously agreed and published in the Official Publication of the Agency. The final decision shall be published in the Official Publication of the Agency."

Statement of Issue

Commission Implementing Regulation (EU) 2019/947 of 24 May 2019 and Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 on Unmanned Aircraft Systems are the cornerstones of the new European UAS regulation. They define the overarching subdivision of UAS operations into three categories - Open, Specific and Certified – and the thresholds between these categories.

The Open Category is characterised by a set of operational restrictions depending on the subcategory of operation (A1, A2 or A3) and technical requirement depending on the UAS Class. The compliance with the technical requirements is determined by market regulation mechanisms linked to the placing of CE Marking on products made available on the European Union market. One of the most important operational restrictions is that all the subcategories of operation must be operated in visual line of sight.

The Specific Category of Operation is based on a risk assessment performed by the Operator according to Article 11 of the Implementing Regulation and on an operational authorisation provided by the National Aviation Authority based on that risk assessment. EASA has adopted AMC and GM to Commission Implementing Regulation (EU) 2019/947 (referred to as EASA AMC and GM in this document) which includes the accepted methodology for the risk assessment

At the time of the writing of this SC, rulemaking on the Certified category of operation is ongoing.

This Special Condition addresses airworthiness specifications for UA, not the authorization of operations in the specific category. Nevertheless, as defined by Commission Implementing

Regulation 2019/947, some operations in the Specific category may be authorised by the NAA only if the UAS operator demonstrates that he/she is operating a UA certified by EASA. EASA has adopted AMC which provide further guidance on when the Regulation requires the certification of the UA.

Until today, the certification basis of UAS has been either derived from manned aircraft CS integrated with Special Conditions to address specific UAS aspects, or defined with Special Conditions based on documentation developed and published by JARUS (joint authorities on rulemaking for unmanned air systems). In both cases the approach has been prescriptive. Objective based CS are deemed more appropriate for UAS.

Therefore, EASA decided to develop a dedicated SC for light UAS, which will be applied in accordance with point 21.B.80 when the Agency has to determine the certification basis for light aircraft, considering that no existing CS is applicable to those aircraft.

The objective airworthiness standards proposed in this SC are intended to be applied for future UAS projects for which a TC/RTC is applied for and which fall within its scope. This SC may also be elected to be complied with by applicants which already applied for type certification and where EASA has already established the certification basis based on other standards.

Most UAS designs have a limited MTOM up to a few hundreds Kg. Especially considering the expansion of urban operations, the vast majority of upcoming UAS operations is expected with UAS of limited mass. The operation of such UAS may often fall in the specific category, where operational approval is provided by the National Aviation Authorities but UAS shall be certified by EASA for higher risk operations and depending on the conops, or might be certified voluntarily for lower risk ones.

Once more experience has been gained with the certification of UAS with the application of the SC light UAS, EASA intends to transpose this SC into a CS.

For UA of higher maximum take-off mass, closer to traditional aircraft or capable of carrying persons the certification basis may be established on the basis of existing manned aircraft CS (CS-23/27, CS-25/29), complemented with appropriate airworthiness standards from a CS-UAS, yet to be created, focused only on UAS-peculiar elements.

The Agency's intent to organise the future CS is presented in Figure 1.

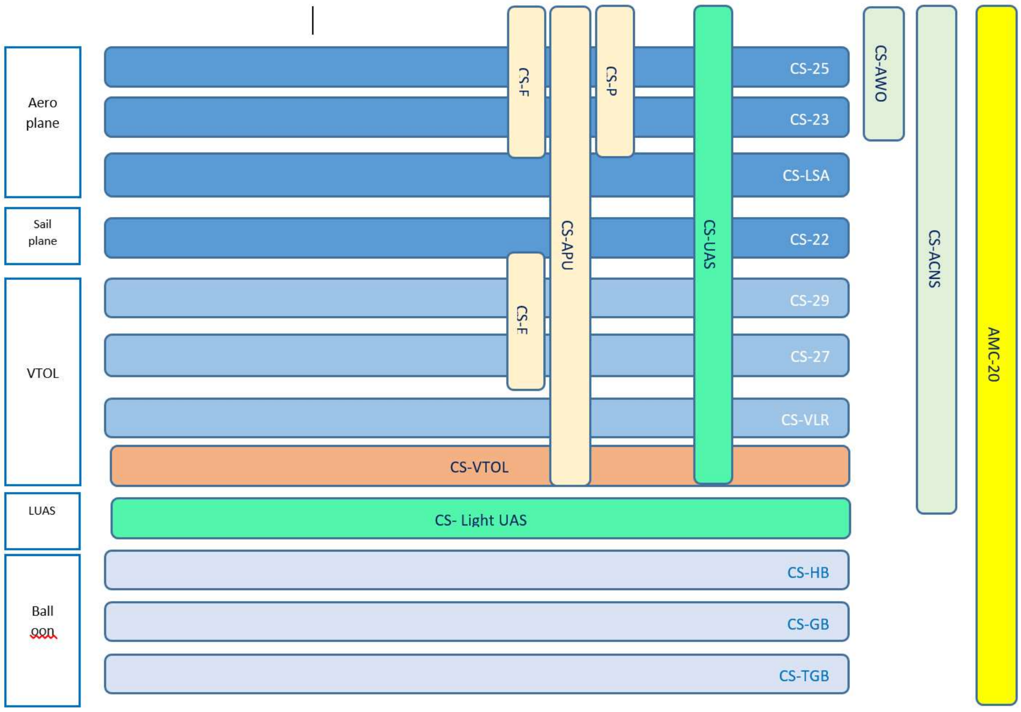

Fig.1 CS Organisation

In the absence of those CS, the certification basis for UAS certification projects ongoing and in the near future will be established consistently with the longer term strategy identified above, on the basis of special conditions.

An objective-based, operation centric and proportional approach to UAS certification

When appropriate, EASA establishes certification specifications or special conditions in an objective based manner, rather than prescribing detailed technical specifications. Examples are CS-23 Amendment 5, and the recent SC VTOL. Such an approach is also deemed to be appropriate for UAS as it provides a safe environment while leaving flexibility to certify various design concepts in an area where the technology and design solutions rapidly evolve.

With no occupant on-board, the risk inherent to any UAS operation is strictly dependent on the characteristics of the operational volume, and of the adjacent ones which the UA might inadvertently enter. An operation-centric and risk-based approach is therefore also necessary in the context of UAS certification. Every UAS certification application shall be linked to a detailed definition of the operational volume, buffers and adjacent volumes, in terms of both ground and air risks, and any restriction, limitation and mitigation means which are assumed to be applicable for its operation. The definitions will be in line with the EASA AMC and GM. The TC issued on that basis will only permit operations in this context.

Suitable means of compliance (MOC) with this SC will be key to ensuring proportionality and to ensure that the same certification basis is suitable for a very wide range of designs including a range of MTOM. This SC presents in Annex I the MOC which can be used to demonstrate compliance with Light-UAS.2510 High Risk. No other MOCs are presented so far, as they will be developed in a second stage and, when considered necessary, the most significant ones may be publicly consulted. For unusual designs and operations, and where MOC have not been developed by the Agency, it is expected that applicants will propose to the Agency new MOC or modified ones. As always, EASA will carefully evaluate any proposed means of compliance that is provided by applicants.

Applicability

This SC is applicable to UAS:

- Not intended to transport Humans
- Operated with intervention of the remote pilot or autonomous [1]
- With MTOM up to 600 Kg
- Operated in the specific category of operations, medium and high risk, or in the certified category of operations

The concept of level of risk in operations of the specific category is based on Art 11 of Implementing Regulation and is hinged on the EASA AMC and GM, and in particular on the SAIL (specific assurance integrity level) as identified by such AMC and GM.

The UAS operator is required to demonstrate the operational safety objectives (OSO) with a level of robustness proportionate to the SAIL. Operational Safety Objectives ("OSOs") related to design need to be demonstrated with a high level of robustness when the operation is classified as SAIL V and VI. SAIL V and VI are herein defined as "High Risk". For operations classified with a lower SAIL the level of robustness may be medium (SAIL 3 or 4) or low. UA Certification standards for low risk operations are not included in this SC

In a few cases the SC differentiates between medium and high risk requirements and provides different airworthiness standards for them. In most instances no distinction is proposed at the objective standards level: Means of Compliance will be tailored to the risk level, and different means of compliance demonstration to airworthiness objectives will be provided for a medium risk and a high risk operation. Airworthiness standards for the certified category of operations are those defined for the high risk part of the Specific category.

This SC does not mandate the use of certain equipment that might be required for specific operations, such a Transponder, ADS-B, Flight Recorders. When this equipment is required, it will have to be installed according to the standards of Subpart F of this SC.

[1] Autonomous operation, as defined by Regulation (EU) 2019/945, means an operation during which an unmanned aircraft operates without the remote pilot being able to intervene.

The SC is considered to be applicable to various designs but additional SC may have to be prescribed in accordance with point 21.B.75, e.g. in those cases in which the product includes specific technology novelties such as fully autonomous operations. .

Methodology and principle at the base of the SC

In order to develop this SC, EASA has analysed and compared the JARUS CS-UAS, previous EASA published RPAS special conditions and EASA SC VTOL. The JARUS CS-UAS and EASA SC VTOL are both based on CS 23 Amendment 5. Another document considered for reference has been the FAA Yamaha Fazer certification basis, keeping in mind the low associated operational risk. As the SC covers certification for operations in the specific category, the determination of airworthiness objectives of Light-UAS has taken into consideration design-related OSOs) determined by the EASA AMC and GM which is based in the JARUS SORA.

The certification of light UAS with highly integrated systems will be fundamentally based on a safety assessment that includes thrust / lift / power systems and also interaction with structures. Applying 2510 systematically to all systems enables a flexible approach on system levels and achieves the overall safety objectives for the aircraft. This approach was introduced for distributed propulsion (lift/thrust/power) in the SC VTOL and this SC has consequently adopted to this approach.

Requirement of previous CSs considered as input have been reviewed with the aim of defining the simplest possible SC but avoiding gaps or redundancies among subparts.

Safety Objectives

This SC sets in SC Light-UAS.2510 the safety objectives for UAS certification. The MOC to Light-UAS.2510 high risk (see Annex I to this SC) provides tables linking the Severity of Failure Conditions, allowable probabilities per failure condition per Flight Hour and Development Assurance Levels (DALs). The tables are accompanied by definitions and notes that are consistent with the EASA AMC and GM. These core elements will be adapted as required for the projects

EASA has considered it appropriate to determine MOC to high risk safety objectives on the basis of an assessment of a probable urban scenario projected in 2035. This is the minimum time frame usually taken as reference for projections of significantly established drone operations and the one adopted by the SESAR Joint Undertaking Outlook Study. It has also been considered that safety objectives assigned to drones for operation in urban environment should be such as to not lead to risks for uninvolved people higher than those determined for UAM operations. A methodology similar to the one utilised to derive safety objectives for SC VTOL has therefore been applied, in synthesis based on:

- the calculated number of FH flown by drones in the generic / average European city in 2035
- a representative urban population density
- representative products and operational assumptions

Safety objectives determined for populated environment have been transposed for operation over assemblies observing the link between SAIL levels in the EASA AMC and GM.

The safety objectives are defined for UAS operating in airspace with a residual air risk class lower than D as defined by the EASA AMC and GM (SORA). The assumption on the air risk class is in line with the typical urban environment and determines a dependence of the safety objectives uniquely on the final GRC.

According to the EASA AMC and GM, mitigation means M1 and M2, when applied, may determine a reduction of the initial ground risk class (iGRC). Such mitigation means may be considered in the determination of the safety objectives:

- Mitigation means M1 are strategic mitigations intended to reduce the number of people at risk on the ground. It should be considered that a decrease in the iGRC of one point could be claimed if the number of people at risk on the ground is reduced by at least one order of magnitude. Such mitigation, if proposed by applicants, will be discussed with EASA in the frame of the determination of the safety objectives and may lead to airworthiness limitations.

- Mitigation means M2 are intended to reduce the effects of ground impacts by design and can either reduce the area affected by the impact (the “crash area”) or reduce the energy transmitted in a crash to a very low level (e.g. a parachute, an energy absorbing design). If a sufficient reduction of the impact area is demonstrated, this may be taken into account when defining the safety objectives in application of the MOC to Light-UAS.2510. -With regard to the Classification of the failure condition, the effectiveness of M2 mitigation means should be taken into account. For example a failure condition (FCx) that would be classified as catastrophic (CAT) when M2 is not applied, may be replaced by two different failures conditions (FCx1 and FCx2) when M2 is applied:

    - FCx1 corresponding to the original FCx when M2 performs as intended, that may be classified Hazardous (HAZ)
    - FCx2 corresponding to the original FCx when M2 is not performing as intended, that may still be classified Catastrophic (CAT).

  In the case of a reduction in the energy transmitted during a crash, depending on the level of reduction EASA will assess the potential link with the failure hazard classification.

The TCDS will provide the dataset on the base of which the product is certified and will reflect the mitigations described above. The reduction of the iGRC on the basis of mitigations will always be determined and tracked, also to identify a possible transition from high risk (SAIL 5) to medium risk (SAIL 4), for which the Safety Objectives determined in Annex I are not applicable. For medium risk operations, different MOCs to address the safety objectives will be developed.

Definitions

The terminology used with this Special Condition is addressed under Subpart A General, with the exception of the definitions of terms already used in the Implementing Regulation, in Delegated Regulation (EU) 2019/945, and in the EASA AMC and GM (namely the terms and abbreviations UA, UAS, Remote Pilot, Operator, Control Unit, VLOS, BVLOS, EVLOS, Operational Volume, adjacent areas). This SC uses the term “remote crew” to indicate the crew made up of the remote pilot in control of the UA and any other personnel actively involved in the operation of the UA. The terms has already been used by other EASA SCs.

CONTENTS

SUBPART A – GENERAL

Subpart A: GENERAL

Light-UAS.2000 Applicability and Definitions

This Special Condition prescribes objective airworthiness standards for the issuance of the type certificate, and changes to this type certificate, for Unmanned Aircraft (UA):

(a) intended to be operated in the Specific category and whose operation is demonstrated to be medium or high risk, or in the Certified category,

(b) with MTOMs not exceeding 600 Kg,

(c) with no occupants and not transporting humans externally.

Note: Additional SC may have to be prescribed in accordance with point 21.B.75, e.g. in those cases in which the product includes specific technology novelties.

For the purposes of this Special Condition, the following definition applies:

(1) ‘normal flight envelope’ means the flight envelope associated with routine operations and/or prescribed conditions;

(2) ‘limit flight envelope’ means the flight envelope that is set by the aircraft design limits or protection limits;

(3) ´ancillary equipment´ means the equipment required for the safe operation of the UA that is not installed in the UA or the Command Unit and that is not part of the specified C2 Link and that is identified and specified in the type design of the UA.

Light-UAS 2005 Definition of the operational scenario

The applicant needs to define the limitations associated with the operational scenario within which a safe flight will be demonstrated.

Every application should include a detailed definition of the operational volume, buffers and adjacent volumes, in terms of both the ground and air risk, and any restriction, limitation and mitigation means which are assumed to be applicable for its operation. The definitions will be in line with the EASA AMC and GM

Light-UAS.2010 Accepted Means of Compliance

(a) An applicant can comply with this Special Condition using an acceptable means of compliance (AMC) issued by EASA, or another means of compliance which may include consensus standards, when specifically accepted by EASA.
(b) An applicant requesting EASA to accept a means of compliance must provide the means of compliance to EASA in an acceptable form and manner.

SUBPART B - FLIGHT

LIGHT-UAS.2100 Mass and centre of gravity

(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.

Light-UAS.2102 Approved Flight envelope

(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

Note: 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.

Light-UAS.2105 Performance data

(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 Light-UAS.2510 must be taken into account.

Note: MOC will specify the performance as applicable for the design and operation of the UA and take into account:

- The UA minimum safe speed or the minimum steady flight speed for each flight configuration and phases of flight;

- The UA minimum performance required for take-off;

- The UA minimum climb performance;

- The UA minimum descent performance;

- At critical combinations of flight parameters:

    - The area required to land and come to a stop, assuming approach paths applicable to the UA; and

    - The approach and landing speeds, configurations, and procedures;

- For UA intended to load and unload cargo or other ballast when the UA is in flight or hovering, performance data within the operational limitations for Loading and Unloading; and

- For UA intended to fly with external cargo or a payload relevant performance data at critical combinations of flight parameters.

Light-UAS.2135 Controllability, manoeuvrability and stability

(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.

Light-UAS.2160 Vibration and buffeting

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.

SUBPART C -STRUCTURES

Light-UAS.2200 Structural design

The structural design envelope must be determined, which describes the range and limits of the UA design and operational parameters for which compliance with the airworthiness standards of this Subpart is shown. This design envelope considered as a limit condition needs to account for all UA design and operational parameters that affect structural aspects.

Light-UAS.2210 Structural design loads

(a) The applicable flight loads, ground loads, handling loads and loads while the UAS is parked or moored must be determined. The loading conditions need to be considered at all critical combinations of parameters, on and within the boundaries of the structural design envelope.
(b) Vibration, including air or ground resonance, and buffeting must not result in structural damage.

Light-UAS.2230 Limit and ultimate loads

Unless special or other safety factors are necessary to meet the airworthiness standards of this Subpart, the applicant needs to determine:
(1) the limit loads, which are equal to the structural design loads; and
(2) the ultimate loads, which are equal to the limit loads multiplied by safety factor of 1.5 unless otherwise provided.

Light-UAS.2235 Structural strength

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.

Light-UAS.2240 Structural durability

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.

Light-UAS.2250 Design and construction principles

(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.

Light-UAS.2260 Materials and processes

(a) Materials must be suitable for the intended use.
(b) Design values must be chosen so that no structural part is under strength as a result of material variations or load concentration, or both.

SUBPART D –DESIGN AND CONSTRUCTION

Light-UAS.2300 UA flight control systems

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

Light-UAS.2305 Landing gear systems

(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 loading conditions must not cause damage to the essential systems of the UA, which could lead to a hazardous or catastrophic event if not detected.

Light-UAS.2325 Fire protection

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

Light-UAS.2335 Lightning protection

(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 lightening, limitations must be developed to prohibit flight, including take-off and landing, into conditions where the exposure to lightning is likely.

Light-UAS.2340 Design and construction information

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

Light-UAS.2350 Forced landing or a crash

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

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

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 avoided by proper design provisions.

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

SUBPART E –LIFT/THRUST/POWER SYSTEM INSTALLATION

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

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 of Lift/Thrust/Power Control Systems and the Lift/Thrust/Power 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 including foreign object threats.
e. All necessary instructions, information and requirements for the safe and correct interface between the lift/thrust/power system and the aircraft need to be available.

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

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

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

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 minimise the probability of failure of the system and sub-systems between overhaul periods, or between replacement intervals of parts,
c) a complete disassembly after the endurance and durability tests has been completed and each component must be within service limits and eligible for continued operation in accordance with the instructions for continued airworthiness,
d) an operational demonstration including tests, validated analysis, or a combination thereof to demonstrate the performance of the system throughout its declared operating range and operational limitations.

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

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) The following ratings and operational limitations need to be established:
   1. Ratings and operating limitations, including ratings and limitations based on the operating conditions and any other information found necessary for safe operation of the system.
   2. Operating limitations including any limitation required to be monitored to ensure the safe operation of the system and its associated sub-systems.
   3. Ratings for Take-off Lift/Thrust/Power and for Maximum Continuous Lift/Thrust/Power, as well as for Emergency Ratings, if needed.
   4. The maximum permitted duration for ratings other than Maximum Continuous Lift/Thrust/Power Rating, if needed.

Light-UAS.2430 Energy storage and distribution systems

(a) Each system must

(1) Provide compatible and uninterrupted energy as required with adequate margins to ensure safe functioning of the supported systems.

(2) Provide information and warnings to the remote crew regarding normal and degraded modes and remaining energy.

(b) Each storage system must be designed and installed to:

(1) Withstand the loads under likely operating conditions without failure, accounting for installation,

(2) 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,

(3) Maintain safe operating temperatures, pressures, or any other identified parameter, during normal operation,

(4) provide means of protection, or controlling to prevent hazardous conditions during normal operation or probable malfunction,

(5) Minimise hazards during ground handling, refilling or recharging, storage and exchange of the storage device or its components if such a function is provided.

SUBPART F – SYSTEMS AND EQUIPMENT

Light-UAS.2500 Systems and equipment function - General

(a) Light-UAS.2500, 2505 and 2510 are general airworthiness standards applicable to systems and equipment installed in the UAS and should not be used to supersede any other specific Light-UAS airworthiness standard.
(b) Equipment and systems required to comply with type certification requirements, airspace requirements or operating rules, or whose improper functioning would lead to a hazard, must be designed and installed so that they perform their intended function throughout the operating and environmental limits for which the aircraft is certified.

Improper functioning of equipment and systems may be caused by intentional unauthorised electronic interaction (IUEI). The applicant may then also consider cybersecurity threats as possible sources of 'improper functioning' of equipment and systems and consider AMC 20-42 in showing compliance with this Subpart for equipment and systems whose improper functioning could lead to a failure condition more severe than major. This AMC provides acceptable means, guidance and methods to perform security risk assessment and mitigation for aircraft information systems.

Light-UAS.2505 General Requirement on Equipment Installation

Each item of installed equipment must be installed according to limitations specified for that equipment.

Light-UAS.2510 Equipment, Systems and Installation (High Risk)

(a) The equipment and systems identified in Light-UAS.2500, considered separately and in relation to other systems, must be designed and installed such that:

(1) Each catastrophic failure condition is extremely improbable and does not result from a single failure;

(2) Each hazardous failure condition is extremely remote; and

(3) Each major failure condition is remote.

(b) *The operation of equipment and systems not covered by Light-UAS.2505 and Light-UAS 2510 must not cause a hazard throughout the operating and environmental limits for which the UAS is certified.*

Note: MOC for Light-UAS.2510 High Risk can be found in Annex I to this SC.

Note: Operational limitations used to demonstrate compliance with Light-UAS.2510 may be taken into account to demonstrate compliance with Light-UAS.2511.

Light-UAS.2510 Equipment, Systems and Installation (Medium risk)

(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 minimised 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) A strategy 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 Light-UAS.2505 and Light-UAS 2510* must be minimised.

Note

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”.

A MOC for Light-UAS.2510 (medium risk) will be developed by EASA at a later stage.

Light-UAS.2511 Containment

(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 less than 10-4 /FH,

(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.

Compliance with the airworthiness standard referred to in point (a) should be substantiated by a design and installation appraisal and should include at least:

— The design and installation features (independence, separation and redundancy);

— Any relevant particular risk (e.g. hail, ice, snow, electro-magnetic interference, etc.) associated with the operation.

Note: The EASA AMC and GM indicates how to determine whether the risk associated with the adjacent areas on the ground or adjacent airspace is significantly higher than the risk associated with the operational volume *(paragraph 2.5.3, Step #9)*

Compliance with the airworthiness standard referred to in points b (1) and (2) should be substantiated by analysis and/or test data with supporting evidence.

The use of the term 'directly' means that a development error in a software or an airborne electronic hardware would lead the UA outside the ground risk buffer without the possibility for another system to prevent the UA from exiting the operational volume.

Factors to be taken into account to determine the extension of the adjacent area include, but are not limited to, the Conops, the UA endurance range, and the failure modes which may lead to the exit of the UA from the operational volume.

Light-UAS.2515 Electrical and electronic system lightning protection (High Risk)

For a UAS where exposure to lightning is likely:
(a) 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:
(1) the function at the UAS level is not adversely affected during or after the time when the UAS is exposed to lightning; and
(2) 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
(b) each electrical and electronic system that performs a function, the failure of which would significantly reduce the capability of the UAS or the ability of the remote crew to respond to an adverse operating condition, must be designed and installed such that the system recovers normal operation of that function in a timely manner after the UAS is exposed to lightning.

Light-UAS.2515 Electrical and electronic system lightning protection (Medium Risk)

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.

Note: Continued safe flight and landing' means, for operations with intervention of the remote pilot, that a UA is capable of continued controlled flight and landing, possibly using emergency procedures, without requiring exceptional remote pilot skill. Upon landing, some UA damage may occur as a result of a failure condition

Continued safe flight and landing' means, for autonomous operations, that an UA is capable of continued flight and landing, possibly using emergency procedures. Upon landing, some UA damage may occur as a result of a failure condition

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

For a UAS where the exposure to HIRF is likely:

(a) 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:
(1) 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
(2) 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.

(b) each electrical and electronic system that performs a function, the failure of which would significantly reduce the capability of the UAS or the ability of the remote crew to respond to an adverse operating condition, must be designed and installed such that the system recovers normal operation of that function in a timely manner after the UAS is exposed to the HIRF environment.

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

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.

Note: A maximum HIRF Clearance Environment in which systems referred to in (a) and (b) of Light-UAS.2520 are not adversely affected could be defined appropriate for the operation / conops. Associated limitations in the Aircraft Flight Manual should be implemented in order to avoid operations where the defined HIRF Clearance Environment is exceeded.

Light-UAS.2528 UAS Envelope protection Function

(a) The UAS must ensure that the UA remains within the limit flight envelope.

(b) Characteristics of any envelope protection feature and combinations thereof must be appropriate for the phase of flight and type of manoeuvre.

(c) Limit values of protected flight parameters must be compatible with:

(i) structural limits,

(ii) required safe and controllable manoeuvring of the UA under anticipated operating conditions with adequate margins on specified limits,

(iii) prevention of hazardous and catastrophic failure conditions,

(iv) applicable lift/thrust/power system limitations,

(v) dynamic effects due to manoeuvring, lift/thrust/power system characteristics and external effects.

(d) The limits and prioritisation of the flight envelope protection provided by the flight control system must be clearly and comprehensively defined.

Light-UAS.2529 UAS Navigation Function

The UAS Navigation function must ensure that the UA remains within the intended flight path and within all spatial limitations in all flight phases.

Light-UAS.2530 UA External lights

(a) Any lights required by operational rules for conspicuity at night must have the intensities, colours, and other characteristics to allow an observer to distinguish the UA from a manned aircraft.

b) Any position lights and anti-collision lights, if required by operational rules, must have the intensities, flash rates, colours, fields of coverage, position and other characteristics to provide sufficient time for another aircraft to avoid a collision.
(c) Any position lights, if required by operational rules, 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) Taxi and landing lights, if installed, must perform as expected.

Light-UAS.2575 Command, Control and Communication Contingency

(a) Where the safe operation of the UAS requires command, control and communication functionality, the UA 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.

SUBPART G – REMOTE CREW INTERFACE AND OTHER INFORMATION

Light-UAS.2600 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 UA 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 required 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 Light-UAS.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.

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.

Light-UAS.2605 Command Unit Installation and operation information

(a) The minimum number of crew members 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 aircraft 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.

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.

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.

Light-UAS.2620 Flight Manual

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.

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

(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'.

SUBPART H – C2 Link

Light-UAS.2710 General Requirements

(a) The C2 link performances must be specified as part of the Type Design of the UA.
(b) Minimum C2 Link Performance needs to be provided in the flight manual.

Light-UAS.2715 C2 Link Performances

(a) Where the safe operation of the UAS requires command, control and communication functionality 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.

Note: usage of frequency spectrum is not approved as part of the Type Certificate

Note: As per EASA AMC and GM and EASA SC-RPAS.C2-01 the main parameters that can be utilized to qualify the performance of a C2 link (RLP) and of other communication links (e.g. RCP for communication with ATC) include, but are not limited to, effective range, latency, availability, continuity, integrity.

Light-UAS.2720 C2 Link Performance monitoring

(a) If required for safe operation, the UAS remote crew must have the means to continuously monitor C2 link performance and ensure that it continues to meet the identified minimum performance.
(b) Appropriate technical and procedural means must be provided to the remote crew to establish and maintain the C2 link, including the interaction with the C2CSP. The Applicant needs to provide these means within the flight manual.

Light-UAS.2730 C2 Link Security

(a) Information exchange between the Command Unit and the UA via the C2 Link must be secure to prevent unauthorised 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 authorised Command Unit.

SUBPART I – Ancillary Elements

Light-UAS.2800 Ancillary Equipment

a) This subpart is applicable to the UA in combination with any ancillary equipment required for the safe operation of the UA.
b) The type design of the UA shall specify the performance and, when required, the design of the ancillary equipment.
c) All necessary instructions, information and requirements for the safe and correct interface between the UA and such ancillary equipment needs to be provided in the flight manual.
d) The UA must be designed to operate safely using the ancillary equipment under the anticipated operating conditions.

Light-UAS.2810 Systems for Launch and Recovery not permanently installed on the UA

(a) If a Launch System is intended to be used in the normal operation of the UA
(1) The UA must achieve sufficient energy and controllability at the end of the launch phase to ensure safe and controllable continuation of the flight under the most adverse combination of the approved environmental and operating conditions;
(2) the acceleration sustained by the UA during the launch phase must be within the loads for normal operation;
(3) A launch safety area must be defined as a predetermined geometrical area in which the UA remains after a failure or malfunction in the launch phase, calculated under any combination of approved environmental and operational conditions;
(4) The applicant needs to provide the size and shape of the launch safety area in the Flight Manual.

(b) If a Recovery System is intended to be used in the normal the operation of the UA
(1) The Recovery System must safely reduce sufficient energy to ensure a controlled termination of the flight;
(2) It must be shown that the deceleration sustained by the UA during the recovery phase is within the loads for normal operation, except where the UA is not designed for multiple recovery;
(3) A recovery safety area must be defined as a predetermined geometrical area in which the UA remains after a failure or malfunction in the recovery phase, calculated under any combination of approved environmental and operational conditions;
(4) The applicant needs to provide the size and shape of the recovery safety area in the Flight Manual.

ANNEX I – Mean of Compliance to Light-UAS

MOC to Light-UAS.2510 Equipment, Systems and Installation (High Risk)

This MoC is applicable to the high risk of the specific category of operations and to the Certified Category of Operations. Failure Conditions are classified according to the severity of their effects as follows:

No safety effect: Failure conditions that would have no effect on safety. For example, failure conditions that would not affect the operational capability of the UAS or increase the remote crew workload.

Minor: Failure conditions that would not significantly reduce UAS safety and that involve remote crew actions that are well within their capabilities. Minor failure conditions may include a slight reduction in safety margins or functional capabilities, a slight increase in remote crew workload, such as flight plan changes.

Major: Failure conditions that would reduce the capability of the UAS or the ability of the remote crew to cope with adverse operating conditions to the extent that there would be a significant reduction in safety margins, functional capabilities or separation assurance. In addition, the failure condition has a significant increase in remote crew workload or impairs remote crew efficiency.

Hazardous: Failure conditions that would reduce the capability of the UAS or the ability of the remote crew to cope with adverse operating conditions to the extent that there would be the following:
i) Loss of the RPA where it can be reasonably expected that one or more fatalities will not occur, or
ii) A large reduction in safety margins or functional capabilities or separation assurance, or
iii) Excessive workload such that the remote crew cannot be relied upon to perform their tasks accurately or completely

Catastrophic: Failure conditions that are expected to result in one or more fatalities.

When establishing the Functional Hazard Assessment, the applicant will have to substantiate the effects of failure conditions with consideration of the Conops for which the certification of the unmanned aircraft is requested.

Table 1 below provides the relationship between Classification of Failure Conditions and Probabilities for UA operated BVLOS in populated environment

Classification of Failure Conditions				
No Safety Effect	Minor	Major	Hazardous	Catastrophic
Allowable Qualitative Probability				
Not applicable	Probable	Remote	Extremely Remote	Extremely Improbable
Allowable Quantitative Probabilities				
Maximum dimension [2] < 8 m AND MTOM < 600 Kg (1200 m^2 worst crash area)	**$<1.10^{-2}$**	**$<1.10^{-4}$**	**$<1.10^{-6}$**	**$<1.10^{-8}$**
Maximum dimension < 3 m AND MTOM < 200 Kg (400 m^2 worst crash area)	**$<1.10^{-2}$**	**$<1.10^{-3}$**	**$<1.10^{-5}$**	**$<1.10^{-7}$**

Table 1: Relationship between Classification of Failure Conditions and Probabilities (BVLOS in populated environment)

[2] Maximum dimension: as defined in EASA AMC to Commission regulation 2019/947

Table 2 below provides the Relationship between Classification of Failure Conditions and Probability for UA operated over assemblies of people

Classification of Failure Conditions				
No Safety Effect	Minor	Major	Hazardous	Catastrophic
Allowable Qualitative Probability				
Not applicable	Probable	Remote	Extremely Remote	Extremely Improbable
Allowable Quantitative Probabilities				
Maximum dimension < 3 m AND MTOM < 200 Kg (400 m^2 worst crash area)	**$<1.10^{-3}$**	**$<1.10^{-5}$**	**$<1.10^{-7}$**	**$<1.10^{-9}$**
Maximum dimension < 1 m AND MTOM 5 Kg (70 m^2 worst crash area)	**$<1.10^{-2}$**	**$<1.10^{-4}$**	**$<1.10^{-6}$**	**$<1.10^{-8}$**
Worst Crash area ≤ 7 m^2	**$<1.10^{-2}$**	**$<1.10^{-3}$**	**$<1.10^{-5}$**	**$<1.10^{-7}$**

Table 2: Relationship between classification of Failure Conditions and Probabilities
(BVLOS over assemblies of people)

Table 3 and 4 below provides the relationship among Severity of Failure Conditions and Development Assurance Levels (DAL) for UA operated BVLOS in populated environment and, respectively, assemblies of people

Classification of Failure Conditions				
	Minor	Major	Hazardous	Catastrophic
Maximum dimension < 8 m, MTOM 600 Kg (1200 m^2 worst crash area)	FDAL D	FDAL C	FDAL B	FDAL A
Maximum dimension < 3 m, MTOM 200 Kg (400 m^2 worst crash area)	FDAL D	FDAL C	FDAL C	FDAL B

Table 3: Relationship between classification of Failure Conditions and FDAL assignment
(BVLOS in populated environment)

Classification of Failure Conditions				
	Minor	Major	Hazardous	Catastrophic
Maximum dimension < 3 m, MTOM 200 Kg (400 m^2 worst crash area)	FDAL D	FDAL C	FDAL B	FDAL A
Maximum dimension < 1 m, MTOM < 5 Kg (70 m^2 worst crash area)	FDAL D	FDAL C	FDAL C	FDAL B
Worst crash area ≤ 7 m^2	FDAL E	FDAL D	FDAL C	FDAL B

Table 4: Relationship between classification of Failure Conditions and FDAL assignment
(BVLOS over assemblies of people)

Notes pertaining to Table 1, 2, 3 and 4:

Note A: Mitigation means as defined by the EASA AMC and GM need to be considered in the determination of failure hazard classification.

Note B: For DAL allocated to Catastrophic and Hazardous (for crash areas below 70 square meters), no considerations of the system architecture for a DAL reduction are acceptable, as the DAL classification already constitute a proportionate approach.

Note C: The DAL assignment method proposed in ED-79A/ARP4754A (ref. [8]) section 5.2 may be used to assign DALs lower than those proposed in Table 3 and 4. Early concurrence with the Agency should take place on the DAL assignment method.

Note D: It is recognised that, for various reasons, component failure rate data may not be precise enough to enable accurate estimates of the probabilities of Failure Conditions. This results in some degree of uncertainty. When calculating the estimated probability of each Failure Condition, this uncertainty should be accounted for in a way that does not compromise safety.

Note E: The applicant is not required to perform a quantitative analysis for minor failure conditions.

Note F: An average flight profile (including flight phases duration) and an average flight duration should be defined as part of the conops.

Note G: The allowable quantitative probabilities are expressed in terms of acceptable ranges for the average probability per flight hour.

Note H: Guidance on how to perform the Safety Assessment process can be found in ED-79A/ARP4754A and ARP4761. The applicant may propose other guidance for the Safety Assessment process, which should be agreed with EASA in conjunction with the overall proposed Development Assurance process and scope.

Note I: Dimensions and MTOM are parameters which provide a simple determination of safety objective for any applicant. Nevertheless an applicant for a UAS with dimension and / or MTOM exceeding the ones associated to any of the category previously identified may provide further evidence to the Agency that the worst crash area is not exceeded. This could be done, for example, limiting the height of the operation or demonstrating a lower speed at impact. Flight termination logics that would aim at impacting the ground with a high angle and high speed are not deemed an adequate way to minimise crash area in a safe manner as they would significantly increase the risk of fatalities in the crash area. Further elements may become available with future JARUS WG6 publications linked to SORA. Any justification of crash area associated to specific UA should be agreed with the Agency.