S. R.

MINISTÉRIO DA DEFESA NACIONAL
AUTORIDADE AERONÁUTICA NACIONAL
Gabinete da Autoridade Aeronáutica Nacional

Alternative Means of compliance for certification of UAS with a MTOW below 150 Kg based on risk assessment

1. Purpose

The purpose of this document is to prescribe the Alternative Means of Compliance for Certification of Unmanned Aircraft Systems (AltMocUAS) with a Maximum-take-off weight below 150 Kg based on risk assessment.

2. Description

This AltMocUAS requirements is based on the requirements of STANAG 4703 (Ref. [1]) and uses a risk matrix, which combines the probability of the loss of the UAS with the probability of hitting people on the ground. The calculation of the probability of loss of the UAS is calculated as function of the UAS design integrity score using a point-based methodology with the answers to the AltMocUAS requirements. The Annex A presents the AltMocUAS requirements that an applicant should demonstrate regarding the intendent use of the UAS including the achievable scores with each method of compliance and the maximum allowable score per AltMocUAS requirement.
The AltMocUAS requirements score can be used to:

- determine the UAS category of risk, which will be used to calculate the allowable population density to be overflown;
- determine the acceptable UAS overflown population density for given score;
- estimate the probability of catastrophic event using overflown population density;
- estimate the probability of hitting people on the ground.

3. Determine the UAS risk category

Step 1: Answer the AltMocUAS questionnaire
Answer to the AltMocUAS requirements and submit the relevant documentation to substantiate such answers.
Step 2: Calculation of the platform score

The UAS design integrity score is calculated based on the answers to AltMocUAS requirements, through the demonstration with documentation and proof of tests concerning eleven domains:

1-Organization;
2- Adopted Design Standards;
3- Tested Usage Spectrum;
4 - Demonstration of Stability and Control / Navigational Accuracy / Emergency Conditions
5- Ground Control Station / Control Box;
6 - Structural Integrity;

7 - Propulsion and Feeding System Integrity;
8 - Systems and Equipment Integrity;
9 - Safety Demonstration;
10 - Software Integrity;
11- Continuing and continued Airworthiness.

It is required to evaluate the answers of the AltMocUAS requirements and the substantiation data in order to determine the score per domain and calculate the total initial score, which is the sum of the initial scores per domain. The calculation of the initial total score can be expressed by:

$$Total\ Score_{(1)} = \sum\left(Domain\ Score_{(1)}\right)_{(i)} \quad (1)$$

The final score of the UAS was designed to obtain as maximum score 100 points. Therefore, it is necessary to apply a correction factor matrix to the initial score per domain. A correction factor matrix was established to reduce the score of specific domains with cross-domain items whose absence will have a negative impact on the reliability of that domain.

The definition of the correction factor matrix combines the influence of relevant items addressed in the UAS assessment with the results of the AltMocUAS requirements for each domain. The relevant items are the following:

1. Quality Assurance System;
2. Technical Occurrence Tracking;
3. Configuration Management;
4. Human Machine Interface;
5. Structural Integrity;
6. Propulsion integrity;
7. E3;
8. FTA;
9. Fail-safe functionalities;
10. Software of life Cycle Assurance;
11. Instructions for continuing and continued airworthiness.

Some of these relevant items are explicitly evaluated in some domains of the AltMocUAS requirements, whereas others are not. For the items, which are not explicitly evaluated, the classification of their impact in each domain were identified as no, medium and high in accordance with the Figure 1.

	Organization	Adopted Design Standards	Tested Usage Spectrum	Stab Control / Nav Accuracy & Emergency Cond.	Ground Control Station	Structural Integrity	Propulsion Integrity	System Integrity	Safety Demonstration	Software Integrity	Continued / continuing Airworthiness
No Quality Assurance System	explicit	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	BIG
No Technical Occurance Tracking	NONE	NONE	SMALL	NONE	NONE	SMALL	SMALL	SMALL	BIG	SMALL	explicit
No DO Configuration Management	explicit	NONE	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	explicit
Human Machine Interface not Considered	NONE	NONE	NONE	NONE	BIG	NONE	NONE	NONE	SMALL	NONE	BIG
No Evidence of Structural Integrity	NONE	SMALL	NONE	NONE	NONE	explicit	NONE	NONE	NONE	NONE	BIG
No Evidence of Propulsion Integrity	NONE	SMALL	NONE	NONE	NONE	NONE	explicit	NONE	NONE	NONE	BIG
Inadequate E3	NONE	SMALL	SMALL	SMALL	NONE	NONE	SMALL	SMALL	NONE	NONE	SMALL
No FTA	NONE	NONE	NONE	BIG	NONE	NONE	BIG	NONE	Explicit	NONE	BIG
No Fail-safe **(functionalities)**	NONE	NONE	NONE	NONE	NONE	NONE	NONE	NONE	SMALL	NONE	NONE
No Software Life Cycle Assurance	NONE	SMALL	NONE	BIG	SMALL	NONE	SMALL	0.9	NONE	explic	NONE
No Instructions for Cont AW	NONE	NONE	NONE	BIG	BIG	BIG	BIG	BIG	SMALL	BIG	explicit

Figure 1 - The impact classification of the relevant items on the 11 domains of the AltMocUAS requirements.

The impact coefficients values regarding their classification are the following:
No impact – Means that those items, when explicitly addressed in the answers to AltMocUAS requirements will not have any impact on the specific domain. As so, the impact coefficient value is 1 (none) in that domain is 1.
Medium impact - 0,8 (small) - Means that those items, when explicitly addressed in the answers to AltMocUAS requirements, will have a medium impact in that domain, which is accounted for with an impact coefficient of 0,8;
High impact – 0,6 (big) - Means that those items, when explicitly addressed in the answers to AltMocUAS requirements, will strongly affect that specific domain. This is accounted for with an impact coefficient of 0,6 in the correlation matrix;
Explicit – 1 - Means that those items are explicitly addressed in that domain in the answers to AltMocUAS requirements, for which no additional correction factor is required.
In addition, the impact coefficient value, when such relevant items are explicitly evaluated at the ALTMOCUAS requirements, is 1. Regarding the impact classification of the relevant items on the 11 domains of the ALTMOCUAS presented in Figure 1 and the impact coefficients values abovementioned, the matrix of impact coefficient values are illustrated in Figure 2.

	Organization	Adopted Design Standards	Tested Usage Spectrum	Stab Control / Nav Accuracy & Emergency Cond.	Ground Control Station	Structural Integrity	Propulsion Integrity	System Integrity	Safety Demonstration	Software Integrity	Continued
No Quality Assurance System	1	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.6
No Technical Occurance Tracking	1	1	0.8	1	1	0.8	0.8	0.8	0.6	0.8	1
No DO Configuration Management	1	1	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1
Human Machine Interface not Considered	1	1	1	1	0.6	1	1	1	0.8	1	0.6
No Evidence of Structural Integrity	1	0.8	1	1	1	1	1	1	1	1	0.6
No Evidence of Propulsion Integrity	1	0.8	1	1	1	1	1	1	1	1	0.6
Inadequate E3	1	0.8	0.8	0.8	1	1	0.8	0.8	1	1	0.8
No FTA	1	1	1	0.6	1	1	0.6	1	1	1	0.6
No Fail-safe **(functionalities)**	1	1	1	1	1	1	1	1	0.8	1	1
No Software Life Cycle Assurance	1	0.8	1	0.6	0.8	1	0.8	1	1	1	1
No Instructions for Cont AW	1	1	1	0.6	0.6	0.6	0.6	0.6	0.8	0.6	1

Figure 2 – The matrix of impact coefficient values.

The calculation of the SCORE of the UAS is a two steps approach. Firstly, the applicant submits the answers to the questionnaire; alongside with the proposed compliance evidences in order to AAN calculate the preliminary score. Secondly, the AAN performs on-desk and on-site technical assessments of the UAS and of the Organization in order to verify and validate the compliance evidences against the requirements defined in the questionnaire answers to the AltMocUAS requirements in order to calculate the validated score.

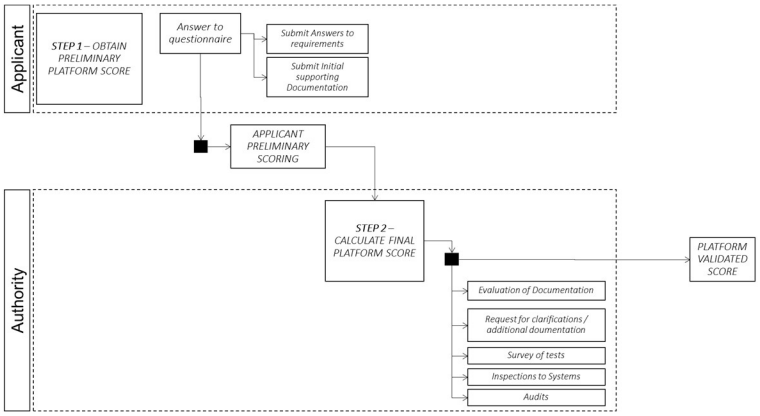

Figure 3 – Scoring Methodology

Step 3: Calculation of the probability loss of the UAS

The calculation of the probability of the loss of the UAS is calculated as function of the UAS design integrity score using a point-based methodology. The UAS total score is correlated with

the probability of loss of the UAS in accordance with the correlation between the UAS design integrity score and the probability of a UAS catastrophic event, as shown below:

$$P_{cat} = 0.1\, e^{-0.069.Score} \quad (1)$$

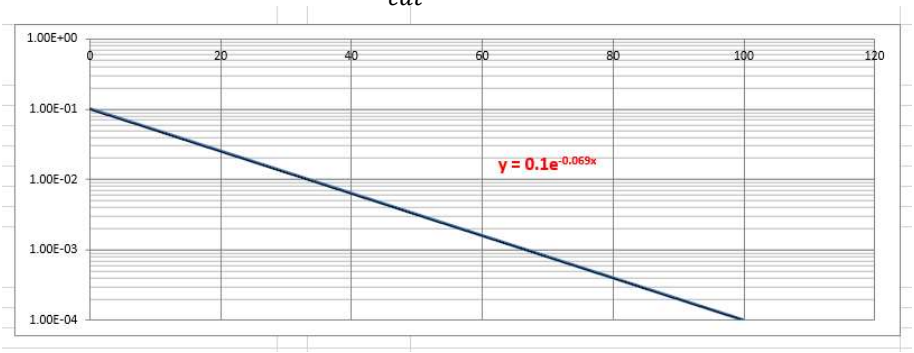

Figure 4 – Correlation between the ALTMOCUAS score and the probability of a catastrophic event.

Step 4: Calculation of probability of hitting people on the ground

The probability of hitting people on ground is function of the wingspan, speed, maximum take-off weight (All up mass) of the UAS and population density. The probability of hitting people on the ground is calculated as:

$$P_{Hit} = A_{debris} \times P_{Den} \quad (3)$$

Where

P_{HIT} – Probability of hitting people on the ground; A_{debris} – Crash/Impact area [m^2]; P_{Den} – population density [people/m^2];

The Crash/impact Area is calculated as:

$$A_{debris} = K \times b^2 \quad (4)$$

$$K = \min[50; E \times 17{,}5 + 3{,}2858] \quad (5)$$

Where

b - Wingspan [m]; K – Dimensionless coefficient;

The kinetic impact energy of the UAS is calculates as:

$$E = 0{,}5 \times m \times V_{impact}{}^2 \quad [1] \quad (6)$$

Where

E - Kinetic impact energy of the UAS [J]; m – UAS mass [Kg]; V_{impact} – UAS impact velocity [$m.s^{-1}$];

[1] The impact velocity is assumed, in the scope of this document, as the maximum UA speed.

Step 5: Define the category of the platform

The risk matrix combines the probability of the loss of the UAS versus the probability of hitting people on the ground. The risk equation is calculated as:

$$R = P_{cat} \times P_{HIT} \times (1 - S) \quad (7)$$

Where

R – Risk equation; P_{cat} – Probability of catastrophic event; S – Shelter factor.

Shelter factor is a dimensionless value between 0 and 1 to estimate the exposure of the population to the UAS or its debris. A value of 1 means that the population is completely sheltered, whereas a value of 0 means that population is completely exposed.

The risk equation is based on the adaptation of the Casualty Expectation Equation based on the Range Commanders Council Supplement to document 323-99.

The ranges of the risk matrix are the following:

UAS risk Category	Risk criticality	Risk criticality ranges
HIGH	VERY HIGH	>1E-3
MEDIUM	HIGH	>1E-4
	MEDIUM	1E-5 to 1E-4
LOW	LOW	1E-6 to 1E-5
	VERY LOW	< 1E-6

4. Define the acceptable overflown population density

The AltMocUAS requirements can be used to obtain the allowable overflown population density for the acceptable risk that ranges up to 1E-5 for a certain UAS. It transforms the UAS final score into the allowable over flown population density. The allowable overflown population density is obtained combining the equations (3) and (7).

$$P_{Den} = \frac{R}{A_{debris} P_{cat} \times (1 - S)} \quad (8)$$

The real population density, which can be overflown by a specific UAS certified by the AAN in accordance with this document, can be calculated from the value of the Maximum Unsheltered allowed population density $P_{unsheltered}$ that is defined in the Military Type Certificate, using the applicable Shelter factor (S)[2] and the following relation

$$P_{Den} = \frac{1}{(1 - S)} \cdot P_{unsheltered} \quad (9)$$

[2] The applicable Shelter factor shall be calculated as defined in section 6 of this document.

5. Conditions of Certification of UAS per AltMocUAS

The certification of UAS per AltMocUAS is made for an acceptable risk of **1E-5** of a certain UAS without a shelter factor. Therefore, the conditions of the Military Type Certificate issued by AAN using this AltMocUAS include the score of the UAS, the acceptable risk of **1E-5** without shelter factor and the value of the Maximum Unsheltered allowed population density to be overflown by that UAS ($P_{unsheltered}$).

To evaluate the possibility of operating that specific UAS in a determined area of operations based on these conditions, the operator must consider not only the average population density of the municipality, but also the percentage of people which are protected against an eventual crash of the UA. (*e.g.* percentage of people protected by buildings or vehicles, which reduce the lethality on ground in case of an UA impact).

That consideration is made through the parameter Shelter (from 0 to 1) which enables the operator to evaluate whether the operation is possible with that UA, without increasing the maximum allowable lethality risk above 10^{-5}.

6. Shelter Factor estimation

The estimation of the Shelter factor depends on a number of elements that must be taken into account and that depend on two main factors:

Factor 1. The type of the UA flying which affects its capacity of penetrating a building/structure when crashing (*Protection_Factor*) and also the lethality it causes when hitting a person[3] (*Fatality_Factor*);

Factor 2. The quotidian routines of the population within the areas overflown by the UA (*Mobility_rate*). In fact, the exposure to the risk of the people on ground (*Exposure*)to an eventual crash of the UA will be different when they are sheltered (inside the buildings) and unsheltered (outside or moving);

While Factor 1 depends on the UA, Factor 2 depends on the areas of operations (urban, residential, rural, etc.), and on the daily mobility pattern of the inhabitants. Therefore, Factor 2 must be defined for each country or State.

[3] Let it be noticed that for calculation of P_Kill (probability of killing a person, when that person is hit by the UA) this was, until now, assumed as 1 (regardless the type of UA). If it hit a person, the UA would always cause the person´s death). The Shelter factor refines the model for this case.

Consequently, the SHELTER FACTOR (S) estimation defined in this document is restricted to the Portuguese Continental Territory and to the archipelagos of Madeira and Azores. The usage of the UAS certified per *AltMocUAS* outside these areas shall use SHELTER FACTOR of 0 or must use a SHELTER FACTOR estimation defined by the competent authority responsible for oversighting those areas of operations.

$$S = {}^{(FACTOR_1 \cdot FACTOR_2)}/_{1{,}5}{}^{4} \tag{10}$$

$$FACTOR_1 = Protection_{factor} \cdot Fatality_{factor} \tag{11}$$

$$FACTOR_2 = Mobility_{rate} \cdot Exposure \tag{12}$$

Estimation of Factor 1:

$$FACTOR_1 = Protection_{factor} \cdot Fatality_{factor} \tag{13}$$

The Penetration factor is given by the ability of a certain UA penetrating a building, when it hits its structure. The Protection factor is considered minimum for the case of the *Reaper*, in which the estimated protection provided by the buildings avoiding their penetration is around 0,75 (25% of the times a UAs of this type crashes and hits a building, it penetrates its´ structure). For the case of UAs as the *Scan Eagle* this estimated factor is 0,9 (only 10% of the times one UA crashes against a building, it will penetrate a building). (See Ref. [2])

[4] The Safety Factor of 1,5 is introduced as a design Safety factor in order to account for the estimations of the model. This factor is introduced to reduce the effect of the Shelter factor, making the model more conservative.

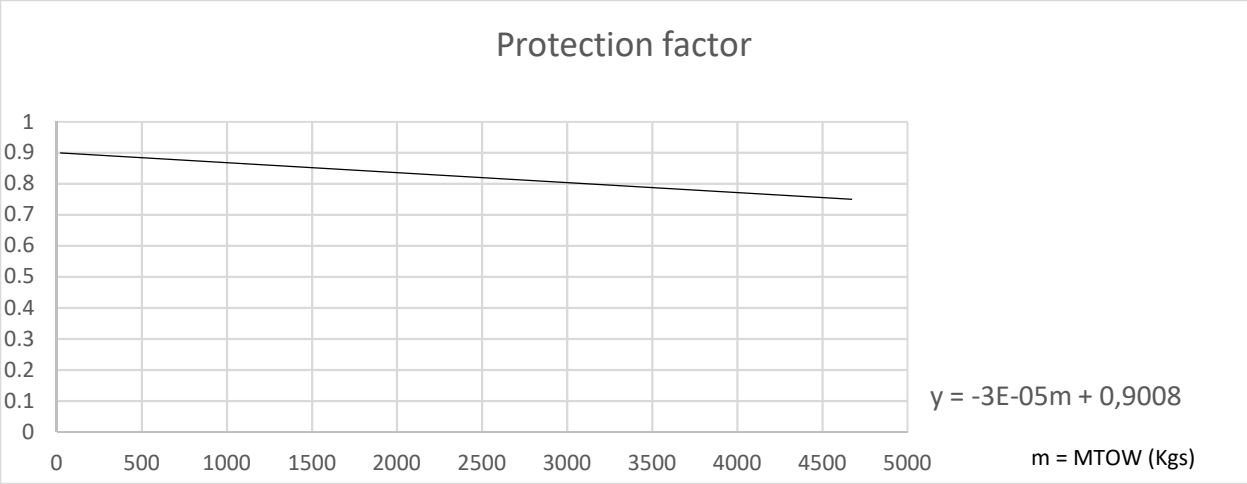

Figure 5 – Estimated Protection Factor

The Fatality factor is the lethality factor of the hit, which depends on the energy of the UA in the impact[5]. The Fatality is considered maximum for the case of the Reaper, which will cause death for all people hit by the UA and only of 50% for UAs with geometry and performance similar to *Scan Eagle.*

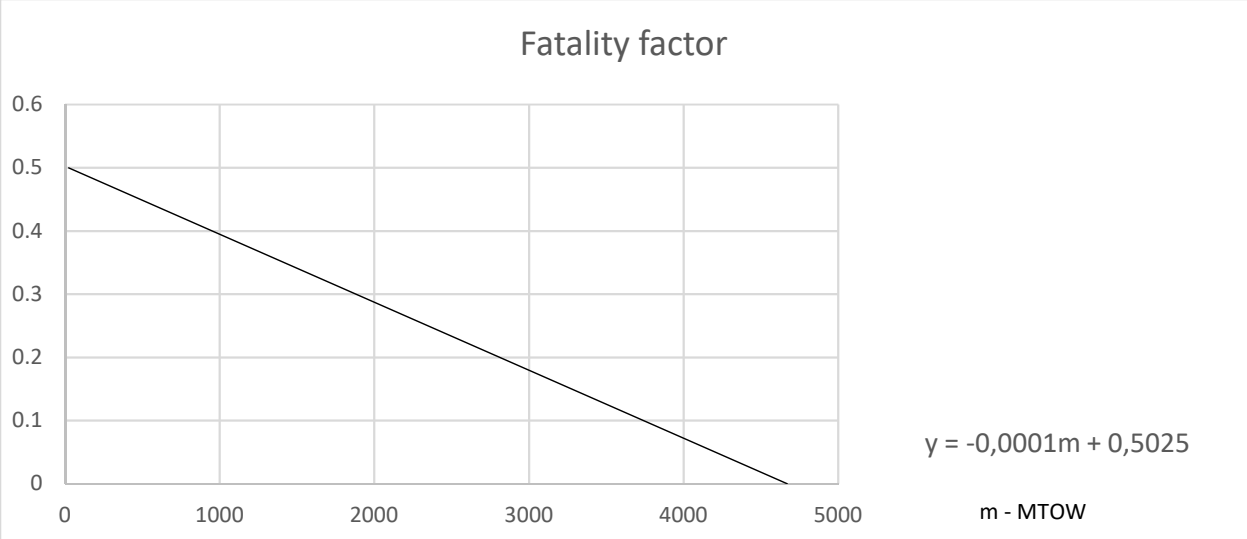

Figure 6 – Estimated Fatality Factor

$$FACTOR_1 = Protection \cdot Fatality \tag{13}$$

[5] Although the Fatality of the UA depends on various factors, as the weapons of the UA which affects the chemical energy of the UA, the present model considers the lethality as dependent only on the mass of the UA.

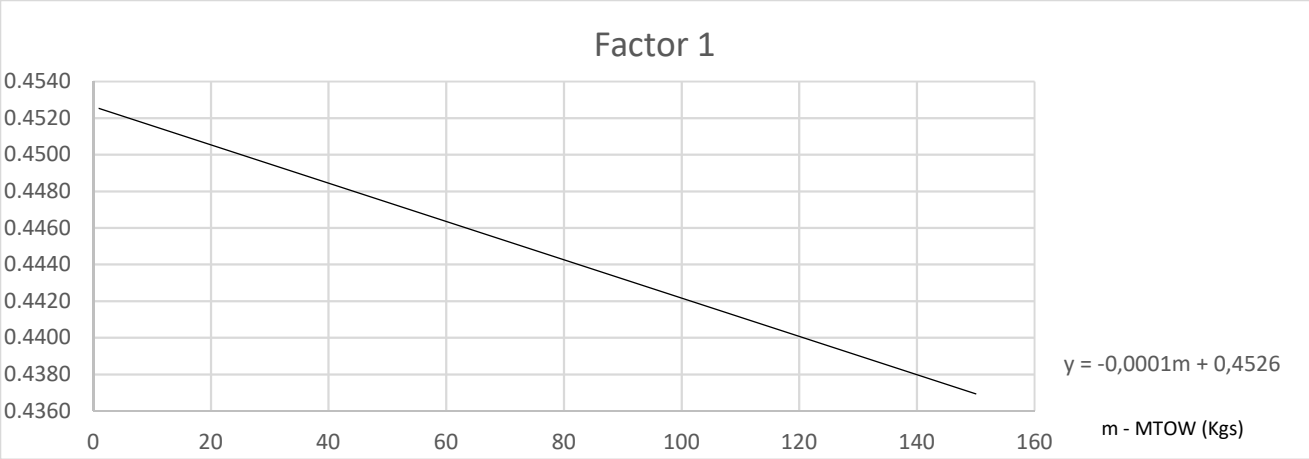

Figure 7 – Factor 1

Calculation of Factor 2:

$$FACTOR_2 = Mobility_{rate} \cdot Exposure = Protected_{Population} \quad (14)$$

The Mobility rate of the population is the percentage of inhabitants that leave their houses during the day on a daily basis. For the case of Portugal, this estimated value is in average 80 % (Ref. [3]), which means that on a daily basis, 20 % of the population remains sheltered in their houses. On-the-other-hand, the remaining 80% that leave their houses on the daily basis are not permanently outside, as most of the day, they are working or have already returned to their houses. For the case of Portugal, the exposure rate of this 80% of the population is calculated in accordance with the average time each person is outside, which in accordance with Ref. [3] is 70 minutes during a working day and the frequency of movements of the population during the day[6]. (See the considered daily distribution of the population movements).

[6] The distribution presented is the mobility of the population survey in the Metropolitan Area of Lisbon in Ref. [2].

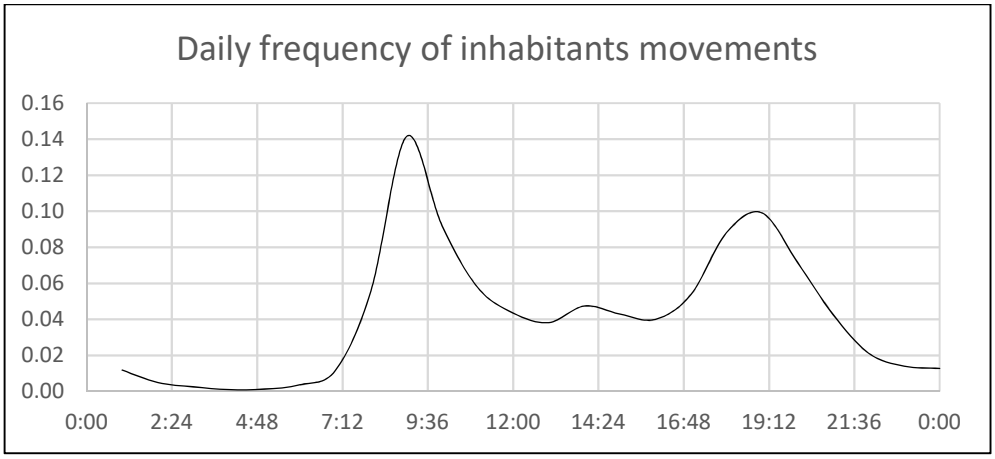

Figure 8 – Daily frequency of inhabitants

As it can be seen the 70 minutes of average exposure of the people during the day is distributed between 07:00 am and 01:00 am, which corresponds to a total of 18 hours (1080 minutes).

$$\%_{Protected\,Population} = \left\lfloor 0{,}2 + 0{,}8 \cdot \overbrace{\left(1 - \frac{70min}{18hours \cdot 60min}\right)}^{Fraction\ of\ unexposed\ people\ during\ the\ da} \right\rfloor \cdot 100 \quad (15)$$

$$\%_{Protected\,Population} = \left\lfloor 0{,}2 + 0{,}8 \cdot \overbrace{0{,}935}^{Fraction\ of\ unexposed\ people\ during\ the\ day} \right\rfloor \cdot 100 \quad (16)$$

$$\%_{Protected\ Population} = (0{,}2 + 0{,}748) \cdot 100 = 94{,}8\ \% = \text{FACTOR 2} \quad (17)$$

Note: This percentage is calculated with the estimated values from Ref. [3] for which it is only valid for Portugal

The Shelter factor (S) results as follows:

$$S = \frac{(FACTOR_1 \cdot 0{,}948)}{1{,}5} \quad (17)$$

$$S = \frac{0{,}948}{1{,}5} \cdot (-0{,}0001 \cdot MTOW + 0{,}4526) \quad (18)$$

$$S = -6{,}32E^{-5} \cdot MTOW + 0{,}286 \quad (19)$$

Note: This Shelter Factor is only valid for Portugal

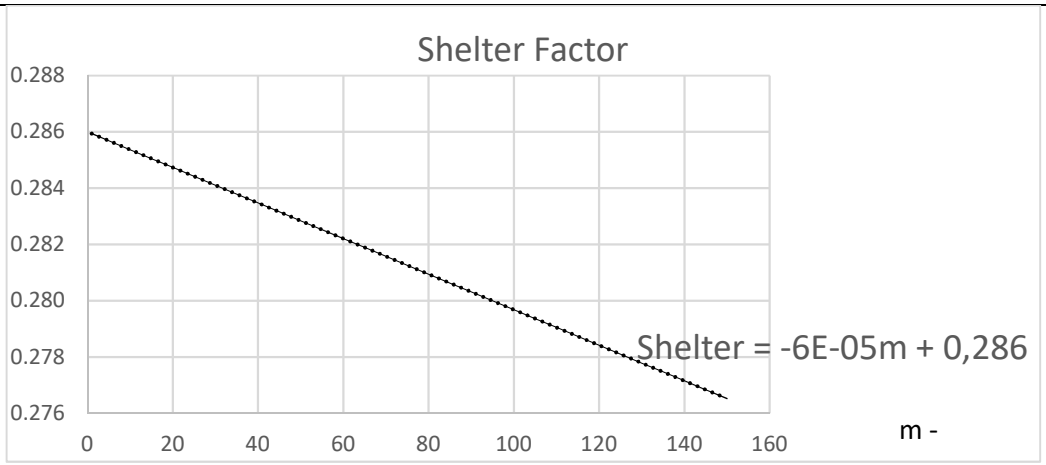

Figure 9 – Estimation of Shelter Factor for Portugal

Note: This Shelter Factor estimation is only valid for Portugal

Mass (MTOW - Kgs)	Shelter Factor	Mass (MTOW - Kgs)	Shelter Factor
1	0,286	80	0,281
5	0,286	85	0,281
10	0,285	90	0,280
15	0,285	95	0,280
20	0,285	100	0,280
25	0,284	105	0,279
30	0,284	110	0,279
35	0,284	115	0,279
40	0,283	120	0,278
45	0,283	125	0,278
50	0,283	130	0,278
55	0,283	135	0,277
60	0,282	140	0,277
65	0,282	145	0,277
70	0,282	150	0,277
75	0,281		

7. Examples

1) A platform of mass of 15 Kgs, with a wingspan of 3,5 m, operating at approximately 40 ms^{-1}, with an integrity score of 70 points will be certified to operate up to a population density of 292 inhabitants /Km2

without shelter factor. If this platform is operating within Portugal, the resultant Shelter Factor (considering the average mobility of the Portuguese People and their average movement frequency during the day) will be of 0,2847, which will allow it to overfly Portuguese districts with population densities up to 400 inhabitants /Km^2.

2) A platform of mass of 50 Kgs, with a wingspan of 5 meters, able to fly at 120 m/s, with an integrity score of 80 points, will be certified to operate up to a population density of 104 inhabitants /Km2 without shelter factor. If this UAS is operating within Portugal, the resultant Shelter Factor (considering the average mobility of the Portuguese People and their average movement frequency during the day) will be of 0,2847, which will allow it to overfly Portuguese districts with population densities up to 145 inhabitants /Km2.

8. References

[1] – NATO (2016) STANAG 4703, Light Unmanned Aircraft Systems Airworthiness Requirements. Edition. 2.0., NSO.
Available at: https://nso.nato.int/nso/nsdd/_CommonList.html (Accessed: 2 December 2019).

[2] - Waggoner, B. (2010) *Developing a Risk Assessment Tool for Unmanned Aircraft System Operations*. University of Washington. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.453.9962&rep=rep1&type=pdf (Accessed: 4 May 2019).

[3] – Instituto Nacional de Estatística, Statistics 2020). Portugal (2018) Mobilidade e funcionalidade do território nas Áreas Metropolitanas do Porto e de Lisboa: 2017. Available at: https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_publicacoes&PUBLICACOESpub_boui=349495406&PUBLICACOEStema=00&PUBLICACOESmodo=2 (Accessed: 29 May

Annex A- Design Integrity Risk Assessment Requirements

This annex is organised into six columns:
A – Describes the requirement;
B- Identify the type of the evidence to be submitted by the applicant to comply with the requirement;
C- Type do requirement. Mandatory requirements are the minimum requirements to be demonstrated by the applicant in order to calculate the preliminary score of the UAS. Failure to demonstrate the minimum requirements will unable AAN to provide the calculation of the UAS preliminary score;
D- Partial score applicable to each method of compliance per requirement;
E- Total score per requirement.
The applicant should answer to all requirements identifying the compliant and none compliant requirements. When compliant with the requirement the applicant should submit to the AAN the respective supporting evidences.
The answers to comply with this AltMocUAS is part of the certification program to be submitted by the applicant identifying the applicable and non-applicable AltMocUAS requirements for a particular UAS with the correspondent substantiation. In addition to this AltMocUAS, the applicant may propose to the AAN another alternative or additional requirements and means of compliance (MoC) which ensure the same or higher level of safety. The submitted certification program shall be agreed with the AAN.

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
1. ORGANIZATION				
1.1 The UAS design and production organizations must be certified as per AS/EN 9100/ ISO 9001 for undertaking UAS design and production activities, and should deliver evidences of usage of approved processes for management of safety within the design and production of systems, or as alternative comply with EMAR-21 Subpart G (or F) and J,	**Doc.**	**Mandatory**	If the applicant is certified per AS/EN 9001, for design and production of the platforms [1] [+1*] If the applicant is certified per AS/EN 9100, for design and production of the platforms. [3] [+1*] * If the applicant shows evidence of the procedures for management of safety issues within the design and production of systems If the applicant is shows evidence of compliance to EMAR-21 (Subpart G or F) and J [5]; If the applicant has no certification [0] [+1*];	**5**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
1.1.1 The applicant shall deliver a copy of the Quality Manual.	**Doc.**	**Desirable**	Work is undertaken by competent individuals (trained and qualified) (1) Adequate facilities, with adequate tools, material, procedures and data (0.8) A safety culture is demonstrated: - The documented statement of the quality policy shall include explicitly system safety as one of the main objectives; - Safety management processes are implemented (0.2)	**2**
1.2 The applicant shall demonstrate that the materials and manufacturing processes used in the construction of the UAS are adequate;	**Doc.**	**Desirable**	- The suitability and durability of materials used is established on the basis of experience or tests. (0.3) - materials conform to approved specifications; (0.7) - manufacturing processes conform to recognized standards; (1)	2
1.3 The applicant shall demonstrate that the materials and manufacturing processes used in the construction of the UAS are adequate;	**Doc**	**Desirable**	Critical parts/systems/components are inspected by special/detailed procedures after manufacture (or prior to installation) for all items; (1) Critical parts/systems/components are inspected by special/detailed procedures after manufacture (or prior to installation) on a sampling basis; (0.7) Critical parts/systems/components are inspected after manufacture (or prior to installation) for all items, but without any by special/detailed procedures; (0.2) Critical parts/systems/components are inspected after manufacture (or prior to installation) on a sampling basis, but without any by special/detailed procedures; (0.1) No inspection is made (0) Notes: For structural part a special/detailed procedure is to be considered NDT or similar test; For systems/avionics, functional tests are to be considered;	1

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
1.4 The applicant must demonstrate the existence of a process to manage design changes and to communicate these to the Operators.	**Doc**	**Desirable**	A process exists to communicate to known operators the Mandatory design changes; (0.25) The control of the implementation of these design changes is traced by the manufacturer; (actual feedback) (0.05) The organisation has a way (e.g. database) to properly identify which platform was delivered with which version of the systems. (0.2)	0.5
1.5 The applicant shall ensure that the operator is educated about the criticality of configuration management processes for the UAS	**Doc.**	**Desirable**	Through developed informatic system (0.5) This shall be done through the delivery of Manuals, through Training; (0.3) or other type of configuration management systems (0.3)	**0.5**
2. DESIGN STANDARDS				
2.1 The applicant shall show evidence of the design criteria and standards used to design the UAS structure, engine, propeller and UAS systems and equipment. Note: the following questions are meant to be answered with respect to the aircraft critical systems, viz., powerplant, critical structures, flight control subsystems (autopilot, actuators).	**Doc.**	**Desirable**	1. Does the organisation design their own engines and propellers? (if yes) 1.1 Does the design consider standards for the design of engines of and propellers? (if yes) Y1.1.1 Are the standards recognized for aeronautics? (Y1.1.2 Are the standards considered adequate? (if no) N1.1.1 Are the standards recognized for general technological industry? N1.1.2 Are the standards considered adequate? (if no) 1.2 Does the organization have adequate control over the norms and specifications of the engines and propellers included in the platforms? (if yes) (1) Y1.2.1 Are the standards recognized for aeronautics? Y1.2.2 Are the standards considered adequate? (if no) (0.7) N1.2.1 Are the standards recognized for aeronautics? N1.2.2 Are the standards considered adequate? N1.2.2 (if yes) 1.2.2.1 Are the standards recognized for general technological industry?	**2**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
			1.2.2 2 Are the standards considered adequate? 1.3 Is the manufacturer of the props and engines recognized for the manufacture of these items with in the market? 1.4 Are the engines and props used in other platforms (from other manufacturers) with adequate reliability? Aerospace standards and practices used to design RPA structure, engine, propeller and UAS systems and equipment are to be considered as best.	
3. TESTED USAGE SPECTRUM				
3.1 **3.1.1 The applicant shall deliver the design usage spectrum as well as the set of all the foreseen operational conditions of the UAS**	**Doc**	**Mandatory**	1. Velocities [0.5] 2. Load Factors [0.5] 3. Weather (Wind, Rain, moist) [0.5] 4. Altitude [0.5] 5. MTOW [0.5] 6. Performance (climb rates, max bank, sideslips) [0.5]	**3**
3.1.2 The applicant shall show evidence of how the design spectrum was defined.	**Doc.**	**Desirable**	Flight Testing (0.13) + Lab Testing (0.06) + Ground Testing (0.06) Has enough and adequate testing been performed? [0-1.0] (open window for evaluator to insert score)	**0.25**
3.1.3 The applicant shall show evidence of the in-service experience accumulated.	**Doc**	**Mandatory**	To what extent do you consider the experience to be sufficient, w.r.t i) number of in service units; ii) number of known operators; iii) number of Known flight hours; iv) other produced and in-service models? To what extent do you consider the flight testing to be representative of the actual platform and configuration? - Same platform with same configuration [1.0];	**1**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
			- Different Powerplant [-0.2] - Diff main frame [-0.5]; - Diff autopilot [-0.15]; - Surface actuators [-0.15];	
3.1.4 The applicant shall show evidence that flight experience and/or in-service experience has demonstrated that the design is free from unsafe features in the complete operational spectrum.	**Doc**	**Mandatory**	1. Has any major system of the platform been involved in unsafe/accident conditions or has the applicant been informed or is aware of past/recent accidents with the platform, regardless of configuration? Note: This shall be demonstrated (for a configuration similar to the proposed UAS) through a statement referring the ratio of known occurrences per flight hour, the number of investigations conducted, the number of necessary redesigns, and the number of eventual unsafe conditions identified. (If no occurrence exists, the applicant must STATE that no occurrence has been reported by the operators in the total of Known flight hours.	**0.5**
3.1.5 The applicant shall show evidence that all safety critical equipment is functioning properly throughout the full tested operational envelope, when integrated in the UAS system (including ground station, datalink equipment, air vehicle, etc.).	**Doc.**	**Desirable**	Is there a way of ensuring that the systems have been fully tested at its functional level prior to installation on the platform? [0.4] Is there a system to ensure that when the system identifies problems, these problems are researched and corrected for? [0.1] Note: This shall be made through: Functional tests of the safety critical systems including ground station, datalink equipment, air vehicle, etc.) for the operational envelope; Safety analysis for the safety critical functions;	**0.5**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
3.1.6 The applicant shall show evidence of the existence of a system to track problem reports from development and qualification tests of the UAS.	**Doc.**	**Mandatory**	Is there a way to follow or track Open Problem Reports (OPR)? Note: Approved Organization Manual with Statement with identification of the section in the approved organisation manual where the system is identified.	**0.5**
3.1.7 The applicant shall show evidence of the state of all the problem reports, that have derived from the development and qualification of the UAS.	**Doc.**	**Desirable**	Is there a system to identify the state of the open problem reports that derived during and qualification phase? Note: The applicant shall state all the reported problems that have derived from the development and qualification of the UAS. If there are open problems yet under investigation, the applicant must identify eventual limitations to the UAS operating Manual that derive from the ongoing investigation of those reports.	**0.25**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
4. STABAILITY AND CONTROL/NAVIGATIONAL ACCURACY AND EMERGENCY CONDITIONS				
4.1 The applicant shall show evidence that the UA is stable and controllable in all sequences of flight and on-ground (as applicable), in all operational modes, throughout the full operational envelope. **Note: Including wind conditions as applicable, phases of take-off/launch and landing/recovery in the worst environmental condition (including wind).**	**Doc.**	**Mandatory**	The applicant shall show evidence of complete testing of the aircraft for the limits of the flight envelope and the A/C was shown to be stable and controllable for all the extent of the flight envelope. - when analysis is performed (0.5) - rig tests (0.5) - flight tests (1) - quantitative evidence of adequate gain/phase margins (0.25), including adequate flying qualities (0.5); - Include the phases of take-off/launch and landing/recovery; (0.25) - The test of these phases shall include the worst environmental condition considered in the usage spectrum (0.25)	**3**
4.1.1 The applicant shall show evidence that operational procedures exist for the phases of take-off/launch and landing/recovery.	**Doc.**	**Mandatory**	Is there evidence that these procedures are implemented in the Operations manual or in the Flight manual? Yes [0.5] No [0] Is there evidence of analysis of procedures of operation at the level of safety [0.5] Note: Sufficient evidence of the assessment of the procedures w.r.t the levels of safety and mitigation of any safety issues that have been identified. The flight manual should include the cautions of each operational procedure.	**1**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
4.2 The applicant shall show evidence of the existing flight control protecting System functions for: **Stall;** **speed exceedance;** **over-load,** **dangerous oscillations;** **spinning**	**Doc.**	**Mandatory**	Evidence of existing control protecting System functions for: Stall;(1) speed exceedance; (0.5) over-load; (0.5) dangerous oscillations;(1) spinning;(0.5) Note: This evidence must be delivered in the form of documentation	**3.5**
4.2.1 The applicant shall show evidence of all UAS features which are meant to minimise the effects of the operator mistake. (in all operational modes including direct piloting and semi-automatic modes as applicable)	**Doc**	**Desirable**	Evidence of UAS features: - including direct piloting; (0.5) - semi-automatic modes as applicable (0.5) - fully automatic mode (0.5) **Note:** Score is based on how many protections (and their margin) are in place. The Design Organization should provide information about protection requirements and corresponding evidences. If requirements and evidences are not provided score is zero.	**1.5**
4.3 The UAS should be stable and controllable after failure of sensors and primary aerodynamic control surface actuation. (even if only in a degraded mode)	**Doc**	**Desirable**	The applicant shall provide documentation demonstrating that the UAS maintains some stability and controllability, after failure of sensors and primary aerodynamic control surface actuation: - Pitot tube/ IAS failsafe [0.5]; IMU Failsafe [0.5]; GPS Failsafe [0.5]; Fail safe design for main flight controls surface actuation [1.5]; , or alternatively by:	**3**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
			- Demonstration by test evidence of ability to control after failure: Pitot tube/ IAS failsafe [0.5]; IMU Failsafe [0.5]; GPS Failsafe [0.5]; Primary aerodynamic control surface (1.5)	
4.4 The applicant should demonstrate a minimum level of navigation precision adequate for the mission profile, and the precision tolerances shall be provided in the operational manual of the UAS.	**Doc**	**Mandatory**	- GPS PDOP values; [max 1.5] - Is the UAV capable of SBAS augmentation? Yes = 0.1; - Nav Solution [0.4] Wind < half of cross-max limit: min req: 10x max dimension of AC [0.2] and wind > half of cross-max limit, min req: 15x max dimension of AC. [0.2]	**2**
4.5 The UAS must include means to monitor and indicate the UAS health status (including Data Link) to the Designated UAS Operator throughout the mission profile.	**Doc & Verification**	**Mandatory**	Proof of the following must be included: - Is there a way of monitoring the UAS data-link on the Operator GCS? Has the UAV monitoring link been tested through flight testing? - Is there a way of monitoring the UAS data-link on the Operator GCS? - Does the system indicate loss of link through visual or sound warning? - Does the system indicate loss of link through RSSI, link of another indicator? **Note: If this function does not exist, the UAS will fail.**	**2**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
4.5.1 The datalink performance must be shown to be sufficiently robust for the type of operations, ranges, environment of the UAS.	**Test**	**Mandatory**	**Test description:** The applicant shall demonstrate by flight test adequate datalink level throughout a mission comprising operation near other systems, maximum operation altitude, and maximum range. Notes **- If more than 3 short datalink loss are verified the UAS will fail. (platform is not accepted)** - If no datalink loss is verified fails during test (2); - If less than 3 datalink loss are verified (1)	**2**
4.6 The UAS shall maintain safe operation in case of datalink loss.	**Doc. & Test**	**Mandatory**	The applicant shall show evidence of procedure for loss of datalink in the Operation Manual (Mandatory) - loss of datalink for short period and long period with adequate warning of operators; (0.75) - possibility of recovery of mission profile, upon reset of datalink (.25) - existence of return home procedure: (0.5) - existence of safe landing procedure for loss of datalink (0.5) Additionally, the applicant shall demonstrate by flight test that a data link loss will not initiate unsafe operation or flight of the UAS. (Mandatory)	**2**
5. GROUND CONTROL STATION/CONTROL BOX				
5.1 The UAS MUST include means to interact with the Operator (Human-machine Interaction), allowing for the management of the mission workload and safety.	**Doc.**	**Mandatory**	The following information must be provided to the operator, depending on the type of operation / distance to operator: For UAS intended to be flown within VLOS: - Elapsed Flight time - remaining battery/fuel - audible buzzer for low battery/fuel - visual/ audible warning for low link / RSSI [0.5 if all the above are satisfied; 0 otherwise]	**1**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
			For UAS intended to be flown BVLOS: - Elapsed Flight time - remaining battery/fuel - visual/ audible warning for low battery/fuel - visual/ audible warning for low link / RSSI - GPS status (PDOP/HDOP + Satellites) - Link and RSSI indication - Altitude - attitude - airspeed - distance to home point - navigation solution status - engine power or RPM - control surface deflection command [0.5 if all the above are satisfied; 0 otherwise] WORKLOAD (Estimated by the evaluator, through the analysis of the procedures that an operator must execute for loading and executing a new flight plan -> software shall ask the applicant to copy-paste the operating procedures for change and execution of a new flight plan in less than 1500 characters); [0-1 to be determined by evaluator x 0.5] Compliance shall be demonstrated by the existence of these functions in the Operation Manual. Note: If HMI and workload aspects are not considered a negative score of -5 is be assigned.	
5.1.1 The information provided by the UAS to the operator must be sufficiently, clear, unambiguous; and should be readable in the worst light conditions.	**Verification**	**Mandatory**	Applicant shall show image or document describing the operator interface with all items identified before duly highlighted. (Verification of quality of information: Clear, complete unambiguous [0.3]) Applicant shall show evidence of GCS modifications that will assure operator readability in worst light conditions (e.g., screen protection for outdoor tactical GCS or high contrast screens, lateral view angle) [0.2]	**0.5**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
			Note: If information is considered insufficient the UAS will fail	
5.1.2 The UAS must show adequate warning for malfunctions, failures or any unsafe condition.	**Doc. & Verification**	**Mandatory**	Applicant shall show image or document describing the operator interface with all items identified before duly highlighted. Compliance shall be demonstrated by the existence of these functions in the Operation Manual. [1] **Note: If warnings are considered insufficient the UAS will fail**	**0.5**
5.1.3 The UAS shall provide to the operator information about limit exceedances and unsafe conditions of the UAS.	**Doc. & Verification**	**Desirable**	Applicant shall show image or document describing the operator interface with all items identified before duly highlighted. Compliance shall be demonstrated by the existence of these functions in the Operation Manual. [1]	**1**
6. STRUCTURAL INTEGRITY				
6.1 The UAS shall have defined the maximum operating for all the conditions (flight, ground, launch, recovery, transportation, handling, etc)	**Doc.**	**Mandatory**	Limits are to be established in the in the Operation Manual. (Limits to be described in the manual: Load factor, Speeds, rate of climb, max RPM, altitude, turn radius, attitude limits) [0-1 based on evaluator's experience]	**1**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance		E Max. Score
6.1.1 The applicant shall show evidence that the UAS withstands, without rupture, the maximum operational loads multiplied by an adequate factor of safety, at each critical combination of parameters.	**Doc.**	~~**Desirable**~~ **Mandatory**	The applicant shall deliver the Structural demonstration. [0-2 based on evaluators experience]	**Notes:** 1) Maximum score may be achieved when loads are established based on recognized aerospace standards and quantitative evidence of positive margin of safety on primary structural elements are shown by an adequate combination of analyses and tests.	**2**
6.1.2 The applicant shall show evidence that all the structurally relevant metallic, composite and polymeric parts of the UAS do not yield (metallic) nor fail / permanently deform at the maximum operational loads.	**Doc.**	**Desirable**	The applicant shall deliver the Structural demonstration.		**1**
6.2 Is there evidence that fatigue inspections are put into the maintenance programme for metallic and/or BVID inspections for composite structures?	**Doc.**	**Desirable**	The applicant shall deliver the maintenance programme The applicant shall identify all components with fatigue limits. [0-0.2]		**0.2**
6.2.1 The UAS maintenance programme should include a pre-flight checklist considering composite parts inspection for identification of damages.	**Doc.**	**Desirable**	The applicant shall deliver the maintenance programme		**0.3**
6.2.2 The applicant shall deliver a maintenance program which is able to ensure the structural integrity of UAS integrity throughout its service life	**Doc.**	**Mandatory**	The applicant shall deliver the maintenance programme, which is to be evaluated for suitability. Areas to be considered in maintenance programme: - Corrosion inspections; - fatigue inspections - life limit components - engine - main structural components		**1.5**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
7. PROPULSION AND FEEDING SYSTEM INTEGRITY				
7.1 The applicant shall demonstrate the reliability of the UAS propulsion system.	**Test**	**Mandatory**	Applicant shall deliver detailed report of: - Inspections / maintenance during test cycle; [0-1] - Inspection after tear down of powerplant [0-1]; - Classification [0-1], 0 = no report submitted	**3**
7.1.1 The UAS shall demonstrate adequate engine reliability by operational experience.	**Doc.**	**Mandatory**	The applicant shall deliver a document stating the reliability of the engine, and the number of flight hours in which that statement is based upon. A failure rate for the propulsion system should be delivered. = 3/0.8 * [1+1/log(probability)] NOTE: Probability of failure larger than 10-3 will have a penalty over 50% of total score of current question	**3**
7.2 The applicant shall demonstrate that the Engine Control System (including propeller pitch) performs the intended functions in all its control modes throughout the full operational envelope	**Test**	**Mandatory**	Have the following been assessed and passed during the test phase: - propeller pitch if applicable [0.25] - fuel admission control [0.25] - air admission system [0.25] - refrigeration system [0.25] **Minimum level of demonstration of engine control system performances is Mandatory, if safety critical.**	**1**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
7.3 For electrical engine applications, the applicant shall demonstrate that the battery is able to provide the necessary voltage and current required by the engine and electrical equipment throughout the operational envelope.	**test**	**Mandatory**	The applicant shall: 1) Include in the Operation Manual, the minimum value of current and voltage required for engine and electro avionic systems functioning [1.5] 2) Demonstrate by test that the during a mission covering the complete mission profile the power voltage supply and the current remains above those values (plus a tolerance for possible degradation of battery performances) [1.5]	**3**
7.3.1 For combustion engine applications, the applicant shall demonstrate that the fuel system is able to provide the necessary fuel flow at the necessary conditions required by the engine throughout the operational envelope.	**test**	**Mandatory**	The applicant shall demonstrate by test, that during complete mission profile, the fuel system allows for the supply of fuel for all requirements, without failures. (1) Is there proof, under the form of a test, that the fuel system is able to supply the necessary fuel to the engine at all operating conditions, viz., Yes [0-1] depending on the description of the conditions that were tested No [0]	**1**
7.3.2 For combustion engine applications, the UAS must include a filtering system adequate to avoid that foreign particles passing through the engine will not critically affect engine functioning.	**Doc.**	**Desirable**	The applicant shall deliver a document demonstrating that a failsafe design is considered for the filtering system, namely through a by-pass in the filtering device? (0.5) Does the system include filter that retains particles harmful to the engine? YES [0.5] NO [0]	**0.5**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
7.3.3 For combustion engine applications, the applicant shall demonstrate that engine oil system will function properly in the complete UAS operational envelope.	**test**	**Mandatory**	The applicant shall demonstrate by test, that during complete mission profile, the lubricating system works without failures, and that the engine temperature does not raise above allowable values. (1) The applicant shall state if the UAS lubricating system should be protected by suitable filter(s) or strainer(s) 0.5) The applicant shall show that lubricant used and lubrication system is adequate to the powerplant installed. Did the tests performed show evidence that: - The Temperature did not rise above the limits [0.5] - For oil-fuel mixture: Was there evidence of wear during tear down? [1 if no wear] - For independence lubricant system: . Was there a reduction of oil level below 2/3 of maximum value? [0-1] . Did the oil inspection reveal any issues or particles above limit? [0-1]	**1.5**
7.4 a For electrical engine applications, the UAS shall include means to minimize the risk of battery overheating / explosion	**Doc.**	**Desirable**	The applicant shall deliver a document demonstrating the existence of systems to means to minimize the risk of battery overheating / explosion for all batteries on board (powerplant + onboard systems): - Depending on the class and type of system: . Should the system have a mean to measure battery temperature? IF YES Is the monitoring system adequate (cooling system, temperature sensor, Active battery management system) [0-2] Note: Active bat. Man. Sys. Should be given highest value. IF NO [1]	**2**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
7.4 b For combustion engine applications, the UAS design should consider ventilation, drainage, fuel lines and tanks installation in order to minimize fire hazard.	**Doc.**	**Desirable**	The applicant shall deliver a document demonstrating the existence of systems to means to minimize the risk of battery overheating / explosion for all batteries on board: - Depending on the class and type of system: . Should the system have a mean to measure battery temperature? IF YES Is the monitoring system adequate (cooling system, temperature sensor, Active battery management system) [0-1] Note: Active bat. Man. Sys. Should be given highest value. The applicant shall deliver a document with a safety assessment addressing ventilation, drainage, fuel lines and tanks installation for the purpose of reducing fire hazards. Does the system show that there are physical barriers between fuel lines and tanks from electrical systems/batteries? [0-1]	**2**
7.5.1.a For electrical engine applications, the UAS should have means to measure the engine battery status (voltage, drown current, estimated battery time)	**Doc.**	**Desirable**	The applicant shall deliver a document defining how the battery status is assessed [0.5] System presents estimated flight time based on battery level [0.5]	**1**
7.5.1.a.1 For electrical engine applications, the UAS should include provisions to alert the UA operator that the battery has discharged to a level, which requires immediate UA recovery actions.	**Doc.**	**Desirable**	The applicant shall deliver a document defining the function for issuing a warning for battery charge critical level. Does the system have means to alert UA operator of low battery? [1]	**1**
7.5.1.b For combustion engine applications, the UAS should include means to measure the UAS fuel quantity during the whole mission.	**Doc.**	**Mandatory**	The applicant shall deliver a document defining how the fuel quantity measurement is made: - direct [1] - calculated from fuel flow. [0.5]	**1**
7.5.1.b 1 The UAS should include provisions to alert the UA operator the fuel quantity has reached a level, which requires immediate UA recovery actions.	**Doc.**	**Desirable**	The applicant shall deliver a document defining the function for issuing a warning for fuel quantity critical level. Does the system have means to alert UA operator that fuel level requires immediate action? [0.5]	**0.5**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
7.5.1.b 2 For combustion engine applications, the UAS should include means to provide to the operator information about fuel quantity.	**Doc.**	**Mandatory**	The applicant shall deliver a document defining the function for providing (in a continuous and permanent way) to the operator the fuel quantity. Does the system have means to inform UA operator of fuel level status? [0.5]	**0.5**
7.5.2 The UAS should include means to mitigate the hazards from engine failures.	**Doc.**	**Desirable**	The applicant shall deliver a document as a safety analysis demonstrating how engine failures effects are mitigated. Namely assessment should consider: There is a strategy to manage loss of power, executed by the operator using checklists. [1] There is a strategy to manage loss of power, executed automatically by the system. [1.5] Is the increase in workload compatible with operator training and experience? [0.5] There is no power loss risk mitigation strategy. [0]	**2**
8. SYSTEM AND EQUIPMENT INTEGRITY				
8.1 The UAS critical equipment should be qualified for worst expected case environmental conditions in accordance with the design spectrum.	**Doc.**	**Desirable**	1. Are all UAS critical equipment qualified for the worst expected case environmental conditions in accordance with the design spectrum? [0-1.5] Are there datasheets and reports confirming the qualification of the system [0.5] 2. Are the UAS critical equipment tested for environmental conditions [0-1]. Are there datasheets of the equipment's? [0.5] 3. Is there an analysis regarding the environmental conditions? [0-1]	**2**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
8.1.1 The UAS installation provisions and the intended usage of all equipment should be designed in accordance with the qualification conditions.	**Doc.**	**Desirable**	The applicant shall deliver a document demonstrating how the environmental conditions were included in the design. This can be made (for example) through a Safety analysis with a specific risk assessment of the humidity, operating temperatures, ice conditions, etc. Was the hazard of humidity considered in the design (Safety analysis)? [0.5] Was the hazard of temperature, including icing conditions considered in the design? [0.5]	**1**
8.2 The UAS must account for electromagnetic Effects (E) in the design	**Doc. & Test**	**Mandatory**	The applicant shall provide documentation that supports qualification and/or design features of the UAS that account for the Environmental Electromagnetic Effects (E3) [1] The applicant shall define in UAS documentation all required operation limitations regarding E3. Statement referring that testing and experience has posed no limits [1] Limits that cause no limitation for desired operation [0.5] Limits that penalize operation [0.25] Note: The applicant is required to demonstrate by test that the UAS is safe when in operation within the established limitations. This test must include ground station, datalink equipment, air vehicle, etc.) If failures or inadequate E3 behaviour occurs during demonstration, the UAS may be penalized with a negative score up to -20	**2**
8.3 The UAS electrical design should be robust and designed to function in the worst foreseen conditions.	**Doc.**	**Desirable**	Did the applicant provide documentation that supports adequate design of electrical systems? [0.2]	**2**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
8.3.1 The UAS electrical capacity generation must be adequate for the intended use.	**Doc. & Test**	**Mandatory**	The flight manual must specify the maximum flight endurance. Does the flight manual include the maximum flight endurance? Note: If this is not demonstrated, the UAS platform will fail. A test must be performed without failure of electrical system for at least 1.5 times the number of allowable hours, with all systems working. Is there test-based evidence that the electrical system sustained full 1.3 times the maximum flight endurance? If No [0] If Yes Is there test-based evidence that the electrical system sustained full 1.5 times the maximum flight endurance? [1.8] If No [0.9]	
8.3.2 The UAS back up energy system must allow for UAS recovery and/or safe flight termination in accordance with the duration defined the flight manual	**Test**	**Mandatory**	A test demonstration must be made for UAS recovery and/or safe flight termination with only the back-up energy system. Is there evidence that the UA is controllable or that flight termination can be asserted on backup battery only? Yes -> pass No -> fail Note: If this is not demonstrated the UAS platform will fail.	

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
8.4 The UAS should be designed to incorporate means for fault detection / fault isolation / fault management:	**Doc.**	**Desirable**	The UAS design should incorporate sufficient set of Built-In-Tests (BIT): power-up self-test [0.25] computers check-sum [0.125] (D)GPS receiver failure indication from power-up [0.2] System health (processor, data packages, memory) [0.2] Navigation solution [0.1] self-test or background BIT [0.125] motherboard under-voltage detection [0.5] temperature monitoring [0.5]	**3**
8.4.1 The UAS should have procedures established to mitigate the effects of detected faults.	**Doc.**	**Desirable**	The UAS should have procedures in place to respond to the faults identified by the system. Does the system respond to faults identified: -Automatically [0.8] -Through operator input [0.5] -Automatic with operator cross-check [1]	
9. SAFE DEMONSTRATION				
9.1 The UAS design should include Functional Hazard Analysis and a Failure Mode Effect and Criticality Analysis for the critical functions	**Doc.**	**Desirable**	All failure modes should be identified. The failure mode analysis should address: - The UAS platform, including: actuators, powerplant, lift surfaces/devices, wheels / landing gear [1] - UCS/UCB, including autopilot, sensors, IMU, control boards, central processing computer, cables to actuators [1] - Data Link and any other equipment necessary to operate the UAS), including data link module (RF module), cables to antennas and antennas [1]	**3**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
9.2 The UAS design should incorporate mitigations established for all failure modes identified.	**Doc.**	**Desirable**	Are all failure modes identified? [1] Are respective mitigation strategies established and documented? [1]	**2**
9.3 The applicant must provide an FTA for the UAS cumulative probability of uncontrolled flight/crash	**Doc.**	**Mandatory**	If the FTA is not done and we do not have a quantitative value for P_cum_cat, but all safety critical systems are fail-safe and/or all safety critical system failures are mitigated in such a way not to have an uncontrolled crash scenario, the total score of 100 could get a penalization of -20 points. If only some systems are fail-safe and/or mitigated adequately, the total budget of 60 points between maximum penalization (-80 if nothing is done on safety) and minimum penalization (-20 without FTA but fail-safe design of all safety critical systems) could be equally split among safety critical systems. Penalization will be calculated as: Score = [-20 – (60/num_of_critical_sys) *num_of_non_redundant_sys] * ClassFactor - With reference to weight classes: - weight < 4kg ClassFactor = 0; - weight <25kg ClassFactor = 1/8; - weight <150kg ClassFactor = ¼; - weight >150kg ClassFactor = 1;	
9.4 The cumulative probability of uncontrolled flight/crash of the UAS should be inferior to 10^{-4}	**Doc.**	**Desirable**	If the Probability of failure is bigger than 10-4 than number of points to be removed is as follows: $Po\,\text{int}\,s\,removed = 100 + 14{,}5 \cdot \ln(\frac{P\_failure}{0{,}1})$ 10^{-4}: No penalty 10^{-3}: - 33 10^{-2}: - 66	
10. SOFTWARE INTEGRITY				

10.1 The applicant should deliver a safety assessment to identify all the software critical functions of the UAS for the lifecycle, including flight control, propulsion, electrical power, etc. **10.1.1 The applicant should deliver documented life cycle assurance processes to deal with the SOFTWARE UAS critical functions.** **10.1.2 Software integrity should be considered in the design of the UAS.**	**Doc.**	**Desirable**	If weight < 4Kg [10] + following questions x 0.3; If weight <25kg [7.5] + following questions x 0.5; If weight < 150kg [5] + following questions x 0.6; If weight > 150kg [0] + scores given by DO-178 DAL compliance. If the applicant delivers a safety assessment to identify all the software critical functions of the UAS for the lifecycle, including: flight control, propulsion, electrical power, etc. (3) If the applicant delivers documented life cycle assurance processes to deal with the SOFTWARE UAS critical functions. (4) ********** (8) For Software development, the applicant should demonstrate that: - requirements for software items are developed; (1) - plans and Accomplishment Summaries to show software integrity are produced by the design organization; (1) - an adequate number of tests is planned, performed and results are recorded; (2) - software problem reports are available and shown to be closed; (1) - configuration management processes for software are established and followed; (2) - in-filed experience as applicable; (1)	**NOTE**: If software development is demonstrated in accordance with DO-178 objectives: For software that may lead to uncontrolled flight or crash: **(15)** - for compliance or equivalency with DO-178 DAL B; **(5)** for compliance or equivalency with DO-178 DAL C; **(+2 *)** **(-20)** for compliance or equivalency with DO-178 DAL D. **(0 *)** **Notes:** If there is no evidence of software life cycle assurance processes, a negative score up to **-50** may be assigned. * Extensive in-field experience with the same software configuration may be considered as credit to increase the scores above, if used with adequate occurrence reporting system for problem report collection.	**15**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
11. CONTINUING AND CONTINUED AIRWORTHINESS				
11.1 The applicant shall provide the UAS Flight Manual, with all the approved standard operating and emergency procedures.	**Doc.**	**Mandatory**	The applicant shall provide the Flight Manual for evaluation. The operational procedures in the Flight Manual shall include (as applicable) take-off, launch, climb, descent, glide, flight in all operating modes, landing, recovery, handover, autorotation, link-loss procedures, etc) The UAS Flight Manual shall define all the operating procedures, limitations and performance information for normal operations and emergency conditions. Does the flight manual provide all standard operating and emergency procedures? Attention to: All operating modes, landing, recovery, handover, autorotation, link-loss procedures [2] Is the flight manual written in English in unambiguous way? [1]	**3**
11.2 The UAS Flight Manual shall be clear, unambiguous, and written in English language.	**Doc.**	**Mandatory**		
11.3 The applicant shall provide the maintenance manual with all necessary instructions for ensuring continuing airworthiness.	**Doc.**	**Mandatory**	Was a Maintenance Manual delivered with the system? If NO [-10] If YES [0-2] <u>Attention to:</u> - life limited parts, equipment inspection intervals and techniques, equipment standard repairs and maintenance, corrosion prevention, etc. - All UAS systems and sub-systems, including propulsion system, airframe, electrical system, fuel system, lubrication system, avionics, sensors calibration, actuators, communication system, ground station; -Transport and handling information.	**2**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
			-Airframe inspection intervals and techniques described adequately in the operational manuals; - Identification of the airframe repairs standard. - Health tracking monitoring equipments and procedures of safety critical systems. - Specification of safe storage conditions. - Identification of corrosion related inspections. **Note:** Lack of instructions for continuing airworthiness or inadequate Maintenance Manual may be penalized with a negative score up to **-10.**	
11. 4 The applicant should provide a pre-flight checklist and a post-flight checklist.	**Doc.**	**Mandatory**	Is there a Pre-flight Checklist? [0.5] Is there a Post-flight Checklist? [0.5]	**1**
11.5 The applicant should provide a training syllabus in accordance with the complexity of the UAS operation and maintenance.	**Doc.**	**Mandatory**	If weight < 4Kg [1] If weight < 25kg NO = [0]; YES [1] If weight > 25kg [1] NO = [-5]; YES = [1]	**1**
11.6 The UAS maintenance manual shall be complete and clearly identify the qualifications for each type of inspection, maintenance and repair required	**Doc.**	**Mandatory**	Does the maintenance manual identify the qualification requirements for performing the inspections? [0.8] Does the maintenance manual [0.2]	**1**

A Requirement	B Type of Evidence	C Type of requirement	D Partial Score applicable to the Method of Compliance	E Max. Score
11.7 The applicant should demonstrate to have a method to track technical occurrences (that have been reported) affecting safety throughout the life of the program.	**Doc.**	**Desirable**	Did the applicant deliver a process to manage tracking occurrences throughout the lifecycle of the UAS? [1] Is the method defined in the maintenance manual for answering reported technical occurrences robust regarding the implementation of preventive measures and corrective actions for future developments or improvements of the system? [0.5] **Note:** If the Company does not manage reported technical occurrences, a negative score up to -5 may be assigned.	**1.5**
11.8 The applicant should demonstrate to have a method to implement preventive and corrective actions as necessary to continuously improve airworthiness.	**Doc.**	**Desirable**		**0.5**