Initial Airworthiness Special Condition

Means of Compliance to Special Condition Light UAS for UAS operated in SAIL III and below.

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EASA European Union Aviation Safety Agency	**Functional Test Based Means of Compliance with SC Light-UAS**	Doc. No. : FTB MOC SC Light-UAS Issue : 1 Date : 26.05.2022 Proposed ☐ Final ☒ Deadline for comments: N/A

SUBJECT:	Means of Compliance to Special Condition Light UAS for UAS operated in SAIL III and below
REQUIREMENTS incl. Amdt:	Special condition Light-UAS Medium Risk, Initial Issue
ASSOCIATED IM/MoC:	Yes☐ / No ☒[Delete last page of associated IM/MoC if not applicable]
ADVISORY MATERIAL:	N/A

INTRODUCTORY NOTE AND IDENTIFICATION OF ISSUE:

Special Condition (SC) Light UAS 'medium risk' defines objective requirements for UAS operated in the specific category and limited to specific assurance and integrity level (SAIL) III and IV. At the time of release of this document, means of compliance (MoCs) for substantiation of requirements of the SC have not yet been adopted by EASA. EASA proposes to utilize extensive evidence from functional tests, as MoC for a significant subset of specifications of the SC. The approach is considered acceptable for UAS operated in SAIL III and below. This MoC should be considered in relation to this limited spectrum and to this subset of specifications. Furthermore EASA reminds that this MoC is only one means of compliance while other MoC can be proposed for acceptance by the Agency.

BACKGROUND: The SAIL represents the level of confidence that the UAS operation will remain under control. It is determined by a combination of the final/residual (i.e.: after mitigations have been applied) ground risk class (GRC) and air risk class (ARC), according to the following table1 :

SAIL determination				
	Residual ARC			
Final GRC	a	b	c	d
≤2	I	II	IV	VI
3	II	II	IV	VI
4	III	III	IV	VI
5	IV	IV	IV	VI
6	V	V	V	VI
7	VI	VI	VI	VI
>7	Category C operation			

[1] As per AMC to article 11 of Regulation (EU) 2019/947

The maximum allowable rate of loss of control of the operation per flight hour (FH) is linked with the SAIL[2] and achieved by means of Operational Safety Objectives (OSOs). In the frame of EASA design verification projects (DVP) / Type Certification projects (TC), compliance with SC Light UAS requirements provides evidence of compliance with technical OSOs.

In statistics, the "rule of three" determines that if an event[3] does not occur in the first n experiments, the maximum probability of its occurrence is 3/n with 95% confidence[4]. For the scope of this MoC, the "event" is loss of control, the "experiment" is the flight hour, the "probability of its occurrence" is the probability of loss of control per flight hour, which is linked with the SAIL as per footnote 2.

Preserving coherence with the utilization of SC Light UAS as design verification basis, EASA has identified in this MoC the subset of SC Light UAS requirements whose substantiation by means of a minimum[5] number of successful flight hours is acceptable and, in consequence, determined which are the SC Light UAS requirements whose compliance demonstration would need further substantiation.

This MoC may require a significant amount of flight test hours to be carried out in approved and safe conditions with a positive outcome, assessing the envelope of the concept of operation (CONOPS) for the UAS configuration under design verification or certification. The applicant should evaluate whether this is an appropriate methodology for its organisation and the product before opting for this solution.

[2] 10^{-SAIL} / FH

[3] Under the assumption of binomial distribution (no demonstration for this element is required as part of this MoC)

[4] considered largely sufficient in view other elements of uncertainty affecting the process.

[5] Nominal (see also chapter 2)

Means of Compliance
Functional Test Based (FTB) MoC for SC Light-UAS

1. Applicability

This MoC is applicable to:

- UAS design verification / type certification for operation in the specific category with SAIL III, and
- Design verification basis / type certification basis provided by SC Light UAS medium risk

2. Methodology

Applicants should refer to ASTM standard F3478-20[6] for the development of their demonstration plans applying the following sections[7] :

1. a demonstration test plan (DTP) (ref. section 8 of ASTM F3478-20)
2. demonstration prerequisites (ref. section 5 of ASTM F3478-20)
3. data collection criteria (ref. section 9 of ASTM F3478-20)
4. final Reporting (ref. section 10 of ASTM F3478-20)

ASTM F3478-20 identifies the forms in Appendix as non mandatory information. Forms used to show compliance based on this MoC and to record relevant information will need to be agreed with the Agency and be coherent with the European regulatory framework. In general, the Agency may define complementing elements to F3478-20 during the execution of any project carried out utilizing this MoC, when this would be necessary to preserve coherence with the European regulatory framework.

[6] F3478-20 Standard Practice for Development of a Durability and Reliability Flight Demonstration Program for Low-Risk Unmanned Aircraft Systems (UAS) under FAA Oversight, published in November 2020.

[7] Where other standards are referenced in F3478-20 (e.g. ICA, UFM), they would still have to be agreed with the Agency, which may provide different indications.

The overall nominal number of flight hours (FH) to be distributed across the DTP is 3000 FH for SAIL III [8,9] Tests should be performed using a number of aircraft in line with ASTM F3478-20 section 5.3 and agreed with the Agency.

Replacing a subset of the above indicated FHs with ground or laboratory testing hours is possible and needs to be discussed and agreed with the Agency. Applicants should substantiate that at least the same level of confidence on the UAS design as if FHs were performed is achieved.

On a case by case basis, applicants may claim that part of the DTP FHs have been demonstrated in lower SAIL operations, provided that:

- configuration differences, if any, are recognized by the Agency as not impairing the applicability for the configuration under assessment with the MoC
- evidence of lower risk operations (flights) has been properly recorded so that compliance with ASTM F3478-20 can be shown

3. Areas of particular attention

The following aspects linked with the application of the methodology may be particularly challenging and require special attention:

- UAS configuration
    - The configuration of the UAS shall be frozen prior to the beginning of the flight testing activities. Configuration changes during the flight testing campaign should be substantiated and might invalidate previous already demonstrated flight hours (see also note 10).
    - Changes to the configuration after project conclusion may require higher substantiation effort than for projects where non-functional test based MoC have been adopted. Strong configuration control during the project is needed and guidance is provided by ASTM F3478.
- Failures
    - Any failure experienced during the execution of the DTP needs to be recorded and analysed to determine whether it infringes the pass criteria defined in the DTP or any SC Light UAS

[8] Specific limitations linked with the CONOPS may be considered for potential adaptation of FHs based on a quantitative approach to ground risk assessment. The EASA DVR will provide such limitations where they are used to decrease the required maximum rate of loss of control and therefore the number of flight hours.

[9] In case a DVP is voluntarily applied for SAILII, EASA would recommend the application of the FTB methodology, leading in this case to a DTP based on a number of FHs not exceeding 300.

specifications. In such cases the applicant needs to perform a root cause analysis and may define design, procedural modifications or limitations to address the failure condition. The root cause analysis and the proposed modifications / limitations should be discussed and agreed with the Agency. Modifications, especially when entailing design changes[10] assessed as potentially impairing the validity of FHs performed before the application of the change[11], will require additional tests[12] to ensure that the cumulated test hours before the change can still be considered valid. The DTP will only be restarted (i.e.: from the point at which it was interrupted before the application of the change) after such additional tests have been successful. In extreme cases, the additional tests would be equivalent to repeat the DTP from the start[13]. The extent of the additional tests would depend on several factors, including, but not limited to, soundness of the root cause analysis and nature of the change / modification. Procedural modifications and limitations, depending on their nature, may have to be tested as well and, in addition, reflected in the DVR.

- CONOPS coverage
    - The DTP needs to substantiate the UAS design in the context of the CONOPS (generic or specific) associated with the DVP/TC application. This may lead to significant effort for the organization of tests in the appropriate scenario. Guidance is provided by ASTM F3478-20.
- Remote pilot
    - Different capabilities of the remote pilot (considering the role asssigned in the UAS operations as a function of the level of automation) may in some cases determine different results in preserving control of the operation. The DTP should be carried out considering that the operator may use remote pilots with limited experience. Higher qualified pilots for testing corners of the envelope or for carrying out likely failure tests can be necessary, in order to ensure proper assessment of the flight envelope, proper triggering of UAS likely failures and thorough design assessment.

[10] This applies also in the case a design change is not originated by a failure and requested by the applicant during DTP execution

[11] This could be the case for design changes affecting the unmanned aircraft, the command unit or the C2 Link. Note: external services and associated infrastructure are outside the boundary of UAS design verification / type certification

[12] Flight/ground/laboratory as agreed with the Agency

[13] This would normally be the case if the design change is applied shortly after having initiated the DTP

4. Compliance with SC Light UAS

This MoC substantiates the following requirements of SC Light UAS :

Light-UAS.2100 (a), (b)

Light-UAS.2105

Light-UAS.2135

Light-UAS.2160

Light-UAS.2240

Light-UAS.2250 (a)

Light-UAS.2260

Light-UAS.2300

Light-UAS.2305

Light-UAS.2375 (a)(1)

Light-UAS.2380 (c)

Light-UAS.2400 (a), (b), (d)

Light-UAS.2405

Light-UAS.2410

Light-UAS.2415

Light-UAS.2430

Light-UAS.2500 (b)

Light-UAS.2510 (partial[14])

Light-UAS.2511[15]

Light-UAS.2528

Light-UAS.2529

[14] Partially covered by the DTP and needing complementing means (e.g. for development assurance aspects)

[15] Only where the SAIL demonstration is considered sufficient to cater for (un)containment risk. In coherence with EASA MoC to 2511 it can be considered that the probability of breaching in adjacent areas / volumes is less than $10^{-SAIL-1}$ / FH..

Light-UAS.2575 (a)

Light-UAS.2602

Light-UAS.2605 (c), (d)

Light-UAS.2615 (a)

Light-UAS.2715

Light-UAS.2720

Light-UAS 2512 is addressed by EASA with dedicated MoC.
Requirements of SC Light UAS not listed above require different means for showing of compliance, such as analysis, inspection of design artefacts, evidence from flight and ground handling manuals, limitations, procedures, maintenance instructions, tests other than flight test and beyond the DTP. Criteria underpinning these means of compliance should be proportionate and pragmatic and should be defined on the base of the first projects opting for a functional test-based (FTB) approach. When mature, EASA may publish the most relevant as further MoC associated with the FTB methodology.

Note: applicants could consider to extend the DTP to substantiate further requirements not above listed provided that they propose adequate complementary means of compliance for those requirements, that the relevant testing is compatible with the functional test campaign and that the Agency agrees with such extension.

5. References

5.1. EU Regulations

- Commission Implementing Regulation (EU) 2019/947 of 24 May 2019 on the rules and procedures for the operation of unmanned aircraft (OJ L 152, 11.6.2019, p. 45)
- Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems (OJ L 152, 11.6.2019, p. 1)

5.2. EASA SC and Guidance Material

- SC for Light UAS
- Guidelines on design verification of UAS operated in the specific category medium risk (SAIL III and IV)

5.3. Standards

- ASTM F3478-20 published on November 2020 “Standard Practice for Development of a Durability and Reliability Flight Demonstration Program for Low-Risk Unmanned Aircraft Systems (UAS) under FAA Oversight”