



The European Organisation for Civil Aviation Equipment
L'Organisation Européenne pour l'Équipement de l'Aviation Civile

UAS SYSTEM SAFETY ASSESSMENT OBJECTIVES AND CRITERIA INPUTS TO “AMC 1309”

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ER-019

October 2018

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CHAPTER 1

INTRODUCTION

1.1 PREAMBLE

This document was prepared by the AMC 1309 Subgroup SG-41 of the EUROCAE "UAS" Working Group 105 Focus Team # 4 (Design & Airworthiness).

The following is a reminder of the various steps regarding the "1309" issue that took place prior to the creation of EUROCAE WG-105:

In 2010-2013, JARUS WG6 and EUROCAE WG-73 had worked in parallel on the subject of UAS System Safety Assessment Objectives and Criteria after the creation of JARUS forum (CAAs experts only) and considering the diverging opinions within EUROCAE WG-73, the European UAS Roadmap (Ref. [1]) called for two inputs:

- JARUS: Draft UAS safety objectives for airworthiness
- EUROCAE WG-73: WG-73 Report on alternative approaches on UAS safety objectives for airworthiness
 - a. EUROCAE WG-73 ER-010 "UAS / UAS 1309 System Safety Objectives and Assessment Criteria" was subsequently issued in July 2013 (Ref. [2])
 - b. JARUS WG6 draft AMC 1309 issue 1 was released for comments in March 2014 and subsequently put on hold.
 - c. A JARUS WG6 – EUROCAE WG-73 Conciliation Team (Ref [7]) was created in June 2015 and a "conciliation team" report was published in November 2015 reviewing eight major "1309" topics raised in the above ER-010 report.
 - d. JARUS AMC 1309 Issue 2 was then publicly released in November 2015 (Ref [3]). This public release was accompanied with the following publication statement:

"An effort to produce an update of the released AMC UAS.1309 Issue 2 has already started. The update will address all topics identified in the "conciliation report" as well as recent developments in the UAS regulatory environment and will accommodate emerging comments from leading regulatory authorities as they gather experience with certification of UAS."

NOTE: *It is recognized that the new Part 23 / CS23 Amendment 5 has replaced and renumbered the previous "23.1309" by "23.2510". For convenience purpose, this report will still use the term "1309".*

1.2 EMERGING UAS REGULATORY ENVIRONMENT

Since the publication of the various documents mentioned in the previous section, the following regulatory activities have taken place:

1.2.1 ICAO

ICAO RPAS Panel is currently working on the update of various annexes to the Chicago Convention (SARPs) for international IFR operations of UAS. This includes in particular additional parts to the Annex 8 (Airworthiness) specifically related to RPA and RPS. Target date for this updated Annex to become effective is now set towards 2021.

1.2.2 European Union

The following steps regarding future UAS regulation in Europe are to be noted:

1.2.2.1 Riga declaration (March 2, 2015)

The Riga declaration, under the auspices of the Council of the European Union, has laid down several principles regarding the safe and efficient introduction of UAS ("drones") in the aviation community, stating in particular the proportionate risk-based approach that should lead future UAS regulation.

1.2.2.2 Basic Regulation (to remove 150 kg threshold)

Until now, it was up to EU Member States to develop rules for the use of drones less than 150 kg, as per Regulation 216/2008. This latter regulation is however currently being revised in order to allow the development of harmonised European requirements for smaller drones as well, based in particular upon the proportionate risk-based approach.

On 26 June 2018, the European Council adopted the updated regulation, following the European Parliament vote on 12 June 2018. The regulation has been signed by both institutions and published in the EU Official Journal, on 22 August 2018.

1.2.3 EASA

1.2.3.1 EASA Opinion 01/2018

EASA has now published a technical opinion [Ref.12] regarding the “Introduction of a regulatory framework for the operation of drones” which implements the proportionate risk-based approach and introduced the following categories.

‘Open’ category, through a combination of limitations, operational rules, requirements for the competency of the remote pilot, as well as technical requirements for UAS, such that the UAS operator may conduct the operation without prior authorisation by the competent authority, or without submitting a declaration.

‘Specific’ category, through a system that includes a risk assessment being conducted by the UAS operator before starting an operation, or an operator complying with a standard scenario, or an operator holding a certificate with privileges.

‘Certified’ category, which means a category of UAS operation that, considering the risks involved, requires the certification of the UA (based upon appropriate airworthiness standards) and its operator, as well as licensing of the flight crew.

1.2.3.2 Handling of the certified category

EASA is currently handling UAS Type Certification on case by case basis, using the guidelines of the EASA Policy on UAS Airworthiness Certification (Ref, [11]) to define, together with the applicant, an appropriate certification Basis, based on the tailoring of a reference manned code and additional special conditions (e.g. S-100).

A new CS-UAS tailored from “new” CS-23 Amendment 5 performance based regulation) for all types of UAS (fixed wing, rotary wing etc...) is planned towards 2019 based upon inputs from JARUS WG-3.

1.2.4 FAA

The FAA is implementing a risk-based approach to UAS integration. The intent is to have a high level of involvement when operational risk to the public is high, and to conserve FAA resources by relying on operator and industry compliance when risk is low, or risk can be appropriately mitigated by industry validated compliance to design and operational standards that are deemed adequate by the FAA.

Albeit the EASA “three pillars concept” is not formally paralleled by FAA rules, the following may be stated.

14 CFR Part 107 is parallel in thinking to the EASA idea of the “Open” category and the JARUS “Category A”.

The FAA approval of waivers to Part 107 is somewhat parallel to the Specific Category and is based upon a risk analysis similar to SORA aimed at streamlining such approval process.

Changes to part 21 are currently envisaged to implement an airworthiness and operational approval process without Type Certification (Special Airworthiness Certificate), similar to the “Specific Category” / medium risk, also based on SORA and acceptable industry standards.

Regarding the “certified” category, FAA uses the provisions of 14 CFR 21.17(b) to handle certification projects (there are currently over 14 in this process) that should eventually lead to a Type Certificate in the special class with a Standard Airworthiness Certificate. The certification basis will be derived from an operational risk assessment

of the unmanned aircraft, the operator, and the concept of operations (CONOPS) to identify hazards and then applies appropriate requirements scoped by six kinetic energy based “risk classes”. Requirements may be drawn either from current rules (e.g. 14 CFR Part 23), industry consensus standards (e.g. ASTM 2910-14), or special conditions (e.g. S-100). Such a process is to be described in an Advisory Circular planned to be published in the fall of 2018 that will provide safety objectives (probability requirements and DALs) as a function of the six kinetic energy based risk classes.

1.2.5 JARUS activities

JARUS being a forum of National CAA experts provides inputs & recommendations to rule-making authorities, noticeably through three Working Groups:

- WG3 relating to UAS Airworthiness Certification Standards;
- WG6 relating to Safety (Specific Operations Risk Assessment “SORA” methodology, AMC RPAS.1309);
- WG7 relating to UAS categorization.

1.3 SCOPE OF THE REPORT

As per WG-105 Terms of Reference, it is intended to “support to the development of future AMC 1309 on UAS System Safety Assessment Objectives and Criteria (for the EASA’s certified category), following up the recommendations of the JARUS EUROCAE WG-73 1309 conciliation team report (Ref. [7])”.

Some recommendations of this document may also be considered for Specific Category (refer to SORA Document Annex E for risk mitigation measures requiring some form of safety assessment to meet level of integrity).

This report aims at analysing and reviewing the JARUS WG6 – EUROCAE WG-73 “1309” conciliation statements previously produced for the eight major topics, identify their impact on current JARUS WG6 AMC RPAS.1309 Issue 2 and future Certification Specification and related Acceptable Means of Compliance to be eventually issued for the UAS certified category. Consideration shall be given to the UAS emerging regulatory context and/or to additional materials that have arisen since then.

Recommendations will be subsequently produced for consideration by different stakeholders, such as ICAO, EASA, FAA and JARUS.

CHAPTER 2

REVIEW OF MAJOR 1309 TOPICS

2.1 GENERAL

JARUS WG6 – EUROCAE WG-73 1309 conciliation team report has identified the following eight major 1309 topics:

- [1] Overall guiding principle
- [2] Interrelation between airworthiness and operations
- [3] Failure severity definition and classification
- [4] Quantitative probability requirements: risk on the ground
- [5] Quantitative probability requirements: risk in the air
- [6] Fail safe criteria
- [7] Development Assurance Levels (“DAL”)
- [8] RPAS categorization.

Each of them has been subject to a statement of issue and a joint conciliation statement (as reminded in Appendix C), based upon rationale and discussions summarized in the report.

The following sections provide a summary review of each of these topics in the light of the evolving regulatory process and of the discussions which took place within WG-105 Airworthiness Focus Team; the conclusions give some recommendations related to the future UAS AMC 1309 and Guidance Material to CS-UAS regarding System Safety Objectives and Assessment Criteria.

Considering the overlap between above topics {2}, [4, [5]] and [8], these will be covered under one section (2.3) under the title of “Interrelation between airworthiness and operations”. Nevertheless, the topic [5] “Risk in the Air” will be subject to an additional and dedicated review under section 2.5.

2.2 OVERALL GUIDING PRINCIPLE

2.2.1 Summary Review

- a) The formulation of the overall guiding principle (“acceptable” risk) remains at a high level and will definitely need to be more explicit once it goes into more detailed and specific criteria.
- b) The Riga declaration (Ref 5) provides some top level criteria for the “acceptability” of such a risk using the following terms: “The incremental integration of drones in the aviation system must not reduce the level of safety presently achieved in civil aviation.”
- c) However, the “acceptable” level of safety may have to be defined in an intrinsic manner and not necessarily “cut and pasted” from manned aviation. The reason is that for unmanned aircraft safety focus has shifted from risk to crew and passengers on board to risk to third parties (on the ground and in the air); the acceptability level of such a risk may not have been explicitly defined for manned aviation and may have to be made more explicit for unmanned aircraft (for instance what is the acceptable level of risk of ground fatalities?), especially when the unmanned aircraft characteristics and type of operation cannot be compared to manned aircraft characteristics.

2.2.2 Recommendation

- a) It is recommended that an overall guiding principle similar to the one agreed in the JARUS WG6 – EUROCAE WG-73 “1309” conciliation report be stated in the introduction of future UAS AMC1309 so that subsequent more detailed criteria and interpretation may be traced back to it.

- b) Such a principle should be formulated as follows, reiterating the conciliation team report statement with the following complements:

UAS shall be designed and operated in such manner that the risk to third parties on ground or in the air is acceptable.

In defining the acceptability of this risk the following shall be taken into consideration:

- The incremental integration of UAs in the aviation system shall not reduce the level of safety presently achieved in civil aviation.
- The specific character of UAs (e.g. designs, types/areas of operations) and the fact that safety focus has shifted from risk to crew and passengers on board to risk to third parties (on the ground and in the air) shall be taken into account.

2.3

INTERRELATION BETWEEN AIRWORTHINESS AND OPERATIONS

2.3.1

Summary Review

- a) As stated in section 2.1, this section covers the three topics of interrelation between Airworthiness and Operations, quantitative probability requirements and UAS categorization.
- b) It appears that, with UAS operations, the operational context and the inherent design characteristics of the UA have a direct impact on basic airworthiness and safety requirements. Whilst this may be more visible in the case of unmanned aviation, such interrelation has also been in place in current manned regulation as well (such IFR/VFR, Part CS27/29 CAT A versus CAT B operations, AWO).
- c) In addition, this approach is consistent with the proportionate risk based approach and with overall guiding principle jointly formulated in the conciliation report (see Appendix C) . It also goes along the proposed classification in draft JARUS document published by WG7 stating that the “C” (Certified) category may also take into account operational risk mitigation or with FAA approach based upon 21.17 (b) considering that the Type Certification Basis may take account of UAS inherent design characteristics as well as the Concept of Operations, based upon the definition of six risk classes.
- d) JARUS AMC1309 issue 2 was published before the new regulatory risk based approach was adopted. It aims at ensuring “that the current overall accident rate/category attained by manned aircraft is not increased with the introduction of equivalent civil UAS”. Such overall objective is different from the overall principle jointly formulated in the conciliation report (see Appendix C) The JARUS RPAS AMC.1309 issue 2 uses a method very similar to the AC.23.1309 (pre-Amendment 5) breaking the UAS into similar classes based in particular on the number of engines, weight & engine type. While this approach has proven very valid for manned aircraft, it cannot be simply re-conducted in the case of UAS, considering the variety of UA configurations and type of operations.
- e) Specific category as described in EASA Opinion 01/2018 and handled through Specific Operations Risk Assessment does well endorse the risk based approach, considering operational context of UAS operations. However it provides an operator approval only. Manufacturers may nevertheless be interested in getting conventional airworthiness approval (through Type Certification or Restricted Type Certification) to their UAS configuration used for specific operations. This kind of airworthiness approval will be granted after showing compliance with Airworthiness Standards (including “AMC.1309”) that should duly consider both UAS design and related Concept of Operations.
- f) On top of above classification, JARUS RPAS AMC.1309 issue 2 introduces the concept of complexity levels (a number of 3). In practice, it is found that only one complexity level is actually relevant.

See Appendix D providing more detailed rationale and discussions on these topics.

2.3.2

Recommendations

- a) The definition of UA classes should be more generic (rather than derived from AC 23.1309 classes) without the need to introduce complexity levels. The definition of risk classes (pending on UA design characteristics such as Kinetic Energy) associated with quantitative probability requirements and DAL criteria (prior to consideration of operational context where relevant) is favoured.
- b) The quantitative probability requirements shall be established in order to provide an “acceptable” risk on the ground according to an agreed rationale, considering the societal and political aspects; this rationale may differ from the one behind the manned aircraft probability requirements. Probability in the region of 1 per million flight hours for a fatal UA crash is a figure that has been often indicated as an acceptable one, although it has not been yet endorsed in any formal civil regulation material.
- c) In performing the analysis of UAS failure conditions and deriving the required level of integrity and assurance, the CONOPS (e.g. flight over crowded area vs flight in remote & unpopulated area, ATM environment) should be taken into account when determining the risk associated with the operation.
- d) Rather than having to assume the number of Catastrophic failure conditions and setting corresponding individual probability requirements a priori, it is recommended to have one primary top level probability requirement related to the combination of all Catastrophic Failure conditions, in combination with and linked to a probability requirement for each individual Catastrophic failure condition. The probability allocation for individual Catastrophic failure conditions shall be such that the top-level probability requirement is met and shall be subject to Certifying authority agreement (usually equally distributed allocation, unless otherwise specified).

2.4

FAILURE SEVERITY DEFINITION AND CLASSIFICATION

2.4.1

Summary Review

- a) JARUS AMC UAS.1309 Issue 2 provides high-level severity definitions largely based on manned AC.23.1309E severity definitions with required slight adaptations.
- b) On the other hand, the proposed classification in ER-010 Appendix 4 had a different intent (as stated in notes a and b of ER-010 Appendix 4 [Ref.2]).

2.4.2

Recommendation

- a) Considering the high-level character of JARUS AMC 1309 failure severity definitions, as recommended in the conciliation report, it is thus recommended to provide FHA alike examples of application of these definitions.
- b) Appendix F of this document proposes, as illustrating guidelines, examples of classification of failure severity definitions (with or without compensating provisions).

NOTE: *The applicant and certification authorities should agree at the earliest phase of the project on the FHA approach with due consideration of CONOPS and RPAS design characteristics, focusing mainly on the following undesirable events based on air and ground risks: deviation from predefined mission with and without capability to perform separation with other aircraft, crash on the different reachable zones with and without being able to reduce the lethality or the probability to impact any people.*

2.5 QUANTITATIVE PROBABILITY REQUIREMENTS: RISK IN THE AIR

2.5.1 Summary Review

- a) It is noted that the section 8 (related to Detect And Avoid) of JARUS AMC 1309 issue 2 is under a large revision.
- b) Nevertheless, it is stressed that like in the case of the risk on the ground, it is important to take first a global approach regarding the risk on the air. Safety requirements on particular systems whose failure may lead to an air collision (not necessarily only DAA) should be derived from the safety target level set forth for the risk in the air.

2.5.2 Recommendation

- a) Regarding the Risk in the Air, rather than focusing only on DAA, and in order to be consistent with ARP 4754A, it is recommended to start with a top safety target and analyse all the systems failure conditions that may lead to an air collision (including navigation, DAA, flight control systems, etc.).
- b) JARUS AMC RPAS.1309 Section 7 ("Failure Conditions classification and probability targets") should not exclude the risk in the air. Section 8 could subsequently refer to specific requirements relative to DAA mandatory equipment depending on operations. It could mention DAA DALs and probability objectives depending on operations (requirements from TSO DAA), as supporting information.

NOTE: *At the time of issuance of this report, there is an ongoing activity at ICAO RPAS level to establish a method and provide guidance to establish DAA safety performance metric(s) allowing States or Regions to define those metrics to enable international RPA operations under IFR without an increase of the risk of a Mid-Air Collision (MAC) compared to today's manned operations. The final result of this activity and its possible impact on safety considerations stated here will have to be taken into account.*

2.6 FAIL-SAFE CRITERIA

2.6.1 Summary Review

- a) The JARUS AMC UAS.1309 Issue 2 introduces the fail-safe criteria in the Note 3 of Table 3: "At UAS functional level, no single failure will result in a catastrophic failure condition."
- b) The fail-safe criteria for Catastrophic failure condition (i.e. leading to an uncontrolled flight and/or crash) which is used in various airworthiness standards is viewed as a sound design principle.
- c) Considering this criteria has a large impact on the system architecture and may not be practical for certain UAS configurations, it should be recognized that, based on the risk based approach, such a criteria may be alleviated, when considering the operation context and a particular UAS configuration.
- d) Potential exception to the single failure criterion (subject to agreement with the Certifying Authority) could e.g. be:
 - Mechanical failures shown to be Extremely Improbable and/or when the design follows recognized industry practices.
 - Failure Conditions with very low exposure time (e.g. engine failure at take-off for single-engine airframe).

NOTE: *The single failure criterion has not been formally introduced in the new CS-23 Amendment 5 or in the new 14 CFR Part 23. with the aim of "having the potential of single-point failures if the risk and probability is acceptable." (Ref.[9], Ref.[10]).*