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Standard Specification for Small Unmanned Aircraft System (sUAS) Parachutes[1]

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1. Scope

1.1 This specification covers the design and manufacture requirements for deployable parachutes of small unmanned aircraft (sUA). This specification defines the design, fabrication, and test requirements of installable, deployable parachute recovery systems (PRS) that are designed to be integrated into an sUA to lessen the impact energy of the system should the sUA fail to sustain normal, stable safe flight.

1.1.1 Compliance with this specification is intended to support an applicant in obtaining permission from a civil aviation authority (CAA) to fly an sUA over people.

1.1.2 Parachute recovery systems that do not include all the minimum requirements of Section 5 and Section 6 of this specification shall not be referred to as meeting this specification.

1.2 This specification is applicable to the design, construction, and test of deployable parachute recovery systems that may be incorporated into the system or structure, or both, of sUA seeking civil aviation authority (CAA) approval in the form of technical standard orders (TSO), flight certificates, flight waivers, flight permits, or other like documentation.

1.3 *Units*—The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2908 Specification for Unmanned Aircraft Flight Manual (UFM) for an Unmanned Aircraft System (UAS)

F2909 Specification for Continued Airworthiness of Light-weight Unmanned Aircraft Systems

F3003 Specification for Quality Assurance of a Small Unmanned Aircraft System (sUAS)

F3364 Practice for Independent Audit Program for Unmanned Aircraft Operators

2.2 *Federal Standards:*[3]

14 CFR Part 107 Small Unmanned Aircraft Systems

MIL-STD-1629A Procedures for Performing a Failure Mode, Effects, and Criticality Analysis

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *abstain, v*—before starting a particular test method, the unmanned aircraft (UA) manufacturer or designated operator shall choose to enter the test or decline to perform the test and any abstention shall be granted before the test begins.

3.1.1.1 *Discussion*—The test form shall be clearly marked as such, indicating that the manufacturer acknowledges the omission of the performance data while the test method was available at the test time.

3.1.2 *acceptable entanglement, n*—interaction of the parachute canopy, risers, or lines with the sUA that does not reduce the effectiveness of the parachute recovery system.

3.1.3 *applicant/proponent, n*—person or organization responsible for seeking the approval to operate and operating a small unmanned aircraft (sUA).

3.1.3.1 *Discussion*—The applicant/proponent may be one of the following entities: manufacturer, operator, or original equipment manufacturer (OEM).

3.1.4 *autonomous triggering system, ATS, n*—device or components independent from any flight critical system of the

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from U.S. Government Publishing Office (GPO), 732 N. Capitol St., NW, Washington, DC 20401, http://www.gpo.gov.

sUA that will detect and initiate parachute deployment upon detection of a critical failure of the sUA in flight.

3.1.5 *ballistic ejection, n*—ejection of the parachute recovery system into free air with the use of springs, pyrotechnic gas generators, or the use of inert gases or compressed air.

3.1.5.1 *Discussion*—Hazardous materials laws (for air transportation, for proper handling, storage, etc.) may apply when using hazardous materials such as pyrotechnic devices, cold gas generators, or compressed CO_2 for a ballistic parachute.

3.1.6 *bill of materials, BOM, n*—specific list of all components defined by this specification that make up the parachute recovery system.

3.1.7 *canopy filling/inflamation time, n*—time from canopy (line) stretch to the first full open canopy position.

3.1.8 *critical number motor failure, CNMF, n*—number of motors required to remove an sUA from stable flight. The subject motors shall be adjacent to one another in cases in which more than one motor is being tested. In the case of an odd number of motors, the number of "failure" motors shall be rounded up to the next even number. If the integrator can demonstrate that the sUA being tested with the PRS needs to have thrust cut from more motors than defined in the example below in order to remove the aircraft from stable flight it is up to the integrator to define the number of motors to reach CNMF. Refer to Section 6 for testing.

Examples of CNMF			
Examples of CNMF	4 Rotor	6 Rotor	8 Rotor
	Immediate Loss of Thrust on one motor	Immediate Loss of Thrust on two adjacent motors	Immediate Loss of Thrust on three adjacent motors

3.1.9 *critical number motor failure plus one, CNMF + 1, n*—number of motors required to remove an sUA from stable flight plus one additional adjacent motor. Refer to Section 6 for testing.

Examples of CNMF + 1			
Examples of CNMF + 1	4 Rotor	6 Rotor	8 Rotor
	Immediate Loss of Thrust on two adjacent motors	Immediate Loss of Thrust on three adjacent motors	Immediate Loss of Thrust on four adjacent motors

3.1.10 *declaration of compliance, n*—mechanism for thorough self-assessment and validation of compliance with this specification in which specific reporting or testing protocols are not listed.

3.1.10.1 *Discussion*—The integrator will keep documentation to support any declarations of compliance. The following information shall be retained on file at the manufacturer's facility for as long as systems remain in service: (*1*) technical data that defines the parachute recovery system's installation in the aircraft; (*2*) technical data that define the components, assemblies, and fabrication of the system; and (*3*) engineering analyses and test data prepared for qualification with this specification.

3.1.11 *demonstration, n*—a practical exhibition of how the PRS or components, or both, work.

3.1.12 *descent rate, n*—final steady state rate of decreasing vertical altitude of the sUA at sea level conditions.

3.1.12.1 *Discussion*—It shall be noted that horizontal speed and the calculation of horizontal impact should be considered based on the worst-case scenario but for the purpose of this specification it is not used as a determining factor. The horizontal impact can be influenced by the construction or deconstruction of the combination of wind or the pendulum effect, or both, both of which are greatly affected by the direction of travel and orientation of the sUA in relation to the PRS during deployment.

3.1.13 *energy measurement, n*—Kinetic energy is calculated as: $KE = 1/2\ mv^2$. Whereas "m" equals sUAs takeoff mass and "v" equals descent speed.

3.1.14 *entanglement, n*—unintended physical interaction of the parachute risers, lines, or canopy with the sUA during a PRS deployment that compromises the functionality and effectiveness of the PRS.

3.1.15 *fail box/orange wire, n*—an independent system from the sUA that is not a normal component of the sUA during operation and is used for introducing the various failure modes independently of the sUA, the PRS, and its FTS and ATS and MTD of the PRS.

3.1.16 *false deployment, n*—an unintentional deployment of the PRS by the ATS during stable flight.

3.1.17 *flight-critical system, n*—system that, should it fail, will cause the sUA to no longer maintain stable flight.

3.1.18 *flight envelope, n*—range of combinations of speed, direction of travel, altitude, roll, angle of attack, and so forth within which the sUA is able to be safely operated without exceeding its structural design load factor.

3.1.19 *flight termination system, FTS, n*—device or components that will disable the propulsion system of the sUA.

3.1.20 *forebody, n*—object connected to the parachute canopy and accompanying drogue chutes, if applicable.

3.1.20.1 *Discussion*—The forebody shall be considered the sUA with any additional attachments (that is, parachute deployment system, payload, electronics, propellers, and so forth).

3.1.21 *full power failure/full power cut, n*—sudden and immediate loss of power function to the critical flight systems of the sUA such as motors, electronic speed controllers (ESC), and avionics.

3.1.21.1 *Discussion*—Throttling down the motors is not the same as a full power cut in a test as the former gives the operator control and advance knowledge that loss of stable flight is going to occur.

3.1.22 *inspection, n*—technique based on visual or dimensional examination of an element; inspection is generally nondestructive and typically includes the use of sight, hearing, smell, touch, and taste, simple physical manipulation, mechanical and electrical gauging, and measurement.

3.1.23 *integrator, n*—entity responsible for the integration of all the various parachute components, the sUA, and the testing of the entire system.