Designation: F2909 – 14

Standard Practice for Maintenance and Continued Airworthiness of Small Unmanned Aircraft Systems (sUAS)[1]

This standard is issued under the fixed designation F2909; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification establishes the standard practice for the maintenance and continued airworthiness of sUAS.

1.2 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2908 Specification for Aircraft Flight Manual (AFM) for a Small Unmanned Aircraft System (sUAS)

F3005 Specification for Batteries for Use in Small Unmanned Aircraft Systems (sUAS)

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *command and control (C2) link(s), n*—safety-critical radio-frequency (RF) link(s) between ground control station (GCS) and the small unmanned aircraft (sUA).

3.1.2 *flight control system, FCS, n*—composed of system components intended to take GCS commands via a C2 link and control flight control surfaces and propulsion systems.

3.1.3 *ground control station, GCS, n*—a land- or sea-based control center that provides the facilities for human control of sUA.

3.1.4 *manufacturer, n*—entity responsible for assembly and integration of components and subsystems to create a safe operating sUAS.

3.1.5 *propulsion system, n*—consists of one or more power plants (for example, a combustion engine or an electric motor and, if used, a propeller or rotor) together with the associated installation of fuel system, control and electrical power supply (for example, batteries, electronic speed controls, fuel cells, or other energy supply).

3.1.6 *shall versus should versus may, v*—use of the word "shall" implies that a procedure or statement is mandatory and must be followed to comply with this standard, "should" implies recommended, and "may" implies optional at the discretion of the supplier, manufacturer, or operator. Since "shall" statements are requirements, they include sufficient detail needed to define compliance (for example, threshold values, test methods, oversight, reference to other standards). "Should" statements are provided as guidance towards the overall goal of improving safety, and could include only subjective statements. "Should" statements also represent parameters that could be used in safety evaluations, and could lead to development of future requirements. "May" statements are provided to clarify acceptability of a specific item or practice, and offer options for satisfying requirements.

3.1.7 *small unmanned aircraft system, sUAS, n*—composed of the small unmanned aircraft (sUA) and all required on-board subsystems, payload, control station, other required off-board subsystems, any required launch and recovery equipment, and C2 links between the sUA and the control station. For purposes of this standard UAS is synonymous with the ICAO definition of a Remotely Piloted Aircraft System (RPAS) and UA is synonymous with the ICAO definition of a Remotely Piloted Aircraft (RPA).

3.1.8 *supplier, n*—any entity engaged in the design and production of components (other than payload if it is not required for safe operation of the sUAS) used on an sUAS.

3.1.8.1 *Discussion*—Where the supplier is not the manufacturer, the supplier can only ensure that the components comply with accepted consensus standards.

3.1.9 *support equipment, n*—all associated equipment, whether ground based or airborne, used to enable safe operation of the sUA. This includes all elements of the control station, C2 links, telemetry, navigation, communications equipment, as well as equipment that may be used to launch and recover the aircraft.

3.2 *Acronyms:*

[1] This practice is under the jurisdiction of ASTM Committee F38 on Unmanned Aircraft Systems and is the direct responsibility of Subcommittee F38.02 on Flight Operations.

Current edition approved Jan. 15, 2014. Published January 2014. DOI: 10.1520/F2909-14.

[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.

3.2.1 *AFM*—Aircraft Flight Manual

3.2.2 *ATC*—Air Traffic Control

3.2.3 *C2*—Command and Control

3.2.4 *CG*—Center of Gravity

3.2.5 *FCS*—Flight Control System

3.2.6 *FTS*—Flight Termination System

3.2.7 *GAA*—Governing Aviation Authority

3.2.8 *GCS*—Ground Control Station

3.2.9 *GPS*—Global Positioning System

3.2.10 *INS*—Inertial Navigation System

3.2.11 *PIC*—Pilot in Command

3.2.12 *RF*—Radio Frequency

3.2.13 *sUA*—Small Unmanned Aircraft

3.2.14 *sUAS*—Small Unmanned Aircraft System

4. Applicability

4.1 This standard is written for all sUAS that are permitted to operate over a defined area and in airspace authorized by a nation's governing aviation authority (GAA). It is assumed that a visual observer(s) will provide for the sense and avoid requirement to avoid collisions with other aircraft and that the maximum range and altitude at which the sUAS can be flown will be specified by the nation's GAA. Unless otherwise specified by a nation's GAA this standard applies only to UA that have a maximum take off gross weight of 25 kg (55 lb) or less.

5. Requirements

5.1 *Continued Airworthiness:*

5.1.1 The sUAS shall be maintained for continued airworthiness to meet sUAS limitations and performance capabilities required by the nation's GAA.

5.2 *Small Unmanned Aircraft System (sUAS) Inspections:*

5.2.1 *Scheduled Maintenance:*

5.2.1.1 The manufacturer shall establish the required intervals for scheduled inspections and publish this schedule in the Aircraft Flight Manual (AFM) conforming to Specification F2908.

5.2.1.2 As a minimum, the sUAS shall not be operated in the GAA's airspace system unless it has undergone a scheduled inspection within the preceding 12 calendar months and has been approved for return to service by a person authorized by the manufacturer or GAA.

5.2.1.3 The manufacturer shall designate the maximum number of hours to be flown between scheduled inspections.

5.2.1.4 The manufacturer shall specify preflight inspection procedures necessary to ensure safe operation of the sUAS.

5.2.1.5 Inspections should address the requirements specified in 5.2.2, as well as any additional items deemed necessary by the manufacturer for safe flight.

5.2.2 *Inspection Requirements:*

5.2.2.1 *Preflight Inspections:*

(1) Airframe shall be visually inspected in order to detect defects resulting from any collision with foreign objects on the ground and in the air.

(2) All critical components as defined by the manufacturer shall be visually inspected for corrosion, degradation, or any anomalies.

(3) The airframe shall be visually inspected to detect potential loose parts or missing fasteners at critical joints and interfaces.

(4) All critical flight controls shall be visually inspected to detect potential loose parts or missing fasteners at critical joints and interfaces.

(5) All critical flight controls shall be inspected to ensure integrity and proper control travel (inclusive of deflection and direction).

(6) If equipped with an internal combustion engine, the fuel shall be verified for correct grade and checked for contamination and degradation. The fuel quantity shall be verified to be adequate for the planned mission.

(7) If equipped with an electric motor, the installed battery shall be of the correct type, properly secured, and adequate charge verified for the flight.

NOTE 1—For certain types of battery chemistry, proper current, temperature, and voltage monitoring may also be required to avoid fire, explosion, or overheating. The inspections shall be performed in accordance with manufacturer's requirements and Specification F3005.

(8) The propeller/rotor components shall be inspected for degradation beyond allowable manufacturer limitations/specifications. Clearance of blades from adjacent structure and/or components as it rotates through its full motion shall be ensured.

(9) The engine control unit(s) shall be inspected and/or tested to ensure functionality without system degradation beyond allowable manufacturer limitations/specifications.

(10) The powerplant components shall be visually inspected for degradation of a material beyond allowable manufacturer limitations/specifications.

(11) The powerplant system areas shall be inspected for extraneous materials and debris.

(12) Each critical electrical sub-system should be checked for component degradation using built in test procedures that will identify component mal-function, if the sUAS has this capability.

(13) The Flight Control System (FCS) computer should be tested on the ground by exercising key functions and visually verifying proper execution of the FCS as per manufacturer's instructions.

(14) The navigation system including, but not limited to, the GPS and INS shall be checked to verify that all systems are providing accurate information.

NOTE 2—This check may be combined with the FCS built-in-test.

(15) If applicable, the hydraulic system shall be visually inspected to detect any fluid leaks, contamination, and proper quantity.

(16) The cooling system shall be visually inspected to detect blockage of any air intake used for cooling critical electronics. Avionics equipment should be checked for proper cooling.

(17) Other critical systems, including Flight Termination Systems (FTS), shall be checked for proper operation.

(18) Latency between command from the GCS and feedback from the airplane shall be measured and within acceptable range per manufacturer's instructions.

(19) GCS software should be tested per manufacturer's instructions.

(20) The commanded inputs shall be verified to be received by the intended aircraft only without any "cross control". The frequency usage shall be per the approved frequency spectrum requirements.

NOTE 3—Cross control means signals meant for one test air vehicle, but received by another sUA in-flight. It may be due to accidental takeover or interference via frequency.

(21) Link between sUA and GCS should be tested per manufacturer's instructions.

(22) Control input devices at GCS should be tested for correct operation.

(23) The GCS shall be verified for proper display operation.

(24) If automatic landing system exists, critical subsystems needed for auto-land shall be tested prior to take-off per manufacturer's instructions.

(25) Autopilot test procedure shall be executed prior to each flight in accordance with manufacturer's instructions.

(26) The GCS configuration shall be verified prior to flight.

(27) The software loads for GCS and sUA, including firmware for system radios, shall be verified for proper configuration.

(28) All sensors, if related to safe aircraft operations, shall be free from any type of blockage and shall be visually inspected for any potential damage or degradation. Some examples may include: blocked pitot-tube, obstructed EO/IR camera, etc.

(29) Launch and recovery systems including landing gear, catapult, etc. shall be visually inspected for potential damage or degradation.

(30) All system antennas shall be visually inspected for potential damage or degradation.

(31) Proper communication between the sUA pilot, safety pilot/trained observer, ATC, and other flight critical decision elements which would reduce and/or eliminate the pilot's ability to control the sUAS shall be verified. Verify proper radio communications between the following:

(a) ATC to Pilot-in-Command (PIC), if applicable.

(b) PIC to ATC, if applicable.

(c) Observer (OBS) to pilot (ground or aerial based, as applicable).

(d) Pilot to OBS (ground or aerial based, as applicable).

(32) Each basic control function shall be exercised with each sUA prior to launch.

(33) All onboard batteries shall be checked to determine battery state. All batteries should have been recharged and balanced per manufacturer's instructions to ensure maximum capacity.

(34) Landing gear, wheels, and tires, if installed, shall be visually inspected for potential damage or degradation.

(35) The aircraft brake system, if installed, shall be inspected for proper operation. Pneumatic brake systems should be serviced per manufacturer's instructions.

5.2.2.2 *Periodic Inspections*—The following inspections (if applicable) shall be performed at the interval established by the manufacturer:

(1) If installed, the fuel quantity indicator(s) shall give an accurate indication of fuel quantity when the aircraft is in a level flight position.

(2) The sUAS fluid system(s) shall be maintained in accordance with the manufacturer's instructions so that the original performance characteristics of the fluid system(s) are not degraded and the reliability of the system(s) is ensured.

(3) The engine fuel, ignition, and intake system shall be inspected and operationally checked to ensure proper operation of each system.

(4) Engine fuel lines shall be inspected for integrity and correct installation. Fuel leaks shall be corrected in accordance with the manufacturer's recommended procedures.

(5) Fuel system filters shall be cleaned, or replaced, at the intervals specified by the manufacturer.

(6) Engine integrity shall be monitored through the use of compression checks, oil analysis, and visual inspections as per manufacturer's instructions.

(7) Battery system indicators shall give an accurate indication of stored electrical capacity.

(8) The engine installation shall be visually inspected for adequate clearance of the engine from the strut/pylon or mount fixtures and/or hardware.

(9) The propeller/rotor components shall be visually inspected for degradation of material beyond allowable manufacturer limitations/specifications. Separation of blades from adjacent structure and/or components as it rotates through its full motion shall be verified.

(10) Perform inspection of, and/or system test of, engine control unit to ensure functionality without system degradation beyond allowable manufacturer limitations/specifications.

(11) The engine case shall be visually inspected for signs of case rupture or burn through.

(12) Powerplant components shall be visually inspected for condition and security.

(13) Powerplant system areas shall be visually inspected for extraneous materials and debris.

(14) The FCS computer shall be tested on the ground by exercising key functions and visually verifying proper execution of the FCS as per manufacturer's instructions.

(15) The electrical wiring shall be visually inspected and tested to avoid degradation due to insulation loss, shorting, etc.

(16) The GCS shall be visually inspected for structural integrity and degradation.

(17) The sUAS health monitoring system shall be inspected as per manufacturer's instructions.

(18) The sUAS shall have contingency plans in place and operational for degraded controllability modes (for example, in-flight emergency, latency, limited response, damage, etc.).

(19) Loss of link "fly home" should be tested by sending simulated information and verifying that autopilot executes appropriately.

5.2.3 *Other Maintenance:*

5.2.3.1 If an engine over speed is encountered during ground or flight operations, a complete engine system inspection in accordance with the manufacturer's recommended procedures shall be conducted.

5.2.3.2 If an aircraft experiences a propeller/rotor strike, as defined by the manufacturer, the propulsion system shall be inspected in accordance with the manufacturer's instructions.

5.2.3.3 The aircraft system(s) shall be maintained in accordance with the manufacturer's instructions and material specifications. The proper use of materials and procedures shall meet the original performance characteristics of the system(s) to prevent degradation or reliability of the system(s).

5.2.3.4 Viewable airframe and powerplant areas should be inspected for extraneous materials and debris anytime maintenance is performed on the sUA.

5.2.3.5 Aircraft fluids, such as lubricating oil, cooling, and hydraulic fluid (if applicable), shall be replaced per the manufacturer's instructions.

5.2.4 *Repairs and Alterations:*

5.2.4.1 The manufacturer shall define a major and minor "repair" and a major and minor "alteration" in the maintenance manual and/or AFM, as well as identify who is authorized to perform each classification of repair or authorization.

5.2.4.2 The manufacturer may require the person performing a major repair or alteration to first obtain written approval from the manufacturer to complete the task.

5.2.4.3 Aircraft weight and balance shall be checked after any aircraft maintenance or modification that may cause a change in the weight and balance.

6. Maintenance Records

6.1 *Logbooks:*

6.1.1 A record of all periodic inspections, maintenance, preventative maintenance, repairs, and alterations performed on the sUAS shall be kept in a logbook. This includes all components of the sUAS, including: sUA, GCS, launch and recovery equipment, C2 link equipment, payload and any other components required to safely operate the sUAS.

6.1.1.1 Individual sUAS components, such as the GCS and sUA, shall have separate logbooks.

6.2 *Return to Service Procedure:*

6.2.1 After scheduled (excluding preflight and postflight) maintenance, repairs, or alterations are performed on any major component(s) of the sUAS, the sUAS can only be returned to service by a person authorized by the manufacturer or GAA.

6.2.2 The sUAS shall be returned to service by an entry in the component's logbook that includes the date, description of work performed, and signature of the authorized person.

6.3 *Deferred Maintenance:*

6.3.1 The manufacturer may define maintenance items that can be deferred by the owner/operator of the sUAS.

6.3.1.1 The manufacturer shall define the maximum duration that the specified maintenance item(s) may be deferred, and any operational restrictions that result from deferral of the item(s).

6.3.2 Deferred maintenance items shall not include any discrepancies that may affect the operational safety of the sUAS.

7. Continued Airworthiness Support

7.1 The manufacturer of a sUAS shall maintain an Operational Safety Monitoring System as a normal business conduct.

7.2 *Assignment of Duties*—Manufacturers may assign operational safety monitoring and continued airworthiness support duties to other entities.

7.3 *Manufacturer's Responsibilities*—sUAS manufacturers shall develop and implement a system of receiving, evaluating, and correcting safety of flight and service difficulty issues.

7.3.1 Manufacturer shall evaluate all safety of flight and service difficulty reports and shall initiate a notice of corrective action (recommended action) or safety directive (mandatory action) as needed to correct any safety of flight related issues.

7.3.2 Manufacturers shall not use notices of corrective action or safety directives to promote or make mandatory non-safety of flight related equipment upgrades or additions.

7.3.3 The manufacturer shall provide with the delivery of each sUAS documented continued airworthiness instructions in the English language. These instructions shall include at least the following:

7.3.3.1 A method for the owner/operator to report maintenance, service, and safety difficulties to the manufacturer, in accordance with 7.4.

7.3.3.2 A method for the owner/operator to obtain and verify that they have the latest safety of flight information developed by the manufacturer in accordance with 7.4.

7.3.3.3 Instructions pertaining to inspection items as needed.

7.4 *Owner/Operator Responsibilities:*

7.4.1 Each owner/operator of a sUAS shall read and comply with the maintenance and continued airworthiness information and instructions provided by the manufacturer.

7.4.2 Each owner/operator of a sUAS shall be responsible for providing the manufacturer with current contact information where the manufacturer may send the owner/operator supplemental notification bulletins.

7.4.3 The owner/operator of a sUAS shall be responsible for notifying the manufacturer of any safety of flight issue or significant service difficulty upon discovery.

NOTE 4—Any issue that may render the sUAS in an unairworthy condition will constitute a safety of flight condition.

7.4.4 The owner/operator of a sUAS shall be responsible for complying with all manufacturer-issued notices of corrective action and/or safety directives and for complying with all applicable GAA regulations in regard to maintaining the airworthiness of the sUAS.

7.4.5 An owner of a sUAS shall ensure that any needed corrective action be completed as specified in a notice.

7.4.6 Should an owner/operator not comply with any mandatory service requirement, the sUAS shall be considered not in compliance with the applicable ASTM standards and may be subject to regulatory action by the presiding aviation authority.

8. Determination of Corrective Action

8.1 The manufacturer of a sUAS shall evaluate and determine corrective action for a safety of flight issue by performing a risk assessment of the issue.

8.2 Manufacturer shall maintain a record of all safety of flight related risk assessments and the resolution thereof.

9. Safety Directives

9.1 A sUAS may have a safety directive issued against an aircraft, GCS, or other component part. The original aircraft manufacturer issues the directive as outlined in Section 8.

9.2 The original sUAS manufacturer is responsible for providing the applicable instructions to comply with any safety directive, which will include:

9.2.1 A list of the tools needed to accomplish the task,

9.2.2 A list of the parts needed to perform the task,

9.2.3 Authorized persons who may perform the task,

9.2.4 Detailed instructions and diagrams as needed to perform the task, and

9.2.5 Method to test/inspect to verify that the task was accomplished properly.

9.3 Safety directives are considered mandatory tasks in order to maintain a condition of safe operation and compliance with the applicable original ASTM design specification and must be completed as specified in the directive.

10. Notice of Corrective Action

10.1 When corrective action is determined to be warranted (based upon risk assessment as described in Section 9), the manufacturer shall issue a notice to the known owner/operators of the affected sUAS's.

10.2 *Notices:*

10.2.1 Notices shall have a page header that contains the following information, when available:

10.2.1.1 The name, postal address, web address, and telephone number of the issuing entity,

10.2.1.2 The date the notice is released,

10.2.1.3 The date the notice takes effect,

10.2.1.4 Limitations for completion of any required corrective action,

10.2.1.5 The make and model of the affected sUAS,

10.2.1.6 The serial number(s) of the affected sUAS,

10.2.1.7 A number that uniquely identifies the notice,

10.2.1.8 The number of the superseded notice, if applicable, and

10.2.1.9 The page number and number of total pages.

10.2.2 The first page shall contain, in large bold uppercase letters, one of the following titles:

10.2.2.1 "SAFETY ALERT" for notifications that require immediate action.

10.2.2.2 "SERVICE BULLETIN" for notifications that do not require immediate action but do recommend future action.

10.2.2.3 "NOTIFICATION" for notifications that do not necessarily recommend future action but are primarily for promulgation of continued airworthiness information.

11. Discontinued Airworthiness Support

11.1 Should a manufacturer no longer be able to support the sUAS produced, the manufacturer should make a timely and diligent effort to contractually transfer any design data needed for continued airworthiness support to a viable entity, such as another manufacturer, type club, user group, or other interested party.

NOTE 5—This section shall not be construed as a requirement for a manufacturer to forfeit for any reason, any patents, copyrights, design ownership, commercial rights, proprietary information, intellectual property, monetary rights, or financial interests in the sale or transfer, or both, of any design data. Should a significant airworthiness issue arise that cannot be satisfactorily resolved, affected sUAS's may be subject to regulatory action by the presiding GAA.

12. Keywords

12.1 airworthiness; continued operational safety; small unmanned aircraft system; sUAS