



Designation: F2501 – 06

Standard Practices for Unmanned Aircraft System Airworthiness¹

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1. Scope

1.1 These practices identify existing regulations, standards, specifications, and handbooks to guide the design, manufacture, test, repair, and maintenance of unmanned aircraft systems and their components.

1.2 *Applicability*—These practices apply to unmanned, powered, fixed wing aircraft and rotorcraft systems seeking government aviation authority approval in the form of airworthiness certificates, flight permits, or other like documentation. It is intended to be used as a reference by unmanned aircraft system designers and manufacturers, as well as by procurement authorities, to help ensure the airworthiness of these systems.

1.3 These practices provide a starting point for developing a standards-based airworthiness certification package for consideration by regulatory authorities. It lists those top-level standards applicable to the major subsystems and components of an unmanned aircraft system. It assumes that Original Equipment Manufacturer (OEM)-provided subsystems and components, purchased and installed as a unit (for example, Global Positioning Systems), are themselves built to applicable standards that are not necessarily listed in these practices. These practices include standards for technologies that are currently in use in unmanned aircraft, as well as those that are not yet, but could be used in the future (for example, radioisotope thermoelectric generators).

1.4 Suggested changes, corrections, or updates should be forwarded to Committee F38.

1.5 *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.*

¹ These practices are under the jurisdiction of ASTM Committee F38 on Unmanned Aircraft Systems and are the direct responsibility of Subcommittee F38.01 on Airworthiness.

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2. Referenced Documents

2.1 ASTM Standards:²

B117 Practice for Operating Salt Spray (Fog) Apparatus

D910 Specification for Aviation Gasolines

D1655 Specification for Aviation Turbine Fuels

F2279 Practice for Quality Assurance in the Manufacture of Fixed Wing Light Sport Aircraft

F2316 Specification for Airframe Emergency Parachutes for Light Sport Aircraft

F2339 Practice for Design and Manufacture of Reciprocating Spark Ignition Engines for Light Sport Aircraft

F2395 Terminology for Unmanned Aircraft Systems

F2411 Specification for Design and Performance of an Airborne Sense-and-Avoid System

2.2 AIAA Document:³

AIAA R-103-2004 Terminology for Unmanned Aerial Vehicles and Remotely Operated Aircraft

3. Referenced Practices

3.1 The regulations, standards, specifications, and handbooks cited as recommended practices herein are referenced for use in the following precedence: U.S. Federal Aviation Administration (FAA) regulations and advisory circulars; U.S. Department of Defense (DoD) standards, specifications and handbooks; documents produced by other government agencies; and non government standards (NGS) produced by standards development organizations (SDOs) and similar bodies. Suffixes indicating editions of referenced standards are omitted to reduce the frequency of updates to these practices. Non-current standards are so indicated at the end of their titles.

3.2 References are made to standards written specifically for other than unmanned aircraft (for example, light sport aircraft)

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 American Institute of Aeronautics and Astronautics (AIAA), 1801 Alexander Bell Drive, Suite 500, Reston, VA 20191-4344.

and for human considerations (for example, personal parachutes) where they are judged to have some degree of parallel applicability to unmanned aircraft design and use.

4. Terminology

4.1 Refer to Terminology **F2395** and AIAA R-103-2004 for definitions of terms used in these practices.

4.2 Abbreviations:

4.2.1 The following abbreviations are used in the titles of the referenced documents.

4.2.2 *AC*—Advisory Circular (FAA)

4.2.3 *AFGS*—Air Force Guides Specifications (DoD)

4.2.4 *AIAA*—American Institute of Aeronautics and Astronautics

4.2.5 *ANSI*—American National Standards Institute

4.2.6 *ARINC*—Aeronautical Radio, Incorporated

4.2.7 *ASTM*—American Society for Testing and Materials (ASTM International)

4.2.8 *BS*—British Standard

4.2.9 *CFR*—Code of Federal Regulations

4.2.10 *EUROCAE*—European Organisation for Civil Aviation Equipment

4.2.11 *IEC*—International Electrotechnical Commission

4.2.12 *IEEE*—Institute of Electrical and Electronics Engineers

4.2.13 *ISO*—International Standards Organization

4.2.14 *JEDEC*—Joint Electron Device Engineering Council

4.2.15 *JIS*—Japanese Industrial Standard

4.2.16 *JSSG*—Joint Services Specification Guides (DoD)

4.2.17 *MIL HDBK*—Military Handbook (DoD)

4.2.18 *MIL STD*—Military Standard (DoD)

4.2.19 *NASA*—National Aeronautics and Space Administration (U.S.)

4.2.20 *RTCA*—Radio Technical Commission for Aeronautics

4.2.21 *SAE*—Society of Automotive Engineers

5. Summary of Practice

5.1 These practices provide references to currently available published standards and practices having wide acceptance in the aviation community and specific applicability to the unmanned aviation community. These standards and practices address material selection (design), structural fabrication and repair (manufacturing), and inspection and quality control (testing) of aviation-quality components and systems. It does not address operating procedures, operator qualifications, or other non-material determinants of system quality and safety. It is recognized that not all of these standards and practices will be equally applicable to all models of unmanned aircraft.

5.2 Organization of Recommended Practices (Section 7):

Airframe	7.1
Materials	7.1.1
Metals	7.1.1.1

Non-metals	7.1.1.2
Structures	7.1.2
Flight Controls	7.1.3
Actuators	7.1.3.1
Control Linkages	7.1.3.2
Autopilots	7.1.3.3
Landing Gear	7.1.4
Wheels/Brakes/Anti-Skid Control	7.1.4.1
Gears/Struts/Couplings	7.1.4.2
Tires	7.1.4.3
Launch Devices	7.1.5
Recovery Devices	7.1.6
Environmental	7.1.7
External (Ambient) Environment	7.1.7.1
Internal (Onboard) Environment	7.1.7.2
Other (Airframe)	7.1.8
Power and Propulsion	7.2
Reciprocating Engines	7.2.1
Turbine Engines	7.2.2
Electric Motors	7.2.3
Batteries	7.2.3.1
Fuel Cells	7.2.3.2
Solar Cells (Photovoltaic)	7.2.3.3
Radioisotope (Thermoelectric)	7.2.3.4
Propellers	7.2.4
Electrical Distribution Systems	7.2.5
Generators/Converters	7.2.5.1
Starters	7.2.5.2
Wiring	7.2.5.3
Fuel Systems	7.2.6
Fuels	7.2.6.1
Pumps/Valves/Meters	7.2.6.2
Tanks and Plumbing	7.2.6.3
Other (Power and Propulsion)	7.2.7
Avionics	7.3
Communication and Navigation	7.3.1
Safety and Situational Awareness	7.3.2
Lighting and Placards	7.3.2.1
Sense and Avoidance	7.3.2.2
Transponders	7.3.2.3
Weather Avoidance/Mitigation	7.3.2.4
Computers and Processors	7.3.3
Hardware	7.3.3.1
Software	7.3.3.2
Data Buses	7.3.3.3
Links	7.3.4
Command & Control and Telemetry	7.3.4.1
Data (Payloads/Sensors)	7.3.4.2
Link Security and Reliability	7.3.4.3
Other (Avionics)	7.3.5

6. Significance and Use

6.1 Designing, manufacturing, testing, and maintaining an unmanned aircraft system to comply with industry standards and recommended practices supports development of a certification package that helps ensure its reliability and can lead to its airworthiness certification. Government aviation authorities' airworthiness certification processes exist to provide some level of assurance that critical systems will operate reliably and pose minimal risk to persons and property. The use of proven standards and practices in the design, manufacture, and test of these systems, especially for the mission critical components, contributes to this goal, as well as streamlining the certification process and simplifying the system test requirements. While developing to a set of standards and practices will not guarantee certification, the ability to show compliance with established standards provides the basis for a well-documented certification approval package.

6.2 Compliance with established standards and practices also provides assurance that a given component will function

as intended in the specified environment and conditions. The standards cited in these practices have been developed by recognized standards-developing agencies; some are accepted by government aviation authorities as an acceptable means of compliance with airworthiness requirements. By their inclusion in these practices, they are considered to be consensus-based for unmanned aircraft-related purposes.

7. Recommended Industry Practices

7.1 *Airframe*—Aircraft materials and structures largely determine the performance limitations (g-loads, flutter, and so forth), safety, and affordability of the overall system. The type and quality of the materials used in these structures, as well as the methods by which they are molded, joined, attached, and repaired, directly impact these three areas. They also impact the equipping and layout of the manufacturer's production floor and the hiring (skill level demands) of production floor employees.

14 *Code of Federal Regulations (CFR) Part 21*—Certification Procedures for Products and Parts

14 *Code of Federal Regulations (CFR) Part 23*—Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes

14 *Code of Federal Regulations (CFR) Part 25*—Airworthiness Standards: Transport Category Airplanes

14 *Code of Federal Regulations (CFR) Part 27*—Airworthiness Standards: Normal Category Rotorcraft

14 *Code of Federal Regulations (CFR) Part 29*—Airworthiness Standards: Transport Category Rotorcraft

14 *Code of Federal Regulations (CFR) Part 39*—Airworthiness Directives

FAA Order 8130.2E—Airworthiness Certification of Aircraft and Related Products—The FAA and Industry Guide to Aviation Product Certification

FAA-H-8083-1—Aircraft Weight and Balance Handbook—An FAA guide to help developers successfully complete the civil certification process.

FAA-AC-23-17b—Guide for Certification of Part 23 Aircraft

FAA AC 43.13-1B—Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair—A description of methods, techniques, and practices for inspecting and repairing wood, fabric, fiberglass, plastic, and metal airframe components, and conducting nondestructive and corrosion inspection. It also addresses aircraft hardware, engines and propellers, landing gear, hydraulics, electrical systems and wiring, batteries, avionics, and pitot static systems.

MIL-HDBK-514—Operational Safety, Suitability, and Effectiveness for the Aeronautical Enterprise

MIL-HDBK-516—Airworthiness Certification Criteria—The DoD-wide guidance (not requirements) for all aspects of airworthiness certification. Cross references its paragraphs with JSSG standards and FAA 14 CFR Parts, and includes criteria for shipborne aircraft.

JSSG-2001B—Air Vehicle

JSSG-2009—Air Vehicle Subsystems

ASTM Practice F2279—Practice for Quality Assurance in the Manufacture of Light Sport Airplanes

7.1.1 Materials:

7.1.1.1 Metals:

FAA AC 25.613-1X—Material Strength Properties and Material Design Values

MIL-HDK-5—Metallic Materials and Elements for Aerospace Vehicle Structures—A description of material properties (strength, fracture toughness, fatigue strength, creep strength, crack propagation rate, resistance to corrosion, and so forth) for metallic materials and fasteners commonly used in airframes to determine design allowables.

7.1.1.2 Non-Metals:

(1) MIL-HDBK-17—Composite Materials Handbook—A description of material properties of non-metallic materials commonly used in airframes such as fiber glass and carbon composites.

(2) SAE-AMS-PRF 46194—Foam, Rigid, Structural, Closed Cell

(3) SAE-AMS-STD 401—Sandwich Constructions and Core Materials; General Test Methods

7.1.2 Structures:

14 *Code of Federal Regulations (CFR) Part 43*—Maintenance, Preventative Maintenance, Rebuilding, and Alteration

FAA AC 20-107A—Composite Aircraft Structures

FAA AC 25.571-1C—Damage-Tolerance and Fatigue Evaluation of Structure

FAA AC 43.13-2A—Acceptable Methods, Techniques, and Practices—Aircraft Alterations

MIL-HDBK-1530—General Guidelines for Aircraft Structural Integrity Program

JSSG-2006—Aircraft Structures

National Aeronautics and Space Administration Technical Memorandum (NASA/TM)-1998-208456—Low-Cost Quality Control and Nondestructive Evaluation Technologies for General Aviation Structures

RTCA DO-213—Minimum Operational Performance Standards for Nose-Mounted Radomes

SAE-AE-27—Design of Durable, Repairable, and Maintainable Aircraft Composites

SAE-ARP-1611—Quality Inspection Procedure, Composites, Tracer Fluoroscopy and Radiography

SAE-ARP-5089—Composite Repair NDT/NDI Handbook

7.1.3 Flight Controls:

JSSG-2008—Vehicle Control and Management System (VCMS)

SAE-AIR-4094—Aircraft Flight Control Systems Descriptions

SAE-ARP-4386—Terminology and Definitions for Aerospace Fluid Power, Actuation and Control Technologies

7.1.3.1 Actuators:

MIL-STD-5522—Test Requirements and Methods for Aircraft Hydraulic and Emergency Pneumatic Systems

SAE-ARP-988—Electrohydraulic Mechanical Feedback Servoactuators

SAE-AIR-4253—Description of Actuation Systems for Aircraft with Fly-By-Wire Flight Control Systems

SAE-ARP-4895—Aerospace—Flight Control Actuator Displacement—Method for Collection of Data