



Designation: **F3002--14a F3002 – 22**

Standard Specification for Design of the Command and Control System for Small Unmanned Aircraft Systems (sUAS)¹

This standard is issued under the fixed designation F3002; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope

1.1 This specification is provided as a consensus standard in support of an application to a nation's governing aviation authority (GAA) for a permit to operate a small unmanned aircraft system (sUAS) for commercial or public use purposes.

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

1.3 *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

[F2910 Specification for Design, Construction, Design and Test Construction of a Small Unmanned Aircraft System \(sUAS\)](#)

[F2911 Practice for Production Acceptance of a Small Unmanned Aircraft System \(sUAS\)](#)

[F3003 Specification for Quality Assurance of a Small Unmanned Aircraft System \(sUAS\)](#)

[F3060 Terminology for Aircraft](#)

[F3341/F3341M Terminology for Unmanned Aircraft Systems](#)

2.2 EN Standard:³

[EN 62262 Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts \(IK code\)](#)

2.3 IEC Standard:³

[IEC 60529 Degrees of protection provided by enclosures \(IP Code\)](#)

3. Terminology

3.1 *Definitions: Unique and Common Terminology*—Terminology used in multiple standards is defined in [F3341/F3341M](#), UAS Terminology Standard and [F3060](#), Aircraft Terminology Standard. Terminology that is unique to this specification is defined in this section.

3.1.1 *bit error rate detection, BER, n*—rate at which errors occur in a transmission system; applicable to any system that transmits data over a network of some form in which noise, interference, and phase jitter may cause degradation of the digital signal.

¹ This specification is under the jurisdiction of ASTM Committee [F38](#) on Unmanned Aircraft Systems and is the direct responsibility of Subcommittee [F38.01](#) on Airworthiness.

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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 standard's](#) Document Summary page on the ASTM website.

³ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, [http://www.ansi.org](#).

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

3.1.3 *C2 range*, *n*—distance between GCS and UA at which positive control of the UA can be maintained.

3.1.4 *downlink*, *n*—any RF link from UA to GCS.

3.1.5 *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.

3.1.5.1 *Discussion*—

The FCS may include autopilot functions, lost-link functions, fly-away protection functions, payload functions, and navigation functions. The FCS may be contained in one discrete component or multiple discrete components.

3.1.6 *fly away*, *n*—unintended flight outside of operational boundaries (altitude/airspeed/lateral) as the result of a failure of the control element or onboard systems, or both.

3.1.7 *fly-away protection system*, *n*—a system that will return the UA safely to the surface, or keep the UA within the intended operational area, when the C2 link between the pilot and the UA is lost.

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

3.1.9 *licensed band*, *n*—any frequency or range of frequencies in which transmission requires permission from a governing body (for example, the Federal Communications Commission [FCC]).

3.1.10 *link error*, *n*—degradation of the digital signal between the GCS and the UA that can be monitored by techniques including BER detection.

3.1.11 *link integrity*, *n*—acceptable rate of transactions completed with undetected error.

3.1.12 *link timeout*, *n*—time between the actual lost-link event being validated and the system initiating the lost-link procedure.

3.1.13 *lost link*, *n*—occurrence in which the pilot in command (PIC) has lost the ability to control positively the sUAS because of degradation, loss or interruption of the necessary control or monitoring link(s), or both.

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

3.1.15 *pilot in command, PIC*, *n*—the pilot responsible for the operation and safety of the UA during flight time.

3.1.16 *positive control*, *n*—a condition in which commanded changes in the UA flight path result in the expected maneuver(s) within an expected period of time.

3.1.17 *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.

3.1.18 *unmanned aircraft, UA*, *n*—airborne portion of the sUAS.

3.1.19 *uplink*, *n*—any RF link from GCS to UA.

3.2 *Acronyms*:

3.2.1 *BER*—Bit Error Rate

- 3.2.2 *C2*—Command and Control
- 3.2.3 *FCC*—Federal Communications Commission
- 3.2.4 *FCS*—Flight Control Station
- 3.2.5 *GAA*—Governing Aviation Authority
- 3.2.6 *GCS*—Ground Control Station
- 3.2.7 *GPS*—Global Positioning System
- 3.2.8 *HMI*—Human/Machine Interface
- 3.2.9 *PIC*—Pilot in Command
- 3.2.10 *RF*—Radio Frequency
- 3.2.11 *RFI*—Radio Frequency Interference
- 3.2.12 *RX*—Receiver
- 3.2.13 *sUA*—Small Unmanned Aircraft
- 3.2.14 *sUAS*—Small Unmanned Aircraft System
- 3.2.15 *TX*—Transmitter
- 3.2.16 *UA*—Unmanned Aircraft

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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 GAA. It is assumed that one or more visual observers 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 gross takeoff weight of 25 kg (55 lb) or less.

5. Functional Architecture

5.1 A high-level functional block diagram of the C2 system is presented in **Fig. 1**.

6. General Requirements

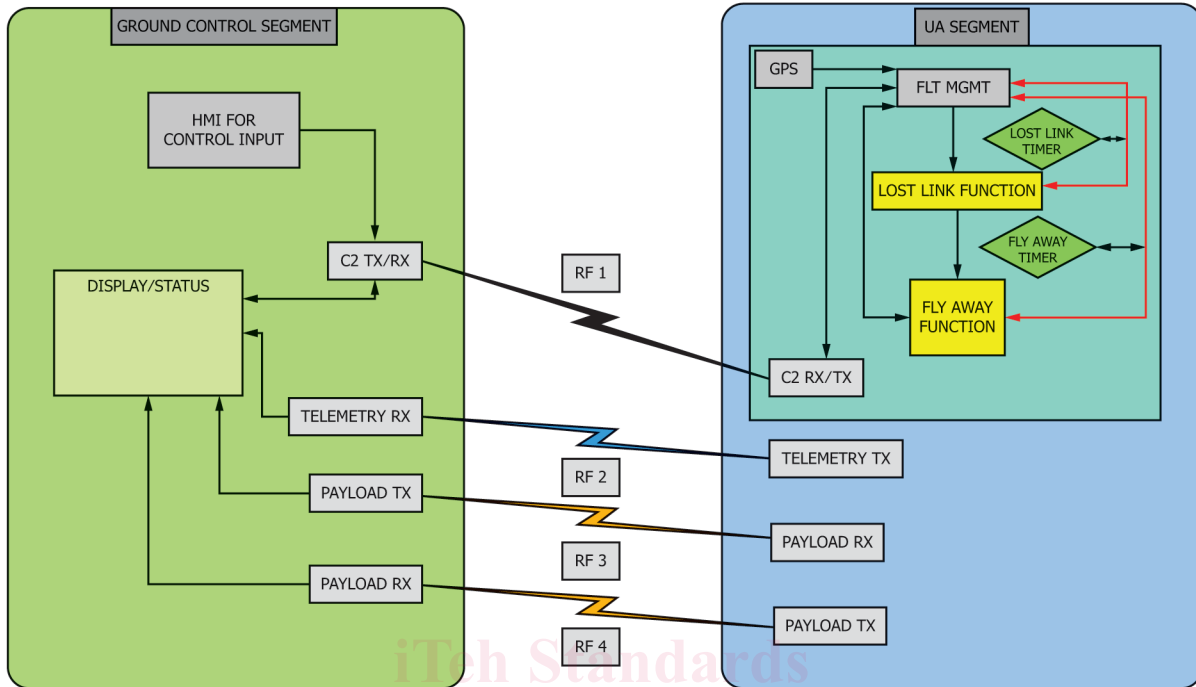
6.1 The following are general C2 requirements involving the system components listed below:

6.1.1 All C2 system and UA components shall minimize RFI so as not to degrade C2 link performance below acceptable levels.

6.1.2 All C2 system and UA components shall minimize RFI so as not to corrupt data transmitted or received over the C2 link.

6.1.3 All C2 system electronic components shall be protected from impacts that may occur during normal operation (an impact rating of EN 62262 IK06 is recommended).

NOTIONAL C2/LOST LINK/FLY AWAY FUNCTIONAL DIAGRAM



DESCRIPTION

On the Ground Station side, the Display function may be separate from the HMI control input function or contained within the HMI control input function

On the UA side, the light green box represents where the flight management, lost link function and timer, fly away protection function, potential navigation input (GPS) and the C2 RX and TX may reside. All of these functions could reside in one physical device or multiple devices.

RF links are depicted as individual link pairs—they may be in one radio or multiple radios, depending on regulatory requirements

The lost link function is depicted to be triggered prior to a fly away function

FIG. 1 High-Level Functional Block Diagram of the C2 System

6.1.4 All C2 system electronic components shall be protected from environmental conditions that may occur during normal operation.

6.1.5 All C2 electronic devices shall be labeled with power requirements.

6.1.6 The C2 system’s antenna, associated RF connections and System Acceptance Test Report shall be furnished as part of the C2 system.

6.1.7 Signal and power connectors for C2 electronic devices shall provide self-locking or positive locking connectors to ensure continuity of power and signal transmission during normal operation.

6.1.8 The C2 system shall provide for mounting to a fixed surface using rigid or semi-rigid fasteners. (Non-rigid fasteners, such as strings, rubber bands, and glue, are not permitted for this purpose.)

7. C2 System Spectrum Requirements

7.1 Small UAS operations using unlicensed bands shall be conducted in accordance with applicable regulations.

7.2 Small UAS operations using a licensed band shall obtain approval to use that band from the appropriate governing agency.

8. C2 Link

8.1 *Functional Requirements*—The C2 link shall provide C2 link status to the UA FCS to allow the UA FCS to initiate lost-link logic when C2 link connectivity is lost.

8.2 *Performance Requirements:*

8.2.1 The rate of C2 link transactions completed with undetected error shall not exceed 0.001 %.

8.2.2 The C2 link shall be capable of transmitting the minimum set of data required by the GAA.

8.2.3 The C2 link shall be capable of receiving the minimum set of data required by the GAA.

8.2.4 The C2 link shall transmit all data that are safety critical as established by the manufacturer.

8.2.5 A loss of connectivity for longer than a maximum duration to be established by the country's GAA shall trigger a lost-link condition.

8.2.6 The C2 link shall prevent unauthorized ground control stations from pairing with or controlling the UA.

8.2.7 The C2 link shall be rated by the manufacturer with maximum range.

8.2.8 C2 radios shall be labeled with operating frequency and channel information.

8.3 *Testing Requirements*—If a C2 downlink is required by the manufacturer for safety-of-flight or operational requirements, or both, the C2 link data integrity shall be monitored while C2 system elements are emitting RF and the GCS transmitter is operating at maximum transmission power.

9. GCS

9.1 *Operational Requirements:*

9.1.1 There shall be a means for verifying before flight that the fly-away protection system is capable of functioning properly during flight.

9.2 *Functional Requirements:*

9.2.1 If a C2 downlink is required by the manufacturer for safety-of-flight or operational requirements, or both, the GCS shall be capable of providing position and altitude data to the PIC.

9.2.2 If a C2 downlink is required by the manufacturer for safety-of-flight or operational requirements, or both, the GCS shall provide the capability to monitor the C2 uplink bit error rate.