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Standard Guide for Training for Remote Pilot in Command of Unmanned Aircraft Systems (UAS) Endorsement¹

This standard is issued under the fixed designation F3266; 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 guide is intended for two distinct readers: educators who wish to develop curricula and training courses and individual pilots wishing to raise their knowledge level for particular flight operations. The guide describes the knowledge, skills, and abilities required to safely operate unmanned aircraft for commercial purposes. A Civil Aviation Authority (CAA) may, at their discretion, use this guide to aid the development of existing or future regulations. This guide addresses powered fixed-wing, vertical-take-off and lift and rotorcraft UAS and not other potential unmanned aircraft categories (for example, glider, lighter-than-air, etc.). This guide has been purposefully designed within the broader context of the ASTM F38 library. Although the original source materials for the content presented here were intended to function as standalone documents, the committee has consciously removed any redundant information in favor of adopting a referential “single-source-of-truth” approach. Consequently, when applying this standard, it is essential to consider and integrate all relevant ASTM F38 standards to ensure its comprehensive and accurate implementation.

1.2 When intending to utilize the information provided in this guide as a means of compliance for operational and/or design approval, it is crucial to consult with the respective oversight authority (for example, CAA) regarding its acceptable use and application. To find out which oversight authorities have accepted this standard (in whole or in part) as an acceptable means of compliance to their regulatory requirements (hereinafter “the Rules”), please refer to the ASTM F38 webpage (www.ASTM.org/COMMITTEE/F38.htm).

1.3 An unmanned aircraft system (UAS) is composed of the unmanned aircraft and all required on-board subsystems, payloads, control station, other required off-board subsystems, any required launch and recovery equipment, all required crew members, and command and control (C2) links between UA and the control station.

1.4 This guide provides fundamental general knowledge, task performance and knowledge, and activities and functions for remote pilots of lightweight UAS (but not necessarily limited to UAs under 55 lb Gross Take Off Weight) or for certain CAA operational approvals using risk-based categories. Flight operations outside the scope of this guide require additional knowledge, experience, and training.

1.5 This guide can be used to evaluate a training course outline and syllabus to determine when its content includes the topics necessary for training individuals to be proficient and competent remote pilot personnel. Likewise, this guide may be used to evaluate an existing training program to see when it meets the requirements in this guide.

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1.6 A person meeting the requirements of this guide does not necessarily possess adequate knowledge, experience, and training to make specific mission-critical decisions safely. This guide merely describes recommended topics and does not provide specific mission training.

1.7 It is not the intent of this guide to require that a training course track the sequence or exact scope of the topics presented. However, the knowledge and skill objectives that are part of the training course should be included in any training course outline and syllabus to be used to train remote pilots. Furthermore, it is not the intent of this guide to limit the addition of knowledge and skill objectives required by local conditions or any governmental body.

1.8 The knowledge, skills, and abilities described in the following sections are not intended to be a rigid training sequence and should be adjusted by the appropriate CAA for specific scope and context.

1.9 This guide does not stand alone and must be used with other CAA/ASTM standards to identify the knowledge, skills, and abilities needed for remote pilots to operate safely and effectively.

1.10 Where proficiency in a skill or ability need be demonstrated, unless stated otherwise they shall be demonstrated for initial qualification, and as frequently as required by CAA.

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

1.12 *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.*

1.13 *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 \(UAS\)](#)

[F3005 Specification for Batteries for Use in Small Unmanned Aircraft Systems \(sUAS\)](#)

[F3060 Terminology for Aircraft](#)

[F3178 Practice for Operational Risk Assessment of Small Unmanned Aircraft Systems \(sUAS\)](#)

[F3298 Specification for Design, Construction, and Verification of Fixed-Wing Lightweight Unmanned Aircraft System Systems \(UAS\)](#)

[F3341 Terminology for Unmanned Aircraft Systems](#)

2.2 U.S. Federal Standards:³

[14 CFR Part 107 Small Unmanned Aircraft Systems](#)

2.3 EASA Standard:⁴

[NPA 2017-05 \(A\) Unmanned Aircraft System Operations in the Open and Specific Category \(Draft\)](#)

2.4 Australian Government Civil Aviation Safety Authority (CASA):⁵

[AC 101-01 Remotely Piloted Aircraft Systems – Licensing and Operations](#)

2.5 South African Civil Aviation Authority (SACAA):⁶

[AIC 007/2015 Remote Pilot License: Training, Examination and Application for RPL Requirements](#)

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 Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, <http://www.access.gpo.gov>.

⁴ Available from European Aviation Safety Agency (EASA), EASA Headquarters Konrad-Adenauer-Ufer 3, D-50668 Cologne, Germany, <https://www.easa.europa.eu>.

⁵ Available from the Australian Government Civil Aviation Safety Authority (CASA), GPO Box 2005, Canberra ACT 2601, Australia, <https://www.casa.gov.au>.

⁶ Available from the South African Civil Aviation Authority (SACAA), Ikhaya Lokundiza, Building 16, Treur Close, Waterfall Park, Bekker Street, Midrand, South Africa, <https://www.caa.co.za>.

3. Terminology

3.1 Unique and Common Terminology—Terminology used in multiple standards is defined in Terminology F3341 and Terminology F3060. Terminology that is unique to this specification is defined in this section.

3.2 Definitions:

3.2.1 *alert, n*—a generic term used to describe a control station indication meant to attract the attention of and identify to the flight crew a non-normal operational or airplane system condition. Alerts are classified at levels or categories corresponding to Warnings, Cautions, and Advisories. Alert indications also include non-normal range markings (for example, exceedances’ on instruments and gauges.)”

3.2.2 *applicant/proponent, n*—the person or organization responsible for seeking the approval to operate and operating a UA. The applicant/proponent may be one of the following entities: manufacturer, operator, or original equipment manufacturer.

3.2.2.1 *manufacturer, n*—the person or organization who causes production of a product or article. A manufacturer may also be an operator.

3.2.2.2 *operator, n*—the person or organization that applies for CAA approval to operate a UAS or who seeks operational approval for types of flight operations prohibited by a CAA for that UAS.

3.2.2.3 *original equipment manufacturer, n*—the person or organization who first produced that product or article. An OEM may also be an operator.

3.2.3 *Authority Having Jurisdiction (AHJ), n*—an organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, in installation, or a procedure.

3.2.4 *automatic flight control system, n*—a system which includes all equipment to control automatically the flight of an aircraft to a path or altitude described by references, internal or external, to the aircraft.

3.2.5 *Control and Non-Payload Communications (CNPC), n*—radio frequency (RF) link(s) between the control station (CS) and the unmanned aircraft (UA), also known as the Command and Control Link(s).

3.2.6 *control station, n*—apparatus for hosting the remote pilot and her/his device to operate the UAS.

3.2.7 *controlled flight, n*—a condition whereby the remote pilot or onboard systems or both, have the ability to perform functions to the extent necessary to continue safe flight and landing, but not necessarily full functional performance.

3.2.8 *envelope protection, n*—the human-machine interface extension of an automatic flight control system that prevents the remote pilot from making control commands that would force the aircraft to exceed its structural or aerodynamic, or both, operating limits.

3.2.9 *lightweight UAS, n*—unmanned small aircraft that are approved for operation under the authority of a CAA (for example, UAS approved to operate by the FAA under 14 CFR Part 107, UAS approved to operate by EASA as Open and Specific Category UA, and UAS approved to operate by CASA as Small, Medium, or Large RPA, or combinations thereof).

3.2.10 *lost link, n*—occurrence in which the control station has lost the ability to maintain a positive C2 link with the sUA due to degradation, loss, or interruption of the C2 link for longer than deemed safe depending on the circumstances or programming.

3.2.11 *remote pilot-in-command, n*—person who is directly responsible for and is the final authority as to the operation of the UAS; has been designated as remote pilot in command before or during the flight of a UAS; and holds the appropriate CAA certificate for the conduct of the flight.

3.2.12 *requiring exceptional pilot capability, n*—a condition whereby the unmanned aircraft system is incapable of normal operations (that is, takeoff, controlled flight, and landing at a suitable location within the operating limitations) within the standards of performance, without requiring considerable intervention and compensation by the remote pilot (that is, exceptional piloting skill, alertness, or strength).

3.2.12.1 Discussion—

Exceptional skill requires additional skill and experience well beyond that of the remote pilots who normally fly the type of UAS under consideration.

3.2.12.2 Discussion—

Exceptional alertness or strength requires additional judgment factors when the control forces are deemed marginal or when a condition exists that requires rapid recognition and reaction to be coped with successfully.

3.2.12.3 Discussion—

This condition is similar to a Handling Qualities Rating (HQR) of 5 on the Cooper-Harper Scale. It should be noted that verification of Handling Qualities requires a well-defined, repeatable task, an unmanned aircraft with control station, and a trained remote pilot that is actively engaged in accomplishing that task with or without the assistance of an automated flight control system.

3.2.13 *shall versus should versus may, v*—use of the word “shall” means that a procedure or statement is mandatory and must be followed to comply with this guide; “should” means recommended; and “may” means optional at the discretion of the applicant/proponent.

3.2.13.1 Discussion—

“Shall” statements are requirements and they include sufficient detail needed to define compliance (for example, threshold values, test methods, oversight, and 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 or could lead to development of future requirements, or both. “May” statements are provided to clarify acceptability of a specific item or practice and offer options for satisfying requirements.

3.2.14 *standard of performance, n*—observable, measurable parameters of performance with tolerances; for example, course deviation degrees, + or –. Includes procedures, maneuvers, and observable behaviors.

3.2.15 *warning, n*—a condition that requires immediate flight crew awareness and immediate flight crew response.

3.3 Abbreviations:

3.3.1 *AHJ*—Authority Having Jurisdiction.

3.3.2 *AFM*—aircraft flight manual.

3.3.3 *BVLOS*—beyond visual line of sight.

3.3.4 *CAA*—civil aviation authority.

3.3.5 *CASA*—Australian Civil Aviation Safety Agency.

3.3.6 *C2*—command and control.

3.3.7 *CNPC*—control and non-payload communications.

3.3.8 *CONOPS*—concept of operations.

3.3.9 *EVLOS*—extended visual line of sight.

3.3.10 *OEM*—original aircraft manufacturer.

3.3.11 *ORA*—operational risk assessment.

3.3.12 *RPIC*—Remote Pilot in Command.

3.3.13 *SACAA*—South African Civil Aviation Authority.

3.3.14 *SDO*—standards development organization.

3.3.15 *UA*—unmanned aircraft.

3.3.16 *UAS*—unmanned aircraft system.

3.3.17 *VLOS*—visual line of sight.

3.3.18 *VO*—visual observer.

3.4 See **Table 1** for task and knowledge definitions relating to the education requirements for Remote Pilot in Command.

3.4.1 *Explanations for Task Knowledge and Subject Knowledge Levels:*

3.4.1.1 A task knowledge scale value may be used alone or with a task performance scale value to define a level of knowledge for a specific task.

3.4.1.2 A subject knowledge scale value is used alone to define a level of knowledge for a subject not directly related to any specific task, or for a subject common to several tasks.

3.4.1.3 *Examples:*

(1) Task Knowledge Example: Emergency procedures; (ref. **Table 1**, Level b: knows procedures). RPIC is expected to be able to recite step-by-step procedures for emergency procedures for the UAS.

(2) Task Knowledge and Performance Example: Emergency procedures; (ref. **Table 1**, Level 3b: competent performance, knows procedures). RPIC is expected to be able to perform the step-by-step procedures for emergency procedures for the UAS.

(3) Subject Knowledge Example: the anatomy of the eye = (ref. **Table 1**, Level A: knows facts). RPIC is expected to be able to identify basic facts about the eye and identify part of the eye in a drawing or diagram.

4. Significance and Applicability

4.1 The purpose of this guide is to provide a standardized means of facilitating Remote Pilot training. The guide should be used by all individuals and agencies that train such persons.

4.2 Successful completion of this training course neither constitutes nor implies certification or licensure from the CAA.

4.3 This guide is intended to provide guidance to:

4.3.1 Individuals, who are currently manned pilots (that is, FAA Part 61 or EASA FCL certificate holders), interested in pursuing academic programs and professional opportunities as a remote pilot,

4.3.2 Individuals, who are currently remote pilots (that is, FAA under Part 107, CASA RePL under Part 101) who want to voluntarily comply with a higher standard, and

4.3.3 Public agencies that self-certify remote pilots interested in developing unmanned aircraft systems programs.

TABLE 1 Task and Knowledge Levels

Scale Value	Definition: The Individual
Task Performance Levels	1 IS LIMITED. (Can do simple parts of the task. Needs to be told or shown how to do most of the task.)
	2 IS PARTIALLY PROFICIENT. (Can do most parts of the task. Needs only help on hardest parts.)
	3 IS COMPETENT. (Can do all parts of the task. Needs only a spot check of completed work.)
	4 IS PROFICIENT. (Can do the complete task quickly and accurately. Can tell or show others how to do the task.)
Task Knowledge Levels	a KNOWS NOMENCLATURE. (Can name parts, tools, and simple facts about the task.)
	b KNOWS PROCEDURES. (Can determine step-by-step procedures for doing the task.)
	c KNOWS OPERATING PRINCIPLES. (Can identify why and when the task must be done and why each step is needed.)
	d KNOWS ADVANCED THEORY. (Can predict, isolate, and resolve problems about the task.)
Subject Knowledge Levels	A KNOWS FACTS. (Can identify basic facts and terms about the subject.)
	B KNOWS PRINCIPLE. (Can identify relationship of basic facts and state general principles about the subject.)
	C KNOWS ANALYSIS. (Can analyze facts and principles and draw conclusions about the subject.)
	D KNOWS EVALUATION. (Can evaluate conditions and make proper decisions about the subject.)

4.4 This guide describes required education, training, and continuing professional development for those performing as professional remote pilot. Remote Pilot courses that do not include all of the knowledge and skill objectives of this guide may not be referred to as meeting this guide.

5. General Knowledge Subject Matter Requirements

5.1 *General:*

5.1.1 A person endorsed to act as the RPIC of an UAS shall have first obtained the necessary general aeronautical knowledge and proficiency required by the CAA or AHJ, or both.

5.1.2 At no time will this guide supersede any established protocols of international, national, federal, state, tribal, local, or regional governments.

5.1.3 Several CAAs have computer-based or written knowledge exams that meet this requirement. Examples include the FAA's Unmanned Aircraft General (UAG) exam, South Africa CAA Theoretical Knowledge Exam for Remote Pilots.

5.1.4 Applicants who are eligible to self-certify Remote Pilot qualifications (that is, public aircraft operations under the FAA) who do not use existing exams, as mentioned in 5.1.3, shall develop a psychometric exam based on the areas described in 5.2 acceptable to the CAA.

5.2 *Knowledge*—The following subject, performance, and task knowledge areas shall be assessed by levels (referenced in Table 1) of competency in the exam items:

5.2.1 Applicable regulations relating to unmanned aircraft system rating privileges, limitations, and flight operation; (ref. Table 1, Level B: knows principles),

5.2.2 Airspace classification, operating requirements, and flight restrictions affecting unmanned aircraft operation; (ref. Table 1, Level B: knows principles),

5.2.3 Aviation weather sources and effects of weather on unmanned aircraft performance; (ref. Table 1, Level B: knows principles),

5.2.4 Unmanned aircraft loading; (ref. Table 1, Level B: knows principles),

5.2.5 Emergency procedures; (ref. Table 1, Level B: knows principles),

5.2.6 Crew resource management; (ref. Table 1, Level B: knows principles),

5.2.7 Radio communication procedures; (ref. Table 1, Level B: knows principles),

NOTE 1—Radiotelephony (RTF) provides how remote pilots and ground personnel communicate with each other. The information and instructions transmitted are of vital importance in the safe and expeditious operation of aircraft. Some CAAs and AHJs require Remote Pilots to obtain a Restricted Radiotelephone Operators' license or similar permit in addition to the applicable Remote Pilot certificate.

5.2.8 Determining the performance of unmanned aircraft; (ref. Table 1, Level B: knows principles),

5.2.9 Physiological effects of drugs and alcohol; (ref. Table 1, Level B: knows principles),

5.2.10 Aeronautical decision-making and judgment; (ref. Table 1, Level B: knows principles),

5.2.11 Airport operations; (ref. Table 1, Level B: knows principles), and

5.2.12 Maintenance and preflight inspection procedures (ref. Table 1, Level B: knows principles).

5.3 *Ground Flight Training:*

5.3.1 The CAA's differ on the requirements for practical skills demonstration.

5.3.2 Practical skills are addressed in Section 6 of this guide.

6. Indoctrination Curriculum Requirements

6.1 *General:*

6.1.1 The second phase of this guide starts upon completion of CAA qualification (that is, award of a Remote Pilot Certificate under Part 107).

6.1.2 A person endorsed to act as the RPIC of an UAS shall have first obtained the necessary manufacturers' systems-specific knowledge.

6.1.3 To ensure an appropriate level of safety, the RPIC should obtain specific ground or flight, or both, training to gain general knowledge and aircraft systems understanding and flight proficiency as described below.

6.1.4 Furthermore, the RPIC shall maintain appropriate levels of practical understanding, flight competency, and flight experience.

6.2 *Knowledge*—The following subject, performance, and task knowledge areas shall be assessed by levels (referenced in **Table 1**) of competency in the exam items:

6.2.1 *Aerodynamics*—The RPIC shall have a basic understanding of:

6.2.1.1 theories in the production of lift (ref. **Table 1**, Level B: knows principles)

6.2.1.2 fundamental forces of flight (Lift/Weight/Drag/Thrust) (ref. **Table 1**, Level B: knows principles)

6.2.1.3 fundamental flight maneuvers (straight and level flight, turns, climbs, and descents) (ref. **Table 1**, Level B: knows principles)

6.2.2 *Aircraft Systems*.

6.2.3 The RPIC shall be familiar with the individual airframe and system components of the sUA as detailed in the following sections and be able to readily identify them and possess a basic understanding of their operation.

6.2.3.1 *Airplane Structures*—Including fuselage, wings, horizontal stabilizer, vertical stabilizer. (ref. **Table 1**, Level B: knows principles)

6.2.3.2 *Rotor-wing Structures*—Including hub, boom and configurations including plus and X layout; Tri / Quad / Hex / Octo and larger. (ref. **Table 1**, Level B: knows principles)

6.2.3.3 *Airplane Flight Controls*—Including ailerons, flaps, rudder, and elevator. (ref. **Table 1**, Level B: knows principles)

6.2.3.4 *Single Rotor Flight Controls*—Include cyclic, throttle, collective, and anti-torque. (ref. **Table 1**, Level B: knows principles)

6.2.3.5 *Multi-Rotor Flight Controls*—Including differential motor RPM/torque and combined motor RPM to effect aircraft movement. (ref. **Table 1**, Level B: knows principles)

6.2.3.6 *Command and Control Link*—Understanding of radio control (ref. **Table 1**, Level B: knows principles) including:

- (1) Transmitters,
- (2) Receivers,
- (3) Propagation/shielding,
- (4) Antennae types and orientation,
- (5) Frequency bands,
- (6) Signal strength,
- (7) UAS behavior on loss of link.