Maintenance And Inspections

AIRMAN CERTIFICATION STANDARDS: REMOTE PILOT SMALL: You will know and be able to explain in writing or oral form the below tasks regarding MAINTENANCE AND INSPECTION

Task	Task F. Maintenance and Inspection Procedures
References	AC 107-2
Objective	To determine that the applicant is knowledgeable in sUAS maintenance and inspection procedures.
Knowledge	The applicant demonstrates understanding of:
UA.V.F.K1	1. Basic maintenance. Time and service limits (LOG and updates for airworthiness)
UA.V.F.K2	2. Preflight inspection. Covered in LESSON 2
UA.V.F.K3	3. Techniques to mitigate mechanical failures of all elements used in sUAS operations such as the battery and/or any device(s) used to operate the sUAS.
UA.V.F.K4	4. Appropriate record keeping.
UA.V.F.K5	5. Persons that may perform maintenance on an sUAS. Covered in INTRO

Maintenance is a requirement for a legal status of "***Airworthiness***". Airworthiness is required otherwise you are in violation of FAA regulations and subject to penalties and safety risks. It cannot be stress enough that you must DOCUMENT each and every maintenance action performed on your sUAS.

Basic Maintenance

The first thing you'll want to know is that if your UA manufacturer does NOT provide a maintenance schedule, you'll need to establish a scheduled maintenance protocol. As an example (DJI Inspire 1), look in the maintenance folder to read a typical manufacturer's maintenance guide.

If your manufacturer doesn't have something like this, you'll need to create your own if you plan to follow the regulations of Part 107. You can do this by reviewing your flight and maintenance log to observe patterns of parts replacements and problems. That will allow you to create your own preventative and scheduled maintenance procedures

Establishing a scheduled maintenance protocol sounds fancy but it essentially means you do 2 things:

1. Document any repair, modification, overhaul, or replacement of a system component resulting from normal flight operations. This should be accomplished with either a written or on-line maintenance log for each of your sUAS.
2. Record the time-in-service for that component at the time of the maintenance procedure.
3. Assess records over time to establish a reliable maintenance schedule

SCHEDULED & UNSCHEDULED

Maintenance for sUAS includes scheduled and unscheduled overhaul, repair, inspection, modification, replacement, and system software upgrades for the unmanned aircraft itself and all components necessary for flight.

MANUFACTURER RECOMMENDED

Manufacturers may recommend a maintenance or replacement schedule for the unmanned aircraft and system components based on time-in-service limits and other factors. Follow all manufacturer maintenance recommendations to achieve the longest and safest service life of the sUAS.

If the sUAS or component manufacturer does not provide scheduled maintenance instructions, it is recommended that you establish your own

Over time, you'll be able to establish a reliable maintenance schedule for your aircraft and its components.

It's highly recommended that the maintenance be performed in accordance with the manufacturer's instructions. However, if you decide not to use the manufacturer or personnel recommended by the manufacturer, and you're unable to perform the required maintenance yourself, you should consider the expertise of maintenance personnel familiar with the specific sUAS and its components. Logging your maintenance is a critical piece to successfully maintaining your aircraft. And not just logging your repairs but also your battery cycles, your firmware updates...anything significant you're doing to your sUAS. **Log it. Log it. Log it**.

Did you know, for example, that your batteries have a shelf life? And that if you're not regularly inspecting your batteries, you could have an in-flight fire? On that note, if you're properly maintaining your LiPo batteries, they can last 3 to 4 times longer, saving you a lot of money throughout the course of your career as a remote PIC.

The FAA provides a helpful checklist of conditions that, if noticed during a preflight inspection or aircraft check, may support the idea that the UAS is not in a condition for safe operation. I want to include this checklist, because I think it's a great starting point for those of you thinking about this stuff for the first time.

- **Structural or skin cracking**

Further inspect to determine scope of damage and existence of possible hidden damage that may compromise structural integrity. Assess the need and extent of repairs that may be needed for continued safe flight operations.

- **Delamination of bonded surfaces**

Further inspect to determine scope of damage and existence of possible hidden damage that may compromise structural integrity. Assess the need and extent of repairs that may be needed for continued safe flight operations.

- **Liquid or gel leakage**

Further inspect to determine source of the leakage. This condition may pose a risk of fire resulting in extreme heat negatively impacting aircraft structures, aircraft performance characteristics, and flight duration. Assess the need and extent of repairs that may be needed for continued safe flight operations.

- **Strong fuel smell**

Further inspect to determine source of the smell. Leakage exiting the aircraft may be present and/or accumulating within a sealed compartment. This condition may pose a risk of fire resulting in extreme heat negatively impacting aircraft structures, aircraft performance characteristics, and flight duration. Assess the need and extent of repairs that may be needed for continued safe flight operations.

- **Smell of electrical burning or arcing**

Further inspect to determine source of the possible electrical malfunction. An electrical hazard may pose risk of fire or extreme heat negatively impacting aircraft structures, aircraft performance characteristics, and flight duration. Assess the need and extent of repairs that may be needed for continued safe flight operations.

- **Visual indications of electrical burning or arcing (black soot tracings, sparking)**

Further inspect to determine source of the possible electrical malfunction. An electrical hazard may pose a risk of fire or extreme heat negatively impacting aircraft structures, aircraft performance characteristics, and flight duration. Assess the need and extent of repairs that may be needed for continued safe flight operations.

- **Noticeable sound (decibel)**

Change during operation by the propulsion system. Further inspect entire aircraft with emphasis on the propulsion system components (i.e., motors and propellers) for damage and/or diminished performance. Assess the need and extent of repairs that may be needed for continued safe flight operations.

- **Control inputs not synchronized or delayed**

Discontinue flight and/or avoid further flight operations until further inspection and testing of the control link between the ground control unit and the aircraft. Ensure accurate control communications are established and reliable prior to further flight to circumvent possible loss of control resulting in the risk of a collision or flyaway. Assess the need and extent of repairs that may be needed for continued safe flight operations.

- **Battery causing distorted (bulding)**

Further inspect to determine integrity of the battery as a reliable power source. Distorted battery casings may indicate impending failure resulting in abrupt power loss and/or explosion. An electrical hazard may be present, posing a risk of fire or extreme heat negatively impacting aircraft structures, aircraft performance characteristics, and flight duration. Assess the need and extent of repairs that may be needed for continued safe flight operations.

- **Diminishing flight time capability (electric powered propulsion systems)**

Further inspect to determine integrity of the battery as a reliable power source. Diminishing battery capacity may indicate impending failure due to exhausted service life, internal, or external damage. An electrical hazard may be present, posing a risk of fire or extreme heat negatively impacting aircraft structures, aircraft performance characteristics, and flight duration. Assess the need and extent of repairs that may be needed for continued safe flight operations.

• **Loosing or missing hardware/fasteners**

Further inspect to determine structural integrity of the aircraft and/or components with loose or missing hardware/fasteners. Loose or missing hardware/fasteners may pose a risk of negatively impacting flight characteristics, structural failure of the aircraft, dropped objects, loss of the aircraft, and risk to persons and property on the grounds. For continued safe flight operations, secure loose hardware/fasteners. Replace loose hardware/fasteners that can't be secured. Replace missing hardware/fasteners.

Preflight inspection

According to 14 CFR Part 107, the responsibility to inspect the small UAS to ensure it is in a safe operating condition rests with the remote PIC. The remote pilot-in-command. Not the visual observer (VO), or the owner of the aircraft, but the remote pilot-in-command.

So prior to each and every flight, the remote PIC must inspect the sUAS to ensure that it is in a condition for safe operation, such as inspecting for equipment damage or malfunction(s).

This preflight inspection should be conducted in accordance with the sUAS manufacturer's inspection procedures when available (usually found in the manufacturer's owner or maintenance manual) and/or an inspection procedure developed by the sUAS owner or operator.

Also published in the FAA's Advisory Circular in June 2016 is a sample pre-flight checklist. Next slide.

The preflight inspection should include a visual or functional check

USE A CHECKLIST (Jewels\Drone Checklist.pdf), don't just rely on memory The typical checklists wont include the following items:

- Visual condition inspection of the UAS components;
- Airframe structure (including undercarriage), all flight control surfaces, and linkages;
- Registration markings, for proper display and legibility;
- Moveable control surface(s), including airframe attachment point(s);
- Servo motor(s), including attachment point(s);
- Propulsion system, including powerplant(s), propeller(s), rotor(s), ducted fan(s), etc.;
- Verify all systems (e.g., aircraft and control unit) have an adequate energy supply for the intended operation and are functioning properly;
- Avionics, including control link transceiver, communication/navigation equipment, and antenna(s);
- Calibrate UAS compass prior to any flight after receiving the drone from the shipper;
- Control link transceiver, communication/navigation data link transceiver, and antenna(s);
- Display panel, if used, is functioning properly;
- Check ground support equipment, including takeoff and landing systems, for proper operation;
- Check that control link correct functionality is established between the aircraft and Control Station (CS);
- Check for correct movement of control surfaces using the CS;
- Check onboard navigation and communication data links;
- Check flight termination system, if installed;
- Check fuel for correct type and quantity;
- Check battery levels for the aircraft and CS;
- Check that any equipment, such as a camera, is securely attached;
- Verify communication with UAS and that the UAS has acquired GPS location from at least four satellites;
- Start the UAS propellers to inspect for any imbalance or irregular operation;
- If required by flight path walk through, verify any noted obstructions that may interfere with the UAS; and
- At a controlled low altitude, fly within range of any interference and recheck all controls and stability.

Remember, you're not just inspecting your sUAS. You should also be inspecting local weather conditions, local airspace and any flight restrictions, and the location of people, animals, or other objects and ground hazards.

And you're communicating these findings with each person involved in the operation. You're discussing operating conditions, emergency procedures, and contingency procedures with them as well. Everyone needs to be on the same page.

Finally, you'll want to make sure that you have the necessary documentation available for inspection, including the remote PIC's remote pilot certificate, aircraft registration (if required), and Certificate of Waiver of Authorization (COA) or waiver (if applicable). The COA is something that we cover in the Drone Laws and FAA Regulations module.

Remember, you're not just inspecting your sUAS. You should also be inspecting local weather conditions, local airspace and any flight restrictions, and the location of people, animals, or other objects and ground hazards.

Techniques to mitigate mechanical failures of all elements used in Small UAS operations, such as the battery and/or any device(s) used to operate the Small UAS

To continue this idea of inspection, there are several things you can do to **mitigate mechanical failures** of each of the varying elements in small UAS operations.

First, you'll want to make sure that each of the control links - your knobs and buttons and settings that speak from your Control Station (CS) to your small UA - are working properly. For example, before each flight, test your dual joysticks to make sure they're properly pitching, rolling, yawing, and thrusting.

You'll want to ensure you have the latest firmware installed and that you've taken the time to understand and to properly test it.

You will also want to make sure your batteries are properly charged, and that you understand what the discharge typically looks like during a routine flight operation. One way that this can be done is by following the sUAS manufacturer's operating manual power consumption tables. Another method would be to include a system on the sUAS that detects power levels and alerts the remote pilot when remaining aircraft power is diminishing to a level that is inadequate for continued flight operation.

Also, if you have any object attached or carried by the UA, make sure that it is secure and does not adversely affect the flight characteristics or controllability of the aircraft. Even a small shift in the center of gravity of your UA can significantly affect your flight operations.

Appropriate record keeping

A HUGE part of operating sUAS safely and responsibly is to log your flight operations and to *log your system maintenance and inspection.* You can do the logging manually or through the help of an automated flight logging system that may be part of your UAS.

DOCUMENT EVERYTHING YOU DO WITH THE sUAS. Even things like changing props, or updating firmware for a controller or UA, or replacing batteries. ***EVERYTHING MUST BE DOCUMENTED***.

Methodical maintenance and inspection data collection can prove to be very helpful in the tracking of aircraft component service life, as well as systemic component, equipment, and structural failure events. So, your batteries, your motors, your props, your servos...these items all wear out in time. The trick is to know when it's time for replacement before they fail in flight. *Proper record-keeping can help you to prevent this situation from happening*.

Flight logging should *include all components of your UA, including: the remote controller, launch and recovery equipment, communications link equipment, payload, and any other components required to safely operate the UA*.

Finally, to ensure that your aircraft continues to perform optimally and fly safely, it is recommended that you *perform maintenance after every **200 flights or 50 flight hours***, unless otherwise stated in your UAS operating manual

Consider maintaining a Toolkit . Here are some Useful Tools

1. Razor Blades, X-Acto knives, etc.
2. Electrical tape - various colors can be nice
3. Glue-some superglue as well as perhaps some other glues or epoxy. A hot glue gun can also be useful.
4. Mini and micro screwdrivers
5. Soldering Iron with small tip ($ 15-$ 2-) - if you intend to progress further in the hobby, pick up a more powerful one with interchangeable tips and variable heat. You can find bargain high-power models for about $40 including the tips. Pick up some solder for electronic use (usually rosin-core).
6. Digital Multimeter (voltage meter)
7. Good lighting for the work area as well as a magnifying glass on a stand for inspection of those tiny parts.
8. Fastening odds and ends such as velcro, rubber bands and zip ties.

NEXT: FARs