UAS AIRCRAFT MAINTENANCE PROGRAM

V1.03

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Note: This UAV maintenance documentation is designed to supplement the training given in Drone WorkForce Solution's [DWS] comprehensive UAV operator course. UAV Maintenance must only be carried out by persons qualified on that Course; failure to comply may invalidate the UAV warranty and may lead to accidents.

Version Record

Version	Date	Description
1.03	14 October 2021	Initial Version

1.0 INTRODUCTION

1.01 Scope of this handbook

This document is about small rotary-wing Unmanned Aircraft Systems (UAS) in which the aircraft weighs between 1 and 100 pounds. The Academy of Model Aeronautics limits the maximum takeoff weight of a model aircraft to 55 lbs. Although much of the public discussion concerning unmanned aviation has been focused on unmanned aircraft (UA) significantly heavier than 100 lbs, it is likely that many small UA will be based on available model designs and will weigh less than 100 lbs.

Public discussion on the emerging UAS industry will be best served if realistic distinctions are made between UA weight classes. Issues that apply to small UA will not necessarily apply to large UA, and vice versa. Large UA tend to be maintained in a similar way to conventional aircraft by qualified aircraft maintenance personnel, working following comprehensive maintenance procedures. As this document shows, the maintenance of small UAS has little in common with conventional aircraft maintenance.

1.02 Purpose of this handbook

This handbook provides an overview and should be used as a guide to performing maintenance on the small UASs used in and within DWS's training courses. The maintenance procedures outlined should be followed for the safe and efficient operation of all of DWS's UAVs.

1.03 Definitions

For this document, an Unmanned Aircraft (UA) is defined as "an aircraft controlled either autonomously or by a control station located on the ground or in a manned aircraft. An unmanned aircraft is not operated by an onboard pilot". The term "UA" is used throughout this document to refer to unmanned aircraft weighing between 1 and 100 pounds. An Unmanned Aircraft System (UAS) is defined as "an unmanned aircraft and all of the associated support equipment necessary to operate the unmanned aircraft in the National Airspace System"

For ease of expression, the terms "UA" and "UAS" are used to denote both the singular and the plural.

2.0 OVERVIEW OF UAS MAINTENANCE

2.01 Definition of maintenance

For this handbook, UAS maintenance is defined as any activity performed on the ground before or after a flight to ensure the successful and safe operation of the system. This definition covers a wide range of ground support activities including but not limited to, assembly, updates to software, and pre-flight testing.

This handbook does not deal with the maintenance of on-board payloads such as sensors, except where this maintenance has implications for the safe operation of the UA.

2.02 UAS maintenance personnel

Most operations of small UAS do not have dedicated maintenance personnel. Instead, a small team of multi-skilled individuals performs the full range of tasks required to prepare the UA for flight. Throughout this manual, "UAS maintenance personnel" refers to a person who performs a maintenance task on a UAS, even though that person may not necessarily consider themselves to be a maintenance technician.

Although some manufacturers of small UAS offer maintenance training courses, most of the people who perform maintenance have no formal preparation for their tasks, but bring experience from diverse backgrounds such as engineering, electronics, or radio control aircraft operations. In most cases, their area of specialty is a field other than maintenance, and few possess aviation maintenance or flight crew licenses.

2.03 Two fundamental hazardous outcomes of UAS operation

The most important objective of UAS maintenance is to manage hazards that threaten people or property. The two most important hazardous outcomes associated with unmanned flight are:

Hazard 1. *The UA collides with people or property on the ground.*
Hazard 2. *The UA becomes an airborne hazard to other airspace users.*

There are several scenarios where maintenance actions could increase the risk of one of these outcomes occurring.

Hazard 1 could arise if the UA became incapable of flight, such as through an engine stoppage or a failure of the gyro system. **Hazard 1** could also occur if the UA, although capable of sustaining flight, could no longer be directed by the operator.

Hazard 2 could arise through a failure of a sense and avoid system; however, at present few small UA possess such systems, and the risks to other airspace users are usually managed by ensuring the UA remains within authorized areas of class G airspace. In common with hazard 1, this requires UAS maintenance personnel to ensure that the UA can be controlled and navigated by the operator at all times.

Some UAS maintenance is performed for purposes unrelated to airworthiness, such as ensuring the operation of sensors or other payload equipment. Such maintenance is not considered in this handbook, except where it could contribute to one of the hazardous outcomes described above.

2.04 Scheduled vs unscheduled maintenance

Ground support activities can be divided into two broad categories of scheduled and unscheduled maintenance, each with its challenges.

Scheduled tasks include routine inspections, adjustments, and time replacements of components. Scheduled maintenance also included planned ground support tasks such as pre-flight system assembly, battery charging, and pre-flight functional tests. Scheduled tasks tend to be performed frequently and become familiar, routine activities for the technician. The routine nature of such tasks can increase the chances of absent-minded errors such as memory lapses.

Unscheduled maintenance includes the identification of damage and the replacement or repair of components. Fault identification and diagnosis can be a time-consuming part of UA maintenance, particularly when faults involve avionics or computer systems. Unscheduled maintenance, by definition, is less predictable than scheduled maintenance, and each task may be performed infrequently. As a result, unscheduled maintenance can impose greater mental demands on UAS maintenance personnel due to the need for problem-solving and the need to deal with unfamiliar situations.

Although the distinction between scheduled and unscheduled maintenance is widely used in the aviation industry, UAS personnel do not tend to make a clear distinction between the two types of maintenance. This is partly because, in the absence of maintenance procedures, virtually all maintenance tasks are unscheduled.

2.05 Levels of UAV Maintenance

The maintenance of DWS's UAVs are divided into two levels:

User Level Maintenance: The maintenance of a UAV system by the operator before and after a flight.

Base Overhaul: Carried out by DWS's specialist UAV Technicians.

3.0 DOCUMENTATION

3.01 Flight Log

For the maintenance schedule to be completed at the correct intervals, a log of the UAV's flight hours, conditions, and performance must be maintained. The recommended method is to maintain this record by using the UAV Navigation 'Flight Log' software.

4.0 UAV MAINTENANCE PROCEDURES

4.01 Safety

Safety must always be the priority. All necessary safety precautions, including Individual Protective Equipment, must be observed when carrying out maintenance. Users should be particularly aware of the risks of electrical short-circuits (especially with Lithium Polymer batteries).

Special care must be taken whenever a motor test is conducted. Ensure that nobody is within the danger radius of a spinning blade and that the UAV is securely anchored whenever a motor is tested in a workshop environment.

4.02 Before Maintenance

Before carrying out any maintenance tasks, ensure the following:

- Switch off all electrical systems.
- Disconnect all onboard batteries before maintaining any of the electrical systems.
- Do not charge an onboard battery while carrying out maintenance.

4.03 Thread Lock

Unless otherwise stated, engineering thread lock (Loctite 222 or blue Loctite 243, depending on the application) must be used on all bolts and grub screws where there is metal to metal contact. This is particularly important in DWS’s helicopter-type UAVs, which experience high levels of vibration. Thread lock is supplied as part of the standard tool kit with all DWS’s UAVs.

4.04 Fasteners Torque Values

Proper torque is critical. Always use calibrated wrenches and undamaged hardware. Ensure all clamping surfaces are clean and no foreign objects are caught in between. Improper torque or dirty surfaces may result in loss of clamp-up, hardware or part damage, and premature failure.

Fasteners shall be torqued to standard values listed in the UAV operation manual unless otherwise specified. Torque seal paint is applied to all critical fasteners after installation, in a stripe extending from

the fastener's exposed threads across the nut onto the component. Any subsequent rotation of the nut or bolt can be detected visually.

4.05 Cables and Connectors

- ✓ Cables and connectors are some of the most important parts of the system. They allow for communication between different components and provide electrical power where it is required. **Keeping them in perfect condition is vital for the performance of the equipment and the safety of the operation**. Most of the cables are affixed to the structure of the UAV and are not meant to be removed unless some maintenance is required. However, some other cables are designed to be connected and disconnected in every operation. These last types of cables and connectors require special care and attention from the operator to be kept in operating condition.

- ✓ Visual inspection of the cables and connectors must be carried out in every preflight check and at the proper intervals indicated in the operation manual.

In this inspection, the operator must visually check the full length of the cables, looking carefully for any signs of wear or ripped off sheath. Exposed or cut wires are reason for immediate substitution. Cables must be clean and dry from oil or moisture. Sand or grit must be cleaned out as well, as it contributes to premature wear of the cable. The operator must pay special attention to the surroundings of connectors as cables are most likely to break in those zones.

- ✓ Connectors must be carefully inspected as well. All pins in male connectors should be straight and level. They also must be clean and dry. The operator will avoid letting the connectors fall or lay on the ground as sand or dirt could ingress and cause malfunctions. Special contact cleaner (Such as 'WD-40 Electrical Contact Cleaner' or similar) should be used if the contactors (pins or sockets) are found to be wet or dirty. Connectors on panels or equipment that are subject to repeated connections are likely to be inspected and cleaned as well. Locking rings must move smoothly with no signs of binding or gritting.

4.06 Checking the Battery System

Check the Intelligent Flight Batteries for damage and deformities. If there are any signs of damage to an Intelligent Flight Battery, stop using it and discharge it fully for disposal. Do not disassemble an Intelligent Flight Battery for any reason.

Check the Intelligent Flight Battery pins and rub them clean with an eraser if any residue is observed. This will help to ensure reliable connections.

On the Intelligent Flight Battery Charging Hub, check the metal pins on the charging ports. Remove any corrosion or residue to ensure reliable connections.

Run the drone manufacturer's app to confirm that each Intelligent Flight Battery's cells are at similar voltage levels and stay at the same level when the Intelligent Flight Battery is fully charged. If all cells maintain voltage levels above 3.7 V but any cell is 0.2 V higher or lower than the others, contact the drone manufacturer support for analysis. You can also check the battery cell warning history. If any warnings are reported, contact the drone manufacturer Support.

Check that the plastic components of the battery compartments are in good condition and that all screws are secure. This prevents the Intelligent Flight Batteries from becoming loose during flight.

Insert an Intelligent Flight Battery into the battery compartment, check that it mounts securely with the Battery Release Button raised, then press the Battery Release Button to make sure the Intelligent Flight Batteries can be released. If not, change the Intelligent Flight Battery or contact the drone manufacturer support.

For Intelligent Flight Batteries in long-term storage, refer to the Intelligent Flight Battery Safety Guidelines and check the Intelligent Flight Batteries once a month to prevent the battery cells from being damaged.

Check the power cables between the aircraft's arms and body. If the cables are worn, contact the drone manufacturer for support to arrange a repair.

4.07 Checking the Motors

Detach the propellers and start the motors. Carefully examine the edges of each rotor and confirm that it is perfectly centered on its motor. Check for any abnormal or excessive vibration. Listen carefully for any abnormal noise, which may be a sign that the bearings are worn. If any problems are detected, contact the drone manufacturer for Support to order replacement motors.

4.08 Checking the Propellers

- ✓ Check the propellers. If there is any bending, breakage, or cracking on a propeller, do not use it. Replace worn-out propellers and propeller bases promptly.

- ✓ Check that when you attach each propeller, the propeller locks (clicks) into place correctly. For each propeller, use one hand to prevent the motor rotor from rotating, and use your other hand to try to rotate the propeller. If the propeller rotates, the propeller base is loose and needs replacing.

- ✓ Attach the propellers to the motors, place the aircraft on the ground, and power it on. Stand 3.3 ft (1 m) away from the aircraft and observe the rotating propellers. If you can see two distinct propeller outline layers, when looking at a spinning propeller from the side, that propeller is damaged and should not be used.

4.09 Checking the Flight Control System

In the drone manufacturer's app, review the IMU bias and compass interference readings. Even if the IMU biases are below the warning thresholds, an IMU calibration can be performed to remove small biases and improve Flight Control System performance. The IMU calibration procedure involves holding the aircraft in five different positions. In each position, the aircraft must be held very stably,

otherwise, the calibration may be inaccurate. The Carrying Case can be used to support the aircraft in positions that require support. Perform a compass calibration if necessary.

The flight control module fan is located at the bottom of the flight control module, just above the Gimbal Connector. Power on the aircraft and listen for any abnormal noise or vibration from the fan. If any irregularity is detected, contact the drone manufacturer for support.

Ensure that there are no obstacles on or around the GPS module. Remove any obstacles (such as tape with conductive material) that might affect or block the signal.

4.10 Checking the Control and Video Transmission System

- ✓ Make sure the aircraft antennas located on the outside of the four landing gear feet are not covered with stickers or tape.
- ✓ Check the remote controller antennas for damage.
- ✓ Check the remote controller neck strap for damage or wear and replace if necessary.

4.11 Checking the Gimbal and Camera

The Gimbal Connector is a particularly vulnerable component. If the gimbal fails to initialize when turned on, fails to work after initialization, or fails to transmit video to the app (while OSD data is displayed), check the metal contacts on the two halves of the gimbal connector. If there is any dirt, rub the contacts clean with an eraser. If any contact is scratched or oxidized, contact the drone manufacturer for Support to arrange repair/replacement of the Gimbal Connector.

If the gimbal is performing stably during normal operation, there is no need to check it. If its performance has deteriorated, contact the drone manufacturer for support to arrange a repair.

Check the camera, especially the lens. If moisture ingress has occurred, use a desiccant or a moisture-absorbing dry box to remove the moisture.

The Gimbal Connector's rubber damping balls are consumable items. It is recommended that they are replaced after 120 flights or 40 flight hours and they also need to be replaced in the following circumstances:

- A ball has been pierced and the white damping grease has leaked out.
- A ball does not return to a spherical shape when uninstalled.
- The rubber has aged and a ball has lost elasticity.
- A ball was subjected to excessive forces during a crash or other incident.

4.12 Checking the Vision System

- Check the camera lens. If any dirt or residue is detected, gently clean the lens.
- Check for and remove objects that might block the sensors.
- Ensure that the Upward Infrared Sensors are securely installed on the aircraft and are not blocked by stickers or tape.
- Detach the propellers and turn on the aircraft. Hold the aircraft 1 to 2 m above a surface with rich patterns, under good lighting conditions. Change the Flight Mode switch to P-mode on the controller and check the drone manufacturer's app. If the app displays an altitude value and indicates that P-OPTI mode is active, the Vision System should function normally.
- If a Vision System abnormality is displayed in the app, connect to drone manufacturer's app and recalibrate the Vision System.

4.13 Checking the Airframe

- Confirm that all the screws are still adequately tightened.
- Check the aircraft for breaks and damage. If there is any reason to believe that detectable damage might affect flight safety, consult with drone manufacturer's support.
- Check the carbon fiber arm tubes for damage and looseness. Grasp and twist the two landing gear feet on one side to ensure they are not loose, then repeat on the other side.
- Ensure that the screws used to secure the landing gear to the carbon fiber arm tubes are tight and the plastic components around the motors are in good condition. If any plastic components are damaged or broken, contact the drone manufacturer's support to arrange arepair.