How to estimate the maximum and recommended flight times of a UAS, UAV, or Drone System

Unmanned Aerial Systems (UAS) are quickly becoming tools farmers use to do many tasks from obtaining overhead images of farm fields, to spotting cows. In Louisiana, these devices will be especially useful to check irrigation flows, spot leaks in terraces and perform surveying tasks. Still, these systems operate on battery power, and flight times are limited.

Most Unmanned Aerial Vehicles, or UAVs, come with manufacturer's estimated flight time. This value can be greatly inflated because manufacturers may flight test UAVs in a no-load condition – no camera, gimbal, etc. – mounted on the airframe. In addition, flight time projections may be based on larger-than-normal battery sizes that can't be carried when the weight of the camera gear is applied, or in light winds or windless conditions. For these reasons, it is helpful to have good working knowledge of the actual flight times that can be expected from a UAV for a particular battery/payload combination, and a good working knowledge of this parameter will greatly help you determine actual coverage areas and recognize premature battery problems. The maximum and recommended flight times for a UAV can be determined as follows:

1. Determine the maximum current that the battery(ies) hold or can supply. This rating is usually given in milliamp-hours (mAh) on the side of the battery. If this rating is not known, approximate values can be determined by fully discharging and recharging the battery, noting the amount of current needed to bring the battery back to a full charge (many chargers list this value as charging occurs). If two or more batteries are used in parallel, add the current rating of each battery to obtain the total current available to the UAV. If in series, the current rating of the smallest battery is used.
2. Convert the mAh rating to amp-minutes by dividing by 1,000 and multiplying by 60. If the amperage rating is given in Ah, only multiple by 60.
3. Determine how much current the UAV uses while flying with a full equipment load (cameras, video equipment, etc.). This value can be determined by noting the instantaneous current flow posted on the ground control station while flying. If a ground control station reading is not available, a current monitoring device can be installed on the UAV, or the vehicle tethered to the ground with a multi-meter attached (note that this value may be slightly different than actual flying for multi-rotors in ground effect). Also, note that the current consumption of UAV's can be very high (> 40 amps), so a current shunt or an induction type amp meter may be needed. If a different battery size is installed in the UAV, or more equipment is added, this process may need to be repeated to obtain the correct reading. Record the instantaneous current consumption in Amps (A).
4. Divide the result of Step 2 by the result of Step 3. This is the maximum flight time in minutes that you can expect the UAV to fly before the battery goes completely dead. Note that the actual flight time will be somewhat lower than this value because the battery should not be pushed to a completely dead scenario. Step 5 gives the recommended flight times to protect the battery and UAV from damage.
5. Recommended flight times are typically 40 percent to 80 percent of the value determined in Step 4 for airplanes, and 40 to 70 percent of that value for multi-rotors. Although these time reductions seem large, they will help prevent loss of a UAV by allowing adequate time to return from a mission and land if battery power runs low. (Also note that a UAV will use 10 to 30 percent more current at the end of a flight as battery voltages run lower.

Generalized equations for the procedure above are given as follows:

$$\text{Maximum Flight Time (min.)} = \frac{\text{Battery Storage Amp Rating (mAh)} \times 60}{\text{Current Draw of UAV (Amps)}}$$

$$\text{Recommended Flight Time (min.)} = \text{Maximum Flight Time (min.)} \times \text{Safety Factor}$$

where: Safety Factor = 0.4 to 0.8 for Airplane type UAV' s

0.4 to 0.7 for Multirotor type UAV's

Example 1 – Airplane type UAV: Assume an airplane-type UAV uses a 4S LiPo battery with a stamped rating of 5,000 mAh, and is observed using 4 amps on average when flying camera work. What is the maximum and actual flight times for this vehicle?

Step 1: The rating of the battery is 5,000 mAh

Step 2: The amp-minute for the battery is 5,000/1,000 * 60 = 300 amp minutes.

Step 3: From observation of the ground control station, the UAV uses 4 amps on average during flight.

Step 4: The maximum flight time for the UAV is 300/4 = 75 minutes.

Step 5: The recommended flight time is 30 minutes (40 percent safety factor - 0.4 x 75 minutes) to 60 minutes (80 percent safety factor - 0.8 x 75 minutes).

Example 2 – Multirotor type UAV: A multirotor-type UAV uses a 4S LiPo battery with a stamped rating of 11,000 mAh is uses 25 amps on average when flying with a full sensor load. What is the maximum and actual flight times for this vehicle?

Step 1: The rating of the battery is 11,000 mAh

Step 2: The amp-minute for the battery is 11,000/1,000 * 60 = 660 amp minutes.

Step 3: From observation of the ground control station, the UAV uses 25 amps on average during flight.

Step 4: The maximum flight time for the UAV is 660/25 = 26.4 minutes.

Step 5: The recommended flight time is 10.5 (40 percent safety factor – 0.4 x 26.4 minutes) to 18.5 minutes (70 percent safety factor – 0.7 x 26.4 minutes).

Conclusion:

By using these methods, operators can easily determine the safe recommended flight times for UAVs or drones. If a UAV or drone does not attain the recommended flight times, and battery fail-safes occur, the battery either needs to be replaced, balanced, or repaired. Note that battery repair requires expert knowledge in soldering and balancing cells. Battery repair can be quite dangerous if cells are not properly discharged before servicing. Battery repair is not recommended for most people.

Flight calculators similar to these equations are available on-line. Note that many do not apply a safety factor to account for the increased flight times needed to return to home and land from a mission, higher energy robbing environments, or older batteries that are not well-balanced.

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Pub. 3469 (online only) 12/15