Rocky Mountain Modeleers Safety Officer Tips: April 2020
By David Dust

Power System Selection for a Kit or ARF Aircraft – Part 1: Motor Selection via the Watts per Pound Guidelines

- **Components of a Power System:** The power system for a basic airplane consists of 4 primary components: the propeller, the motor, the ESC, and the battery. With the exception of the propeller, the components of an aircraft's power system can be assessed in terms of amperes (or amps, denoted by "A"), which is a measure of electrical *current.* The motor controls the capacity of a power system as a function of the motor's maximum current specification. Some manufactures provide the "maximum constant current" and/or the "maximum surge current" specifications for their motors in units of amps that can be found on retailer's websites. (For example, AltitudeHobbies.com provides the maximum constant and maximum surge current specifications for Suppo and other brand motors on their website.) The ESC and the battery are sized as a function of the motor's maximum current specifications, as described in "Part 2" of these Safety Officer Tips.
- **Watts per Pound Guidelines:** Over the years, RC pilots have related the capacity of a power system, in terms of Watts per Pound (W/lb), to the requirements of various types of aircraft.
  - ❖ Less than 50 W/lb – very light-weight slow flyers, with a low wing loading.
  - ❖ 50 to 80 W/lb – light powered-gliders, basic park flyers and trainers, classic biplanes, and vintage "old timer" type planes.
  - ❖ 80 to 120 W/lb – aerobatic aircraft (intended for general sport flying through intermediate aerobatics) and smaller scale-type aircraft (e.g., warbirds), with lighter wing loadings.
  - ❖ 120 to 180 W/lb – aerobatic aircraft (intended for advanced aerobatic, pattern, and 3D type flying), aircraft with moderately high wing-loadings, and scale EDF jets.
  - ❖ 180 to 200+ W/lb – high-speed aircraft and aircraft with high wing-loadings.
- **Calculation of Watts per Pound:** The power, in watts (W), that can be supplied by a power system is computed as follows: Watts (W) = [battery voltage (volts(V))] x [motor's current (amps(A))]

  For example, a motor operating at 25 amps on a fully charged 3 cell LiPo battery supplies:

  (3 x 4.2 V) x 25 A = 315 W

  The corresponding W/lb value for an aircraft with a total flying weight of 2.3 lb would be:

  (315 W)/(2.3 lb) = 137 W/lb
- **Initial Evaluation of Optional Power Systems:** When evaluating optional power systems for an aircraft, I recognize that both the voltage of the battery and the flow of current through the motor will both decrease during flight; hence, I estimate the minimum and maximum power that can be supplied over the course of a flight as follows:

  Minimum Watts(W) = [(# of battery cells) x 3.8 V] x [(motor's max. current (A)) x 0.75]

  where the "0.75" adjustment factor is based on direct measurements with a watt meter

  Maximum Watts(W) = [(# of battery cells) x 4.2 V] x [(motor's max. current (A)) x 1.0]

  Dividing these values by the estimated total flying weight for the aircraft provides an estimate of the range of "Watts per Pound" values that can be expected over the course of a flight. Comparison of this range of estimated "Watts per Pound" values with the Guidelines, provided above, provides a means to evaluate the adequacy of various power systems for a specific type of aircraft. Of course, the specifications of the propeller will determine the actual performance of the motor/power system and this is a subject of "Part 2 – ESC, Battery, and Propeller Selection."

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Power System Selection for a Kit or ARF Aircraft – Part 2: ESC, Battery, and Propeller Selection

- **ESC and Battery Selection:** The power system for a basic airplane consists of 4 primary components: the propeller, the motor, the ESC, and the battery. With the exception of the propeller, the components of an aircraft's power system can be assessed in terms of amperes (or amps), which is a measure of electrical *current.* The motor controls the capacity of a power system as a function of the motor's maximum current specification. Some manufactures provide the "maximum constant current" and/or the "maximum surge current" specifications for their motors in units of amps that can be found on retailer's websites. The ESC and the battery are sized as a function of the motor's maximum current specifications as follows:
    1. **The Electronic Speed Controller (ESC)**: ESC's are selected to meet the electrical current requirements of the motor and it is generally recommended that an ESC be selected with a safety factor of about 1.2 (i.e., a safety factor of 20%). For example, a motor with a "maximum surge current" rating of 35 A, would require an ESC with a capacity of at least:
       1.2 x 35 A = 42 A, using a safety factor of 1.2.
    2. **The Battery**: Batteries are selected such that their "safe maximum discharge current" is greater than the motor's maximum current specification and have sufficient storage capacity for useful flight times. Multiplying the "C-Rating" by the storage capacity for a battery yields the "safe maximum discharge current" for the battery. For example, a 35C-2200mAh battery has a safe maximum discharge current of:

       $$\text{Max Safe Current} = \textit{C-Rating} \times \textit{Battery Capacity}\,(\text{mAh}) \times \frac{1}{1000}\,\frac{\text{A}}{\text{mA}} = 35\,\frac{1}{\text{h}} \times 2200\ \text{mAh} \times \frac{1}{1000}\,\frac{\text{A}}{\text{mA}} = 77\ \text{A}$$

       A conservatively low estimate for the maximum flight time for a battery is:

       $$\text{Conservative Max Flight Time (m)} = \textit{Battery Capacity}\,(\text{mAh}) \times \frac{1}{1000}\,\frac{\text{A}}{\text{mA}} \times 60\,\frac{\text{min}}{\text{hour}} \times \frac{1}{X\ \text{A}} \times \frac{C_1}{C_2}$$

       $$\text{Or Simply: Conservative Max Flight Time (m)} = \textit{Battery Capacity}\,(\text{mAh}) \times \frac{1}{X\ \text{A}} \times 0.032\,\frac{\text{min}}{\text{hour}}\frac{\text{A}}{\text{mA}}$$

       For X = the motor's "maximum constant current" in Amps
       C_1 = percentage of the battery capacity that can be used while not discharging below 3.8 volts per cell = 0.40
       C_2 = average percentage of the motor's "maximum constant current" used during flight = 0.70

       For X = 25 A and a 2200 mAh battery: Max Flight Time = 2200 mAh x (1/25 A) x 0.034 = 3 min

- **Propeller Selection**: Some motor manufacturers provide propeller compatibility information for their motors; however, it is best to select the most appropriate propeller for an aircraft's power system using a watt/amp meter to ensure that the motor is operating within maximum current specifications. Watt/amp meters are inserted in between the ESC and the battery of an aircraft's power system, as shown below. If a propeller results in the current through the motor being greater than specifications, the motor can be permanently damaged, the ESC can overheat and shutdown, and/or the battery can overheat and be permanently damaged.