Selecting an Electric Powersystem R1.0
By Bill Stevens - Sunday, March 23 2008

Last Updated: Friday, March 28 2008
Comment(s): 13 | Overall Rating:

"I want to know what size motor I need for my airplane..."

We get this support query quite frequently both from our on-line customers and our local clients. Most hobbyists have become accustomed to recommending a motor by size or displacement for a particular airframe as opposed to suggesting a motor by power output. It is more correct to select an electric power system based on power output than simply size, current, or capacity. I suspect that recommending motors, batteries, and electric speed controls based on size or capacity stems from the legacy use of internal combustion type engines in model aircraft. This practice has become so common place that a few electric motor manufactures have named their electric motors in marketing literature to resemble that of their glow counterparts - a practice we find particularly misleading. We understand that there are several factors that will influence your power system selection and motor "size" is not always the proper answer. This article was designed to give you some basic guidance on how power loading affects your flight performance and how to match components based upon meaningful power output figures rather than size.

The Basics: It's all about Watts

Lets take the mystery out of this electrical jargon. Watts are to electric motors what horsepower is to internal combustion engines. Watts are a measure of power and can be derived by multiplying the voltage (Volts) times the current (Amps) in your electrical system. When selecting electrical components it's best to level the playing field and convert all numbers to reflect the products Power Rating (Watts). Why watts? Speed controller ratings in Amps do little to describe the actual amount of power they are capable of delivering. The same holds true for motors and batteries.. Initially, we want to classify all of our electrical components by the power output they are capable of delivering. We then use other information such as Voltage or Amps to ensure that our final system will operate within the manufactures specifications. To find out what a products Power Rating is use this simple equation:

*Power Rating (Watts) = Volts * Amps*

Step 1 - Target Power Loading for your model based on desired performance level

These following table will give you a good idea of how Power Loading influences model performance. I've found these figures to hold true from the smallest of R/C models on up to giant scale models and even full size general aviation aircraft. Review the information in the table below to find the Power Loading figure that delivers your Desired Performance Level.

Power Loading (Watts / Lb)	Desired Performance Level
50	Minimal. Minimum required for flight. Model flies "on wing" with little reserve power. Difficult if not impossible to Rise Off Ground (ROG) depending on runway surface.
70	Trainer. Good for general flight and trainers. Not enough power to get into trouble... not too little to avoid trouble. Model readily ROG's from smooth surfaces. Sport aerobatics possible with good energy management.
100	Sport Aerobatics. Best for sport and performance models. Model readily ROG's from unimproved fields or short grass. Consecutive loops from level flight. Model can fly entire IMAC basic sequence. Vertical performance is good but not unlimited. Model can "hang" on prop with thrust to weight often approaching 1:1.
130-150	Unlimited Aerobatics. 130 Watts/Lb is considered the minimum acceptable for 3D flight. Most 3D pilots agree that 150 Watts/Lb is more appropriate. At this power loading model will have unlimited vertical, can hover, has enough power on reserve to climb vertically from a hover.
200+	Obscene. As power loading approaches this figure vertical climb from hover is notably improved. Model appears to "rocket" out of hover and accelerate vertically.

Step 2 - Determine the Required Power Rating for your model airplane.

We have determined how we wish our model to perform and now have a solid idea of our target Power Loading. Now, we need to rate roughly how many watts will be required from our electric power system to meet our performance expectations we will call this figure our "Required Power Rating". Weigh your complete airframe less motor, flight pack battery, and electric speed control (ESC). Make certain you include all linkage, hardware, servos, servo extensions, and receiver. Use the following formula to determine the Required Power rating ie. how much power, in watts, you will require from your electric power system to meet your performance expectations:

*Required Power Rating = [Power Loading] * [Airframe Weight in Lbs.] * 1.5*

Note: Our formula for estimating your Required Power Rating assumes that your electric power system will weigh in at 50% of the completed airframe weight you can fine tune this number as you see fit.

Step 3 - Explore your options

Armed with your models "Required Power Rating" figure you may now begin researching motors, batteries, and speed controllers capable of delivering your required power. Wherever possible our web site classifies electrical components by their peak power output or Power Rating you will find this data in the specifications tab for most electric power system products. Develop a short list of compatible motors, battery, electric speed controller that are capable of meeting or exceeding your "Required Power Rating".

Note: always select batteries and speed controllers that meet or exceed the electric motors power rating.

Step 4 - Perform a reality check on your selected components

Select from your short list of electric power system components the most suitable items based upon mounting considerations, recomended propeller size, and system weight. Now that you've selected an electric motor, flight pack battery, and electric speed control (ESC) for your aircraft add the weight of these components to your total airframe weight and run the following formula:

Power Loading = [Power Rating] / [Airframe Weight in Lbs.]

Compare your Power Loading figure back to the table in Step 1 to see if your selected system will meet your performance expectations. If you turn up short on Power Loading select a lighter weight electric motor, battery, or electric speed control that still meets your [Power Rating] figure. If you have come out ahead in power you have more power system choices and could consider lighter weight systems to minimize your models wing loading.

A real world example

Airframe: Stevens AeroModel G-480 Groove
Completed airframe weight: 16 oz. (1.00 lbs) (Less Motor, Battery, ESC)
Desired Performance Level: 150 Watts/Lb - Unlimited Aerobatics
Required Power Rating: 225 (150*1.0*1.5)

Power System Option A
Motor: Hacker A30-28S
Weight: 2.5 oz (0.16 lbs)
Peak Amps: 25
Input Volts: 11.1V
Power Rating (Watts): 277

Battery: ThunderPower 2100 Pro-Lite
Weight: 4.98 oz. (0.31 lbs)
Max Continuous Amps: 31.5
Voltage: 11.1
Power Rating (Watts): 350

ESC: Castle Creations Phoenix 25
Weight: 0.60 oz (0.038 lbs)
Continuous Amps: 25
Max Input Volts w/BEC: 12.6
Power Rating: 315

For option A our Power Rating = 277 the limiting factor is the motor power output. Batteries and ESC are capable of higher power output which is desirable to prevent burning out a speed control or over amping a battery. The weight of this system is: 8.16 oz (0.51 lbs) Which brings our airframe complete weight up to: 24.16 oz (1.51 lbs). Running this through our reality check in step 4 we find our power loading equals: 183 Watts/lb which exceeds our Required Power.

Power System Option B
Motor: E-Flite Park 480 910kv
Weight: 3.1 oz (0.19 lbs)
Peak Amps: 25
Input volts: 11.1
Power Rating (Watts): 277

Battery: E-Flite 2100 20C
Weight: 6.6 oz. (0.41 lbs)
Max Continuous Amps: 44A
Voltage: 11.1
Power Rating (Watts): 488

ESC: E-Flite Pro 25A Brushless ESC
Weight: 1.2 oz (0.08 lbs)
Continuous Amps: 25
Max Input Volts w/BEC: 12.6
Power Rating: 315

For option B our Power Rating remains the same at 277 the limiting factor is again the motor power output. Batteries and ESC are capable of higher power output which is desirable to prevent burning out a speed control or over amping a battery. The weight of this system is: 10.88 oz (0.68 lbs) Which brings our airframe complete weight up to: 26.88 oz (1.68 lbs). Running this through our reality check in step 4 we find our power loading equals: 165 Watts/lb which still meets our performance expectations though it produces the heaviest flying weight of the bunch.

Power System Option C
Motor: Hacker A20-20L
Weight: 2.01 oz (0.13 lbs)
Peak Amps: 19
Input Volts: 11.1V
Power Rating (Watts): 211

Battery: ThunderPower 1320 Pro-Lite
Weight: 2.95 oz. (0.18 lbs)
Max Amps: 17 / 27 (continuous / burst)
Voltage: 11.1
Power Rating (Watts): 188 / 299 (continuous / burst)

ESC: Castle Creations Thunderbird 18
Weight: 0.60 oz (0.038 lbs)
Continuous Amps: 18
Max Input Volts w/BEC: 12.6
Power Rating: 227

A case can be made for exploring lighter power systems that still meet your needs. For option C our Power Rating = 211 that's 14 watts shy of the Required Power Rating of 225 calculated in Step 2. Limiting factor is the motor and battery power output. Batteries and ESC are closely matched to peak motor power output so it would be wise to use a bit of restraint with the throttle on this setup. The weight of this system is: 5.57 oz (0.35 lbs) Which brings our airframe complete weight up to: 21.57 oz (1.35 lbs). Running this through our reality check in step 4 we find our power loading equals: 156 Watts/lb which exceeds our original target by 6 watts, and produces the lightest overall airframe weight of the selected options.

So there you have it.. a real world example of the process of selecting a power system based on power output and power loading. As in our Option C example don't discount a slightly lighter power system as long as it is still within 10% of your Required Power Rating.