the Ampeer

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The Next Meeting: Thursday, May 4, The Rushton Rd. Field, South Lyon, ASAP

WHAT DIFFERENCE DOES A BIT OF WIRE MAKE ANYWAY?

By Keith Walker
from the E.M.F. of S.O. newsletter

A few weeks ago I finished building my very first sailplane. It is a “Dalmatian Lady” which is a very inexpensive and very ordinary 2 meter sailplane. The kit has been in the basement since last November, when I picked it up on special for $15.00. How could I not own a sailplane for that price?

The only modifications I made were to add top spars and sheer webs to the wings, and extend the wing sheeting out to the polyhedral breaks. I naturally had to electrify it, and did it by replacing the nose block with a fibreglass firewall to which is bolted the motor and gear-box. I used a junked "Trinity" car motor that I bought in Toledo for $5.00, and an old "Tekin" frame-rate car speed controller which has a brake. I made a cowling from a piece of pop-can tin-plate to cover the gear box. I cut it with scissors to match a paper template. I soldered the two ends together to form a loop and attached it with a couple of screws. It looks great, weighs nothing, and took five minutes to make!

The only folding prop I could find was only 10 x 6 so I had to select a gear ratio to match the prop to the motor. The motor draws about 17 amps on 6 cells, on the ground. I figured that this should give me about six minutes of running time on six 1400mAH in the air at a good steady climb - enough for two good ups!

I have taught five people how to fly, using their Goldberg "Electras" and most of the guys I fly with own one or something similar. When I tried my "El-cheapo", I was pleasantly surprised with the results. It flies just as I had planned, with a good steady climb to about 1200 ft. in around three minutes. It glides well too, and I am very happy with its performance. The only thing that bothered me about it was <u>why did it perform so much better than similar planes, even those on 7 cells, with better motors and bigger props!</u>

After thinking on this awhile, I realized that there have been a number of occasions when my mediocre equipment has noticeably out-performed other people’s state of the art stuff in identical airframes. I thought about their installations, and what the differences were. Equipment-wise, they should have flown rings around me. I don't use Sermos connectors - I use the standard Tamiya ones. I usually use old, frame-rate speed controllers, even on my Astro 25s. I very rarely allow for any kind of motor or battery cooling. Most of my radio equipment is of "antique" vintage, and I do not own a computer controlled transmitter, or even one with electronic mixing.

Could the difference be in the length or gauge of wire used between the battery, the speed controller and the motor? I wasn't sure so I checked the AWG tables, pounded on my calculator, and sure enough, it doesn't make any difference. Two feet of fourteen gauge wire will only drop 0.1 volt when 20 amps are shoved down it. You can drop this much on a fuse or a pair of good connectors! If you commit a cardinal sin and use 18 AWG hook-up wire, you will only be two and a half times worse. If you shorten it to a total of 10", which is about what I use, it will be the same as the two feet of 14 AWG. You would really have to work at it to screw up here.

Trim and balance can have a drastic effect on the way a plane flies. An old wife's tale says that it's safer to try a new model with the CG further forward than the recommended position. I have seen nose-heavy planes struggling along in a semi-stall, even though they have lots of power available. I have seen quite a few new planes stall and crash, for the same reason. Why is this? If a plane is nose heavy, the elevator must be raised to try to keep the plane level. Flying with up-elevator causes a lot of drag. This slows the plane down, which reduces the amount of lift. A greater angle of attack is needed on the wings to generate enough lift to keep flying. More up-elevator is needed to make this happen. The extra drag of the elevator and the wings slows the plane down even more. You can see the vicious circle of events, and the ultimate result.

Test your planes with the CG in the recommended position. At least you know that the original flew OK like this. If it turns out that it is a little too far back, the elevator and ailerons will be very responsive, making the plane difficult to fly, but not impossible. Another symptom of aft CG is that if you try to climb fairly steeply, you may see the nose slowly bob up and down. If you recognize any of these symptoms soon enough, at least you get a chance to land and correct the condition. Be warned though, if you continue to fly like this, the plane will snap-roll when you least expect it - usually when it is less than one mistake high!

After much pondering, I have concluded that the biggest problem most people have is in selecting the right battery, motor, propeller and gear ratio combination. To do this right, you need at least a tachometer, an ammeter and a bit of common sense. If you don't want to understand how to use these simple tools, at least find someone who does, and get them to do a quick check on your setup. It will immediately tell you what is happening, and how your plane could possibly be improved. If you throw up your hands in dismay, and say "I don't know nuthin' about that technical mumbo-jumbo!", you've missed the point! You don't need to be a whiz-kid. You just need to know a couple of simple facts and how to apply them.

The first fact is that the the speed at which a propeller will want to fly is approximately its pitch in inches times its RPM in thousands! i.e. MPH = pitch x rpm/1000. Now you know what use a Tach' is! You can work the thing out in your head once you have the RPM! In the air, the prop will unload a little, so add about 10% to its static RPM to get its flying RPM. Now you know why a 12 x 6 prop turning at 4,000 RPM will not give a sparkling performance to an aerobatic sport plane that has a stall speed of 25 MPH. You also know that a 12 x 8 folder turning at 6,000 RPM on your 25 MPH sailplane is just eating up batteries and cooking the motor.

The second fact you need to know is that Power is amps times volts. At the current levels we use, we can assume that there is about one volt across each ni-cad cell in the battery pack, therefore Power = Amps x number of cells. This will tell you how much electrical power is being converted in your motor into mechanical energy and heat. Now you know the use of an ammeter! Again, you can do the calculations in your head! In the air, the motor will draw about 20% less current as it unloads, so flying current = 80% of static current. Now you know that if your 100W can motor is drawing 25 amps on seven cells, you know it is not long for this world! You also know that if your Astro 40 is drawing 10 amps on 16 cells, you need a bigger prop, or you might as well use an Astro 05!

You must admit, none of the above really strained your brain, and you didn't even have to find batteries for your calculator! When you put the two simple facts together, you can find the right sized prop to match your motor and plane. If you can't guess roughly how fast your plane will fly, ask someone with experience. You will know if they have experience because they will ask you what the wing area is, and how much the plane weighs. If they can't see your plane, they will also ask you how thick the wings are, and what shape the airfoil is, as well as what kind of performance you want. Then all you need to do is borrow a few props if you don't have any, and check the motor current and the RPM for each until you get the results you want. Then you can go out and buy the right sized prop, and confidently join me in the clouds.

Servo Wiring

Submitted by George Siposs
from *Flightline* - August 1994

If you have several radio sets of various manufacture and would like to switch servos among them you should know that they don't all get wired the same way in the factory. Each servo has three wires: one for ground (or return or negative), one for battery power (this is called "hot" and supplies +4.8V), and the last one is for "signal" (i.e., the radio control input). The three wires have three different colors and you must not assume that they match. Here is the color code for each system:

Color	Futaba "G"	Futaba "J"	"JR"	"Airtronics"
Red	hot	hot	hot	hot
White	signal	signal	----	----
Black	ground	ground	----	edge(#1)signal center=ground
Brown	----	----	ground	----
Orange	----	----	signal	----

Note: On Hitec or World Engines radios:
black = ground, yellow = signal, red = hot.

Charging: The transmitter charging plug on ACE, AIRTRONICS, Hitec and Futaba is hot = center, and ground = outside ring.

On "JR": the center = ground, and outside ring = hot!

NOTE: A universal servo connector is available. It is equipped with 4 pins and 3 wires. By removing the cap you can convert it to a male connector. The catalog number is "CEU" and it costs $3 each. Order from: Custom Electronics, RR1 Box 123B, Higginsville, MO 64037; Telephone 816-584-6284, Fax 816-584-6285.

(This information is assumed to be accurate, but you should check your own systems before accepting it as 100% accurate. km)

BEC or NO BEC? That is the question. .

The **Battery-Elimination-Circuit, or BEC,** found in some motor controllers is used to supply power to the receiver and servos. This power is conveniently derived from the motor's battery pack. This is done to avoid having to use a separate four cell battery pack to serve the same purpose, saving some weight in the process.

We can probably say that the beginner or average modeler is much better off using BEC than not. This of course assumes moderate motor currents (20 to 30A) and cell counts (6 to 10). With BEC you don't have to worry about taking care of a separate receiver/servo (RX/S) battery pack. A fact very seldom mentioned or understood is that a well constructed motor battery pack can actually enhance the overall reliability of your system when compared to the of a separate RX/S pack. Motor packs get a lot more attention than most receiver packs ever get. Because of the way they are used we can generally tell when a pack is not in top shape right away.

Somewhere above 30 A is a "fuzzy" zone beyond which you should not use BEC. At very high motor currents a lot of electrical noise is generated, this noise can sometimes make it into the receiver via the BEC. Then again, we have not had problems using BEC in systems running at 50A with the proper precautions taken. Officially speaking, we do not recommend using BEC above 30 A. If you know what you are doing you may choose to ignore what we say and just go fly.

We offer a companion product to any BEC-equipped motor controller called the "**BEC SAVER/NOISE FILTER**". This tinny device is wired in line with the servos and provides noise filtering as well as relieving the BEC from having to handle short high current spikes. This is particularly useful in two aileron-servo setups and for long rudder or elevator wire runs.

Our BEC is equipped with thermal and over-current protection separate from the protection circuit used in the motor drive electronics. If you over-load or short-circuit the BEC it will shut itself down. Whenever this happens the motor is shut down as well. The BEC can be overloaded if any of the following conditions exists:

Too many cells and no cooling.
Too many micro servos.
Friction in control linkages.
Stiff control surface hinges.
The BEC is short-circuited.
Servos "twitch" frequently due to interference.

Micro servos can draw very high currents when starting up or changing directions. It is a good idea to measure typical current drain of your system to make certain that it is reasonable. Consult your radio system manufacturer's data sheets for this information.

Many electric glider pilots are concerned about not having enough power left in the pack to thermal after reaching the motor-cutoff point. The short answer is that the typical 3 channel glider has more than enough power left in the pack to fly for at least 45 minutes to 1 hour. The long version of the answer has some numbers attached to it.

First let's figure out how to get a rough idea of what kind of flight time to expect from a typical pack. The "mAh" rating simply means that the battery in question will deliver a certain amount current for one hour. A 1000 ma/hr pack, for example, will deliver 1000 ma. (or 1 A) for one hour, 2A for 30 minutes, 4 A for 15 minutes and so on. A simple formula can be used to calculate the theoretical duration for any size pack at various currents:

The "Power ON flight time", P_{ON} ,in minutes is:

P_{ON} = (Pack capacity in mAh/current drain in amps) x 0.06

In the real world you might need to multiply this by a factor of 1.1 to 1.4 because during flight the propeller becomes less of a load for the motor. The immediate consequence is a reduction of current draw resulting in an extension of flight time with respect to the "on the ground" numbers.

It's hard to say just how much of a reduction can be realized, 10 to 40 % is a possibility. It would be nice to know how much of the battery's capacity is being used per minute at a given current. Call this "% Capacity Per Minute" or "% CPM":

% CPM = (Current drain in amps x 10000)/(battery capacity in mAh x 6)

Let's see how much of the total battery capacity is consumed per minute by the motor and the receiver/servos (RX/S) through the BEC. Given,

motor current = 15A
RX/S (average) = 0.25A
battery capacity = 1400 mAh

Current (Amperes)	Battery Capacity (mAh)	%CPM
15	1400	17.86
0.25	1400	0.30

This means that in a typical flight of about 6 minutes the RX/S will use up about 1.8% of the pack's capacity. This translates into a reduction in flight time of about 6.5 seconds due to the use of BEC!. Clearly then, the total flight time would not be severely impacted by the use of BEC. If you consider that the typical remote control airplane pilot cannot possibly fly the plane at it's best efficiency-not being on board is a problem here-you could argue that the pilot has the potential to waste a lot more power than the BEC ever could! A separate RX/S pack could very easily make a bigger dent in the performance of the airplane.

* * * * *

How about all that heat generated by the BEC? Doesn't this drain the pack faster? and,
Why is there a limit on the number of cells you can use with BEC?

Heat is a by-product of current flow, not the other way around. Without current flow nothing gets hot.

As we saw before, **battery consumption is a function of only two numbers: The capacity of the pack (mAh) and the current drain placed on it.** The fact that we are using the energy to make some heat as well as making things move has nothing to do with how long the pack will last. While it is true that other factors come into play in a more sophisticated analysis of battery consumption, in this simple overview there is not need to complicate matters beyond the basic concepts.

The current demanded from the pack by the BEC is simply that required by the RX/S. This current will be the same whether you are using a 4 cell receiver pack or BEC, it's a characteristic of the servos and receiver you choose to use.

Once you know the current you can figure out how much heat will be generated. Let's just talk about electrical power, measured in Watts -just like in light bulbs. This is simply the product of Voltage and Current.

P = V x I (I is engineering talk for current)

That means that if you have a system that pulls 1 Amp from a 10 Volt source it is using 10 Watts. What happens with the 10 Watts is a different story. you could use it to spin a drill bit, run a TV set or waste it all an just make things hot. Going back to the BEC we find that it will hold it's output at a constant (approx.) 5.0 Volts no matter what input voltage (number of cells) it has to deal with. In that case, **if your RX/S normally pull, say, 1A with the usual 4 cell receiver pack setup, we can assume that it will still pull pretty much the same current from the BEC.** The BEC circuit will asks for the same current from the main battery pack. With that established we can figure out how heat develops:

We said that power (which can be converted into heat, light, motion, etc.) is:

$$P = V x I$$

The total power being handled by the BEC, call it P_T, will then be:

P_T = Battery pack voltage x RX/S average current

For sake of argument let's assume a 10 cell pack. about 12V, and a typical 0.25 A average current requirement from a standard RX/S setup. Then:

$$P_T = 12\text{ V} \times 0.25\text{ A} = 3.0\text{ Watts. (1)}$$

This means that the receiver and servos require 3.0 Watts to run from a 12 Volt pack using BEC. How-ever, not all of this power goes to the RX/S, some of it is converted into heat. The two components of P_T are:

$P_T = P_H + P_S$ and,

$P_S = V_S$ X I this goes to the RX/S.

$P_H = V_H$ X I this goes into making heat.

... remember I is the same for both and is determined by the RX/S requirements.

But what are V_H and V_S? Well, V_S is the voltage output of the BEC, namely 5.0V. V_H is the difference between this voltage and whatever the battery pack's output may be (call it V_B). V_H is very important in understanding many of the limitations and operating characteristics of BEC's. The diagram below will help you understand V_H and V_S:

For example, in the case of a 10 cell NiCd pack (12 Volts nominal):

$V_H = V_B - V_S$ V_H = 12-5 or 7 Volts

Now we can figure out where that heat comes from and how much power goes where. The power going to the typical RX/S is:

$$P_S = V_S \times I = 5.0\text{ Volts} \times 0.25\text{ Amps} = 1.25\text{ Watts}$$

The power being converted to heat is:

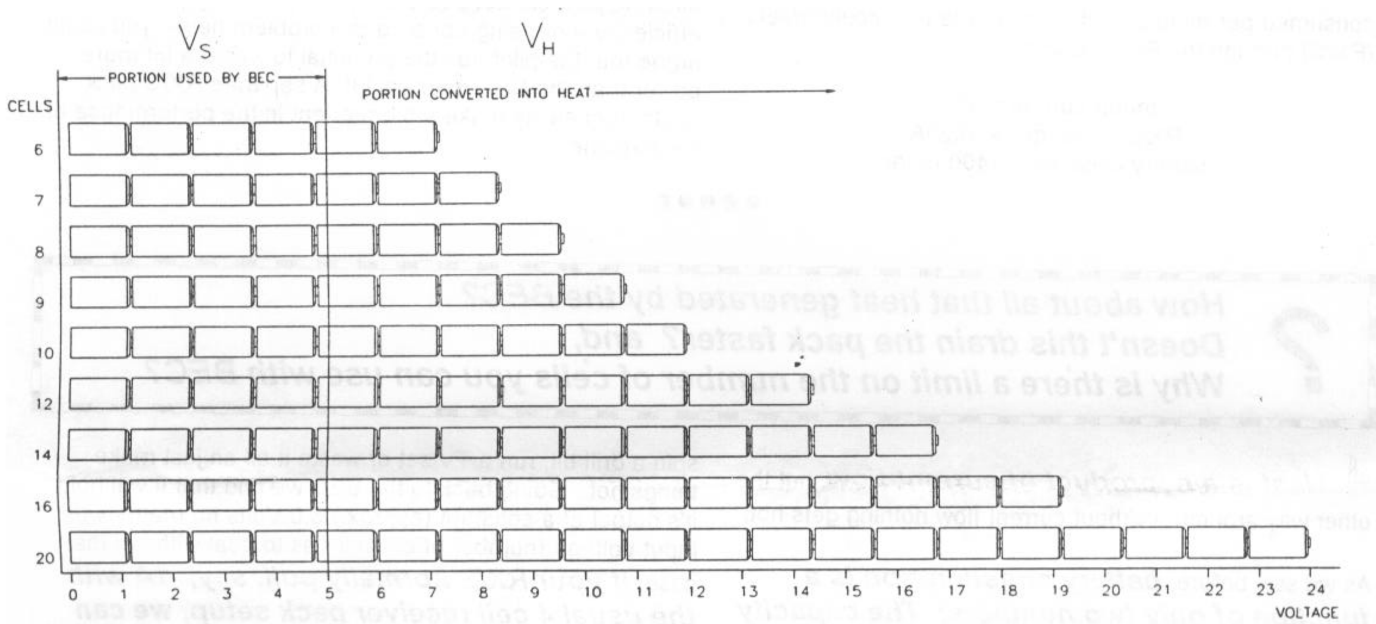
$$P_H = V_H \times I = (V_B - V_S) \times I$$
$$P_H = (12V - 5.0V) \times 0.25A = 1.75\text{ Watts}$$

If all of the above is to be true $P_S + P_H$ should add up to the 3.0 Watts we calculated in (1) before...and they do!

Now let's vary the size of the battery pack and see what happens. The portion of power being used by the RX/S will still be 1.25 Watts, nothing has changed, right? However, note what happens with the heat portion of the deal. Let's do a few pack configurations. Take a look at the table on the below for the results...

Cells	**Power converted to heat (P_H)**	
6	(7.2 Volts - 5.0 Volts)	x 0.25 A = 0.55 Watts
7	(8.4 Volts - 5.0 Volts)	x 0.25 A = 0.85 Watts
8	(9.6 Volts - 5.0 Volts)	x 0.25 A = 1.15 Watts
9	(10.8 Volts - 5.0 Volts)	x 0.25 A = 1.45 Watts
10	(12.0 Volts - 5.0 Volts)	x 0.25 A = 1.75 Watts
12	(14.4 Volts - 5.0 Volts)	x 0.25 A = 2.35 Watts
14	(15.6 Volts - 5.0 Volts)	x 0.25 A = 2.65 Watts
16	(19.2 Volts - 5.0 Volts)	x 0.25 A = 3.55 Watts
20	(24.0 Volts - 5.0 Volts)	x 0.25 A = 4.75 Watts

Keep in mind that during the flight RX/S current changes depending on the loading on the control surfaces and how smoothly maneuvers are being performed. It is not uncommon to reach levels around 1.0 Amp. In that case you are converting four times



more power into heat. A LOT more! **What is important in the determination of the suitability of BEC for a particular application is some knowledge of the most severe peak currents that will be demanded of the BEC in flight.** Frequent current peaks in the order of about 1.0 A and above are guaranteed plane-killers, don't even think about using BEC in these cases.

You can now see why it is that a limit is placed on the number of cells that can be used with BEC, more cells equals more heat. **The BEC circuit in the FX35D will go into current-limiting if it overheats.** This means that the BEC will limit how much current it sends to the RX/S to try to “save itself" from the damaging effects of heat accumulation. If current limiting doesn't do the trick and the temperature keeps rising the BEC will shut itself down. You do not want this to happen! **That's why we must place a conservative limit on the number of cells used with BEC.** Manufacturers are forced to set these limits on their specifications because not everyone is as well informed as you are going to be when you get done reading this section.

It is also true that if the BEC circuit had enough cooling to remain at 25 deg. C (70 deg. F) or below, you could use it all the way up to the 20 cell rating of the FX35D. This wouldn't mean that the BEC becomes more "efficient" with cooling, all you are doing is removing heat to prevent the circuitry from shutting down due to the resulting rise in temperature. Indeed, running the BEC with 20 cells is very inefficient in the sense that more energy is going into making things hot than to move control surfaces. However, note that **the % of the battery pack used by the BEC per minute isn’t affected by the increase in cell count.** The only two numbers that come into play are the battery capacity (mAh) and the current drawn by the BEC-effectively constant because it is the current required by the RX/S! The high cell count inefficiency we talk about simply refers to all the heat that is generated. Energy is being wasted and not being used to make anything useful, like servo motion. It might be hard to under-stand why it is that the battery consumption per minute is not affected by the heat generated, even after taking a look at the numbers that back up the claim. At the risk of being a bit redundant and making this section way too long, let's take a look at a useful analogy that should help clarify the overall picture.

Imagine the NiCd pack being a water tank whose height is equal to 1 foot per cell. A 12 cell pack would be a 12 foot high tank. The BEC is a fixed 5 foot high tank. The height of the water in the tanks symbolizes voltage. Connect both tanks with a 4 inch diameter hose. Had we used a 2 inch hose less water would flow, right? The rate of flow is analogous to electrical current. Now we have current flowing from the large tank into the smaller tank. Eventually the 5 foot tank will be full and start to overflow. This overflow is equivalent to the energy wasted by the BEC. The tank will not get fuller than 5 feet, that's the limit, everything else goes over the edge. What you do with the overflow water is another story, you can use it for irrigation or let it go to waste. This is a very inefficient setup, the extra water is not being put to good use. If the large tank was 6 feet tall there would be very little water waste and a 30 foot tank would be even less efficient. However, in both the 6 and 30 foot tank examples, the rate of water consumption is exactly the same: the rate of flow through the hose. Both tanks are drained at the same speed. That's exactly what happens with the BEC efficiency and battery consumption.

Like all analogies this one is far from being perfect and it is not intended to be a precise model of what actually happens. It's just meant to be a thinking" tool.

One more thought on BEC usage beyond 10 cells. As we said before, if the circuitry is kept at about 25 degrees C you should not have a problem. You must be careful of what happens during the time just before a flight. In this case there is no airflow whatsoever and the temperature of the BEC components could rise very rapidly by simply having the system powered up.

What does all this mean? Simply stated, you cannot use BEC blindly. **The technology is very well understood and is extremely reliable when used properly.** You must take a look at the system you will be installing the motor controller in and determine if it is within the limits of BEC operation. Next time someone tells you that BEC caused them to have a problem, ask some hard questions and get to the bottom of it!

...now you are an expert on BEC!
(and officially dangerous)

Application note written by Martin Euredjian, AI/ROBOTICS (818) 892-9671.

Should I use BEC?

If you check ANY of the following DO NOT use BEC...

o The model has a total of more than 3 standard servos.
o The model has a total of more than 2 micro servos.

o ALL servo linkages are NOT friction-free.
o The model uses more than 10 cells.
o The motor draws more than 30A.
o The motor has worn out brushes.
o The motor does not have capacitors installed on the brushes.
o Not using good quality connectors.
o No cooling is provided for the motor controller and battery.
o Using an AM radio.
o You regularly fly with your eyes closed.

Nats at Muncie

Fri. Jun 23 - KRC fun-fly type day, fly any electric
Sat. Jun 24 - LMR class “A” sailplane & Old Timer
Sun. Jun 25 - LMR class “B” sailplane & Old Timer
Jun 26 & 27 FAI events, if there is interest - BE THERE

The Big One In Britain

from Dave Durnford - Editor Electric Flight UK
32, West Drayton Rd.
Hillingdon
Middlesex UB8 3LA
Britain

If you plan to be in Europe June 25, you’ll want to catch this one, The British Electric Flight Association International Electric Meet! According to Dave: The venue is superb, the largest (full-size) grass airfield in Europe. Last years event at this venue, featured three separate flight lines. In case you think this sounds a little crazy, they each had about a mile space between them and allowed F5B Competition, Pylon and Sport/Scale to have individual freedom (& time) to run their events. This year we will add electric free-flight too, but this is no problem such is the open space at our disposal.

Already I have heard of several ‘overseas’ visitors attending, including at least one from the U.S.A.

Sounds like a great time!! You can contact Dave at the above address or tel: 0181-569-3219.

By the way, I highly recommend that you contact Dave about receiving Electric Flight U.K. It is a superb publication and keeps you up to date on what is happening in Britain and on the continent.

The Real Motor in the Real World

by Ken Myers
3/5/95

This article is designed with sport and sport/scale electric applications in mind. By this I mean that the plane is flown with power on throughout the flight, while power reductions and increases are being handled by a speed control. The information does not apply directly to task specific planes such as old-timers, powered gliders, FAI rockets or others that have a specific task to perform. Some sport/scale planes might fall outside the parameters used here, but most should conform to the following data as well.

I designed a new spread sheet to use some of the data presented in the Astro Flight, Inc. Electric Motor Handbook by Bob Boucher. This is an excellent resource, with some excellent information. I **highly recommend** this book. I've been looking at the data a little differently and feel that I have a method for getting closer to *real world* results than just using the motor data in the book. I've been using a similar method for several years, thanks to Ed Westbrook and his DOS motor program, as well as various other spread sheets that I've designed.

For raw data, you can use some of the motor data in the book, the new 1995 Astro Flight data sheets, or measure your own motor constants as per Chapter 2, Measuring Motor Constants. One thing that Bob does in his book is to use a higher "constant" voltage than can be supplied through the typical electric power system, while using the recommended cell count, to set up his mathematical examples. He also only takes motor resistance (Rm) into consideration. In actuality, the motor terminal voltage drops as the current increases through the whole system. What he is doing is really okay, since he wants to just compare motors. The batteries, speed control, fuse, wire, switch, and connectors all cause a voltage drop that increases with the current. Once these have been factored into the mathematical formulas, then the formulas are closer to what is happening in the *real* power system. These "additions" to the formulas don't change the relative motor performance and motor relative efficiency in any way, they just more accurately reflect the total power out of the power system for a given load. This is more like what Bob was doing with the Brushless motor example in his book, since the Brushless motor needs its speed control added into the system to be able to run.

An example should clearly show what I mean.

From the book and Astro Flight Data sheet for 1995:
Astro Flight Cobalt 05 on 7.7 Volts - Volts per RPM (Kv) = 2125, Motor Resistance (Rm) = 0.045, No Load Amps (Io) = 2.5
Speed at 30 amps = 2125[Kv] x (7.5V - (30A x 0.045[Rm]) = 2125 x (7.5 - 1.35) = 2125 x 6.15 = 13069 RPM
Using data to provide the voltage drop for 7 SCR cells (.009 ohms per cell), a high rate speed control (.005 ohms), 3 Sermos connections (.0004 ohms per con-

nection), a fuse (.003 ohms), 24 inches of wire (.0002 ohms per inch), yields a “system” resistance of .077 ohms. If the cell voltage is 1.25 per cell (this changes, but is a reasonable estimate when you don’t know exactly) and 7 cells, the voltage is 7 x 1.25 = 8.75V. Subtracting the system loss yields 8.75 - (30A x .077 ohms) = 8.75 - 2.31 = 6.44V at the motor terminals. Speed at 30 amps = 2125 x (6.44 - (30 x 0.045)) = 2125 x 5.09 = 10816 RPM

This could explain why some people think that Astro Flight motors are "over" rated, that doesn't mean over-rated, but power and RPM rated too high. They aren't "rated too high", it's just that you have to know what you are looking at. Actually, if you used 8.1 SCR cells, then the motor terminal voltage would be 7.5 volts and yield 13,100 RPM at 30 amps.

An interesting note is that Bob claims that the power out for the motor is 180 watts at 30 amps and 7.7 volts and it probably is, but when the other losses are taken into consideration the power out is 140 watts. The 78% efficiency, listed by Astro Flight occurs at 17.5 amps, not at 30 amps. At 30 amps the motor is about 72.5% efficient, which is still excellent!

For sport flying, you should draw a current as close to the maximum efficiency as possible (17.5 to 20 amps in this case, with a power out of 99.2 - 110.4 watts, for this cobalt 05) for the best performance to flight time. You can now figure the prop that will most likely draw the current you want.

It is not unusual for this motor to power a 48 oz plane. To find the prop range: Prop diameter = SQRT((48[wt. in oz]/150)*45.836624)*2 = 7.66" up to sqrt((48/100)*45.836624)*2 = 9.38". This shows the range of props for a 48 oz sport plane to be 7.66" to 9.38" diameter.

Use the formula:
pitch = (watts[Pout]/(1.31(dia/12)^4*(RPM/1000)^3)*12). Note that **this formula uses diameter in inches** and yields pitch in inches and **is** the same formula as used to see how much power is being absorbed by the prop! This formula is used to get a starting point for the pitch of the prop only, a ball park figure. The static current should be about 15% to 20% above the flying current, therefore use the data for 24 amps static through the system for a flying draw of about 20 amps. The 24 amp draw data is: 12372 RPM and a power out of 125.2 watts.

Diameter	Pitch	
7.5" dia	3.97" pitch	pitch to dia = 0.53
8" dia	3.07" pitch	pitch to dia = 0.38
9" dia	1.91" pitch	pitch to dia = 0.21

Since any prop with a pitch to diameter ratio below 0.5 shouldn't be considered for flying, the 8" and 9" diameter are eliminated. The 7.5 x 4 is viable. Going to a larger diameter or larger pitch, without gearing this motor, moves the motor use away from its most efficient area, but may be necessary. Using an 8x4 or 7.5x5 yeilds a static current around 27.5 amps with a flying current of about 22 amps.

There are other prop considerations as well, because the prop must be matched to the airframe and how you want the plane to fly. If the 48 oz model is a fairly clean monoplane, then this plane could have an airspeed of about 53.6 mph with the 7.5x4. The 8x4 could be about 51.6 mph and the 7.5x5 could be about 64.5 mph.

Remember that I’ve been talking sport models here, so it will not be a rocket and will not climb like an F5B, but it should give pleasing results when flown as a sport flier.

A few small Problems I found with the <u>Electric Motor Handbook</u>

The motor examples used in Chapter 1 are a bit curious. Bob uses an Astro Flight FAI 15 on 10V as his example for a cobalt motor in this chapter. There is no FAI 15 listed in the book data or the 1995 Astro Flight data sheets. The Mabuchi ferrite example uses a much higher Rm (0.150) than either Mitch Poling, Bob Kopski or I have found for this type of motor. The data that I have shows a Goldfire with a Kv = 2300 RPM, Rm = 0.060 and Io probably about 2 amps and a Turbo 550 with a Kv = 2050, Rm = .100 and Io probably about 2 amps. Using my data places the ferrite Goldfire pretty close to the cobalt 05 in efficiency and performance while the Turbo 550 is really not usable because of the low power, RPM and efficiency. I have found my statement about the Goldfire to be true, since I did over a year's flying on one with an 8x4 prop on my Yahoo. I also suspect that the Brushless example is somehow eccentric as well, but having no firsthand experience with them, or how to accurately test them, I cannot say for sure. It's just a hunch. The most important thing to remember is the validity of the comparisons in the book are real, while some of the specific data is slightly skewed towards the Astro Flight motor.

In Chapter 1, on the page to the right of Figure1.3 & Figure 1.4, in the left column just above the last paragraph, the formula should read Eff. = (Iin-Io)x(Vin-Iin x Rm)/Vin x Iin. In the right hand column of this same page, near the bottom, the formula should be Speed@ 40A = 2125 x 8.0 = 17,000 RPM. On the next page, near the top of the right hand column the formula should be Free Speed = 2200 x 6.7 = 14,740

It is also very important to note that in Equation 4.3 **the pitch and diameter measurements are in feet!** In the spread sheet I have changed the equation so that the input diameter is in inches and the output pitch is in inches.

The Spread Sheet

A1 Motor Data: B1 Input: C1 Calculated Torque Constant (Kt): D1 =1355/B2
A2 RPM per Volt (KV): B2 (Kv input here - leave blank now)
A3 No Load Current (Io): B3 (Io to be input here)
A4 Motor Resistance (Rm): B4 (Rm to be input here)
A5 Gear Ratio: B5 (gear ratio input here - use 1 for direct drive or 2.38 for a 2.38:1 drive etc.)
A6 System Data: B6 Calculated System Losses:
A7 Number of cells: B7 (# of cells to be input here) C7 Battery Resistance: D7 =B6*0.009
A8 Number of Sermos Connections: B8 (# of Sermos connections input here) C8 Sermos Connector Resistance: D8 = B8*0.0004
A9 Number of High Rate Speed Controls: B9 (# of high rate controllers) C9 High Rate Control Resistance: D9 =B9*0.0050
A10 Number of Fuses: B10 (# of fuses input here) C10 Fuse Resistance: D10 = B10*0.0030
A11 Inches of wire: B11 (in. of wire input here) C11 Wire Resistance: D11 = B11*0.0002
A 12 Number of Tamiya type connections: B12 (# of Tamiya connections here) C12 Tamiya Connector Resistance: D12 =B12*0.0015
A13 Number of Low Rate Speed Controls: B13 (# of low rate controls input here) C13Low Rate Control Resistance: D13 =B13*0.0200
A14 Number of Switches: B14(# of switches input here) C14 Switch Resistance: D14 =B14*0.0010
C15 Total System Resistance: D15 =SUM(D7:D14)
(16 is a blank line)
A17 Amp Draw: B17 Mtr Volts C17 RPM D17 Power In E17 Power Out F17 Efficiency
A18 input amp draw* B18 =(1.25*B7)-(A18*D15) C18 =B2*(B18-(A18*B4))/B5 D18 =A18*B18 E18 =(A18-B3)*(B18-(A18*B4)) F18 =E18/D18
A19 input amp draw* B19 =(1.25*B7)-(A19*D15) C19 =B2*(B19-(A19*B4))/B5 D19 =A19*B19 E19 =(A19-B3)*(B19-(A19*B4)) F19=E19/D19
continue this pattern through the maximum amp draw
* I started mine at 2.5 amps and went through 55 amps at 2.5 amp increments. You can go by single amps or 5 amps or .5 amp, what ever you feel like typing in. I figured 2.5 amp increments were good enough.
Your line numbers may not match the following, depending on how you input the amps above, adjust your numbers as needed.
A41 Input Model Weight in ounces: C41 Calculation Smallest Prop Dia. D41 Calculation Largest Prop Dia.
A42 (input weight in ounces here) C42= SQRT((A42/150)*45.836624)*2 D42 =sqrt((A42/100)*45.836624)*2
A43 Input Diameter in inches to try: B43 Power Out C43 RPM at Pout D43Pitch
A44 (input diameter in inches to try here) B44 (input Pout to try here - see note) C44 (input RPM to try here - see note) D44 = (B44/(1.31*(A44/12)^4*(C44/1000)^3)*12)
A45 Note: Choose the static power out and RPM about 20% higher than
A46 the amp draw that you want to fly the plane at.

Important Correction:

When I made up the proof for the "Crunching Numbers" spread sheet, there was an error in the proofing. The figure you should get in E15 is 4654.652826 (or however many places you have chosen.)

Don't Forget the Howell (Livingston County) Electric Fun Fly on Sunday, May 21
For More info: call the C.D.
Keith Clark (517) 546-2462

A Little More on the Nats a Muncie

Larry would like me to remind all of you that Friday will be a fun day of flying, like KRC. Bring any electric to fly and enjoy the day. You don't have to be a "competition" flyer to enjoy the competition on Saturday and Sunday, just bring a plane that qualifies, and enjoy yourself and show the AMA that electric is!! If you don't have a plane to fly in competition, then your help will be greatly appreciated. See you there, June 23 - 27.