the Ampeer

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The Next Meeting:
Thursday, Feb. 1, 1996
Dublin Community Center, Union Lake Rd.
Union Lake, MI - Everyone Welcome!

A CASE FOR LARGER ELECTRIC MODELS

By Tom Hunt
from Silents Please - December 1995
editor: Fred Dippel, 2 David Ct., Glen Cove NY 11542

Why is the electric community still clinging to the "05" mentality? Astro Flight has been making large motors for quite some time. I must admit, KRC has shown us that larger electric models are becoming more popular. So are multi's (small and large!!). But, day in and day out we still see a proliferation of "05" sized models, with and without gearboxes, showing up in the magazines as construction articles or wet (or slope) conversions. To their advantage, they are cheap!! $13.00 motors and $13.00 gearboxes and only 6-8 cells do keep the cost down. Usually, however, the more expensive "micro" radio gear units are required for these models. The 2 meter sailplanes powered by these systems are, and probably always will be, a good way to get your feet wet (or should I say staticky) in electric flight. But why aren't these modelers graduating to larger models as they would if they were flying ....ugh!!!.... glow fuel? Expense is one reason. Larger motors with speed reducers are more expensive than "05". They require more batteries (more expense), and they require a more capable battery charger (to charge higher cell counts.)

There are advantages to large models. They can (and should) use - those larger (and cheaper) servos and receivers that came with the radio you bought. The use of the stock 500 -700 mAh Rx battery that came with it also can be used in the larger models as the model is capable of carrying a few extra ounces here or there. These larger models are easier to see (a plus for those getting on in years). They are capable of flying comfortably in higher winds than you would fly your "05". You don't have to have a pair of tweezers to work inside the fuselage (you can usually get your whole hand in!!)

Most of us fly 7 cell models, right? Most of use have one or two extra of these packs, right? Why not build a 14 or 21 cell model to go out on the days that are inappropriate

What's in this issue?

A case for Big Ones - Visitor from Las Vegas - Mega 3-turn vs AF 40 FAI 5-turn ? - Be Safe - "Plastic gears"? - Doug Answers Some Questions About Speed 400s - A Scaling Spreadsheet - Choosing the Best Prop

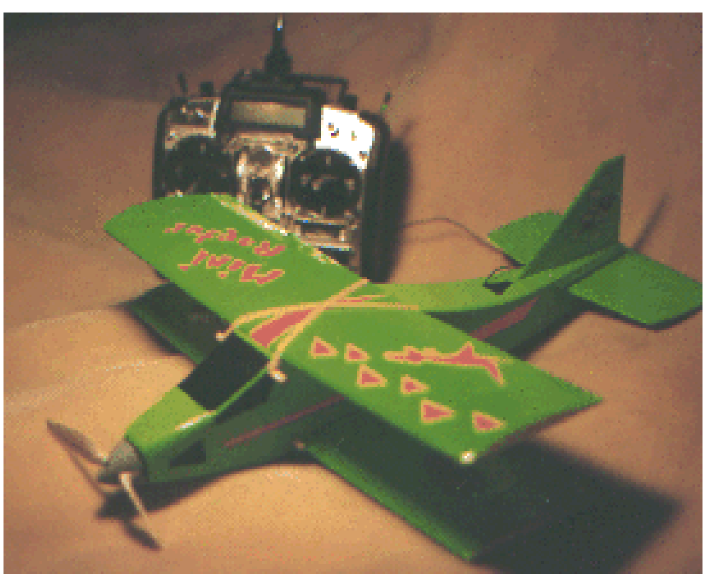
for your hand-launched "05"? Many popular wet kits adapt easily to these cell counts. Sunday flyers can get Sig Senioritas, Kadets, Goldberg Eagles and many other "stick-built" 500-600 sq.in. models flying on 14 cells with the right motor/speed reducer/prop combination. On 21 cells, Senior Kadets, Telemasters, and many other 40-60 sized trainers with 700-1000 sq.in. can be flown. Many larger "Old Timers" are great for lazing about the sky on similar cell counts.

How 'bout it? Fly bigger models and use up some of that "big" hardware collecting dust since you started flying electric. Or, for those of you just starting out in E-flight, a powered sailplane might not be the cheapest way to go. A larger older model glow model converted to electric might just be the way to get flying quickly without too big a hole in the checking account!!

Remember, don't spend money experimenting when you're just getting started. Many of us here in SEFLI are happy to advise you on picking proper propulsion systems for your next project. All that we ask is that you have the wing area, weight (less motor/batteries) of the vehicle handy, and many of us can pick a system right on the spot with this little information to go on. There is no real mystery to electric flight; just buy yourself an ammeter and a tachometer, if you don't already have them. With these two pieces of equipment you will be able to tell whether your model has a chance of flying or you're under- or overburdening your motor and/or batteries.

From One Extreme to Another

Dave Jones of Las Vegas, NV, has a nifty little bipe called the Mini-Rapter (correct spelling - he told me while he was standing by the computer in my living room!). It is powered by a speed 400 6V on 6 x 600AE cells, using a Robbe 6x3.5 folder. It has a 15.5" wing span and weighs



14.5 oz. ready to fly. He is using Doug Ingraham's (Lofty Pursuit) speed control for the Speed 400 and states that it works very well. The photo is courtesy of Dave Jones dropping by while on Christmas/New Years leave. He also brought along the photo of the Graupner JU-88 trimotor. It was seen at Salinas Aeromodeler's flying field in California.

Mega 10 3-Turn vs 5-Turn AF 40 FAI

response by Mike Banyai, Ampeer subscriber, to a question from Tom Vaccaro

Tom asked:

Does anyone have any experience with the mega FAI 10 SP motor? I have one in a Falcon 880 on 10 Sanyo 1700 SCRC cells.Plane climbs and flies well but the current drain of this motor is excessively high when compared to my Astro 40 5T turning the same prop @ same rpm.

Dear Tom,

I was just getting to my old mail when I read your post. I also have both moters and have been experementing with them. I think that part of the misunderstanding resolves around the idea that they both are turning the same rpm on the same prop. In general a three turn motor (ie the Mega 10) will turn a higher rpm as compared to the Astro 5-turn at a given input voltage. So at an input voltage of ten cells with the same prop the mega will draw more current but also give a greater rpm. You can also increase the rpm by increasing the voltage on a given prop. I think that it works out that the Mega10 on 10 cells turns a 12x6 at about the same rpm as the astro 40-5t does on 14 cells. I haven't proven this on the bench but should be doing some of this during the winter. Please let me know if anyone else gave any input to the question. I will send a copy of this to Ken Myers who edits the Ampeer to see if he has any input.

I also wonder if the 1700 SCRC are up to the 50-60 amp draw the Mega requires as there is a higher internal resistance with the SCRC as compared to the SCR cells. You may be dropping the voltage the the motor sees as it tries to draw this many amps whereas the Astro is drawing less amps and may be getting more voltage.

Warmest regards. Mike Banyai, Petoskey, Michigan 616-

348-3595
Steve Neu also replied to Tom:

What prop and what rpm are you seeing with the 2 motors. The Mega is best at very high current >60 amps if you operate at less than 60 or so the Astro might be better, but at higher current the mega will be much better.

My Mega 10sp will turn a 12x6.5 prop at 9800 rpm@70-75 amps on 10 cells.

Are any of you using these motors? What information can you provide for Tom. I have his CompuServe address and can get info to him that way. km

Think About It; Be Safe
by Rob Keeling
From the SKYWRITER
via the AMA National Newsletter
Tom Hill, Editor
PO Box 8604
Santa Fe, NM 87504

Whether flying full scale or models, we are often reminded of the dangers of even the slightest inattention. We must always think about what might happen. Most accidents, when reviewed after the fact, have a very obvious series of events leading up to the actual accident. If we can break this chain of events, we will be able to prevent the accident. I don't suggest that we all become gloomy predictors of trouble and doom, but a moment to think and look ahead might prevent losing that model, or even a serious injury.

Here is a case in point, one that led to a serious injury to one of our own club members.

Norm had finished changing the receiver in his motor glider and was performing the normal bench checks. Normal procedure was to use a bench vice to secure the model. He could then run the electric motor to test the controls for interference. His model had a BEC switching device allowing the motor and receiver to operate off the same seven cell battery pack. Norm's bench vice was damaged and inoperable. He decided to go ahead with bench checks with the glider mounted on a cardboard box. He watched closely as the motor ran out the battery pack and he did his checks. The BEC worked as it should, switching off the motor, leaving enough power for the receiver. When the prop stopped, Norm turned his back on the glider to attend to other things. Minutes later Norm was startled to hear the motor again come to life. Knowing his model would slip off the box and be damaged, Norm spun around reaching out to save his work. Instead he stuck his left hand into the spinning prop. There was no damage to the plane but Norm suffered severe cuts to four fingers and his thumb. Several follow-up doctor visits will be needed to tend to 61 stitches. Norm is grounded as his hand heals and vacation plans are in jeopardy. And there are financial costs.

This accident is an unfortunate example of some of the "not-so-obvious" dangers of electric power. With a glow engine we must take positive action to start them. If they quit, they are, for the most part, safe. With an electric, the motor is a loaded gun as long as a battery is connected. In Norm's case, the battery seemed to be run out, however, after several minutes of "rest," it recovered enough power for the BEC to switch the motor back on.

As is always the case after an accident, Norm's hindsight allows him to give all of the details of his mistakes that would have prevented it; the improperly secured aircraft on the bench, the new prop blades with unsanded razor sharp edges, and not switching off/disconnecting the battery. There is also the quick grab for the plane. Norm now says that he is not even sure if it was moving, he just overreacted.

I'm sure Norm is unhappy and somewhat embarrassed about this incident, but he has graciously allowed me to write about it for its educational value. Best wishes, Norm, for a speedy recovery.

On Using "Plastic Gears"
from an answer to ModelNet question by
Tom Cimato

Hi Herm,

I was reading thru the thread and came across your comment about gearboxes. (*He had stated that a person would need metal gearing for a project that he had in mind. km*) >>Make sure you get a heavy duty gearbox, I'm sure no gear box with plastic gears is up to the job<<

Tom responded:

I must humbly disagree with you one this one :-). We've been using a variation of the Model Electronics Superbox for 2 years with the MaxCim Brushless motor power systems. These have a 60 tooth, 48DP spur gear on the output shaft which is machined from acetal plastic (Delrin). This has proven to be totally reliable through 20 cells and ratios from 2.5 to 4.5:1 in flying planes up to 8+ lb. Piper Cubs.

The Max15 brushless motors have a designed in property that makes gearbox use not only more reliable, but quieter, longer lasting and less stressful on the gearing.

What is it - he asks <g>? Have you turned the shaft of a "powerful" brush dc or Aveox brushless motor? Noticed the heavy stepping (we call it cogging)? Well, this is what hammers gearing into oblivion in very short order. I'm not criticizing others here, just stating what is.

We have designed the Max15 brushless to have nearly zero cogging torque. As a result, the shaft turns very freely, and smoothly. The motor will start and run at between 100 and 200 ma. (Which BTW is the true definition of Io) The smooth shaft rotation allows the use of plastic main gears. A side benefit beyond smoothness is very little residual vibration.

Bottom line, we could fly the Kadet Senior with 16-20 cells, a 4:1 gearbox, 13x8, or 13x10 MA electric prop, using our sofware controlled current limit of 45-50 Amps for brisk climb-out, then throttle back to enjoy a 15 minute flight with 1700mah cells. Actually, we've done similar jobs with these results.

Anyway, thanks for giving me the opportunity to tell you a little about how we can use plastic gearing <g>.

Doug Ingraham on Speed 400 Motors

Lifted from ModelNet Conversation

The question asked:

I am about to finish a 15 ounce high wing (310 sq in) model with Speed 400 power (direct), on 6 cells. I want to fly the first flights with a folder, but my smallest is a Sonic Tronic 7/4. Can anyone predict how much power loss I'll get with the 7/4 over a 6/3?

The reply from Doug Ingraham, (Mr. Lofty Pursuits!)

I wrote a computer model of Speed 400 power systems to help me with a newsletter article I am writing. If you tell me which motor (i.e. 7.2V, 6V, 4.8V), and the types of the cells I can give you a close gustimate of the estimated full throttle power and duration.

This is what the program spits out for 2 common cases using the Graupner 6x3 folder.

8 cells of Sanyo N-600AE on the Graupner Speed 400 7.2 volt motor. The maximum power is produced at a current draw of 11.1 amps, 10702 RPM, an efficiency of 52.25% and 49.8 watts output power. The 6x3 prop will load the motor to about 8.6 amps with an estimated 13200 RPM, an efficiency of 62% and 47 watts output to the propeller. Energy wasted in the motor will be about 29 watts. Estimated duration of 251 seconds.

7 cells of Sanyo N-600AE on the Graupner Speed 400 6 volt motor. The maximum power is produced at a current draw of 13.3 amps, 11397 RPM, an efficiency of 53.79% and 52.3 watts output power. The 6x3 prop will load the motor to about 11 amps with an estimated 13500 RPM, an efficiency of 61% and 50 watts output to the propeller. Energy wasted in the motor will be about 33 watts. Estimated duration of 196 seconds.

The maximum power figure is the point where if you load the motor to more than that number the power output to the prop decreases. In fact these numbers are based on the motor constants of a cold motor so from that standpoint are going to be a tiny bit higher than reality. The program also can tell the max efficiency point for a given power system but this is lots less useful because it is usually too low to launch and climb the plane so you have to prop a given setup for launching and throttle back to get maximum duration.

The analysis above is intended for use with Limited Motor Run (LMR) applications. These motors are overpropped (or over celled) for continuous run unless you have lots of cooling airflow. The little ducted fan models come to mind.

I just went to my unix box and ran a couple of scenarios. The only one that comes close to being usable is 6 cells on the 7.2 volt motor with the 7x4 prop. The maximum power point for 6 cells on the 7.2 volt motor is a dismal 29 watts output power at 8.8 amps and 7949 RPM with N-600AE cells. It is a fractional amount better with 1000AE and 1200AE cells but not enough to consider the extra weight. Compare the 29 watts to the 47 and 50 watts output above. With the 7x4 prop you would be running right on the ragged edge at an estimated 8500RPM and 8.2 amps load with 28.8 watts output power. Your best bet is to cut down the prop to 6 inch diameter and use 8 cells as in the first example.

Another question:

I have all three winds of the speed 400, and was planning to use the mini-olympus gear box (2.2:1) with the 6v wind, and a graupner 9x5 slim prop.(*on a plane previously described to Doug. km*)

Doug replied:

I ran several cell counts for each motor. Starting with the 7.2V motor

12 cells: 12.7A 8959rpm 105.5 Wout 63.4% effic 340 secs
11 cells: 11.2A 8508rpm 87.8 Wout 64.7% effic 386 secs
10 cells: 10.0A 7897rpm 72.4 Wout 65.1% effic 432 secs
9 cells: 8.6A 7357rpm 57.5 Wout 66.1% effic 502 secs
8 cells: 7.4A 6706rpm 44.7 Wout 66.6% effic 584 secs

For short bursts of power 12 cells would be interesting to try. Wout is the computed actual output power of the motor to the prop. 10 cells would be about the most I would try. Maybe you should consider 10 cells of the 1000AE type.

Now the 6V motor:

8 cells: 12.6A 7716rpm 67.3 Wout 61.6% effic 343 secs
7 cells: 10.6A 7043rpm 51.1 Wout 62.6% effic 408 secs

Finally the 4.8V motor:

8 cells: 26.9A 9194rpm 114.3 Wout 55.6% effic 160 secs (past max power)
7 cells: 23.3A 8509rpm 91.1 Wout 56.8% effic 185 secs

(past max power)
6 cells: 19.5A 7784rpm 69.1 Wout 58.3% effic 222 secs

The program predicts that 6 cells is not over the Max power point of the motor but it doesn't understand that the brushes can't transfer that much current to the motor. Probably 5 cells would be the most for that motor and I didn't bother to run it because you can't run a BEC from 6 cells at that kind of load and you can't run a BEC on 5 cells at all.

I would run the 6V motor and throttle back immediately after takeoff. There is quite a lot of headroom with that prop on 8 cells with that motor so it won't be an instant fry of the motor. For the 7.2V motor you need a larger prop or a lower reduction ratio for 8 cell operation. Let me know how these numbers compare to "reality". After all, they are just numbers and probably a bit optomistic at that. I need to put in several reality compensations.

The 4.8 volt motor is way overloaded with this prop/reduction ratio. It needs a higher reduction ratio.
Comment to Doug:

These 1200AE packs are disappointing, they get too warm when voltage peaked and can only handle a 2A charge current without getting warm..
From Doug:

In my view this is the only problem with using them for small planes. You CAN'T constant current change them at more than about 2 amps and this takes a long time. They seem to handle 15 amps discharge rate pretty well. Of course if you have oh, say 10 of the 110D chargers you can charge lots of packs at once <BIG GRIN>. You can try higher charge rates for the initial 60% of the charge and then cut it back to 2 amps when you get near that point but this could result in an accident.

(*Anyone have any comments on what Doug has had to say - how about those cells - true? Next Month Doug shares directly with us via an article on LMR using Speed 400 motor - km*)

A Scaling Spreadsheet
by Dick Comber
from: Electric Flight U.K.
Winter 1995
editor: Gordon Tarling

The purpose of this spreadsheet is to help to scale models up or down from a known plane. The original could be a model or the full size plane. In the top part of the spreadsheet you insert wing dimensions, the weight of the known model and other information if required. The wing areas and wing loading are calculated automatically in both imperial and metric units.

In the lower part you enter up to 6 different wing spans in inches (in cells G24, H24, I24, J24, K24 and L24), and the spreadsheet calculates theoretical wing areas, flying weights, wing loadings, approximate wattage requirements and several related parameters. The basic assumptions are that when you double the wing span the wing area is increased 4 times, and the volume and weight are increased 8 times. Metric conversions are included automatically to satisfy the EEC.

This version allows for bi-planes but not for planes with more than 2 wings - you are on your own there, but could add the spans of 3rd, 4th etc. wings to the "second wing" figures, leaving the chord unchanged if appropriate.

The two spreadsheet programs I use are WindowWorks and Quattro Pro (DOS version). The former is good at pretty (but slow) graphics printing and the latter is particularly good at printing out the formulae. The example given was printed out from WindowWorks (all in 8 point character size) but the formulae were printed out from Quattro Pro. In both programs the $ sign fixes a cell position and without it the positions are relative. Cell numbers and letters were deliberately printed for this note, but normally would not be needed.

When a number is too large for a cell, these spreadsheets show rows of asterisks. WindowWorks can show a number in a cell but print out a row of asterisks, so what you see is not always what you get. Some of the figures, such as watts required to power the original plane, or even a 6" span version, may be nonsensical, but this will be rather obvious.

It is possible to export a spreadsheet from either program into a Lotus 1-2-3 format and then import the Lotus version into the other or to some other spreadsheet program such as Excel. When this is done many column widths can be wrong and will need to be adjusted. Also, DOS Quattro Pro formulae start with a + sign while WindowWorks (and Lotus 1-2-3 and Excel?) start with an "=" sign. Any member wanting a copy of this spreadsheet in WindowWorks, Quattro Pro (DOS version) or exported as a Lotus 1-2-3 version can have it if they send a 3.5" disc to: Dick Comber; 99 Nutshalling Avenue, Rownhams, Southampton S016 8AY.

There are many other excellent spreadsheet programs available, all having slightly different characteristics. The formulae are given below for anyone wanting to make up a sheet using a different program or a system which is not IBM compatible.

If you ask a photocopy shop to enlarge a plan, they usually want to know the percentage increase required. This is given in row 25. One point not very obvious is that if everything is in proportion, doubling a wing span doubles the wing loading.

In the example illustrated, it was known that a model of the Zeppelin Staaken with a span of 1.89 metres and weighing 1.7kg had been built (and flown!) in Germany. I was scaling this down to 2/3rds of the power and weight. In this example the wing spans are (1) that of the little published plan which was enlarged for building a model, (2) that of the new model, (3) that of the original German model, (4) and (5) the likely spans of a model a friend was thinking of building [have you started it yet Dave?] and (6) that of the full size plane.

The formulae

For use in other spreadsheet programs the "+" signs will have to be replaced by "=" signs or whatever the program demands. Quattro Pro (DOS version) requires + signs and WindowWorks requires = signs.

Top part of spreadsheet

R2: +P2*25.4 L3: +F11 P3: +P2/L3
R6: +Q6*25.4 G7: +F7*25.4 I7: +J7*25.4

All subsequent inch to mm conversions are: the relevant cell x 25.4

Q8: +P7*12/P3 Q9: +Q8/6 F11: +F7+F9
H11: +H7+H9 F13: +F7*F8 G13: +F13*0.0645

All subsequent square inch to square decimeter conversions are: the relevant cell *0.0645

H13: +H7*H8 Q13: (@ATAN(Q11/Q12))*360/6.28
F14: (F8+F10)/2*F9 H14: (H8+H10)/2*H9
Q14: +F11/(F15/F11) F15: +F13+F14+H13+H14
I15: +F15*0.0645 Q15: 40*F16/16
H16: +F16/16 J16: +F16*28.35

All subsequent ounce to gram conversions are: the relevant cell x 28.35

D17: +F16/F15*144 G17: +D17*3.05
F19: +E18/F16*100 N19: +F16/N18

Bottom part of spreadsheet

G24, H24, I24, J24, K24 and L24 are any numbers - wing spans in inches

Enter the formulae in column G, cell numbers 025 to 039 and copy these to
columns H - L (same row numbers).

G25: 100*(G24-$G24)/$G24 G26: +G24/$F11*$F7
G27: +G24/$F11*$F8 G28: +G24/$F11*$F9
G29: +G24/$F11*$F10 G30: +$Q11*G24/$F11
G31: +$Q10*G24/$F11 G32: +$Q6*G24/$F11
G33: +G24/$F11*G24/$F11*$F15
G34: +G24/$F11*G24/$F11*G24/$F11*$F16
G35: +G34/(G33/144) G36: 40*G34/16
G37: +G34/$N18
G38: +$E18*G24/$F11*G24/$F11*G24/$F11
G39: +$P2/G24

Enter the formulae in column N, numbers N24 to N39 and copy these to columns O - S (same row numbers).

N24: +G24*25.4 N25: 100*(N24-$N24)/$N24
N26: +G26*25.4 N27: +G27*25.4 N28: +G28*25.4
N29: +G29*25.4 N30: +G30*25.4 N31: +G31*25.4
N32: +G32*25.4
N33: +G33*0.0645159 N34: +G34*28.35
N35: +N34/N33 N36: +G36 N37: +G37*28.35
N38: +G38*28.35 N39: +039

Note that the formula in Q13 calculates the incidence angle in degrees, but unless told otherwise Quattro Pro expects you to be using radians.

Notes on a scaling spreadsheet

Enter information only immediately after >>>>>>>
Information after .... is calculated.
Enter dimensions of a known model and the wing span of the original if known.
Wing span & area, and scales are calculated.
Enter the flying weight of the known model.
Its wing loading is calculated.
For the chosen new scales, enter the new wing spans in inches under the numbers 1,2,3 etc. in the IMPERIAL section.
The new wing areas, weights and wing loadings are calculated.
All metric figures are calculated.
For more than 2 wings insert the total spans of parallel and tapered sections but mean chords.
The % difference from Span 1 can be used to get plans reduced or enlarged in photocopy shops.
Where a wing curves at its junction with the fuselage, the "Chord of parallel section or root" may differ from the "Root chord for incidence
A row of asterisks indicates that the number is too large for the cell; the number may appear on screen but fail to print.
Insert a figure such as 3, 3.5 or 4 as weight / thrust ratio in cell N18.
The calculated watts for r.o.g can only be approximate.

For those of you interested in the spreadsheet, I made it in MicroSoft Works 3.0 and can save it as a lower form of Microsoft works, Excel 4.0 or 5.0, Lotus 1-2-3 or as a text file with tabs or commas. If you'd like a copy I can send you the file over CompuServe or you can send me a 3.5" floppy with return postage and I'll make you a copy. km

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	1/6/96	20:36		Scaling Spreadsheet					**Enter Information Only Immediately After >>>>>>**										
2		Name of Plane >>>>>			Zeppelin Staaken 65" span					Span of full size if known >>>>>>>>						1221	in. or	31013	mm
3										Scale of		65	in. span plane is			18.78	to 1		
4	Calculating Wing Area of Original Model													(German model was 1.89m span, 1.7kg)					
5	[Metric Figures are Calculated]					First Wing		Second Wing									inches	mm	
6						inches	mm	inches	mm				Propeller diameter >>>>>>				6.55	166	
7	Wing Span of Parallel Section >>>>					24.5	622	0	0				Assume pilot is >>>			5.8	ft. tall		
8	Chord of Parallel Section or Root >>					8.5	216	0	0				Model Pilot Height			....	3.7	94	
9	Span of Tapered Section >>>				>>>>	40.5	1029	0	0				Height of Pilot's Head				0.62	16	
10	Chord at Wing Tip >>>			>>>>>	>>>>>	4.4	112	0	0				Di- or Poly- hedral >>			>>>>	2.1	53	
11	Wing Span		....	....	....	65	1651	0	0				Wing Incedence >>>			>>>>>	0.45	11	
12						sq.in.	sq.dm	sq.in.	sq.dm.				Root Chord for incidence >				10.3	262	
13	Wing Area, Parallel Section ..				....	208	13.4	0	0.0				Incidence angle				2.5	degrees	
14	Wing Area, Tapered Section				....	261	16.8	0	0.0				Mean Aspect Ratio ..			....	9.0	to 1	
15	Wing Area Total			....	....	469	sq.in.	or	30.3	sq. dm			Approx. Power for ROG ...				100	watts	
16	Model Flying Weight			>>>>>	>>>>>	40	oz. or	2.5	lbs. or	1134	g								
17	Wing Loading		....	12.3	oz/sq ft or		37.4	g/sq dm											
18	Weight of Power Pack >>>>				12	oz. or	340	g		Weight / Thrust Ratio >>>				3.50					
19	Power Pack as % of Flying Weight ..					30	%			Thrust to fly	....		....	11	oz. or	324	g		
20																			
21	Same Model, New Scales																		
22							<______________Imperial______________>							<______________Metric______________>					
23	Wing span numbers						1	2	3	4	5	6		1	2	3	4	5	6
24	Wing Span, inches & mm >>				>>>>>	>>>>>	6.38	65	74.4	80	84	1221	....	162	1651	1890	2032	2134	31013
25	% difference from Span 1				....	....	0.00	919	1066	1154	1217	19038	....	0	919	1066	1154	1217	19038
26	Span of Parallel section, inches & mm						2.4	24.5	28.0	30.2	31.7	460.2	....	61	622	712	766	804	11690
27	Root Chord, inches & mm				....	....	0.83	8.5	9.7	10.5	11.0	159.7	....	21	216	247	266	279	4056
28	Span of Tapered section, inches & mm						3.98	40.50	46.36	49.85	52.34	760.8	....	101	1029	1177	1266	1329	19324
28	Chord at wing tip, inches & mm					....	0.43	4.40	5.04	5.42	5.69	82.65	....	11	112	128	138	144	2099
30	Wing incidence, inches & mm				....	....	0.04	0.45	0.52	0.55	0.58	8.45	....	1.1	11	13	14	15	215
31	Di- or Poly- hedral, inches & mm					....	0.21	2.10	2.40	2.58	2.71	39.45	....	5.2	53	61	66	69	1002
32	Propeller Diameter, inches & mm					....	0.64	6.55	7.50	8.06	8.46	123.0	....	16.3	166	190	205	215	3125
33	Wing Area, sq. inches & sq. decimeters						4.5	469	615	711	784	165660	....	0.29	30	40	46	51	10688
34	Flying Weight, ounces & grams					....	0.04	40	60	75	86	265135	....	1.07	1134	1701	2114	2447	######
35	Wing Loaging, oz/sq.ft and grams/sq.dm						1.2	12.3	14.0	15.1	15.9	230.5	....	3.67	37.4	42.9	46.1	48.4	703.3
36	Appromimate Watts for ROG				....	....	0.0946	100	150	186	216	662837	....	0.095	100	150	186	216	662837
37	Thrust to Fly, ounce & grams				....	....	0.0108	11	17	21	25	75753	....	0.306	324	486	604	699	######
38	Weight of Power Pack, ounces & grams						0.0113	12.0	18.0	22.4	25.9	79540	....	0.322	340	510	634	734	######
39	Scale with reference to full size					1:	191.4	18.8	16.4	15.3	14.5	1.0	1:	191.4	18.8	16.4	15.3	14.5	1.0
40																			
41	Enter dimensions of a known model and the wing span of the original if known. Wing span & area, and scales are calculated.																		
42	Enter the flying weight of the known model. Its wing loading is calculated											For the chosen new scales, enter the new wing spans							
43	in inches under the numbers 1, 2, 3, etc. in the IMPERIAL section.									The new wing area, weights and wing loadings are calculated.									
44	Alll Metric figures are calculated.						For more than 2 wings insert the total spans of parallel and tapered section but mean chords												
45	The % difference from Span 1 can be used to get plans reduced or enlarged in photocopy shops.																		
46	Where a wing curves at its junction with the fuselage, the "Chord of parallel section or root" may differ from the "Root chord for incidence"																		
47	A row of asterisks indicates that the number is too large for the cell; the number may appear on screen but fail to print.																		
48	Insert figures such as 3, 3.5, 4 as weight / thrust ration in cell N18																		
49	The calculated watts for ROG can only be approximate.																		

Propeller Optimization

by Bob Smith

via Electric Flight U.K. - edited by: Gordon Tarling

At the 1995 Technical Workshop I gave a talk on a system I have developed for the determination of the best propeller to use in a particular model. The system is fairly technical and requires the use of some formulae and graphs, but it aroused enough interest to make me think that it was worth putting into print so that we could have a permanent record of the procedure which could be used in the future.

Static Testing

If we have a particular electric power system chosen to fly a particular model e.g. a battery pack, controller motor (and gearbox), then there will be an "ideal" propeller to give an optimum performance from the model. There may be more than one ideal, and the optimum performance may be in terms of speed, rate of climb, duration, or other variable but each situation will have a best solution. We can move towards this solution by running some static tests on the system and measuring the current draw voltage, and thrust for a range of propellers. It may be difficult to measure the thrust accurately without an appropriate test bed but there have been a number of curves published which give thrust / RPM for commercial propellers so that an optical tachometer can give the required value.

These results will give an idea of the best propeller to use to maximize the static performance of the system but we know that once the model is flying, the conditions change. As the model is flying at a particular airspeed the propeller is cutting through air which is already moving relative to the model rather than the static air in the case of the bench test, and this means that the propeller load decreases, the RPM increases, the current draw decreases, the voltage increases and the thrust decreases. The problem that we have is to estimate by how much?

Propeller Pitch

Let's concentrate for the moment on the pitch of a propeller expressed in terms of the distance advanced by the propeller in one revolution in a perfect, no slip, situation. This is the same as the distance a nut will advance along a threaded rod in one turn. On a flying model, in normal circumstances, the thrust developed by the propeller is part of the balance of the aerodynamic forces and must therefore be a positive, forward acting, value. For this to occur there must be an angle of attack for the propeller blades on the moving air which means that the actual total pitch of the propeller must be greater than the value for the no slip situation.

A better analogy is to consider a propeller running in a wind tunnel. The tunnel air speed is constant, the propeller RPM is constant but the blade pitch is variable. When the pitch is zero the propeller creates drag, a rearward acting force which can be thought of as negative thrust. If we gradually increase the pitch of the blades this drag will decrease until we reach the perfect, no slip, condition, at which point the value of the force will be zero. If we continue to increase the pitch the propeller starts to produce thrust, a forward acting force, and it is in this condition that our models normally fly in the power on mode. We can now think of the total pitch of the propeller (the value indicated by the manufacturer) as having two components on the flying model.

At a particular airspeed the Total Pitch will be the sum of the Zero Incidence Pitch (equivalent to the zero force condition in the wind tunnel) and the Effective Pitch (the additional pitch required to create positive thrust)

Total Pitch = Zero Incidence Pitch + Effective Pitch

Although the total pitch of a propeller is set by the manufacturer during production (unless you devise a variable pitch propeller) the ZIP is dependent only upon the flying speed of the model and the propeller RPM in flight. It is easy to calculate since if:

S = model flying speed in MPH
N = propeller RPM in flight
P = propeller total pitch in inches

then flying speed = (S * 5280 * 12)/60 = 1056 * S ins/min.

for the ZIP equivalent to zero slip the
flying speed = P * N ins/min = ZIP * N ins/min.
therefore ZIP * N = 1056 * S
or ZIP = (1056 * S)/RPM inches

if a model is flying at 20 MPH with a propeller doing 5000 RPM the ZIP is 4.2 inches

*(1056*20)/5000 = 4.224 inches km*

This formula can be used to produce a set of curves which make the estimation of ZIP even easier.

Remember that the ZIP is dependent on speed and will therefore vary during flight. We can only calculate values for typical situations, e.g: level flight for a pylon racer or a steady climb for an electroslot model.

Using the ZIP

When a model is released at the beginning of its flight it accelerates in level flight until the drag balances the thrust and we have a constant speed. If the model is climbing the forces are more complex but they must still be in balance to reach a constant rate of climb. Since a positive thrust is required to achieve this balance we know that the ZIP must be less than the total pitch. To determine the difference between them we need to know or to estimate the model flying speed and the propeller RPM.

If in the earlier example the model was flying at 20 MPH using a 10" x 7" propeller at 5000 RPM then the ZIP would be 4.2" and the effective pitch would be 7" - 4.2" = 2.8"

If we carried out a static test on this model we would have obtained a very different set of figures, perhaps the static results might be 500 grams (*17.5 oz. km*) of thrust at 4000 RPM and drawing 15 amps. As the model accelerates to the 20 MPH flying speed these figures change to 5000 RPM with the thrust decreasing to 300 grams (*10.5 oz. km*) and the current reducing to 10 amps. We can simulate the flying condition by static testing the same system but with the propeller pitch reduced to the effective value i.e. a static test of the same motor battery, controller gearbox etc. But using a 10" x 2.8" propeller would give a static thrust of 300 grams at 5000 RPM drawing 10 amps.

Of course we are unlikely to find the same make of propeller with a 2.8" pitch but if we could it would enable us to get a very good idea of the airborne performance.

As Alternative Approach

The problems associated with limited pitch ranges in commercial propellers (not to mention variations in blade shapes, sections, and non-helical pitches) mean that the static testing of effective pitch propellers is not a viable approach. Additional factors are the restrictions involved in competition flying where there may be limited cell counts or weights, minimum motor run times, motor maximum current draw and similar limits.

We can avoid most of these problems by using an aspect of motor performance which is much easier to deal with. All DC motors have a relationship between RPM and current draw which produces a straight line graph for a particular voltage (i.e. a certain size drive battery). We only need two points on the graph to plot it and this allows us to extrapolate additional data.

The points indicated on this line are as follows:

A - the no-load RPM, the free running speed of the motor (or the motor and gearbox) with nothing mounted on the output shaft. Note that this is not at zero amps since current is required just to spin the armature.

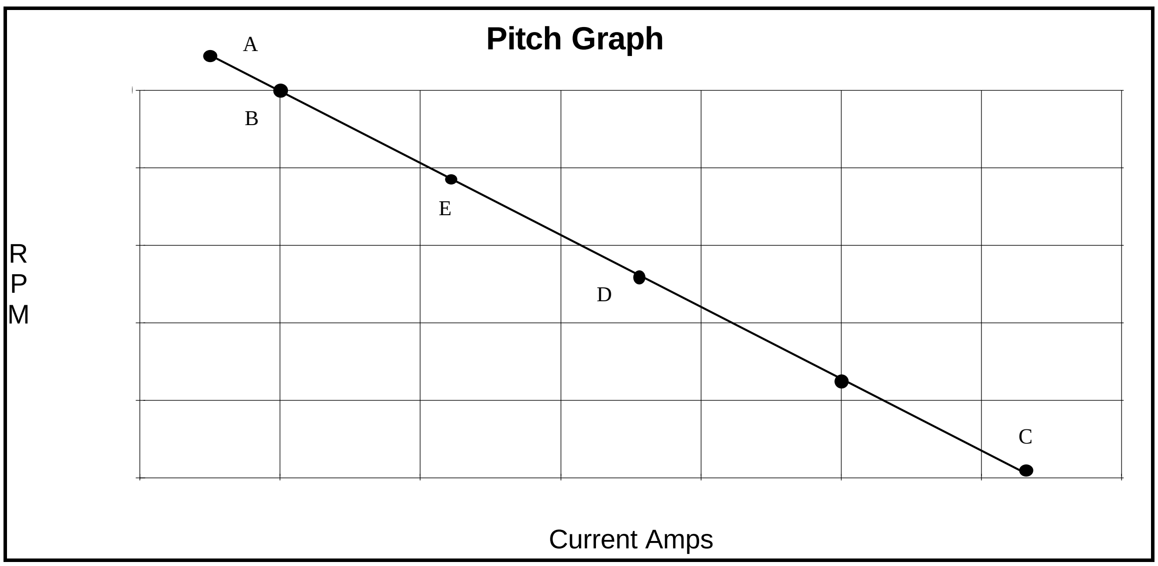
B - the minimum load value resulting from mounting a tachometer disc on the shaft to take a reading with an optical tachometer.

C - the stalled current. The current drawn by the motor if the shaft is locked to prevent any rotation. **This is not a recommended test procedure.**

D - the result of a typical static test for any particular propeller

E - the point representing the in-flight performance of the same propeller.

Two simple tests with a tachometer disc and a suitable propeller will give points B and D and allow the graph to be plotted. If we can then estimate the position of point E we will have the airborne data for this propeller.



If the test to fix point D uses a propeller which is one of a family with the same diameter but different pitches then a further test will give a pitch increment along the graph but even if this is not possible then an estimate will still produce a guide.

Test Examples

EXAMPLE 1 - E400 model **-** Graupner 6 volt Speed 400 motor with a 3:1 gearbox driving a Graupner 11x8 Camprop and using a 7 x Sanyo 500AR battery. The motor runs at 21000 RPM on a Tachometer disc whilst drawing 1 amp (7000 RPM on the gearbox shaft). With the 11x 8 mounted the static RPM is 4900 drawing 12 amps.

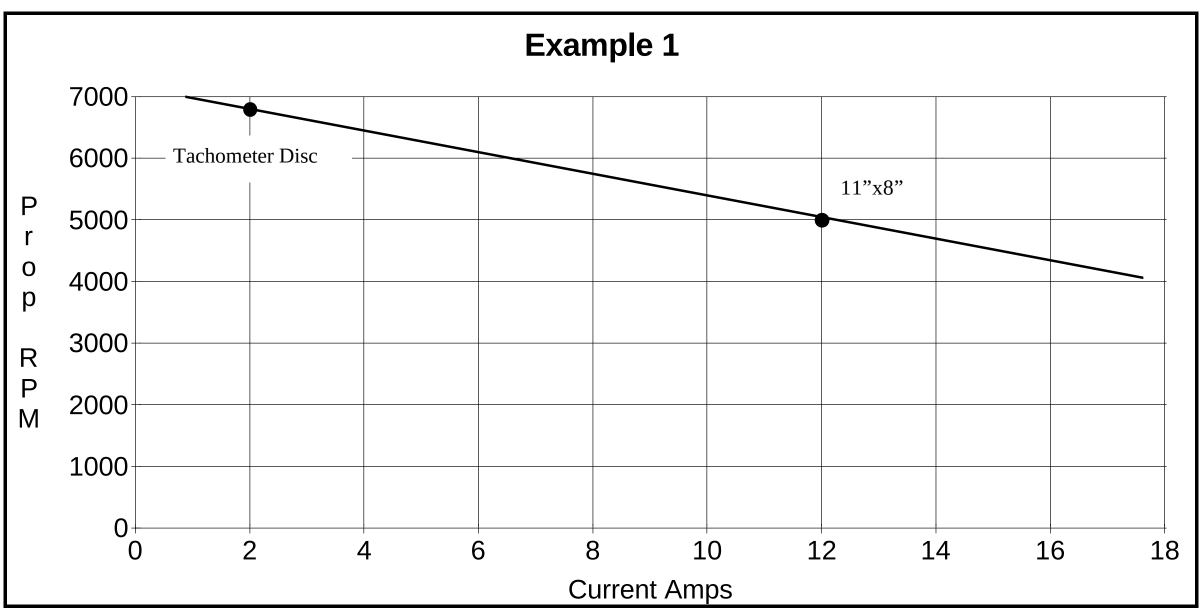
If we want to estimate the best propeller for this model we can apply the motor current limit and aim at an in-flight current draw of 10 amps. From the graph this would be at an RPM of 5300 and would be achieved in the static test by something like an 11x 6 Camprop (if one existed). If the model were flying in a steady climb with an airspeed of 15 MPH and 5300 RPM the ZIP would be 3" and therefore the propeller needed to achieve these values in flight would be an 11 x (6 + 3) i.e. an 11x 9 Camprop (again if one existed).

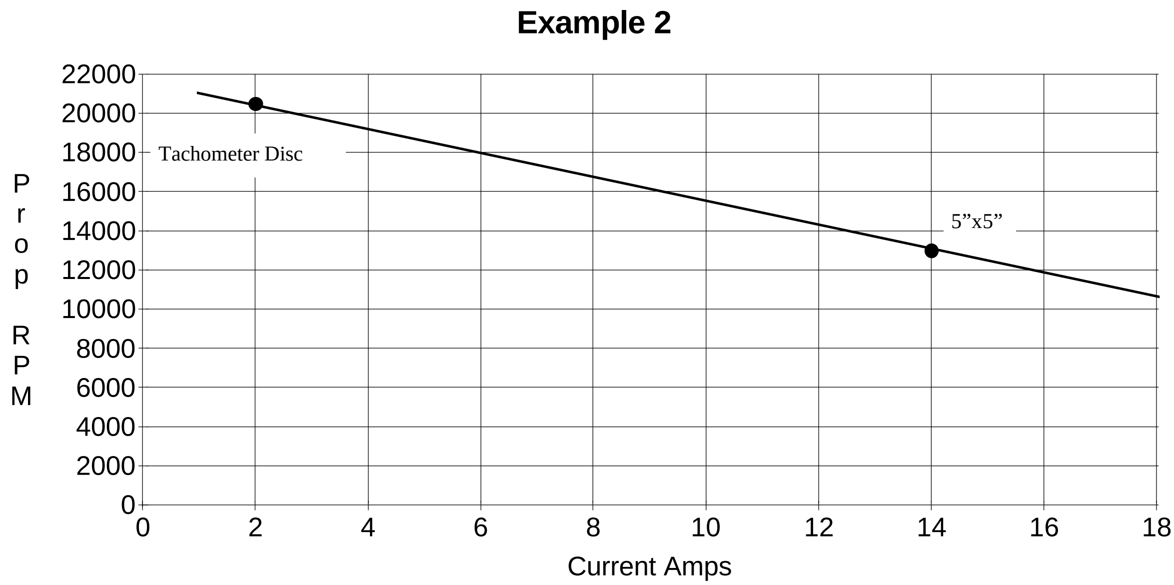
In this example the calculations show that the original 11x8 propeller is slightly under-pitched but it is interesting to note that if the model were climbed more steeply the airspeed would drop, the ZIP would decrease, and the propeller would be nearer to the optimum.

EXAMPLE 2 - 400 Pylon Race Model **-** Graupner 6 volt Speed 400 motor a 7 x Sanyo 700 AR battery direct driving a Graupner 5x 5 Camprop.

Static tests gave the same 21000 RPM tachometer reading at 1 amp (no gearbox) and a propeller speed of 13000 RPM drawing 14 amps.

If we again use the 10 amp limit for our in-flight current then we obtain 15500 RPM and a Camprop of around 5x3 to achieve this in a static test. If the model flies level at 70 MPH and 15500 RPM the ZIP will be 5" and the propeller needed would be a 5x (3+5) i.e. a 5x8 Camprop (which also does not exist). In a static test this prop would draw



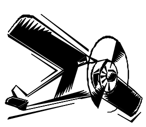


around 18 amps so you would not do much static testing.

Conclusions

This approach to propeller analysis is not original work. The theory has been around for some time in various guises but I have tried to present it in a "user friendly" way As with all theories, there will be some gaps between actual and theoretical behavior and some of the results may be extreme (as might well be the case with the 5x8 propeller). There are also some factors which I have not yet been able to include and the propeller diameter is one of these. Changing the diameter affects all of the calculations by varying amounts and I have not yet been able to analyze the overall result. I normally run static tests over a set of propellers of different diameters but the same (or at least similar) pitches and select the diameter on the basis of current drawn using the largest diameter possible within the current limitations of the motor/battery. This is consistent with the diameter/thrust relationship (see previous EF-UK) and gives me a starting point for the pitch calculations.

Try the calcs on your own models. I would be interested in hearing if you find them useful.



The Ampeer
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Last Page First

Well we’ve had some “teething” problems. I am not sure that all of you got last month’s (Jan.) Ampeer via e-mail. It seems that some did and some didn’t. Remember that you can click the second upper left button in the Acrobat Viewer to get a table of contents. Remember that if you print this on a monochrome printer, the color pictures may not come out too well, but a color printer should handle them fine.

Please be sure to let me know if you don’t get your on-line version, because I want to soon go to only on-line for those of you who perfer it that way. Everyone who has been getting the snail mail version should still be getting it.

Can Spring Be Far Away?

Next Meeting:
Dublin Community Center
Thursday, Feb. 1 - 7:30