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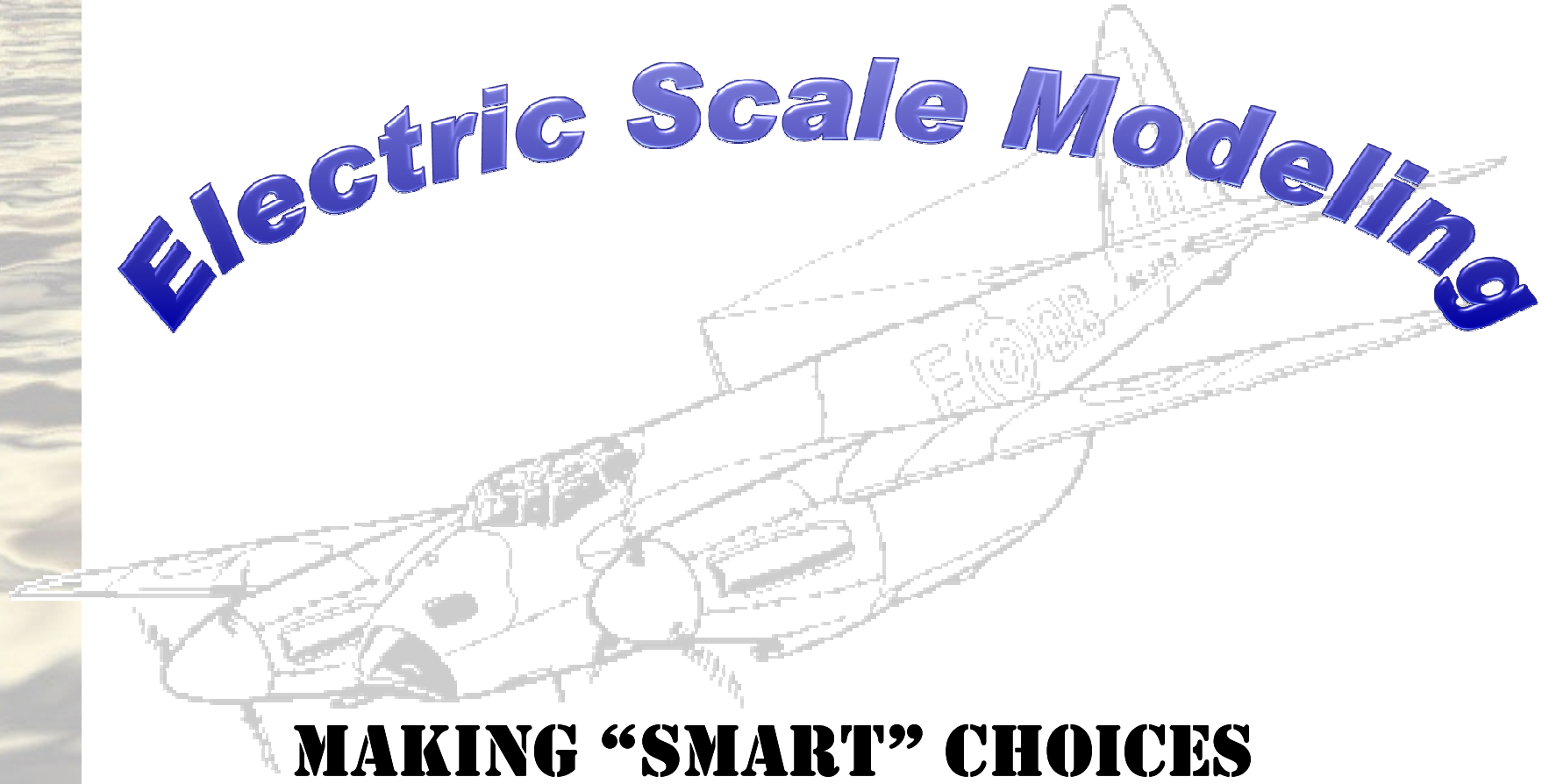
Electric Scale Modeling



MAKING "SMART" CHOICES FOR GREAT FLYING AND LOOKING SCALE MODELS

Tom Hunt WRAM 2010

Overview

- Properly Choosing Power Systems for Scale Models With Respect to:
  - mission (power loading)
  - wing loading (skill level)
  - scale size props
  - multi-motor
  - number of blades
- System Cooling
- Weight and CG Consciousness
- Flying

The Subject, The Mission

Choosing a subject aircraft essentially chooses the "mission" of the model.

The "Mission" of a model is the manner in which it is to be flown:

- **Fighter (Sopwith,P-51)**
- **Ground attack (JU-87, P-47)**
- **Utility/transport (Ju-52, D-18)**
- **Bomber (Gotha, B-25)**
- **Observation (L-4, OV-10)**

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The Subject, The Mission cont

The "mission" determines power loading
= performance
P (watts) = Volts x Amps
$P_{loading}$ = watts/model weight = $$$$$

WWI fighters --- 70-100 watts/lb
WWI bombers--- 60-80 watts/lb
WWI or II observation --- 60-80 watts/lb
WWII fighters --- 100-150 watts/lb
WWII bombers--- 80-100 watts/lb
jets (all era's) --- 150-200 watts/lb

The Subject chosen… the fun begins

Origin of the subject:

- **Scratch from own plans**
- **scratch from available plans**
- **kit**
- **ARF bashing**

Determining the scale:

Full scale wingspan/model wingspan

37′ full scale P-51, 57″ model = 37*12/57 or 1/7.85 scale.

Determining the wing area (important later)

full scale wing area/scale² 242sqft x144/7.85² = 565.5 sqin (or 3.93sqft)

The Subject Chosen… the fun begins

Wing loading = weight/wing area = skill level

- **10-15 oz/sqft = novice**
- **15-20 oz/sqft = advanced**
- **20-30 oz/sqft = skilled**
- **30+ oz/sqft = expert**

Take a crack at what you think your "subject" may weigh…… what would it weigh it were "glow powered"? *Electric models today do NOT have to weigh more than a comparable glow model!*

40 glow Mustang (approx 1/8th scale) = 7 lbs (with retracts)
7(lbs)x16(oz/lb)/3.93(sqft) = 28.5 oz/sqft = skilled model flyer!

The Subject Chosen… the fun begins

However…….

40 glow J-3 cub (approx 1/6th scale) = 5 lbs

5(lbs)x16(oz/lb)/4.94(sqft) = 16 oz/sqft = advanced model flyer

The Subject Chosen... power required

1/6th scale J-3 cub
- 70" span
- 5 lbs target weight
- 16 oz/sqft wing loading
- 80 watts/lb power loading
- Scale prop is 12" Dia, two blade
- need to input 5lbs x 80 watts/lb = 400 watts

1/8th scale P-51
- 57" span
- 7 lbs target weight
- 29 oz/sqft wing loading
- 120 watts/lb power loading
- Scale prop is 17" Dia, 4 blade
- need to input 7lbs x 120 watts/lb = 840 watts

The Subject Chosen... battery cell count

1/6th scale J-3 cub

400 watts required.....

400watts/30amp = 13.3V (round to 14.4 V) = 4 li-poly cells.

1/8th scale P-51

840 watts required.....

840 watts/40amps = 21V or 6 li-poly cells

The Subject Chosen... propeller selection

CHOOSE PROPELLER **- (PITCH/DIAMETER (P/D) RATIO)**
A 12 X 6 PROP HAS A P/D RATIO OF .5
A 14 X 10 PROP HAS A P/D RATIO OF .71

Low P/D ratio = big thrust, low top speed
Medium P/D ratio = good thrust, good top speed
High P/D ratio = poor climb, great top speed

Drag burdened scale models (such as WW1 era) need low P/D props. Sleeker WW2 model more pitch is required to get "scale" speed look, but over-pitching for the sake of speed can get you a poor climb.

WW1/GOLDEN AGE .4-.6
WW2 FIGHTER .6-.75
WW2 BOMBER .5-.6

The Subject Chosen... propeller selection

1/6th scale J-3 cub

Scale prop is 12" Dia two blade (use 6" pitch)

need to absorb 400 watts

Question: what brushless outrunner motor will swing a 12 x 6 prop on 4S li-poly for about 30 amps?

Answer: Axi 4120/14 or BP hobbies A4120-7

1/8th scale P-51

Scale prop is 17" Dia 4 blade

(very unlikely you will find a COTS one, we will talk more about this later) Let's use a 14 x 10

need to absorb 840 watts

Question: what brushless outrunner motor will swing a 14 x 10 prop on 6S li-poly for about 40 amps?

Answer: Axi 4130/16 or BP hobbies A41308

Multi-motored models

Same principals apply when choosing power systems, the difference becomes the wiring scheme.

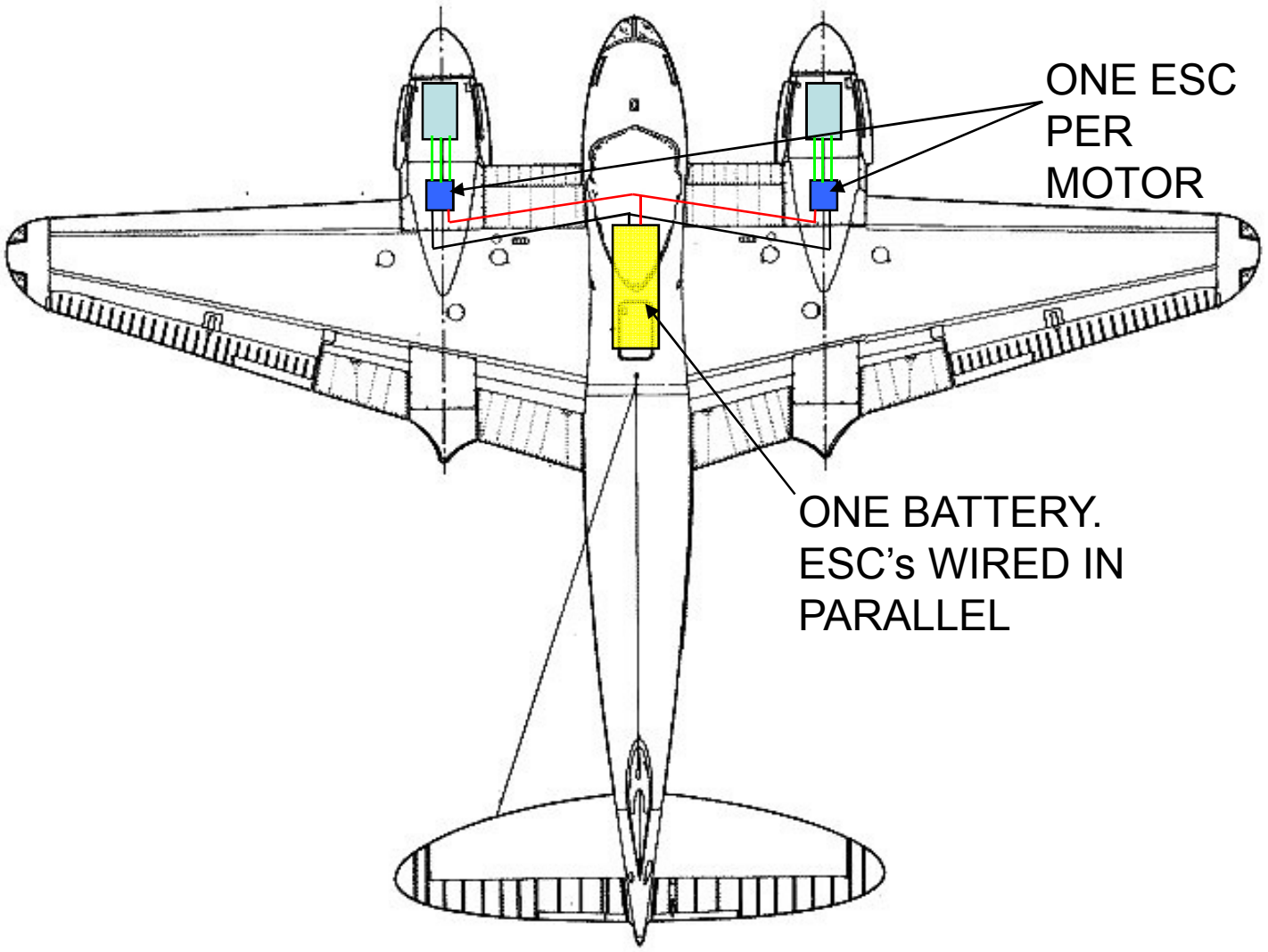
Brushless motor systems must have one ESC per motor.

Model Size Matters

•Smaller models, those usually needing less than 300watt (150 per motor), the two motors can draw off of one battery of sufficient “c” rating.

• As models get larger, the power required to fly grows exponentially. Physical limitations and maybe even CG considerations will drive us to choose either completely separate electrical system for each motor, or a simple parallel system “buss bar” type approach to gang more than one battery into a single “tank” for all the motors to draw from.

Multi-motored models – *smaller models*



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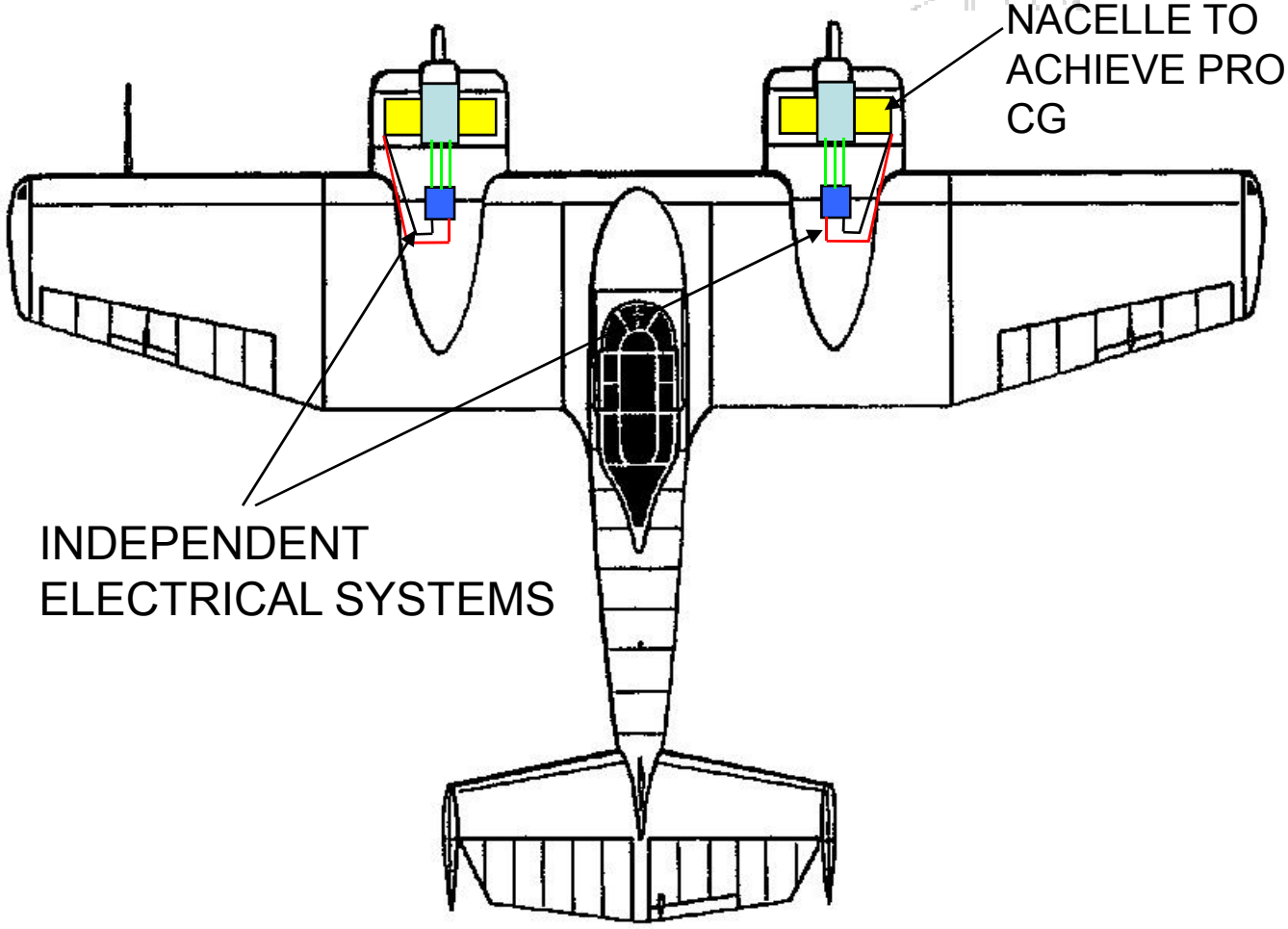
Multi-motored models – CG issues

SMALL OR LARGE MODEL WITH CG ISSUES



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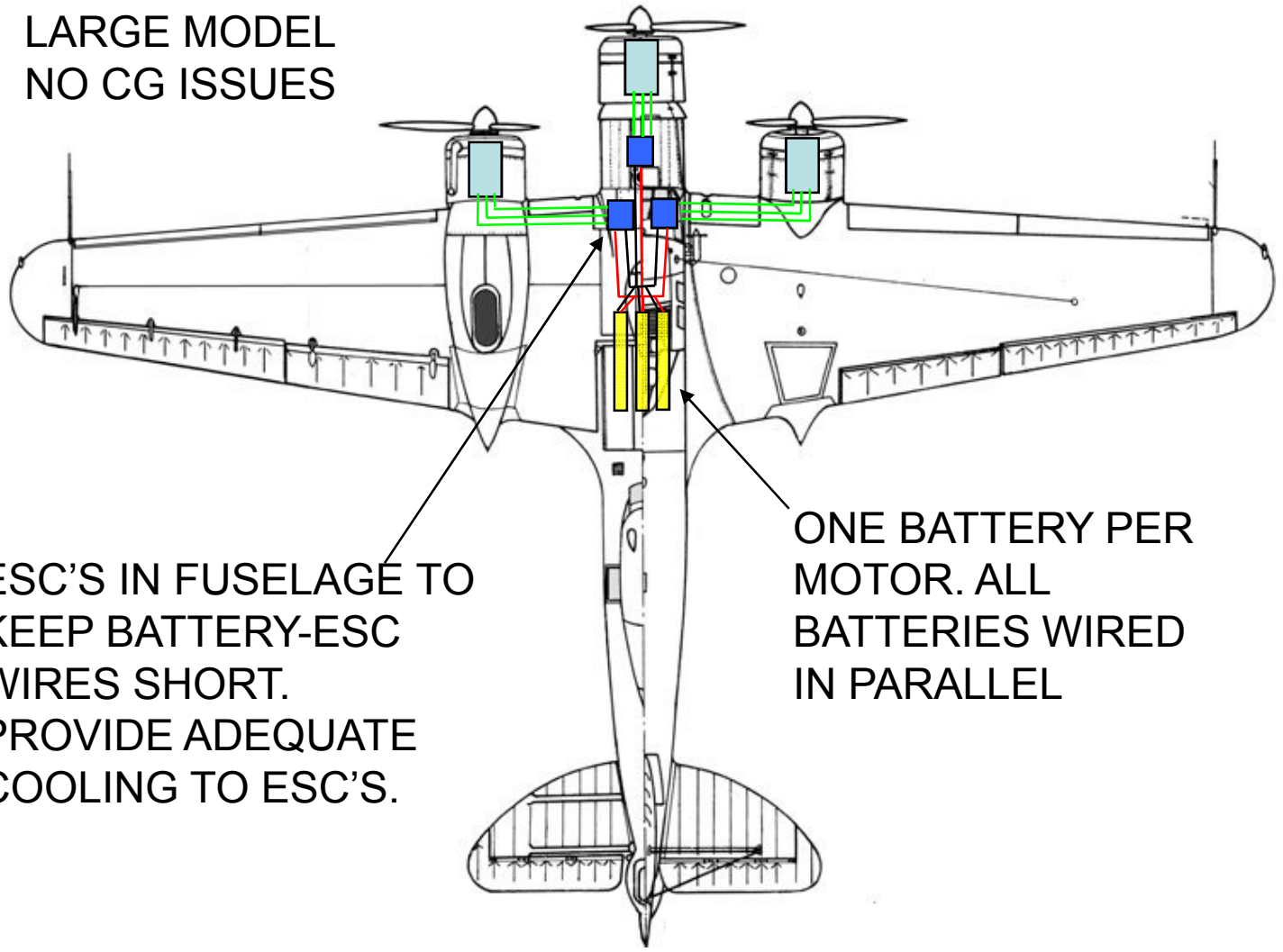
Multi-motored models – CG issues

LARGE MODEL
NO CG ISSUES



ESC'S IN FUSELAGE TO KEEP BATTERY-ESC WIRES SHORT. PROVIDE ADEQUATE COOLING TO ESC'S.

ONE BATTERY PER MOTOR. ALL BATTERIES WIRED IN PARALLEL

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Multi-bladed props

Why would I want to use one?

Hey it's a scale model…. If you can find one that "looks good" and performs well… it adds cool factor!

And besides… isn't the whole point to a scale model is to make it look as closely as possible to the "full scale" in the air AND on the ground?

If… and this is a big "IF"….. you chose a motor that was capable of swinging a BIG scale like multi-bladed prop, the performance of the model can still be "exceptional" as well as very scale-like with just some loss in top speed (over a 2 bladed prop).

One must enter the process of knowing that a multi-bladed prop is in the running BEFORE making a decision on a motor.

Multi-bladed props

What happens if you do not change the diameter between 2 blade and a 3 or 4 bladed prop?

Power consumption increases approximately 15-20% going between a 2 bladed prop and a 3 bladed prop with only a 10-12% increase in thrust, however, the speed of the model will drop by 5-8%!

Power consumption increases approximately 30% going between a 2 bladed prop and a 4 bladed prop with only a 20% increase in thrust, however, the speed of the model will drop by12-15%!

This may result in you letting the smoke out of your motor and or ESC!

Multi-bladed props

Simply changing between a 2 and 3 or more bladed prop without considering the power change may result in you letting the smoke out of your motor and/or ESC!

Going into a scale project knowing that you want to drive a multi-bladed prop will drive you to a much larger motor with a lower Kv (RPM/Volt constant).

Only you can decide whether this decision is within your $$$ or weight budget.

Typically the battery size will not change as the input power is going to be the same or only marginally higher.

Multi-bladed props – Mustang revisited

1/8th scale P-51

840 watts required.....

840 watts/40amps = 21V or 6 li-poly cells

4 bladed 16-17" prop required.

Is there an "off the shelf" one (COTS)? Not really.

APC makes only one; a 15.5 x 12 and the blade profile is not very scale like, but for the sake of comparison, let's use this one.

Original motor for a 14 x 10 2 blade = AXI 4130/16

To swing a 4 blade 15.5 x 12 for 840 watts will require the next bigger AXI : the 5320/28 or OK-C6354-A (Nitro planes) or even the Rimfire 63-62-250

These are significantly larger and heavier motors than the AXI 4130

But that is what it takes to swing big multi-bladed props!

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Multi-bladed props – Three bladers

There are a number of 3 blade props still available and many from Master Airscrew.

Though designed for "glow" applications they make fine scale looking props and perform well even at the lower RPMS we spin them on electric motors. They have many sizes and even some with reverse rotation!

A German company named "Varioprop" also has a number of multi-bladed systems for smaller diameters (up to 12" diameter). They have many style prop blade shapes and the pitch is ground-adjustable.

System Cooling

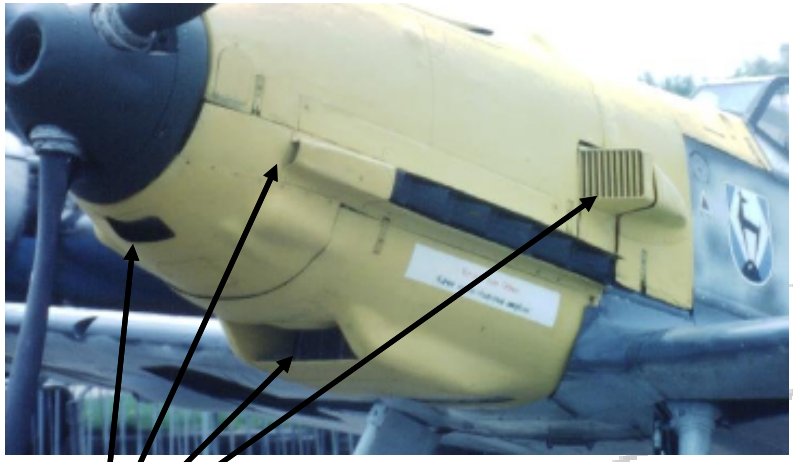
Electric motors need to be cooled just like a Recip.
In addition, the ESC and batteries must also be kept from getting too hot.

Contrary to popular belief, you do not need a hurricane running through the inside of your model to keep the equipment cool. You just need to let enough air in to "exchange" the volume once every minute or so.

Whenever possible, take advantage of "scale" scoops/vents in your subject model to get air in and out of the model.

Most radial engine aircraft don't pose a problem, but sleek in-line engine aircraft like a spitfire need some help.

System Cooling



Use all of these if possible

Bf-109e has lots of great scale "holes" to get air in

If possible, let air vent out around or thru the scale exhaust

The clean lines of the spitfire don't offer many "innies"

Use the carb scoop to get Air into the battery compartment

System Cooling

Providing areas to let the air in is not enough, it needs to get out too!

Use a non-retracting tail wheel well to let air out, or leave the doors off the retracting tail wheel.

The bf-109 had a non-retracting tail wheel, but a "well" and open bay like it should have. Use it to let air out!

Open cockpit airplanes of WW1 and the golden age make great places to let cooling air exit.

Even a sliding side window in a greenhouse canopy makes a great place for cooling air to escape.

Note: I even placed the ESC near the open window in my 95" KMP BF-110!

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Weight Control

All scale models (regardless of the power system) suffer from weight creep due to "scale detailing".

The one advantage an electric model has over its glow or gas powered brethren is the lack of vibration. Scale details can be made of very light weight materials and secured with; double back tape, very little glue, Velcro, or even magnets (if they need to be removed for service).

Electric models do not need to be "fuel proofed". Water based paints and glues (which are typically lighter than mineral spirit types) can be used. "Glassing" a model for strength and/or finish can be done with water-based polyurethanes instead of smelly, messy polyester or epoxy resins.

CG Control

If at all possible, try to not let the "battery" determine the CG. i.e., the model should balance with the battery not installed. This affords the modeler the ability to change the capacity or configuration of the pack without effecting the CG. This then implies that the battery must reside at the CG of the model.

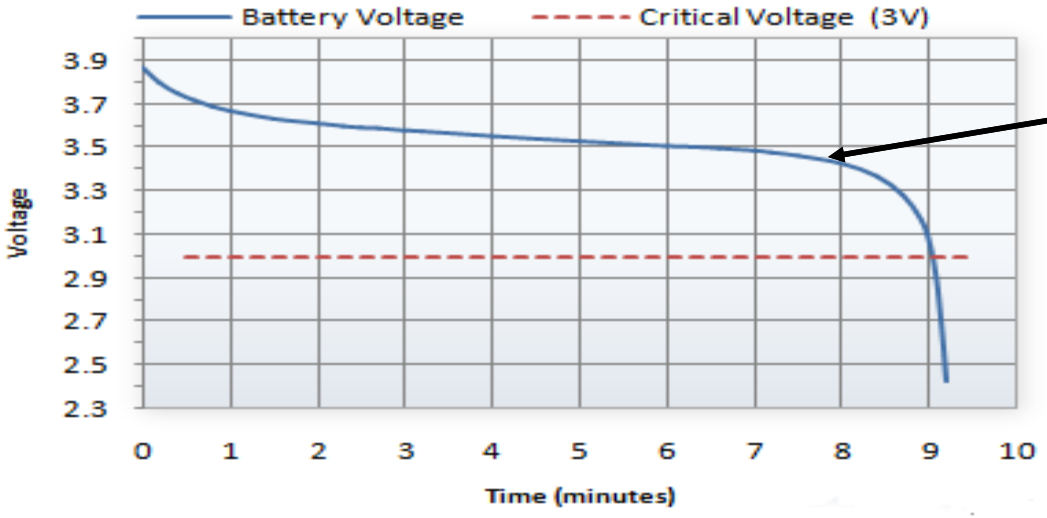
If the battery must be located in the model to create the correct CG without adding copious amounts of lead, or it would interfere with other "scale" details of the model, care must be taken to distribute the load into the fuselage (or nacelle). I have seen all too many times a battery pack come falling out the bottom of a model on a hard landing due to insufficient structure around the battery support.

Flying

Though the flying of a scale model has nothing to do with the type of power system, one must remember that one is flying a continually degrading power curve.

You will NOT have the same power near the end of the flight that you will have in the beginning.

It is important to know where the "knee" of the battery pack is and land well short of that time.



Land before here!

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THE END

FLY CLEAN!

FLY QUIET!

FLY AND CHARGE SAFELY!

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