Electric C/L Stunt – lessons learned

April 02, 2017

Two years ago I knew almost nothing about electric C/L stunt.

Today, I understand the complexities of it much better and decided to share this what I have learned with you.

I believe that electric power is the future of control line. It is clean, the noise level in flight is substantially lower than for the glow engines and there is no problem with painting/covering on the model. You can use any paint or covering and any structural material without worrying about effects of the glow engines fuel.

Lastly, you will not mess up your car while transporting the plane dripping burned oil.

Electric C/L systems are, however, a bit difficult to understand if you do not spend some time trying to really understand them.

This understanding comes from learning, slowly and carefully, from your own mistakes and from talking to the people that know more than you. For me, such "talk" has primarily the form of exchanging e-mails and participating in various forums on the web. Stunhanger.com is not bad but you must know how to distinguish between really useful information and the "white noise" that is sometimes created by excited 65+ retirees who want to prove that they were right, forgetting in the process that human communication is a bi-way street.

Let's start from the most important component of the system – LiPo batteries.

I abused and subsequently destroyed four of my batteries because I simply did not know how to use them properly. I mean, I thought I knew but my knowledge was fragmented and incomplete.

The basic principle here is: **never discharge your LiPo more than 80% of its nominal capacity.**

Simply put: if you have 3S, 2200 mAh 30C LiPo you should not draw more than 1760 mAh from it.

This 1760 mAh can be drawn in two ways:

1. During static tests
2. During flights

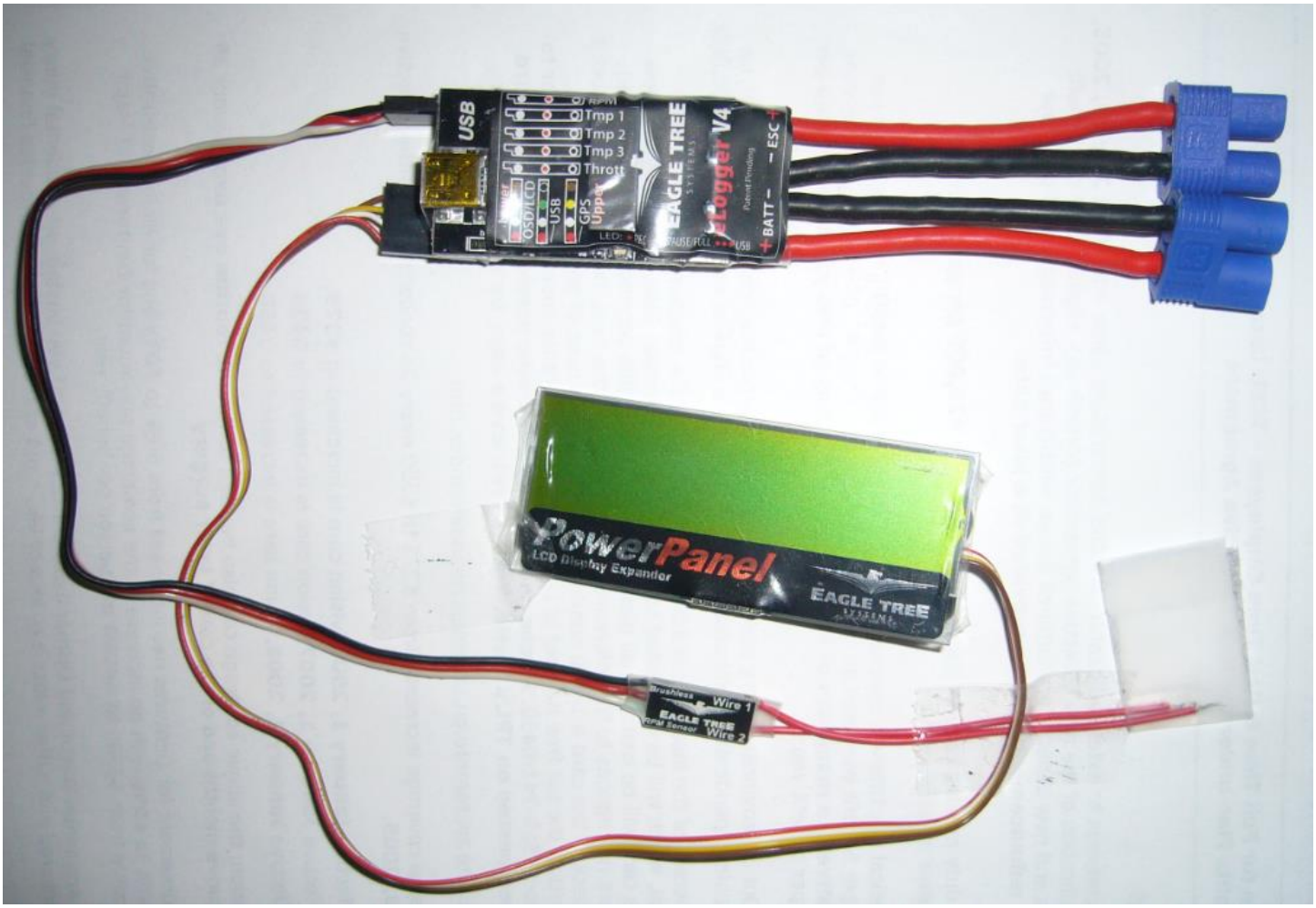
Last year, after many tests, I have formulated the "¾ Rule".

The rule says: "the average current drawn in flight by certain electric system is about 75% of the current drawn during the static test of the same system". The ¾ Rule was published on the Stunthanger.com forum.

The ¾ Rule allows to estimate the time of flight knowing the following:

a. Motor static current with certain propeller at certain RPM
b. LiPo battery capacity

To record the static current of the motor, I use the EagleTree eLogger (http://www.eagletreesystems.com). ELogger with the Power Panel (allowing to interactively monitor the parameters) and the RPM sensor is shown on the next page

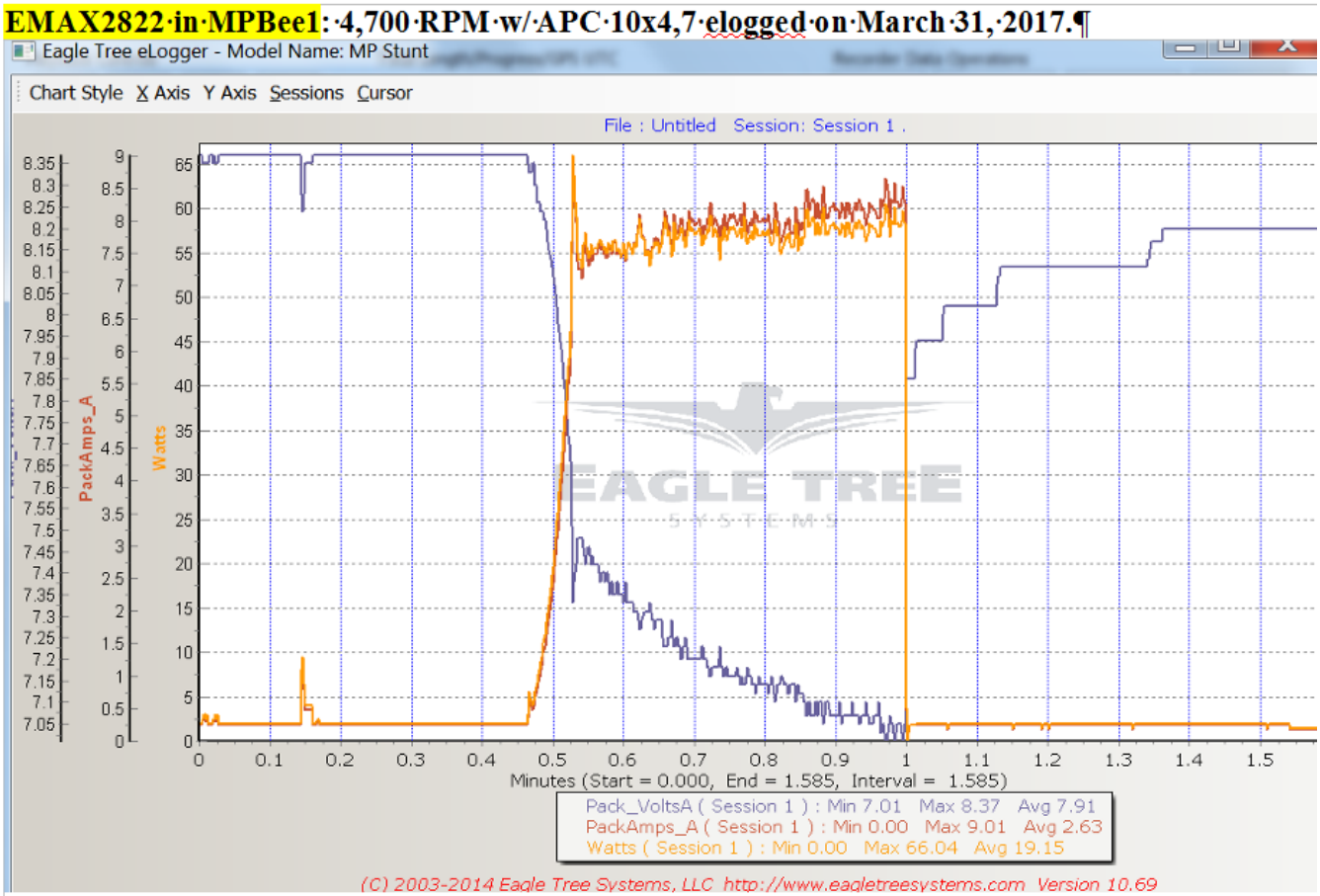


The example of the eLogger recorded data is shown on the next page.

ELogger can of course record the in-flight parameters and I will do it ASAP.

The ¾ Rule has been confirmed experimentally during almost hundred indoor flights this winter.

EMAX2822·in·MPBee1:·4,700·RPM·w/·APC·10x4,7·elogged·on·March·31,·2017.¶



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Amps·average:8.25,·Watts·average:·58¶

The battery used during this static test: 2S 800 mAh 30C.

This static run lasted about 30 seconds and the Emax2822 motor with APC 10x4.7 propeller used 88 mAh. **The limit of safe battery drain is 80% of the battery capacity => 800 x 0.8 = 640 mAh.**

640 mAh./88 mAh=7.27, 7.27 x 30 seconds=218.2 seconds=3.63 minutes of static run before the battery loses 80% of its stored capacity.

Applying the "¾ Rule": 3.63 minutes/0.75=4.85 minutes of flight.

The "¾ Rule" is very conservative - I was regularly getting five minutes of indoor pattern flying and then charging the 2S 800 mAh. batteries between 490 and 550 mAh.

The KR governors I am using need programming of four parameters (RPM, Start Delay, Gain and Time of Flight) while the motor is running. It is better to do this programming one by one running the motor statically no longer than for two minutes, then replace the battery, program the next parameter and so on.

During one of my early tests of Little Great White, I run the motor for four minutes statically and carelessly drained the 3S 2200 mAh, 30C battery to zero mAh.

It was possible to charge this battery but I could do it only five times. The battery's internal resistance (IR) was going up with each charge, the heat was building up and the battery finally seriously swelled.

I had to drop it into salty water to discharge and disposed it to avoid possible battery fire.

The word of caution: be careful while charging, using and storing batteries. Remember that **If they are not abused they will not abuse you or your property**. Always store them in the safe place and charge using only good quality, programmable charger. DO NOT OVER-DISCHARGE!

DISPOSE A BATTERY IMMEDIATELY WHEN IT IS SWELLING AND IS GETTING HOT WHILE BEING USED OR CHARGED.

Like I wrote above: drop such battery into salty water, it will discharge in 4-8 hours due to shorting and then you can put it in your garbage or recycling bin as it is chemically inactive.

I store my batteries in the fireplace, each in a protective bag. The no load storage voltage must be 3.8V.

When I carry them in the car, they travel in the ammo boxes. These are precautions of the higher order as **they will not explode or/and start burning if they were not abused**.

Do not believe all the horror stories you can read and watch on the web. They were published for the same reason as the "aliens are coming tomorrow-are you not horrified?" warning.

Abusing means:

1. Discharging below 80% capacity and below 3 Volts no load voltage
2. Exposing the LiPo to shock load (crash) in which the battery's cells were punctured
3. Purposely hitting the battery pack with a heavy and/or sharp object (!!)
4. Heating the Battery in the microwave oven (!!).

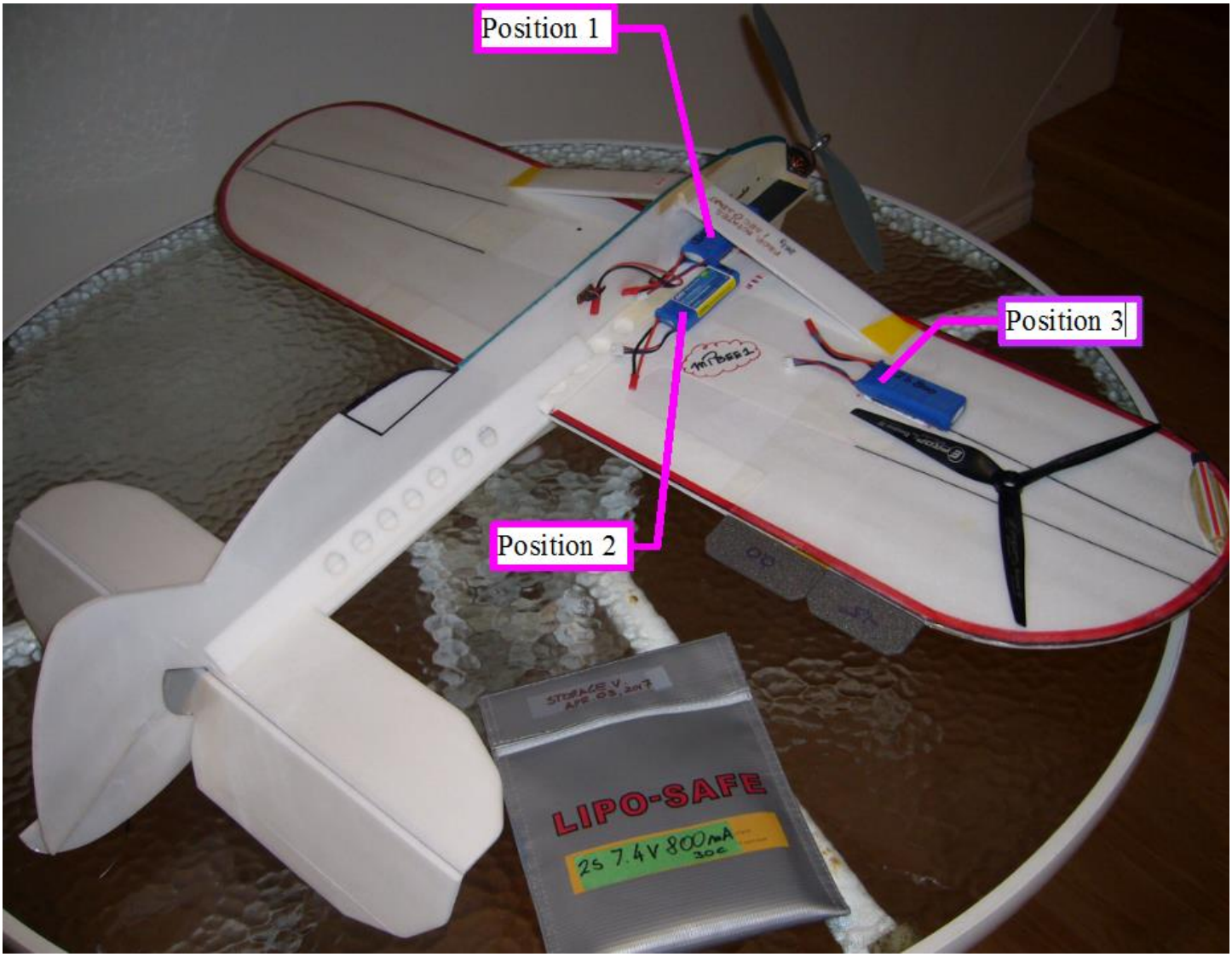
#3. and #4. will most likely qualify you for the Darwinian selection.

The photo below shows my Bee1 and the LiPo 2S 800 mAh in three positions.

Position 1 gave the RTF Bee1 CG location as recommended for beginners. The model was nose heavy but, at the same time, very stable.

I moved the battery to position 2 after I learned to fly triangles and square figures to achieve sharper corners.

Finally, I moved the battery to position 3 when I removed the 12 grams outside wing weight previously placed in the plastic tube glued to the outside wing tip (visible below) and wanted to fly better vertical eights.



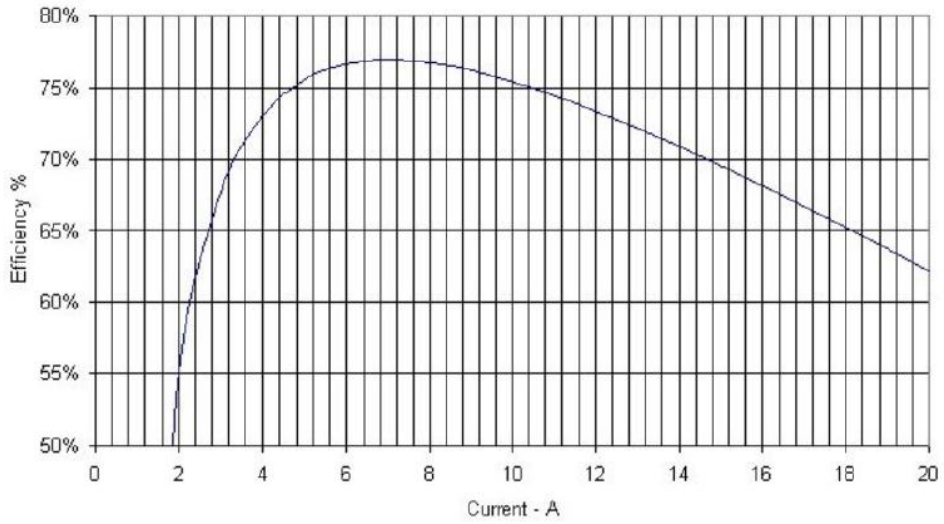
The 3 blade propeller resting on the outside wing is Graupner 9x5x3. I was considering this propeller for one of my future indoor planes.

Propeller selection for the indoor C/L stunt.

The main reason I do the things the way I do is curiosity and I became curious **why** almost all the people flying the indoor stunt in Europe use APC 10x4.7 two blade slow flight propeller.

The obvious answer to **why** is "because Igor Burger and many top indoor flyers use it in indoor Bees". This is true but I still wanted to know why. The next obvious answer " because these models are light, fly slowly and this is the propeller everybody uses..." is not satisfying either. The fact that everybody does something the same way does not explain the real reason – it only confirms that when we do not know we tend to emulate the choice of other people.

The main reason these propellers are so good for indoor electric C/L stunt is the shape of the blade and the distance of the largest blade cross-section from the axis of rotation. This propeller is very effective in the range of RPM it is usually used an loads the motors in the optimum way.



The graph above is for EMAX2822 used in my indoor planes. I shows the max. 77% efficiency when the current is about 7 Amps. EMAX2822 in my Bee1 and Wasp draw 8.2-8.4 Amps. statically and about 6 Amps average in air (¾ Rule). At 6 Amps the efficiency of EMAX2822 is 76% - not bad.

I have compared the static thrust of APC 10x4.7 and Graupner 9x5x3 propellers (next page) using 2S 800 mAh 30C battery with the RPM set via KR governor (KRG) to 4,700.

I was considering Graupner 9x5x3 as the replacement for APC 10x4.7 because I wanted to limit the gyroscopic moment acting on propeller. The weights of these propellers are 13 grams and 12 grams respectively but the rotational inertia of the propellers matters more and Graupner has about 20% less of it.

For those who are interested, the exact process of calculating the rotational inertia of any shape is described in http://www.paultitchener.com/dynamics-trifilar-pendulum.html.

The static thrust (ST) is one of the indicators of propellers efficiency. I have found that the ST of Graupner 9x5x3 is 60% smaller (!) than APC 10x4.7 at the same RPM (4,700) and this killed the idea. The numbers are: **155 grams** for Graupner and **390 grams** for APC, when EMAX2822 is used with 2S 800mAh 30C battery.

Graupner 9x5x3 shows much better ST and efficiency at 10,000 RM when powered by Cobra 2814/12 and 3S battery. Perhaps I will use it in my LGW II?

I will build the two motor electric stunt indoor/outdoor plane with build-up wing (12-14% airfoil) and another Bee for the next indoor season of the MP Stunt Academy. Two motor electric stunter building log will be published on Stunthanger.com as many people expressed interest in design and construction details.

Summary:

1. Build light but **not too light** to avoid twisting wings or/and fuselage
2. Respect and watch your **batteries** – number them and **keep log of charging**
3. Use only **well tested system**
4. **Inspect the motor and battery mount, electrical connectors, control system, lines and main structural connections <u>before</u> flights**
5. **Stay in one place otherwise you will hit the walls or/and overhead obstacles** – I used a rubber mat and tried to stand only on it
6. Practice "**C/L Stunt Tai Chi**" before first flight
7. Drafts are always present in large spaces like gyms – **fly your pattern down the draft**
8. If you fly level, you will get vertigo faster than flying outdoor. **Six laps of inverted flight is a challenge**

5, 7 and 8 are characteristic for the Indoor C/L Stunt.