E-20 Static Thrust Study for Various Propeller / Battery Combinations

Ates Gurcan – Oakland Cloud Dusters – 2015, 2019

Introduction

This document summarizes the results of my experiments to study the performance of various battery propeller combinations under static conditions. Throughout the experiments I have used a E-200 timer and a Parkzone PKZ3616 motor, which I set up for a 20 seconds motor run.

Due to the relatively large variations in the data towards the end of the motor run (which in turn is due to the design of the timer), I have considered only the first 15 seconds of motor run where a more reliable comparison could be made.

My main goal was to find the amount of energy output useful for propulsion within the given time window (e.g. 15s), for various propeller and battery combinations. To this end, I generated static thrust versus time plots as well as a single number which is similar to the "total impulse" parameter that's used in rocketry, which is basically the integral of the static thrust curve over time.

Batteries and Propellers Tested

I have tested four batteries and four propellers. These are shown in the picture below.

Figure 1 - Batteries and Propeller Tested

Experimental Setup

I have put together a 11" long lever, with a pivot point in the center. The motor is mounted at one end of the lever arm. The end of the other arm rests on a digital scale and is preloaded by a counterweight. The motor wires were not found to affect the measurements as they are considered in the tare and do not change position during the experiment.

I have videotaped the motor runs and collected the read-outs from the digital scale by going over the video recordings in a video editing software.

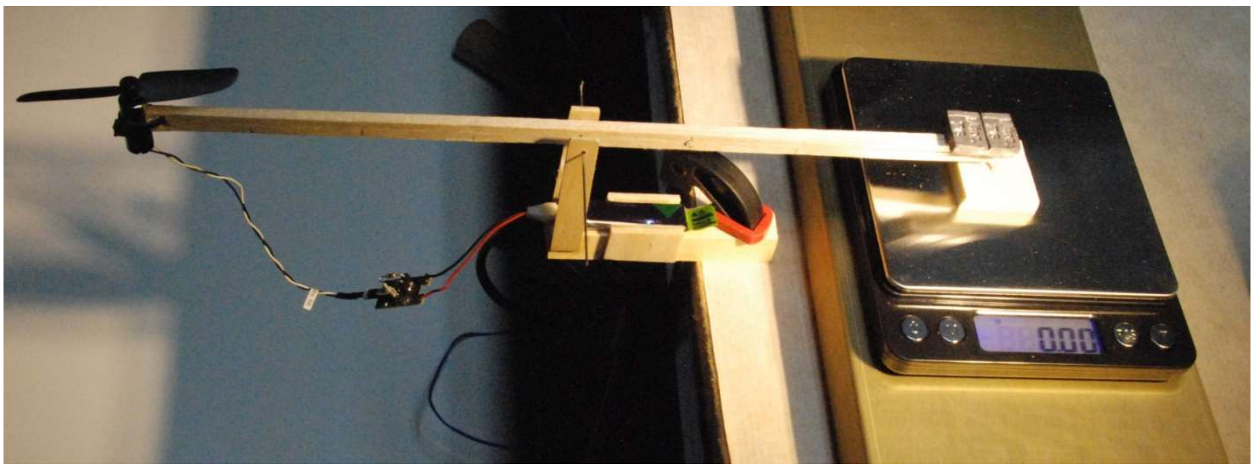

Figure 2 - Test Setup

Throughout the tests, I have used the same E-flite USB charger to top off the batteries before each measurement (except for the multiple consecutive runs). A video recording summary of the tests can be found at https://youtu.be/PcFPVVtWI98.

Figure 3 - Charger Used in Test

Battery Comparison

The experiments revealed that the type of battery used is not very critical provided that it fulfills the basic requirements of peak current delivery. The current draw of the setup was found to be around <2A under static conditions, or around 13C for a 150mAh battery. All the batteries I've tested were capable of operating at 25C or higher discharge rate. Furthermore, in flight, the current draw is expected to be lower due to the unloading of the propeller.

Although the E-flite battery with the 45C discharge rate showed consistently higher thrust output than the other three batteries which have 25C discharge rate, the difference was limited to a few percentage points. This observation held true for all the propellers tested. Below is the static thrust versus time plots given for the Plantraco propeller.

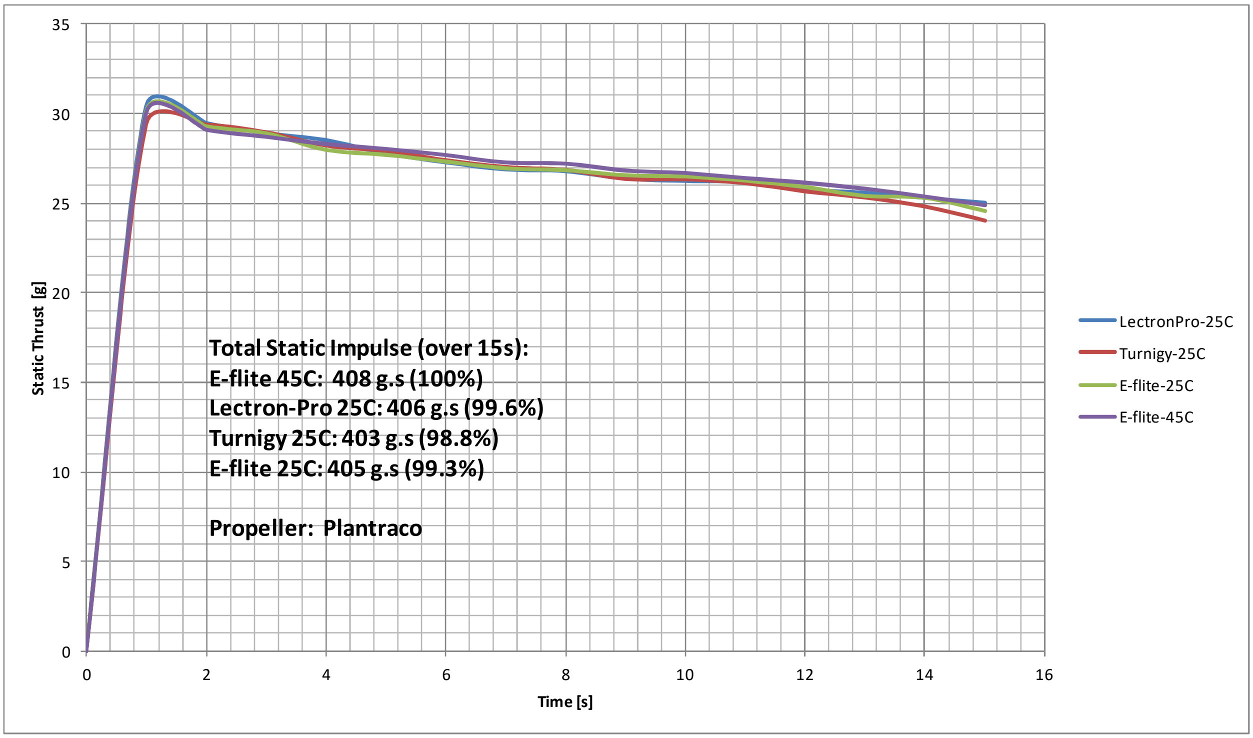

Figure 4 - Static Thrust versus Time for Different Batteries

Propeller Comparison

The most significant finding of these experiments was that the choice of propeller made a significant difference in the static thrust output of the system. The best propellers for the setup under static thrust conditions were found to be the white propeller of unknown origin and the GWS 2510, with the GWS unit having an advantage over the other as it had significantly lower current draw (1.6A vs 2.0A) while generating almost the same amount of static thrust - thus is a more efficient setup.

The Plantraco propeller generated considerably lower static thrust (-18%) than the best propellers, while drawing a current similar to the white propeller (2.0A). An interesting observation was that the Plantraco propeller caused the motor to heat up considerably more than the other propellers. At this point, I'm not sure how static thrust measurements would map onto dynamic measurements (e.g. in flight). To make a conclusive assessment of the performance of the propellers, a similar study needs to be done under dynamic conditions.

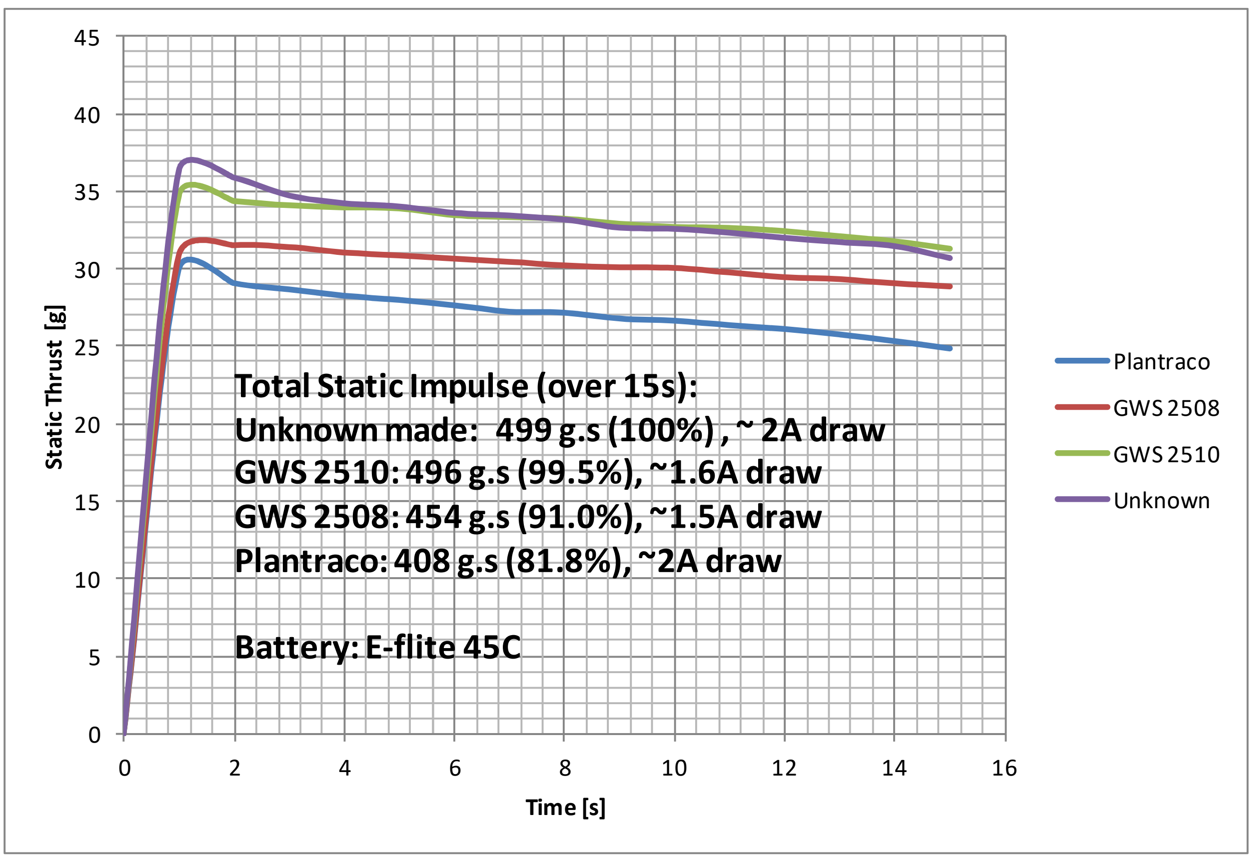

Figure 5 - Static Thrust versus Time for Different Propellers

Multiple Runs with One Charge

I also looked at the performance decrease caused by running the motor with the same battery, without recharging it between subsequent runs. Roughly speaking, each 20s motor run is expected to use about 8% of the battery capacity. The impact of this on the thrust output of the system is given in the plot below, taken with an E-flite 45C battery and the white propeller of unknown origin, in 5 consecutive motor runs with 3 min rest between runs, and no recharge.

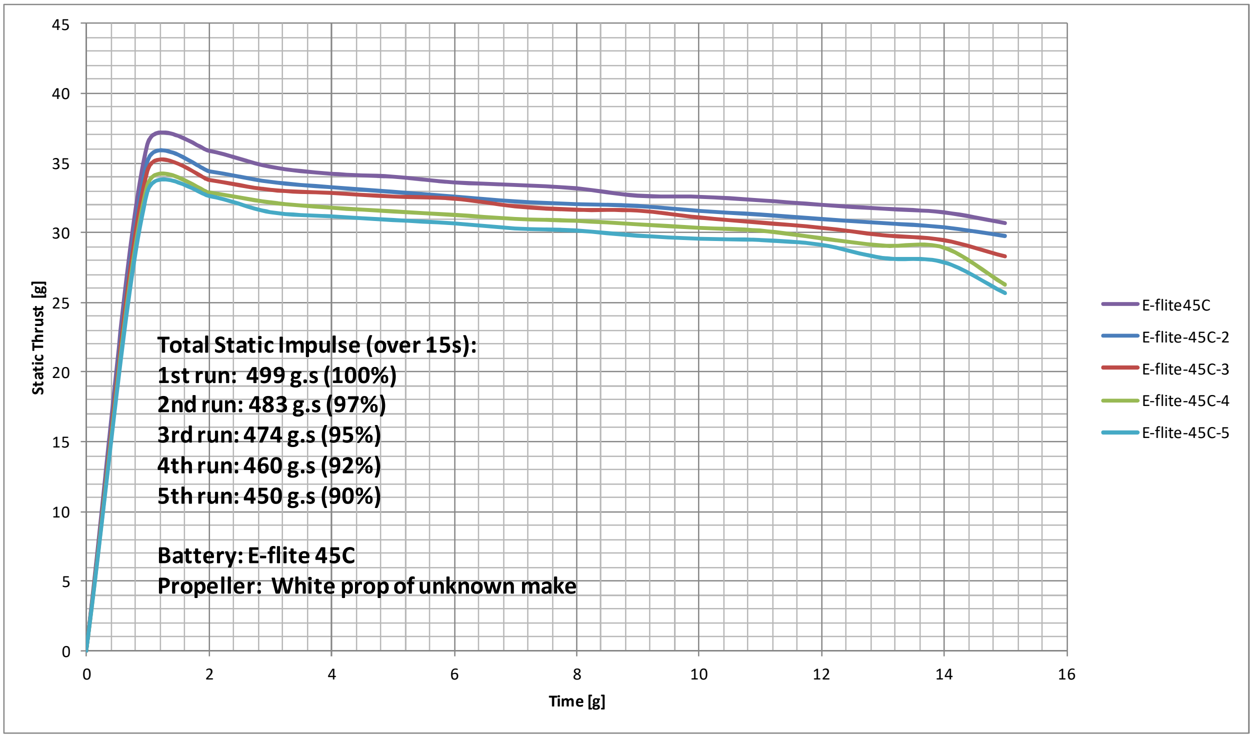

Figure 6 - Static Thrust versus Time in Multiple Consecutive Runs

RPMs

The RPM measurements were taken 1s after the start of the motor run.

- Plantraco propeller 16.4k RPM
- White propeller of unknown make 22.3k RPM
- GWS 2508 29.7k RPM
- GWS 2510 28.8k RPM

Feel free to contact me at ates@gurcan.us with any comments, corrections, questions, suggestions.

Gentle breezes to all,

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