F2D News - May 2012

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For those of you who have been following along, you may recall that last fall I had a chance to go fly with Lothar and the Germans in the suburbs of Munich while over in Europe for work. During that flying session, I got to see (and try for myself) the setups they've been developing for a new class of electric F2D combat. In their country, there are very severe noise restrictions which have nearly wiped out all viable flying sites for internal combustion engine powered models. Developing something more neighbor-friendly is very important to them, for the survival of hobby.

The models that I saw performed better than I had imagined beforehand, though still not at a level comparable to a modern competitive F2D ship. Greg Wornell and I had been toying with the idea of making an electric combat plane for some time, and the results I saw in Germany were encouraging enough to motivate me to seriously start working on the project. It's interesting both because it's something new, offering a fresh platform for trying out all kinds of different ideas, and because having a quiet version of a high-performance model that could be flown in local parks/athletic fields would open up a whole new world of opportunities for more regular and frequent training.

As soon as I got back to the US just before Christmas, Alex Prokofiev and I started brainstorming, and produced a temporary plywood mount that could adapt an electric motor (which he had lying around) to a normal F2D model. I cut a slot in the bladder tube, popped in a LiPo (lithium-ion polymer) battery pack, and carved a trench in the wing for an electronic speed controller (ESC) and a 2.4 GHz spread-spectrum receiver (so that we could control the throttle by radio). After about 45 minutes of work (and another 20 for the CNC router to cut out the mount), the electric plane was ready to fly. The random assortment of components (motor, ESC, prop) that we found around the house were way off spec for what we would need for a combat model, but it was enough to get us in the air and launch the project into phase 2.

With that initial success under our belts, Greg and I started working on pinning down the kinds of specs we'd need to make a competitive model. In diving into electrics there are a lot of new parameters to think about. As combat fliers, the natural place to start is of course with horsepower. In an electric motor, power comes from the product of voltage (V) and current (I), $P = I \times V$. If you use voltage in volts and current in amps in this formula, you will get power in watts. One horsepower is equal to 746 watts (that's a lot of light bulbs!). If we decide that in order to match a Fora we're going to need nearly a horsepower's worth of watts, then our formula says that we can achieve this in a few ways: we can use a battery with a low voltage but pump out a ton of amps, or we can use a battery with a high voltage, and get away with fewer amps. The thing about current, as anyone who has ever cut out foam wing cores before knows, is that when you start pumping lots of amps through a wire, it heats up. Heat doesn't come for free, either. That heat is energy that you could have been using to spin the prop and make the airplane go around the circle. Our goal is to avoid heating as much as possible.

Taking into account this discussion, it seems that going for a higher voltage, lower current setup might be more efficient. When I met the guys in Germany, they were running "3S" LiPo battery packs, which means they consisted of 3 cells wired in series. When batteries are wired in series, their voltages just add up. For standard 3.7 V LiPo cells, this means that they were running on 11.1 V. To reach that target of just under a horsepower, they would therefore need to push something like (700 W/11.1 V) = 63 A of current. That's a lot, and they told me that they were even hitting up into the high 70s. With the hope of improving the efficiency of the system (by avoiding some of that nasty heating), and taking some advice from Pete Young, whom Greg and I met at MIT, we decided to up the voltage and go with 4 cell (14.8 V) batteries.

So far we're just playing with numbers, but we haven't said anything about the motor itself, which will eventually have to convert all of that electrical energy into some bone-crushing, streamer cutting, loop flying power. It turns out that electric motors come in all kinds of shapes, sizes, and specs. Two key parameters that we focused on were power rating (essentially how many hp the motor can generate from a battery without melting/flying apart) and "KV" which determines how many RPM you get for each volt that you supply it. There's a trade-off between torque and RPM, which in principle means that we could aim to swing a small prop at high RPM or a big prop at low RPM, and achieve similar speeds. Which one is better? It's hard to say. From a noise standpoint, a bigger prop at lower RPM will certainly be an improvement on the shrieking sounds of today's F2D engines (which I do enjoy, responsibly with earplugs, but which neighbors and cops not surnamed Stas usually don't). How about speed through the turns and ability to tow a streamer? My guesses would also be that big props would help there too, though for some reason the RC electric pylon guys are spinning super tiny props at 48000 RPM, and it seems to work well for them.

The good news is that electric motors are dirt cheap (15-20 bucks cheap), so we found a spread of motors which should operate between 13000 and 30000 RPM (with similar power ratings) to experiment with. The bolt hole patterns for mounting them are only sort of standardized, so I ended up making two different mounts for the three motors that I picked up. After considering a few possible approaches, the one that I settled on is that shown in the pictures. I took a set of aluminum F2D engine mounts and sawed them off just ahead of where they stick out past the front of the leading edge (nearly flush). Then, coming in from the front on each mount, I drilled and tapped a pair of holes (one on each mount) that I could use for attaching a flat carbon plate. This plate provides a strong, flat surface for mounting the motor. It's essentially just making a radial-style mount that adapts to a conventional model via the beam-type mount bearers. The good thing about having the front plate bolt on, rather than machining the whole thing from one solid piece of aluminum, is that variations in block thickness from model to model can be compensated for with a little "wiggle room" in the holes, whereas a solid mount would be held under stress on any model with a slightly over- or under-sized block.

As far as speed controllers are concerned, there are tons out there on the market. To be honest, apart from the maximum current rating, I don't know what distinguishes one from another. They all seem to have a pretty identical set of features. Expecting that we would need to pull about 45 amps, I went with the Phoenix-45 from Castle Creations. So far it's working well, but for the future it might be nice to have a little more headroom.

Now for the results. I've put a couple of videos up on YouTube showing how it looked with the two motors that we tried so far:

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http://www.youtube.com/watch?v=w99qXqiTf-Y
http://www.youtube.com/watch?v=XY6AAVvxzDs
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The first was the 1450 KV Turnigy XP 3536 motor from Hobby King (see picture) with a 7.5" x 6.5" prop (an old fast combat prop). We clocked it at 24.6 seconds/10 laps (91 mph). The second was the NTM Prop Drive 28-36 motor, also from Hobby King, with a 6" x 4" Taipan prop. It was turning about 27800 RPM, and put in a very similar time of 24.7 s/10 laps. My aim is to get below 24.0 s, which will be quite respectable. Already, both setups are in the range where they are quite fun to fly. The speed through the turns feels good. The higher RPM setup is not-so-neighbor friendly on noise, but the 1450 KV motor sounded about like a vacuum cleaner. We could definitely get away with flying that one at many fields where our normal engines would get us kicked out.

The bad news is that I suffered some battery problems. On the next weekend, performance was heavily degraded. It turns out that you're not supposed to run these LiPo batteries all the way down (should always leave at least 20% charge left). Unknowingly, I violated this rule on those early flights. We also had a problem with the batteries heating up while buried inside the plastic bladder tubes. Currently I'm working on making a small air duct through the leading edge that will direct some additional cooling air onto the batteries to keep them from overheating. It's a little bump in the road, but I'm sure we can overcome it and keep progressing towards our target.

For now I'll leave it at that. Hopefully the pictures will tell the rest of the story. The summer's approaching, so it's about time for everyone to start getting tuned up for the NATS. Hope we get another good turnout this year!