Supercapacitor Electric Power for FAC Models

Supercapacitor power systems are the most practical form of power systems for the FF airplanes we fly after rubber motors. Supercapacitors are about as light as any form of electrical storage, are very robust and easy to handle, and are even reasonably inexpensive.

I've been playing around with supercapacitor powered FF airplanes and I'm having a lot of fun. These power systems do a pretty good job of emulating the power delivery of a rubber motor. Like rubber motors, they have a power burst, followed by a longer period of cruise, and then a very long descent. The length of time that the prop keeps turning is what makes these systems different than rubber motors- often the prop will keep turning for a minute or so. Doesn't mean that the airplane will stay in the air though. What I'm finding is that supercapacitors have a lot of advantages over batteries: they're more robust, have easily variable power levels, are reasonably safe, have good power/weight ratios andalso eliminate the timer requirement of lithium polymer batteries.

I've gotten a "portly" Ranger 21 flying quite well using a supercap setup. Originally the airplane needed a 5" Guillow's prop and 2 loops of 1/8th to fly for about 25 seconds since the airplane weighed over 50 grams. Going to a supercapacitor- flight times increased to 45-50 seconds- and maybe a bit more. Last time at Pinkham Field, we had some decent walks for retrieval. Although a supercapacitor power system is slightly heavier than a rubber motor (well, not if you run more than 20% motors), since it can be mounted in the nose, there's little need for additional noseweight which can lighten the airplane up overall. For people that like to build robust airframes- these power systems will make life much easier.

There are some Youtube channels on supercapacitor powered FF, but it's probably just as well that I never bothered to look at them before playing around on my own as I think the folks doing the videos haven't really understood the capabilities of these power systems. Plus their charger is both a bit intimidating to construct and less effective than commercially available units.

There are several components to a supercapacitor power system:

1) Geared electric motor. I've used 6, 7, and 8 mm geared motors so far. I do NOT recommend direct drive setups for scale/sport airplanes- the run times are too short- the props are very inefficient. Yes, I know that the E-20 events use these setups, but they have a very different flight pattern.
2) Supercapacitors. Table 1 lists some of the dimensions of the supercapacitors I've purchased. You can use any size supercapacitor with any motor. What changes is duration. The systems I've used in my airplanes generally have enough energy to provide 30 seconds or more of climb and cruise. It's very similar to a rubber motor. It turns out that my supercapacitor choices are around 10-15% of total flying weight.
3) Switch/charging jack. I'm just using a 3/32" audio jack receptacle and a small 3 pole slide switch. Together these weigh a gram. I'm sure you can shave more weight if you want to do the digging for lighter components. They need to be able to take a couple of amps for an 8mm motor. For a 6 mm motor or smaller- less than an amp.
4) Charging system. I'm using a buck/boost power supply.https://www.ebay.com/itm/384396903233 I don't know much about these things, but boy, they work well and don't cost a lot of money. You will need a way to connect the power supply and come up with a charging cord. I'm just using 3/32" audio jacks with cords. You can also go old school and use a pair of AA lithium ion primary cells.

Figure 1 shows a direct drive system. Well, it's what I have wired up that's not in an airplane. This is a 7mm direct drive motor and a 15F supercap. Total weight is a smidge under 10 grams. I occasionally wind up soldering components as I'm installing them in the airplane so it's not so easy to take photos afterwards. But the photo shows the general layout- just change the direct drive motor for a geared motor.

I'm not good at wiring diagrams, but I think the photo is pretty explanatory. Supercaps do come with the negative terminal labeled. I find a multimeter invaluable to make sure I'm soldering to the right posts on the charging jack and that I keep the polarity straight. Unfortunately, there are no useable "plug and play" systems, so you need to be able to solder or find a good buddy who can help.

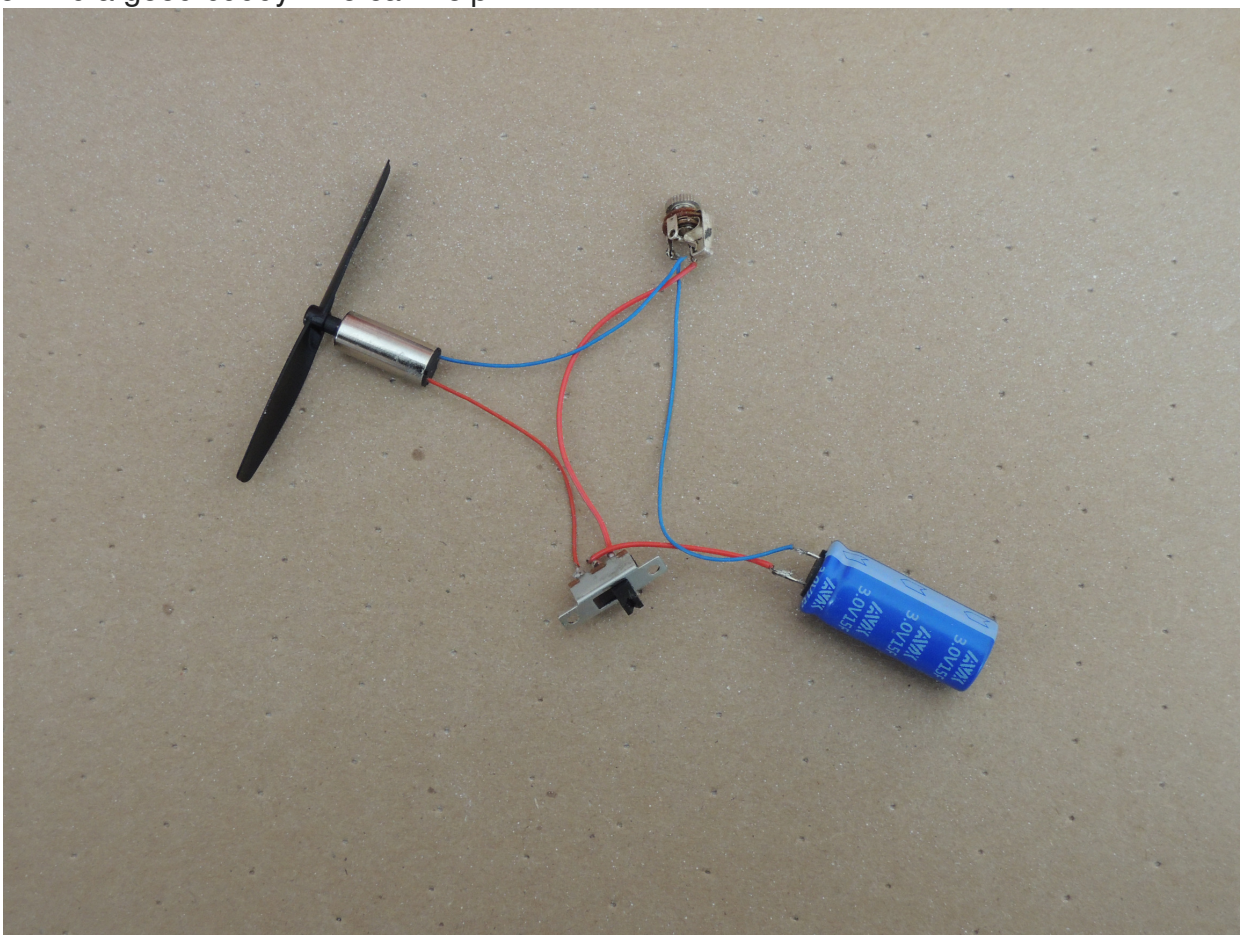


Figure 2 shows a few geared systems. Unfortunately, my only 6mm geared system is in an airplane, so I'm going to have to point you to a web page for that one. (https://micronwings.com/Products/Gearbox%206mm%20Ball%20Raced/index.shtml) I do have some 4mm systems- haven't figured them out yet. They're probably for p-nuts. From L to R- that's a geared (I think it's a 4.4:1 ratio but not sure) 8523 motor, 8520 motor in a Parkzone gearbox, a 7mm geared system (716 motor), and a 4mm geared motor in the baggie. The nomenclature on the motors: 8520 means 8,5 mm diameter, 20mm long, 716 motor is 7 mm in diameter, 16 mm long. The 8520 motor alone weighs about 6 grams. The Parkzone setup as pictured weighs 7.4 grams, the 7mm geared motor with prop weighs 5 grams. The problem is that the kV- that's the motor constant of how many rpm/V is not specified and is variable depending on the manufacturer. I'm not confident in the color coding of the wires either. The other joy is that shaft size can vary as well which is really annoying.

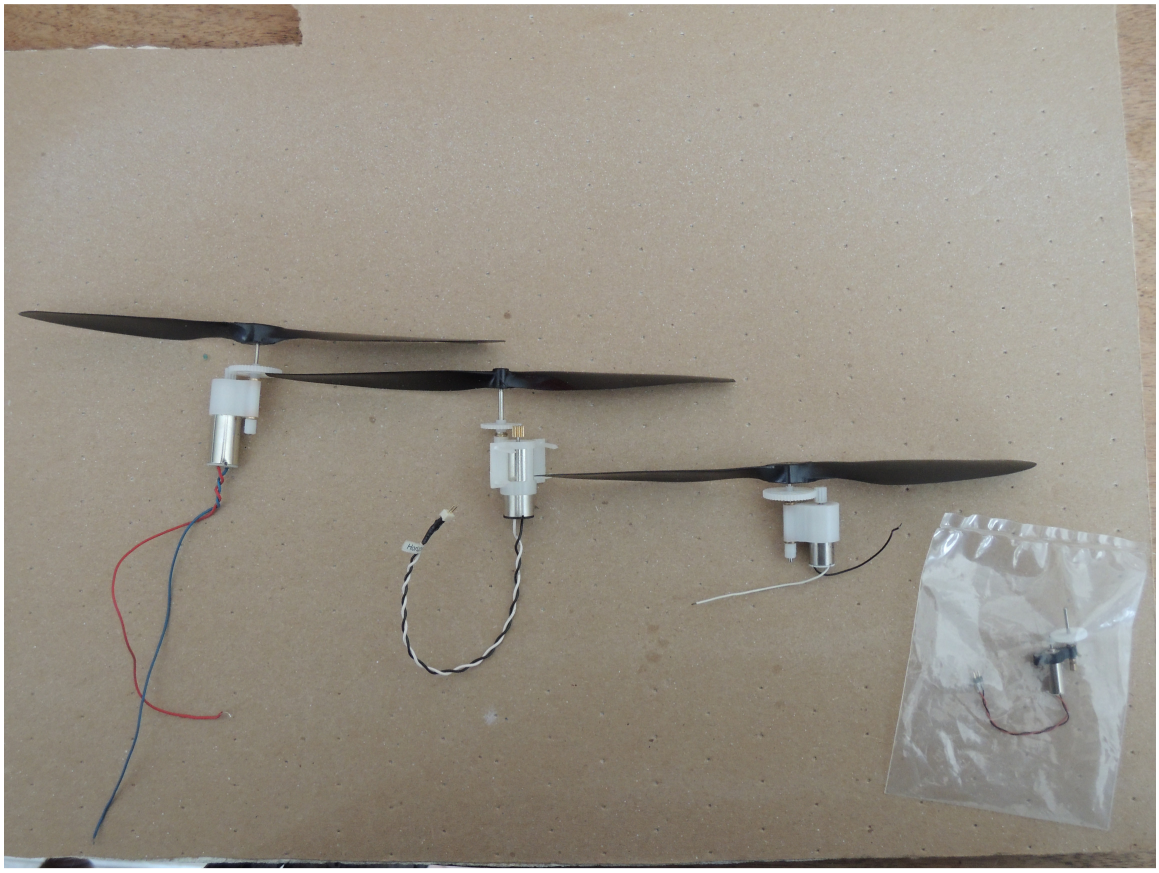
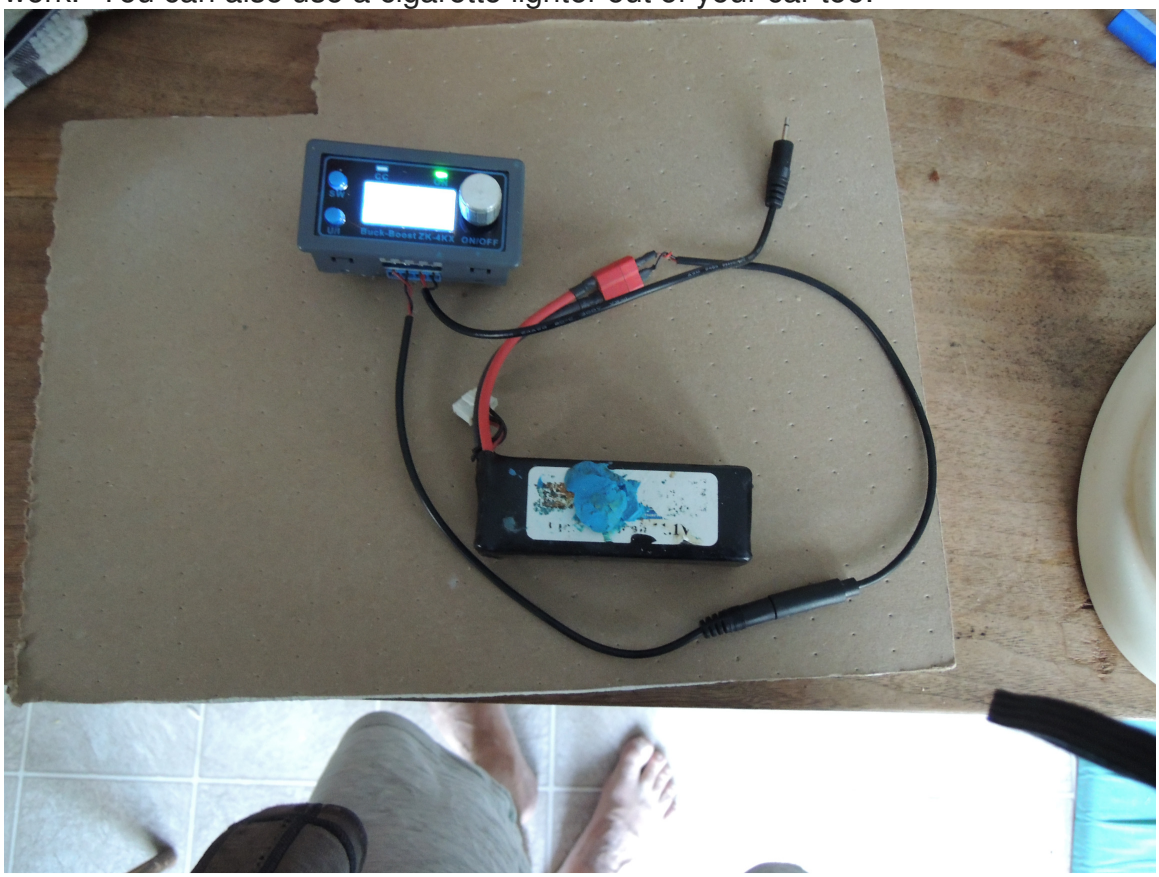


Figure 3 shows my charging setup. I'm using a tired 3 cell lithium polymer battery, but these units are very versatile and just about any power source of less than 25 volts direct current will work. You can also use a cigarette lighter out of your car too.



You can't see it in this shot, but the output voltage has been set to 3.22V. That's the voltage the unit will charge the supercapacitor to. It'll take a couple of minutes. The charging doesn't

stop once it reaches the set voltage though, the buck/boost unit ramps down the current but holds the voltage. Allowing this “trickle” charge to the capacitor easily increases run time by 1/3rd or so.No worries about overcharging- can’t happen unless you set the voltage or the charge current too high.

Figure 4 shows the unit charging. The supercap is at 1.41V. It’s put in 0.01A- typically this 15F supercap will take around 0.1A to be fully charged (3.22V) from zero. No issues about storage- you can leave the supercap at zero V or fully charged- won’t hurt it either way.

Figure 5: Here are some supercaps. L to R, 5F, 10F 2.7V, 10F 3.0V, 15F 3.0V, 25F 2.7V, and 35F 3.0V. I don’t really see much difference if the cap is rated at 2.7V or 3.0V. I suggest just buying 3.0V supercaps.

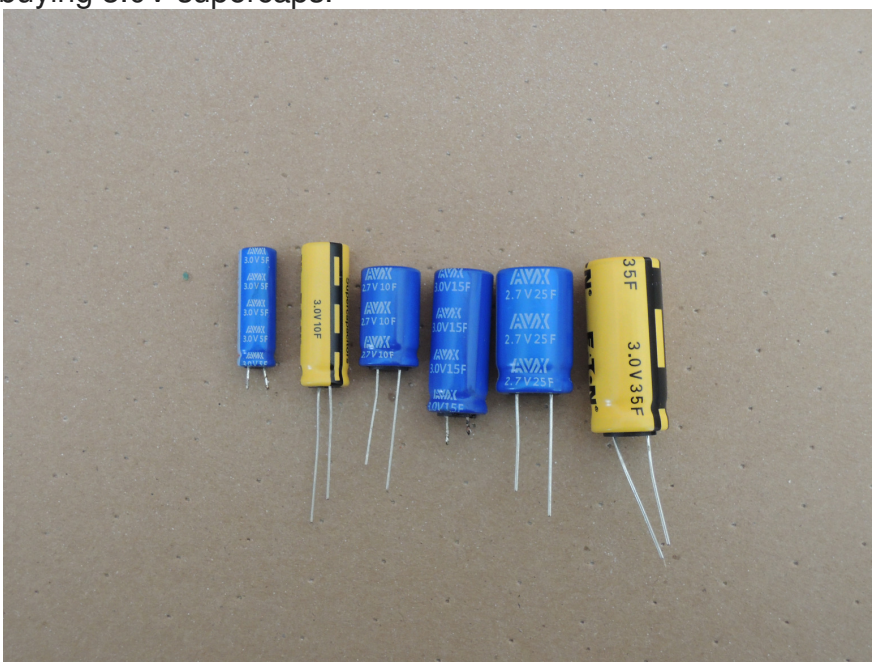


Table 1: Supercapacitor weights and dimensions:

Capacitance (all rated at 3.0V except the 25F)	Size (length, diameter in mm)	Weight (grams)
5F	25, 7	1.7
10F	30, 9	3.3
15F	30, 12	4.5
25F (rated at 2.7V)	25, 15	7.3
35F	36, 16	9.8

Figure 6 shows my current supercapacitor powered fleet. All have flown.

So if you're intrigued, let me describe some of the airplanes I've been flying:

Smallest:
Vought fighter- dime scale. Weighs 20 grams ready to rock. Best flight so far: 50 seconds- it hit a tree. Uses a geared 6mm motor, GWS 4040 prop and a 10F supercap. I don't think the lower pitch GWS props are much use with this system.

Kharkov: EB kit. I inherited the airplane, so I thought it'd be a good test bed. I put in a 7mm geared motor, 138 mm prop and a 15F supercap. Weighs 43 grams Best flight so far is 45 seconds (IIRC), but I've been too chicken to really charge it up much. At Pinkham Field, Tom Nallen and I had a nice walk retrieving the airplane- never got very high, but stayed up for awhile. Neither of us put it on the clock. Tom thought it flew at least as well if not better than his rubber ship. Even with the supercap pretty far forward, it still needed some extra noseweight. It's clear that this supercap setup is lighter than rubber power- there's no motor weight aft of the cg.

Ranger 21- BMJR kit.8520 geared motor, 138mm prop powered by a pair of 10 F supercaps in parallel (20F). Weighs 53 grams (a gram lighter than rubber powered- not a lightweight.) This definitely has more oomph than the 7 mm system although when I tried to use a tach on it, it looks pretty close. I'm wondering if the tach is good enough to pick up the relatively small differences. Lots of people like how this airplane flies- handles a bit of breeze well.

Diels Tigercat- F7F.I inherited the airplane from Mark Fineman. Pair of 7mm motors geared, GWS 4040 props, and a 35F supercap. Weighs 78 grams. Did not fly on the 138mm props, but the smaller, higher pitch props turned the trick. Best flight was 47 seconds, but it spiraled in at the end. Luckily, my RC field has tall grass surrounding the runway. I added a bit of noseweight, cured the stall, and got a lot more height on the next flight. The turn opened up and the airplane got snagged by a very tall tree. I got it back rather the worse for wear- have to build a new fin, retissue most of the wings, add a rib or two….However, this does show that supercaps are a heck of a lot easier when it comes to the mechanics of flying a twin (I think rubber powered twins are 4x the work of a single prop.)

For whatever reason- the airplane does not turn left well, but seems to do OK turning right- just not tight enough.

Suppliers:

There are lots of motor suppliers on sites like Ali Express. I strongly suggest NOT buying motors without gearboxes. Sourcing gearboxes is a nightmare.

There are the Parkzone 8mm setups from their Champ and other UMX airplanes. Their motors have a brass pinion and swing a slightly smaller prop that of course has too big a hole for the shaft on the other 7mm or 8mm gearboxes. I haven't used one of these gearboxes for FF yet.

FlyBoyz store is selling Tony Ray kits and an 8 mm gearbox with prop. (8520 motor) Needs a bit of assembly, but it's not too bad. Do a couple and you'll get the hang of it. See: https://www.flyboyzblog.com/product/super-micro-universal-motor-gearbox-prop-set-for-tony-ray-kits/ I'm building one of the Tony Ray kits of the Zero- it goes together very well. I'm tempted to try making one of these airplanes FF. However, the motor/gearbox is not really a good match for airplanes in this size range…. This gearbox/motor is what's in my Ranger 21 which is a considerably larger and beefier airplane. Go figure…

The most complete site for this stuff is Micron Wings in Australia: https://micronwings.com/Products/SectionGeardrives/index.shtml. I've bought not only motors but switches and shrink tube from them. They also have the best selection of props and various sleeves to allow you to use GWS props with gearboxes. Warning! Lots of stuff here isn't sized identically- which can be really annoying for things like gearshafts that mount propellers. Extra parts like end caps for the gearboxes can be helpful as well. Also- if you want to use GWS props, you may need some adapters.

Another site that has a good selection is Minimum RC: https://www.minimumrc.com/collections/electronic-parts-372

I've ordered from all three of these suppliers- no problems to report.

Chargers for supercapacitors are not hard to come by. A very simple charger can be made from a pair of AA lithium cells, or you can go with buck/boost power converters. These power

converters are really flexible and allow easy access to the tunability of the supercapacitor. They're not expensive either- the basic unit cost less than $20 on Ebay, (See: https://www.ebay.com/itm/384396903233) but does need some cabling and a power source (highly flexible). I'd get the one that comes with the enclosed case. Warning- the 3 cell AA charger that comes with some pre-wired supercap power systems (etiher ARF or sold separately) needs a board to limit the voltage to the supercap. It's a real kluge of a system- not recommended.

Supercaps and other electronic components: I've been ordering from Newark Electronics- www.newark.com Don't expect much customer service- you're pretty much on your own. About supercaps. They're basically a can with an electrode and a liquid electrolyte. Over time, the electrolyte will evaporate, so if you keep your airplane for a decade, you may need to change out the supercap. I've been using both the Eaton and the Kyocera units- can't tell any difference. There is one big difference between supercaps though- the rated voltage. There are three voltages they come in: 2.7 V, 3.0 V and 3.8 V. I think the 3.0 V supercaps have better energy storage than the 2.7 V units, but this is only based on the fact that I got better duration out of a 7mm setup with a 3.0V 15F supercap than an 8 mm setup with a 2.7V 20F (actually a pair of 10F supercaps in parallel) supercap swinging the same prop- at pretty close to the same rpm. The 3.8V units are very different. My guess is that the electrode material is similar to what's in a lithium polymer battery- they can't be discharged below 2.0V. They also cannot handle the current of the larger supercaps- by a factor of 10. Note that a 2.7V 25F supercap can handle 150 watts. The advantage of the 3.8V supercaps is that they are much smaller and lighter- I think the 35F 3.8V supercap is close in size/weight to a 5F 3.0V supercap. The biggest problem is that the 3.8V supercaps again need a battery protection circuit board which cuts off the voltage when it drops too low which adds to the weight and complexity. Haven't found a decent source for these boards yet.

If you're going to worry that we're using these devices at higher than their rated voltage, well, the 2.7 V supercaps are 20% overvoltage, while the 3.0V ones are within 10%. The best I got from Eaton technical support was that this isn't considered "severe overvoltage" but they didn't define that term. My hunch is that the electrolyte breaks down over 4.0V pretty quickly, so as long as we keep well under that, we should get decent longevity. Apparently it takes "severe overvoltage" to cause the supercap to blow its bung. Like a lot of devices, it looks like the enemy of longevity is heat- so if they're not getting hot, odds are they'll be fine in service.

Note- if you want to try higher V systems, there are supercaps that are already assembled in series to get to 5.5V. I think for FF, the lower V systems work better because when the motor stalls out, there's less voltage trying to keep it turning, but that's a guess on my part. In practice, stalling out these motors doesn't seem to heat them up much.

The biggest challenge for some folks who want to try these systems is the need to be able to solder up the flight components. These components include: a switch, charging jack (I'm using 3/32" phone jacks), supercap, and motor. Total cost of the airborne system is <$20 which means that if you lose it, it's not such a big deal.

Summary:
Advantages of supercapacitor powered FF:
1). Lightweight, easy to install, can be retrofitted into existing aircraft.
2). Good power match to rubber power systems up to 1/4" motors.
3). Easily tailored power output. (just select a lower voltage on the power converter to charge the supercap to that level.)
4) Inexpensive

5). Robust, easy to handle. No temperature or storage issues. Cases are not easily punctured.
6). Reasonable duration for sport flying, i.e. ~ 1 minute without electronic timers.

Just start thinking about all the airplanes where a rubber motor is a PITA. DH-2 anyone? What about the Short Maya Composite?

If you have questions: feel free to get in touch. Sambrauer1960@gmail.com