Electric Ducted Fan Aircraft for 2018, at the Pony Express Model Airfield!

A Freewing 80mm Avanti EDF pauses for a moment before another sortie

I hope you are all having a fantastic 2018 season! I was asked earlier to write a few things down about my latest EDF. Before I knew it, my keyboard was smoking away, and I became a bit long winded. I ended up with what may be a passable primer for those who are thinking about getting into EDF's. I'm also writing this for those who may have tried EDF's before, perhaps had a few "strange" encounters, and have been discouraged.

I'll start off by mentioning one of the latest models that I've brought into my fleet. This is the 90mm powered F-4 Phantom introduced by Freewing in 2018, and marketed in the States by Motion RC. I'm flying the most basic version, an ARF running 6s voltage lipo battery packs in the 5000mah range. The airframe is built to accept larger power systems too so the battery bay is accommodating for larger packs. I'm flying this aircraft with HobbyStar 6s, 5200mah packs at 660g; and also, HobbyStar 6s 8000mah packs at 920g. Another interesting pack RCJuice sells that I have to try, is the 6200mah pack. It weighs in the high 780g range for a good 1000mah more capacity than most 5000mah packs of the same weight. The F-4 Phantom is not an EDF I'd recommend for someone to jump right into who is new to EDF. But it sure does make a good third or fourth follow-on EDF project. It also follows the basic path of what makes a good EDF a good EDF, so I'll continue using it as an example as we move through some of the concepts that define EDF flying.

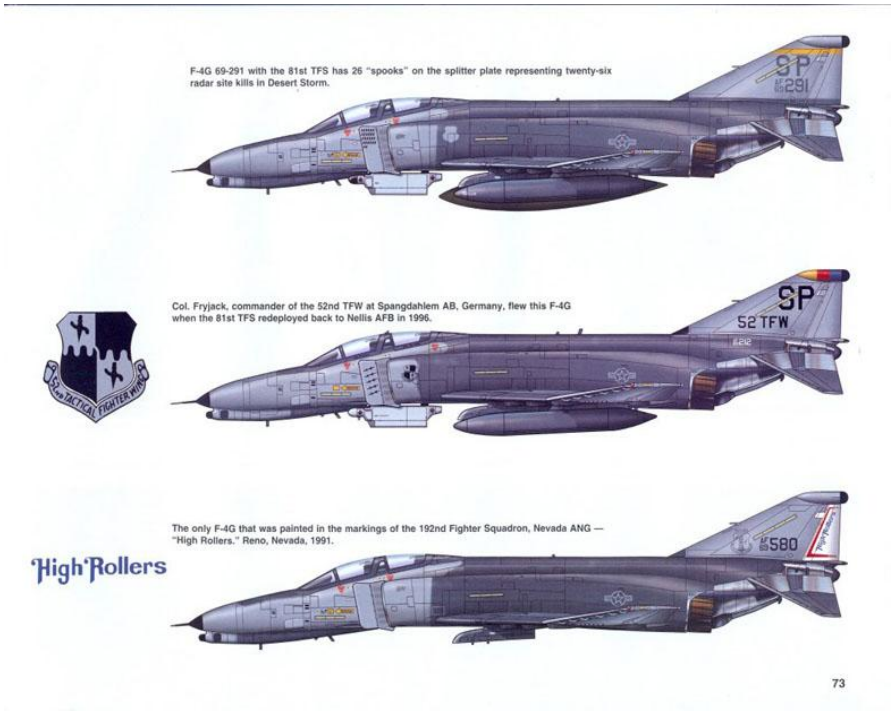
Weight
Weight of components can be overlooked but are just as important as the quality of the components themselves. EDF jets pack a lot of power into a small package and weight can pile up quickly if the components are not carefully selected. A few extra grams here and there add up. An ARF “can” help if we select one that has been designed and provisioned well. The F-4 Phantom ARF kit gets just about everything right, with few exceptions, for a scale, stock 6s flyer. We mentioned battery weight earlier and I would recommend shopping for packs that don’t tip the scales so much. There are discount online hobby shops that sell cheap packs. And there are online hobby shops that sell good packs for a good price. Go with the latter. EDF’s demand power but one way to get power is buy a lighter pack with a little more capacity. C rating is a factor but as long as you are buying a known type of pack that has the capability to deliver 120 amps continuous, you are fine. Packs I’m using these days advertise as 35 to 45c but test at about 25C. At 5200mah, 25C gives you about 130 amps capability (25X5.2=130).

Freewing F-4 Phantom (Single 90mm fan, 6s PNP ARF, released 2018)

Design
EDF airframes themselves are also somewhat marginalized because many EDF’s are scale models. The scale models they emulate tend to be high performance and supersonic designs. These designs by nature are not as efficient at slower speeds as a trainer, and this can be seen in the traffic pattern. Some of that “strange behaviour” can be polished by excellent design (good airfoils, good CG setup, good flight control tuning), by weight management, and by flying discipline (more on that later). The right choices allow the design to fly in a docile, forgiving manner most model flyers can enjoyably manage. And I can say with confidence, it is quite rewarding to be able to master a variety of different jet aircraft types throughout their performance envelope. While a supersonic fighter may not be as efficient as a trainer in the traffic pattern, they are in my opinion a lot more fun to master and fly. There is a point to all of this “overcoming adversity” talk here!

EDF Particulars

The EDF unit is essentially a ducted propeller. This “Impeller” or “Rotor” or “Fan” is interesting to ponder. The modern rotors have changed over the last decade to include more blades. Many are at 12 blades these days and look a lot like a larger fan rotor on a real turbofan jet engine. The higher count blade rotors are largely to enhance the “sound” the fan produces in action. The higher count blade fans will “whoosh” more than scream, sounding more like a real jet. This sound treatment comes at some cost in efficiency however compared to older designs.



More than a decade ago the rotors looked more like chopped 3 or 4 blade props and sounded like a high pitch dentist drill in action. They were more efficient than today’s fans and sounded horrible to many at the same time. The pendulum of preference swings however and there again has been some movement recently to bring the blade count down again (9 blade rotors) as a compromise back toward efficiency at the cost of some of the “scream” creeping back into the sound signature. My F-4 Phantom has a 9-blade rotor to deliver a mix of good sound and efficient performance.

Changesun 70mm 12 blade rotors (2011) and Robbe Rojet 4 blade rotors (1995)
Brushless HET motors and Robbe Brushed motors

Ducting
The inlet and duct that brings air to the fan rotor is actually one of the more important parts of the system. There has been a range of great to horrible ducting used over the years, largely due the quality of the design and the type of scale model built. The recent offerings of well-performing ARF's have been partly due to a renewed attention to keeping the ducting well-tuned for the installed fan. Some ducting by design (like the F-4 Phantom's split twin exhaust) is a result of bowing to the scale model fixation and making the model look like the real thing. Since the F-4 Phantom I'm flying has a single fan for weight, simplicity and cost; the price to be paid is a loss of efficiency in the exhaust ducting. All things being equal, it's a price that is tolerable given the designers made other great choices in equipment, weight, inlet ducting and airframe particulars.

Should I buy this cool new jet model?
When I heard about the F-4, I was ready to assume it would fly on the heavy side and perhaps remind me why it was always known as the "flying manhole cover" or "an example of enough power being able to make anything fly". Hey, this was an F-4 so I was ready to pay some of the price for the cool ride. However, in the case of this particular F-4 Phantom, the designers really performed quite admirably. They covered all the bases as well as they could be covered and still produced something that looks like the real thing. For example, the model weight is reasonable considering the wing area. The components were well chosen, airframe design made for a strong model but the added weight of the structure was controlled. The landing gear are sturdy but it's not a truck. The airfoils and thrust lines were well created, something other F-4 model designs did not get right. The inlet ducting is better than most (as seen by the work the designer put into it). Yes, scale issues are present. However, they have been well designed (limiting the liability of it). There were so many competing requirements in this project they really walked a fine line in delivering a model with total performance. It doesn't do anything particularly amazing, but it does a lot particularly well. In other words, it's a rarely modelled scale model that is also fun to fly.

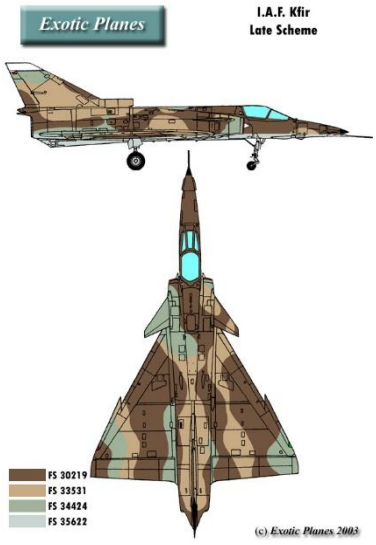
Stranger Things
OK, how does it fly? Well, this is where EDF's tend to each be their own unique case. Unlike WWII warbirds that tend to take on familiar airframe handling, EDF jets tend to be quite unique in handling. There is a familiarity that defines "different" EDF jets however. For example, EDF jets can be generally categorized in three groups (my opinion).

Group 1 are EDF's with straight wings: These EDF's tend to fly much like a warbird, except for the well-known idea that the control surfaces don't get any airflow from a propeller and acceleration is generally slower. Examples: T-33, P-80, L-39, A-10… I also consider a generally mild "trailing edge" sweep sport jet to be more of a "higher taper" straight wing, than a traditional swept wing. These tend to have reasonable stall behaviour too (Avanti, Bandit, Stinger, etc) but also share some behaviors of a swept wing (softer stall transition, smooth handling). The models I promote for new or returning EDF flyers are the Freewing 80mm Avanti and the

Freewing De Haviland DH-112 Venom 90mm, and they can have trainer handling when flown smoothly. Types to respect tend to be the T-33 (sharp stall and roll off behaviour) and any model with a heavy taper, very small wing tip chord combined with higher wing loading.

Group 2 would be EDF's with swept wings:
Example include F-86 Sabre, Mig-15, F-100, Me-262, T-45, Hawk, Jaguar, Hunter, A-6, Airliners, etc. These models generally fly well and start to introduce concepts of "body angle" as they will fly slightly more nose high when stabilized in slow flight or in the pattern. This is normal. It pays to start using power for sink rate and pitch for speed control, especially in the traffic pattern. Be aware of sink rate and body attitude, being smooth and understanding heavier G's (hard pulling) will scrub speed with excess drag, more so than with a straight wing. The model may even be partially stalled and producing high drag even if still under mushy control. Stall recoveries in swept wing models need more power (or altitude) and time to get flying again.

Group 3 would be EDF's with delta type wings, modified delta wings or partial lifting bodies:
These would be made up from the ranks of F-16, F-15, F-4, F-106, A-4, Mirage, Mig-21, Su-27, Mig-29, F-22, etc. All models tend to have individual characteristics that set them apart, but this group is going to feel different than a straight wing EDF or warbird. These models demand more of awareness of pitch and power. The payoff is the stall characteristics can be somewhat easier to deal with and more controllable, in fact some of these models can fly along very happy partially stalled and at incredibly slow speeds as long as the pilot understands pitch and power capabilities well enough to keep the model stabilized.



So,

what does the F-4 Phantom fly like?
The F-4 Phantom flies like jets in group 3, to some extent. Unlike the Mig-21 / F-16 / Su-27, it won't crawl around like a Sky Crain at ultra-low forward speed, hanging on the thrust. It will fly nose high and slow, but the beloved "manhole cover" has her limits on slow flight. If the pilot flies with pitch for speed and power for height, she will respond accurately though. The sharp sweep leading edge and tail configuration offer somewhat of a modified delta type behavior. This is very helpful on final approach. The model can be spot landed nearly every time with little float or tendency to sink unexpectedly since the approach is accurately flown with power and pitch. After touchdown there is little tendency to bounce or demand a long roll out. The tires chosen are somewhat soft and higher drag, combined with good suspension struts. The wide spaced main landing gear and long wheel base give this model an extremely easy ground handling signature.

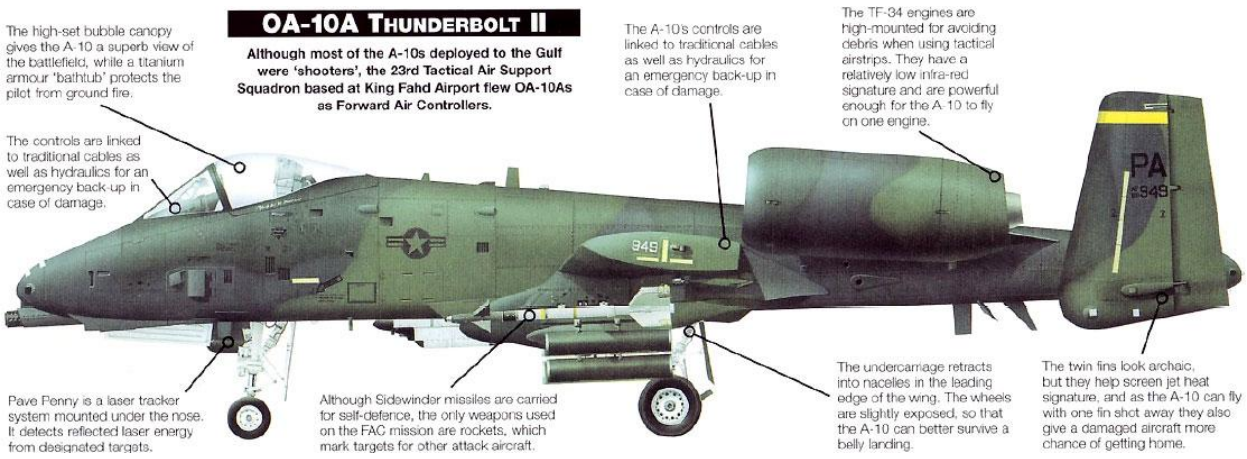
I prefer flying her with the larger 8000mah, 920g HobbyStar packs mentioned already. This gives me about 5 minutes of flight time at a reasonable weigh gain considering the capacity. The extra weight is not an issue in flight. I can leave the power slightly higher for faster speeds and not worry about flight time like I do with the smaller 5200mah packs. While the F-4 flies very sweet on those 5200mah packs, I limit flying time to 2:45 to 3:00. Having that extra couple minutes available with the 8000 mah packs brings a lot to the table for enjoyment (provided weight stays low like the HobbyStars provide).

A standard routine is to take off with flaps 20 degrees, after a few seconds pull about half elevator and wait for the nose to begin to rise, then back of elevator to hold about 10 degrees nose up. Let the model fly off on her own, don't force flight, she'll rise when she wants to and accelerate. Bring the gear up immediately, start a low bank crosswind turn at 15 feet and climbing. Bring flaps up, then reverse to bring her around for a pass. Either that or continue coming around to a mid-altitude, reducing throttle, downwind leg. Large 300-foot, round loops can be had from a full throttle, higher airspeed entry. The F-4 needs to be brought back into the down line in a way that a nice, round loop builds up G smoothly, to recover predictably. Pulling hard, suddenly, will increase drag a lot. This may affect altitude required to pull level. This is a typical behaviour to watch out for in a modified delta or highly swept wing. Not an issue if planned for.

Fast passes look great. I estimate this plane on stock 6s power is about 120mph at most. I'm probably going 100mph most of the time and slower when doing aerobatics. Mid speed passes at 50 percent power are beautifully stable, graceful and allow the pilot to behold the Phantom's accurate lines. If the pilot wants to loaf around at 50 percent power the plane will fly great and look fantastic the whole time flying at an estimated 80mph. This plane is efficient at a variety of power and maneuvers thanks to the ducting, wing loading and design. For those looking to speed around at 150mhp this is not the plane. But for those looking to parade a scale model around, this is a sweet ride that gets a lot correct and makes life easy for the owner and pilot.

Minimal Investment EDF Training?
If you want to learn an EDF jockey skill right now, and don't have an EDF yet, here is a suggestion. Fly the plane you have right now, or a simulator, and try a few circuits in slow flight, at altitude. We will try a new skill where we use pitch inputs for speed and power for altitude. While in cruise flight, most all planes use pitch for altitude and power for speed - but at slow traffic pattern maneuvering, the more highly swept wing jets use pitch for speed and power for sink rate (mixing and matching between at times too). Try this up high to start so you have room to recover if things get confusing.

First, at straight and level flight and three mistakes high, bring the throttle down to an approach power setting (low). If the model won't slow at level flight, try pulling back a touch and climbing slightly until the model is just about stalling. Keep her on the edge (but out of) a stall with the elevator. If the model is on the edge of the stall in a buffet and the nose is bobbing up and down a bit, relax a bit of elevator and watch the model stabilize again at the slightly faster and more stable speed. Experiment with measured, smooth rudder and aileron at height to control your flight path laterally as you play with the elevator pull. See if you can go back to nibble on the edge of a stall and get used to recovering to slow flight (just to slow flight) a few times to get comfortable with that transition. This gets you used to the idea where pitch can control speed. Then reduce power to idle. Watch the model descend. Keep using your elevator to control speed, don't let the speed build up too high, you may notice the nose drops a lot with less power (less blown air over the elevator). You might actually pick up too much speed, don't let that happen, use your elevator control. Go into and out of the edge of stall in the descent just like you did in level flight earlier. This gets you used to watching the sink rate with low power and controlling the speed still, with pitch. Then as you descend to 2 misstates high, add just enough power to stop any further descent. But don't speed up. If you are speeding up, you aren't pulling back enough to keep the speed low. If you are climbing, you have too much power. Use power for altitude and pitch for speed. After stabilizing at level flight long enough to say you did it, now add a bit more power and keep the speed stable with pitch and control the climb with various power inputs. Repeat. After a few flights of playing with that up high, it's time for an approach attempt. Of course, add a sensible speed safety margin and don't do this on a windy day. Try this on a calm morning. Try a few approaches using pitch for speed and power for sink rate. Keep in mind, there still remains the flexibility to simply do what it takes to accurately control the plane. Sometimes it makes sense that a float or nose rise just needs a little elevator correction. I don't want anyone to think they have to be overly rigid with the concept of power for sink rate and pitch for speed, there is a spectrum of control here but favor the pitch for speed idea for a while and see how it works for you. Smaller, measured changes are key in a stabilized approach, to keep it stabilized! If you can do this in a trainer or a forgiving warbird, you can progress to an EDF with a concept of how to manage speed and approaches in a sleek airframe already.



Is EDF for me?

The answer is, if you have read this much, and are a coconscious flyer - or think you might like something new, then it probably is something to start planning for! If you are an intermediate pilot looking to get better, it is something you might be ready for now. If you enjoyed doing the exercise mentioned above, you already have begun the process. I'd like to suggest one of the

things a new EDF pilot needs going into the game is to re-dedicate themselves to being “a safe and predictable pilot” in the pursuit of learning to be a good EDF pilot. The reason I mention this is that EDF’s, while not dangerous, do present additional concepts to manage. Three additional concepts to consider are “energy management, orientation management and ego management”. These models have the capability to maintain speed well after the throttle is reduced. The lack of external propeller means idle power or low power does not add any drag or immediate speed reduction. The main point of speed on elevator, sink rate on power is to manage this type of airframe behavior on approaches. Also, a transition to a full power climb after slow flight (in a go around for example) can take a little while longer to build speed or control effectiveness to the aircraft. Patience with the speed build up and the capability of the wing to tolerate a heavy elevator pull right after full power is applied may take a second or two longer than pilots might be used to. The mixture of using your speed plus flight path plus throttle and altitude is all a part of your energy management plan. The “orientation management” concept refers to some EDF’s having radically different shapes than a traditional aircraft. It takes a few flights for some to get used to translating what they are seeing. Making the correct control inputs while maintaining a solid aircraft orientation relies on this concept. This means a pilot with good judgment will take their time to progress in steps, not letting the model get too fast, too far away or in too awkward of an orientation, too soon. “Ego management” is a simple concept but sometimes hard to see in one’s own situation. Staying well within one’s own progression of capability (and fellow flyers comfort margins) is important and even more so with EDF’s. Higher speeds are inherently less predictable for pilots and observers. Staying several steps ahead of the model is important in planning your flight maneuvering. Never point the nose of the jet at the pits for very long except for distant maneuving transitions and always ask yourself where the model will go if you lose the radio link or have a control problem at any one time. This means always fly proactively and have safety in mind. Keep the aggressive flying in check for a while and don’t put your fellow flyers in an uncomfortable situation of being afraid of your aircraft control or judgment at the field.

Freewing DH-112 Venom and FlyFly Mirage

Manage Risk by Flying with Intent and Consistency
In EDF flying, when new, it's all about limiting the number of changes we make at one time while making deliberate moves. Stabilized approaches with a target sink rate, standard approach pattern and target speed go a long way in keeping this new type of flying fun and simple enough to get used to without having a mishap! The main challenge I've seen new EDF pilots face has been in getting comfortable with flying target sink rate, target body attitude and target speed on approaches to land. These concepts define what's called a stabilized approach. The second most troubling concept for some is learning to use partial power more than full throttle and being disciplined enough to stay ahead of their skill set and the jet at all times. This is a matter of judgment and flight discipline more than a skill. As much as flying a good rudder is a necessary skill in a tail dragger warbird, flying a good throttle is a skill required for jets. The throttle should be used actively and accurately, not set and forgot about. The rudder you learned about with warbirds is just as important but a nimble, responsive, measured and accurate throttle finger might actually be more important in an EDF and a skill I suspect takes some time for some to appreciate. Having experience flying slow flight up high, as described earlier, will give the necessary practice on the feel and sight picture to manage a "target" speed, pitch and sink rate using all available flight controls.

Landings
An EDF landing is just an extension of the approach. And, the last 5 feet of altitude is a lot easier to deal with if we are flying it the same way we are flying the first 50 feet of the approach. Just before estimated touchdown, pull power to idle and use the elevator stick to make very fine input adjustments to round out and flare the model's main wheels into the asphalt. It's OK to touch down with some sink rate, but we just don't want to touch down on the nose wheel first. That will cause the nose to rebound, shoot the model nose high but below stall speed, and a dreaded kangaroo bounce will follow. Getting comfortable with fine tune elevator and throttle handling up high correlates to comfort in the approach and flare too. It tends to all come together in the flare and all the advanced "studying" up high and in the approach pays off here.

Conclusion
For those still looking to get into EDF or those thinking about coming back, the time is now, and it has never been better! Suggestions? I'd say a Freewing Avanti 80mm EDF or a Freewing De Haviland DH-112 Venom V2 90mm would be a great place to jump in (or jump back in)! The EDF's I've suggested tend to require 6s power and 5200's or similar. At least two lipo battery packs will get most started. There are smaller EDF jets that cost less and still fly very well for sure. One thing to consider in starting a new type of flying are the flight packs themselves. One thing I've noticed over time is it's easy and efficient to base your models around a general battery pack you think you'll use a lot. I settled on the base line of the 6s, 5000mah pack. I use other packs, but those 6s, 5000mah packs tend to work in most of my planes weather I gang two up in series or parallel for larger planes or just fly single packs in EDF's or warbirds. If you have a lot of another pack, take a look around and see if there is an EDF with good reviews that fits that pack. There are many choices!

If anyone in the club has specific questions about EDF setups, I suggest posting on the RC Groups forum page here: https://www.rcgroups.com/forums/showthread.php?2572909-High-Sierra-Club-House-Chatter This is an interactive thread running on RCGroups and would be a good place to ask general questions about EDF setups from one club member to another. It used to be more active of a place to post and has gone somewhat quiet lately. But I can commit to looking here every so often and helping out with a setup, if there are EDF questions.

Fly safe and Tally Ho!