# SYKOSIS DESIGN PHILOSOPHY

By Dave Rice

The Sykosis is an attempt to create a fully pattern capable 1/2A size aircraft with sparkling vertical performance without resorting to many hundreds of dollars worth of brushless motors, multiple airborne packs, a smart charger and a deep discharge battery to power it. Call me old fashioned, but I like methanol powered planes.

The plane is designed around the Norvel .061 RC Revlite engine. True, the .074 has a bit more power but not enough to justify the extra ounce over the weight of the .061. And weight, or the lack of it, is the key to this plane's performance. The Sykosis' weight, minus fuel, is **12.7 ounces.** This is some 2.5 to 3 ounces less than the static thrust from the .061 with an APC 5.7-3 prop. And that is with a stock engine running 10 % nitro. This static thrust to weight ratio of about 1.25 to 1 is still not particularly outstanding, so we are going to need a little more help.

That help will come from drag reduction. I like to fly the Sykosis around at cruise airspeed with about 1/2 to 2/3 power and then be able to pull straight up, go to full power, and have about the same airspeed as before and enough power margin to hold that airspeed through at least one roll and continued vertical flight. That is a tall order for a plane with a mere 1.25 thrust to weight ratio. This 1.25 number is a static thrust to weight ratio. This tells us that if you hold the plane pointing straight up with the engine running full bore, you will feel a vertical pull on your hands and that the airplane will accelerate straight up from a standstill. But what happens as speed builds toward that vertical cruise?

Static thrust becomes dynamic thrust with airspeed and then begins to increase a bit, but it reaches a point somewhere in the airspeed range where it stops increasing and remains pretty well constant. Drag, on the other hand, keeps increasing with airspeed. In fact it increases with the square of the airspeed! In flying uphill we are working against drag and gravity. The effects of gravity can be minimized by keeping the weight down, but drag is a different matter.

Sykosis is not as low in drag as a dedicated racer, but it does employ several strategies which, when taken all together, give it low enough drag to provide the vertical performance desired. First, it's a bit on the small side at 160 sq. in. of wing area. Less wing, less drag. The wing carries the NACA 0013 airfoil which is noticeably thinner than most airfoils in this size range but still thick enough for good low speed handling.

Second, the fuselage is as spare as possible in cross section with just enough space for the equipment and to allow a tight clean cowl enclosing as much of the engine as possible. This also reduces frontal area and wetted area, which is the total amount of surface the air must pass over.

Third, and this one really hurts, we have to toss the landing gear for both drag and weight considerations.  I do love to take off and land, so a landing gear may find it's way back on the plane at a later date.  How much it would hurt the vertical performance remains to be seen.

Fourth, a few smaller things.  The antenna can be routed through the wing to get it out of the slipstream.  Take it out through the most forward holes in the ribs beginning at the center section, right out through the tip plate, then back to the rear most holes and back into the wing all the way in to rib #2.

Install soda straws through the rib holes for routing the antenna <u>before</u> you install the leading edge sheeting or you won't be able to spot glue the straws into place.  A small hole in the center section sheeting allows access to the end of the straw for threading the antenna through.  Don't forget to balance the weight of the antenna by adding a little bit of weight to the other panel.  A #6 x 3/4 steel wood screw at the opposite tip made my wing balance.  If you take this antenna option you must cut about 8 inches off of the antenna.  With the FMA M5 receiver this is a perfectly viable situation, even with the U-shaped antenna routing.  This reduces the range from about 4 times more than you need to about 3 times more than you need.

Every control surface should be gap sealed.  This not only reduces drag a little bit when the surface is at neutral, but it also reduces the amount of deflection required to produce a given response.  The less aileron deflection used to produce a vertical roll or rudder deflection to touch up a vertical climb, the less drag from the use of that control surface.  Gap sealing also reduces the possibility of control surface flutter

The choice of a turtle deck of elliptical cross section behind the canopy represents a reduction in drag over a square cross section fuselage, even one with rounded corners.  It also seems to eliminate the irritating tail wiggling that happens at medium to high speeds in some square fuselage airplanes I have built.

If you snip off the Norvel's needle valve extension and file it flush you will bite off a teeny bit of drag and improve the looks considerably.

None of this stuff is really new, nor is any one thing by itself very dramatic. But I have never seen these strategies all combined in one 1/2A sized airplane. All the drag reduction and all the weight reduction add up to make a very capable little airplane.

Here is a list of weight saving strategies that all helped to give the Sykosis it's all up weight of 12.7 oz.  Some of them are also part of drag reduction:

**1** No spinner.  They're beautiful, but none that are easily available and inexpensive are small enough. And they never run quite true enough to be turning at around 20,000 r.p.m. And they are Heavy. Toss it! Goodbye .375 oz.

**2** No landing gear. Painful. I tell people it has the exclusive *No Gear* retract system. It might sprout landing gear this summer. 1.5oz. gone.

**3** It is rather small and spare. There is just less lumber in it.

**4** Light balsa 4-6 lb. stock is available from several mail order houses. *Superior*, *Lone Star,* and *Balsa USA* are three that I have used. Order more than you need; some of it may not be useable. If you build it out of medium or heavy balsa you will gain 2 or 3 ounces and it will probably be a little tail heavy.

**5** Sparing use of plywood. 1/8 in. ply only in the firewall, mostly 1/32 in. everywhere else. Fuselage doublers are spare and full of holes. Don't beef it up, it's plenty strong. Please bite the bullet and include all the holes in all the parts. They really add noticeable lightness.

**6** The lightest radio possible. But please don't use the really tiny servos or the single conversion receivers made for the indoor electric micro aircraft. Hitec HS-55 size servos (about 16 in. oz. of torque) are the right size and strength. Also the single conversion receivers are a little too deaf for this type of airplane. Here's what's in mine:

- FMA Direct M5 receiver. The only one that will fit if you use the clear canopy. It also tolerates the cutting of the antenna well and has nearly bullet proof radio contact with the transmitter. It weighs .3 oz.

- Hitec HS 55 servos. Small, light and strong enough but there are other brands that would work as well. The Hitec weighs .28 oz. You must use rubber grommets of some sort. These servos are too tender to be screwed directly to the vibrating airframe. I have not seen commercially available grommets this size. You can make some by cutting a slice about .040 in. thick from some small silicon fuel line. Put one slice above and one below the servo's mounting ear and use the screw provided, but don't over tighten or you will loose much of the vibration protection. Tighten just until the rubber begins to compress.

- 280 mAh nickel metal hydride airborne batteries, weighing about 1.1 oz. Now there is even newer battery technology in the lithium ion cells. They are about 1/2 again the weight of Nimh cells. These would be even better. The NiMH cells in the prototype came from Radical RC.

- Futaba Mini Switch with the cover removed and the wires all shortened and resoldered at the switch contacts. The connector in the battery lead was eliminated by soldering the shortened battery leads directly to the switch contacts.  There is just not room for all those long wires and connectors. Do leave the charging lead long enough to comfortably reach the charging jack Wrap the bottom of the switch and solder joints with electrical tape for dust sealing.

- Ernst charging jack.  You will need the capability to recharge at the flying field if you want to fly more than 2 or 3 flights before going home.

- Bubble wrap for shock mounting the receiver and battery.  The type with small bubbles.  Foam rubber is too heavy for a plane this small.  The bubble wrap is nearly weightless and is adequate at vibration damping if you wrap loosely.  The down side?  FMA says it will void your warranty.  The good news is that this receiver is so good you won't need the warranty.

**7** Minimal rib count in the wing, minimal wingtips, minimal number of bulkheads in the fuselage, built up tail feathers.

**8** Very light fiberglass cowl.  I made mine with laminating epoxy from *E Z Lam* and light fiberglass cloth.  There are 2 layers of 3/4 oz. cloth and then 1 layer of 2 oz. cloth, resulting in about .010 in. wall thickness.  Also there is a 1/4 in. wide band of 2 oz. cloth around the rear rim to reinforce the mounting holes. Polyester resin would work, but it is heavier and shrinks a lot more and shows the weave of the cloth.  I used the balsa plug and female mold technique for my cowl but blue insulation foam could be used to make a cowl with the glass layed up on that after under sizing it slightly.  Then remove the foam from the inside. However you do it keep it light.  It should be strong enough to stand a minor landing mistake but not much stronger.

**9** Plastic film covering.  Unless you're a magician, you won't be able to silkspan and paint it for less weight than if you use film.

## MORE SYKOTIC RAMBLINGS

The engine is inverted to get the cylinder out of the breeze, (less drag, remember?) I knew from experience with this same engine and cowl setup on another airplane that it would run, idle, and otherwise act normally while inverted under this cowl.  But there are a couple of points to observe.  One is that it should be started with the plane upside down to prevent engine damage from hydraulic lock.  It is very easy to turn it right side up after starting because it's so small.  Another is to make sure that you have enough air moving through the cowl.  The hole for the air intake needs to be generous.  This provides air for the crankcase and some for the fins, but only if it can find an exit once it passes over the engine.  The biggest exit is the hole for the muffler.  Don't skimp on this hole even though it could be smaller and still clear the muffler.  Likewise, don't be tempted to leave off the little exits on the sides at the rear of the cowl.  The cylinder head clearance hole should have about 1/16 in. clearance all around the fins. If all this stuff is taken care of, you won't have overheating problems caused by the cowl.

One thing I was not sure about was the way the glow plug sticks down so far below the cowl. It is definitely the lowest thing on the airplane. Well, you certainly don't want to land on the pavement but as long the landings occur over grass I have not had any problems damaging glow plugs. Over close cut grass I may have to dig a little bit of dirt out of the glow plug well if I make a small mistake on landing. Over medium or long grass, the Sykosis is so light the grass stops it like a catchers mitt! The best landing technique is to make your approach and final with power, then when you know your touch down spot is made, shut the engine down with throttle trim. This plane will really slow down before it finally gives up, and if you land it nice and slow it will travel about 6 inches after touchdown accompanied by a *sshoomp* as the blades of grass caress the wing covering and the belly pan. Ignominious, I know. A plane like this deserves a more dignified landing than that. Maybe a carbon fiber landing gear . . . Until I get a landing gear, a strip of Scuff Guard on the underside of the nose and belly pan will have to do.

And the pressure system is a little unorthodox. The stock location of the muffler's pressure tap must be changed for this setup. The pressure line must enter the muffler on exactly the opposite side from the factory location. To plug the factory pressure tap snip off the nipple and file the stump down to the <u>flange</u> but do not file off the flange itself. This leaves the flange intact and still sealed to the muffler but with a tiny hole in it. Get a really tiny brass machine screw ( 0-80, available from an HO train supplier) and thread it into the hole until it breaks off and then file it flush with the flange.

Now we must tap into the muffler's pressure at the new location. Since available pressure taps are unacceptably large, I opted for a more direct approach. I always wanted to try this and here was the chance. Drill a hole at the right place in the muffler for the pressure line to enter (see plan and pictures). Make the hole a bit smaller than the diameter of the silicon pressure line. How much smaller? About .020 in. smaller. Then simply push the end of the pressure line about 1/8 in. through the hole and into the muffler. That's it. No pressure fitting. The end of the silicon line inside the muffler will blacken and burn away a bit, but it will stop short of the wall of the muffler. Still, just to be on the safe side I replace the silicon line into the muffler every 10 flights or so. The little brass elbow shown in the pressure line on the plan and in the picture <u>must</u> be there. If it is not there, the pressure line will be slowly pushed out of the muffler and the engine will go lean and overheat. Use 1/8 in O.D. soft brass for the elbow, not the plastic tubing that comes in the tank The plastic tubing will soften in the heat and close down at the end closest to the muffler. This will reduce fuel system pressure and cause a lean run and overheating.

The tightness of the cowl forces another slight modification to the engine. There is not enough room for the throttle arm to swing far enough forward to reach the idle position. To fix this the arm must be rotated on the throttle barrel such that when the arm is just a bit shy of the point in it's travel where it hits the inside of the cowl, the throttle is closed enough to shut down the engine. Oh yeah, I forgot to mention that the little idle limiting screw must be removed to allow the engine to be shut down by the throttle.

To rotate the arm on the throttle barrel you must first note the position of the arm when the throttle is closed. Remove the throttle barrel / arm assembly from the carburetor by rotating it counterclockwise until it comes out. Remove the needle valve. Loosen the brass nut that holds the arm on the throttle barrel but do not take it off. A small adjustable open end wrench or a very thin walled 5 mm socket will loosen the nut for you, but be careful not to weaken the retainer spring by bending it open. After the nut is loose, rotate the arm about 15 degrees counterclockwise in relation to the arm and retighten the nut. Thread the barrel / arm assembly back into the carb and see if this is enough change. If not, repeat the above steps until it is. It's trial and error and different for every engine. If this all sounds like gobble-de-gook don't worry about it. If you have made it this far you are already in line for congratulations. With the airplane, the cowl, and the engine parts in your hand it will make much more sense.

The 2 oz. tank is a tight fit but it can be installed through the radio compartment with the receiver, battery, and the charging jack removed. Note the bubble on top is rotated to the 45 degree position. It is the only way the tank will pass through F2. A 1 oz. tank could be used but the fuel run would be only about 4 - 5 minutes. Note also that the brass tubing with the silicon lines <u>around</u> it pass through the firewall and into the engine compartment. To achieve this without allowing oil residue to pass through and back into the tank bay and beyond, the holes in the firewall are slightly smaller than the diameter of the silicon line slipped over the brass tubing. About .015 in. smaller. The tank can be installed by first inserting a length of 1/16 in. welding wire through each of the holes and back all the way into the radio bay. With the silicon lines pushed all the way onto the brass tubing on the tank, the welding wires are inserted into the silicon lines and the tank maneuvered forward. The welding wires will guide the lines into and through the holes in the firewall. Continue bringing the tank forward until the brass tubing starts through the holes. If the holes are sized properly the brass tubing will come through the holes with <u>gentle</u> pressure forward on the rear of the tank. And maybe a little wiggling.

There is no side thrust in this plane. Whatever side thrust would be required for an inside climb or pull to vertical would be the exact <u>opposite</u> of that required for an outside climb or pull to vertical. I prefer the approach of learning to fly the rudder in every maneuver that requires it.

Pushrods were chosen for their lightness and more importantly for directness and lack of slop. These itty bitty servos (all of them, not just Hitec) don't have the really tight centering that can be found in the larger servos. If plastic flex cables are used there will be a small amount of slop or play in the control linkages. This tends to combine with the slight dead bands in the servos to decrease the directness of response to the slight control inputs required for really smooth flight in a plane as fast and small as the Sykosis. And of course sloppy control linkages also contribute to the possibility of control surface flutter. We all know that can be devastating. But pushrods have their own problems too. To enjoy the precise nature of pushrods they must be absolutely <u>straight</u>. No bends. Not even slight ones. Also clevises, control horns and servo arms should be replaced when the holes and pins begin to wear.

Don't use Ca hinges. They are too stiff for a plane this small. I prefer the small flex point hinges by Klett Plastics. Piano type hinges are really free moving, but they are a little bulky.

Put some kind of snappy color scheme on it. It gets small fast and it will help with orientation if you use contrasting colors and colors with a lot of difference on the light and dark scale. Also make the scheme on the bottom look a lot different than the scheme on the top so you can tell at a glance which side you are looking at.

The APC 5.7 x 3 is a pretty good all around prop for this plane. In fact I have not tried any other props yet. You probably won't need higher than 10% nitro content in the fuel. Higher than 15% will attack the paint on the cowl anyway.

Also don't be tempted to over lean the needle valve looking for that last 100 r.p.m. Stay slightly on the rich side of that screaming peak. Even with all the precautions, on a hot day it can overheat if you peak it for absolute maximum revs.

The dihedral shown on the plan is 1/8 in. more than on the prototype. The 1/2 in. on the prototype was a guess and it was not quite enough. In knife edge flight it has a slight roll against the rudder and a slight pull in pitch toward the belly. Both of these could be fixed easily with electronic mixing.

As built and with the 2 oz. tank the Sykosis is just a taste on the nose heavy side. The prototype is flying with the built up horizontal and vertical stabilizers, but with the solid rudder. This was done to get the CG back just a little but I think it could go back another 1/16 or 1/8 in. and still have plenty of stability and maybe have a bit better knife edge and snap roll response. It is quite good in both of these areas with the CG where it is on the plans, though. Using either the solid or built up tail feathers can give you some control over the CG without resorting to dead weight. If it is turning out nose heavy, use the solid tail feathers. If tail heavy, use the built up ones.

The Sykosis is moderately fussy to build but the flight characteristics are really worth it. If the glass cowl and vacu-formed canopy are a bit more than you want to tackle give our Mini Pacer a look. It's just a touch heavier at 14.5 ounces, easier to build and has close to the same performance.

A package of digital photos (in WINZIP format) is available by sending an email to fain@brightdsl.net