"SLICK WILLIE ", AN E-36 TO THE NEW NFFS RULES SET

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Falling participation in the beginners-class E-36 event led NFFS President Phil Sullivan to convene a sub-committee to look into a possible revision of the rules in early 2010. Phil appointed David Mills of Atlanta chairman, and David rounded up six electric FF fliers from around the country as committee members. I was asked to represent the West Coast fliers. The thrust of the endeavor was to consider the use of lithium-polymer (LiPo) batteries, and maybe brushless motors to give the models more performance, particularly in the climb, and hopefully revive interest in the class. More participation in an improved E-36 class was also seen to be a boon and as a feeder event to the larger and more complex electric events.

We exchanged ideas and views via e-mail, in an often spirited discussion forum, among ourselves and perhaps twenty other participants. The consensus came down to the following: any brushless motor allowed, any 2-cell LiPo pack allowed, maximum projected wing span of 36 inches, and a minimum weight of 120 gm, ready-to-fly. A 15- second motor run for a two-minute max was proposed. As the views on the changes and the evolution of the proposed rules set progressed, the most frequently posed question was what kind of performance would result from permitting brushless motors and LiPo batteries on an airframe of this size. The prudent approach seemed to be to build some prototypes and see how they performed. Slick Willie was one of these prototypes.

My approach to e-design is straightforward: estimate the weight of the finished plane and allocate 50% to the airframe and 50% to the e-system. If the 120 gm proposed minimum weight was to be achieved, that meant that the motor, ESC, battery and timer together would have to weigh in at 60 gm. I found a motor and a battery at 20 gm each, and aimed for 20 gm for the rest, ESC, timer and other miscellaneous bits. In fact, the e-system ended up at about 65 gm, suggesting a possible AUW of 130 gm. Not bad. However, this was a rapid prototyping effort, and the result would be used for extensive testing, so I built on the sturdy side. (Full disclosure: I always build on the sturdy side!) Slick Willie #1 ended up at 145 gm, but is fairly robust.

I chose a straightforward, rectangular wing and stab planform, a 36 x 5 inch wing and a 15 x 3.5 inch stab (Fig 1.) The short-coupled tail moment probably sacrifices some glide performance in the interests of transition stability. The fuselage is a simple balsa box, with plenty of room in the pylon area to accommodate a range of batteries and ESCs. I elected to use a geodetic construction to improve stability of the flying surfaces; since the plane was to be a workhorse development platform, I needed to have an airframe that was the same each time I changed some e-component. The 70 watt e-system initially selected proved to be more than adequate for the job at hand, but the motor was lighter than I had expected and I had to lengthen the nose by a half inch to get the CG in the right place.

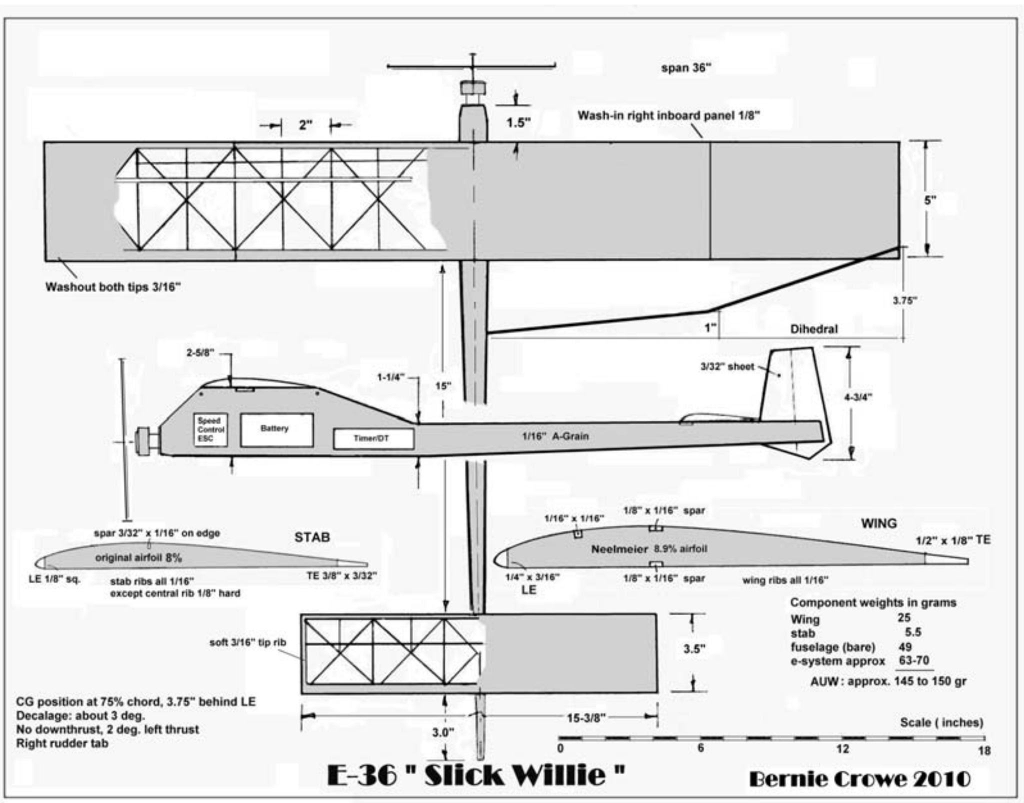


Fig. 1 A 3-view with details of the " Slick Willie"

Fig. 2 Hobby King AX1806N1200 motor in Slick Willie

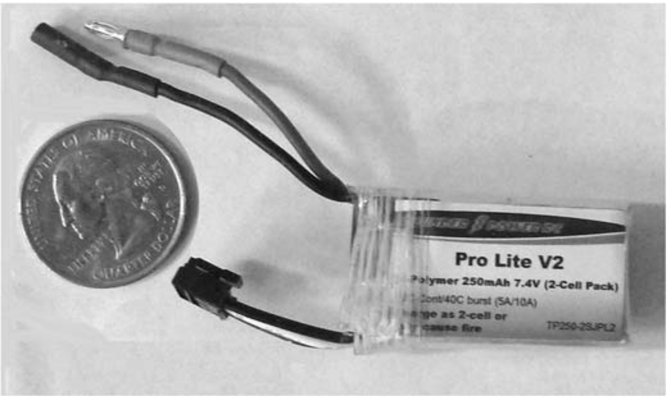


Fig. 3 Battery pack

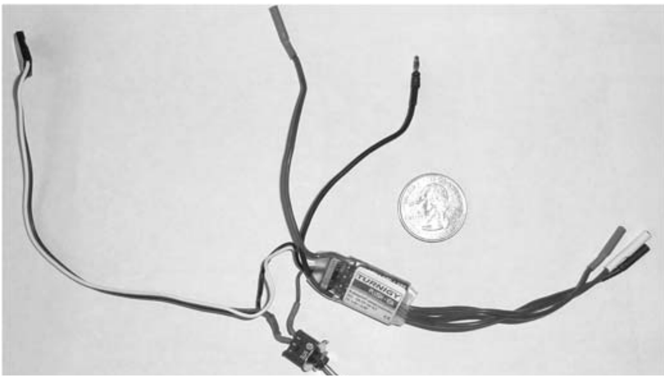


Fig. 4 Speed Control (ESC)

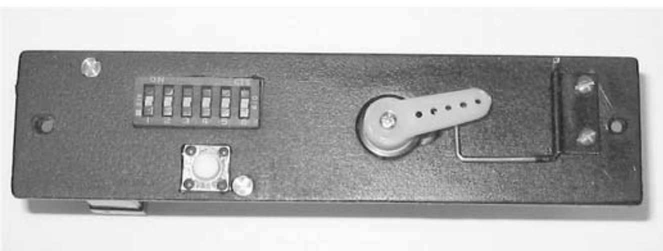


Fig. 5 Timer Panel

Once that was taken care of the little plane trimmed out fairly easily, and showed a strong desire to get high quickly. Because we were looking for a design that would do two 2 minutes on a 15- sec motor run, the tests were focused on achieving this performance, and then assessing the likelihood that it could also get close to 2 minutes from the proposed 10- second fly-off motor run, without making that a slam dunk. Slick Willie fit the bill perfectly. It did 2 minutes regularly from 15 secs, and on five flights from 10 second motor runs in early morning air, it maxed on two of the five. I reported back to the subcommittee that this experiment, at least, seemed to validate the rules set we had developed. It turns out prototypes by other members and friends brought similar results.

Electric System

The motor selected is the AX1806N1200 from Hobby King (www.hobbyking.com) Fig 2. Though having a diameter of only a 25 cent coin , this little gem is a 70 watt powerhouse weighing a mere 23 gm and comes with a pedestal mount. In tests it produced 230 gm of thrust on a static test stand, turning a 7 x 5 APC prop at 7600 rpm, while pulling 7 amps. At 50 W this is well within the motor's rating.

Several batteries were used in testing, but the one selected is the Thunder Power (www.thunderpowerrc.com) ProLite V2 250 mAh, 20C 2-cell pack (Fig 3.) This weighs only 17 gm and can easily provide the desired current for 15 seconds. I also tested a Thunder Power 325 mAh 45C 2-cell battery, but it did not produce noticeably better performance and was heavier and more expensive, so we dropped it. More thrust can be achieved with a 3-cell battery and a 5 x 4 prop, but the rules had evolved to a 2-cell limit, so this was not an option. *(A 3-cell Lipo pack is legal for the new AMA A Electric class, however,--Ed.)*

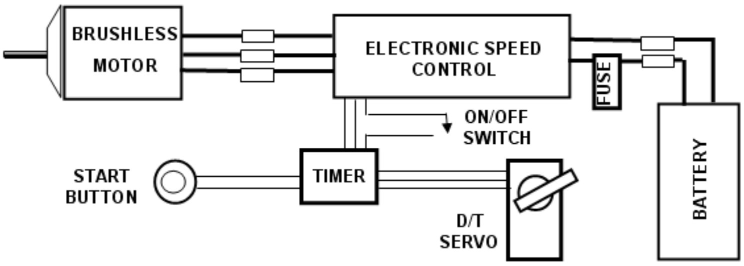
The electronic speed control (ESC) chosen is the Turnigy Plush 10A unit (Fig 4) from Hobby King (www.hobbyking.com.) It weighs in at 9 gm and is about the size of a 25 cent coin. The three wires to the right go to the motor, while the two at the top of the picture connect to the battery. The long 3-wire cable to the left of the picture connects the ESC to the timer module. To facilitate programming the timer, and for safety reasons, I splice a switch into the positive (red) line close to the ESC as shown. Because this switch is only dealing with a few milliamps at 5v, a small switch may be used. The one shown is a sub-micro SPST 3A switch from Radio Shack (www.radioshack.com), weighing 2.4 gm.

The timer and DT servo module (Fig 5) I salvaged from one of my F1Qs, so it is a little large for the model, but hey, this was a rapid prototype. The timer is a Z-Tron FF chip from Bob Selman Designs (www.bsdmicro.com) mounted in a 1/16 in. plywood panel. I like this timer because it is self-contained and can be set to any value of motor duration or DT time at the field. The DT servo is a Sky Arrow Sub-Micro HS weighing 3.7 gm. This is available from several sources, but mine came from Dymond Modelsports (www.rc-dymond.com)

The system is wired using small 2 mm bullet connectors which are adequate for this power level and save space and weight. These are available from your local hobby shop. A schematic of the electric system is shown in Fig 6.

Construction

Wing and Stab: Construction of wing and stab is straightforward since the wing section is flat-bottomed. Build each of the panels separately. Most of the ribs are from 1/16 in. C-grain 6 lb balsa, but the center ribs and the ribs at the dihedral breaks are from 3/32 in. hard balsa to facilitate joining the panels after sanding to shape. Use the template shown in the plan drawing to set the angle of



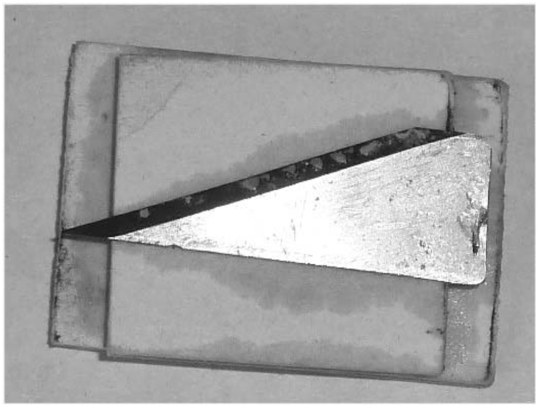


Fig. 6 (above) System Schematic Fig. 7 (right) Spar slot tool

Fig. 8 Union Jack geodetic rib construction in the Slick Willie's wing

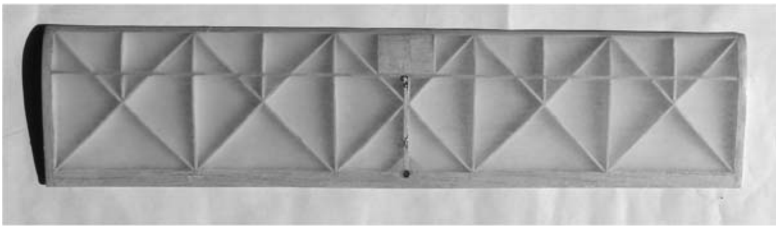


Fig. 9 Geodetic stab construction, light and rigid at 5.5 gr.

these ribs as you install them to get the correct dihedral angles. Be sure to build-in the 3/16 in. washout at the tips, and the 1/8 in. wash-in at the dihedral break of the right inner panel. Build these warps in after the straight ribs, but before the diagonal ribs are added.

Geodetic construction of wing and stab

If you haven't tried geodetic construction before, don't despair; it is quite easy. Cut the diagonal ribs as shown, but do not put in any spar slots yet. Build the wing in the usual manner using the straight ribs, blocking up the TE of the tips 3/16 in. and the LE of the right inboard panel 1/8 in. to set the required wash-in and wash-out. Add the diagonals one at a time, splitting each one at the intersection with the straight rib. Sand the diagonal rib so that it is a good fit at the LE and at the joint with the straight rib. To cut the spar slots, lay a rule along the wing surface along the existing slots in the straight ribs, and use a new double-edged razor blade to cut down to the depth of the spar in each diagonal rib. Make up a simple tool from a scrap of spar material or material of similar thickness, plus a broken piece of razor blade or X-acto blade, as shown in Fig 7. Cap it with another piece of scrap to the tip of the blade. Rest the top scrap on the rib you are cutting at one of the cuts you have made, and move the blade forward into the rib, and then slide it towards the other cut. Use this to slice the rib between the two cuts already made, and the spar slot will pop out easily. Nothing to it once you get into rhythm. Make sure the spars fit well at the root and dihedral break ribs. Glue all in place using CYA.

Add the 3/16 in. blocks at each tip. Sand each panel to the desired section, then dry-assemble the wing and check that the dihedral angles are correct. Any adjustments can be made by holding the wing to the edge of the bench and blocking up the panel to the desired height. Block sand the end ribs carefully until the desired angle is achieved. Carefully match up the end ribs of one inboard and one tip panel, clamp them with clothes pins, then CYA them together. When both wing halves are assembled, join them at the center in the same way. Be sure to add the 3/32 in. webs between the main spars in the first bay of each inner panel. Add the 1/16 in. sheet between two stub ribs at the centerline as shown and you are done, see Fig. 8.

The stabilizer (Fig. 9) is built in much the same manner. The center rib is 1/8 in. hard balsa to take the hold-down and DT hooks. Add the center panel sheeting and the 3/32 in. gussets at the TE. Drill a 3/16 in. hole for the DT line as shown, and add a piece of thin wall 3/16 in. aluminum tubing to reinforce it. Add the 3/16 in. tip blocks and sand to shape.

Fuselage

Make a bulkhead as shown from 3/32 in. ply with three 2-56 T-nuts drilled to match the holes in the pedestal mount provided with the motor. (Fig. 10) Set this on one side. The fuselage is made from identical 1/16 in. sheet sides cut to match the plan. Add 1/8 in. sq. reinforcing strips around the edges as shown, then add the 1/16 in. doublers with the grain vertical between these. These extend to the back of the pylon. Leave a space of 1/8 in. at the base of each side for the fuselage bottom. Before you join the sides together, cut the hatches for the ESC, for the battery access, and for the timer panel. Use a sharp blade to cut them cleanly from the side panels. Cut some strips of 1/64 in. ply about 1/4 in. wide, and glue these to the inside top and bottom edges of the cut-outs with about 1/16 in. protruding into the hatch space. These will serve as seats for the hatches. Glue some similar strips about 1/2 in. wide to the inside front edges of the hatches themselves to act as retainers, making sure these will clear the seats.

I used four small magnets, about 3/16 x 1/32 in. to retain the battery hatch (Fig 11.) These can be obtained from EasyBuilt Models (www.easybuiltmodels.com) Glue a piece of hard 3/16 in. balsa 1/2 in. wide at the rear of the battery hatch cut-out, leaving 5/16 in. overlapping the hatch cutout. Put the hatch in place and use a pin to mark the position of the two magnets, about 3/16 in. from the rear edge and 3/16 in. from the top and bottom of the hatch. Remove the hatch and make two holes in the balsa lip deep enough to imbed the magnets. Press a magnet into each hole and glue in place. Now make two similar holes on the inside face of the hatch, using the pin holes as a guide. Before you put them in the hatch, place a magnet on each of the magnets already fastened in. They will flip hard to align their poles opposite to the poles of the fixed magnets. Mark the outside faces of these two magnets, and then remove them and place them into the holes in the hatch. Be sure to place them marked side down into the hole! Failure to do this will result in a hatch that will push itself open instead of pulling itself closed. Glue the hatch magnets in place with CYA and check that the hatch fits and seats snugly. Drill a hole through the hatch to receive a 2-56 nylon screw to act as a handle. Set it in the midpoint of the hatch just in front of the magnet ledge. Put a nut on the screw both inside and outside the hatch, leaving about 3/8 in. standing proud of the hatch, and tighten firmly. A drop of CYA will ensure that your handle stays secure. Don't omit this step or you won't be able to remove the hatch once the fuselage is finished!

Treat the ESC hatch in the same way, but use small wood screws to secure it at the rear of the hatch. Glue small pieces of 3/32 in. ply in place at the rear corners of the hatch opening, and then drill through the hatch and the ply pieces with a small drill for the core diameter of the screws you selected. Drive the screws into these holes to thread them, and then open the holes in the hatch to the outside diameter of the screws. Countersink the holes, and screw the hatch in place. Drill a hole in the ESC hatch for the switch and ensure that it fits and is secure. Do the same for the timer/DT panel. Glue small pieces of 3/32 in. ply at the front and rear of the timer hole and drill to fit the panel. If you choose to use a different timer than the one I use, cut the hatch to suit.

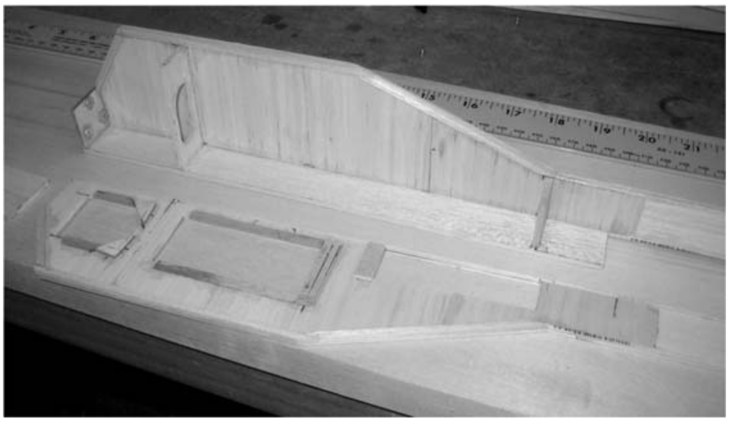


Fig. 10 Fuselage construction

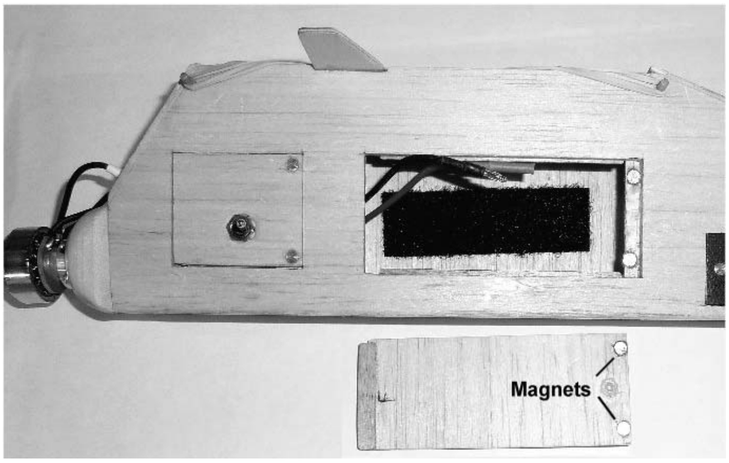


Fig. 11 Battery hatch magnets

Fuselage assembly

Once you are happy with the hatches, it's time to assemble the fuselage. Make the fin from med-hard 3/32 in. C-grain balsa, reinforcing the outline with 1/8 in. x 3/32 in. basswood strips. Sand to shape and set aside. Reinforce the sides of the fuselage from the rear of the pylon to the tail with 1/16 in. sq.balsa strips. Chamfer the sides slightly where they will join to the fin. Lay the right fuselage side on a flat surface and glue the motor bulkhead in place. Glue in the 1/8 in. fuselage floor, butting it up against the vertical grain doublers. Add the formers at the midpoint and rear of the pylon box as shown in Fig 10. Offer the left fuselage side up to the assembly, making sure the two fuselage sides are aligned. When you are comfortable with the alignment and fit, apply glue to the bulkhead and formers, and to the edge of fuselage floor, and glue the left side in place.

Place the assembly on a flat surface and draw the two sides together, using a piece of 3/32 in. scrap where the fin will go. Secure the sides temporarily with a clamp such as a clothes pin. Cut the rear former and the balsa fill that will go at the stab mount position and do a dry fitting to ensure that these fit well. Remove them and place the fin in the position shown. Again clamp the sides together, and then sight down the fuselage and adjust the sides until the fin is aligned with the fuselage centerline and is vertical. Glue in place. Spring the sides slightly and insert the former and the balsa fill, and then glue in place. Cover the top and bottom of the rear fuselage with 1/16 in. balsa and trim to shape. Cover the rear of the pylon area in 1/16 in. and the front of the pylon in 1/8 in. balsa in the same way. Fill in the top of the pylon with 1/16 in. balsa grain crosswise. Make the wing platform from 3/32 in. ply to the shape shown. Score lightly along the centerline mark, and carefully crack the plywood part way through along this score line. Hold the platform to the wing lower surface so that it takes up the wing dihedral angle. Run a small amount of CYA into the scored area, being careful not to glue it to the wing! When it has set, fit it to the top of the pylon as shown and glue in place. Fit wing hold-down dowels at the front and rear of the pylon as shown and secure. Fit the two 3/32 x 1/8 in. hard balsa rails to the top of the pylon to accommodate the wing dihedral and complete the wing mount. Trial fit the motor to the front of the fuselage and mark where the wires will go through the 1/8 in. pylon front. Make a 1/4 in. hole here and reinforce the rim of it with CYA.

Make the stab mount from 1/32 in. ply to the shape shown, and glue a piece of 1/8 in. sq. basswood to the leading edge to act as a stab stop. Glue it to the top of the fuselage as shown. Fit a length of 1/16 in. dowel through the fuselage just to the rear of the front of the stab mount. Place the stabilizer on the mount and mark the position of the stab DT hole on the fuselage. A piece of 1/16 in. aluminum tubing bent into a curve will serve as a conduit for the DT line. Fit this through the fuselage at the DT mark

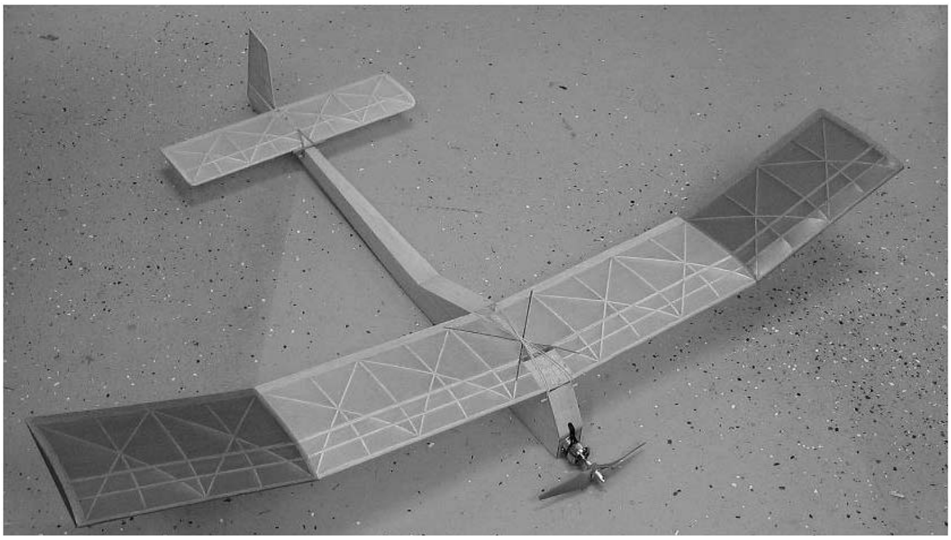


Fig. 12 A top view of the completed " Slick Willie" shows its undeniable British lines: geodetic wings with a simple planform, medium height pylon and rear fin remind us of many great designs of the 60-70's.

the ESC to the motor. Carefully place the ESC into its hatch, ensuring the switch is clear to fit, and secure the ESC hatch in place. Connect the timer lead to the timer and secure the timer/ DT panel in place. Ensure the switch is in the "off" position and connect the battery. Hold the plane well clear of any obstacles and turn the switch to the "on" position. Press and hold the start button on the timer. The motor will start and ramp up to speed. Release the button and the timer will start to count down. Check that the motor run is as set, and that the DT time corresponds to the one dialed in. You're ready to go flying!

and secure it. Make a loop in a piece of monofilament or Dacron line and feed the other end through the conduit. Bring the line down the side of the fuselage to the timer and mark where it will fit on the DT release arm. If you are using a spring to tension this line, take this into account. Slip a small piece of 1/16 in. aluminum tubing over the DT line and push it down towards the stabilizer. Do not secure it at this time. Make a loop at the DT arm mark and check to see that you have enough tension when it is placed over the DT arm. When you are satisfied, hold the stab down and release the DT loop. Slowly let the stab rise to its DT position (about 45 deg) and mark where the DT line enters the conduit. Position the 1/16 in. tubing at this mark and crimp it with a small pair of pliers. Place a tiny amount of CYA on the tubing just for good measure (be careful not to get any in the conduit!) Set the DT line on the timer again and ensure that when the line is released the stab pops up reliably to its desired position.

Covering

Cover the wing and stabilizer with good tissue, and water shrink. When dry, give all the surfaces two- to three coats of nitrate dope thinned to 50%. Sand the fuselage all over down to 400 grit, and then give it four coats of 50/50 dope to seal it. Remove the hatches and dope them separately during this operation, or they may cease to be hatches!

Electrical System

When all is dry install the electrical components. It is a good idea to assemble the electrical system on the bench and try it out first. Run it without the propeller on for this test, and make sure the motor runs in the right direction. If not, swap any two of the motor leads. Dial in a motor run and a DT time and check that the system works as required. When satisfied, mount the motor and feed the wires through the pylon hole into the ESC space. Place the ESC near the hatch and feed the timer lead through the mid-wing former, through the battery space, and out the timer hatch. Feed the battery wires through the former and into the battery compartment. Place a piece of Velcro fuzz material on the far wall of the battery hatch. Add a small piece of the hook material to the battery, so that it will stay in place when in the hatch. Connect the three wires from

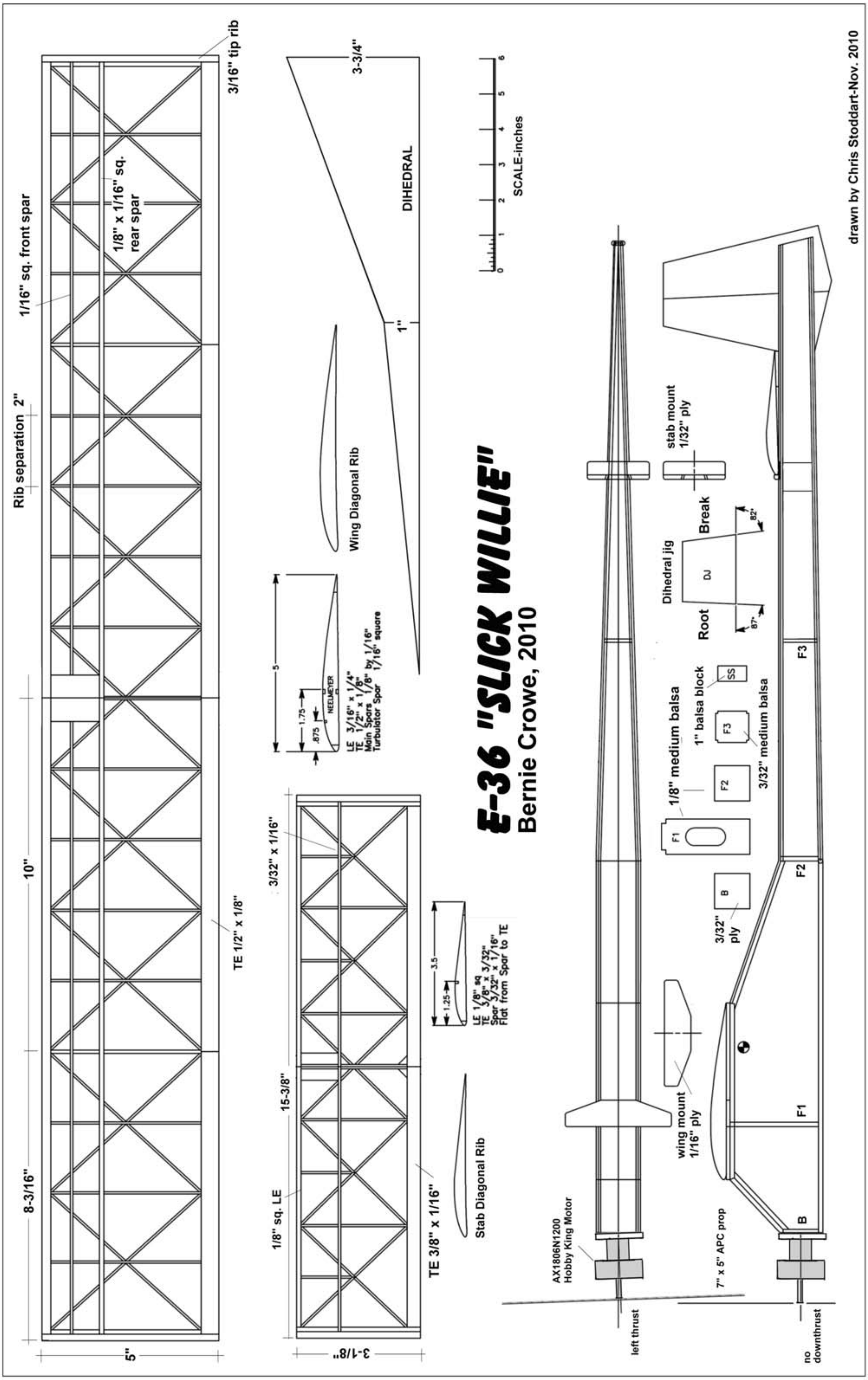
Trimming and Flying

Assemble Slick Willie with a battery in place. Check to see that the CG is at 75%, 3-3/4 inches behind the wing LE. Adjust if necessary. Test glide and adjust using small shims under the stabilizer TE until a floating glide with no serious stall tendencies is achieved. Use small trim tabs cut from stab TE stock to achieve a slight right turn. Attach the tabs to the upper rear TE of the fin using a glue stick to allow easy repositioning. When all seems OK, set the motor run for about 4 to 5 seconds at full power. If your timer will allow you to DT at the end of the power run, select this. Otherwise, set the shortest DT time your timer will allow. Switch to the "on" position and press the start button.

Release the plane at about a 30 deg climb angle and let it fly out of your hand. Observe the climb carefully. If the plane wants to climb to the left, stop this immediately with more right trim tab on the rudder; left climbs with high-powered electric models are often fatal. If the model turns too tightly to the right, add a small shim behind the motor mount pedestal to give it left thrust. Use small (less than 10 thousand in.) shims to start and increase only as it seems safe to do so. When the model makes a half-turn to the right in a fairly steep climb, increase the motor run to 8 seconds. Make sure the climb is not diverging from the pattern you have established, and observe the transition to the glide and the glide itself. Adjust the stab shim if the glide is too steep or if the plane stalls.

When you have the glide to your satisfaction, increase the motor run to 10 seconds and try again. The model should attain good altitude and glide well. If the transition into the glide is poor, try increasing the left thrust shim and increase the right rudder tab to compensate. A little trial and error should bring the plane into compliance in a few flights. If the climb is still shallow and too tight to the right, increase the built-in wash-in in the right inner panel by adding a trim tab made from wing TE stock to the bottom wing TE just inboard of the dihedral break. When all looks good, crank up the motor run time to the full 15 seconds and watch as your creation climbs high into the blue. Enjoy!

Readers will find useful to check the full NFFS E-36 2011 rules set, which can be found in the NFFS website: <www. freeflight.org> Ed.


E-36 "SLICK WILLIE"
Bernie Crowe, 2010
drawn by Chris Stoddart-Nov. 2010
3/16" tip rib
1/16" sq. front spar
1/8" x 1/16" sq. rear spar
Rib separation 2"
10"
8-3/16"
5"
TE 1/2" x 1/8"
3-3/4"
DIHEDRAL
1"
Wing Diagonal Rib
LE 3/16" x 1/4"
TE 1/2" x 1/8"
Main Spars 1/8" by 1/16"
Turbulator Spar 1/16" square
NEELMEYER
3/32" x 1/16"
15-3/8"
1/8" sq. LE
TE 3/8" x 1/16"
3-1/8"
LE 1/8" sq
TE 3/8" x 3/32"
Spar 3/32" x 1/16"
Flat from Spar to TE
Stab Diagonal Rib
SCALE-inches
stab mount 1/32" ply
Break
Dihedral jig
DJ
Root
82°
87°
1" balsa block
SS
1/8" medium balsa
3/32" medium balsa
F1
F2
F3
B
3/32" ply
wing mount 1/16" ply
AX1806N1200 Hobby King Motor
7" x 5" APC prop
left thrust
no downthrust