SHORT SOLENT Mk IV
BY IVAN PETTIGREW
CONSTRUCTION NOTES

This model was designed to use the GWS Speed 400 geared drive motors and the GWS 9x7 three blade props. At the present time GWS only makes three blade props in one size, so it is fortunate that they are just right for the scale of this model. The same can be said for the 35 mm three blade spinners. The props come in orange, but can be painted with Krylon spray can paint. It is very light and covers well. The GWS spinners are rubber, but can also be painted with Krylon. The paint may peel with flexing of the rubber. Installation of the spinners is no trouble, but removing them without cracking the paint is a challenge. Details on gear ratios are given in the summary at the end of the construction notes.

For ease of construction and weight saving, the wing of the prototype was built in one piece. Builders who find the wing too large for convenient handling could build it in three pieces with the outer panels being detached from the point where the ailerons start. The easy way to connect the ailerons then is to put the aileron horn right at the inboard end of the aileron, and the aileron bell crank as far out as possible in the last bay of the main section of the wing, just behind the nacelles of the outboard motors. The aileron pushrods can then be run diagonally across the ribs where the outer panels join the main wing. The Solent has a very high fin and rudder, so to help in transportation, the prototype was build with the upper half being detachable. This again is optional. The tip floats can be removed for transportation, but with careful handling, this is not necessary, and assembly at the field is very easy without the need for any tools.

The airframe construction is very light, but adequately strong for all flight stresses. The maiden flight of the prototype included the customary loop just to prove to the skeptics that it was built strong enough. However, during construction it may appear to be very flimsy. Please resist the temptation to use thicker wood than specified. When finishing details and covering are added, the airframe will become quite rigid. Think in terms of building a park flyer. With the light wing loading of this model, maybe it should be termed a “pond flyer.”

Some builders of this type of model have described the components as being like spaghetti during construction, but have been amazed at how firm they are when completed. Old timers will relate to this in how rubber powered free flight models were built years ago. Don’t be discouraged if a few pieces break during the handling of the airframe during construction. Be patient; the end result will be fine.

The sizes given for the trailing edge stock may be non standard. That is because it suits the airfoil shape better, and this builder has always shaped trailing edges from regular strips cut from sheet balsa. All the strips for the longerons etc have been cut from sheet balsa using a stripper. Looking at the typical sheet of balsa and checking the density (hardness) with a finger nail, it can often be seen that one side of the sheet is harder than the other. The hard side makes for good strips which are better in quality than many of the ready cut strips that are available. The remaining softer part of the sheets can be used for bulkheads and other secondary components.

FUSELAGE

The fuselage is a simple framed up box with bulkheads added to the top and bottom. First build the two sides of the fuselage over the shaded sticks shown on the plan. Use 3/16 square balsa cross pieces to initially join the two sides together. The top and bottom bulkheads can be attached to these cross pieces later. Take note that the sides slope inwards slightly towards the top, the width of the fuselage at the top being less than at the bottom. The top and bottom sections of the sides of the fuselage are in two sections aft of bulkhead #9. The upper sections come together at the tail, while the lower ones come together at the point of the second step.

Add bulkheads and sheeting to the curved upper surface of the fuselage. The lower semi circular bulkheads from 10C to the tail should then be added to the bottom of the upper section of the fuselage and sheeted with light 1/16" balsa. The remaining part between the upper and lower sections of the fuselage are next covered with 1/16" sheet, but before proceeding to cover this area, read through all of the instructions and get the complete picture in your mind. While the shape of the outer skin on the section of the hull from bulkhead 10c to 12c is the most challenging part of the fuselage construction, it is not as difficult as it might seem. My problem is not in doing it, but in explaining it in words that make it easy to follow.

The sides of the fuselage are just sheeted from the bottom up to a point an inch or two above the water line. This sheeting is straightforward from the nose back to bulkhead 9. To sheet the lower section of the sides from bulkhead 9 to the end of the second step, including the 3/32" balsa fillet attached to the keel bulkhead between 11C and 12C, use a single piece of 1/16" balsa. The bottom part of this sheet is glued to the side (lower section) of the secondary step. The top curls out to meet the sheeting that was earlier applied between bulkheads 10C and 12C. It is much easier than it sounds, especially if this 3" wide piece of sheet is dampened before applying. Most modelers attempting a project like this have built a low wing scale model like a Spitfire that has a gusset where the trailing edge meets the fuselage. One way to visualize this is to lay the fuselage on its side, and think of the 3/32" gusset at the end of the second step as being the gusset where the trailing edge of a Spitfire meets the fuselage. Forward of the main step, the bottom of the hull is covered with four strips. Start by attaching the outer strips as if this was a flat bottom hull. Next attach the triangular bulkheads, 1B to 6B, then the inner two strips that form the "V" section of the hull. This results in the bottom of the hull having a concave contour. This shape really helps in reducing spray and getting the model on the step promptly. The Sealand will take off easily with about 75% power. Use of reduced power during take off adds much to realism by lengthening the take off run.

TAIL SECTIONS

These are of conventional construction. Notice that the spar (post) for the fin goes down through the stab to cross pieces that are attached to the top longerons of the original "box" part of the fuselage. This adds strength to the mounting of the fin. Before starting construction of the tail surfaces, it is best to make all of the spars and hinge them carefully. Notice that the stabilizer has slight dihedral. Glue the two pieces of the stab spar together over the plan to get the correct dihedral angle. While making the first half of the stab, prop up the other end of the spar. When completed, prop up this half while the other half of the stab is built. The tail surfaces have a symmetrical airfoil surface. This type of construction adds depth to the spar which makes for more strength, meaning that the tail surface can be built lighter than if a flat surface was built. It also resists warping better than a flat surface and makes for smoother flying. Because or the dihedral in the stab, independent control rods are necessary to the elevators. It is best to use nyrods and have a "Y" junction just forward of the stab leading edge. Lightweight nyrods should always be braced at each station along the fuselage to prevent "bowing" under load.

WING CONSTRUCTION

The wing is built in one piece. The basic airfoil is a Selig 7055, but outboard of the second engine nacelle it uses a NASA leading edge cuff to reduce tip stall tendencies. The wing construction is different from the usual, but is extremely strong for its weight. A full depth 1/16" sheet balsa spar is continuous throughout the wing The ribs are cut into two pieces where they meet the main spar, and are butted to the front and rear surfaces of the spar. First cut the main spar from 1/16" sheet balsa (yes, 1/16", but hard) and splice the pieces together over the plan so that the dihedral angle is correct. Now glue the hardwood strips to the top and bottom edges of the spar as indicated. These strips should be bass or spruce.

Cut all the ribs in two at the point where they join the spar. Assemble one half of the wing section with the spar of the other half propped up. It is best to start by attaching the rear half of each rib, then the trailing edge and secondary spars including the one used to hinge the aileron. The ailerons may be cut out and hinged later. Next glue the front section of each rib to the front face of the spar. Notice that the leading edge consists of two strips, the inner one of 3/32" sheet balsa, and the outer one of 3/16" balsa. Only the first (inner) strip should be applied at this time. Notice that there is a step in the leading edge where the cuff starts. The leading edge strips actually overlap, with a little spacer between in the area where this cuff begins.

Build the other wing panel over the plan by propping up the already constructed panel to the correct dihedral angle. Notice that the main spar is slightly swept back. For maximum strength at minimum weight, the spar was not cut and rejoined at the centre line to incorporate this sweep back. The spar is so flexible, that a gradual bend is incorporated. The correct way to build the second wing panel would be to prop up the completed wing panel and sweep it back at the same time while building the second panel over the plan. An easier way though is to build the second panel as if there was no sweep back. The inboard ends of the trailing edge will be a small distance apart. When these ends are later drawn together and joined with a doubler, the correct sweep back angle of the spar will be formed. The rest of the wing is now completed including the tips. Also install the 1/8" sheet balsa strips where the tip floats are mounted to the wing. Notice the 1/16" plywood plates that are necessary to hold the attaching screws.

Sheeting is now applied to the lower surface of the wing from the leading edge to the main spar. At this point the motor wiring should be installed running along the wing midway between the leading edge and spar. No 18 gauge wire was used in the prototype with independent wires to the inner and outer motors. It will be noted at this point that the wing is still not torsionally strong, meaning that it can easily be twisted. After the sheeting is applied to the upper surface from the LE to the spar, the wing will be very rigid and difficult to twist. Hence it is very important when applying the sheeting to the upper surface, to weight the wing down on a surface that is perfectly flat. The top sheeting should be applied in two stages, the first one being from the centreline out to the point where the wing cuff and the aileron start. There should be no washout in this section, so the wing should be weighted down flat. From this point to the tip there should be 3/16" washout. When the wing is weighted down with this amount of washout at the tip, the sheeting is applied to the upper surface of the outer part of the wing. The remaining strip of 3/16 sheet balsa that forms the outer part of the leading edge is now glued to the one in place and contoured to shape. Finally sheeting is added to the centre section and areas where the engine nacelles will join the wing.

TIP FLOATS AND NACELLES

The tip floats are built up and covered with 1/16" sheet balsa. Construction is fairly basic, especially for anyone who has built a set of floats. The struts are built into the floats. The struts are attached to the wing with #2 screws passing through small 1/32" plywood plates. The float struts are butt glued to these plates with epoxy. For getting the correct angle on these plates, it is best to screw the plates to the wing first, then with the wing resting upside down, glue the ends of the struts of the completed float assembly to these plates.

The engine nacelles are built by first gluing the 3/8" x 3/8" motor mounts in place, securing them firmly to the leading edge of the wing and the main spar. Next the nacelle bulkheads are made. Notice that there are small plywood plates glued to the rear of the first bulkhead, N1, where the cowlings attach. Before gluing the nacelle bulkheads in place, it is a good idea to make each cowling bulkhead, C2, that attaches N1, and drill the screw holes to get correct alignment. The nacelle bulkheads are then glued in place and the nacelles planked with 1/16” sheet balsa. To provide for cooling air to pass through the motor, outlets are cut on the inside wall of the lower part of the nacelles under the wing. In this location they are not noticeable to anyone except to the lower deck passengers. The nose rings of the cowling are cut out like doughnuts, and can be of one piece of thick balsa, or laminations. They are then shaped to the correct cross section and the cowling assembled. Do this by damping the 1/16” sheet covering that forms the cowling, wrap it around to form a sleeve and join the edges with CA glue. Check the fit of the nose bulkhead C1, and also C2. Since the cowl is slightly tapered, these should be slid in from the rear. If the cowl is too small or too large, a small sliver can be added or subtracted. When the fit is correct, apply regular wood glue to the bulkheads and slide into place.

CONTROL THROWS

Control travel for the elevators is 3/4” up and down. For the rudder it is 2 1/4” each way. The ailerons should travel 1 1/4” up, and no more than 1/2” down. Importance must be given to this amount of differential in the ailerons, and it will be achieved if the control arm on the aileron servo is made as shown.

At the start of the take off run in a flying boat, one of the tip floats will be in the water. It is necessary to lift this float out of the water using ailerons, or the model will want to turn in the direction of the float that is dragging in the water. Poor aileron design aggravates this problem in many models because of the adverse yaw that is inherent at larger angles of attack, such as while getting on the step. The down going aileron produces more drag than it does lift and turns the model in the wrong direction.

Two things are done in the design of the Solent to overcome this problem. Frise ailerons are used, and a substantial amount of differential is used in the aileron linkage. The position of the aileron horns affects the amount of differential. Placing them too far forward reduces differential. Putting them further back increases it.

At the start of the take off run, while holding “up” elevator to get on the step, advance the throttle just a small amount at first until the wings are leveled with both tip floats out of the water. When this is under control, advance the throttle further and relax on the “up” elevator as the model gets on the step and accelerates. With practice this becomes one smooth continuous movement.

A very slight amount of up elevator may be necessary at the point of lift off, especially if operating off glassy water. If a flying boat ever swerves while on the step during take off, it is an indication that there is not enough back pressure on the elevator stick, but don’t overdo any corrections. Because of the light wing loading, the Solent is like a park flyer and slows up quite fast during the landing flare if no power is used. Landings are more realistic if a small amount of power is left on right through the landing, and even while the model is still planning on the hull.

If the elevator throw is set correctly (very little on the Solent,) but the model tends to balloon in the flare for landing (elevator seems too sensitive) the CG is likely too far back. The motor battery should be moved forward about half and inch. In any landings on water, the model should be slowed gradually by holding off in the flare as long as possible, and the elevator stick should be well back before touch down, much as in doing a three point landing in a tail dragger.

In multi motor electric models, there is an increased risk of problems with radio interference from motor brush noise and also the increased length of wiring used for the motors. While it is always recommended to put a Schotky diode across the terminals of each motor when they are wired in series, it is not so critical in these smaller motors, especially when wired parallel. The normal capacitors should of course be used across the motor terminals, whether or not Schotky diodes are used. The wires carrying current to the motor should be kept touching each other, and twisted about one turn to the inch. The radio and servos should be kept as far as possible from the motors and motor wiring, but this is taken care of with the layout shown in the plans. Servo leads must be kept short. Do not use outboard servos for the ailerons. These would require long leads running along the wing parallel to the motor wiring, and they would be very prone to picking up interference. At the low airspeed of this model, one standard servo is ample to operate the ailerons.

Before using a speed control with BEC, think of the effect it has on taxiing back to shore at the end of the flight. Without BEC, if the battery is run too far down before landing, the motors will usually still run sufficiently to taxi back to shore. With a BEC however, the motor 'cut out' takes over, and it is necessary to call for the rescue crew.

COVERING AND FINISHING

Most of the airframe on the prototype is covered with low temperature film. Avoid the use of fabric type (….tex) coverings. They are heavy, and the powerful shrinkage could warp the light weight construction. Film covering does not stand up to repeated use in water, so the hull and tip floats are best covered with light tissue (silkspan) applied with nitrate dope. This should be done before covering the upper part of the fuselage with regular film or mica film. The silkspan should be applied to the entire hull, and up to the top edge of the sheeting on the sides, this point being a few inches above the water line. Be sure to prime the hull and tip floats by applying two coats of clear nitrate dope before covering.

When applying the tissue, first spray it lightly with water and rub it on to the surface while damp. Next brush a coat of dope on to the tissue. It will bleed through the tissue and cement itself to the primed surface below. After it has dried, apply at least one more coat of clear dope. The hull should be sanded after each coat of dope is applied, and when a smooth surface has been obtained, the colour should be applied. Krylon spray paint is known to be one of the lightest and most suitable for models of this type. When painting is completed, cover the remaining section of the fuselage. Allow about an inch overlap where the film joins the top edge of sheeting on the lower part of the fuselage sides. It should not be continued to a point below the water line.

EMERGENCY FLOTATION

With an electric powered model, because of the weight of the batteries and motors, there is not enough flotation to keep the plane on the surface of the water in the event of a crash, or the hull being punctured. Hence it is recommended that blocks of foam be placed in the fuselage, or even some of the wing bays. The small air sacks that are often used as packing are another option. When asked why the model of the Solent is so light, I point out the air bags and say that they are filled with helium. In the case of several multi motor flying boats that I have flown for several years now, I have fortunately never had to put these flotation devices to the test. But in earlier years I lost a flying boat with a single pylon motor following a crash due to radio failure. When I got to the crash scene, all that was floating was the wing and tail section that had torn loose. The weight of the battery and motor had taken the fuselage to the bottom of the lake complete with radio gear and ESC. Had it been a multi motor flying boat, the wing would have probably gone down as well because of the weight of the motors. Flotation is like insurance. You will only need it if you don't have it. For further details on flying boats, read the page about "Flying Boat Design" on Ivan's web page, www.ivansplans.com.

Enjoy building and flying your Solent
Ivan Pettigrew

Summary - Short Solent. Mk IV

March 2004. Scale 1:16.5. Span 82 in. Wing area 905 sq.in. Length 65 in. Airfoil, Selig 7055 with NACA leading edge cuff on outboard sections. Weight with eight RC1700 nicads, 83 ounces. Wing loading 13.2 oz/sq.ft. Four GWS Speed 400 geared drive motors, "E" series with gear ratio 3.4:1 driving GWS 9x7 three blade props (EP9070x3) and GWS 35mm three blade spinners. Motors are wired parallel, static current 35 amps at battery, 8.25 amps to each motor. Static thrust 48 ounces at 4,900 RPM. Flies for 9 minutes on eight 1700 mAh nicads and 15 minutes on nine 3000 NiMH cells. Alternate power would be "F" series gear drives with 3.9:1 reduction from nine nicads. This should give the same power for a 12% reduction in current, resulting in longer flight duration. If extra power is needed, the 3.4 ratio gear drive can be used on nine nicads resulting in a current close to 40 amps, still below 10 amps to each motor, so considered safe for these motors.

March 2005 update

The GWS 9x7 three blade props seem to be difficult to find now. The prototype MiniCat which uses the same motors and props as the Solent used to fly with the three blade GWS 9x7 props which looked very nice, but it now flies with two blade APC 9X6 slow flyer props. The static current draw is slightly less and the performance seems better. This change may not seem consistent with the usual rule of increasing prop diameter when going from a three blade prop to a two blade. The inconsistency here is because of going from one manufacturer to another. The MiniCat now has 65 flights on the original motors and they are holding up fine. The Solent is coming along a little behind with 60 flights and the motors are doing well.

August 2005
Both models have over a hundred flights on them now and all of the original motors are still running fine.

May 2007
If using Li-Poly cells, a 3S pack would be equivalent to a nine cell packs of nicads, and the “F” ratio of 3.9:1 would be recommended. The cells should be capable of a 40 amp discharge rate.

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