Diva, Part 1

Alyssa loves to fly the Blackbird XC.3, primarily because she’s discovered that she really likes flying large sailplanes. Driving home after a recent day of flying, she asked if we could build a Blackbird XC for her. We told her she could fly the Blackbird XC any time she wanted to do so and went on to suggest she look for another design for a building project.

Basis

We encouraged Alyssa to go through some of the material we have in our files to see if there might not be another large sailplane which would take her fancy. She worked her way through an old Dave Jones/Western Plan Service catalog, then began looking at some magazine articles we have on file. She gravitated toward Deiter Paff’s PN9f, a model we’ve covered previously in this column. After explaining that the planform looked good, but the structure would need changing, Alyssa announced she’d like to help draw up construction plans. She immediately had a name for the new creation — Diva!

The only “plans” we have for the PN9f consist of a three inch by four inch two-view published in *The White Sheet* “Flying Wing Special.” It’s reproduced here for reference. Luckily, most of the dimensions can be discerned. The first task involved converting the dimensions from millimeters to inches for our construction drawings.

The White Sheet article which accompanies the PN9f plans states the wing was constructed using an obechi covering over a foam core. The total weight is given as just under 60 ounces and the wing loading as 9.5 ounces per square foot. This is heavier than we’d like, so one of our goals during both the redesign and construction processes will be to build lighter than the original. We very much enjoy building with wood and using D-tube construction, so our initial concept gravitated toward a spruce spar system, balsa ribs, and 1/16th inch balsa sheeting. We settled on a rib spacing of three inches.

The original PN9f has a span of 3080 mm (just a bit over three meters, 121 inches) and a fuselage length of 920 mm (36 inches). The wing is of triple taper with a straight leading edge. The root chord is 370 mm (14.5 inches) and the tip chord is 125 mm (five inches). As we had chosen three inch rib spacing, the wing was set up such that the inboard panel spans 15 inches, the second spans 18 inches, the last spans 24 inches for a total of 57 inches. Adding three inch wing tips gives a single wing panel span of 60 inches. A fuselage width of two inches makes the full span 122 inches.

For ease of plotting, the root chord is set at 14 inches. The other panel breaks have chords of ten inches, seven inches, and five inches for the wing tip. This planform area is almost exactly 1000 square inches, 6.94 square feet. If we can keep the weight to 50 ounces, the wing loading will be 7.2 ounces per square foot.

The fuselage side view of the PN9f is not in keeping with what we now know about winch launching and landings on slippery grass. The original required a tow hook under each wing. We’re going to use the *MB* Raven style fuselage, where the single tow hook is mounted a short distance below the bottom of the wing. Additionally, we're adding a rather large ventral fin. This provides directional stability at high angles of attack when a portion of the upper area is blanketed by turbulent air. The added depth at the rear of the fuselage tends to drive the wing to a negative angle of attack once contact with the ground is made, preventing ground looping.

Off to the drawing board

After formalizing the various dimensions, a large roll of plain paper was opened and a long length attached to the drafting table. A horizontal line down the length of the paper served as the leading edge for both wings. Vertical lines were then dropped at three inch intervals to mark the locations of the wing ribs. The vertical lines associated with the panel breaks were identified and marked for placement of the trailing edge. It should be noted that nearly all of this measuring and line drawing was accomplished by Alyssa as she crawled back and forth across the flat surface, pencil and four foot straight edge in hand.

The elevator and ailerons were marked out using 25% of the local chord as the hinge line. We debated about installing flaps on the lower surface of the wing. In the end, we decided flaps would greatly complicate the construction process. Flaps must be located at 40% of the MAC and away from both the ailerons and elevator surfaces. On Diva, this forces the flap location to the rear of middle wing panel, not an ideal location. Additionally, there is the problem of extra weight. The flap structure and two additional servos would do nothing to help us achieve our flying weight goal.

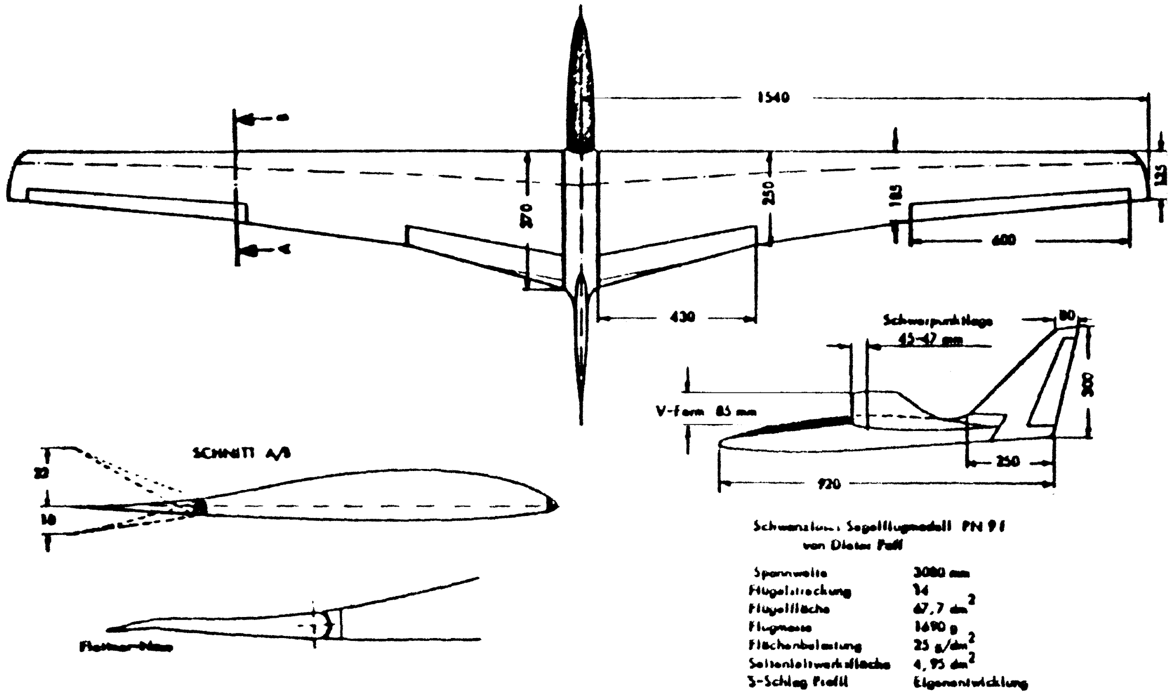
The fuselage turned out to be fairly easy to lay out, due in major part to our experience with the *MB* Raven and R-2. It will consist of balsa and plywood sides, thick balsa sheet for the upper and lower surfaces, and balsa block for the canopy area.

Modifications and preliminary decisions

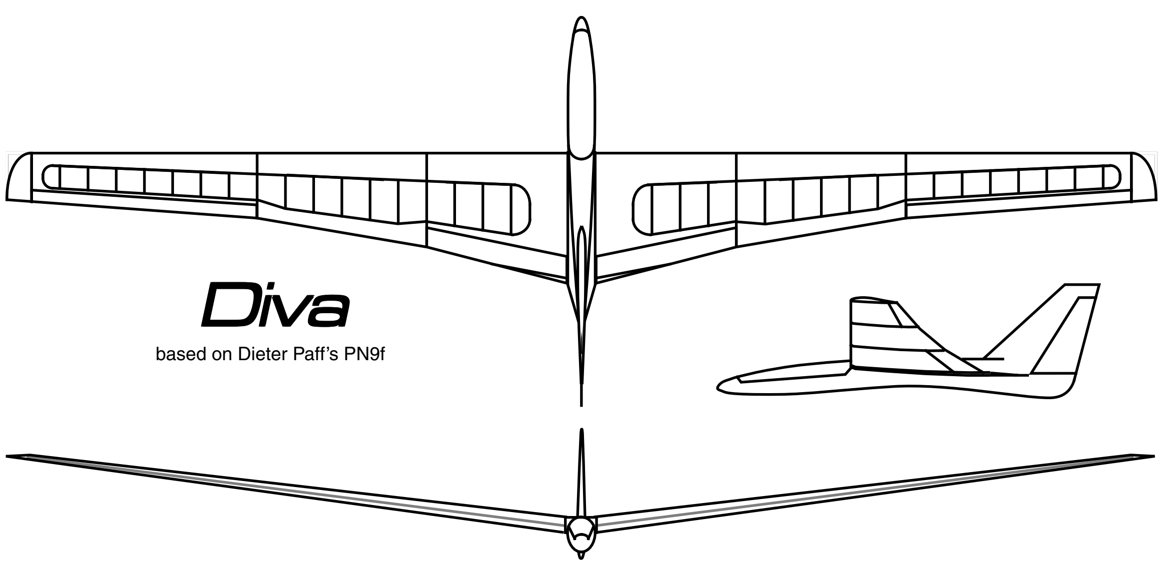
Another change to the basic PN9f design involves a preliminary increase of the geometric dihedral angle. Dihedral angles of just a few degrees are sufficient to provide the requisite levels of lateral and spiral stability, but dihedral angles of five to ten degrees have been shown, theoretically and in practice, to assist in maintaining well coordinated thermal turns. We've tentatively set the dihedral angle at seven degrees per side pending further research.

All of the control surfaces are rather large, so the chosen servos must put out substantial torque. The servo selection is as follows: the elevators will be driven by a single Hitec 605BB (76 in.oz.), the rudder by a Hitec 300 (42 in.oz.), and each aileron by one Hitec 225BB (54 in.oz).

The White Sheet sketch shows a “Flettner flap” on the elevator. The purpose of the Flettner flap is to counter the downforce produced by the control surface due to airfoil reflex. Despite the extremely high torque of the Hitec 605BB, we're going to use the Flettner flap. Part of this decision was based on plots of reflexed sections found in Dr. Richard Eppler's book, “Airfoil Design and Data.” Dr. Eppler's design of reflexed sections for full sized aircraft with trailing edge control surfaces includes a slight reversing of the reflex near the trailing edge. This camber line reversal does not substantially affect the pitching moment of the airfoil, but does reduce the mechanical load on the actuator while the control surface is around neutral. This is an important consideration, particularly when the aircraft is traveling at high speed, as in a prolonged sloping dive.



Dieter Paff's PN9f, reproduced from *The White Sheet*, Sean Walbank, editor.



Because of the forward swept hinge line of the elevators, some sort of universal joint is need when using a single driving servo. Sullivan Products makes a specialty fitting to actuate anhedral elevators on aerobatic aircraft. We're going to use this fitting in conjunction with separate control horns to actuate the elevator halves.

Our most difficult task involved finding an aileron servo with sufficient torque which would fit in the wing ahead of the aileron inner edge. To give an idea of the difficulty, the thickness of the JR 341 (32 oz./in.) which Alyssa used in her 2x6 exactly matches the height of the interior of the wing at the mounting location, one half inch. The Hitec 225BB, with its higher available torque, would be the ideal choice if only it would fit in the wing... Alyssa suggested we simply mount the Hitec 225BB servo closer to the fuselage, where the ribs are deeper. We quickly measured the thickness of a mounted Carl Goldberg 90 degree bellcrank and found that it would fit very nicely in the area ahead of the aileron. A music wire pushrod and bellcrank system much like that within the wing of Bob Dodgson's Windsong was sketched onto the plans. We can use a servo with relatively high torque to drive the large aileron surfaces, there will be no weight penalty over having the servo mounted further outboard, and we won't have to worry about long servo leads near the antenna.

The triple taper wing planform allows the inboard elevators to have sufficient moment while placing the ailerons close enough to the CG that differential deflection does not have an adverse effect on pitch. This allows aileron differential to be used, and the need for large rudder excursions is reduced.

The original PN9f used a specially designed section with a large amount of reflex. This section was used at the root, then progressively modified over the outboard portion of the wing to reduce the reflex and simultaneously achieve a near elliptical lift distribution. We've chosen Barnaby Wainfan's BW 05 02 09 section for this project due to its relatively low positive pitching moment and otherwise excellent performance on plank planforms. The low pitching moment should allow us to use the same section across the span, thus eliminating the need to modify the section and impart wing twist to account for various zero lift angles, and the lift distribution should be acceptable.

We've included a small 3-view of the revised aircraft along with a reproduction of *The White Sheet* illustration. Comments are welcome! We are especially eager to hear from *RCSD* readers who would like to have full size construction plans be made available.

Suggestions for future columns are eagerly received at either P.O. Box 975, Olalla WA 98359-0975 or <bsquared@appleisp.net>.

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