On the ’Wing... #152

Dave Jones’ R-2, Part 2

This installment will be devoted to wing construction. The planned modifications to the wing include a change of airfoil, reducing the original polyhedral to simple dihedral, and adding ailerons. The primary focus of this article will be how those modifications have been realized.

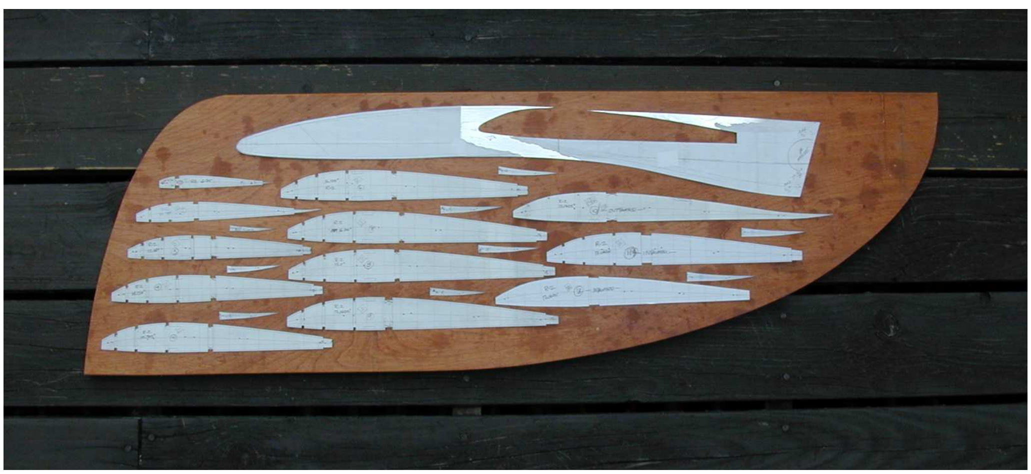
The airfoil

The airfoil shown on the R-2 plans is the CJ-3406. This section has 4% camber and is just 6% thick. The R-2 was not designed for high winch loads, yet the wing structure does reflect the structural difficulties incurred when using such a thin section. Notable is the use of 3/32 inch balsa sheet in those areas of high loads — the main wing center sections and the area where the wing rods are located.

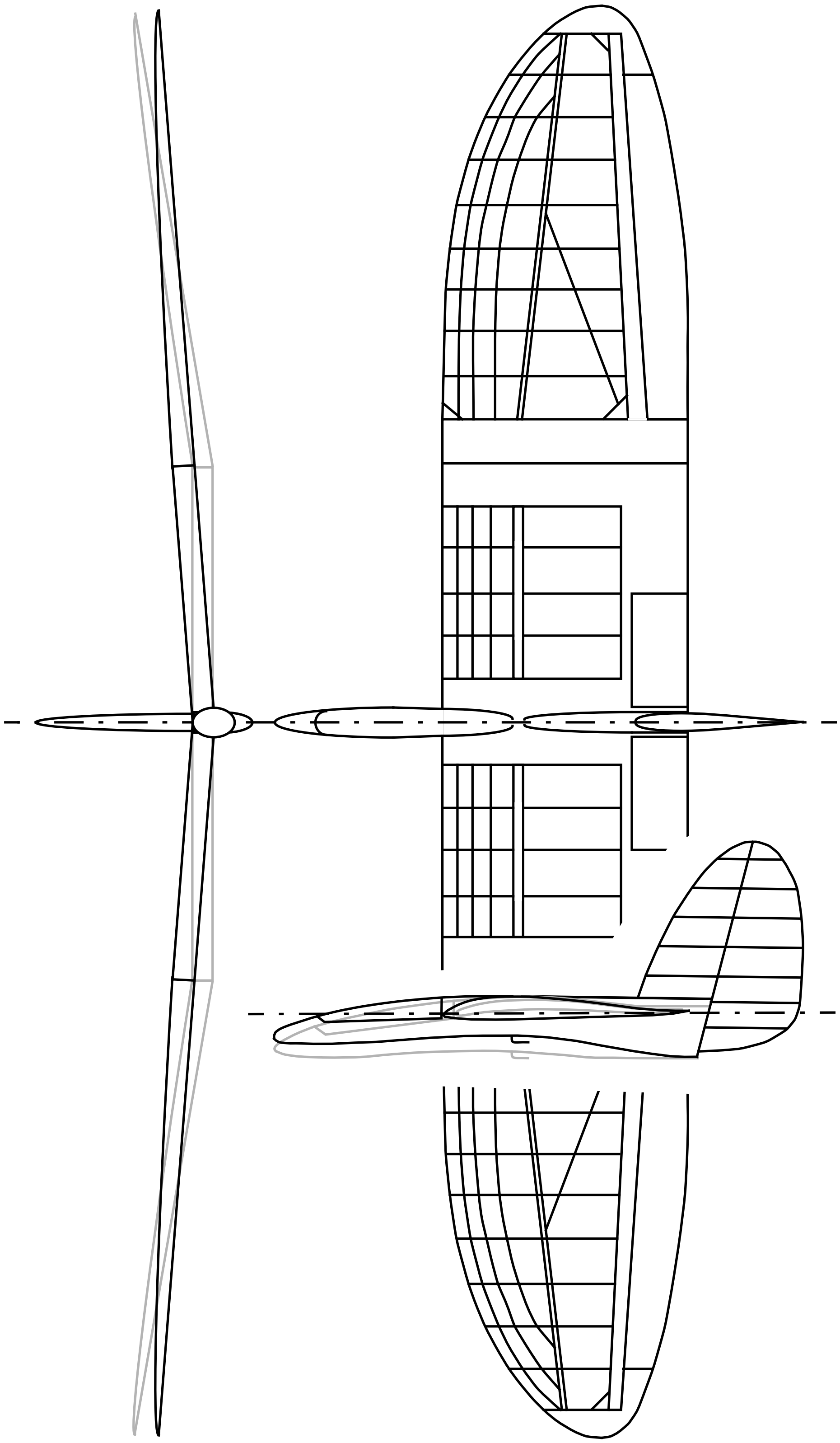
We decided early on to use the CJ-25^{2}09, a section with which we’ve had a lot of success. This allowed us to replace the 3/32 inch balsa sheeting with sheeting of 1/16 inch thickness, while using the same spar structure. The sheeted portion of the structure is thus significantly lighter, but that savings is partially offset by the larger ribs and the additional sheeting needed for the aileron structures.

Since we had already made nearly all of the templates for the various wing pieces, our first project consisted of cutting out all of the wing, elevator, and aileron ribs. This used up nearly five 4" by 48" pieces of 1/8 inch balsa. We put numbers on everything as we went along. Several templates are so similar to each other that having some means of rapid identification is necessary.

We’ve become accustomed to building on a large piece of ceiling tile and an equally large piece of glass, and the framework for the R-2 is being constructed on these two surfaces. For the R-2, we initially placed the plans on the ceiling tile and assembled the entire bottom surface first. This included the lower spar caps and all of the sheeting. Using a steel machinist’s block, all of the ribs were then glued in.



The R-2 templates: fuselage sides, wing, elevator, and aileron ribs all rest on the 3/4" plywood form for the fin leading edge (left) and wing leading edge (bottom right).



From polyhedral to dihedral

The R-2 was originally designed to use a flat center section and separate outer wing panels using five inches of dihedral at their tips (10.5 degrees). Our tack was to use simple dihedral, four inches (4.5 degrees) per side, with a break only in the center of the wing. A heavy plywood shear web made from two layers of 1/8 inch plywood and extending outboard two bays takes care of the anticipated loads. Webbing made from 1/8 inch vertical grain balsa is used for the remainder of the wing center section

The plywood dihedral braces/wing rod receptacles in the outboard portion of the wing remain, made taller by the thicker wing section.

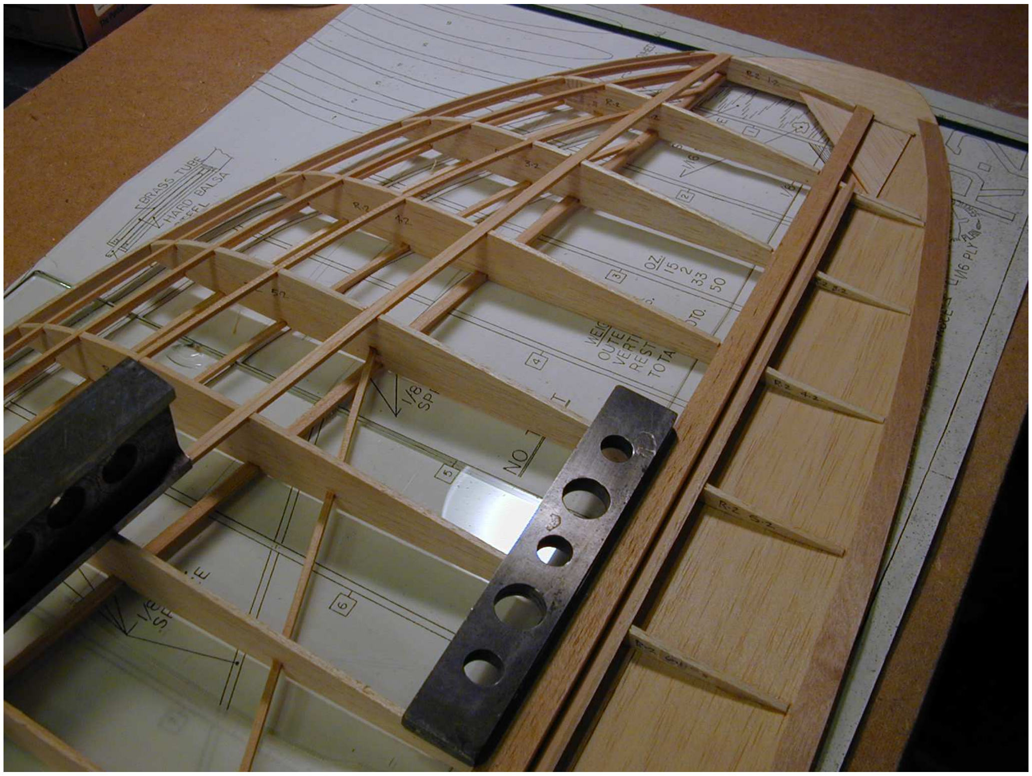
Spar webbing for the outer wing panels consists of 3/32 inch vertical grain balsa for the first open bay, then 1/16 inch vertical grain balsa for the second and third. Because the spar caps do not taper, and the airfoil is so thick, there is no spar webbing in the outer bays.

Laminating the leading edge

The progressively curved leading edge of the outer wing panels is a lamination of four layers of 1/16 inch balsa sheet. As can be seen in a couple of the photos, we made a form for the laminating process. The inner outline of the leading edge was traced from the plans onto a large piece of 3/4 inch plywood, and a long arm jig saw was used to cut the curve. Some sanding with course PermaGrit attached to an aluminum T-bar smoothed the contour to final shape. Paraffin was then rubbed over the open edge to seal it against moisture and prevent the parts from sticking.

Long strips of 1/16 inch by one half inch balsa were cut from an appropriate sheet, wetted with warm water, and taped to the form. This preliminary lamination was allowed to dry

Laminating the leading edge.



Construction and placement of the right aileron

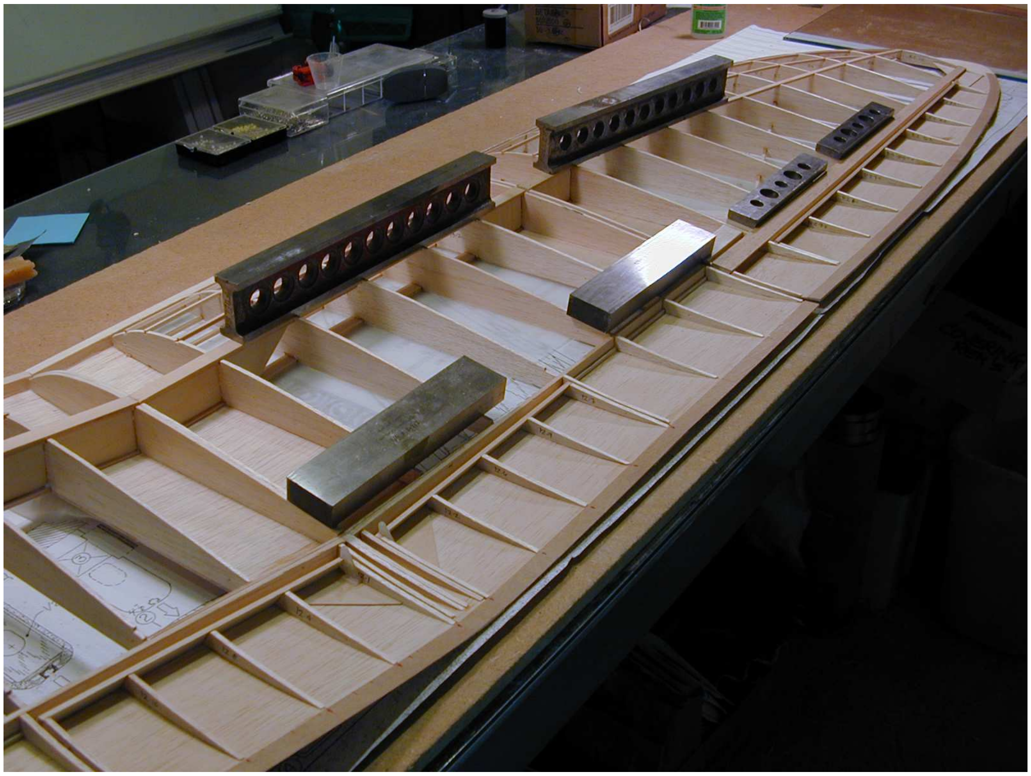
overnight. Upon removing the tape strips, we found the curve to be fairly well set in all four laminations. The first lamination was taped to the form at the ends, and then other layers were progressively added using CA glue as the adhesive. A few minutes later, all of the tape was removed, and the formed leading edge compared with the contour on the plans - a nearly perfect match! The completed leading edges were glued directly to the ribs.

Adding ailerons

Sizing the ailerons posed little difficulty. We knew the portion of the span they were to cover, and simply computed a width of around 20% of the wing chord for the broader portion. The sheeted trailing edge depicted on the plans was extended forward about one inch so it could form a stiff trailing edge for the main wing and a hinge point for the aileron. A length of 1/8 inch balsa forms the trailing edge webbing for the wing. The fronts of the aileron ribs were cut to a 30 degree angle before installation, and a second piece of 1/8 inch stock was trimmed and then glued in to form the leading edge of the aileron. A razor plane was used to get the upper portion of the aileron leading edge to match the rib contour across the span.

The entire wing was constructed on a flat surface so that the bottom of the wing forms a plane. This allows the ailerons to be hinged from the bottom, as has become our practice, despite the compound parabola of the wing.

A template for the aileron sheeting was made from aluminum flashing material. This template was also used when cutting out the 1/64 inch plywood trailing edge reinforcement.



The nearly completed wing. Missing servos and wiring, some spar webbing and top surface sheeting, plus the elevator control system.

JR 101 servos are being used to power the ailerons. These servos are slightly lighter than the JR 505s we're going to have in the fuselage to actuate the rudder and elevators.

The elevators

Since the center of the wing is bent to form the dihedral, it's somewhat difficult to fabricate and install a torque tube arrangement to drive the elevators. We initially chose to instead drive both elevators through a single servo using a forked control cable. This does pose some geometry difficulties when hooking up the connection to the servo, but we thought we could handle that problem. In the end we reverted back to the torque tube assembly. This involved major revisions to the wing center section. We'll cover both the problem and our eventual solution in the next installment.

In the initial setup, the GoldenRods serve as the push-pull connections between the servo and the elevators. Because there is no area above the wing to run the pushrod assemblies, we drilled appropriately sized holes in the dihedral brace and leading edge sheeting. The photo of the completed wing may have enough detail that this elevator hook-up can be discerned.

The elevators on our version are somewhat simplistic affairs. The 1/8 inch ribs are between two layers of 1/16 inch balsa sheeting, and the control horns are glued to a rather large triangle of 1/32 inch plywood which spreads the loads over a greater surface. The trailing edge of the main wing is reinforced with 1/8 inch balsa webbing, and the elevator leading edge is 1/8 inch stock as well. The elevators are bottom hinged, as are the ailerons.


Bill and the completed R-2 wing structure.

Completion

The plans show a curved trailing edge stiffener composed of two strips of 1/16 by 1/8 inch spruce, laminated to be 1/4 inch wide, and 1/16 inch plywood. This stiffener is placed between the upper and lower 1/16 inch balsa sheeting. Unfortunately, while it does make the trailing edge stiff and strong, it also makes the trailing edge thick enough to adversely affect performance. We've used 1/64 inch plywood for this purpose in the past, and so felt confident using the same materials and methods here as well. The completed ailerons are very stiff, and the trailing edge turned out to be more than sufficiently strong.

The upper surface sheeting was glued on once all of the internal structure was complete. It's imperative that the wing structure be firmly placed on a flat surface during this process, as any warps built into the wing at this point are extremely difficult, if not impossible, to remove. Appropriately sized pieces of trailing edge stock were used to maintain the proper reflex along the entire wing span as the sheeting was applied to the aft portions of the wing.

Rather than use a balsa block for the tip of the wing, we used 1/32 inch plywood for the bottom surface and then added sheet balsa triangles from the last rib to the wing tip outline. The resulting structure is lighter, and the transparent covering will allow this detail to be seen.

We're pleased with the final structure. It is very light — just 36 ounces including servos, wiring harness and wing rods, before covering. The curves are just as beautiful as we had anticipated!

The next installment

The next installment will cover construction of the remaining major parts. Special attention will be paid to the servo-elevator connections within the fuselage and the techniques used in putting together the fin and rudder.