HORIZONTAL SPAR DETAIL
BUSHING
3/32" OD BRASS TUBING
90 DEG WHEN STABILATOR IS
IN NEUTRAL POSITION
NEMESIS II
1970 NATIONALS OPEN COMBAT WINNER
DESIGNED JULY 1963 BY HOWARD M. RUSH
DRAWN FOR AAM BY HOWARD M. RUSH
WING SPAN 39 in. AREA 339 sq.in.
ASPECT RATIO 4.49
ALL MATERIAL BALSA UNLESS
SPECIFIED OTHERWISE
(re-drawn in CAD drawing by Gary James)
STABILATOR
4-6 LB C-GRAIN
SHAPE TO 10% THICK AIRFOIL
CONTROL HORN
HINGES 1/16" WIRE
DU-BRO KWIK-LINK
1/2" BALSA BLOCK
NOTE THAT GRAIN RUNS VERTICALLY
GRAIN DIRECTION
ENGINE MOUNT ASSEMBLY DETAIL
BOOMS
3/16" BASS
PUSHROD
1/16" MUSIC WIRE
BELLCRANK MOUNT DETAIL
TRAILING EDGE
1/16" 10-16 LB C GRAIN
2 REQUIRED
TIP
4 - 8 LB C-GRAIN
2 REQUIRED
LEADING EDGE SHEETING NOT SHOWN ON THIS SIDE FOR CLARITY
RIB
1/8" 8-12 LB
END OF CENTER
SHEETING IF
PLASTIC FILM
COVERING MATERIAL
IS USED
RIB
1/8" 8 -12 LB
C GRAIN
LEADOUT GUIDES
3/16" BRASS TUBING
FLATTENED AND BONDED
TO TIP WITH EPOXY
CENTER SHEETING
1/16" 6 - 8 LB
CENTER RIB
3/16" 8 - 12 LB
2 REQUIRED
RIB
1/16" 4 -6 LB C GRAIN
8 REQUIRED
VENT AND DRAIN HOLES
TOP AND BOTTOM
SPAR
1/4" X 1/4"
2 REQUIRED
PEN BLADDER
ACCESS HOLE
BELLCRANK MOUNT
1/8" PLYWOOD
ENGINE MOUNTS
3/8" X 1/2" MAPLE
PARTIAL RIB 1/16"
LEADING EDGE
3/8" X 3/8"
OPTIONAL HORIZONTAL SPAR
1/16" OR 3/32" 10-16 LB
PEN BLADDER TUBE
ESTES MODEL ROCKET
BODY TUBE SIZE BT-55
ENGINE MOUNTING HOLE LOCATION
SHOWN FOR SUPERTIGRE G21 .35
NACELLE - 1/2" 8 -12 LB
LEADING EDGE SHEETING
1/16" 3 - 6 LB A GRAIN
LEADOUT POSITION SHOWN FOR .018" LINES

Nemesis II

by Howard Rush
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The Nemesis II is the result of an extensive research and flight test program followed by nine years of refinement in competition Combat flying. The design objective of the Nemesis was an aircraft that would be a shade faster than the competition in level flight, turn much faster and tighter than any opponent, be able to survive most crashes, and be stable and easy to fly. This objective was realized by finding an extraordinary airfoil and carefully working out a structure and controls to complement it.

The airfoil is a modified NACA four-digit section which is capable of an unusually high maximum lift coefficient with a high lift/drag ratio at high lift, as in tight maneuvers. Because a small deviation from the correct airfoil can cause a plane to lose these desirable characteristics, it was necessary to use a sheeted leading edge on the Nemesis to avoid airfoil anomalies caused by covering material dipping between ribs near the L.E.

The control system of a Combat plane is simple, but details of stabilator configuration, stabilator and leadout positions, and control linkage can make a big difference in how a plane flies. The Nemesis II uses an airfoiled stabilator which operates pretty far behind the wing. A decent airfoil is needed on a stab for good control response and low drag, but it is not necessary to be as particular about airfoil shape here as on the wing because less maximum lift is required of the stab. I have been using long tails on Combat planes since 1961. Somebody maintained that short planes turn quicker than long planes and Combat fliers believed it for years. Actually, a stab which is next to the wing TE can cause flow over the wing to separate, causing a stall at low lift which badly inhibits a plane's performance. A stab placed farther aft will cause much less interference with the wing. The longer tail also increases stability for a given CG location. The greater leverage and farther aft allowable CG reduce induced stabilator drag. A nontechnical explanation of why planes with shorter tails do not necessarily have faster control response is given by F.A. Cleveland in "Size Effects in Conventional Aircraft Design," AIAA Journal of Aircraft (Nov.-Dec. 1970, pp 483-512)

Of course, a long tail requires a heavier structure and increases moment of inertia, so there is an optimum stab position. Position is not too critical, but that shown on the plans has worked best-credit for finding this distance goes to Brooks Herndon of Kansas City. Incidentally, the Nemesis tail assembly works very well on a Voodoo.

Structure for the Nemesis II has grown heavier as engines have become more powerful during the last nine years and weak spots have been corrected. Fliers who hit the ground a lot or who fly in windy places should lean toward heavier wood and should include the horizontal spar. This spar adds effort and weight, but can save the plane in crashes. Weight of the plane without fuel is 16 1/2 to 20 oz. Mine usually weigh 18 oz. with an 8 1/2 oz. engine, using the horizontal spar.

Construction

Throughout the construction of the Nemesis II the builder should keep in mind that the airfoil is very important and care must be taken to avoid an anomaly in the shape of the wing. Density and grain are specified on the plans for many balsa parts. If you are not familiar with balsa selection, see the first pages of the Sig catalog or ask someone who flies FF.

Begin by gluing the maple engine mounts to the 1/2" balsa block with Titebond or epoxy. Several coats of glue are necessary on the block because a lot soaks into the end grain of the wood. When this is dry, grab one mount in each had and pull on them like a wishbone. If the assembly doesn't break with a good tug it can be used with confidence on a plane. If it does break, reglue and try again. Now sand the mount assembly on a flat surface so that both faces are flat. This prevents damage to the engine from mounting on an uneven surface. Drill engine mounting holes and install blind nuts. Glue the left-hand 3/16" center rib to the engine mount assembly, making sure that it is aligned so the thrust line is straight ahead. When this dries, cut a slot in these parts for the bellcrank mount with a jigsaw, then glue on the right-hand center rib.

Sand the rear corner of the 3/8 sq. in. LE so there is a 1/16" wide edge to glue to the horizontal spar. Without gluing, hold the LE to the horizontal spar with small rubber bands and slide the ribs and center assembly on the spar. These will hold the LE in position. Remove the ribs one at a time from the horizontal spar, add a dab of glue, and slide them back on. Glue the LE to the ribs and spar. Don't attach the center assembly yet. Make sure everything is square, allow to dry. Now add the center assembly, bellcrank mount, lower spar, and outboard 1/8" rib.

The pen bladder tube is Estes model rocket tubing, size BT-55. If this is not available, the paper tub from a roll of Baggies will work. Fuel-proof the inside of the tube with epoxy, FasCal or polyurethane varnish. Coat the 1/8" balsa end plugs with epoxy and insert them in the ends of the tube. Now add the bladder tube assembly and top spar to the structure. Glue the partial rib in place between the bladder tube and LE.

Chamfer the 1/16" TE pieces as shown in the side view. Place the lower half on a flat surface and position the ribs on it by propping up the front of the wing. Glue ribs to the TE and pin them to it to dry. When dry, add the top half of the TE. glue, and clamp together with a lot of pins and weights. Install the 3" Veco bellcrank and pushrod. No Z-bend or retainer is necessary because the bellcrank mount keeps the pushrod in place. Note that the pushrod goes in the hole closest to the pivot of the Veco bellcrank. Poke the leadout wires through the holes which you were so clever to drill in the ribs before starting construction.

Leading edge sheeting is best done with epoxy because it stays wet for awhile after it is put on a surface. Take a tiny brush and pain epoxy on the top of the spar, ribs and LE on the top side of one wing; then hustle the rest of the mixed epoxy to the freezer where it will stay unhardened until you are ready for the next piece of sheeting. Pin the super light 1/16" sheet to the 1/4" sq. in. spar, then bend it over the ribs and pin it to the LE, pulling forward a bit as you bend. Make sure the sheet is down against the spar, LE, and all the ribs. If it sticks up anywhere, the resulting bump will hurt performance. Repeat this procedure on the same side of the other wing. When dry, run a knife or razor blade along the bottom front edge of the LE sheeting to cut off excess top sheeting. Save the excess to make cap strips. Now sheet the bottom of the LE. Add cap strips and center section sheeting. Cap strips are easier to work with and follow the rib shape better if they are cut from very light sheet such as that used for the LE sheeting. Strips of balsa available in the hobby shop are usually made from very hard stock.

While sheeting the center section, check alignment of the two 1/8" ribs by looking are the structure from behind to make sure the TE is parallel with the rest of the wing cross the enter section. Twist out any warps in this section *now* because they are hard to get out after the glue on the sheeting dries. The pushrod exits through a 1/6" dia. hole made from a notch in the TE and an adjacent notch in the center sheeting. This hole serves as a pushrod guide. Because the pushrod is straight, 1/16" music wire is more than adequate.

Sand the entire wing using a block and silicon carbide paper. Make a template to check the leading edge contour against the plans. Note that the LE is quite blunt. Finish sanding with No. 400 paper on a block. Be sure to remove any sharp corners or discontinuities in joints at the surface. Radius slightly the rear edge of the 1/16" LE sheeting to avoid a sharp corner in the covering material.

Now add the nacelle and wing tips. No tip braces are used because they are structurally unnecessary and they cause nasty air flow. Epoxy brass leadout guides to the tips. Carve and sand the engine pod to shape; cover it with silk and dope. The wing is now covered with either pure silk or FasCal; other covering materials are unsatisfactory for this type of structure.

The stabilator is carved and sanded to an airfoil shape and is covered with silk. Shaping is easier if a centerline is drawn around the uncarved stab; place a ballpoint pen on a table top so that the point is exactly 1/8" from the surface of the table; then, holding the pen stationary, move the stab past the pen point to draw the centerline. While covering the stab, warp a two-in. bandage of silk around the basswood booms just behind the TE to keep them from splitting. When silked, the bass booms are much stronger than plywood booms of the same weight. Cut grooves in the stab for the wire hinges, notches for the booms. Remove covering material from the wing where the tail booms attach. Epoxy the booms and stab in place.

Carve out the engine pod until an engine fits without being forced in place since this can bend a crankcase. Cut pen bladder access and vent-drain holes: fill in any gaps around the holes between the bladder tube and LE sheeting. Finish the plane to suit your fancy.

Install control horn with both bolts and epoxy. Ascertain that a line from the pushrod holes in the horn through the stabilator hinge is perpendicular to the pushrod, with the stab in the neutral position. This ensures equal control sensitivity with the same stab deflection up or down and minimum sensitivity around neutral.

It is essential that all warps be taken out of a Nemesis before flying. Look at the wing directly from the rear. The TE should be exactly centered on the wing along the entire span. If not, pour boiling water on the wing while twisting to remove the warp. A hot iron works well with plastic covering, but boiling water works best for a silked structure.

Flying

When you are sure that all warps have been removed. it is time for the test flight. Pick a windy day so maneuvers can be kept downwind until the plane is adjusted: the Kwik-Link makes on-the-field adjustment easy. Plug it into a hole in the control horn about 7/8" above the hinge line and adjust the stab throw so that there is equal movement up and down. Using an 8-8 prop and hot fuel, fly it. Check to see that in level flight the plane is banked neither in nor out. Now turn it upside down (this won't take long) and check again. If it flies in a banked attitude or if there is a difference in line tension between upright and inverted flight, you missed removing a warp. Fix it before attempting any loops. Next, do some wide maneuvers, again looking for differenced in line tension between inside and outside loops that could indicate a slight warp. Now, keeping downwind, cautiously try full control. By experimenting, find a hole in the control horn that gives enough stab travel to turn the plane tight enough that it slows down somewhat after a few consecutive loops with full up or down control, but not so much that the wing stalls. Adjust pushrod length with the Kwik-Link so that full up and down give the same size loops. Now go cut streamers.

The Nemesis II can give its pilot a big advantage in Combat. The speed and maneuverability will enable you to follow an opponent through anything he tries and will allow you to make a few mistakes and get away before you're caught.

These articles always contain a speed claim. Powered by a Supertigre G21/35 burning 45% nitro and turning a Rev-Up 8-8 prop, my Nemesis IIs have gone 113-plus mph. Nobody will believe that, so I won't even claim it. You can expect 115 mph without a streamer from a Nemesis II with a honkin' engine. An average, stock Supertigre with 40% nitro and a Rev-Up 8-8 will do better than 110 which is very competitive.