MODEL BUILDER RAVEN

By DAVE JONES . . . The latest in a long series of tailless designs by the author, this one features a higher aspect ratio, a different wing section, and 'D' tube costruction in the center section for additional rigidity.

• The M.B. Raven is a competition soarer of tailless configuration. It will not make you fly better or worse. But, perhaps you can utilize the different capabilities it provides. The 'Plank' configuration relies on simplicity to provide a reliable soaring machine. Sweep and twist are not necessary for stability. Twist has a tendency to change during the heat of battle, causing inconsistent results. The total pitch stability is provided by the wing section in conjunction with the correct center of gravity. Pitch inertia is very low because of the lack of an aft body and a tail some distance behind. Inertia values are determined by the weight of an item times its distance to the center of gravity squared (wd²). This means that a 10% decrease in arm results in a 19% decrease in inertia for an item. Consequently, a small control surface provides sufficient power for maneuvering in pitch. The prototype has a throw of 17.5 degrees of up elevator. This is more than adequate for thermal flying. A full 40 degrees of up can be used for special stunts such as hovering into the wind. Directional control is accomplished by a vertical tail similar to a tailled sailplane. The pod, center wing including elevator, and the fin/rudder are one unit, allowing a permanent hook-up of the controls.

Designer Dave Jones holds his prototype in right hand and Phil Burton's in his left.

This type of sailplane can be built light without extra effort. Your local flying conditions can be matched by building the model light or heavy. A satisfactory range of wing loadings is from 4 to 8 ounces per square foot. The only noticeable difference is in flight, stall and landing speed. As you might expect, the heavier loadings provide better penetration. Consistent with a tailled airplane, down elevator is not as effective as ballast. As shown, this model should come in with weights of 6 ounces for each outer panel and 29 ounces for the center and equipment (2 channels). A completely sheeted wing (1/16) should put the loading in the 5-6 ounce range.

BACKGROUND

This type of model has a long history with me. I built my first 'Plank' style flying wing 32 yeas ago. Later, when I returned from a stint in the Air Force and completed my schooling, I built another small free flight plank. This plane showed some promise, so I doubled its size and later added a radio for slope flying. Since then I have built upwards of twenty different radio control plank designs. The biggest improvement in performance came with the development of higher performance wing sections. This led to the well known Raven design.

Since then, several different configurations have been tried. None have shown an overall improvement to the forgiving characteristics of the Raven. More than 400 contest flights have been flown by members of the Soaring Union of Los Angeles (SULA) with plank type flying wings. This has been invaluable in improving this type of sailplane.

M.B. RAVEN

The **Model Builder** version draws heavily on the original Raven for its basic configuration and control arrangement. Known improvements from other models have been included. These include the most obvious higher aspect ratio, as well as a different wing section. This employs 3.3% camber and 9.4% thickness combined with essentially a flat bottom. The wing center section also includes a sheeted 'D' tube leading edge to improve the torsional stiffness. The tip panels are of the turbulator spar type, which help to keep the inertia low. This improves the roll/yaw response.

The prototype is a little lighter than I expected, coming in with a loading of 4.3 ounces per square foot. Thermal flights should be satisfactory up to a loading of at least 8 ounces per square foot. So a lot of room is available for experimentation as far as structure and weight carrying is concerned. One thing has been obvious, a lot of dihedral is not needed for these plank configurations. More dihedral than shown will cause the turn to tighten. As little as 4 degrees have been tested with adequate turn control. However, the turn will automatically open unless held. Also, the type of dihedral is not critical. Straight, Raven type, and multiple dihedral have all been tried with no apparent 'best' type. The flat center section allows a simple control hook-up. Nothing has to be unhooked for disassembly, possibly changing a trim to your flying detriment. Straight dihedral does give more ground clearance for landing. Flight characteristics will be essentially equal.

DIFFERENT VERSIONS

This model has been designed for local conditions, as you might expect. These consist of low winds and light to strong lift. Contest tasks that it must fly include time in excess of its unaided glide time. This requires a model that can go some distance looking for lift or utilize very light lift. This model has both of these characteristics; hopefully in the right ratio. Don't give up at low altitude. This model is very much at home in light, low-level lift. M.B. Raven is stable enough to fly 'hands-off' as well as come

GEOMETRIC DATA

Item	Wing	Tail
Area-square feet	9.51	0.75
Aspect Ratio	8.84	1.33
Taper Ratio	0.61	0.39
Leading edge sweep-degrees	10.06	33.69
Wing Section	CJ-3309	Flat Plate
Thickness	9.4%	0.5 In.
Span-inches	110.0	12.0
Root chord-inches	14.0	13.0
Tip chord-inches	8.6	5.0
Mean Aerodynamic Chord-inches	12.71	9.59
Weight-ounces (Prototype)	41.0	
Length-inches	34.5	

back from downwind in winds up to 12 mph. This is with the prototype wing loading, but don't get below 30 degrees above the horizon before starting back. The other requirement for this model is to get those landing points. This requires practice with the plane to become familiar with its characteristics. The most successful approach in our club has been to keep the speed up during landing. The wings must be level and not turning when the nose is forced down. It can be floated in during no-wind conditions.

This model can be customized to your local conditions or requirements. I don't expect that you will need a lighter model, but it can be done for special uses. A one-piece wing will save around 5 ounces. The wing spar is oversize for winch loads, and the body is strong for spot landing loads. A savings of 10 ounces should be possible for an electric powered model before the motor and batteries are added. Most places have more severe conditions than here in Southern California. A heavy duty version, including complete sheeting of the center section with 3/32 balsa, and the tip with 1/16 balsa, should be feasible and within reasonable wing loadings. The prototype turns easily with 20 degrees of rudder each way. With 20 degrees more available, the extra tip inertia should not cause a problem. This would be a very sturdy model that will be at home in strong winds or on the slope. The body size and shape has very little effect on the stability, so it can be changed for special purposes. A longer nose would be required to offset the increased weight behind the center of gravity for the sheeted model. A deeper body can be used if tow launching is not going to be used. I have found that having the two hook close to the bottom of the wing improves the launch stability. Ballast tubes can be added to the wing center section if desired. I intended to install KDH speed brake/spoilers, but couldn't locate a set before I completed the model.

CONSTRUCTION

(A complete parts list is included with the full-size plans.)

Start with the wing center section. I prefer cutting all the ribs first. All spar material is of a slightly different size, to make sure the notches in the ribs match your wood. Choose a hard, straight 1/2-inch triangle for the leading edge. Cut the rear 1/16 off the triangle, so the sheeting will butt against it squarely. Then remove the front (15/64) as shown on the plan. Place it on the plan, making sure it is straight. Fit and glue a sheet of 1/16 x 4 behind the leading edge. Put the 1/16 x 1/2 sheet lower rear spar in place. Fill in the lower sheeting in the required areas. Use the ribs and locate the lower main spar cap (1/8 x 1/2 spruce) on the lower sheeting, gluing it in place. Fit the ribs and glue. Assemble the 1/8 vertical grain webs, and glue. All the joiner tubes should be roughened for better epoxy and glue adhesion. Fit wood below the joiner tubes, epoxy the tubes in and add the wood over the tubes. I prefer the square tubes as they glue into the structure easier. Locate the dihedral braces in place and glue. Now the upper main spar cap (1/8 x 1/2 spruce) can be glued in. Add the cap locks of 1/16 ply. These keep the caps from separating under high loads. The upper leading edge skin should be assembled on the board to provide a width of about 4-1/2. Fit it to the top of the leading edge triangle as shown on the plan. Use a slow drying glue to fasten the upper skin in place from the leading edge to the main spar.

Fit the 5/16 x 1/8 rear spar between ribs number 14. Outboard of rib 14 the spar is between the ribs. Assemble the joiner tubes and spruce spacers with epoxy between ribs 13 inner and outer. Make sure the top of the spar does not stick above the ribs. Glue the upper 1/16 x 1/2 rear spar in place. Now, fill in the sheeting between the spars. The trailing edge aft of the rear spar is now constructed. Cut a piece of 1/16 sheet for the lower part. Taper the last 3/4 inch in thickness. Glue to the ribs and spar using a piece of trailing edge stock to hold up the rear. Cut 1/16 sheet for the upper part and glue in place. The wing center section should be allowed to dry thoroughly on a flat board. Any twist built in at this stage will be very difficult to remove. The elevator is built later after the wing is removed.

The rudder and fin can be built now. It is a basic flat plate of 1/2-inch thickness. The trailing edge is tapered and blocked up from the building board by the forms shown. The structure is aimed primarily at keeping the wrinkles out of the covering. The 1/8-square spruce prevents the root rib from bending up in the middle. The prototype has a removable vertical tail. This allows the model to fit into a box about 38 x 22 x 8 for storage and travel. To make it removable, an aluminum tube was added to the back of the leading edge located as shown on the plan. Two 4-40 anchor nuts were added to the 1/4 x 1/8 rear body post. The 4-40 screws were countersunk into the rear fin spar. The spars are slotted and hinges fitted. They are pinned in place. The hinge pins are removed and replaced by a long 1/32 dia. pin through both hinges.

Remove the wing center section and build the elevator. It is built upside down on the plan. A small strip of 1/16 is placed down first to give it a curve. The top 1/16 x 3 x 24 is pinned to the board and the 1/16 x 1/2 spruce or ply added. The 1/8 leading edge is fitted and glued in place. Add the ribs. Place a scrap of hard 1/8 between the center ribs as shown on the plan. Size the lower skin and taper the last 3/4 inch to fit the top skin and glue in place. Be sure it is dry before removing from the board.

Shape the leading edge of the center wing using the template as a guide. The next step is to separate the center wing from the outer stubs. I used a Dremel jig saw with a fine tooth blade. Mark a straight line between the ribs and follow it with care. Take it easy and you can cut through the brass and aluminum tubes. This will give you a perfect match between the two panels.

You are now ready to build the tip panels. *Warning:* The stock 1/4-square leading edge hangs below the level of the building board. Place the plan on the building board so that the first 1/2-inch is off the edge. Fasten down the lower main spar cap (1/8 x 1/4 spruce). Epoxy tip parts to the stub. Fit the ribs and glue in the parts at each step. Add the two 1/8-square spruce auxiliary spars and the 1/4-square spruce leading edge. Assemble the 3/32 vertical grain web. Fit the upper spruce 1/8 x 1/4 spar cap. Add the trailing edge, using a piece of trailing edge stock to hold it in place. Add the corner gussets. Construct the other panel. Add the tip ply cap ribs. Fit the ply cap ribs at the wing joints. Trim the lower parts of the 1/4 square leading edge to the rib shape and round the front.

Time to construct the body: Cut out the sides. The forward part is three-ply mahogany plywood which can be obtained from a lumber yard in sizes up to 4 x 8 feet. Mahogany plywood has many uses and is relatively inexpensive. The rear is of 1/8 balsa. Glue the forward and rear parts together using the wing cutout as a reference line. Cut out the nose block, tapering the sides as shown in the top view. Glue the sides to the nose block and make sure it is set before bending the sides. Add the 1/8 x 1/4 spruce upper stiffeners and the 1/2 triangle lower corners. Cut frame 6, a 1/8 x 1/4 spruce or ply rear post, and a small block 1-3/4 inches long. Bend the body sides around the block which is placed about 6-1/2 inches behind the nose. Glue and clamp at frame 6. Cut a notch and add the 1/8 ply tow hook mount. Then cut out and add stiffener B. Compression strength is needed here because this is the area that you hold during launch. Mount the adjustable tow hook. Add the cross-grain 1/4 body bottom. With a felt tip pen draw a centerline on the upper and lower wing surfaces. Add stiffener 7 to the wing. Fit the rear post, taking care that it is perpendicular to the wing. Add the aft bottom 1/2 inch balsa. Drill and tap for the skid. If the wood is soft, it should be strengthened with glue on the threads and retapped. The nylon screw makes an excellent skid and can be replaced if worn down from landing on rough surfaces. Fit frame 1 and add the upper aft nose block, shaping it to frame 1. Shape the inside nose to take the battery snugly. Carve the outside lower corners to a rounded section. It can be done with a model knife or belt sander. The next step is to mount the wing. However, I think the lower body should be filled and sanded ready for the final color before attaching the wings. It can be fiberglassed at this time, if you desire. Cut the wing rods of spring steel. All are just under 6 inches long. Two are 3/16 diameter and two are 1/8 diameter.

Draw lines representing the sides of the body on the top and bottom of the wing. Cover the wing center section up to the body sides and install the covered elevator. I use clear Monokote as a continuous hinge on the upper side. Regardless of the hinge used, this joint should be sealed. Iron it on with the elevator in the full down position. This will give enough freedom after it shrinks. Turn it over and add one inch wide strips at the ends, midpoints and center. This prevents the elevator from moving vertically when the horn is loaded. Attach the wing to the body. Use epoxy and make sure stiffener 7 is glued to the body. When this is dry insert the fin leading edge between the body sides. If it is to be removable, drill two 4-40 holes in the fin rear spar and the rear body post. Install anchor nuts inside the body. If the tail is to be fixed in place, it should be covered before fastening. Make sure it is perpendicular to the wing. For the removable version, saw through the leading edge and tube 1/8 above the body sides after it is dry. Cut out the elevator horn and epoxy in place. It should be off center slightly toward the side of the rudder horn. Add frame 3 ahead of the wing. Install upper body sides and frame 9. Add 1/8 square corners at this time.

Cover the outer wing panels. Cover and install the vertical tail if it is removable. Install the outer wing panels. Place the battery in the nose. Mark 3.8 inches on the sides of the body behind the wing leading edge. Put your servos and receiver in the body to balance the model at the mark. If the model is tail heavy, add ballast to the nose block or lighten the tail. If ballasting, put it inside the nose block. Install the servos, making sure the elevator pulls for up. Remove the construction block. Complete the radio installation and assure yourself that the elevator and rudder move enough. Add the body top from the C.G. to the rear. Carve the corners to a rounded shape.

A tricky little area is next: This is between the C.G. and frame 3. I wrapped flexible 1/16 around a subframe attached to frame 3 and 1/16 smaller. This 1/16 was copied from a paper pattern that was made by the 'cut and try' method. This area can also be constructed with small, soft balsa blocks. Put masking tape on the wing surfaces next to the body. Fill and sand the upper body. The canopy cam be made now (I sawed mine from a soft balsa block). Hollow it to clear the equipment. Carve the outside to a rounded shape using frames 1 and 3 as guides. It can be painted or covered with Monokote. The body can be painted now with its final color.

Use your own method of holding the canopy on. I prefer to tape mine, for I have seen quite a few batteries come out during maneuvers, with the expected results. Check the center of gravity to make sure that it falls in the allowable range. Set the two hook about 1/8 inch ahead of the center of gravity for a start. Install your favorite skid and you are ready to fly.

TEST FLYING

Before test flying, the model must be in balance *both* longitudinally and laterally. Although lateral imbalance can be trimmed out, it is drag producing. You *must* have the longitudinal balance within the limits shown. If M.B. Raven is nose heavy, the elevator does not have enough power to keep the nose up. If it is tail heavy, the center of gravity is too close to the neutral stability point, causing erratic flight. If the center of gravity is 3.8 inches behind the wing leading edge, the elevator should be set to trail with the rest of the wing. This will produce a fast glide with a very slight stall.

Please be careful that the batteries are fully charged and make sure you do a range check. No sense destroying a model because of an oversight. If anything appears to be wrong, don't fly until it is fixed. If all is ok, turn your radio on, *check the control movement,* and launch into the wind with a strong level throw. Adjust the controls to obtain a steady glide. It is much easier at this stage if you can have a friend launch for you. This allows you to have your hand on the controls at the time of launch. Be ready! This type of model responds *rapidly* in pitch. When a good glide is obtained, observe the position of the surfaces. Adjust the push rods to get this position with the trim and stick at neutral. You are now ready for your first winch, hi-start, towline, or slope launch. I don't recommend your first launch to be in a strong cross wind. After you are familiar with the model, wind direction shouldn't bother you any more than with a tailled plane. Be sure the winch line is tight before you launch. Note, I said launch, *don't* just let go of the model. Thrust the plane firmly into the air at flight speed and up at least 45 degrees. The model should then assume an attitude of about 80 degrees and go to the top. Leave the line just as with a tailled plane. Check and adjust your glide if necessary. The two hook can be adjusted aft to get a steeper climb, but I don't recommend it being behind the center of gravity.

Try these maneuvers as you fly. First, very slowly feed in full up elevator. You should notice that the forward speed drops off and the nose comes up without a stall. Now apply full rudder; the model should turn very tightly and speed up. Release the turn and apply enough rudder to straighten out. Now release the up elevator and watch the model shoot forward. After the glide has stabilized, apply partial up to obtain a stall. The elevator can be stalled if full up is given too quickly. All the elevator controls should be given with gentleness. You will receive better response. During the stall, little altitude should be lost. No tip stall should be noticed. Now try a loop. Give a small amount of down (down is very powerful) to pick up speed. Ease back on the elevator to about half-throw and hold. You should get a large, round loop. Try another, and this time, apply full up as you start up. Properly done, you will get what I call a comma. As the plane reaches the top and is upside down, the speed drops to zero and the weight in the nose takes over and rotates the plane around to the opposite direction. If the up elevator is released as it rotates, it will accelerate out in gliding flight. Note, this can't be done with a tailled plane.

Before attempting dives, let me offer a suggestion. This plane is hard to see coming down, especially toward you. Position the model a hundred or so feet from directly overhead. Then make a diving turn around your position. This allows you to have a good view of the altitude and attitude. A tight elevator turn will bleed off the extra speed. Don't be afraid of breaking the wing as you pull out of a dive. The elevator cannot apply nearly the load that a tail can to the wing of a tailled model. Be warned that this means that you need more room to pull out of a dive if you overcontrol. I have never been able to do a spin with this configuration so you need to dive to get it down. Spot landings are a matter of practice.

POSTSCRIPT

I would like to take this opportunity to thank the members of the Soaring Union of Los Angeles (SULA) for their support in my flying wing projects. Especially the building and flying of various designs. This large, harmonious group under the direction of President Ron Brown is a pleasure to associate with. Members assisting in this project include Phil Burton and Ed Schnakenburg, who built copies to check out the flight characteristics for consistency.

Other flying wing designs are available from Western Plan Service, 5621 Michelle Drive, Torrance, CA 90503. Send a first class stamp for a flyer, or $1 for a catalog. These models are for thermal and slope flight under moderate conditions. Good Lift!

AUTHOR

David L. (Dave) Jones is 49 years old and has been modeling for 40 years. His direction has been sailplane, since 1948. He switched to radio control when it started to become reliable. First, with single-channel tone and then with an early PCS. He is reponsible, with Chuck Clemans, for 'Little Plank' RCM, May 1972 and 'Standard Plank' RCM, July 1975. He designed 'AR-25' MA, August 1978. He is also responsible for the Soaring article in MAN, May 1977 dealing with flying wings.

Dave is employed as a configuration designer at North American Aircraft Division of Rockwell International. During his five-year Air Force tour (four in Europe) he was schooled in Electronics and Combat Intelligence. He is a graduate of Northrop Aeronautical Institute with an associate in Aeronautical Engineering Technology and a BS in Engineering Technology from Northrop University. ●

Dave Jones

LIST OF MATERIALS

Center Wing Panel

Leading Edge	1	48 x 1/2 x 1/2 triangle
Main Spar Caps	2	48 x 1/2 x 1/8 spruce
Main Spar Webs	1	36 x 3 x 1/8
Leading Edge Skin	2	48 x 4 x 1/16
Rear Spar Caps/Upper L.E. Skin	3	48 x 1/2 x 1/16
Rear Spar Web	1	48 x 1/8 x 5/16
Other Skin	4	36 x 3 x 1/16
Ribs	3	36 x 3 x 1/8
Cap Ribs	1	14 x 6 x 1/16 ply
Cap Locks	8	1-3/16 x 1/2 x 1/16 ply
Dihedral Keeper	1	6 x 3 x 1/8 ply
Main Joiner Tube (Square Brass)	1	12 x 3/16 inside
Rear Joiner Tube (Round Aluminum)	1	12 x 1/8 insude

Elevator

Skin	2	24 x 3 x 1/16
Joiner	1	12 x 1/2 x 1/16 spruce
Front Spar	1	24 X 3/8 x 1/8
Ribs from scrap.		

Tip Panels

Leading Edge	2	36 x 1/4 x 1/4 spruce
Auxiliary Spars	4	36 x 1/8 x 1/8 spruce
Main Spar Caps	4	36 x 1/4 x 1/8 spruce
Main Spar Webs	1	18 x 3 x 3/32
Ribs	2	36 x 3 x 3/32
Trailing Edge	2	36 x 1 x 3/16 triangle
Tip Cap Ribs	1	9 x 2 x 1/16 ply

Vertical Tail

Fin Leading Edge	1	14 x 1/4 x 1/2
Fin Spar	1	13 x 1/2 x 3/16 spruce
Fin Ribs	1	11 x 1/2 x 1/16
Fin Root/Tip Ribs	1	6 x 1/2 x 1/8
Rudder Front Spar	1	18 x 1/2 x 1/4
Rudder Trailing Edge	1	12 x 1 x 3/16 triangle
Rudder Ribs	1	36 x 1/2 x 1/16
Rudder Tip Rib	1	3 x 1/2 x 1/8
Rudder Root Rib	1	9 x 1/2 x 1/2
Rudder Stiffener	1	6 x 1/8 x 1/8 spruce
Hinges	2	Klett RK 3-7 type
Horn	1	CG #215 type
Gussets from scrap		

MODEL BUILDER RAVEN

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Body

Front Sides (Three-ply)	2 14 x 2 x 1/8 ply
Rear Sides	2 13 x 3 x 1/8
Frames 1, 3, Horn & T.H. Mount	1 9 x 2 x 1/8 ply
Upper Stiffeners	2 10 x 1/4 x 1/8 spruce
Joiner Frame 6	1 2 x 2 x 1/2
Rear Post (ply alternate)	1 3 x 1/4 x 1/8 spruce
Rear Skid Screw	1 1/2 x 3/16 dia. Nylon
Lower Corners	2 16 x 1/2 x 1/2 triangle
Front Bottom	1 10 x 3 x 1/4
Rear Bottom	1 11 x 2 x 1/2
Adjustable Tow Hook	1 Airtronics #9511 type
Front Upper Nose	1 2 x 3/4 x 1-1/2
Nose (pine alternate)	1 2 x 1-1/2 x 1-1/2
Canopy	1 9 x 2 x 1-1/2
Parts 7, 8 & 9 from scrap	

Other Parts

Push Rods (cable)	1 Pylon #GRC-6 type
Clevis (small steel)	2 SIG SH-134 type
Connector-Adjustable	2 Du Bro #121 type
Hinge Pine (rudder)	1 13 x 1/13 dia. piano wire
Main Joiner Rods	2 6 x 3/16 dia. piano wire
Auxiliary Joiner Rods	2 6 x 1/8 dia. piano wire

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