F-117A

BY PARKER LEUNG

ABOUT THE AUTHOR

Parker Leung is 43 years old and is living in Ontario, Canada. He is married and has two children. He was the designer of Model Tech Co. Ltd. in the 80's. Many of his designs are still on the market. He likes special designs that challenge his imagination and flying skill, yet suitable for average sport fliers.

F-117A Stealth Fighter. At Last ... A Truly Unique Warbird For The Sport Flier!

If this article was published a few years ago, I bet most of you would question the designer's knowledge of aerodynamics or RCM would simply reject this article. It's no surprise that people always ask me if it can fly or how it performs. Happily, I can usually demonstrate a perfect flight, which is always worth a hundred words.

A few years back, I designed a .40 size Space Shuttle, of which I believe no one had a similar design at that time, simply because it is an orbiter rather than an airplane. This design was published in the February 1992 issue of *RCM*, Plan No. 1110. Since that time, I have been planning for another special model. Many ideas came up such as the YF-22, YF-23, F-117A, SR-71, and the B2. They are the most advanced aircraft although some of them are now history. I liked the YF-23 because of the "butterfly" type tail. So I started working on the drawing. Unfortunately, it lost to the F-22. I did study the F-22 but, after the Gulf War, the F-117A drew my attention again and decided it would be a real challenge if I could build a model that flies as well as the full-scale one with all the parts "off the shelf."

Needless to say, there were no plans or kits available then, so I started to collect photos, drawings, and plastic kits in 1993. I learned that Yellow Aircraft had been working on a ducted-fan version which flew successfully. This didn't surprise me because this company always does its best. This twin ducted-fan model is certainly top of the class. As a sport modeler myself, I prefer a relatively easy-to-build, easy-to-fly airplane, and most important, it must not dig deep into the wallet.

Since then, additional studies revealed more problems coming, but I like to work out any special, or hidden problems before

F-117A

Designed by:
Parker Leung

TYPE AIRCRAFT
Sport Scale

WINGSPAN
42-3/8 Inches

WING CHORD
19 Inches (Avg.)

TOTAL WING AREA
810 Sq. In.

WING LOCATION
Low Wing

AIRFOIL
Semi-Symmetrical (Diamond Section)

WING PLANFORM
Double Taper — Swept Back

DIHEDRAL, EACH TIP
0

OVERALL FUSELAGE LENGTH
48-1/4 Inches

RADIO COMPARTMENT SIZE
Ample

STABILIZER SPAN
NA

STABILIZER CHORD (inc. elev.)
NA

STABILIZER AREA
NA

STAB AIRFOIL SECTION
NA

STABILIZER LOCATION
NA

VERTICAL FIN HEIGHT
(2) 12-1/4 Inches

VERTICAL FIN WIDTH (inc. rud.)
(2) 4-1/2 Inches (Avg.)

REC. ENGINE SIZE
.40-.46 2-Stroke

FUEL TANK SIZE
8 Oz.

LANDING GEAR
Tricycle

REC. NO. OF CHANNELS
4-6

CONTROL FUNCTIONS
Rud., Elev., Elevons, Throt., Retracts, Exhaust Reflectors

C.G. (from Nose Ring)
19-13/16 Inches

ELEVON THROWS
3/8" Up — 3/8" Down

EXHAUST REFLECTOR THROWS
1/2" Up — 3/4" Down

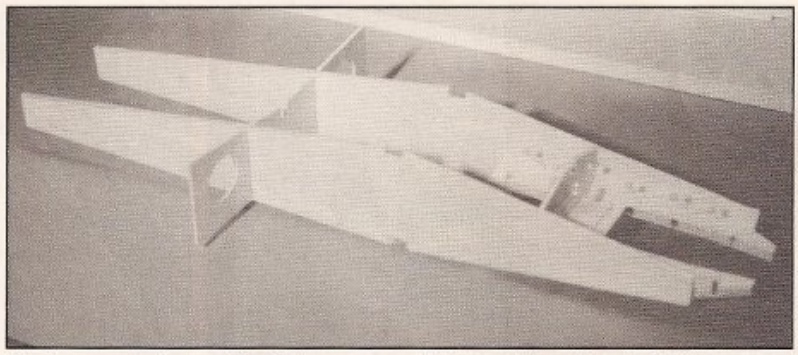
RUDDER THROWS
1/2" Left — 1/2" Right

SIDETHRUST
1° Right

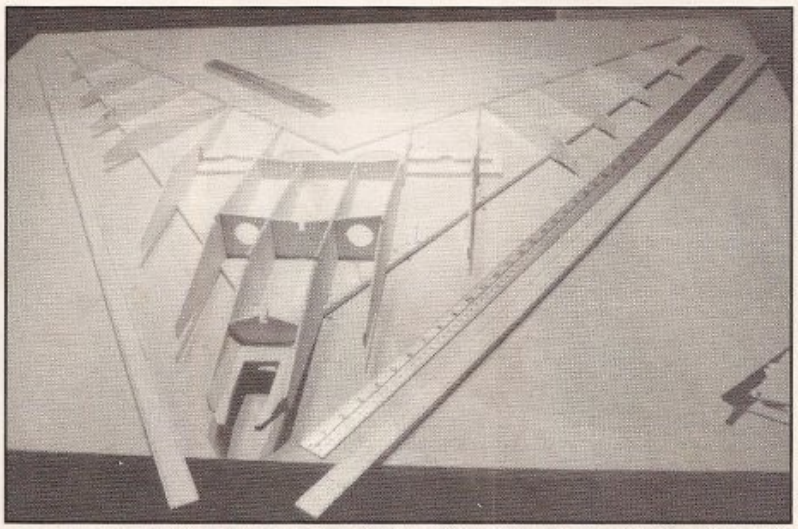
DOWNTHRUST
1°

BASIC MATERIALS USED IN CONSTRUCTION

Fuselage	Balsa & Ply
Wing	Balsa & Ply
Empennage	Balsa
Wt. Ready To Fly	5 Lbs. to 5 Lbs. 8 Oz.
Wing Loading	14.2 to 15.6 Oz./Sq. Ft.



Engine mount subassembly. Make sure correct right and down thrust is built-in.



The entire wing is built on a piece of particle board. A straightedge is used to line up the ribs at the front. Note reference lines marked on leading edge.

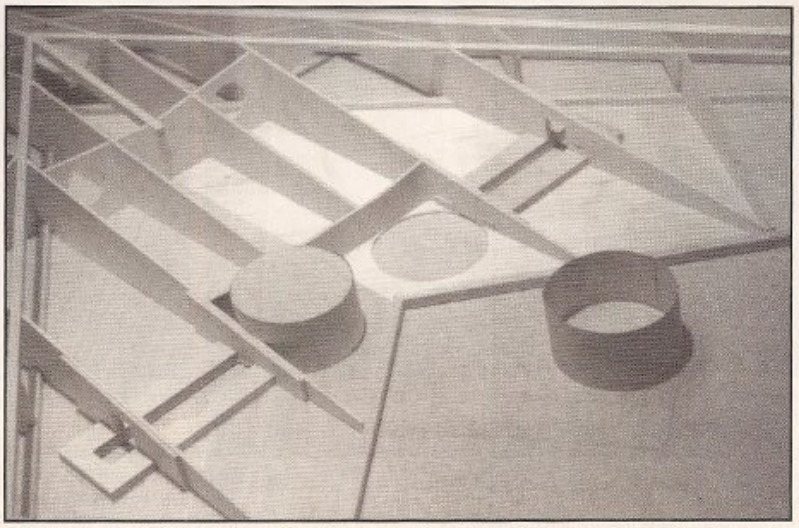
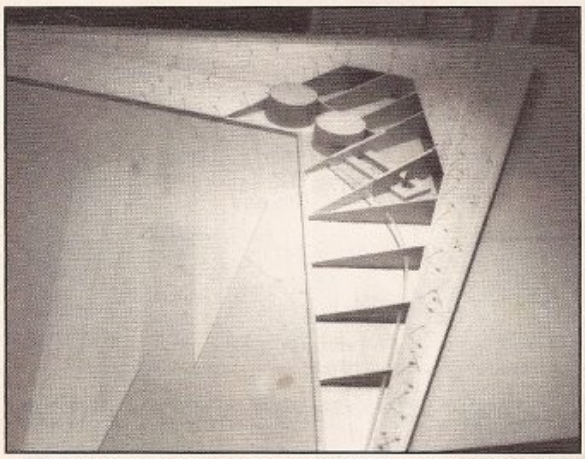
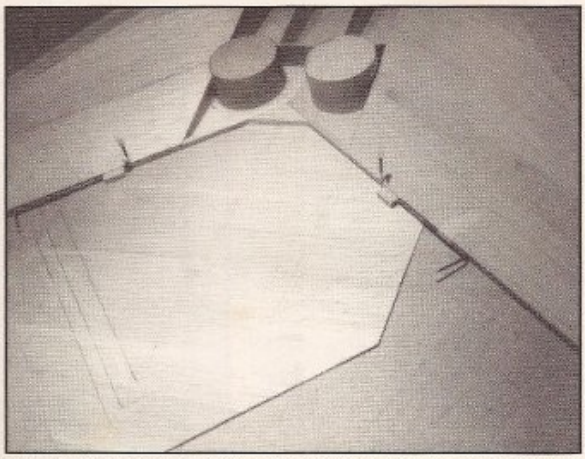


Photo shows all ribs and spars in place, as well as retract gear mounts and cups.

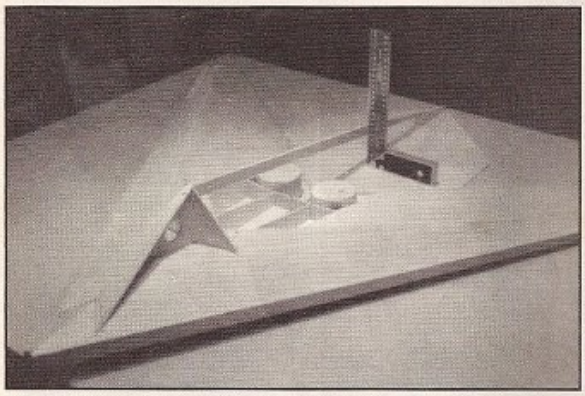
they show up in the air. The fuselage is assembled by many irregular shape panels and the airfoil section looks like a diamond for starters! Furthermore, the wing is highly swept back which means it's easy to tip-stall, so how do we prevent it from happening at low speed?

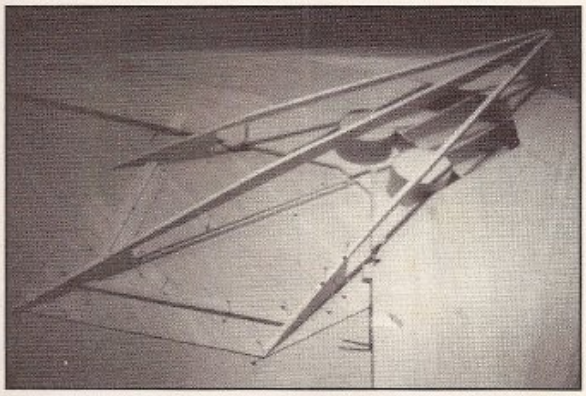
As an average modeler, I couldn't afford any expensive experiment. Instead, I made a few paper airplanes with highly swept back wings. I believe that if it is designed properly, it is not easy to tip-stall. On the other hand, I purchased a used .40 size airplane called "Illusive," which was designed by my friend, John Cook. One of the major characteristics of his design is that he employs a "diamond" type airfoil section to all his airplanes. This type of airfoil section was once adapted for pattern ship's stabilizer in the 1970's, such as Saturn Compensator, etc. It seems that there are certain advantages that we might ignore. The "Illusive" I got was quite heavy because the builder used door skin plywood for the fuselage sides. But



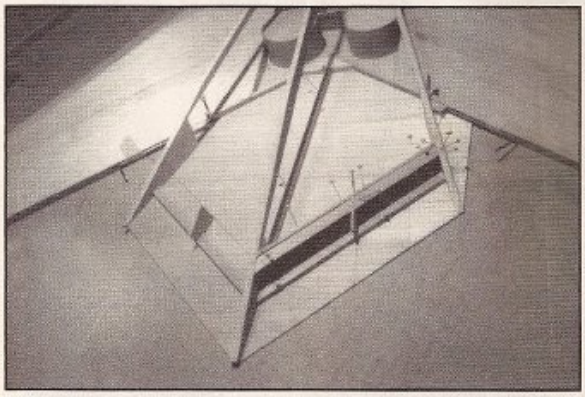


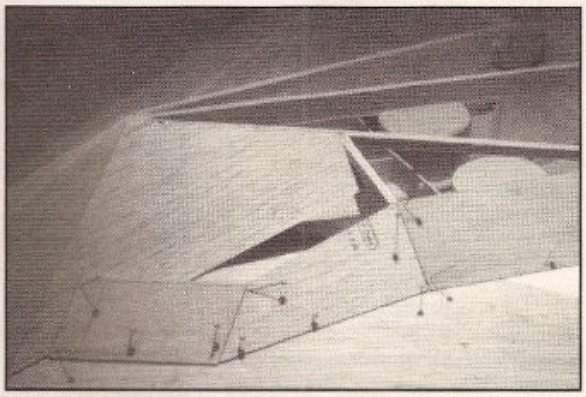
LEFT: Top sheeting is being applied. Notice the nylon tubing for antenna. RIGHT: Elevon torque rods installed. Notice pencil marking on fuselage bottom sheeting.





LEFT: The center longeron glued in place. Alignment is very important. RIGHT: The side longerons glued in place. Glue E2 on the pencil mark.

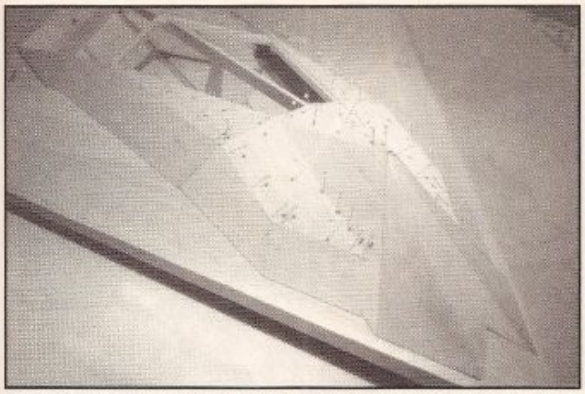


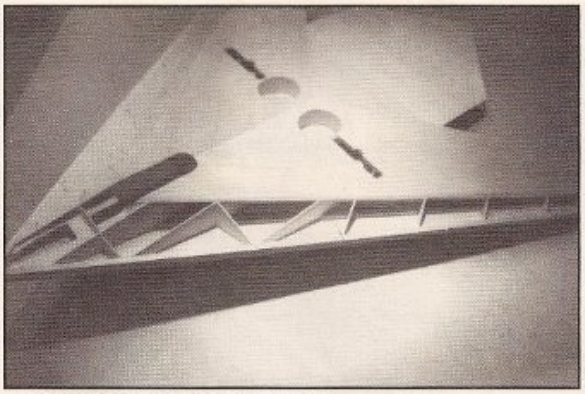


LEFT: Exhaust slot structure. Note the reference line on L2B for E4. RIGHT: Fuselage panels being glued in place. Install one panel at a time, on each side.

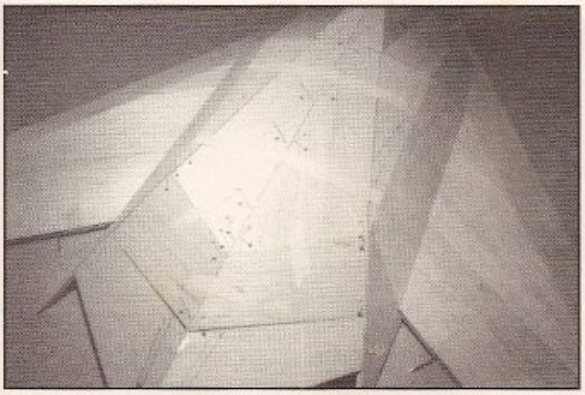
once she was airborne, she could keep floating at 1/3 throttle, then took off and landed as a conventional aircraft. The only difference in this airfoil is just the appearance, not the performance. Since then, I gained more confidence with this project. Then I built a small size free-flight scale model for further testing and also to practice the construction. I found that it was very unstable around the pitch axes. The C.G. point was so critical that it either went nose up or into a dive. At this point, I needed some sort of breakthrough. When I designed the Space Shuttle, I made two movable side intake flaps to make it flyable. In this case, I noticed there are a pair of lips attached to the narrow exhaust slots. The lips (I call them exhaust reflectors) are reflexed upward slightly and are supposed to minimize the infrared image.

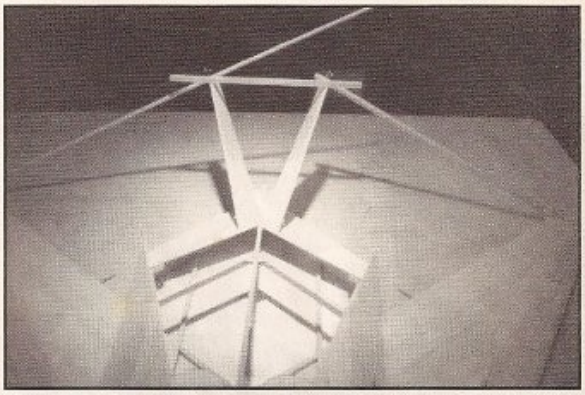
I cut two slots underneath the fuselage just in front of the exhaust slots (Patent pending) such that the bottom side air current is sucked into these slots and pass over the exhaust reflectors. The principle is very simple. The exhaust reflectors become very aerodynamically effective which, in turn, improves pitch stability and when coupled with elevons, also provides pitch control. Furthermore, this configuration highly improves the aerodynamics of the fuselage. The slots are hardly visible in the air and thus do not affect the scale appearance. Later testing proved that this concept works well. In order to prevent tip-stall, the swept back angle is reduced and wash-out is



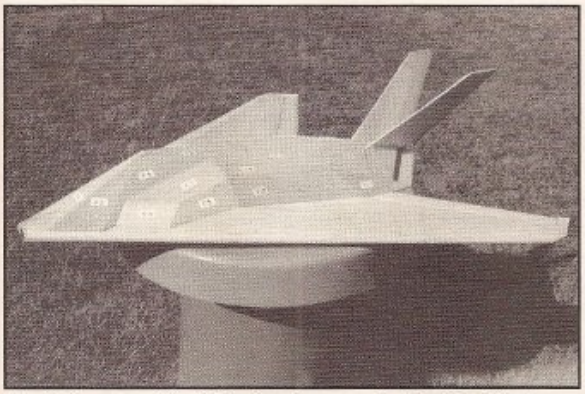


LEFT: Continuing with gluing fuselage panels into place. RIGHT: Remaining wing sheeting is glued in place.

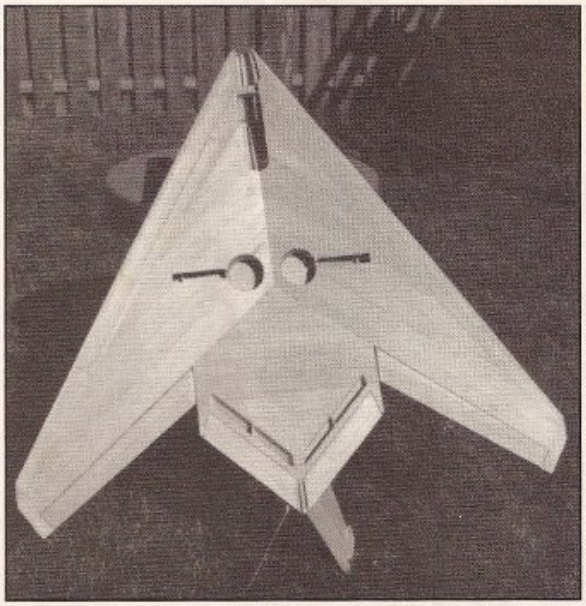




LEFT: The hatch being built on top of fuselage. Note reference lines for fins. RIGHT: Dual fins glued in place. Check for proper alignment.



The built-up model with the fuselage panels clearly labeled.

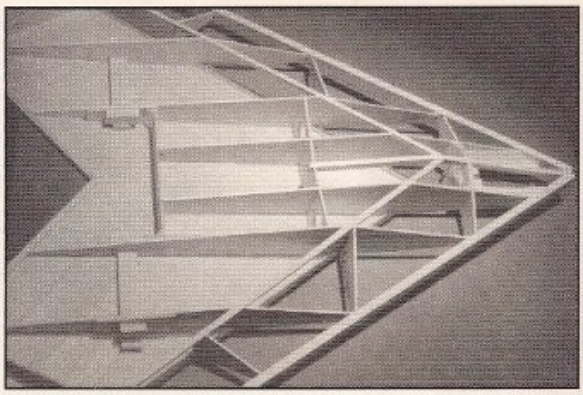


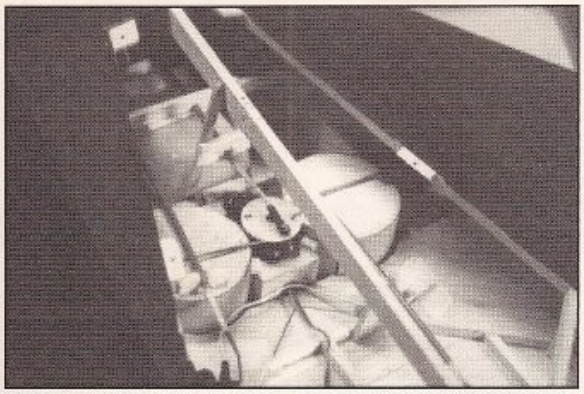
Bottom view of model, ready for covering.

built in the wing. The elevons are also carved with more reflex towards the tip (wash-out).

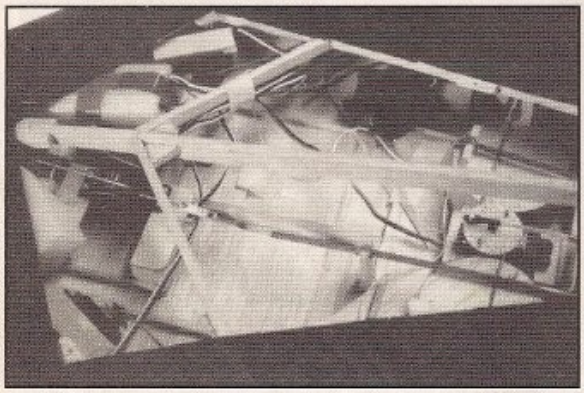
The fuselage is built on the wing to simplify construction. Engine size is limited to a .40 to .46 cu. in. 2-stroke so that transportation is not a problem. It can be stored in the trunk of a mid-size sedan, or rest on one wing between the front and rear seat of any compact size car. (You can't believe how many considerations there are when you start to design a project like this.) The fuel tank is located close to the C.G. point for stability reasons and to leave room for the nose retract gear; therefore, a fuel pump is necessary to ensure consistent fuel supply. The wing is relatively easy to build but the fuselage is more complex and is combined of many irregular panels. The prototype really gave me a headache even though I had tried my best to simplify the structure. Please keep this in mind when you start to feel frustrated; don't blame me, it was the guys in the "Skunk Works" that designed it that way!

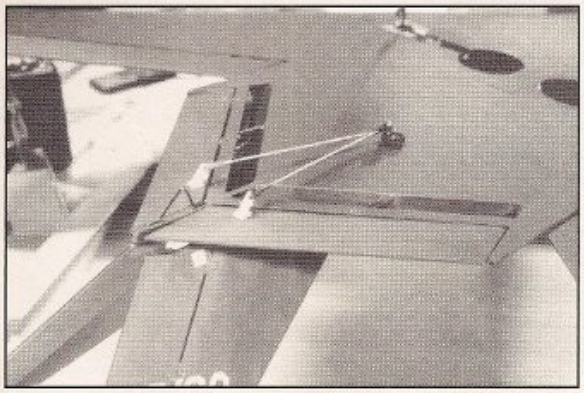
I spent about nine months building my prototype, the retract gear was installed but not activated during the first test flight. One day, I brought my model to the Whitby Aeromodellers Club for show and tell. A member asked if I could fly it at the upcoming fun-fly event. Needless to say, people wanted more fun. That day eventually came. The members were kind enough to stop flying to let me have the sky all alone. I started the engine and brought it to the far end of the runway because no one knew



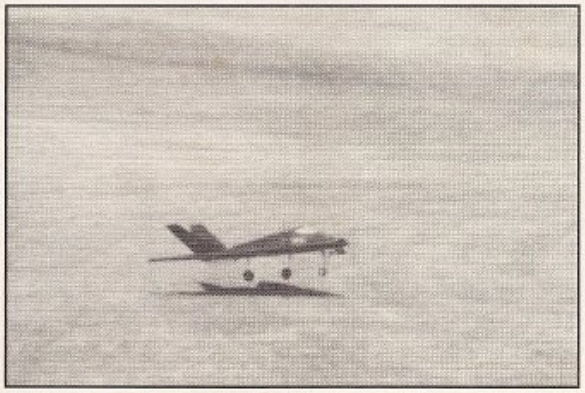


LEFT: Fixed gear version with plywood mounts glued in place. RIGHT: The fuel tank and retract gear servo in place. Note the antenna routed to the built-in nylon tubing.





LEFT: Rudder servo and NyRod to nose gear. Elevon servos are side mounted; battery and receiver are located at the rear. RIGHT: The elevator servo is mounted inverted and linked to exhaust reflectors. The slots are shown clearly here.



LEFT: The finished model. The nose gear is slightly longer for test flight. RIGHT: A nose high landing and touchdown on the main gear.

how far it needed to rotate. The engine was given full power and it took only 200'. Up trim was dialed in to maintain level flight because I intended it to have a slightly nose heavy situation for safety reasons. It flew around like a blackbird. The shape and color scheme do not make it stealth, just confusing. I did try some rolls and a loop. Eventually, I brought it down and taxied to the pit area. Everyone cheered except me, since my hands were still shaking. Later, I attempted a second and third flight but with bad luck. The wind was blowing across the runway down the hill. One wingtip was raised and the propeller hit the ground and the nose gear steering arm was broken.

Since then, the main gear was widened by 1" and all gear were hooked up to a retract servo. During the fourth flight, I tested the authority of twin-rudders and was impressed with the response; there was no adverse roll induced. But just then, the fin started to flutter and something came loose. I was lucky to bring it down without much difficulty. The left rudder was torn apart. I figured out that the fin was too thin and that it was flexing in flight. It also appeared that I didn't put enough CA glue to secure the hinges properly. The thickness of the fin and rudder is now 1/4" instead of the original 3/16".

Later, I also inserted some lead weight into the rudders in front of hinge line as counterweights to prevent flutter, and also to move the C.G. back. I tried both ASP .40 and .46 size engines and they both work fine. There are numerous .40-.46 class engines on the market, some are lighter than others by 2-3 oz. If you can save such weight at the nose, you can reduce the same amount of balance weight at the tail. That means a double saving in total. Keep in mind that a lighter but more reliable engine which swings a 10 x 6 or 10 x 7 prop at 11,000 to 12,000 rpm is the ideal choice.

Due to the unique appearance and flight characteristics, I'm afraid this aircraft is not suitable for beginners. Please study this

article and plans thoroughly before you start. I have done as much as possible to simplify the structure; for instance, the entire wing is built flat on a 3' x 3' building board in such a way that proper wash-out and dihedral are automatically achieved, no wing jig nor shims are required. It's a good investment to buy a 3' x 3' (minimum) piece of particle board or plywood from a lumberyard. Be sure that it is warp free.

CONSTRUCTION

Wing:

It's easier to build than it appears. Prepare all parts required. Cut ribs from 3/32" balsa; you will have to bevel all the edges later on. Cut main gear mounting plates and necessary reinforcement parts to match your retract gear. If you prefer fixed gear, make the necessary modifications.

Cut engine mount from 1/4" plywood to fit your favorite engine. You might have to move the fire wall to accept any fuel pump. Note: You can double the thickness of the fire wall to support the nonretractable nose gear if you wish. Cut out the dihedral brace, miscellaneous item, etc. Prepare the bottom wing skins from 1/16" balsa; cut to shape so that it covers only half the width of the bottom main spar. Cut opening for the wheels.

Protect the plan with wax paper, etc. Pin down the wing skin over the plan. Mark reference lines for ribs and spars. Glue trailing edge and bottom main spar in place. Trial fit every rib before it's glued in place. Note: It's necessary to level the rear end and bottom slots to match the spars. Don't trim the upper slot at this time. Trial fit the engine mounting plate with rib W2 and the dihedral brace, then glue this unit in place. Add main gear mounting plates and remaining ribs and all reinforcement parts. I used aliphatic glue for most construction because it is pollution free, dries slowly, and fills minor gaps well. Thin and thick CA glue surely speed up the job. After the glue has set up, trim all rib top slots for the top main spars. (A long straight ruler is useful here.)

Cut the leading edge from 3/8" balsa. You may have to join two pieces together for desired length. Personally, I cut it 1/8" wider than necessary so that there is extra material for trimming. (Remember it's not unusual for the balsa strip to bend by itself after being split off from the sheet.) Draw top and bottom lines on it to provide reference for ribs. Then, slightly sand the ribs to match leading edges before it's glued in place.

Make two wheel cups from 1/64" plywood with 1/8" balsa covers on top. The cups are oval in shape to provide extra room for the wheel if the wheel struts bend backward.

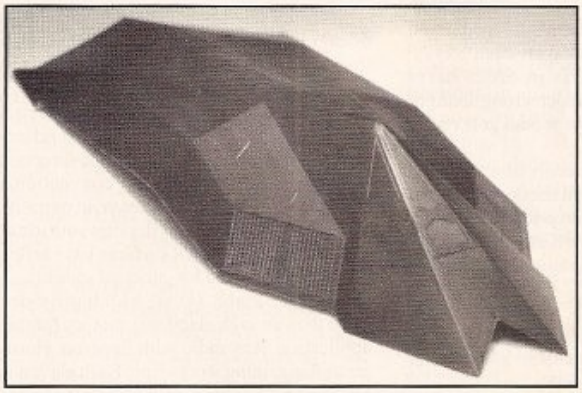
Insert a nylon tube (from NyRod inner tube) from W2 to the right wingtip as an antenna guide. It doesn't matter if you drill holes in the ribs before or after they are glued in place. You can also use an alternative whip antenna widely used in helicopters. This short antenna is very easy to fit inside the fuselage so that no nylon tubing is required.

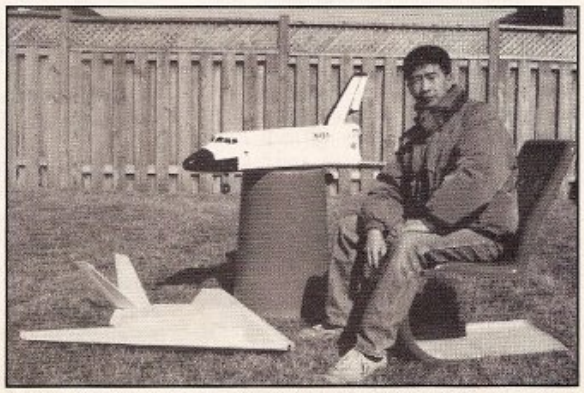
Sand the top edge of ribs smooth and flush with the trailing edge and main spar, which is also leveled to match the ribs' contour. Prepare top sheeting from 1/16" balsa and trim to size, then glue in place, be sure to leave open space for fuel tank and retract servos.

Flip the wing over to add the remaining sheeting. Add 1" x 1/64" plywood strip or glass tape underneath the wing joint. Cut slots at the bottom, then sand the trailing edge flush. Carve and sand leading edge to shape. Trim at the front for nose ring. Note: You might have to relocate the nose ring for propeller clearance. Add wingtip blocks, then carve and sand to shape. For scale purpose, there is less reflex at the tip blocks. Install elevon torque rods (any commercial aileron torque rod with 3/32" dia.). If you choose mechanical mixing, extend the torque rods close to each other, so that you can hook them up to a sliding aileron servo (a longer rod, with thicker dia. is required for rigidity). There are a lot of articles regarding how to make a sliding servo tray, so I'm not going to cover that here.

Fuselage:

Usually, this model will come out nose heavy, so use light balsa at the front and heavy wood at the back. Prepare the fuselage bottom sheeting from 1/16" balsa, cut





LEFT: The phototype fiberglass fuselage cover shows the panel lines and grilled intake. It is available at a very affordable price from author. RIGHT: Author with his previous design, the Space Shuttle. Another design that doesn't fly is the streamline FRP chair.

to size. Mark the centerline, slots, etc., as a reference, then glue it to the wing trailing edge, making it as accurate as possible. Glue L1A, L1B, and L1C together to form the center longeron. Use hard balsa and make sure L1B is straight. It's a good idea to mark the C.G. point on L1B before you glue the assembly in place. Use a square to ensure that it is perpendicular to the centerline. Prepare another two pairs of outside longerons from L2A and L2B. Bevel the front end of L2A to match L1B and glue them in place. Again check for proper alignment. Glue the 3/16" x 1/2" balsa stock E2 on the previous marked position. Glue the 1/8" balsa E4 between L1C and L2B. You might need a simple rib cut from cardboard to set it up.

Add the three 1/4" balsa sticks to reinforce the bottom skin, then glue the 1/8" plywood E3 in place. Add some 1/2" triangular stock to E4 between L1C and E3, E3 and L2B. I usually cut this stock oversize, then gradually sand the ends to fit in place. Sand all top surfaces flush. Trim F-11 to shape and glue it in place, bevel L2B at half width to fit F-11.

Now comes the most difficult part because all fuselage panels are glued to each other at various angles. After you prepare the panels, temporarily pin them in place, bevel the edges to match the adjacent panels, and mark all reference lines. Remember, if one panel is out of shape or misaligned, the following panels have to be reshaped or moved out of position. A tip here is, after you finish a panel on one side, make and install the same panel on the opposite side immediately, so that everything is symmetrical.

Once you get "warmed up," you will find out that it's not really difficult. Even though it is not built perfectly, you can seal the gap with covering material or primer. Note: A fiberglass fuselage cover is also available which greatly speeds up the building job and enhances scale appearance. See note at end of text.

Glue F2 and F3 in place. Trim the corresponding portion of L2A to fit F6, then glue F4 and F5 in place. The bottom and inside edge of F4 has to be sanded to a sharp bevel and F7 has to be slightly bent to match F3, F4, F5, and F6. Glue F9 and F10 in place, slightly bevel L2A to match F9, then followed by F8. Glue plywood F12 in place, adding 3/8" triangular stock underneath each end as reinforcement. It's optional to use epoxy glue for this application. Add a 3/8" stick between L1B to L2A as hatch support. Use scrap wood to reinforce the joint.

Cut six plywood gussets as hatch mount.

The hatch is made up of four panels of H1 and H2. Place wax paper or plastic food wrap on the fuselage so that you can build the hatch over it and remove it easily, after the glue has set up.

Epoxy the fins in place. Make sure each fin tip is equal distance to the wingtip. Reinforce the root with 3/8" triangle stock epoxied in place. Use 1/8" scrap wood to make the tail fairing.

Prepare the miscellaneous parts such as the rudder, exhaust reflectors, elevons, etc. Cut the elevons from 3/8" balsa sheet. Bevel the leading edge, then mark a straight line from the inside bottom corner to the outside top corner at the trailing edge. Carve it to a wedge shape and provide a lot of twist (wash-out) towards the tip. It is worthwhile for this extra work because this additional wash-out helps prevent tip-stall. However, one might want to "down trim" the elevons for static display.

Finishing:

Sand all parts smooth, then make sure they are dust-free. I used black Solartex to cover the whole plane because I liked the textured matte finish. This fabric is very easy to apply around corners. I use Balsarite or equivalent on certain areas to prevent the covering from being peeled off later.

A note of caution is in order here: prevent long exposure under strong sunlight or you will find that your model gets really hot!

The self-adhesive decals don't stick to Solartex well, so I painted the details on, but the paint tends to weep around the masking. You may also use MonoKote and dull the finish with fine sandpaper or fine steel wool.

If you prefer painting, make sure to keep the weight to a minimum. Fuelproof the engine compartment, exhaust area, wheel wells, etc., with black paint.

Hinge all control surfaces in place, making sure they move freely. It's up to you as to when to do this job, before or after finishing.

It is optional to leave the fins partially uncovered so that proper weight may be added later on.

Rather than discuss the stealth characteristics of this aircraft, I'd like to suggest how to make it more visible. It is a good idea to stick or paint bright strips underneath the wingtips so that you don't lose orientation in flight. These strips can be easily peeled off or repainted after you get used to it. I did not do this, so, occasionally, I lost orientation of it after performing certain maneuvers.

Fuel Tank:

Prepare an 8 oz. tank. Put all tubing in place and make sure they are secured properly because once you servo-taped the tank in place, it is very difficult to remove it for service. Install your favorite engine together with fuel pump or fuel regulator. Connect all fuel tubing. I use a Robart Fuel Filler to make refueling easier.

Install all retract gear. I used a single servo to activate all gear and hook up pushrods to the main gear, making sure they work properly before I hook up the nose gear. Optionally, you can install an extra servo to reduce the servo loading and make hook-up easier, or some people prefer pneumatic gear because they are much easier to hook up. Just make sure you give enough consideration to modifying the mounting plate and allow space for the air tank, etc., ahead of time.

Radio:

Before I talk about other servo installations, I think it is necessary to explain how they work. The twin rudders move in the conventional way, so does the throttle. However, the servos for pitch and roll control are unique. Both the exhaust reflectors and elevons move in the same direction for pitch control, just like the conventional elevator. Only the elevons move in opposite ways for roll control, like conventional aileron. All four control surfaces have reflex (up trim) to provide longitudinal stability.

I use a Futaba 7UAP which provides more than enough electronic mixing for this application. Any radio with flaperon, elevator to flap mixing works fine. Each elevon is operated by a servo which is mounted sideways. Use side mounts if available, or build

more sluggish than a conventional model. Therefore, try your first loop at a safe altitude. I believe it is possible to move the C.G. point farther back to achieve a tighter loop. However, move it 1/8" at a time, only after you are totally familiar with the model. This model does not tip-stall, which was another surprise to me. Therefore, it also does not spin; instead, it enters a spiral dive and recovers quickly as soon as the sticks are released. For the same reason, it will not perform snap rolls. It will perform a stall turn, but watch very carefully which way it recovers, as it may flip over and thus confuse you.

If you *RCM* readers discover any new performance, please share it with me. It is always a pleasure to hear any feedback from the readers.

This is a unique model for those who demand something special and, once you become familiar with it, it will pay you back. Whether at the club meeting or at the flying site, you will certainly become a star attraction.

In order to encourage more people to start this project, I have prepared a homemade flight demonstration video tape for $9.50 plus $3.50 shipping and handling. There is a $4.50 discount coupon enclosed for the purchase of the fiberglass fuselage cover and other related products. For further information, write to Parker Leung, P.O. Box 298, Ajax Ontario, L1S 3C3, Canada or call/fax (905) 305-0603.

After my first article, the .40 size Space Shuttle was published, quite a lot of readers expressed their interest in a bigger .60 size version. I have a lot of projects in the planning stage, such as SR-71, B2 Bomber, F-22 Fighter. They are all sport versions.

If you have any suggestions, please write to me or RCM.

BILL OF MATERIALS

Balsa Block
1 — 1" x 1" x 10"
Balsa Sheeting
4 — 1/16" x 4" x 42"
7 — 1/16" x 4" x 36"
5 — 3/32" x 3" x 36"
5 — 1/8" x 4" x 36"
2 — 1/4" x 4" x 36"
1 — 3/8" x 4" x 36"
Balsa Stick
2 — 3/8" x 1" x 36"
7 — 1/4" x 1/4" x 36"
Balsa Triangle
1 — 1/4" x 1/4" x 36"
1 — 3/8" x 3/8" x 36"
Hardwood Dowel
1 — 1/8" x 12"
Plywood
1 — 1/64" x 2" x 12"
1 — 1/8" x 12" x 24" (lite ply)
1 — 1/4" x 3" x 20"
Miscellaneous
1 — Nose gear (fixed or retract)
1 set — Main gear (fixed or retract)
1 — Elevon torque rod
1 — 2" spinner
1 — 8 oz. tank
1 — 2" wheel
2 — 2-1/2" wheels
Covering material, NyRod, hinges, horns, bolts, collars, clevises, glue, fuel tube, prop, pump, fuel filler, engine, and R/C, etc.