# Quadratwirl Electric Autogyro
## By Al Foot

### Introduction

Quadratwirl is the fourth iteration of the "Twirl" electric autogyro. Twirl was a side-by-side twin rotor autogyro built primarily from 3mm depron sheet with carbon reinforcement. It was designed for lightweight radio equipment and a 50 Watt outrunner brushless electric motor, for a total weight of around 7 to 9 ounces. The plan for Twirl was given as a free plan in the January 2006 Radio Control Models and Electronics (RCM&E) magazine.

Since then, I have developed a single rotor version, (Monotwirl) which is to appear in the same magazine. Additionally, I made a 50% scale version of Twirl using Falconmodels radio and a small outrunner motor. Minitwirl, as I called it, weighed just 1 ¼ ounces ready to fly.

Having tried twin and single rotor autogyros, I was looking for another challenge, and happened across a couple of drawings of the proposed Bell-Boeing Heavy Lift Helicopter. It has a front and rear wing with rotors at each wingtip which can tilt up vertically for hovering, and then rotate forwards and act as giant propellers when in conventional flight, just like the V-22 Osprey. I liked the look of the thing with the rotors in the vertical position, and pondered whether I could produce an autogyro with the same rotor configuration. I doodled away, using my previous Twirl design as the basis, and came up with Quadratwirl.

*A 50 Watt CD ROM- based motor was used on the prototype*

Quadratwirl was conceived using the same "keep it simple" philosophy as my other autogyro projects, is straightforward to build and fly, and uses readily available materials, motors and radio equipment. As with all autogyros, the secret is getting the key angles right, these being the pitch of the rotor blades, the tilt angle of the rotors relative to the wing, the wing and tailplane incidence, dihedral and downthrust. With Quadratwirl there is the additional complication of the extra rotors and the canard configuration, but you will be pleased to know that the correct angles have been built into the design. So without further ado, let's get on and build one!!

### Building sequence

#### Fuselage

Cut out the fuselage and rudder from 3mm Depron. Sand a 45 degree chamfer on the leading edge of the rudder. Cut out the slot for the front wing, noting that it is set at 5 degrees to the longitudinal fuselage datum line. Do the same with the slot for the rear wing. Cut out the front fuselage doublers, and the horizontal fuselage pieces. Cut out the fuselage stiffeners and sand a 45 degree chamfer on both edges. Glue the left front doubler to the side of the main fuselage using UHU Por glue, ensuring that the assembly remains flat whilst the glue dries. Then glue the left fuselage sidepiece to the fuselage, making sure that it aligns exactly with the datum line, and is at right angles to the main fuselage, and allow to dry. Apply glue to the chamfered edges of the fuselage stiffener and then glue to the main fuselage and below the horizontal fuselage piece. Allow to dry thoroughly, and you should have a reasonably rigid and torsionally stiff fuselage. Glue the right front fuselage doubler, the right horizontal fuselage piece and the right chamfered fuselage stiffener in the same way, and allow to dry.

#### Wings and Elevators

The wings are cut from Depron, with 3mm by 1mm carbon leading and trailing edges glued using UHU Por from the root to where the rotor pylon fits. You may need to retain the trailing edge of the front wings in place at the tip until the glue is dry. When dry, sand the roots to the correct angle, lay one wing on a flat surface and raise the tip of the other wing to achieve the correct dihedral angle. Glue the wings together using your favourite epoxy, using as little as possible to make the joint. Allow to dry thoroughly.

Cut out the left and right elevators from 3mm depron Sand the leading edge of the elevators to a 45 degree chamfer. The elevators use a top hinge made from adhesive tape. I used "proper" modelling hinge tape. Lay the left side of rear wing on a flat surface, top surface up, with the trailing edge overlapping the surface. Lay the left elevator on top of the left rear wing so that the 45 degree chamfer is exactly on top of the trailing edge. Cut two pieces of hinge tape and apply them close to each end of the elevator at 90 degrees to the hinge line and round the bottom of the rear wing. You should now be able to pivot the elevator on these two hinges to the fully down position, and then apply adhesive tape along the length of the wing/elevator joint to form the top hinge. What we want is a free hinge without resistance or binding. The procedure for the right elevator is similar **BUT DO NOT INSTALL THE RIGHT ELEVATOR AT THIS STAGE**

### Rotors and Rotor Pylons

Cut out the rotor blades from 3mm Depron. Cut some printer/photocopy paper to the length of the blades, and cut into sixteen 20 mm widths. The paper, once glued to the leading edge of the blades, forms the spar. Moisten the paper and glue the paper symmetrically around one edge of each blade using

*Side view showing the struts and the thread bracing*

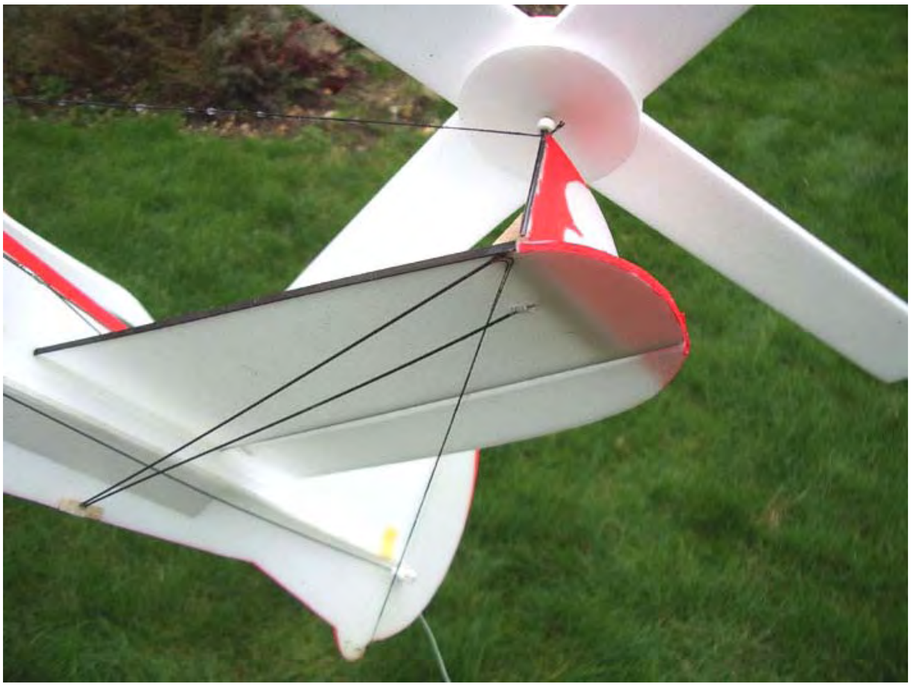
white glue. Allow drying thoroughly overnight, ensuring that the blades remain flat. Note:- I have also tried rotor blades without the paper spars, and these were entirely satisfactory.

Cut out the 50 mm and the 40 mm diameter rotor discs and the squares of balsa for the rotor centres. Drill a central hole in the discs and rotor centre to take the brass rotor pivot tube, ensuring that it is square. Glue the balsa to one of the discs and allow to dry.

To make a rotor, add the square of balsa to the centre of one of the Depron circles and allow to dry. Make one rotor up by overlapping each rotor blade, and butt up against each face of the balsa. The leading edge of the blade with the paper reinforcement should be closest to the building board. You will need to feed the last blade in. Once happy, glue the blades and the top Depron circle and weigh down, checking that the central hole is vertical. The blade angle is self-jigging.

Make the other rotors in exactly the same way, **but note that the overlap of the blades must be in the opposite direction for each pair of rotors** to make sure that you have one rotor that rotates clockwise and one that rotates ant-clockwise.

The rotor pivots are cut from 2 mm id brass tube (slightly longer than the completed rotor thickness so that it protrudes either side)



*Rear wing struts and thread bracing.*

which are then glued into the holes previously drilled in the centre of the rotors.

The rotor pylons are cut from Depron. The rotor axles are cut from 2mm carbon rod, sufficiently long to allow for a bush above and below the rotor. Glue and tape the axles to the front of the rotor pylons.

### Undercarriage

Bend the 1mm/16g wire to the shape shown on the plan. Cut and drill the undercarriage blocks from balsa and glue the wire into the balsa. I used plastic milk bottle tops for wheels, but you can choose your own favourites.

### Final Assembly

Slide the front wing into its slot in the fuselage, ensuring that it is square to the fuselage and glue with UHU Por. Do the same with the rear wing, again making sure that everything is square. – Now you can see why the right elevator was not added earlier!! Allow the glue to dry. Don't worry too much if the wings feel floppy at this stage, this will be sorted with carbon rod bracing in a short while. Hinge the rudder to the fin using adhesive hinge tape. Do the same with the right elevator.

Glue the undercarriage and wing strut balsa blocks to the fuselage sides with foam-friendly CA.

Glue the rotor pylons to the wings, and brace with triangular

*Rearwards view showing a fuselage sidepiece and 45 degree stiffener.*

section balsa inboard of the pylons.

Drill the wing strut blocks and the rotor pylons/triangular balsa, and CA the 1mm struts in position, ensuring that the wings remain correctly aligned. Note that the rear wing has two struts per side.

Tie a double strand of thread, and glue through the leading edge of the bottom of the left rear rotor pylon. Pass the thread rearwards behind the top of the tailskid just below the rudder, and glue it through the leading edge of the bottom of the right rear rotor pylon. Add a further double strand of thread from the top of each rear rotor pylon just below the bottom rotor bush through the fuselage about 2 inches forward of the cockpit just above the fuselage horizontal sidepieces. Please do not omit the thread as it reduces the rearwards tilting of the rear rotors when in flight. The thread should be taut, but not stretched. Strengthen the thread by soaking with foam-friendly CA.

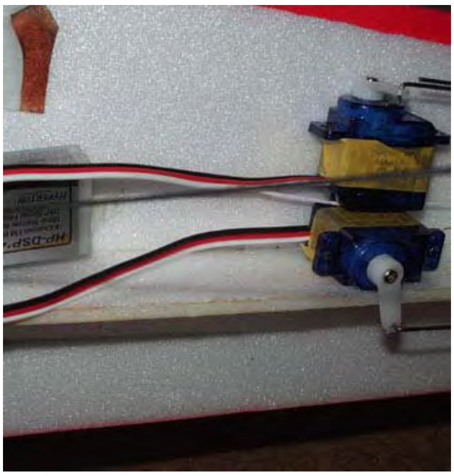
Glue engine mount to the front of the fuselage, and mount the motor using your favourite method.

Slide the rotors on to the rotor pylon axles. If, as mine did, they squeak when they rotate, rub the carbon axle with a pencil, taking care to avoid the uppermost part where the retaining bush will be glued. This will lubricate the axle and stop the squeaking. I prefer the left rotors to rotate clockwise and the right ones to rotate anti-clockwise as seen from above. When happy, glue the retaining bushes above the rotors.

Plan the radio installation and battery retainer to obtain correct C of G without ballast.

Make control horns from 1mm ply, and then glue them into slots cut in the elevators and rudder.

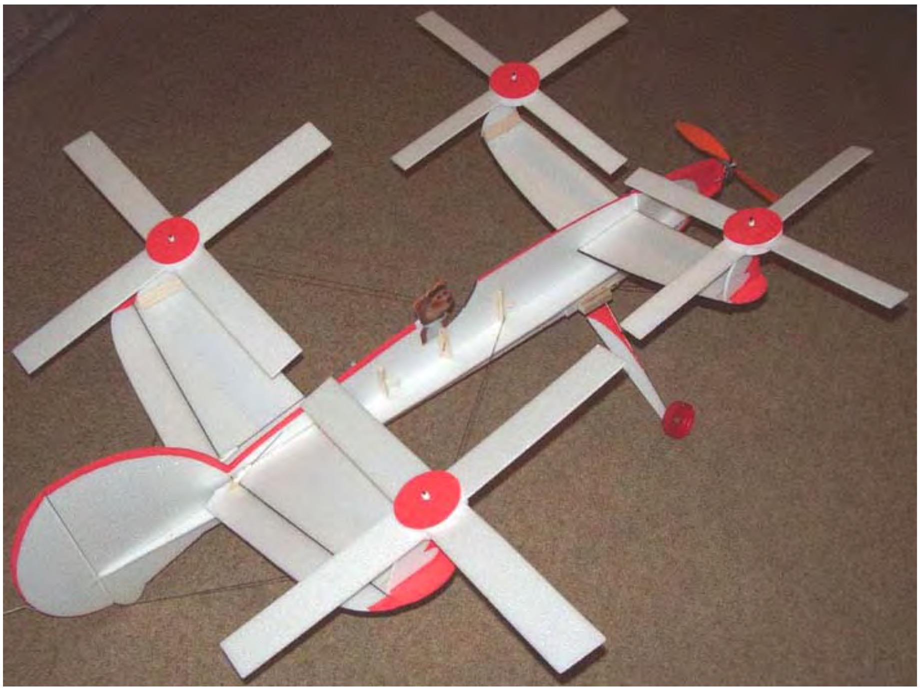
Make up the control rods, and connect the servos to the rudder and elevator horns.



*Servo installation used on prototype.*

### Flying the Quadratwirl

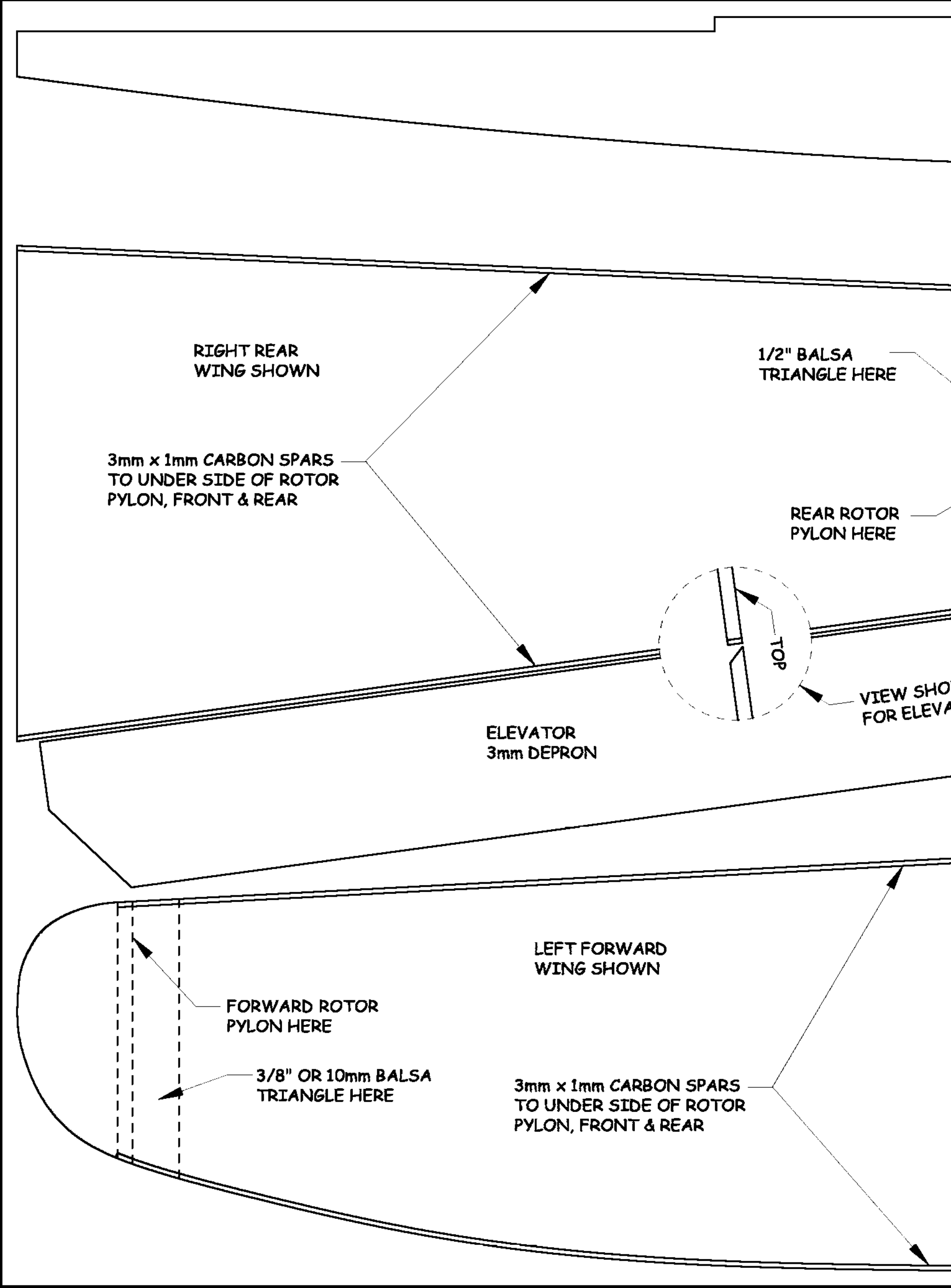
Flying the Quadratwirl is very similar to flying the Twirl. Take-off from short grass is no problem, but it can also be hand launched if needs be. It flies slightly slower and, although I have flown it in winds up to 15 mph, it is most enjoyable to fly in light breezes where its full potential can be realised. It flies slowly enough to fly indoors as well. One of the great things about autogyros is that they are impossible to stall in the conventional sense, so you can have fun pulling the nose up higher and higher, which causes the rotors to rotate faster and faster. Play with the throttle and elevator and you can have Quadratwirl in a nose high hover into wind, or do very tight turns indeed. I have found that the front rotors speed up slightly when in a nose high attitude, and it is possible to get it moving backwards relative to the ground in even a light breeze. Mild aerobatics such as loop are also possible, but I would recommend doing this from a slow climb before pulling over the top. With appropriate power, it is possible to climb Quadratwirl vertically at a very slow speed so that the rotors actually stop!! In flight Quadratwirl is not quite as flexible as the Twirl, but has proved to be adequately strong in the field. Normal landings can be done, or you can do slow steep approaches to land almost vertically with appropriate use of power and elevator.

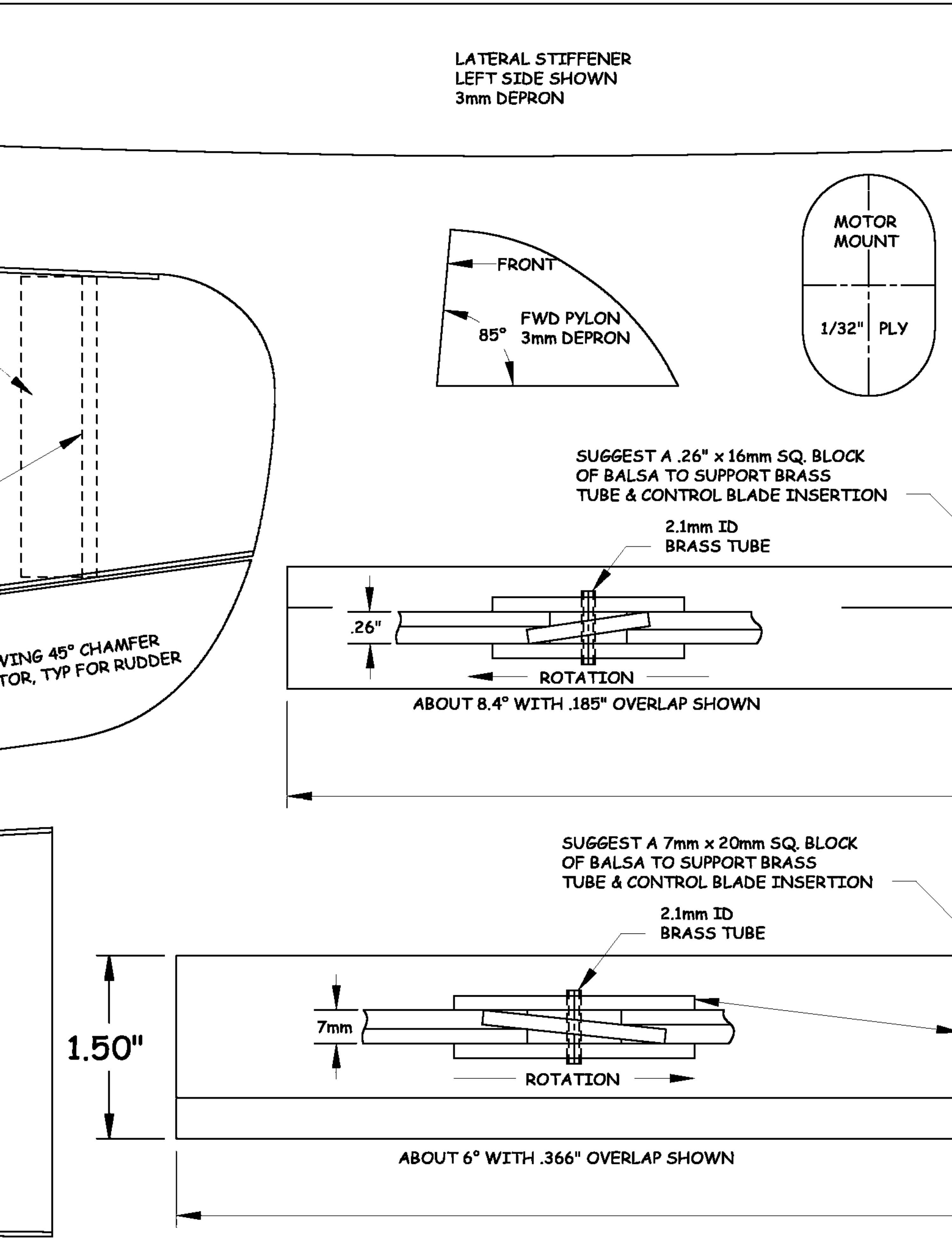


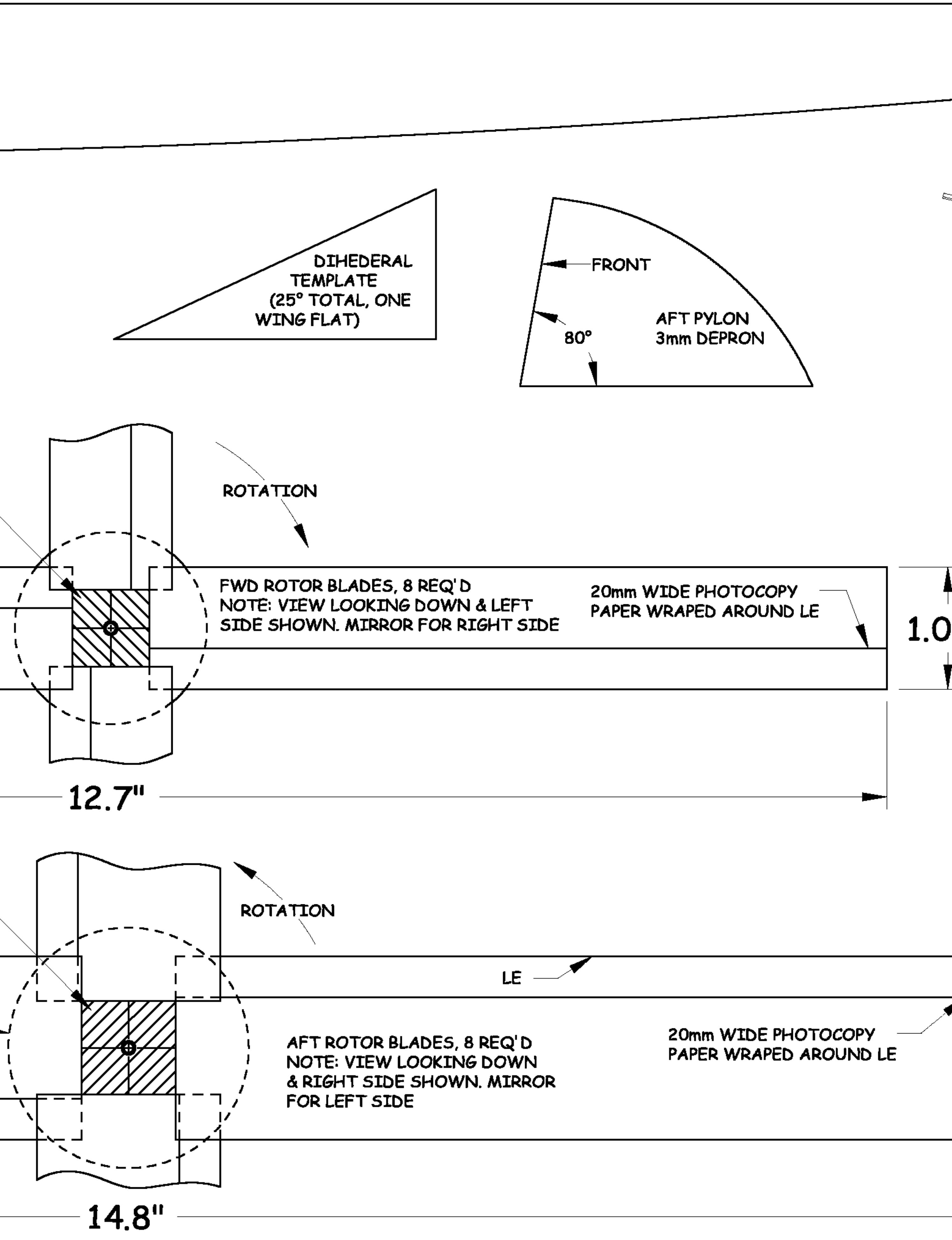
**Happy gyro-ing!**!

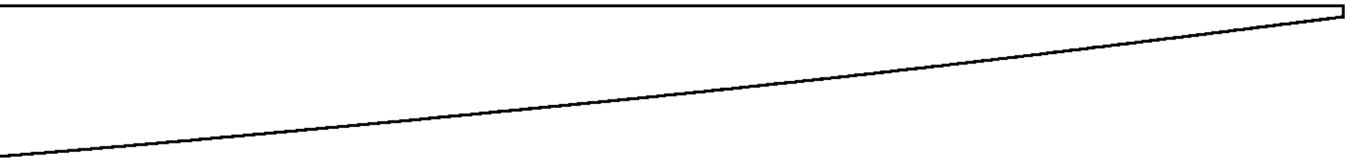
**Quadratwirl Datafile**

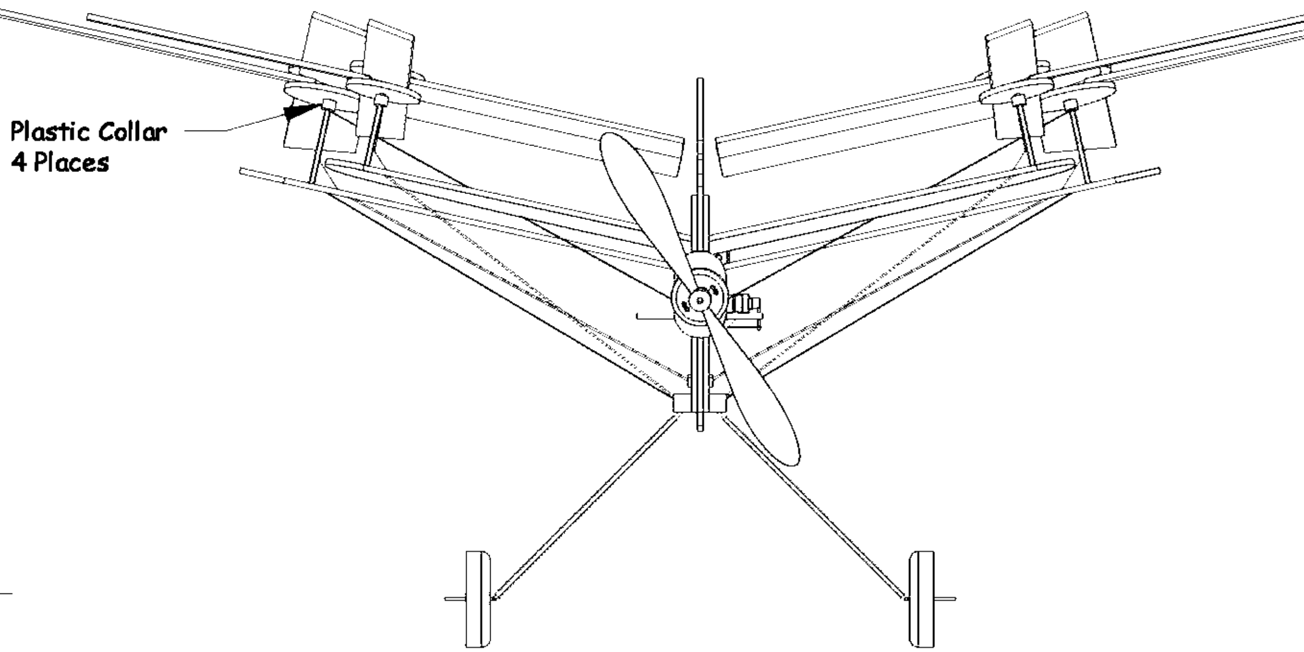
| | | | |
|---|---|---|---|
| Front Wingspan | 16.00” | Wing section | Flat Plate |
| Chord at centre | 3.35” | Rotor blade section | Flat plate |
| Span (rotor tip to rotor tip) | 25.50” | Tail and fin section | Flat Plate |
| Front Rotor diameter | 12.70” | Rear Wing incidence | 0° |
| Rear Wingspan | 19.65” | Front Wing incidence | 5° leading edge up |
| Chord at centre | 4” plus 1.25” chord elevators | Rear Rotor blade angle | about -6° (self jigging) |
| | | Front Rotor blade angle | about -8.4° (self jigging) |
| Span (rotor tip to rotor tip) | 29.77” | Rear Rotor post tilt angle | 10° aft |
| Rear Rotor diameter | 14.80” | Front Rotor post tilt angle | 5° aft |
| Front Rotor central hub | 16mm Sq. x .26” balsa | (Note: - with front wing incidence of 5°, front and rear rotors are both tilted 10° aft) | |
| Rear Rotor central hub | 20mm Sq. x 7mm balsa | | |
| Front Rotor hub disc | 50mm dia. 3mm depron | | |
| Rear Rotor hub disc | 40mm dia. 3mm depron | | |
| Front rotor blades | 6” x 1” x 3mm depron | Weight | 7 1/4 oz (prototype) |
| Rear rotor blades | 7” x 1.5” x 3mm depron | Rotor loading | about 2 oz/sq. ft. |
| Fuselage Length | 32.60” | Rudder movement | 1.5” each way |
| Rear wing area | 83.74 sq. in. | Elevator movement | 1” each way |
| Front wing area | 44.51 sq. in. | Balance point | 11.75” aft of firewall |
| Rear Swept rotor area | 342 sq. in. (both) | Motor | outrunner up to about 50W |
| Front Swept rotor area | 254 sq. in. (both) | | |

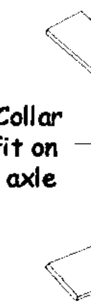

RIGHT REAR
WING SHOWN
1/2" BALSA
TRIANGLE HERE
3mm x 1mm CARBON SPARS
TO UNDER SIDE OF ROTOR
PYLON, FRONT & REAR
REAR ROTOR
PYLON HERE
TOP
VIEW SHOW
FOR ELEVAT
ELEVATOR
3mm DEPRON
LEFT FORWARD
WING SHOWN
FORWARD ROTOR
PYLON HERE
3/8" OR 10mm BALSA
TRIANGLE HERE
3mm x 1mm CARBON SPARS
TO UNDER SIDE OF ROTOR
PYLON, FRONT & REAR


LATERAL STIFFENER
LEFT SIDE SHOWN
3mm DEPRON
MOTOR
MOUNT
1/32"
PLY
FRONT
FWD PYLON
3mm DEPRON
85°
VING 45° CHAMFER
TOR, TYP FOR RUDDER
SUGGEST A .26" x 16mm SQ. BLOCK
OF BALSA TO SUPPORT BRASS
TUBE & CONTROL BLADE INSERTION
2.1mm ID
BRASS TUBE
.26"
ROTATION
ABOUT 8.4° WITH .185" OVERLAP SHOWN
SUGGEST A 7mm x 20mm SQ. BLOCK
OF BALSA TO SUPPORT BRASS
TUBE & CONTROL BLADE INSERTION
2.1mm ID
BRASS TUBE
7mm
1.50"
ROTATION
ABOUT 6° WITH .366" OVERLAP SHOWN


DIHEDERAL
TEMPLATE
(25° TOTAL, ONE
WING FLAT)
FRONT
80°
AFT PYLON
3mm DEPRON
ROTATION
FWD ROTOR BLADES, 8 REQ'D
NOTE: VIEW LOOKING DOWN & LEFT
SIDE SHOWN. MIRROR FOR RIGHT SIDE
20mm WIDE PHOTOCOPY
PAPER WRAPED AROUND LE
1.0
12.7"
ROTATION
LE
AFT ROTOR BLADES, 8 REQ'D
NOTE: VIEW LOOKING DOWN
& RIGHT SIDE SHOWN. MIRROR
FOR LEFT SIDE
20mm WIDE PHOTOCOPY
PAPER WRAPED AROUND LE
14.8"

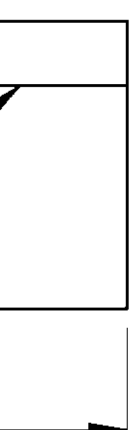


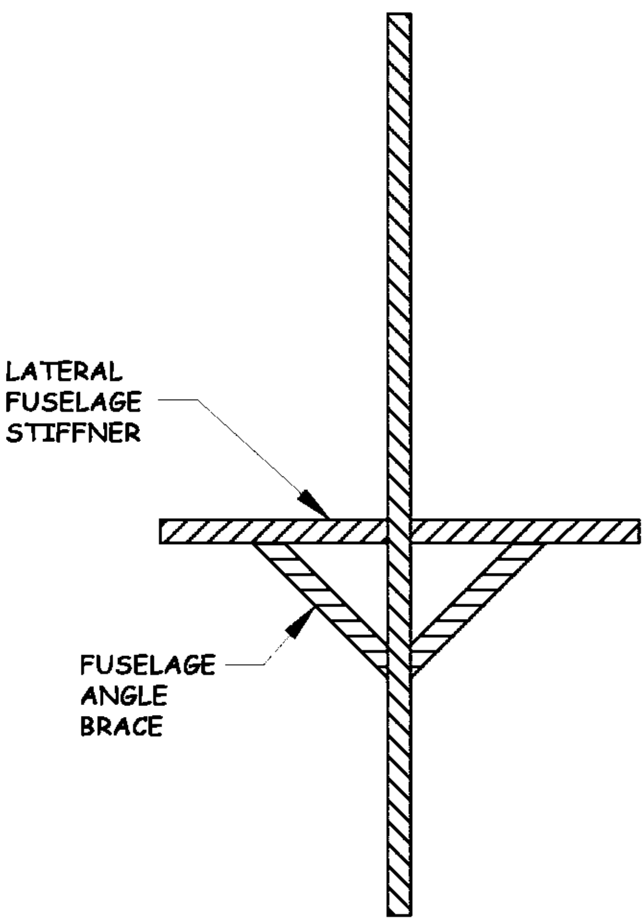


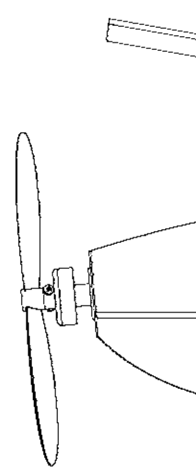

0"

THESE VIEWS,
1/4 SCALE

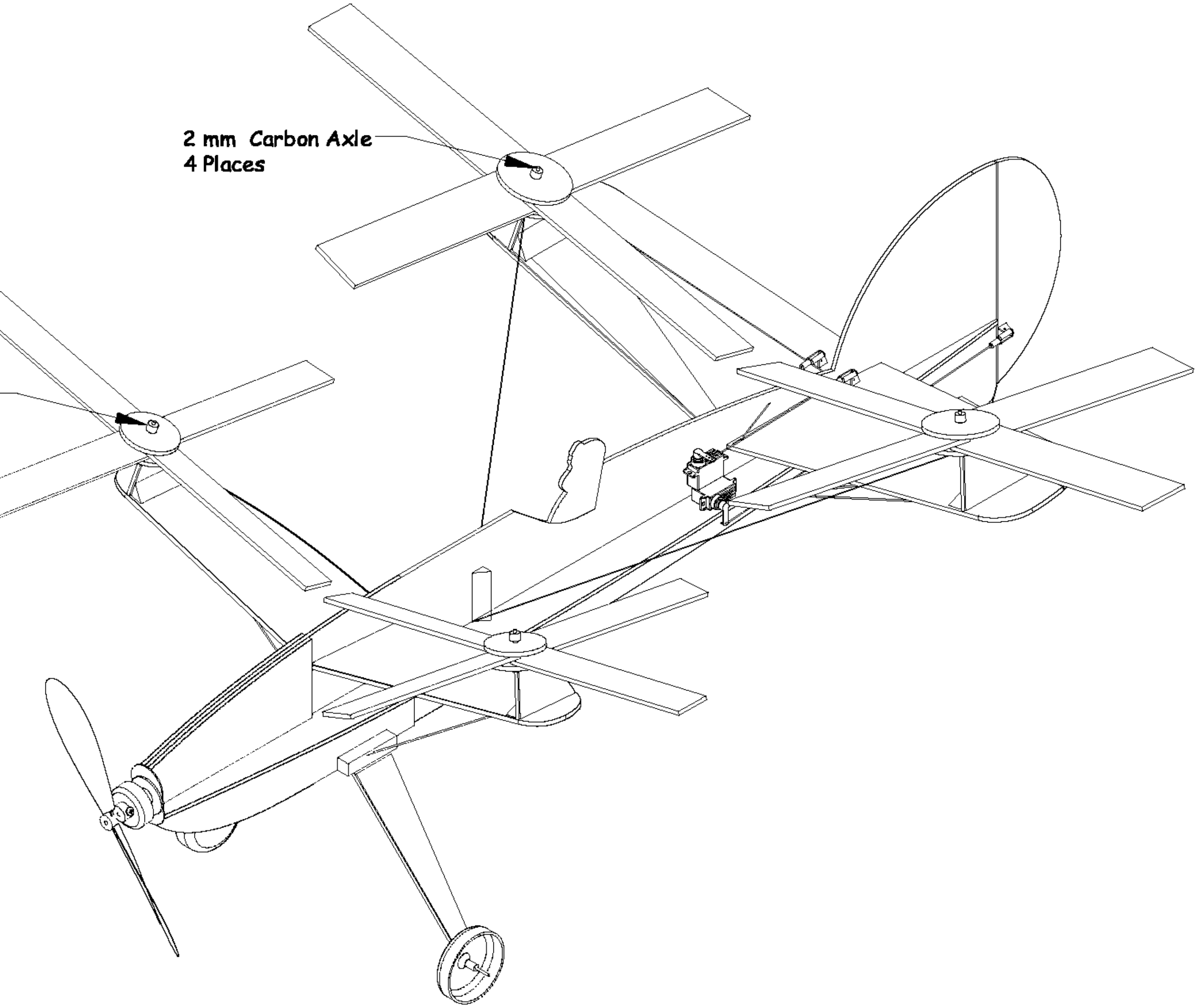


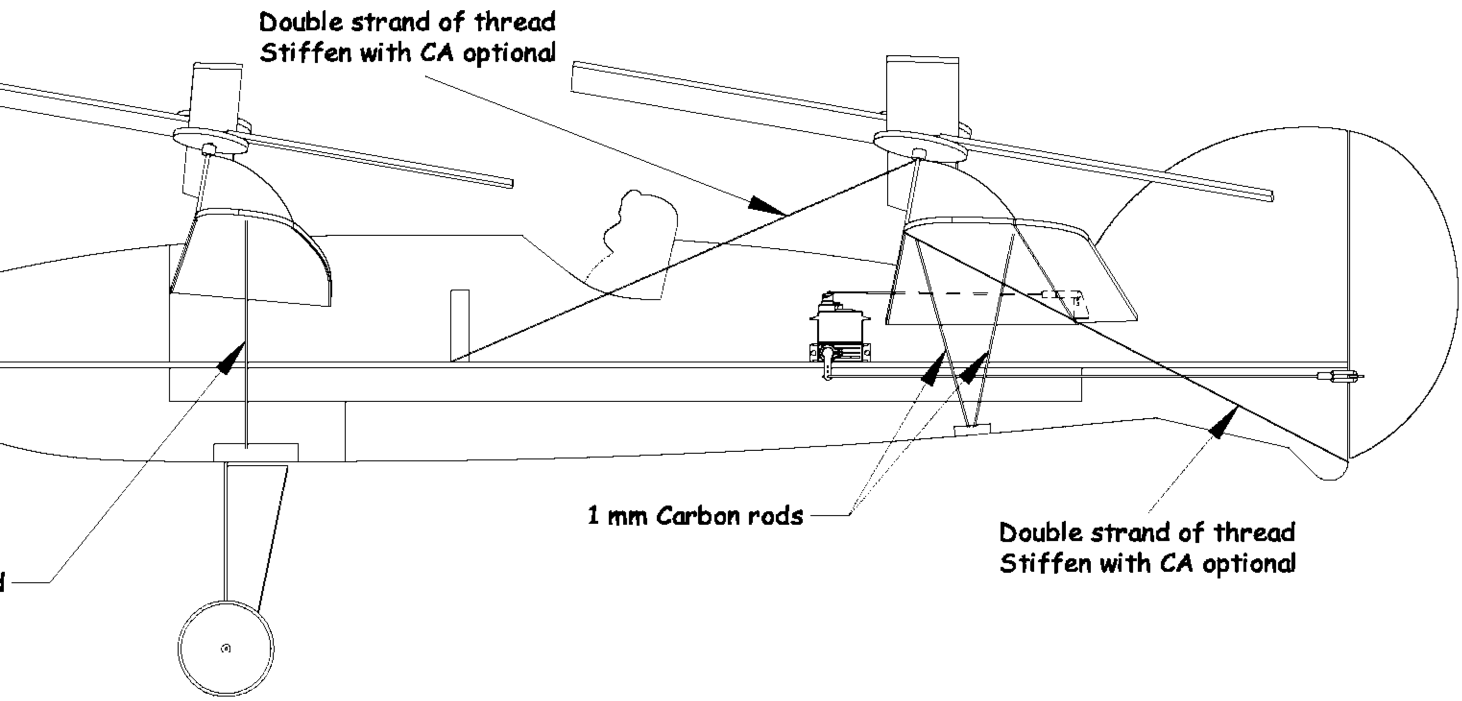


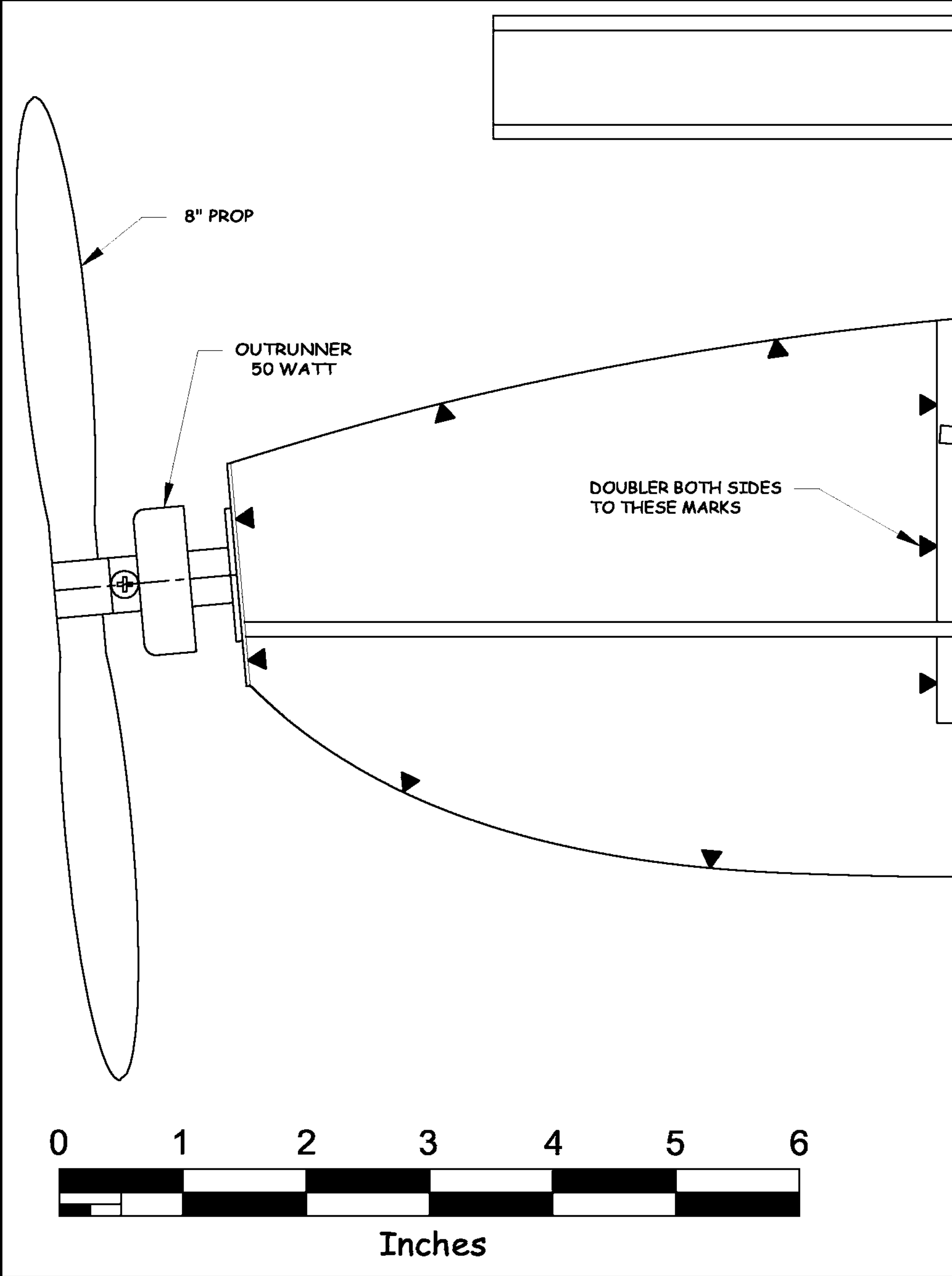

SECTION A-A



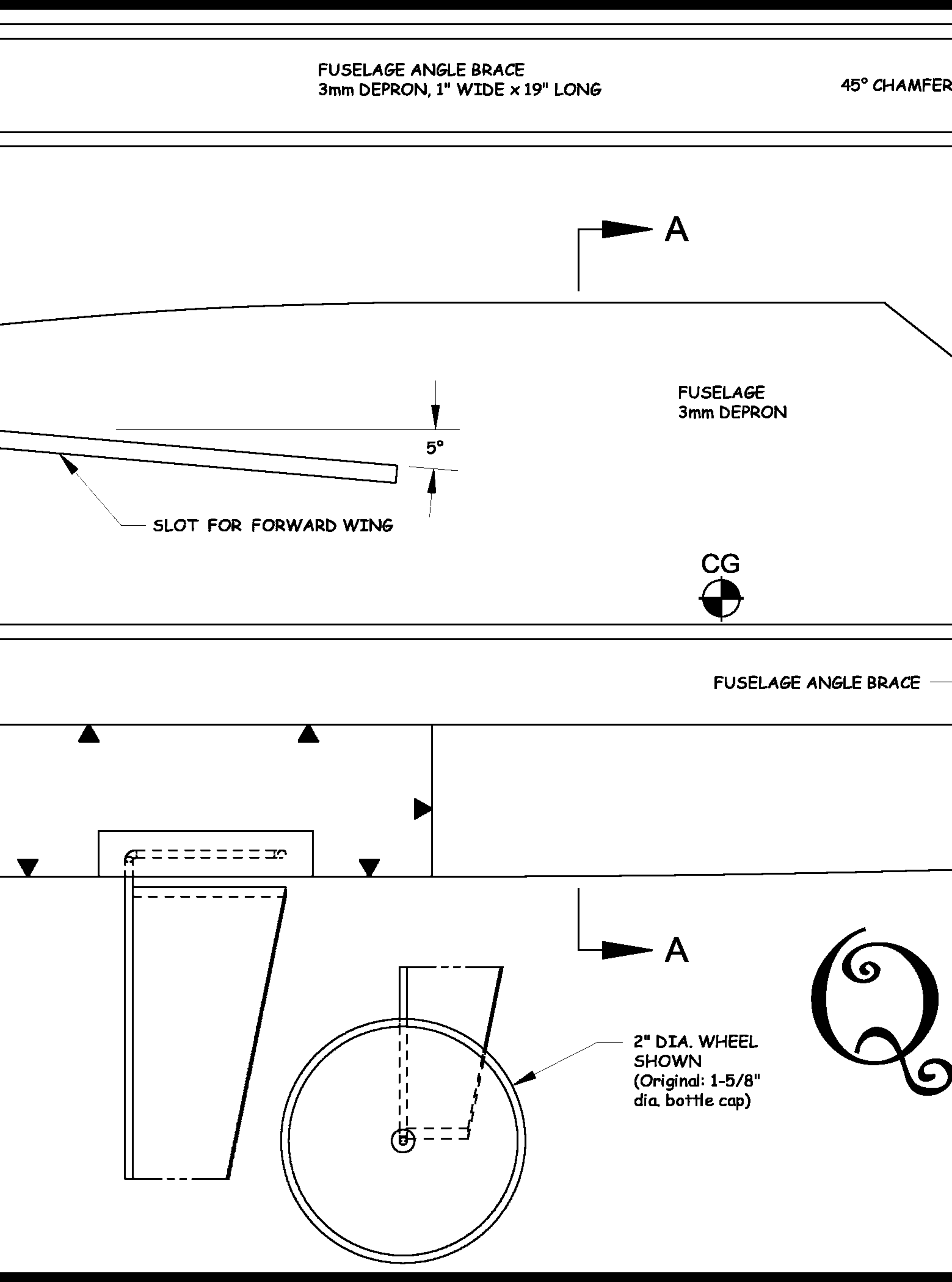
1 mm Carbon roc

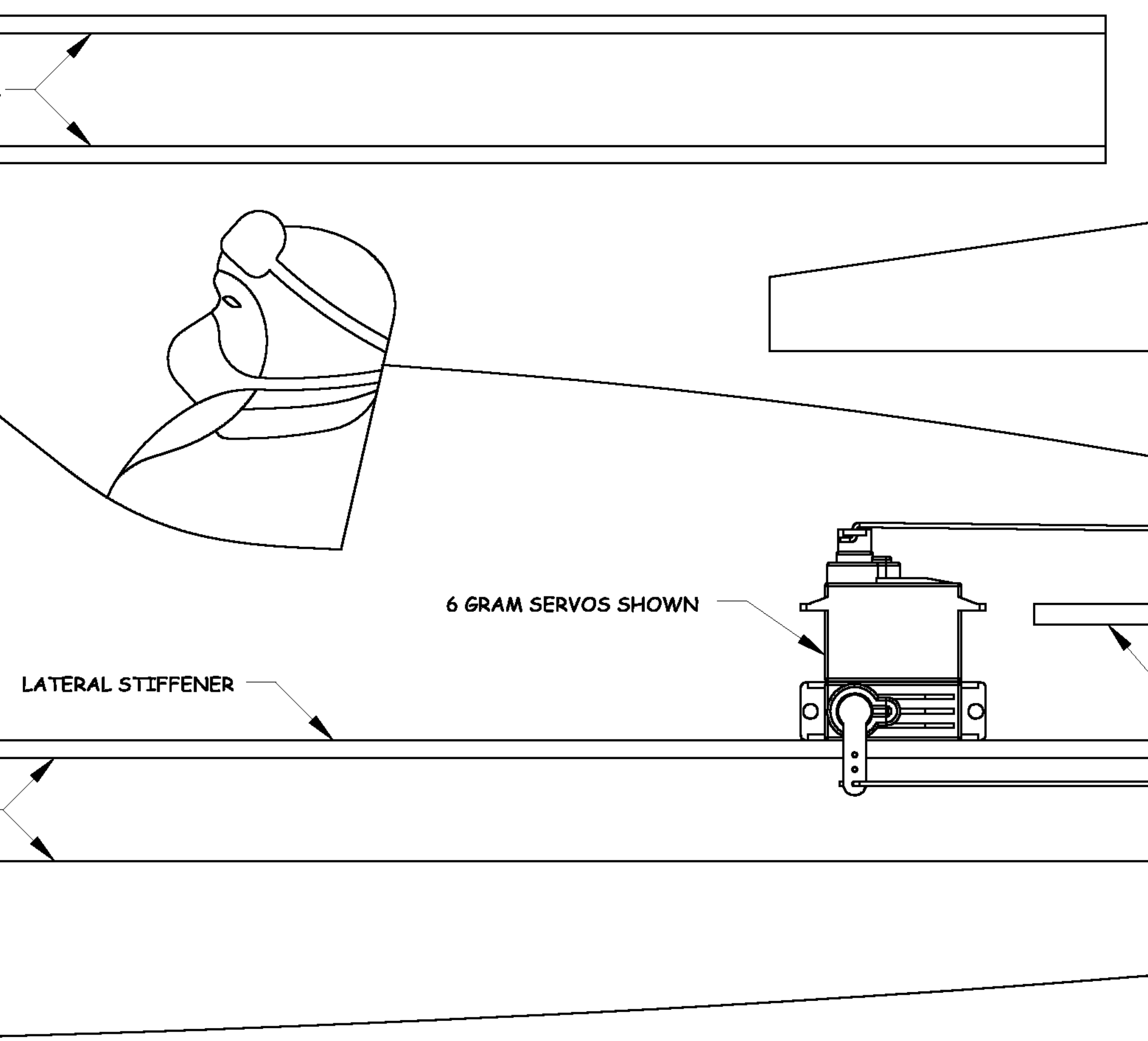

2 mm Carbon Axle
4 Places


Double strand of thread
Stiffen with CA optional
1 mm Carbon rods
Double strand of thread
Stiffen with CA optional



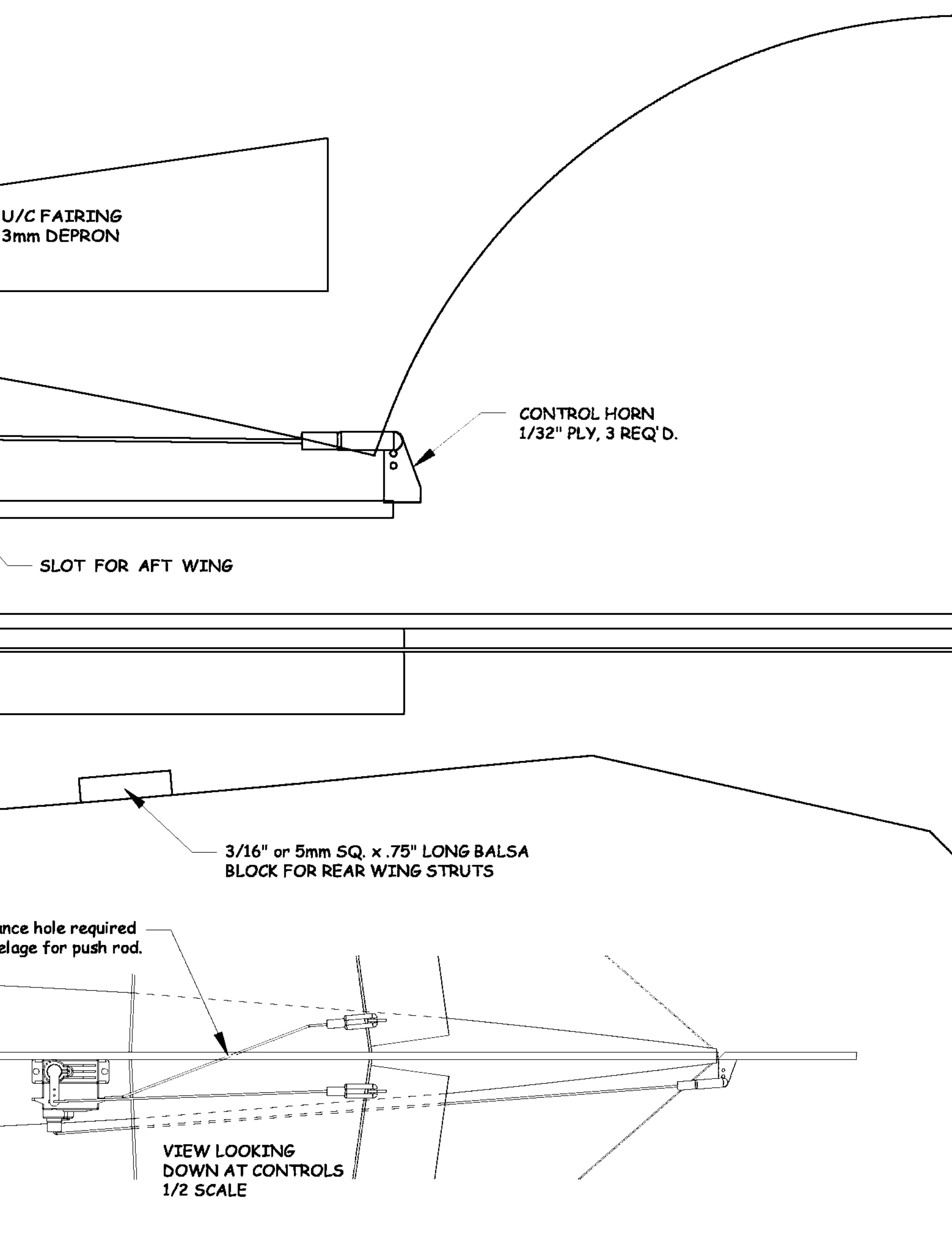
8" PROP
OUTRUNNER
50 WATT
DOUBLER BOTH SIDES
TO THESE MARKS
0
1
2
3
4
5
6
Inches

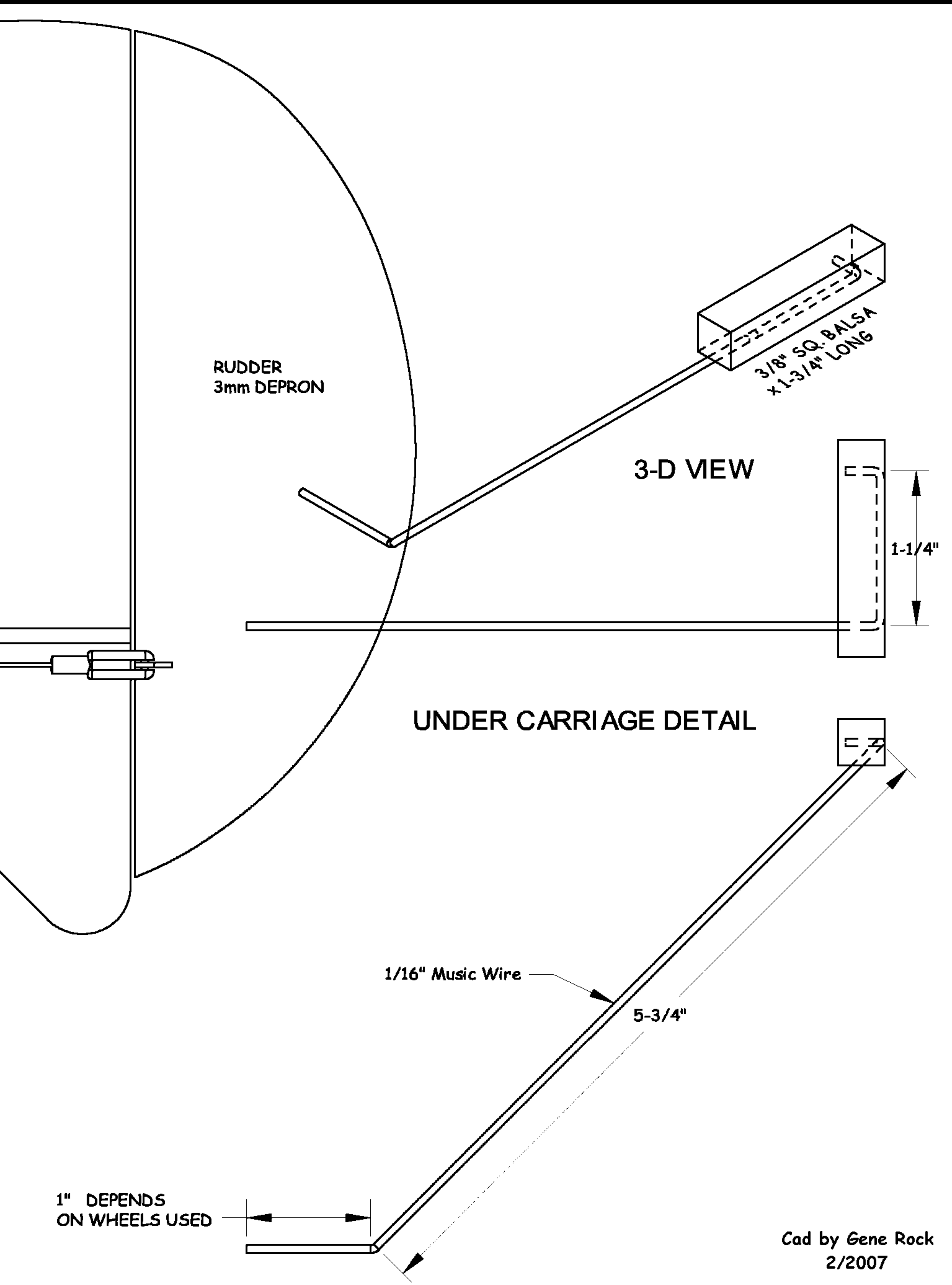

FUSELAGE ANGLE BRACE
3mm DEPRON, 1" WIDE x 19" LONG
45° CHAMFER
A
FUSELAGE
3mm DEPRON
5°
SLOT FOR FORWARD WING
CG
FUSELAGE ANGLE BRACE
A
2" DIA. WHEEL
SHOWN
(Original: 1-5/8"
dia. bottle cap)




# uadratwirl

ELECTRIC AUTOGYRO
DESIGNED BY AL FOOT


U/C FAIRING
3mm DEPRON
CONTROL HORN
1/32" PLY, 3 REQ'D.
SLOT FOR AFT WING
3/16" or 5mm SQ. x .75" LONG BALSA
BLOCK FOR REAR WING STRUTS
ance hole required
elage for push rod.
VIEW LOOKING
DOWN AT CONTROLS
1/2 SCALE



RUDDER
3mm DEPRON
3/8" SQ. BALSA
x 1-3/4" LONG
3-D VIEW
1-1/4"
UNDER CARRIAGE DETAIL
1/16" Music Wire
5-3/4"
1" DEPENDS
ON WHEELS USED
Cad by Gene Rock
2/2007