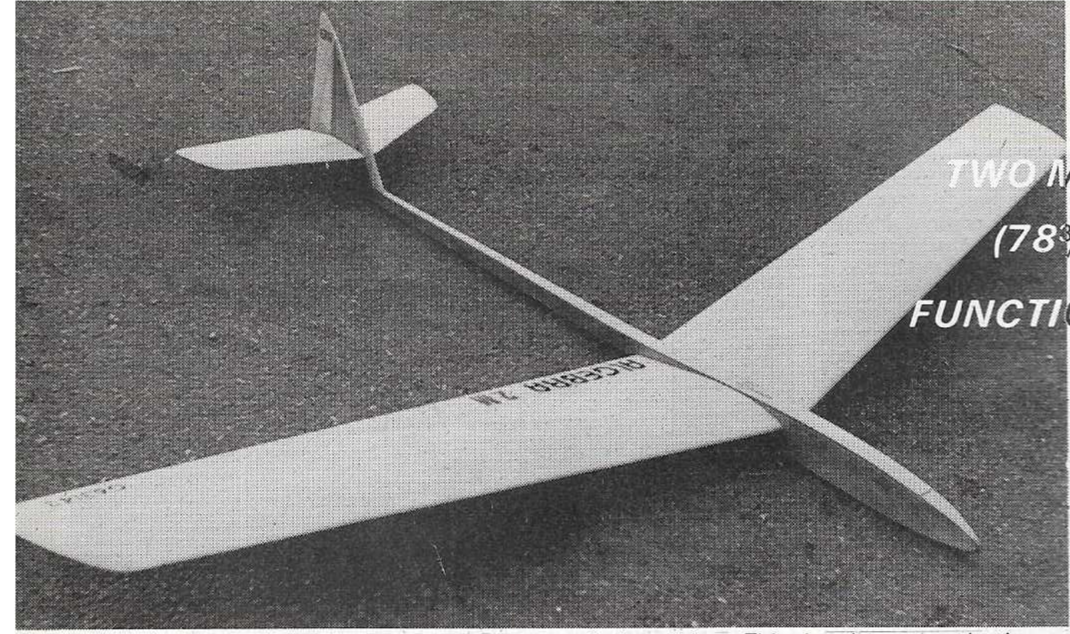


TWO METRE CLASS SOARER (78¾in. WINGSPAN) FOR 2 FUNCTION R/C CONTROLLING RUDDER & ELEVATOR

ALGEBRA 2M (Two Metre) is a serious attempt at investigating the feasibility of a 2 metre soaring class. The 2 metre concept originated in the United States of America, and has undergone some development there during the last 2 years. The first of what was intended to be an Annual 2 metre World Cup event was organised in California in January 1980 with the second event now due, both with British participation. This event is based on a multi-task flying programme, contrasted with other soaring events in the States, which have a bias towards a duration only flying programme.

Various 2 metre designs have been presented in the American modelling press, and a few kits are also available, generally of a lightweight open structure style and thus favouring the duration task. Presented here is a European, and especially British approach to the 2 metre concept, for British soaring enthusiasts are encouraged to develop soarers that can perform in fairly strong winds, whereas the American continental climate, in general, produces more gentle wind conditions. This situation means that in Europe, glide angle is important, whereas in America minimum sink is the dictating design requirement.

Having placed a 2 metre wing span restriction on a soaring design, a low aspect ratio layout is dicated in order to keep the wing loading within practical limits. A mean wing chord of 22cm (8.7in) was selected giving an aspect ratio of 9:1, also keeping the wing loading down to 26 g/dm^2 (8.6 oz/ft^3) for a sturdy structure capable of withstanding the rigours of multi-task flying. A thin 8% wing section based on Eppler 176 is used, in an endeavour to give an above average flying speed, and flat glide without the necessity of carrying large amounts of ballast. The fuselage is kept as small and as clean as possible, to minimise drag at the higher flying speeds. The structure is heavy because of many bad habits cultivated by building too many F3B models, but is nevertheless very strong. Construction is quick and simple, because I am impatient and prefer flying to building!

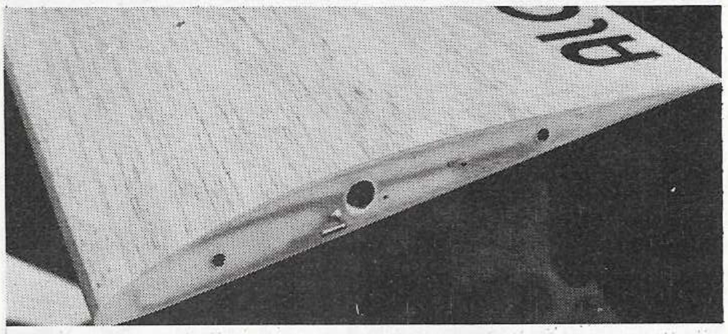
Construction

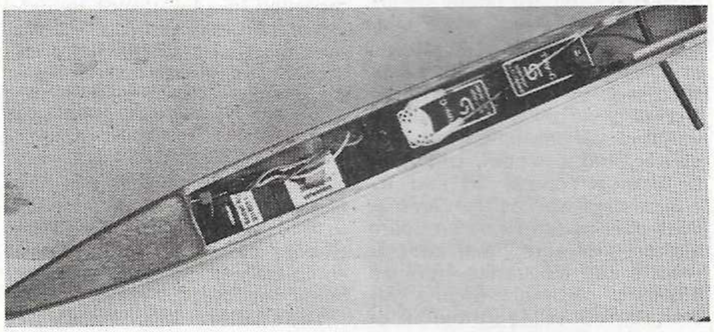
We all have our own particular construction techniques which are satisfactory on an individual basis. Many different construction styles can be used to assemble a particular structure, and they can all be considered successful, if the completed structure is as strong and true as the designer intended. The following instructions should therefore be considered perhaps as guidance notes.

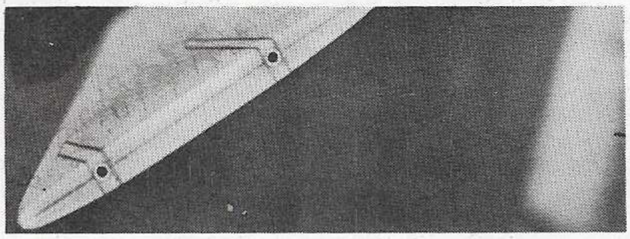
Finishing techniques are even more individual than construction methods. One finishing philosophy is that as soon as an airframe can be flown, it is taken out and tested. If it flies it is complete, if it does not fly, don't finish it! (With thanks to Mister David Thornburg, who lives in New Mexico, where rain is very rare). 'Algebra 2M' is suited to all the traditional finishes, i.e. Dope and tissue, plastic film, and even nothing, as described above. My prototype was finished in lightweight glass cloth (24 g/m^2) applied with epoxy resin. Although this is a comparatively new technique in Britain, those enthusiasts who have tried it have been very pleased with the results. Perhaps a fully illustrated article is needed to encourage this technique, but let us just say here that glass is very easy to apply as a one operation exercise, it is light, giving a typical finished result in the range 0.25-0.35 oz/ft^2 and adds great strength to the structure as a bonus.

ALGEBRA 2M

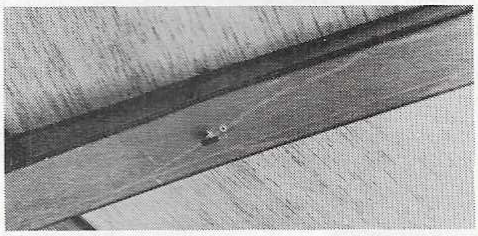
DESIGNED BY SEAN BANNISTER

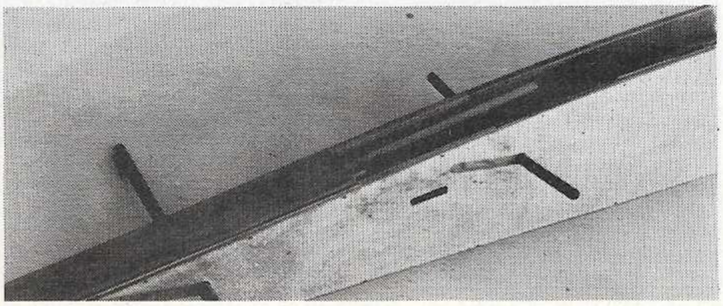


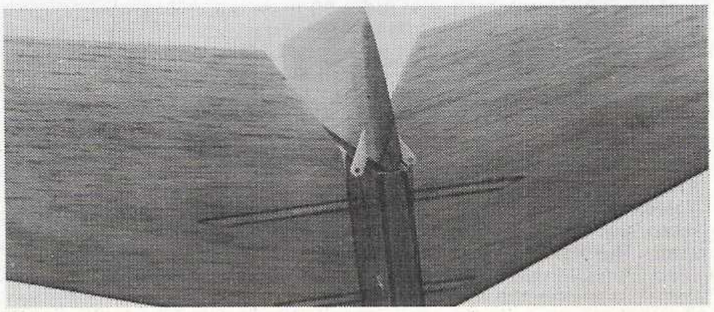




Above left: wing root detail – note the aluminium alloy ballast tube. Above right: R/C equipment layout is simple – line astern! Left: tailplane root; plywood dowel tube reinforcement can be clearly seen. Right: ultra simple towhook unusually placed below the CG. Below left: wing dowels and retaining hook slot. Below right: rudder connection via closed-loop cable system.







Wings

Commence wing construction by assembling oversize 1.5mm medium balsa wing skins and sanding the exposed sides to a smooth finish. Prepare the root and tip rib sandwich templates from 3mm plywood and sandwich 25 2.5mm medium balsa rib-blanks between these templates, bolting the assembly together. I use 16s.w.g. bicycle spokes, bent over at one end and secured with an 6B.A. nut and washer. Before removing the finished ribs from the sandwich, mark the centre line of the spar/ballast tube with a straight line along the rib pack top. This line is then used to accurately pierce ½in. diameter holes in the inner ribs to accommodate the ½in. outside diameter 18s.w.g. wall thickness high tensile aluminium tube. A Swan Morton P.M. (Post Mortem?) knife with its firm 3in. blade is very handy for carving the sandwich pack to shape, and other large carving jobs.

Mark the rib positions on the lower wing skin inside surface, and pin this skin to your building board, adding the 12mm medium balsa leading edge. Drop on the ribs, trimming to length at the leading edge. White glue is used for this operation, and the addition of the vertical grain shear webs. Slide in the ½in. tube with a plug at the outboard end, and epoxy in place. Slow setting epoxy is advised for this joint, and wing finishing epoxy is dropped in with a small brush to complete the joint between the tube and adjacent webs. Most slow-setting epoxies can be conveniently thinned with methanol for this purpose, if you do not use epoxy for finishing. Slow setting epoxy is advised for all joints because it provides a stronger joint than 5-minute epoxy, and edges epoxied with this material can be sanded more successfully. Gentle application of heat to epoxy cement with a heat gun will also decrease its' viscosity, and allow application to innaccessible joints.

Rib positions are now marked on the underside of the top wing skin, so that impact adhesive can be accurately applied for fixing this skin. Apply impact adhesive to all the ribs and their corresponding skin undersides. Use *Joy/Evostik* but not Thixofix. It has been found that this particular glue is not strong enough. Spread a generous amount of white glue on the 3mm ply root ribs, and all the vertical grain webs. Apply a bead of white glue along the top skin leading edge, and to the bottom skin along the rib trailing edge line. Now just pop on the top wing skin commencing at the leading edge and working back towards the trailing edge. You will find that the impact adhesive holds this stage of assembly together with no need for pins, tape or bricks. However, take care that the root joint is tightly in place.

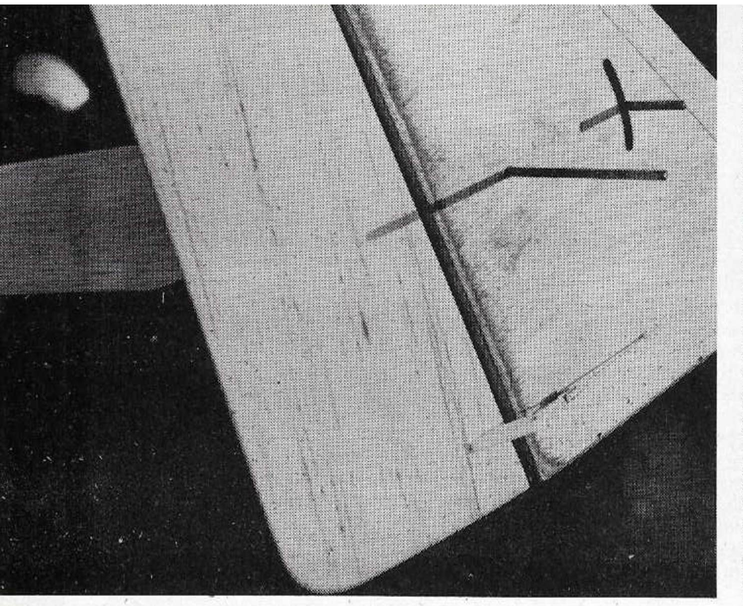
Sandwich 1mm ply wingtip cores between 15mm and 5mm soft balsa checks with epoxy. Prepare the wing root facing ribs to an accurate profile from 1.5mm epoxy sheet or ply. Attach the 3mm medium balsa trailing edge completing the basic wing structure ready for removal from the building board. Now apply the 3mm × 10mm spruce leading edge, and hold in place with tape. When this complete assembly is set, trim the root to the dihedral angle and the tip to a clean 90° angle to the bottom skin. Epoxy the root facing rib and wing tip assembly into place. Draw a straight line along the spruce leading edge at its foremost radius 4.5mm up from the bottom wing skin surface at the root and 3.1mm high at the tip. This line then joins the facing rib leading edge and wing tip ply core leading edge and is used to facilitate final wing leading edge shaping. Commence rough wing shaping with a razor plane/spoke-shave/block plane, whichever is most convenient and finish off with glasspaper from 120 to 320 grades.

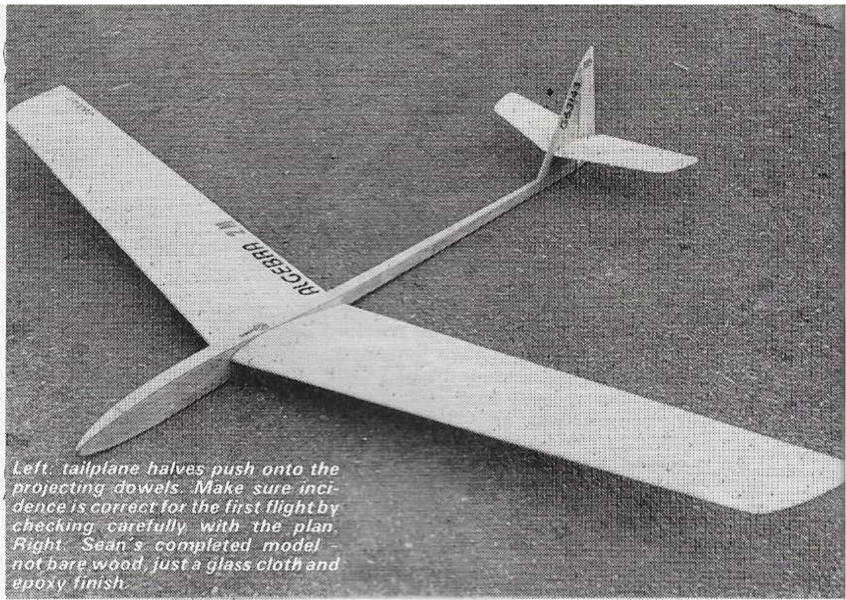
At this stage on the prototype 1mm of undercamber was carved into the undersurface and finished with sandpaper to the section as drawn on the Plan. This feature will leave only 0.5mm of wing skin at the deepest underchamber point and great care must therefore be taken with this operation. In fact this 'tweak' will probably only be of interest to the competitive modeller and the sports flyer would be advised to leave the section with a flat bottom.

Tail Surfaces

Select the lightest piece of 10mm sheet you can find for the solid balsa tail surfaces. Make up the tailplane tube boxes with 0.4mm ply front and rear members 10mm deep, and fill the area above, below and at the end of the 14 s.w.g. tubes with hard balsa. Construct this assembly with epoxy, and when cured, chamfer the inner ends and use this assembly as a template for slotting the tailplane blanks. Insert the tube boxes into the tailplane blanks with epoxy and line up both tailplane blanks on a flat surface with both tailplane 14 s.w.g. joining rods temporarily inserted in their tubes to ensure that the completed assembly will accurately align. A section centre line is now drawn around each blank edge, 6mm from the bottom surface. The blanks can now be shaped to an airfoil section with 60% below and 40% above the centre line, giving a semi-symmetrical section, *but mounted inverted.* The thickness is tapered, from 10mm at the root down to 5mm at the tip, while retaining the 60%/40% section.

You might now expect me to advise mounting the wing upside down as well as the tail surfaces! Traditionally, free-flight gliders have upright tail surface because they are trimmed with the centre of gravity behind the centre of pressure. This trim results in a nose-up instability which is stabilised by the tailplane lifting the rear of the fuselage. How-





Left: tailplane halves push onto the projecting dowels. Make sure incidence is correct for the first flight by checking carefully with the plan. Right: Sean's completed model — not bare wood, just a glass cloth and epoxy finish.

ever, in the interests of flyability, radio-controlled soarers are generally trimmed with the centre of gravity in front of the centre of pressure with the tailplane stabilising by lifting in a downwards direction. As the tailplane is lifting in a downwards direction, it will work more efficiently if mounted inverted. You will find that this arrangement will also give differential elevator response in favour of up elevator. This is a desirable feature on a thermal soarer, but not on a fully aerobatic soarer. Nevertheless, enough control response is retained with the control surface movements shown, to fly inverted and execute outside loops (bunts).

The rudder blank is next shaped to section, again with its thickness tapering from bottom to top and with a chamfer on its leading edge to facilitate rudder movement as shown on the Plan. If you are not anticipating a glass finish to the flying surfaces, it would still be wise to soak some epoxy/polyester resin into the rudder base and tailplane roots, to prevent longitudinal cracks.

Fuselage

Prepare the 1mm plywood fuselage sides and 3mm plywood doublers. Each fuselage side assembly is prepared by pinning the sides to the building board and adding the 3mm ply doublers and 3mm square spruce longerons securely pinned in place with white glue at a maximum of 50mm centres. The finished side assemblies can now be held together and sanded until they are identical in side elevation. Now drill the front and rear wing joiner holes, rear tailplane rod hole and front tailplane actuating slot. Part the side assemblies and prepare the fin false-leading-edge and trailing-edge parts, remembering that the fin tapers in width. Prepare the tailplane bellcrank assembly with a 20mm diameter 1mm ply disc either side ready to slide into the fin as a complete assembly.

Draw 9 parallel lines at 5mm spacing on your building board as an aid to final fuselage assembly and accuracy when viewed in plan form. It is quite easy at this stage to assemble a straight fuselage, it is also easy to assemble a banana shaped object. Insert the bellcrank assembly and temporary lateral spacers between the fuselage sides. Hold in place with rubber bands/tape ensuring that at the wing/fuselage joint area, a perfectly straight side is retained, and using the parallel lines on your building board for guidance. As an extra guide to square alignment, lengths of wing and tailplane joining rod can also be temporarily inserted. Hold the fin sides together with clothespegs. Now place the 3mm square spruce horizontal spacers to the fuselage top and bottom. This assembly is now placed on the remains of your 1mm ply and drawn around to obtain the fuselage top and bottom decks. These decks are held in place with white glue, secured with rubber bands.

Pour 1 oz. of epoxy/polyester resin into the nose cone void and leave the fuselage assembly in a vertical position until set. The nose can now be blunted to the 5mm minimum radius as required in the SMAE safety code. Epoxy the 12mm ply towhook block across the fuselage base at the position marked on the plan.

Radio Installation

The prototype is equipped with a *Simprop* 'Contest' SSM system with 450mAH battery pack. A slim nose profile is retained in Plan view by reassembling the four 450Mah cells in line abreast fashion. No On/off switch is used, the radio system is switched on by plugging the receiver directly into the battery pack. The rudder servo is positioned in front of the elevator servo with rudder actuated by a closed loop system.

For convenience the rudder wire loop tubes are secured to one side of the fuselage with a saddle clamp. The elevator servo output arm is now free to operate on the opposite side to this saddle clamp. A 5mm diameter hardwood dowel is used as an elevator pushrod.

Flying

Check the complete airframe for accuracy of incidences etc., and that all surfaces are warp-free and the centre of gravity corresponds with the plan position as this is a 'hot' soarer. If you are not too experienced with soarers, you might wish to move the centre of gravity forward by up to 15mm for reduced elevator sensitivity on early flights. Remember that towhook position corresponds to the centre of gravity and should always fall in the range between the centre of gravity and up to 5mm in front.

45lb. breaking strain nylon monofilament line is suitable towline for a small soarer like 'Algebra 2M'. Allow good tension to develop in the line, before launching with a stout throw skywards, at an angle of about 45°. Finish reading these instructions now, because you will have no opportunity once the model has been launched! Your tow man will have been given instructions to run as fast as possible, but also will have been informed that the launch phase takes no longer than 20 seconds. A fast tow follows with no elevator application necessary to keep good line tension and with only minimal rudder corrections to keep on course into wind. Pulling up elevator on tow can result in a stall.

Using this rather brutal towing technique results in the model reaching full line height very quickly, but what is more important, good line tension is maintained throughout. This tension is now used to gain bonus height. The tension is converted into speed by a gentle application of down elevator and when the tension has all been converted, a gentle up elevator command is given to now convert the speed into extra height by zooming upwards. You might now appreciate why the wing structure appears over-designed! The foregoing launch technique could be summed up in terms of potential and kinetic energy conversions, but this author is not up to it! However a summary could be expressed: Tension + speed = Bonus Speed = Bonus Height. Practice this technique, but be gentle on your first few launches.

Trim the elevator until level flight can be maintained hands off — just! Now start looking for that thermal. My technique is to try and fly in a straight line and watch the model until lift is encountered. Some experts like Neil Webb and Al Wisher can predict where the lift is, so watch them and ask how they do it. You will find that 'Algebra 2M' has an above average flying speed, so use this capability to good effect, and have a good look around for lift covering as much sky area as possible searching. Maintain this high-flying speed in thermal turns as the airfoil works efficiently at this speed, you will find that very little elevator is required in thermal turns.

To practice the racing distance task, insert full ballast into the wing tubes which will raise the wing loading from 26 g/dm² up to 44 g/dm² (14.6 oz/ft²). Apply a small amount of down elevator trim and let her move. With practice, good anticipated turns can be perfected. Three ballast slugs can be inserted into each wing tube, and with equal length 10mm diameter balsa blanks wing loading steps of 6 g/dm² (2 oz/ft²) can be utilised to give a range of wing loadings of 26, 32, 38 and 44g/dm² to suit various tasks and wind conditions.

Ballast slugs are made from 10mm outside diameter brass tubes filled with tube bending alloy and cut to 150mm lengths. Brand names of tube bending alloy are *Fry's* and *Curvabend*. The advantage of this material is that it will melt in boiling water and pour easily. Lead is 5% heavier, a lot cheaper to buy, but more difficult to melt and pour. An old tin (beer can) with a spout bent into one side containing the alloy is immersed in a saucepan of boiling water to melt and then pour.

With this ballast capability, 'Algebra 2M' is equally at home on the slope in most wind conditions. Most aerobatic manoeuvres can be performed including loops, bunts, inverted flight, rolls, stall turns and landings. Square loops are to be recommended as particularly good fun, especially when you have outflown those nasty large soarers in an open competition.

Take care with the construction, then get out and have fun.