



The skeleton slot was developed in the UK for TV use soon after WW2. Someone had worked with slot aerials on aircraft, and the use of a half wave vertical slot in a very large piece of sheet metal, results in radiation very much the same as a horizontal dipole. They then set out to find out how much you could reduce the metal around the slot, and have it still radiate. Pictures of 2m version.



Here is a close up of the 2metre driven element, which is the actual skeleton slot. It is (a little less than)  $\frac{5}{8}$  wavelength in the direction perpendicular to the radiation polarization, and about 0.2 wavelength for the driven element part of each yagi. This sets the spacing between the two yagis at  $\frac{5}{8}$  wavelength too.

This is well written up in the RSGB books, and the RSGB Handbook 8<sup>th</sup> edition page 16.4 & 16.5, gives a set of curves of gain & SWR for various aeriels, including single yagis and skeleton slot fed yagi pairs of 4, 6, & 8 elements each. On this version shown I have chosen to mount it vertically polarized, which is convenient because the supporting pipe comes up through the centre, and doesn't interfere with the pattern and gives balanced wind loading. I have prepared several MMANA-GAL files you can get from [DOWNLOADS](#).

The RSGB published figures for this "6 over 6" version show a gain of 11.5 dbd, and its main advantage is that the bandwidth over which that gain is maintained within 0.5db, is 5Mhz, about twice as wide as the conventional yagi, making it equally usable for SSB or FM. Recent computer optimized designs will probably equal this. A word of caution, there are two sets of dimensions, that are different, given in this RSGB handbook (see also page 16.12), so use all of one or the other, don't mix them up.

I decided that a simplified means of construction was worth a try, so I used 12 x 12 x 1.6mm aluminium angle (the smallest I could get) for all the elements, pop-riveted to 25 x 25 x 1.2mm square aluminium tube for the booms. The booms of this material are very light, and flex a little, so the next ones were made thicker. I couldn't get 1.6 mm, so used 2mm thick square tube. This worked well, as two full lengths (6.5m) of the angle and one length of the tube will make the aerial, for under \$50 outlay.



There are two of each length for the complete array, so the two lengths of angle can be cut together. Now cutting the elements needs care, measure within 1mm for each dimension, and cutting one wrong length can leave other parts short, I know!

To transport the angle aluminium home, either get all pieces cut to length by your supplier, or get 2688mm cut off the 5.6m length, the sum of  $D1 + D2 + D3$ , then the the longer driven element 1192, cut off the remainder, so it would all fit in a car. The two booms were cut to length, leaving

some spare, even after the horizontal support. Even a blunt hacksaw will cut it readily. The driven element dimensions by the RSGB are centre to centre for tube, whereas I have given “cutting length” for the aluminium angle.

To start building it, make a drilling jig, from a piece of 25 x 3mm (1” x 1/8) steel strip (not aluminium) about 100 to 200mm long, with two 3mm holes, 10mm apart, and 4.5mm in from one end. Then drill the elements as shown, and I found that I needed to grind away part of the pop riveter so as to clear the angle aluminium, but the joints are quite firm. I have ordered some Multicore AluSol 45D, a resin cored solder especially for soldering aluminium, and I will use that



as well, to make a more permanent joint. A most important point is to remove the drilling burrs by putting a small chamfer on the holes, I simply hand turn a 10mm drill in the hole.

This is necessary to get the pop-rivets to tighten well, otherwise the elements will loosen in a short time. Use aircraft or marine grade (high strength) pop rivets, not “supermarket” or “hardware store” quality. The driven element can be pop-riveted or screwed together, but I wanted to be able to pack the



aerial onto a car roof rack, to set it up on field days, so I assembled the driven element with M3 stainless steel nuts & bolts. Other versions have been made to be fully collapsible, and are assembled with 35 x 3mm stainless nuts & bolts, right through the booms. Don't be tempted to use self tapping screws anywhere, you'll have corrosion and loose elements after a few months!

The inside of the terminating box shows a short length of RG58 cable, later changed to lower loss RG8X, stripped and soldered to lugs that make contact with the delta matching section via two more M3 SS bolts. Proper weather proofing requires sealing of the cable, else the slow ingress of moisture will gradually build up as serious losses. Although not shown, I have dosed it with a liberal coating of “Liquid Electrical Tape” (don't leave the lid off the can, as it evaporates very quickly). I also sealed the driven element screws too, but they can still be removed with a little effort

The Pictures show the driven element in “kit form” and the inside of the terminating box. The ferrite around the coax reduces radiation from the outside the cable, and the corners of the driven element are bolted as shown, but if portable operation is not required, pop rivets could be used. Aerials installed outside suffer from considerable vibration from the wind, so sealing of nuts & bolts is recommended to reduce the risk of loosening with time, likewise, good quality pop rivets, for aircraft or marine use, from industrial fasteners suppliers cost a little more, but last longer than supermarket quality ones!



The Coax cable “tail” is about a metre long, terminated in a female type N connector, although a flange mount type N could be screwed onto the box. The reason I didn't do this is to reduce the weight on the driven element from RG213 or similar coax cable, and to have a flexible section to allow for rotation. RG58 cable is too lossy to run any length, why build a high gain beam, and waste its gain with cable loss? I very strongly recommend that type UHF (PL259) connectors (1930's technology) are NOT used, because they allow moisture into the cable, gradually causing huge losses, and are prone to intermittent contact of the outer (earth) connection, use type N or BNC, and seal them thoroughly with tape and “liquid electrical tape”.

I made no attempt to calculate the effective length of the elements, to allow for the difference between the original design using 6 to 9.5mm diameter tube, as compared to this use of 12 x 12mm angle. I don't currently have an aerial simulation program that does this, but the “proof of the pudding” is that it works very well, and on the FM portion of 2m, 145 to 148Mhz a noticeable drop in signal strength happens by rotating +/- 15°, and minor lobes are well down. Signals that I didn't know were there are now Q5 copy, if the beam is pointing the right way.

2metre version

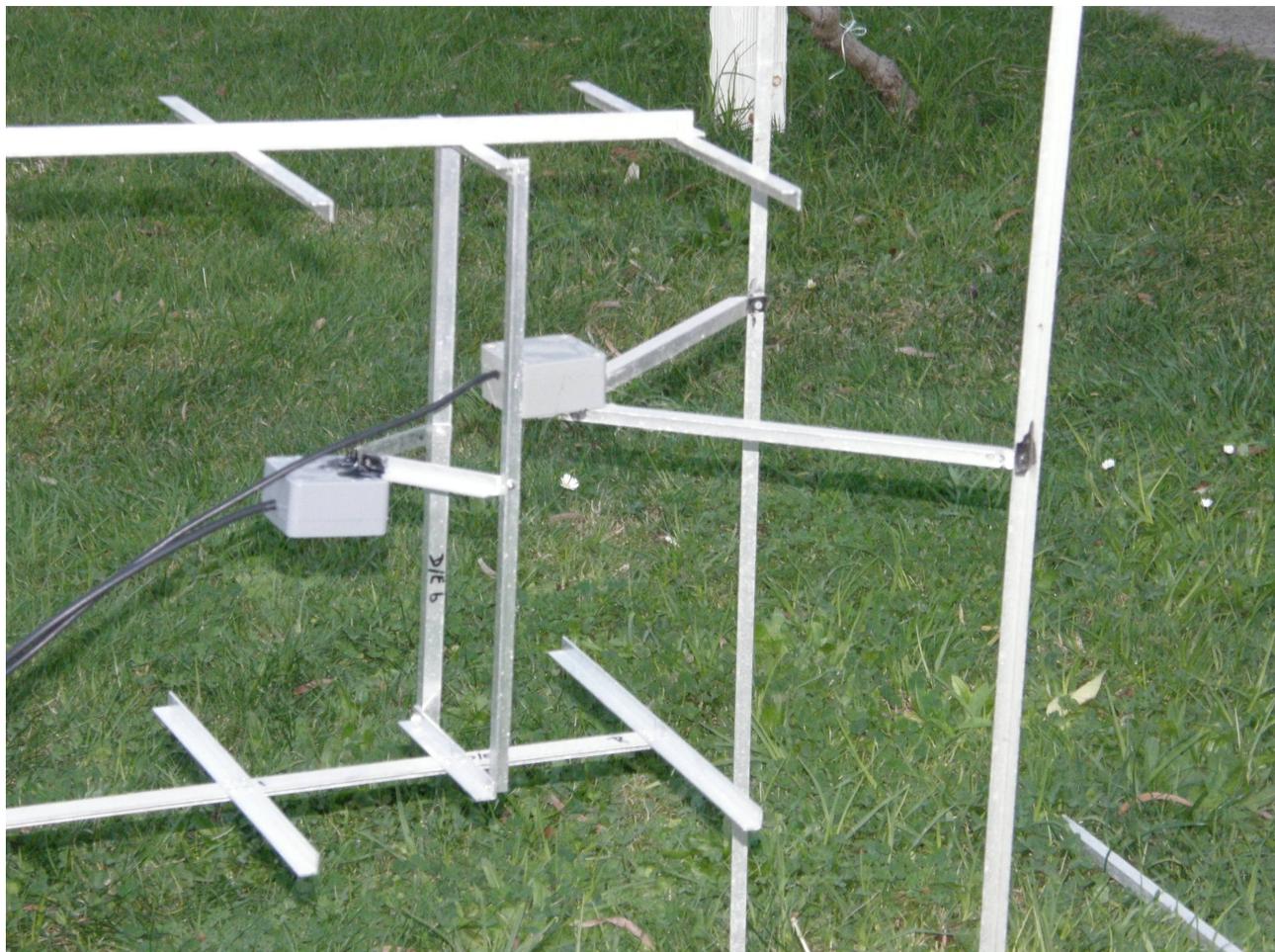
Dimensions.	Length mm	spacing mm	boom position mm
Reflector	1010	445	20
Driven Element a	402	445	465
Driven Element b	1192		
1 <sup>st</sup> Director	902	445	910
2 <sup>nd</sup> Director	895	445	1355
3 <sup>rd</sup> Director	890	445	1800
4 <sup>th</sup> Director	877	445	2245
Delta feed section	300	16mm hole centres, feed end	
Boom length	2255		2255
Boom separation	1118	(the gap)	
Gusset plates	1.6 or 2mm aluminium, 100mm square.		

The driven element is drilled with 3mm holes 6mm from the end of each part, and the RSGB driven element dimensions being centre to centre, whereas these dimensions shown above are adjusted for overall metal length for cutting.

For horizontal polarization, the centre of each boom is clamped to the vertical support with TV “U” bolts, be careful to get the spacing correct before assembling the driven element. As shown, for vertical polarization, an additional 1117mm piece of the square tube is used with a single TV “U” bolt in the centre, and gusset plates pop-riveted to each end, and bolts through the gussets and the booms. Care is needed to not over tighten the bolts and collapse the thin wall boom tubing. There is no reason why a pivot couldn't be put in the centre, so that the polarization could be changed at will.

I built this using the RSGB dimensions from page 16.4, but as the UK band is 144 to 146, and ours is 144 to 148, some pruning may shift the centre frequency. As time permits, I intend to do accurate pattern measurements across the band, and beyond the band if necessary, and checking the minor lobe levels, to find the centre frequency, and so judge if pruning is necessary. The original was designed for 75Ω feed cable, and I am using 50Ω cable, so a reduction of the reflector spacing was tried on simulation, but did not bring the impedance down nearer to 50Ω. Decreasing the delta matching section spacing at the feed end however did get nearer to 50Ω, with the angle as shown in the dual band pictures pictures, ie. the parallel flat sides facing in, instead of out.

Checking with MMANA-GAL, the expected drop in impedance with reflector spacing didn't happen, it went up a little. Doubling the diameter of the delta section did reduce the impedance, as did halving the diameter of the two 5/8 wavelength sides of the skeleton slot. It has yet to be tried on the actual aerial. I note that the minor lobes between 90 and 120 degrees off rise as the frequency rises, so this will need to be measured too, whilst vertically polarized.



Version 2. Added 2011. I've now built thinking about a a 70 cm version, and maybe 6m version using two 3 element yagis, but its too big for my QTH. The limitation of the spacing between the two yagi booms limits the effect of longer booms. Ie. going to 8 elements does not give a useful increase in gain for the extra material and effort on 2m, but I've used 8 elements on 70cm. I have tried several ways to increase the spacing, but MMANA-GAL does not indicate any advantage.

I have recently tried a simulation of 70cm inside a 2m skeleton slot with MMANA-GAL, and there is little interference with either pattern or impedance. This encourages me to even try a 6m 2 x 3 element also. A point about using MMANA-GAL, I find entering all the dimensions a bit tedious, so I put in the 2m & 70cm separately, then using a text editor added the dimension of one “.maa” file into the other file, remembering to change the number of elements from 19 to 38.

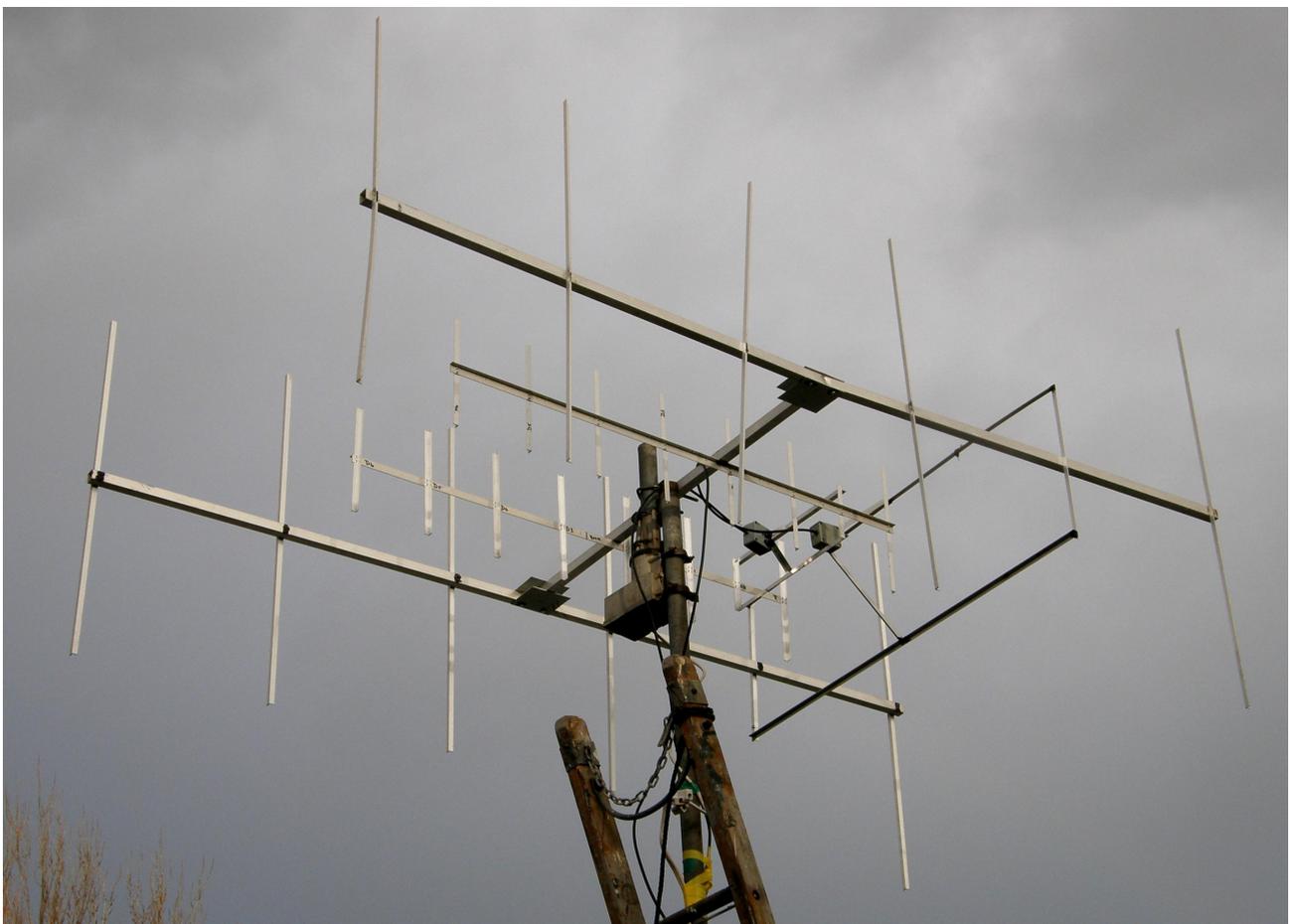
There is no boom shown, but could be included to no advantage. To get the driven element to work effectively, I used a very short 20mm piece, wire 19, for 70cm, & 38 for 2m, as driven element, with drive at the centre, and the delta pieces joined to its ends. The other ends of the delta matching pieces need to join to the two 5/8 wavelength driven element pieces. These however need to be entered as two separate halves (eg 11 & 17, or 12 & 18) each, otherwise the program will not see the junction. See 2m70cb\_6x6SkeletonSlot6v1.maa.

70cm version, with mounting for the 2m yagis via the gusset.

Dimensions.	Length mm	spacing mm	boom position mm
Reflector	337		10
Driven Element a	144	140	150
Driven Element b	407		
1 <sup>st</sup> Director	286	140	290
2 <sup>nd</sup> Director	282	178	468
3 <sup>rd</sup> Director	279	178	646
4 <sup>th</sup> Director	276	178	824
5 <sup>th</sup> Director	273	178	1002
6 <sup>th</sup> Director	270	178	1180
Delta feed section	100	16mm hole centres, feed end	
Boom separation	1118	(the gap)	
Gusset plates	1.6 or 2mm aluminium, 100mm square.		
Boom length angle	1012	12 x 12 x 1.6mm, 7 elements	1012
Material total	2384	12mm angle aluminium, 7 elements	
Boom length tube	1190	12 x 12 x 1.6mm, 8 elements	1190
Material total	2654	12mm angle aluminium, 8 elements	
booms			

The RSGB handbook gives a set of dimensions for the 70cm version that differ considerably from what you get if you simply scale the 2m version. This caused me some head scratching, but I tried simulation of both approaches, and settled for a scaled version, mainly because I had tried this approach before I realized that the published 70cm version was different. The performance seems little different.

I have also devised a simple way to change polarization from vertical to horizontal, for field day portable use. This is done by drilling the supporting boom for the “U” bolt on the other faces, and



clamping it to a short horizontal pipe at to top of the main support pipe. This can be loose enough to rotate the polarization, but is not recommended for home station use.

I also like the thought of a 4 stack array on 70cm, also mounted through the centre of the 2m array, (perhaps a two stack for 2m), with the 4 being one above the other, (vertical polarized view) and spaced one wavelength. Gain should be about 17dbd.

I had thought that increasing the spacing by a half wavelength each side of the centre might work ok, and allow effective use of longer yagis on 70cm, but so far MMANA-GAL doesn't confirm this.

It seems that MMANA-GAL simulates the pattern in terms of the mechanical sizes quite well, although the centre frequency may not be exactly where the simulation suggests, however you will learn how the minor lobes change with frequency, so can determine from measurements you make of minor lobe levels at several frequencies exactly what the centre frequency of your built aerial is. The program does not seem to accurately model the close spacing of the delta matching parts well enough to give good impedance results for this type of match. Also I haven't found a way to simulate the angle material, so have to assume tube.

Measurements show 70cm received signals audible via the 2m cable, but about 20db down.

Peter Ward, VK3ZAV. Updated August 2011



Sitting on the back lawn, in the horizontal polarisation view, ready to install.