A Folding 5-Element Yagi for 144 MHz

Steve Kavanagh, VE3SMA, April 2017

1. *Introduction*

I have found antennas which fold up quickly to take less space in the car to be useful in VHF/UHF portable operating. For some years I have had a 4-element 2m Yagi along with me on VHF contest trips, which folds up to fit in the back of my Toyota Matrix. While there have been many designs published for 2m beams which can be dismantled for backpacking, I haven't seen any which can be assembled in a few seconds, which is desirable for those of us entering the Rover classes in VHF contests and don't want to drive with the antennas up all the time. My old 4-element antenna does this, and fits right in front of a 6m dipole, but doesn't have a lot of gain or good SWR over very much of the band. An improved version was called for. I get about 1.5 dB more gain from this new 5-element design and decent SWR up to about 147 MHz. Plus it still fits in the same space in the car.

2. *Dimensions*

Element diameter: 3/16 inch (solid aluminum parasitic elements, brass tubing for driven element)
Boom: ¾" thick pine (made from 1X2), total boom length 52 inches, folds to 26 inches
Boom depth (top-to-bottom): Mostly about 0.8 inch, tapering up to 1.5 inch at mounting clamp and hinge
Tolerances: I tried to stay within ±2 mm on element positions, about ±1 mm for element lengths
Length Corrections: No boom correction factor is applied to the element lengths and it should not be necessary with a wood boom of this thickness. The parasitic element lengths were adjusted according to a simple formula [1] for solid elements, while the tubular driven element was not corrected.

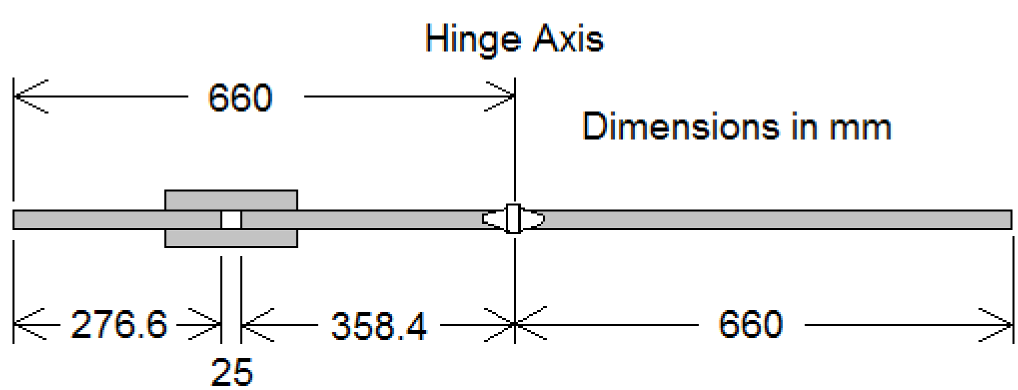
Element	Distance from rear end of boom (mm)	Distance from forward end of boom (mm)	Element length in NEC model (mm)	End correction (mm) [1]	Actual element length (mm)
Reflector	10.0	1310.0	1027.8	2.4	1025.4
Driven Element (at centre)	289.1	1030.9	(see details below)	(none)	501.8 (each half, see below)
Director 1	434.7	885.3	965.2	2.4	962.8
Director 2	785.2	534.8	944.2	2.4	941.8
Director 3	1310.0	10.0	893.6	2.4	891.2

3. *Boom Details*

Refer to the sketch below. The boom is made from 1x2 pine (actually ¾" x 1-1/2"). The front part is 660 mm long (from the hinge point to the tip). The rear part is made up from 4 pieces. The main part is 358.4 mm long, from the hinge point to the gap for the driven element. There are two driven element mounting blocks and a reflector support piece (276.6 mm long) also made from ¾" thick pine, arranged to provide a 25 mm gap around the driven element and a total rear part length of 660 mm (from the hinge point to the rear end of the boom). The lengths of the driven element mounting blocks is not critical, but they need to be long enough that their joints with the main and reflector mounting parts of the boom are strong enough , but short enough to keep clear of the reflector and first director.

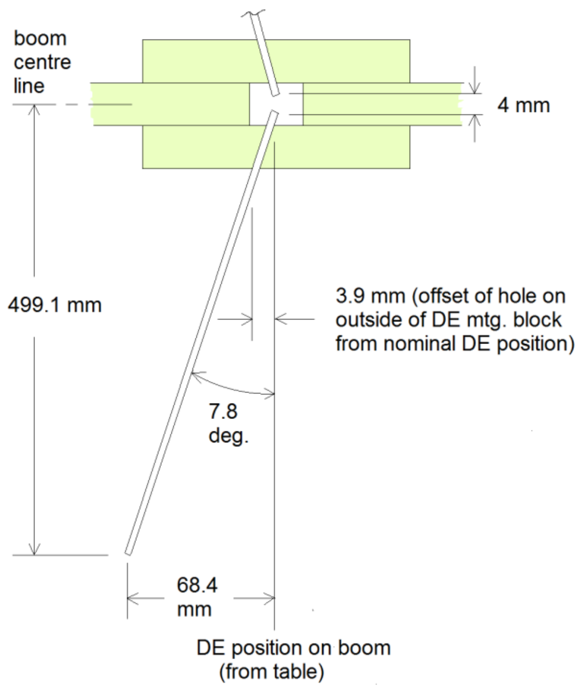
In general the boom cross-section is 0.75 x 0.80 inch, but near the hinge point the depth of each part is tapered from 0.8 inch up to the full 1.5 inch dimension of the 1X2 in order to provide a place to attach a mounting clamp and to ensure that the boom is straight when opened out. The rear part pieces are joined together with wood glue and 1/4" inch dowels through all three pieces, with two dowels on each side of the driven element. The hinge is a "2 inch strap hinge" fastened to the tops of the boom sections with wood screws (drill pilot holes first to avoid splitting the wood). I found it necessary to tighten the hinge before mounting it to the boom (by squeezing it carefully with vice-grips) to avoid too much wobble.

The boom is drilled (using a 3/16" diameter bit) for each of the elements at the positions given in the table. The elements are epoxied into place with a small fillet of epoxy where they exit the wood. The boom is then painted or varnished. Don't paint the elements unless you know very well the RF properties of the paint! A TV-antenna-type U-bolt clamp is used to mount the antenna to the mast, with the original nuts replaced with wing nuts for quick assembly without tools.



4. Driven Element Details

See the following figure. A bent dipole driven element is used for matching and control of coupling to the nearby elements, as introduced by K6STI and developed and described in more detail by DG7YBN [2]. The element halves are inserted in 3/16" holes (drilled at an angle) in the mounting blocks such that there is a 4mm gap between their inner ends.   Dimensions of the driven element half are to the centre line of the tubing. The driven element should be soldered to the coaxial cable, and then epoxied in place.



5. Balun and Connector

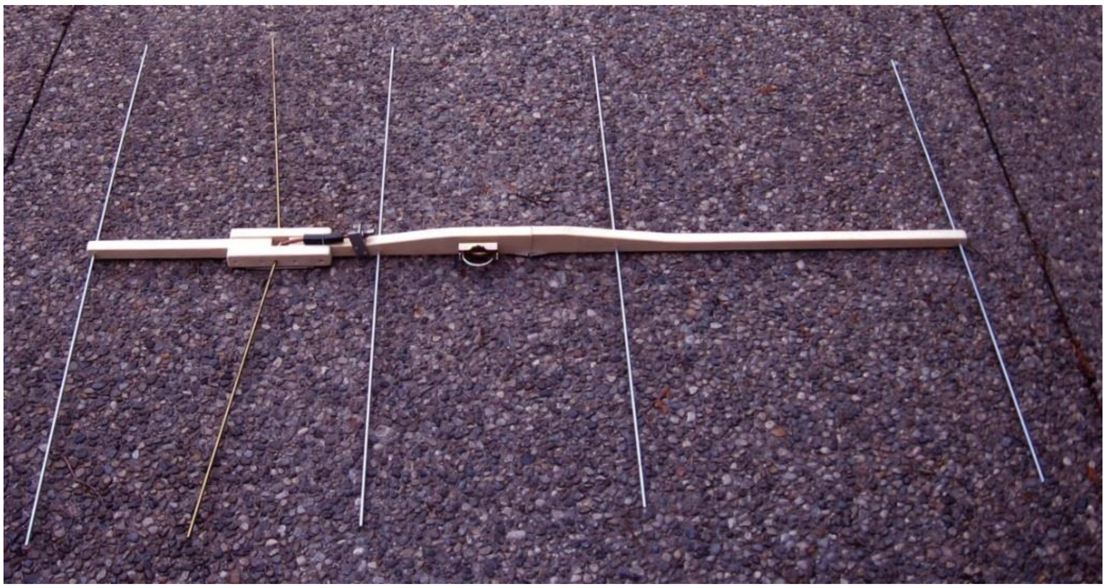
I put two 1.125 inch long by 0.562" O.D. by 0.250" I.D. Type 31 ferrite beads on the coax near the driven element to reduce current flowing on the outside of the coaxial cable. This should be adequate up to about 100 watts. On another antenna I have used 3 beads at 300 watts (CW, SSB and JT65). You can see the ferrite beads in the photos, under the boom between the connector and the driven element, with a small plastic spacer between them that I hope will reduce the chance of breakage (ferrite is brittle). After the varnish was dry I fastened the ferrite beads to the boom with a cable tie.

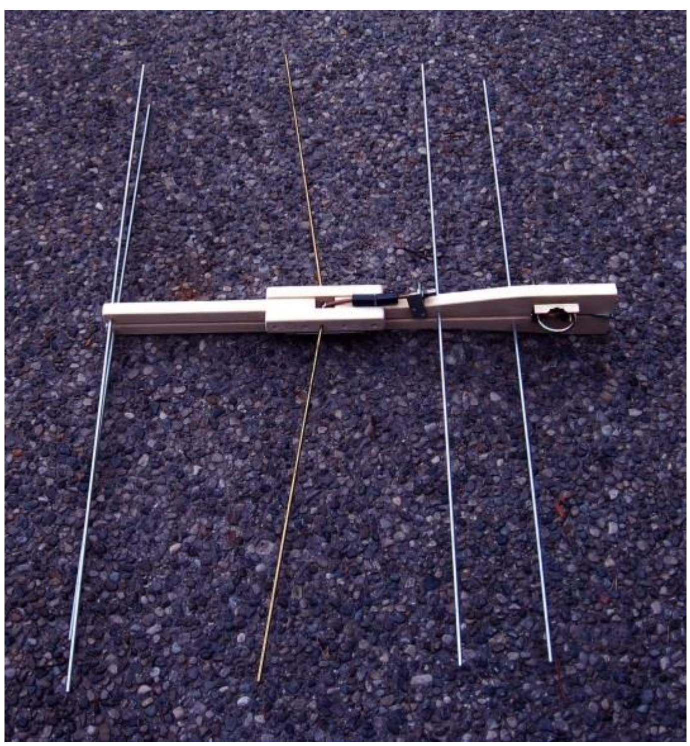
I used a female BNC connector mounted on a bracket made from aluminum angle. An alternate would be to simply put your favourite connector on a dangling pigtail of coax (taped or cable-tied to the boom to relieve stress at the connection to the driven element).

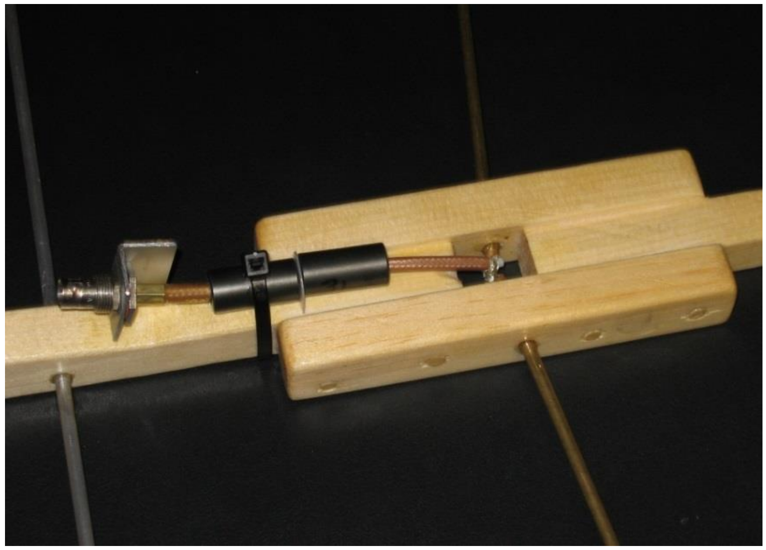
6. Feed Cover

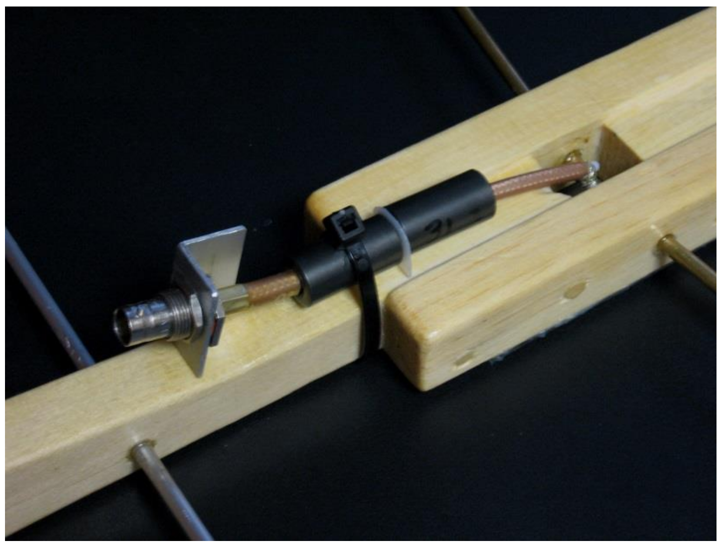
The boom gap at the feed point is protected from rain by a small piece of Plexiglas (any rigid plastic or thin wood would probably do) which is held in place with screws into the boom. I sealed the edges with silicone sealant.

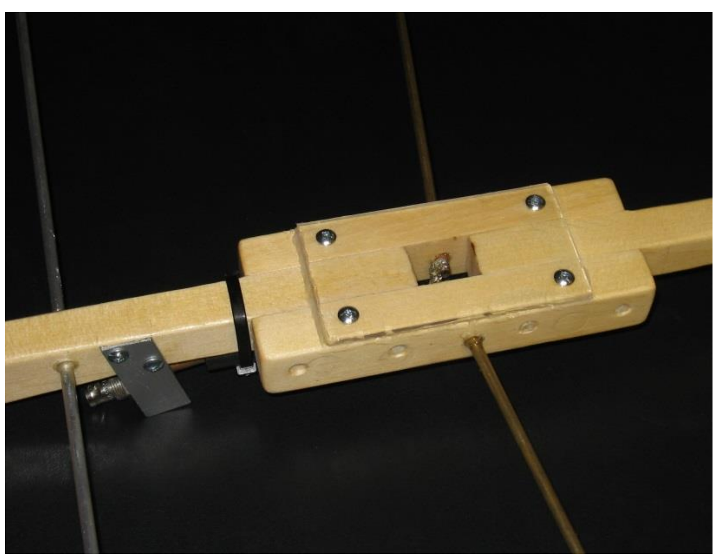
7. Photographs







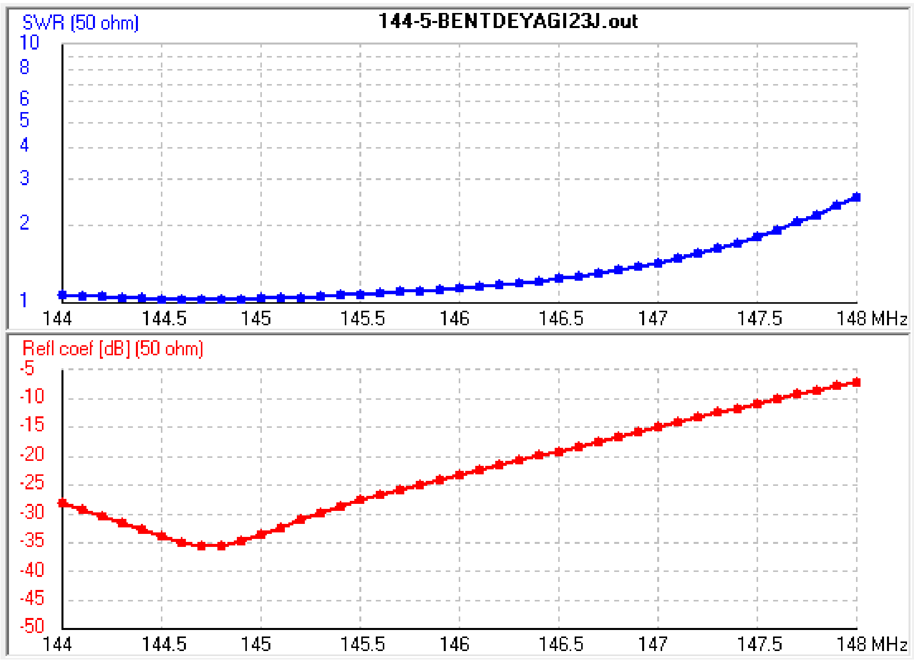




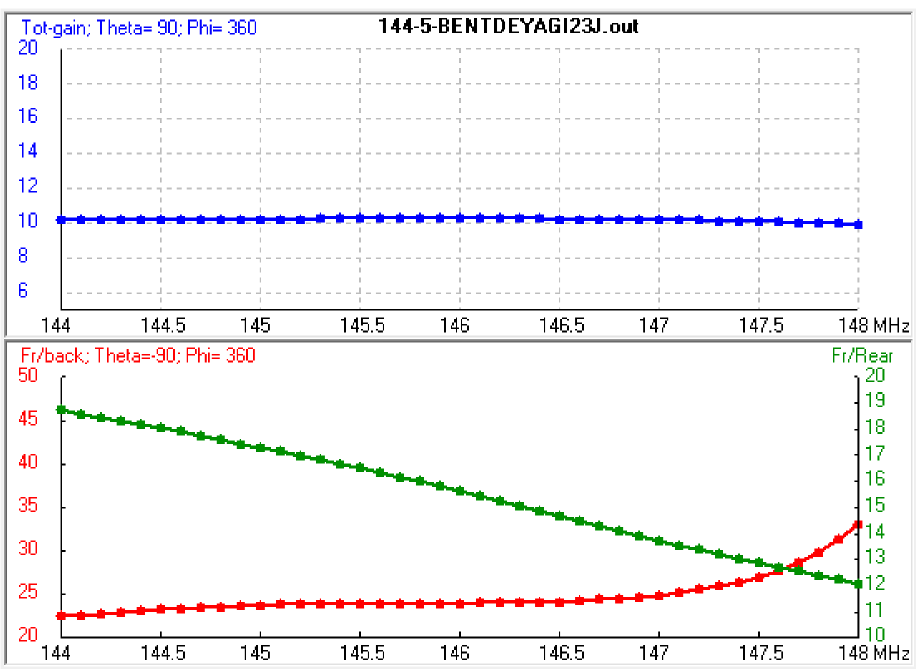
8. Predicted Performance

Software: 4NEC2 File: 144-5-BentDEYagi23j.nec
Assumptions: No conductor loss, no balun loss. Note that the driven element geometry is slightly different in the model, to accommodate NEC limitations.

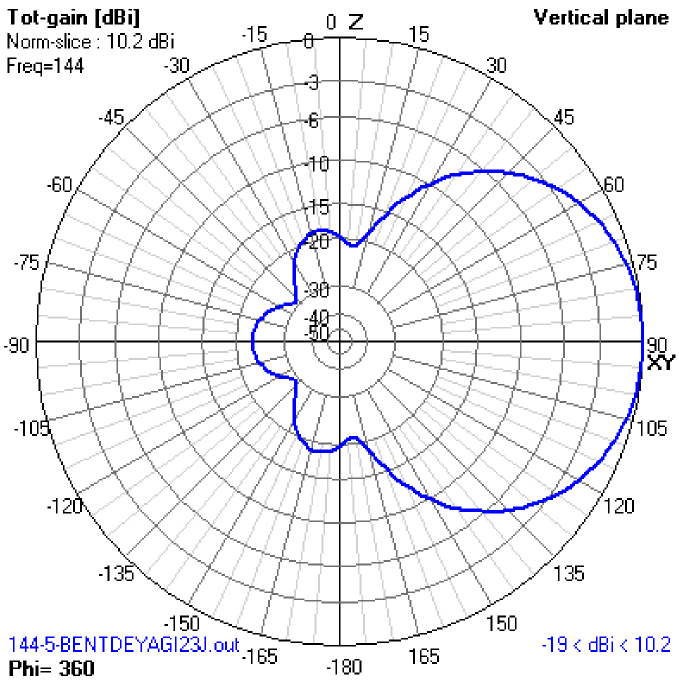
SWR/Return Loss:

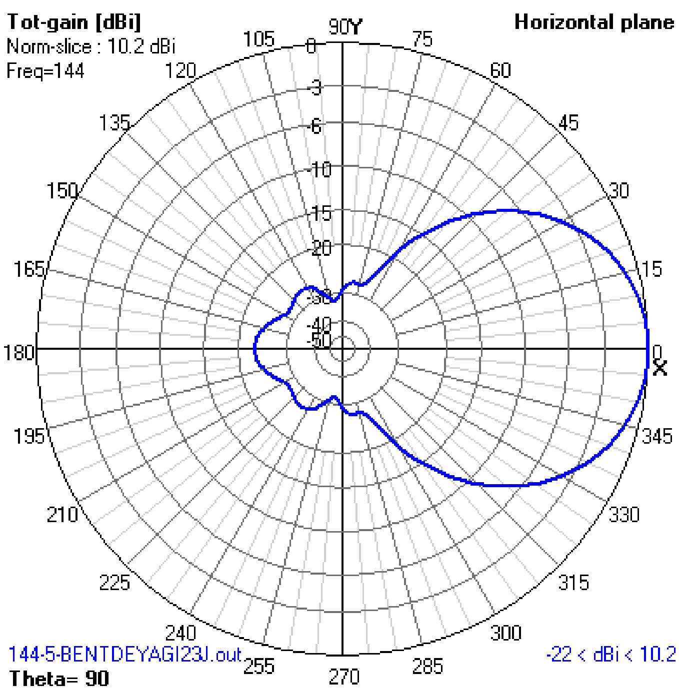


Gain/Front-to-back ratio/Front-to rear ratio:



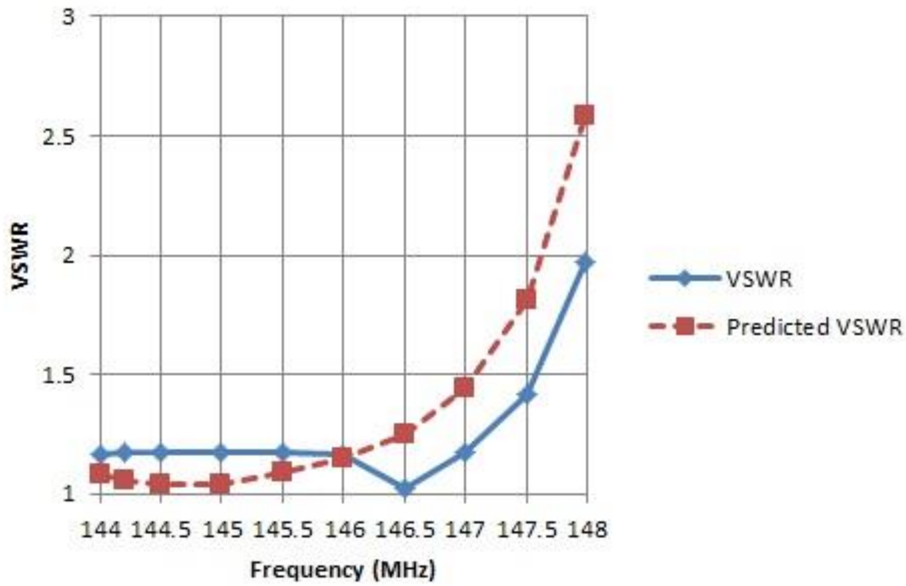
Radiation patterns at 144.2 MHz:





9. Measured Performance

The initial SWR measurement was done using a Bird 43 Wattmeter with a 50C element and about 25 watts transmitter power. The antenna was at the far end of 25 feet of RG-8/M coaxial cable. The SWR values were corrected for the estimated loss of the cable.



I have not had an opportunity to get the gain measured.

This antenna was used in my winning June 2016 ARRL VHF Contest Rover entry (with VE3RZ) and performed as expected with no problems.

10. References

[1] http://www.qsl.net/ve3sma/Length_Correction_for_Solid_Yagi_Elements.pdf

[2] http://dg7ybn.de/Milestones_Bent_DE_Yagi_Design.htm