# An Aluminum Moxon Rectangle for 10 Meters

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I occasionally receive inquiries from folks who cannot quite support the width of a 10-meter Yagi of two or three elements because obstructions restrict them to less than the 16.5 feet needed. Is there an antenna with decent performance that will fit in a space about 13 feet wide? If it can be home-built to save money and to require no complex tuning or matching system, so much the better.

In fact, there is an antenna that fits this description almost perfectly. Imagine an antenna with the gain (over real ground) of a two-element Yagi (> 11 dBi), nearly the front-to-back ratio of a three-element Yagi (> 20 dB from 28.3 to 28.5 MHz), and an SWR below 2:1 from one end of the band to the other. Also imagine that the antenna has better than 15 dB F/B all the way down to 28 MHz, and retains about 12 dB F/B at 29.7 MHz.

Imagine also that the antenna can be directly connected to 50-Ω coax (even though I always recommend a 1:1 choke or bead balun). Now imagine that you can make it yourself from hardware store materials, that it will weigh about 10 pounds including the boom (under 5 pounds without the boom), and that you can make it in your garage with no special tools. Finally, imagine that when it is done, you will still have change from a $50 bill.

Imagine no more. The antenna is the Moxon rectangle. Les Moxon, G6XN, derived the original design from VK2ABQ squares. He tunes both elements of his wire version to form a two-way, fixed-mounted beam.[1] However, we can optimize the dimensions to form an aluminum beam that is easy to rotate.[2]

**Fig 1** shows a sketch, with dimensions, of my latest version. It uses hardware-store $^7/_8$ and $^3/_4$-inch diameter aluminum tubing to form the main elements, with $^3/_4$-inch tubing for the side elements. The corners can use radius-bent tubing or be squared by making corner supports from L-stock. Cut the straight tubing at 45° end angles and use $^1/_{16}$-inch thick L-stock to fashion upper and lower supports. One- to two-inch lengths of support each way around the corner, using stainless-steel sheet-metal screws or pop rivets, solidify the corners with minimal weight. I also tried $^1/_2$-inch conduit Ls, but had to ream out the ends to accept the $^3/_4$-inch tubing.

The corners I use are $^7/_8$-inch aluminum radius-bent sections sent to me by Tom Schiller, N6BT (of Force 12), to speed up the experimentation. You can bend your own by filling the aluminum tube with sand (or cat litter) and bending it around a 6-inch or larger wheel or pulley. Work slowly. Keep the sand well packed in the tube to prevent kinking.

The combination of $^7/_8$-inch and $^3/_4$-inch aluminum tubing lets you telescope the ends into the center for a precise fit or a center frequency adjustment. A similar advantage accrues from using 1-inch and $^7/_8$-inch hardware-store aluminum tubing. **Fig 2** is a close-up photograph of a corner assembly.

The side-to-side length is the key to centering the SWR curve for lowest reading at 28.4 to 28.5 MHz. The center frequency changes about 150 kHz for every inch of length adjustment. Hence, using the U-shaped outer ends as trombone slides will let you center the antenna anywhere in the 10-meter band. If you use slightly larger stock, say 1-inch and $^7/_8$-inch tubing, performance will change very little. With $^7/_8$-inch tubing for the outer main elements and the sides, you can weld or otherwise fasten (with Penetrox or another conductive paste) $^3/_4$-inch copper plumbing pipe Ls at the corners.

Since the end spacing and alignment is somewhat critical to the antenna's full performance, you can slide a piece of CPVC or similar lightweight, durable tubing either inside the ends or over the ends and fasten

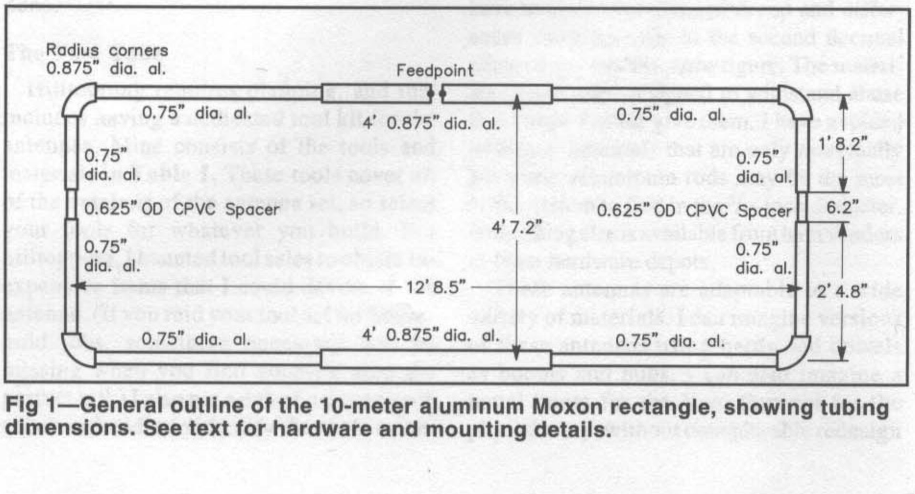


**Fig 1—General outline of the 10-meter aluminum Moxon rectangle, showing tubing dimensions. See text for hardware and mounting details.**

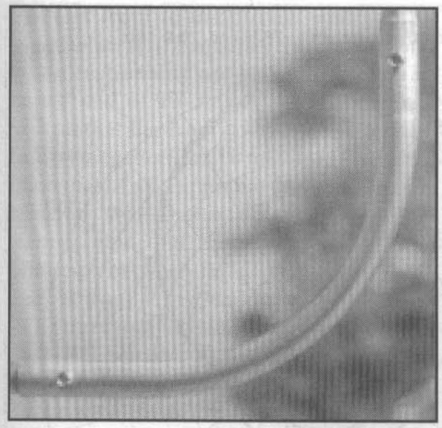

**Fig 2—A close-up of the corner assembly. The 7/8-inch diameter corner piece makes a good fit over the 3/4-inch diameter straight pieces and requires only a single fastener at each end (with a light coat of "Penetrox A" at the joint).**

them in place with sheet-metal screws. The rigid spacer also limits the twisting force placed on the corners. Sheet-metal screws also connect the 3/4-inch and 7/8-inch tubing together. Be sure that all hardware is stainless steel. Pop rivets will also do well, if you use sufficiently sturdy ones.

The feed-point assembly is shown in **Fig 3**. I used a very simple system. I cut one side of the driven element tubing 1 inch short at the feed point. I then cut a 2-inch section of 1/16-inch thick L stock, and cut a 5/8-inch diameter hole at one end. A chassis-mount female coax connector (with a lock washer) fits into the hole, with the plug side pointed at the mast. Stainless-steel sheet metal screws attach the longer side of the L stock to the cut-off tube. A #14 copper wire (tinned the entire length) goes from the center pin to the other side of the feed point, where it is fastened to the tubing by a sheet-metal screw. Feel free to devise your own method of feed-point connections. After testing, but before committing the antenna to permanent installation, be sure to waterproof the rear of the coax connector as well as the coax plugs.

**Fig 3—A close-up of the feed-point assembly, with 3/4-inch wide U-stock used for the coax receptacle. After initial tests the rear of the coax fitting, the bare wire-to-tube connection and the connector from the ferrite-bead choke balun were sealed with butylate. Experience with other outdoor uses suggests that the gray PVC half-clamps should be replaced every two to three years during routine maintenance.**

For element-to-boom plates, you can use any durable material. Spar varnished 3/8-inch plywood or LE plastic make good plates. About 3 by 9 inch (or longer) plates give ample room to U-bolt the elements to the plate and have room for U bolts that go over the mast. My prototype uses 1/2-inch PVC electrical conduit U straps fastened in place with #8 stainless-steel hardware. Since 7/8-inch tubing overstresses these straps, I placed an extra washer between the U strap and the plywood plate. The object is a firm grip, but not a broken strap. Two straps hold the reflector center tube in place; the driven element requires two on each side of the feed point.

As with all good antenna structures, let the elements hang under the boom. What boom? Well, you can use almost anything, from 1 1/4-inch PVC (which I had on hand) to a good grade of aluminum tubing (thicker-wall than the usual 0.055-inch hardware store variety–or two pieces nested) to a 5-foot length of spar varnished 1 1/4-inch-diameter closet rod. PVC is the heaviest, aluminum the lightest; but at 5 feet, the boom weight is not a significant issue. Make a boom-to-mast plate similar to the boom-to-element plates, only a bit more nearly square, and you are in business.

The antenna dimensions in the drawing are given to three decimal places, being direct translations of the computer model used to generate the antenna. Try to keep the dimensions within about 1/4 inch of the drawing, and you won't be able to tell any difference in performance. Squaring the corners or missing the dimensions by a half inch will shift the performance centers by about 100 kHz at most. In most cases, you will not be aware of any difference at all. To assure that the assembly is neatly squared and close to the prescribed dimensions, you can draw the outer dimensions and center line on the shop/garage/basement floor with a marker pen and then assemble the pieces within those boundaries. As shop experts always say, measure twice, cut and assemble once.

Note that the antenna is about 12 feet, 8 inches wide and under 5 feet front-to-back, for a turning radius of about 6 feet, 8 inches. Strapped up on the side of the house, the antenna is unlikely to overhang the property line. The antenna is light enough for hand rotation, but an old TV rotator might come in handy. Because of the antenna's characteristics, you may not need to rotate it much.

The free-space azimuth patterns, shown in **Fig 4** for 28.1, 28.5, and 28.9 MHz, show the possibilities for the Moxon rectangle. Note the very broad forward lobe, almost a cardioid, giving reception and transmission

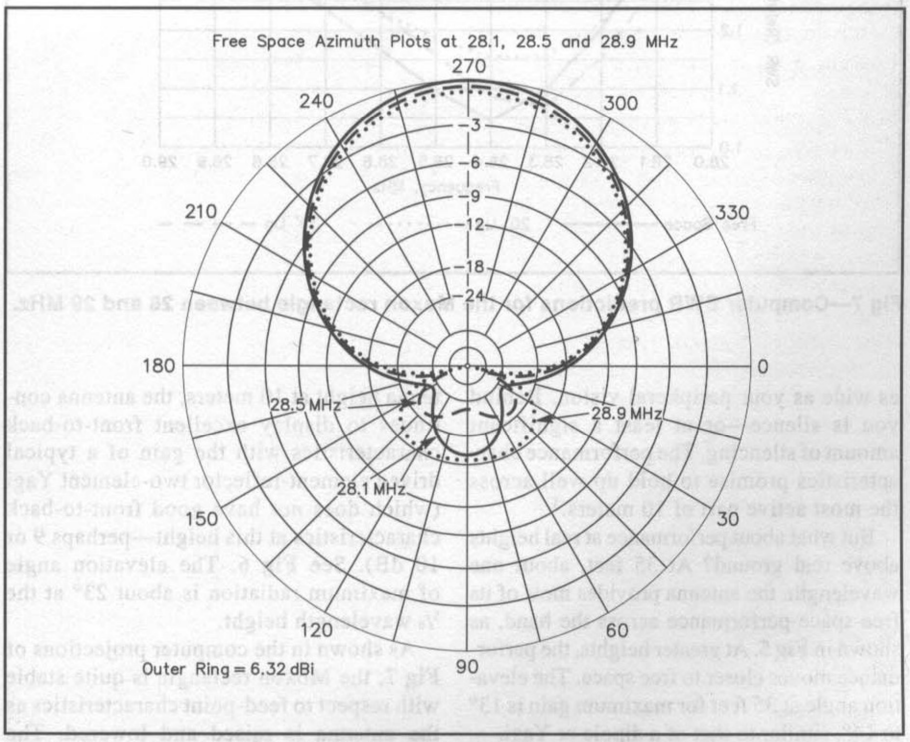


**Fig 4—Free space azimuth plots at 28.1, 28.5 and 28.9 MHz.**

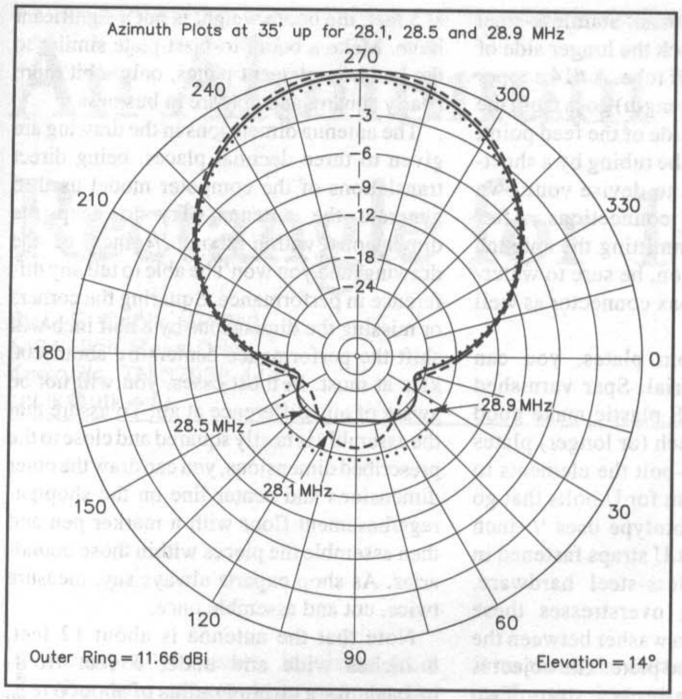


**Fig 5—Azimuth plots at 28.1, 28.5 and 28.9 MHz at an elevation angle of 13° with the antenna at 35 feet.**

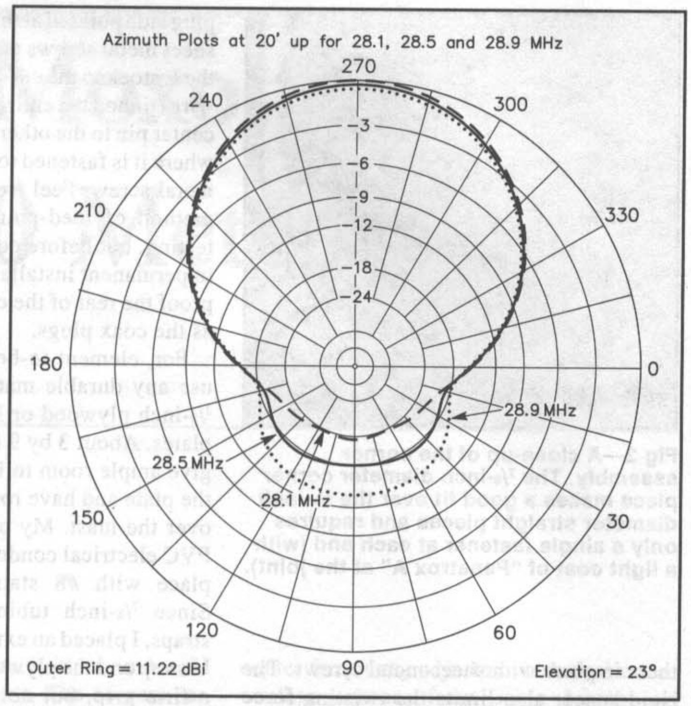


**Fig 6—Azimuth plots at 28.1, 28.5, and 28.9 MHz at an elevation angle of 23° with the antenna at 20 feet.**

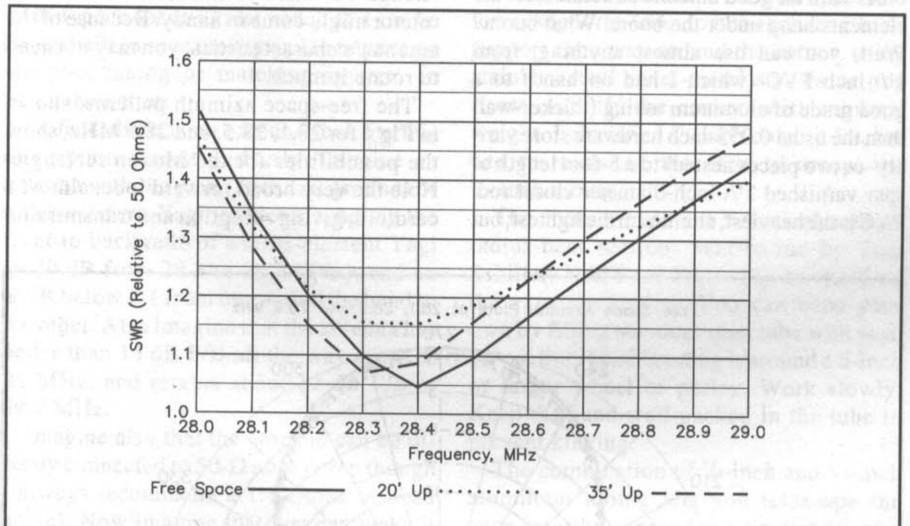


**Fig 7—Computer SWR predictions for the Moxon rectangle between 28 and 29 MHz.**

as wide as your peripheral vision. Behind you is silence—or at least a significant amount of silencing. The performance characteristics promise to hold up well across the most active part of 10 meters.[3]

But what about performance at real heights above real ground? At 35 feet, about one wavelength, the antenna provides most of its free-space performance across the band, as shown in **Fig 5**. At greater heights, the performance moves closer to free space. The elevation angle at 35 feet for maximum gain is 13° to 14°, similar to that of a dipole or Yagi.

Even at 20 feet up, a typical portable antenna height at 10 meters, the antenna continues to display excellent front-to-back characteristics with the gain of a typical driven element-reflector two-element Yagi (which does *not* have good front-to-back characteristics at this height—perhaps 9 or 10 dB). See **Fig 6**. The elevation angle of maximum radiation is about 23° at the $^5/_8$ wavelength height.

As shown in the computer projections of **Fig 7**, the Moxon rectangle is quite stable with respect to feed-point characteristics as the antenna is raised and lowered. The curves actually flatten somewhat over real ground. Therefore, setting up the antenna for operation is simple.

My initial procedure was to fasten the antenna, pointed straight up, to a 20-foot mast propped up by a sturdy tripod. The reflector was no more than 5 feet above ground. I then adjusted the side-to-side length to minimize SWR at 28.450 MHz, using the trombone-slide end sections. After fastening down the sections and raising the antenna, there was no detectable change in SWR performance from the adjustment position pointing at the sky.

**Fig 8** is a photograph of my antenna mounted in place on its test mast. On-the-air tests with Moxon rectangles verify that the antenna shows less than 2:1 SWR across the entire 10-meter band when the design center frequency is about 28.5 MHz. The

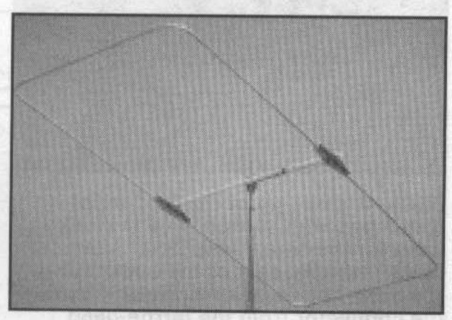

**Fig 8—The completed 10-meter aluminum Moxon rectangle on its test mast. Despite some stiff breezes, the physically closed assembly has remained very stable.**

gain and front-to-back ratio continue to decrease as the frequency increases, but some directionality and gain persist even at the top end of 10 meters. Local contacts confirm that the front-to-back ratio within the first megahertz of 10 meters is far superior to that of a comparable driven element-reflector two-element Yagi. I cannot measure gain, but there is no detectable difference between the Moxon and a two-element Yagi at my station.

Contrary to claims made for the VK2ABQ squares, these antennas do not like to be nested for a multiband array. Stacking requires a minimum of 10 feet between 10 and 15-meter models. However, you might consider back-to-back 10 and 15-meter antennas. Computer studies suggest that a 13-foot boom would hold both antennas, reflector-to-reflector, with minimal interaction.

The Moxon rectangle will not overpower big competition. However, it does provide wideband gain with very good directional performance and a good match to common coax for the 10-meter operator with limited space and budget. Construction is straightforward using commonly available materials. These may be enough good features to earn the antenna a place at many stations.

**Notes**

[1] L. A. Moxon, G6XN, *HF Antennas for All Locations* (London, RSGB: 1982), pp 67, 168, 172-175.

[2] Past versions that I built using wire elements required lots of PVC to support them. See "Modeling and Understanding Small Beams, Part 2: VK2ABQ Squares and Moxon Rectangles," Spring 1995 *Communications Quarterly*, pp 55-70. Those versions were constructed to prove the principles of the Moxon rectangle, not to produce an easy-to-build antenna.

[3] All computer plots were made with *NEC-4* using the *EZNEC Pro* software from Roy Lewallen, W7EL, PO Box 6658, Beaverton, OR 97007.