



# A Three Element Lightweight Monobander for 14 MHz

Not only is this portable antenna easy to build, it's light as a feather!

**In** preparation for the 2000 CQWW-CW contest for the PB6X Contest Group ([www.qsl.net/pb6x](http://www.qsl.net/pb6x)), I started looking at my homemade 2-element 20-meter beam (see my Web site at [www.qsl.net/pa3hbb](http://www.qsl.net/pa3hbb) for the article on this antenna). I decided that I needed more gain on 20 meters, along with a bit more front-to-back (F/B) ratio. But the beam had to be light and it should have the following qualities:

- easy to handle with one or possibly two people
- lightweight—but sturdy enough to handle the winter weather (always bad during a contest) and be built/taken down many times during a year
- reliable construction
- full size—to meet the F/B ratio and the forward gain required
- the ability to dismantle it easily for storage. I am not in a position to keep my antennas permanently erected because I live in a rented property.
- the ability to take the antenna into the field and on vacation.

## Finding the Right Materials

With these goals in mind, I started looking into possible designs and materials to make the boom. Having designed and built a lot of beams in the past, I knew from experience that 3-element all-metal construction was possible. But to keep the elements from drooping too much and, mainly, to keep the weight down (and thus, the diameter/thickness/weight of the main boom), I ruled this option out at an early stage. I did explore the possibility of using metal elements, and performed some experiments; all of these proved that I was not going to meet all of my design criteria.

I had recently been experimenting with fiberglass fishing poles for making verti-

cals, single-element delta loops and dipoles. So, I had a few left lying around the shack. Each of these was 6 meters long and extremely lightweight. “Perfect!” I said. “I have my elements. Now I just have to work out a way to mount them on a boom.”

Again, experience held the solution. I opted for a piece of angle material made from aluminum, which is bolted to the main boom with two zinc-plated bolts at right angles to the boom. The zinc-plated bolts are important because if you use stainless steel, it will corrode the aluminum if you live in an environment where the air often carries a substantial salt content (near the ocean, for example).

I had done experiments with gain, SWR and front-to-back ratio on the 2-meter band a few years ago, so I dug out my notes and then scaled the dimensions to 20 meters.

But because I was planning to use wire for the elements (instead of 1/4-inch tubing), I knew the diameter-to-wavelength ratio of the elements was going to be higher than the 2-meter equivalent. This meant that my wire elements had to be longer than the scaled design. The question was, how much longer?

To solve this problem, I first constructed an exact model of just the driven element from the same material I had used in my original research on the 2-meter model. I then scaled this to 20 meters, but replaced the tubing with the #14 copper wire. I knew it would be too short—but I also knew that if I measured the resonant

frequency of the 20-meter wire version I could calculate how much longer I needed to make the final driven element.

As the whole antenna design is scaled, I could calculate the percentage of the difference and apply this percentage to the other elements. The spacing between the elements was going to change so minimally that I decided not to alter these dimensions.

Now I had the dimensions for the three elements: reflector, driven element and director. The spacing was a direct scaling from the 2-meter model.

I calculated the weight and wind loading for the antenna and, to see if my calculations were in the ballpark, I compared them to some commercial monoband antennas. My results were very favorable. I am by no means a mathematician, so I always make sure that my calculations are in the same region as other antennas. Now to build the prototype...

## Designing the Prototype

With the lightweight fishing rods as the elements, I decided the boom could be much lighter than a beam with all metal elements. The boom was calculated to be 16 feet, 3 inches long. I made it from three 6-foot, 6-inch lengths of 1-inch × 2-inch extruded aluminum channel stock. The three boom sections were overlapped by 20 inches and two zinc-plated bolts were used in each section to bolt (2-inch) sides together in an overlapping fashion. See Figure 1.

This made a strong boom that could

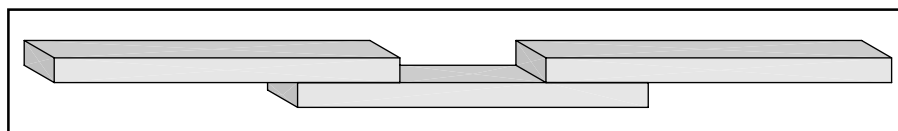


Figure 1—The boom sections.



An angle section bolted to the boom.

be dismantled into its original three pieces whenever necessary. The correct position of the elements was measured and marked on the boom and the three 3-foot, 3-inch pieces of angle aluminum were bolted to the boom sections at the appropriate places. These element bracket angles are held in place with two zinc-plated bolts each. See Figure 2.

The fishing rods were strapped to the angle material using three removable/adjustable zip-wraps per fishing rod. Once the elements were strapped to the angles, it was possible to determine the center of gravity of the beam in the middle of the garden and mark this on the boom (more about this later).

A short piece of 2x2 lumber was used as a temporary stub mast mounting. This was bolted to the boom using four metal plates with bolts going all the way through the boom and stub. (This was eventually replaced by two triangles of thick printed circuit board material.)

I raised my homemade mast and rested it on the fence surrounding my tennis court and then climbed a ladder with the antenna in one hand—it really *is* light and easy to handle—because the elements can stay telescoped while I am attaching the beam to the rotator.

Having put the boom (with the telescoped elements) onto the rotator, I extended all of the fishing rods and friction-locked them in place. I extended the reflector first, then rotated the antenna through 180° and extended the director. Finally, I extended the driven-element rods.

The last step was to raise the mast to the vertical position. It all seemed too easy. No problems were encountered and there was no time when I felt unsafe or unsteady on the ladder.

These experiments proved that it was possible to build the prototype mechanically, and it even looked like a real antenna. I left the antenna up for a week to see if it would suffer in the weather. We had some high winds and a lot of rain, but the antenna still stayed up and I was pleased when I took it down and found

## Bill of Materials

- 6—20-foot fishing rods. If you have difficulty locating suitable fishing rods, substitute six SD-20 antenna supports from WorldRadio, 2120 28th St, Sacramento, CA 95818; tel 916-457-3655. \$19 each plus \$5 shipping and handling.
- 3—aluminum rectangular box sections, 1 × 2 inches for the boom.
- 3—1.2 × 1.2-inch sections of angle material for the element brackets.
- 6—2-inch bolts for attaching the angle material to the boom.
- 4—3-inch bolts to hold the boom sections together.
- 4—4-inch bolts to attach the boom to the mast plates.
- 1—14 × 1/4-inch square printed circuit board for the boom-to-stub mast mounting plate.

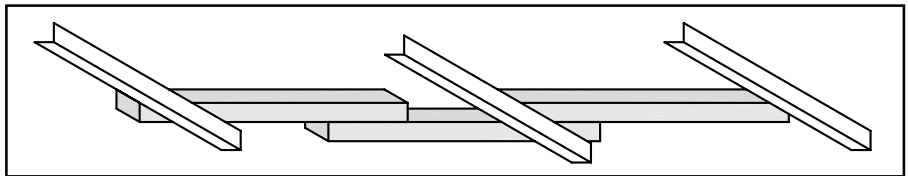


Figure 2—The boom and element brackets.

that all the parts were in perfect condition. It looked like I had a mechanical structure that would stand up for a lot more than just one weekend of heavy contesting.

The next step was to cut the wire elements, attach them to the fishing rods and put the whole antenna back up in the sky to see how it performs. Using the lengths I calculated earlier, I cut the #14 solid copper wire, marked the center point with tape and threaded it through the hoops on the fishing rods. I then taped the ends of the wire to the fishing rod so that tape at the center was sitting between the two rods at the centerline of the boom. Additionally, I secured the wire ends to each fishing rod with an extra zip-wrap fastener just to be sure they would stay in place.



The antenna elements secured to the angle sections.

In the prototype, the driven element was connected to the 50-Ω coaxial feed line through a 1:1 homemade balun, which allowed me to test the resonance of the beam and determine the type of matching unit I required for the final antenna. A balun is generally necessary if you want your beam to have a directional pattern that is not distorted by the unbalanced feed line. However, it will also work without a balun. My preference is to use a balun on balanced antennas, but not on simple dipoles (or low beams such as my 2-element 80-meter wire beam, which is only 10 meters (33 feet) above the ground).

I assembled the beam again and put it back up on the mast. I connected my MFJ-259B antenna analyzer to the coaxial cable and the resonance was measured at 14.030 MHz and the impedance was 34 Ω. This was satisfactory. I could just use a 1:1 balun and still have an SWR of only 1.47:1. The 250-Hz 2:1 SWR bandwidth was about what I expected and it would certainly be sufficient for my needs as a CW-only antenna.

My first balun would not handle 400 W output, so a new one had to be built and tested. A 1:1.33 unun followed by a 1:1 balun would provide better match and Jerry Sevick, W2FMI, has some interesting designs in his book *Building and Using Baluns and Ununs*. But, because I am looking for a simple, lightweight design, I opted for the higher SWR and a simple 1:1 balun; my amplifier will easily load into 1.47:1.

With my first balun still on the antenna, I decided to check out the properties of the beam by listening on 20 meters to stations in different parts of the world



The author holds the finished antenna.

Temporary plates for the boom-to-sub mast.

using my Elecraft K2 QRP rig and rotating the beam to record the pattern, directivity and front-to-back ratio. Well, it acted like a beam; the front-to-back ratio was consistently over 20 dB. I compared the results against my 2-element 20-meter antenna, which has a front-to-back of approximately 12 dB and the 3 element was always superior.

While the K2 was connected to the antenna, I could not resist calling CQ with the beam pointing Stateside. After a couple of calls I raised a few stations on the East Coast (while only running 3 W into the beam) and was getting 559 to 579 reports.

As far as forward gain goes, the antenna seemed to be quite a bit better than my 2-element antenna. Certainly I received better reports on the 3 element in every case.

### Building the Antenna Yourself

If you'd like to duplicate my design, you'll be pleased to know that it is a simple matter of drilling the holes in the correct places and bolting the boom sections together, the angle sections to the boom and the mast mounting plates in place. The last step is to clamp the fishing poles onto the angle sections and secure the antenna element wires to the poles. If you have never built a Yagi antenna before, you should know that the driven element is essentially a dipole, so the wire must be cut into two equal halves and attached at the center to the feed line (in this case, to the two wires from the balun). See Figure 3.

The only tools required are a drill (with the right size of drill bits for the bolts), and an adjustable wrench to tighten the bolts. No cutting or bending or folding is required, making building the antenna easy even for less experienced amateurs. It also has another ad-

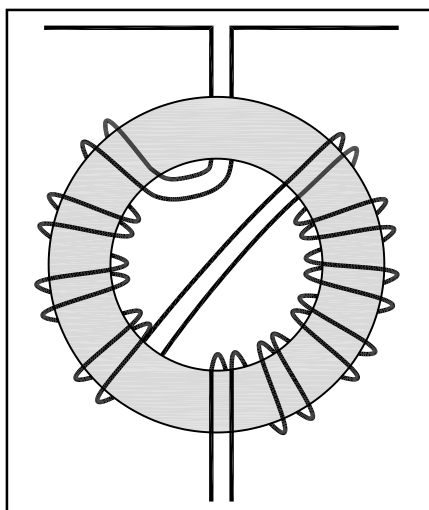


Figure 3—A diagram of the antenna balun.

**Table 1**  
**Element Dimensions**

Note: All wire elements are composed of #14 solid copper wire.

Director	Driven Element	Reflector
31', 6"	32', 4"	35', 10"

vantage when on vacation or in the field—only one tool is required for assembly (an adjustable wrench). The element dimensions are shown in Table 1. See the "Bill of Materials" sidebar for a list of the necessary parts. A drawing of the boom and element dimensions is available in Figure 4.

The fishing-pole supports for this antenna are a dielectric, so they actually lower the resonant frequency of the elements taped to them. There may be some variation in the exact dielectric properties of different brands of poles, so the antenna elements may need to be

changed a bit. The director and reflector should not be very critical, so you can cut those to the lengths shown in Table 1. The driven element will be a bit more critical, so it may be necessary to add about 6 inches to the lengths shown and prune the length of the driven element until the antenna is resonant in your favorite part of the band. As designed, the SWR may be 2:1 at the point of best resonance.

### The Balun

The 1-kW balun is made from a 2<sup>1</sup>/<sub>2</sub>-inch diameter ferrite toroid with a permeability of 40, wound with 10 bifilar turns of #12 copper wire (Figure 3). The wires are taped together first, then wound onto the core. The windings are crossed through the core at the 50% point (5 turns) to allow easy connection of the coax to one end and the driven element wires to the other. The whole balun is mounted in a suitable plastic box to keep it out of the weather.

### The Spacing Between the Elements

The spacing for the elements is a direct scaling from my 2-meter model and it provides a reasonable front-to-back gain and forward gain as well as an acceptable SWR (2:1 or less) for the transmitter.

The angle section for the reflector is bolted to one end of the boom at 90° to the boom. The driven element is placed at the end of this section of boom, 6 feet, 6 inches from the reflector (on the second section of the boom). The director is placed at the far end of the boom on the third section.

### Finding the Center of Gravity

The next step was to find the center of gravity of the completed antenna. The boom and angle mounting brackets were ready for the elements (fishing poles) to be temporarily



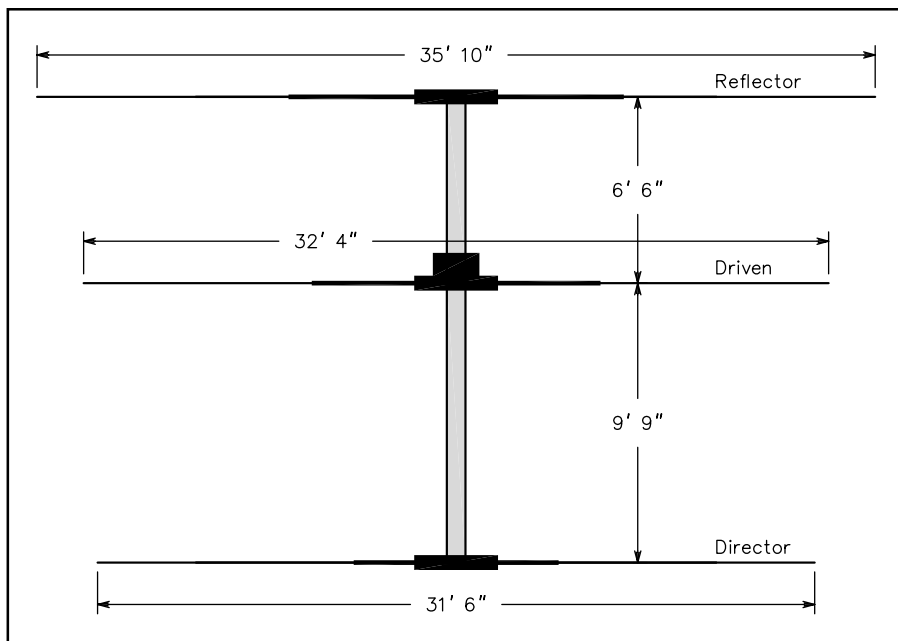


Figure 4—A drawing of the boom and element dimensions.



Here you can see the wires on the elements themselves.

### The Boom-to-Mast Clamp

There are several approaches you can use to secure the boom to the mast. One is shown in Figure 5. After several experiments with various materials, I wound up using plates made from printed circuit board material cut into triangles and bolted securely to the mast stub and the boom.

### What Does it Weigh?

Traditionally, I weigh my antennas by putting the bathroom scales in the garden and, while holding the antenna, standing on the scales and recording the weight. Then I stand on the scales without the antenna and see the difference. With some quick subtraction I can determine the actual weight of the antenna. However, this method didn't work for this design—it was too light to measure the difference! So, I had to build a quick balance using a sawhorse and a long board, putting the beam on one end and weights on the other until it was stable and horizontal. According to my jury-rigged scale, the antenna only weighs 10 pounds!

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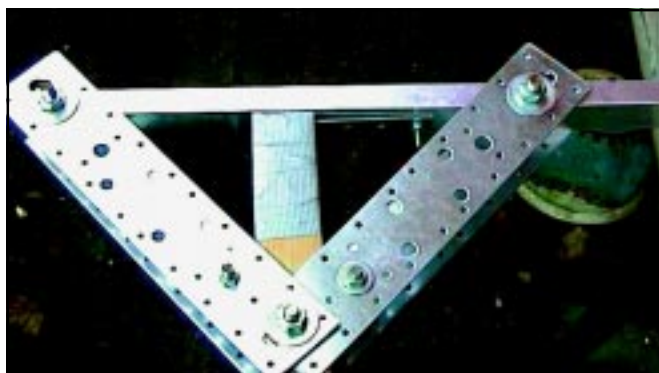


Figure 5—One approach to securing the boom to the mast.

strapped in place. The antenna was assembled in the garden and I just picked up the beam and, using one hand, just kept moving my hand back and forth until the

beam was stable and horizontal. When I found this point, I marked it as the beam center of gravity—the point where I wanted to fit the boom-to-mast clamps.