More Cheap Yagis

WA5VJB's series on cheap Yagis has generated more "do-it-yourself" enthusiasm than anything else we've published to date. So here are more, this time for 902/903 and 1296 MHz.

If you've been following this column over the past few installments, you know that I first dubbed the antenna design I'm describing here as the "Simple Yagi," and when its low cost became as great a draw as its simplicity, I began calling it the "Cheap Yagi." Actually, its "official" name is the *Controlled Impedance Yagi* because of its wide bandwidth.

My first Controlled Impedance Yagi was made for 915-MHz spread-spectrum systems and used 75-ohm coax. A long-time friend was working for the phone company and had the job of chasing down "cloned" cellphones. He was having a heck of a time running around apartment complexes with his portable equipment and a rubber duck antenna. So I whipped up a short 840-MHz 50-ohm version for him to carry around and the Simple Yagi was born.

The challenge with spread-spectrum is that the antenna must have the same efficiency (for amateur use) from 902 to 928 MHz. Note that I didn't say the same *gain* across the entire band. By peaking the gain of the antenna at the top end of the band, but optimizing the matching section at the bottom of the band, the signals coming out are just about equal over the entire 902- to 928-MHz band. This can be quite important for wideband modes such as spread-spectrum packet and FM ATV (amateur television).

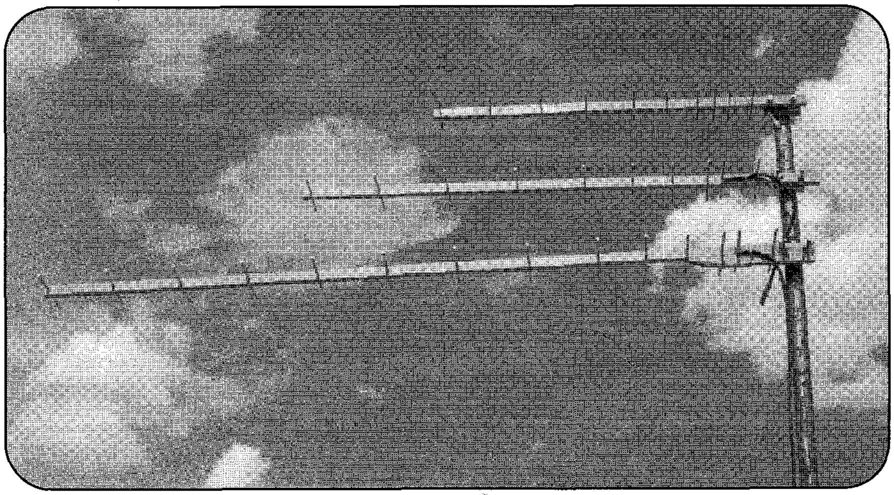

Photo A. A triple stack of Cheap Yagis. The top one is for 1296 MHz and the bottom two are for 902. See text and tables for details on dimensions.

The 33-Centimeter Cheap Yagi

Photo A shows three Cheap Yagis, the top one on 1296 MHz and the bottom two on 902 MHz (the bottom one's longer). You'll find the dimensions and construction details in Figure 1 and Tables 1 (915-MHz spread-spectrum) and 2 (902/3-MHz SSB/CW). The computer predicts only a .04-dB difference between 902 and 903 MHz, so this antenna works well on both calling frequencies (see "A Note on 902- vs. 903-MHz Activity" for discussion of SSB/CW calling frequencies on 33 centimeters). By the way, shortening each element on the 902/903 design by .1 inch will give good 50-ohm performance at 915 MHz.

Movin' on up... to 1296 MHz

A good story on this one: Back in 1994, I had been corresponding with Ed Krome,

Table 1. Measurements for 10-Element 915-MHz Spread-Spectrum Cheap Yagi

Element	R	DE	D1	D2	D3	D4	D5	D6	D7	D8
Length	6.1	*	5.6	5.5	5.4	5.3	5.2	5.1	5.0	5.0
Spacing	0	2.4	3.5	6.0	8.9	12.3	17.2	22.3	27.4	32.5

*Table 1. Element length and cumulative spacing dimensions (in inches) for a 10-element 915-MHz spread-spectrum Cheap Yagi. Element material: 3/16-inch diameter rod; if 1/8-inch material is used, make each element longer by .05 inch, or about 1/16 inch. Typical average performance: 14.3 dBi gain, 25 dB front-to-back ratio. *See Figure 1 for driven element dimensions.*

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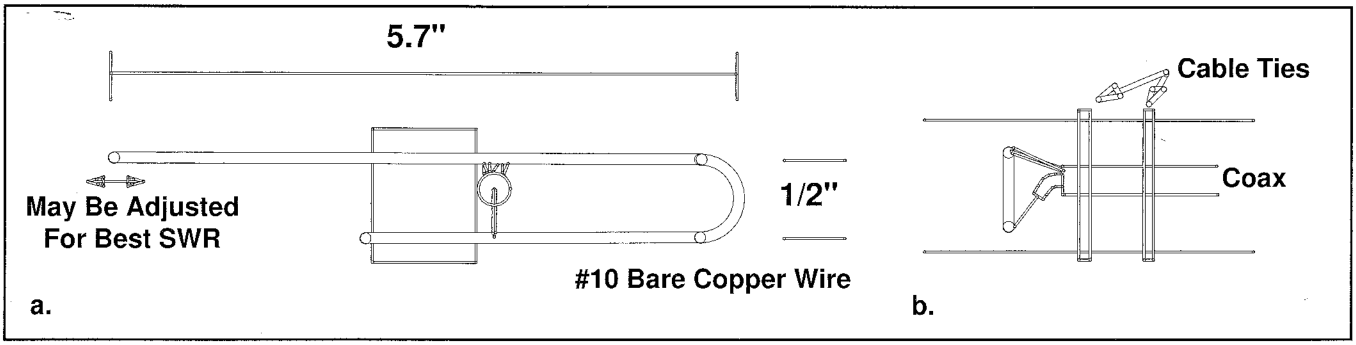

Figure 1a. Driven-element dimensions for all 900-MHz versions of the Cheap Yagi. See Table 1 for other element dimensions and spacings for 915 MHz and Table 2 for 902/903 MHz. Figure 1b. Detail of feedline connection to the 900-MHz Cheap Yagi.

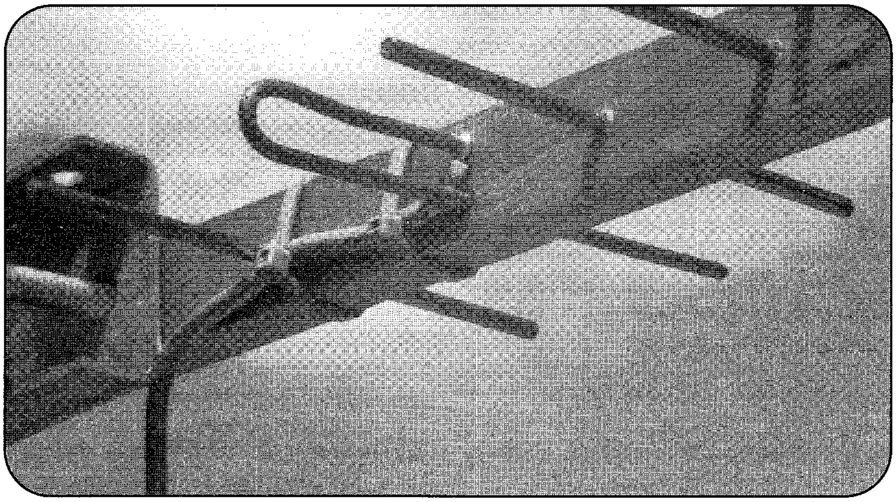

Photo B. Closeup of the feedpoint area of the 1296-MHz Cheap Yagi. I'm using semi-rigid coax as the feedline here, and I recommend it if you can get your hands on it. Can you find the "23 dB RL" notation in the photo? Guess what it means and then go find the discussion in the text to see if you're right.

K9EK, about the 1296-MHz Simple Yagi. Well, Ed also showed up at the Central States VHF Society antenna contest in Memphis, Tennessee, with a 1296-MHz Simple Yagi. He won the 1296 category, beating me by .2 dB *with my own design*!!! At least he proved the design was duplicable.

Figure 2 and Table 3 have all the numbers you'll need to build the 1296-MHz Cheap Yagi. And Photo B is a closeup of the area around the feedpoint. Those of you with sharp eyes will note "23 dB RL" written on the bottom of the boom. This stands for *return loss*. When measured on a network analyzer, the reflected power was 23 dB weaker than the forward power. Return loss is a more precise way of measuring SWR, especially when the values get very low. Twenty-three dB RL works out to about a 1.15:1 SWR. With a little tweaking and fancy test equipment, I've had many of these antennas show 40-dB return loss, or about a 1.02:1 SWR. Of course, the guy at the other end of the QSO is never going to hear this, but it's just fun sometimes to see how low you can go and for no other reason.

Back to Photo B—you may note that I used .141-inch semi-rigid coax. This stuff solders really well and makes an excellent RF connection. I recommend semi-rigid coax it you have it. I've also seen 1/4-inch hardline soldered to the driven element.

Watch That Boom

One problem did show up when the Houston ATV group (HATS) started building 1260-MHz versions. Someone substituted 1-inch square wood for the boom instead of 1/2 x 3/4-inch wood. This put nearly one-third of the element *inside* the wood—kind of like using a telephone pole as the boom for a 2-meter Yagi. This much wood did affect the antenna and shifted the frequency enough to just about kill it on the design frequency. So stay with 1/2-inch-wide wood.

My Secret Tuning Stick

In Photo C, you'll see one of my secret weapons for when I'm working with antennas. It's a stick with a 1-inch piece of element rod taped to one end, and a 2-inch piece of element material taped to the other end. When you place either end of the stick near an element, the coupling effects make the element electrically slightly longer.

When I think I've got an antenna working well on the antenna range, I just place

Table 2. Measurements for 10-Element 902/903-MHz Cheap Yagi with Direct Feed

Element	R	DE	D1	D2	D3	D4	D5	D6	D7	D8
Length	6.2	*	5.7	5.6	5.5	5.5	5.3	5.3	5.2	5.2
Spacing	0	2.4	4.0	5.75	9.0	12.5	17.5	22.5	27.75	33.0

*Table 2. Element length and spacing dimensions (in inches) for a 10-element 902/903-MHz Cheap Yagi with direct 50-ohm feed. Element material: 1/8-inch diameter (silicon bronze welding rod works well). Typical performance: 14.5 dBi gain, 40 dB front-to-back ratio. *See Figure 1 for driven element dimensions.*

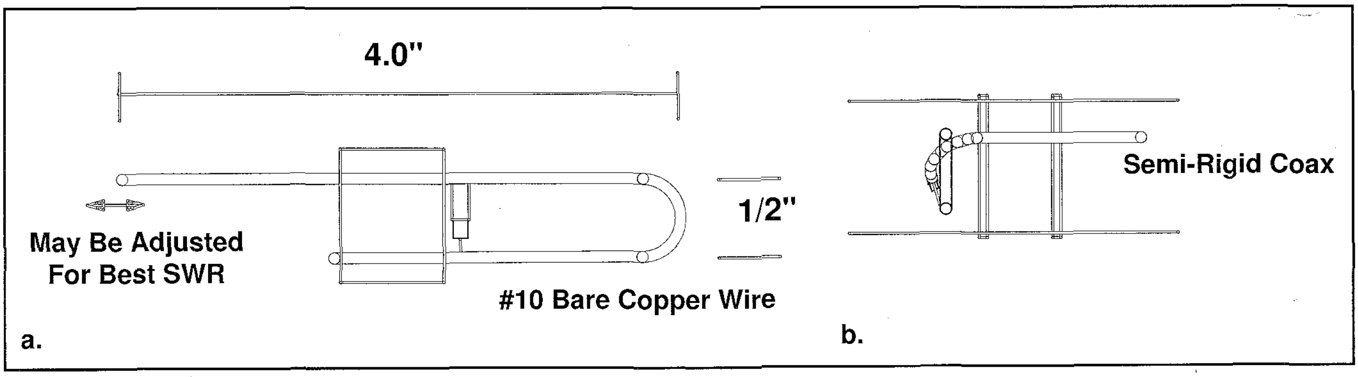

Figure 2a. Driven element dimensions for 1296-MHz versions of the Cheap Yagi. Figure 2b. Optional use of semi-rigid coax.

the tuning stick near each element (Photo D). In theory, detuning each element should make things worse. Well, sometimes (often), placing the tuning stick near the element *improves* gain. So I try again with that element slightly longer. On the other hand, if getting the tuning stick simply near the element instantly makes things worse, I trim off a little of that element and try again.

Table 3. Measurements for 10-Element 1296-MHz Cheap Yagi

Element	R	DE	D1	D2	D3	D4	D5	D6	D7	D8
Length	4.3	**	3.9	3.8	3.75	3.75	3.65	3.6	3.6	3.5
Spacing	0	1.7	2.8	4.0	6.3	8.7	12.2	15.6	19.3	23.0

*Table 3. Element length and spacing dimensions (in inches) for a 10-element 1296-MHz Cheap Yagi. Measured performance: 13.5 dBi gain, greater than 30 dB front-to-back ratio. Element material: 1/8-inch diameter rod. Making each element .1 inch longer will give good performance between 1260 and 1280 MHz for AMSAT, ATV systems, or for links. The F/B ratio will drop to 20 or 25 dB, but the gain will still be 13.5 dBi. **See Figure 2 for driven element dimensions.*

I never publish one of my designs unless it's been tested out on the antenna range. Computer programs are excellent design tools, but they only get you close to the final design. Computer modeling is valuable, but it's no substitute for testing full-size antennas. In a future article, we'll be covering how to use antenna design programs—and what to watch out for so you don't get burned by them.

We Get Letters...

In my last antenna column, I said that I make sure my projects are duplicable before I publish them. Duplicable means I take my early write-up and diagrams over to my friend Terry Turner, W5ETG,

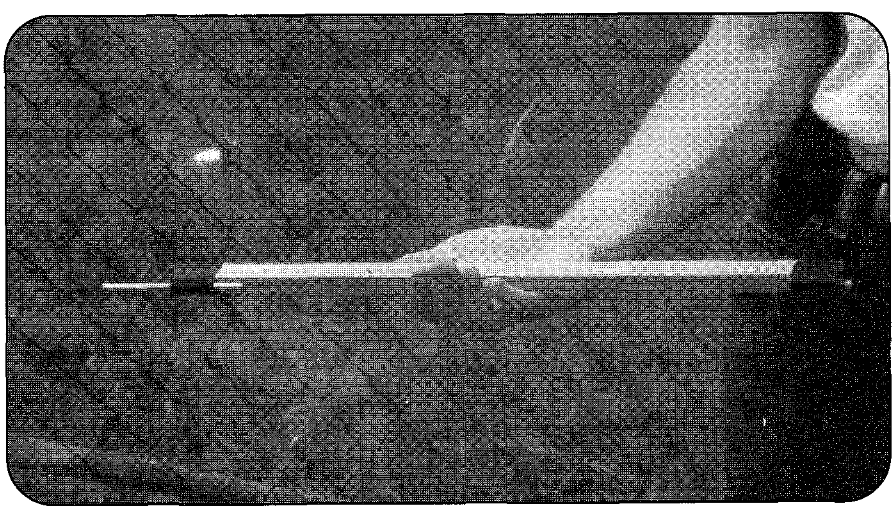

Photo C. One of my "secret weapons" for designing antennas: a "tuning stick" with a 1-inch piece of element material taped to one end and a 2-inch piece at the other end.

A Note on 902- vs. 903-MHz Activity

When 902 to 928 MHz was first opened for amateur use, many hams went for the traditional weak-signal frequency of 100 kHz above the bottom of the band. So, in the midwest and on the west coast, 902.100 MHz became the SSB/CW calling frequency. Up in the northeast, though, it was noted that 144 to *903* MHz converters could use commonly available oscillator crystals. So, much of the northeast activity is on 90*3*.100 MHz.

If you're building a new transverter for our 33-centimeter band, I'd like to put in a plug for 902.100 MHz for a couple of reasons. First, it's easy to tune your 2-meter rig from 144.100 to 145.100 MHz and work anyone using 903.100 MHz. (It's a bit more difficult to tune most rigs down to 143.100 MHz.) Finally, as more and more consumer products are sharing 902 to 928 MHz, the noise level is getting higher and higher. These products have very little filtering, yet are required by the FCC to have near zero output on 901.999 MHz. So the wireless modems, spread-spectrum cordless phones, security devices, etc. tend to avoid the very bottom of the band. In many metropolitan areas, 902.1 MHz is about a full S-unit quieter than 903.1 MHz.

and ask him to build one. Terry then gets back with me and we test it out. He usually has several suggestions on how I can make my instructions "clearer"! If his version works, I print it.

I know many of you are reading this column carefully. I made one tiny comment a few months ago about a 6-meter version of Cheap Yagi, and I received at least 15 inquiries for the dimensions. My 6-meter beam didn't tune up the way it should have, and I used some parts from my junk pile. So even I can't built another one just like it.

But even I can only take so much. I picked up a supply of aluminum tubing and promised a 50-MHz Cheap Yagi in the coming months. The "J" driven element doesn't scale well to 50 MHz, so I'm looking at several other designs. I only promise they'll be simple and cheap! For those of you who can't wait for my 6-meter beam, may I suggest the June '96 issue of *CQ VHF* and the three-element "Featherweight" 6-meter Yagi by K1BQT on page 24.

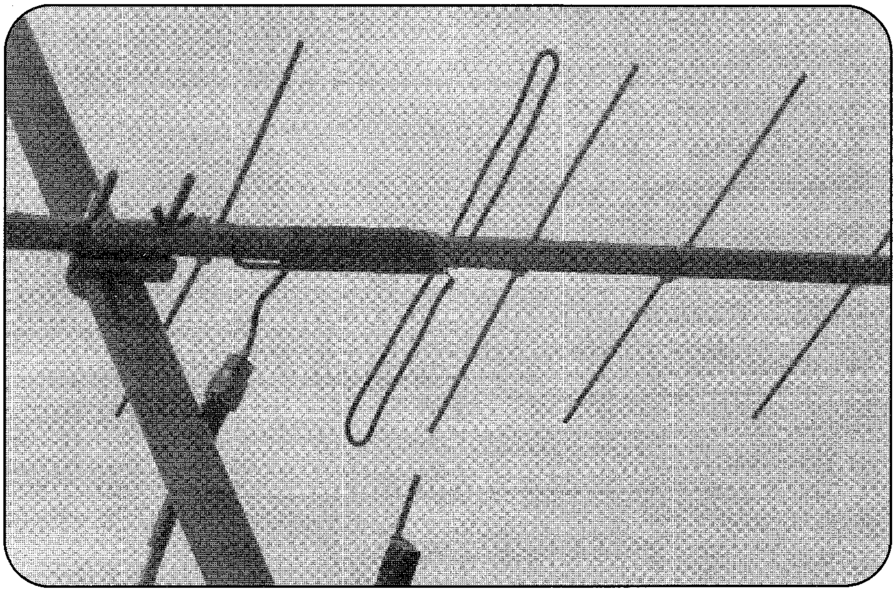

Photo D. The tuning stick in use. By holding it close to the elements of an antenna under test, I can get an idea of whether that element is resonant where it should be, or if it needs more work.

And finally, I realize some of you want the AMSAT 435-MHz versions *now*! I have a computer design and parts strewn about my workbench for a circularly polarized 435-MHz version to go along with that column. I just ask for the time to build a working model before publishing the plans. So *hold your horses*! Until next time, Happy Holidays and 73.

—WA5VJB