By Kent Britain,* WA5VJB

Connecting the Radio to the Sky

Cheap Antennas for LEO Satellites

Handheld dual-band antennas are popular for QSOs through many of the LEO (Low Earth Orbit) satellites. This month we have several 145-MHz antennas and a larger number of 435-MHz antennas. We'll show how to combine them into one antenna.

If you have a strong arm or plan to use the antenna with a tripod, then by all means the 4-element 145-MHz and 8-element 435-MHz antennas can be used together. Another choice is the 2-element 145-MHz and 5-element 435-MHz combination used in AMSAT demonstrations. It's is only 32 inches long.

Would you like something much lighter for backpacking? How about a 20-inch long 2-element antenna on 145 MHz and a 3-element one on 435 MHz. For the Arrow antenna enthusiasts, this smaller 2 elements on 145 MHz and 3 elements on 435 MHz version will actually outperform the standard Arrow. More on that in a bit.

One popular commercial antenna mounts the elements 90 degrees to one another. This is a mechanical, and not really electrical, decision. On this antenna the elements can be mounted crossways, but mounting them flat makes the antenna much easier to lay down in the back of a truck or store in a garage.

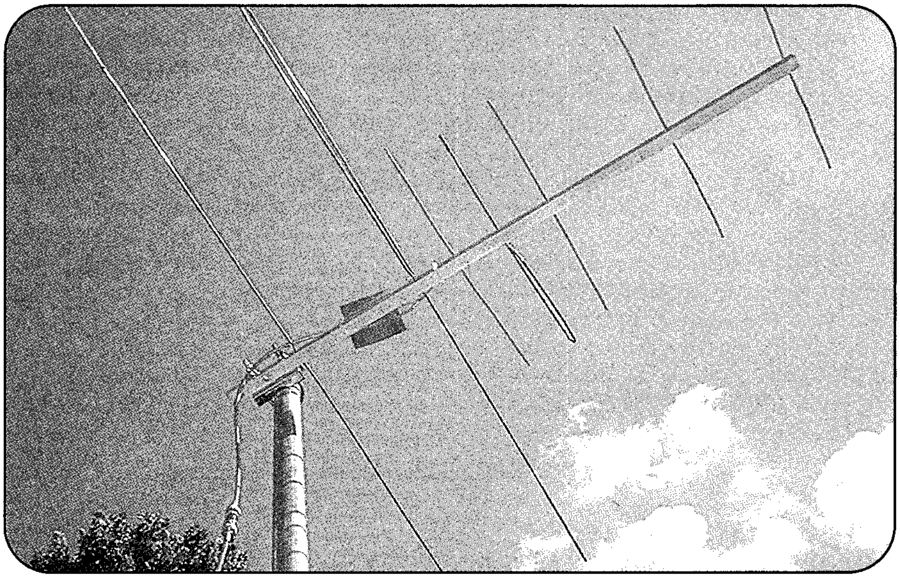

Photo A. "Cheap LEO" antenna.

Construction

For the boom, 5/8" × 5/8" or 3/4" × 3/4" wood works well. If you plan to mount the antenna outside for the long term, a coat of spar varnish, spray enamel, or some of the waterproofing stuff used on wood decks will add years to the life of the antenna.

For the elements I used 1/8-inch material. The 435-MHz reflector and directors were made from a roll of RadioShack aluminum ground rod wire. Forty feet will run you about $5.00 and will make a lot of antenna elements. However, #10 bare copper wire, bronze welding rod, and hobby tubing all have been used. If you want to use 3/16-inch diameter elements, cut them .2 inches shorter than the dimensions to compensate for the thicker material. The 2-meter elements were all made from bronze welding rod. I like to use something to which I can solder the coax, and the welding rod solders well.

The welding rod is only 36 inches long. A section of 1/8 ID copper or brass hobby tubing makes a good splice. Just slip it on and solder them together—and save some of that hobby tubing. If you have a habit of trimming an antenna twice and finding it's still too short, then you can solder a piece on the end of the driven element and start over.

I usually hold the elements in place on the boom with a drop of super glue, but

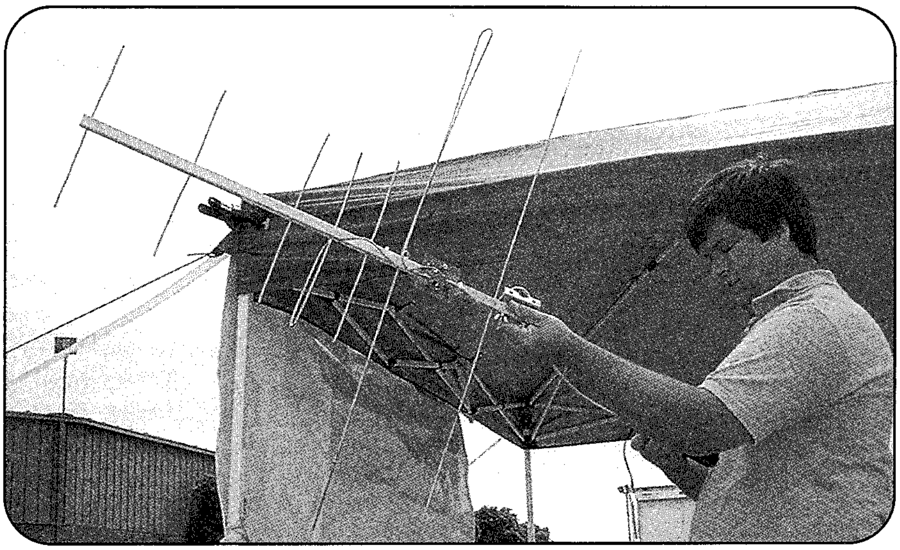

Photo B. Drew, KO4MA, using the Cheap LEO during a Dayton Hamvention® AMSAT LEO demonstration.

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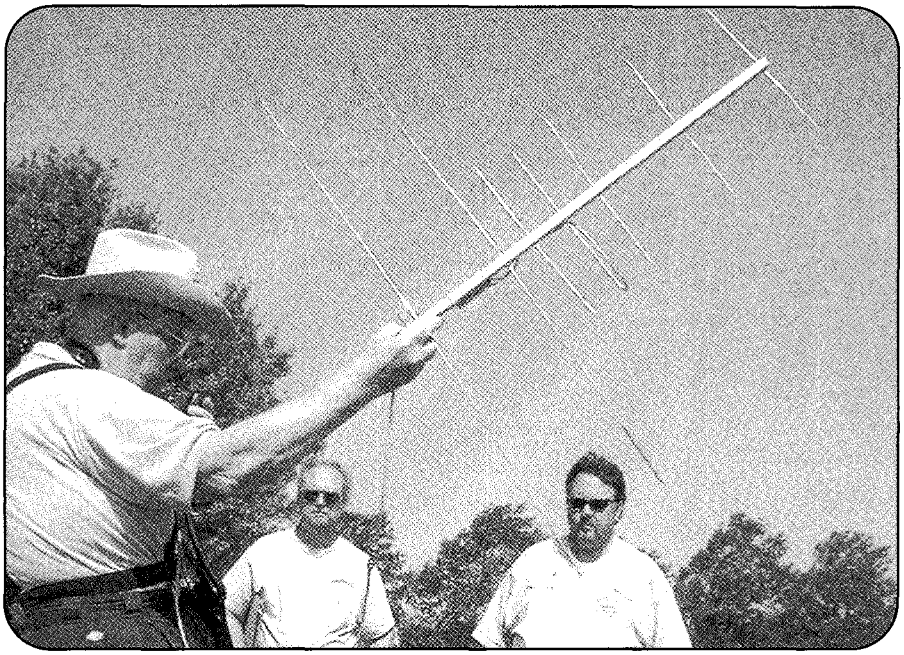

Photo C. CQ VHF *Satellites Editor Keith Pugh, W5IU, and his FT-817 using a Cheap LEO at Dallas Ham-Com for AO51 QSOs.*

silicon glue and even paint have been used.

Splitter

The band splitter is just a 250-MHz high-pass filter and a 250-MHz low-pass filter connected together.

This doesn't have to be very complex, or even very accurate. As long as the filters cut off somewhere between 200 and 400 MHz, they will work fine. Thus, if the coils get squashed, just bend them kind of back in shape and go for it. This one is cheap to build, as it's just out in the air on a piece of PC board. You can build the splitter into a box if you like, with connectors and all, but it's not going to change the performance. This band splitter even makes a good project if you want to use two other 145/435-MHz antennas.

Remember, we are not trying to filter off harmonics. We are just making the 2-meter signals go to the 2-meter antenna, and the 435-MHz signals go to the 435-MHz antenna.

Here are the parts lists:

435 high pass—two 4.7-pF capacitors; one coil, $1^1/2$ turns #18 or #20 wire on a pencil.

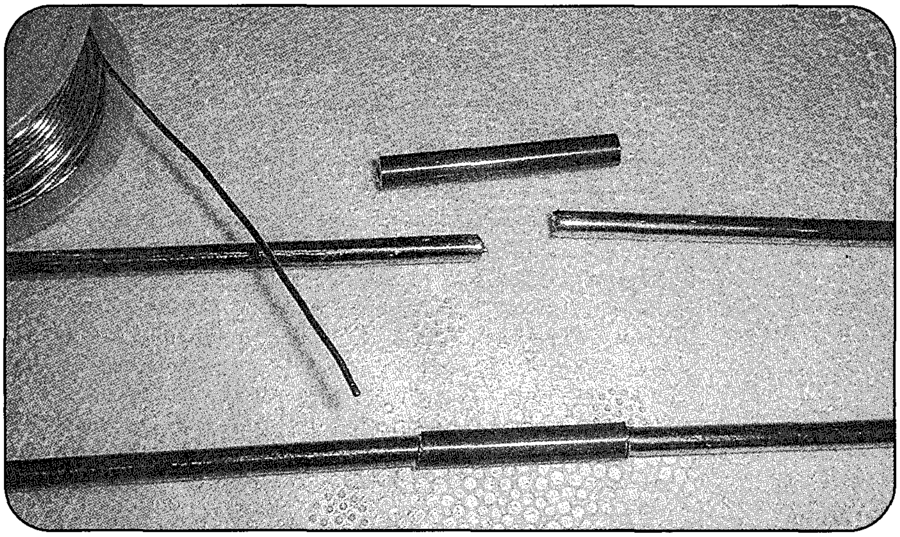

Photo D. Element splice.

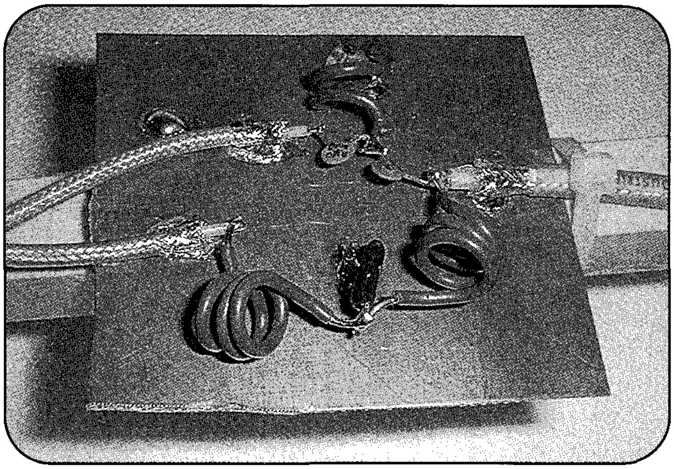

Photo E. A 145/435-MHz band splitter.

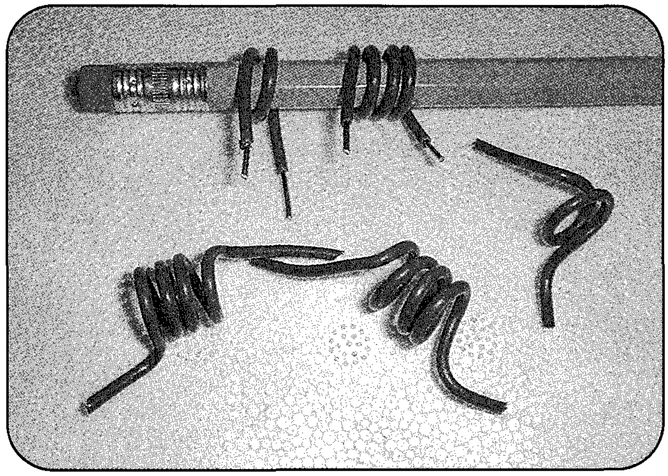

Photo F. Winding the band-splitter coils.

145 MHz low pass—one 10 pF capacitor; two coils 3 turns #18 or #20 wire on a pencil.

By the way, you're too late . . . I have already been asked if it needs to be a #2 pencil or a #3 pencil.

For the record, I wound my coils on a red grading pencil. For those of you with a more mature sense of humor, just about all wood pencils make a .3-inch coil form.

We are frequency splitting the signals, not power-dividing, so the length of the coax between the splitter and the antenna is not critical. You want to keep the coax as short as practical, but its exact length is not important. If you have a box of 4.7-pF capacitors, you can use two of them instead of the 10 pF capacitor. Be sure to keep those leads very short. I used Teflon® coax on my splitter, as it solders so much more easily than foam RG-58. You're free to build it in a box and use connectors if you like, but it's not really necessary.

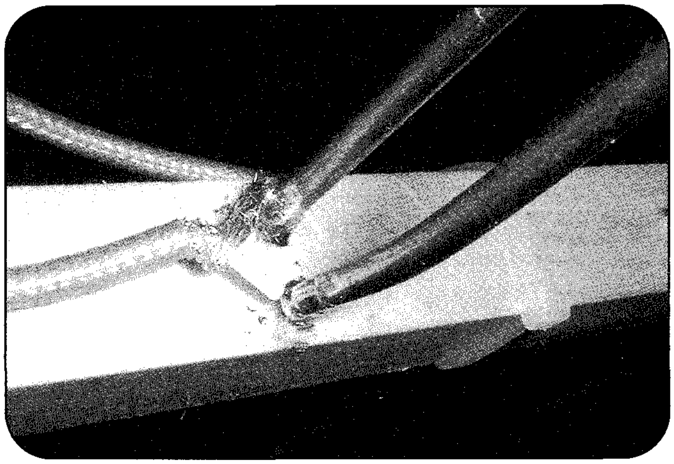

Photo G. Close-up of the driven element.

Power Handling

Power handling of this band splitter depends almost entirely on your capacitors. With 50-volt caps, 20 watts is about your limit. Dig up some 1-kV caps, and the coax will probably melt first as you warm up that 4CX250.

For one of my first prototypes, I tried to use the last 2-meter director as the 435-MHz reflector. It's an interesting idea to save weight and make the antenna shorter, but performance suffered too much. Therefore, all versions now have a reflector on the 435-MHz portion. The last 145-MHz director and the 435-MHz reflector will interact. If you plan to mount them in the same plane, space them 3 inches apart.

These J driven elements usually bring several comments from people new to "Cheap Yagis." The shield of the coax goes near the center of the top of the element. This is a voltage null and directly soldering the coax to the driven element has a lot of advantages. The tip of the coax goes to the tip of the J. Thus, you can think of this driven element as three-quarters of a fold-

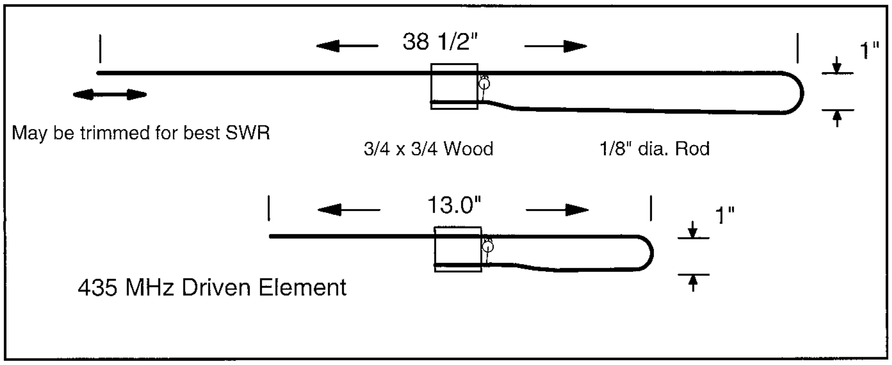

Figure 1. Dimensions of the driven elements.

ed dipole or a gamma-match with no capacitor. In free space, the J driven element has about a 150-ohm impedance. As other elements are added, they load down the impedance of the driven element. If the antenna has relatively wide element spacing, then a direct match to 75 ohms is possible. Bring in the reflector and directors a little closer, and then you have a direct match to 50 ohms. Therefore, the impedance matching is the length and spacing of the other elements. Just build the antenna to the dimensions, solder on the coax, and start talking. No tuning is required.

Tuning It Up

For the ultimate in performance, connect coax to just the 2-meter portion of the antenna and trim the free end of the J for best SWR for your favorite LEO uplink frequency. Then connect the coax to just the 435-MHz portion and again trim the free end of the element for best SWR. Now install the band splitter and this time tweak the coil spacing for best SWR at your spot frequencies.

You have now gotten the last .1 dB out of the antenna. For everyone else, just build the antenna to the dimensions (Table 1) and the SWR will be under 2 to 1 on both frequencies. Just build it and talk. The design is pretty foolproof.

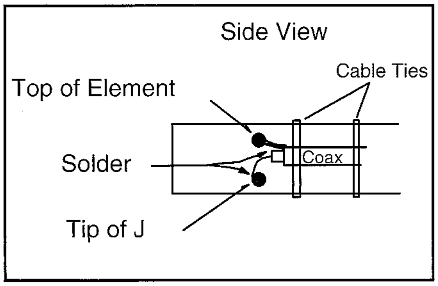

Figure 2. Attaching the coax to the driven elements.

This antenna can be built in 30 combinations of elements and polarizations. One of them should fit your need. The 2 elements on 145 MHz and 5 elements on 435 MHz version has done great in the field tests. Now you can have fun with the LEOs for less than $10.

Arrow Antennas

My first question was why the Arrow antenna has performed so poorly in the

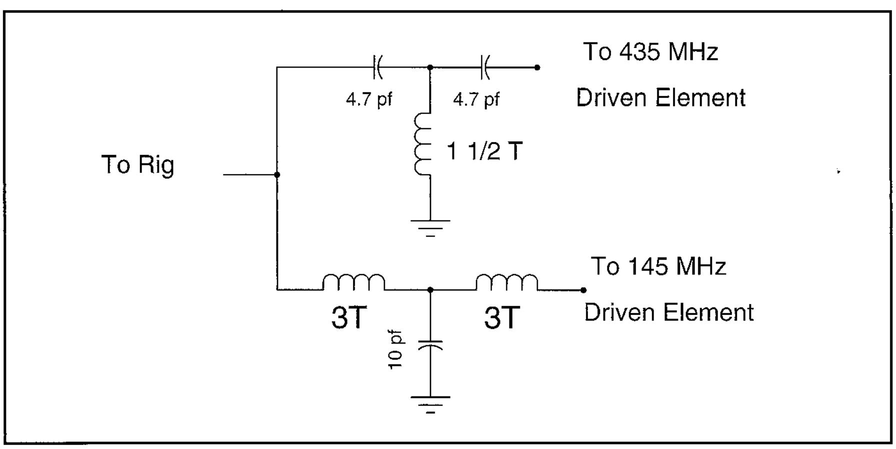

Figure 3. Schematic of the band splitter.

AMSAT demos. Arrows have been on the antenna range at several conferences showing 435-MHz gain as low as 4 dBi. I would like to thank SAM, G4DDK, for sending me the detailed dimensions of his Arrow antenna. I built an NEC model of the 435-MHz portion, and the model showed the forward gain peak to be near 457 MHz, not 435 MHz.

When you change the diameter of an element, you also have to change the length of that element to compensate for the new diameter. Two common ways to mount elements are to make the antenna element part of the boom, or using insulators, electrically isolate the element from the boom. When you make the element part of the boom, you radically change the diameter of the element in that area. Now the length of the element must be changed to allow for this new diameter. This is called the "boom correction factor." I try to avoid correction factors as best I can by using thin wood booms with my Cheap Yagis.

I don't know the history of the development of the Arrow antenna, but the model suggests that the dimensions for a 435-MHz Yagi using insulated elements were used for the Arrow, but mechanically the elements were made electrically part of boom. It appears no boom correction factor was used.

I would love to play with one on the antenna range, but it looks like a new set of 435-MHz elements, each about 1/2 inch longer, would correct the problem and give the Arrow several dB more gain.

Keep those e-mails coming. I'm always looking for antenna topics. For even longer versions of AMSAT Cheap Yagis, visit <www.wa5vjb.com/Reference>.

73, Kent, WA5VJB

Antenna Dimensions

145 MHz Version	Ref	DE	D1	D2
2 element				
Length	40.5	**	—	—
Spacing	0	7.0	—	—
3 element				
Length	40.5	**	36.5	—
Spacing	0	8.5	19.75	—
4 element				
Length	40.5	**	37.0	32.5
Spacing	0	8.5	19.0	40.0

435 MHz Version	Ref	DE	D1	D2	D2	D3	D4	D5
3 element								
Length	13.5	**	12.2	—	—	—	—	—
Spacing	0	2.5	5.5	—	—	—	—	—
4 element								
Length	13.5	**	12.4	11.5	—	—	—	—
Spacing	0	2.5	5.5	11.5	—	—	—	—
5 element								
Length	13.5	**	12.5	12.25	11.75	—	—	—
Spacing	0	2.5	5.25	12.0	18.5	—	—	—
6 element								
Length	13.4	**	12.4	12.0	12.0	11.0	—	—
Spacing	0	2.5	5.5	11.25	17.5	24.0	—	—
8 element								
Length	13.4	**	12.4	12.0	12.0	12.0	12.0	11.1
Spacing	0	2.5	5.5	11.25	17.5	24.0	30.5	37.75

***Driven element dimensions from figure 1*
Ref is the reflector; DE is the driven element; D1, D2, etc., are directors; and all spacings are measured from the reflector element.

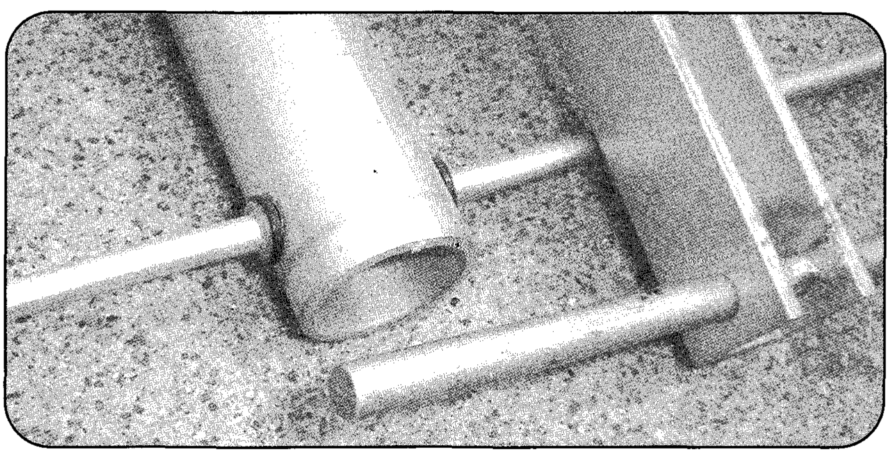

Photo H. Direct and insulated element mounting.