A Collection of 220-MHz Yagi Designs: Part 1: Utility Beams: Boom Lengths under 100" and from 3 to 8 Elements

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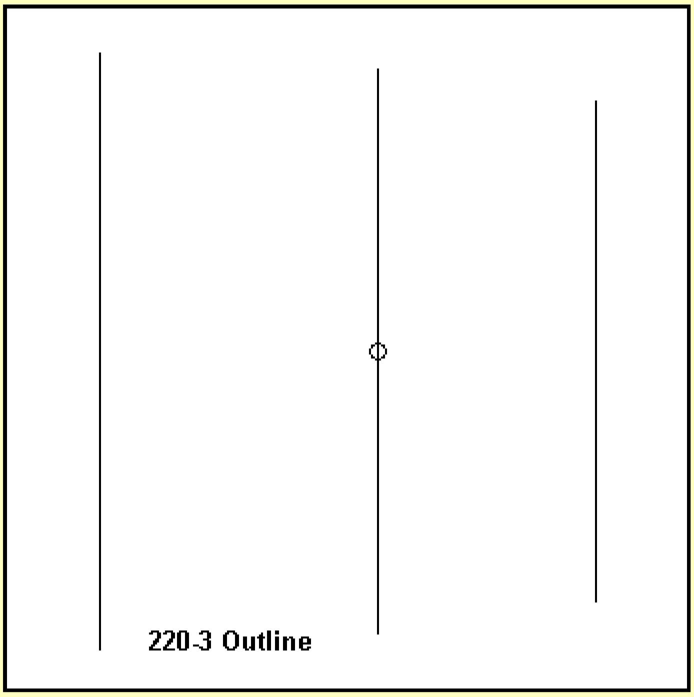
The first collection of Yagi designs for 222-225 MHz might be called utility beams, since they are all of relatively small size. The boom lengths range from 21" to just over 80", which translates into boom material lengths between 2' and 7'. Element lengths run from 22" to 27". This range will not change, since it is a function of the frequency of operation.

In the following notes, we shall introduce each design with a very short commentary and an outline sketch captured from EZNEC. Then, we shall present a table of dimensions, a table of performance data, and free-space azimuth patterns taken at 222, 223.5, and 225 MHz. Some patterns will be pointed right, others will point straight up. Since these models originate over a long period of time, the conventions of arranging elements on the X and Y axes have varied. However, the pattern shapes are unaffected by their modeled orientation.

Please note the element diameter for each design. It will change from one design to another. Do not use an alternative element diameter without first optimizing the design for the new size. Performance will suffer--often dramatically. As well, note that elements are presumed to be well isolated from the boom. If you wish to use through-mounting for the elements with a metallic boom, consult other sources for applicable correction factors. However, for these shorter arrays, you may well wish to consider alternative boom materials, such as polycarbonate rods or tubes.

220-3: A 3-Element Yagi



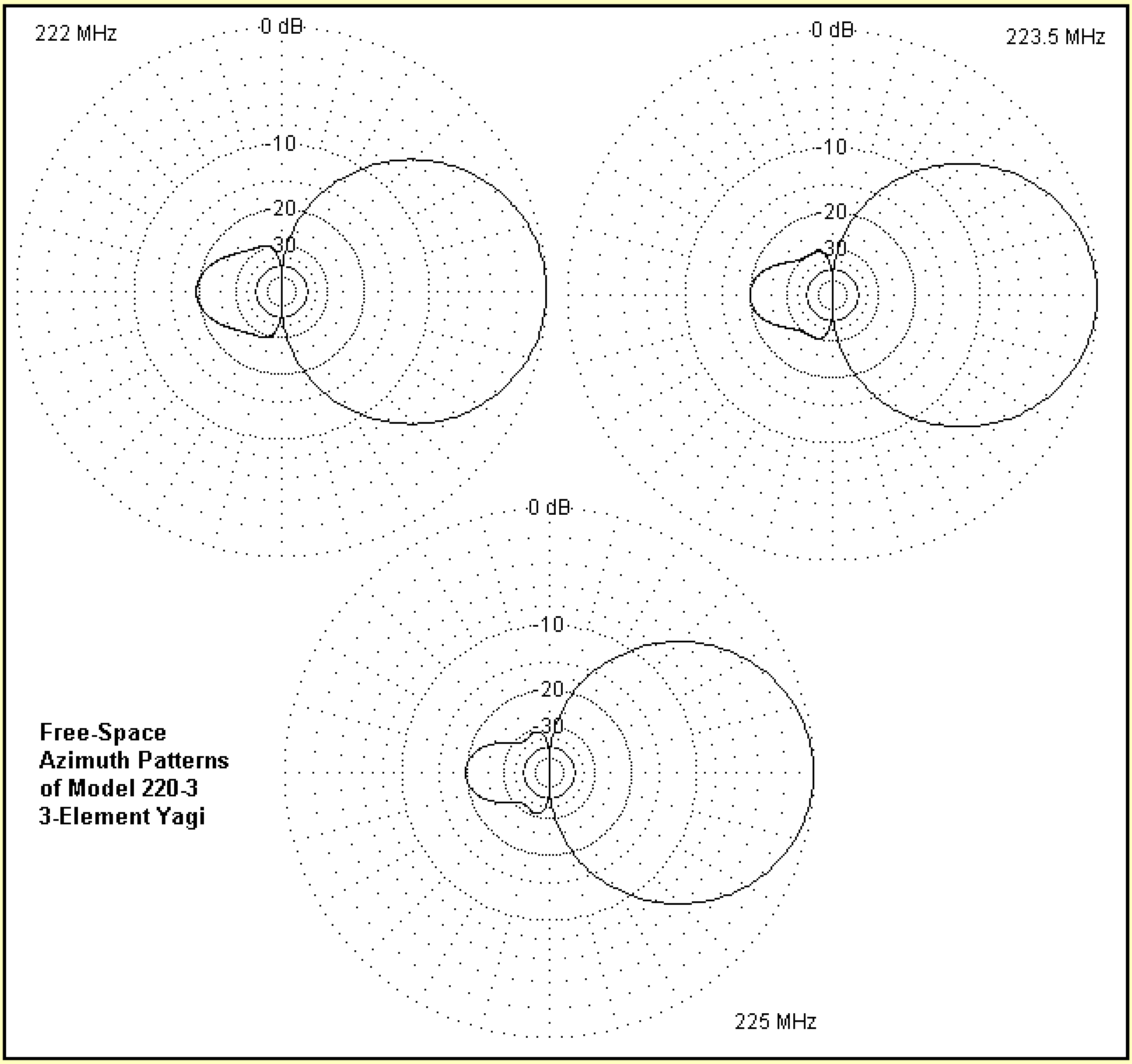
The smallest Yagi in the group, but not the shortest, is a 3-element array that follows the general parameters of a Bill Orr HF design from the 1980s. A 50-Ohm wide-band match is obtained almost solely by the spacing between the reflector and the driver, as well as the element lengths themselves. At HF, this array is capable of just over 7-dBi gain in free space using standard element sizes. However, the 3/8" diameter elements used her place the free-space gain closer to 8 dBi. However, the Yagi design achieves a 180-degree front-to-back ratio of between 19 and 20 dB. The 50-Ohm SWR is very low across the band.

Model 220-3 Dimensions (in inches): Element Diameter 0.375"

Element	Length	Space from Reflector
Reflector	25.92	----
Driver	24.40	12.06
Director	21.68	21.45

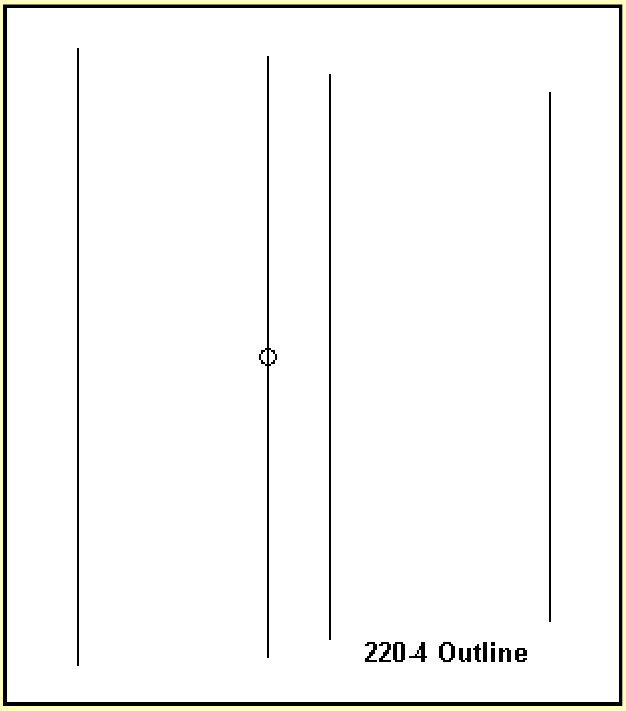
Modeled Performance

Parameter	222 MHz	223.5 MHz	225 MHz
Gain dBi	7.80	7.88	7.96
180-deg F-B	19.40	19.93	19.69
-3dB Beamwidth	65.0	64.7	64.4
Impedance (R+/-jX)	41.9 - j 1.1	41.5 + j 3.4	40.8 + j 8.2
50-Ohm SWR	1.19	1.22	1.31



Free-Space Azimuth Patterns of Model 220-3 3-Element Yagi

220-4: A 4-Element "OWA" Yagi



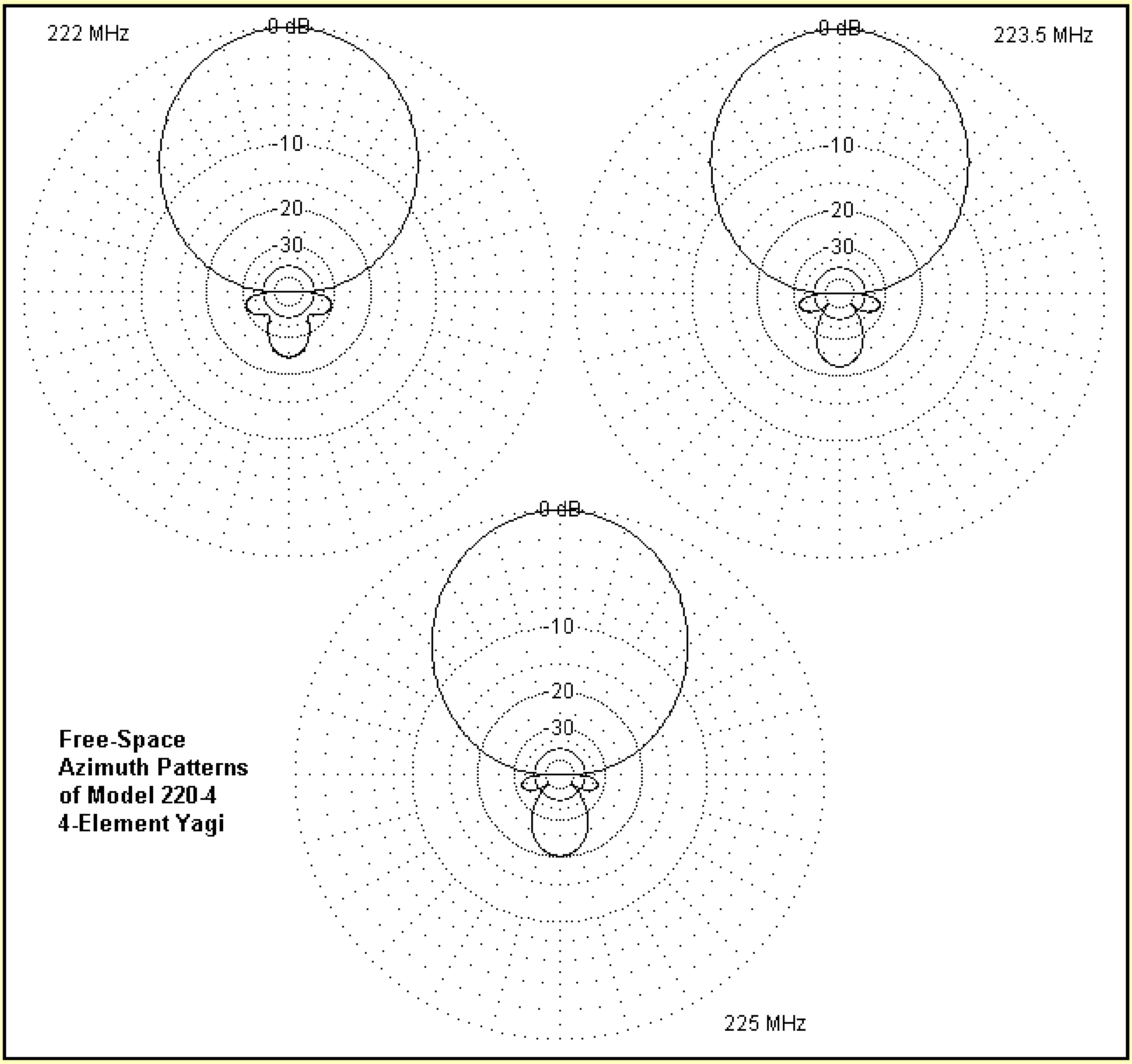
Model 220-4 is a 4-element "optimized wide-band antenna" (OWA) Yagi, the smallest number of elements to which OWA design can be applied. Note the position of the first director in the outline sketch. The reflector and first director are sized and spaced relative to the driver to provide a very wide-band SWR curve at the desired feedpoint impedance--in this case 50 Ohms. The 1/8" element design shown here is scaled from a 2-meter design. It yields a shorter boom than the 3-element design with an even flatter SWR curve across 220. Despite the short boom, it achieves a bit higher gain than the 3-element model. Consequently, using a 4th element may be worth the investment in aluminum and mounting hardware. However, note the rate of change in gain across the band, which is higher than with the 3-element model due to the use of a thinner element. At just over 20" long, this array promises excellent performance.

Model 220-4 Dimensions (in inches): Element Diameter 0.125"

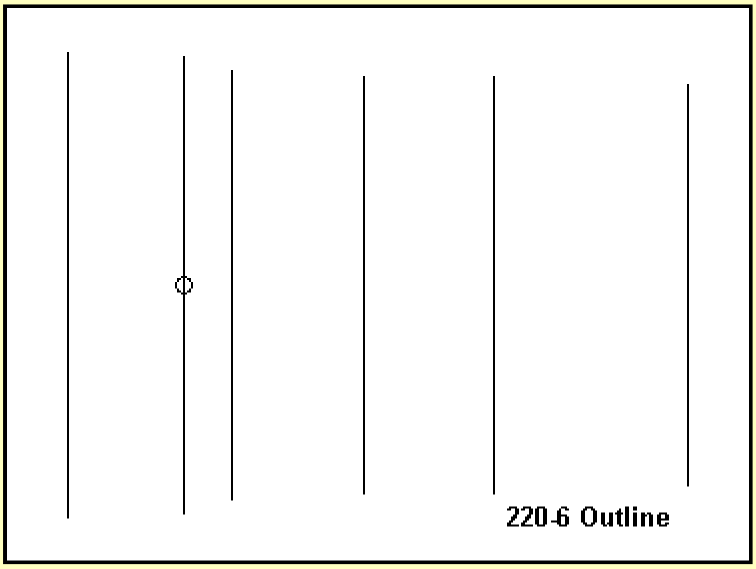
Element	**Length**	**Space from Reflector**
Reflector	**26.51**	**----**
Driver	**25.78**	**8.14**
Director 1	**24.16**	**10.82**
Director 2	**22.70**	**20.19**

Modeled Performance

Parameter	**222 MHz**	**223.5 MHz**	**225 MHz**
Gain dBi	**8.16**	**8.22**	**8.29**
180-deg F-B	**23.91**	**22.07**	**20.19**
-3dB Beamwidth	**62.8**	**62.5**	**62.2**
Impedance (R+/-jX)	**47.2 - j 2.0**	**47.6 - j 0.2**	**47.4 + j 1.0**
50-Ohm SWR	**1.07**	**1.05**	**1.06**



220-6: A 6-Element "OWA" Yagi



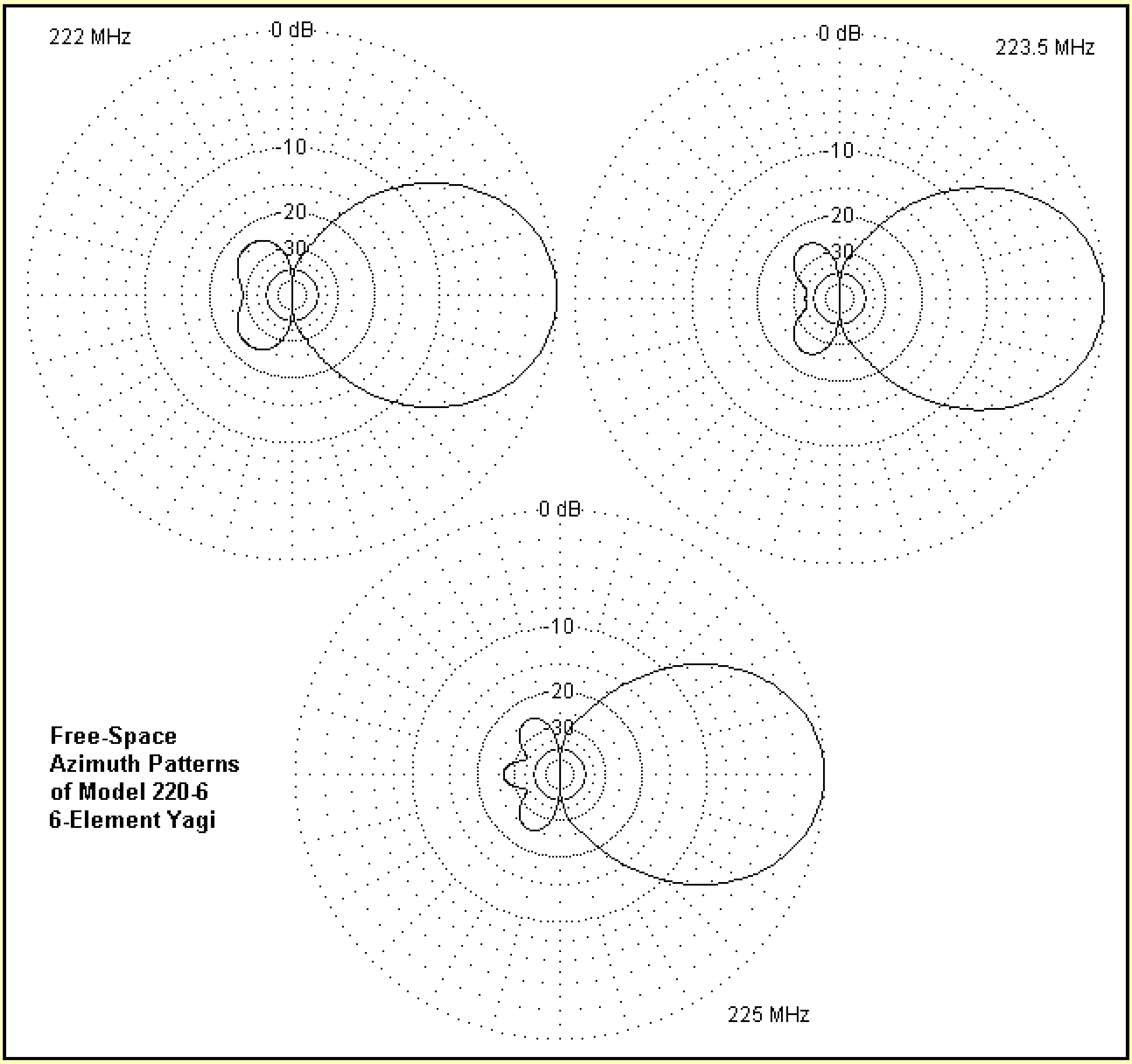
Application of the OWA design is more easily implemented as the number of elements increase. The 6-element design shows the same general arrangement of reflector-driver-first director, although the precise dimensions will be a function of the overall design. The increase in boom length to just under 3' yields an additional 2 dB of gain using 1/8" elements. Note directors 2 and 3: a common phenomenon in OWA design is that these directors will have the same length or director 3 may be slightly longer than director 2. Note the evenness of gain across the band. This design was scaled from a 2-meter design.

Model 220-6 Dimensions (in inches): Element Diameter 0.125"

Element	Length	Space from Reflector
Reflector	26.47	----
Driver	26.10	6.62
Director 1	24.42	9.36
Director 2	23.72	16.94
Director 3	23.72	24.35
Director 4	22.84	35.42

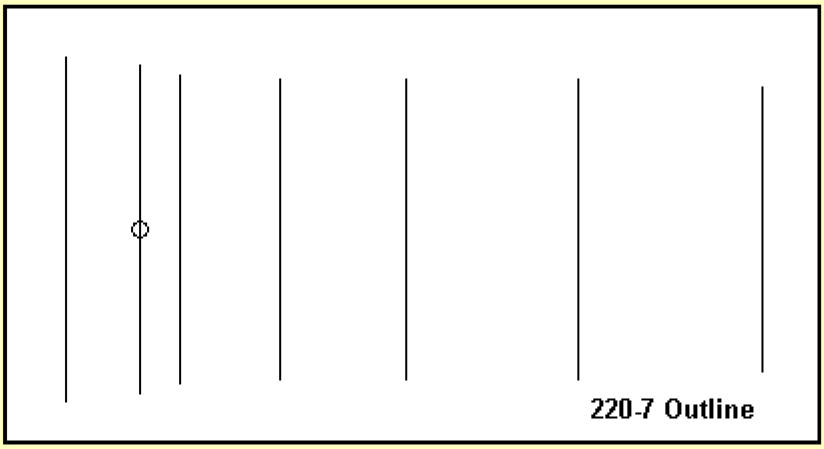
Modeled Performance

Parameter	222 MHz	223.5 MHz	225 MHz
Gain dBi	10.19	10.22	10.21
180-deg F-B	28.77	34.98	26.47
-3dB Beamwidth	53.2	52.6	52.0
Impedance (R+/-jX)	47.3 + j 9.7	50.1 + j 9.4	50.9 + j 4.0
50-Ohm SWR	1.23	1.21	1.10



Free-Space Azimuth Patterns of Model 220-6 6-Element Yagi

220-7: A 7-Element "OWA" Yagi



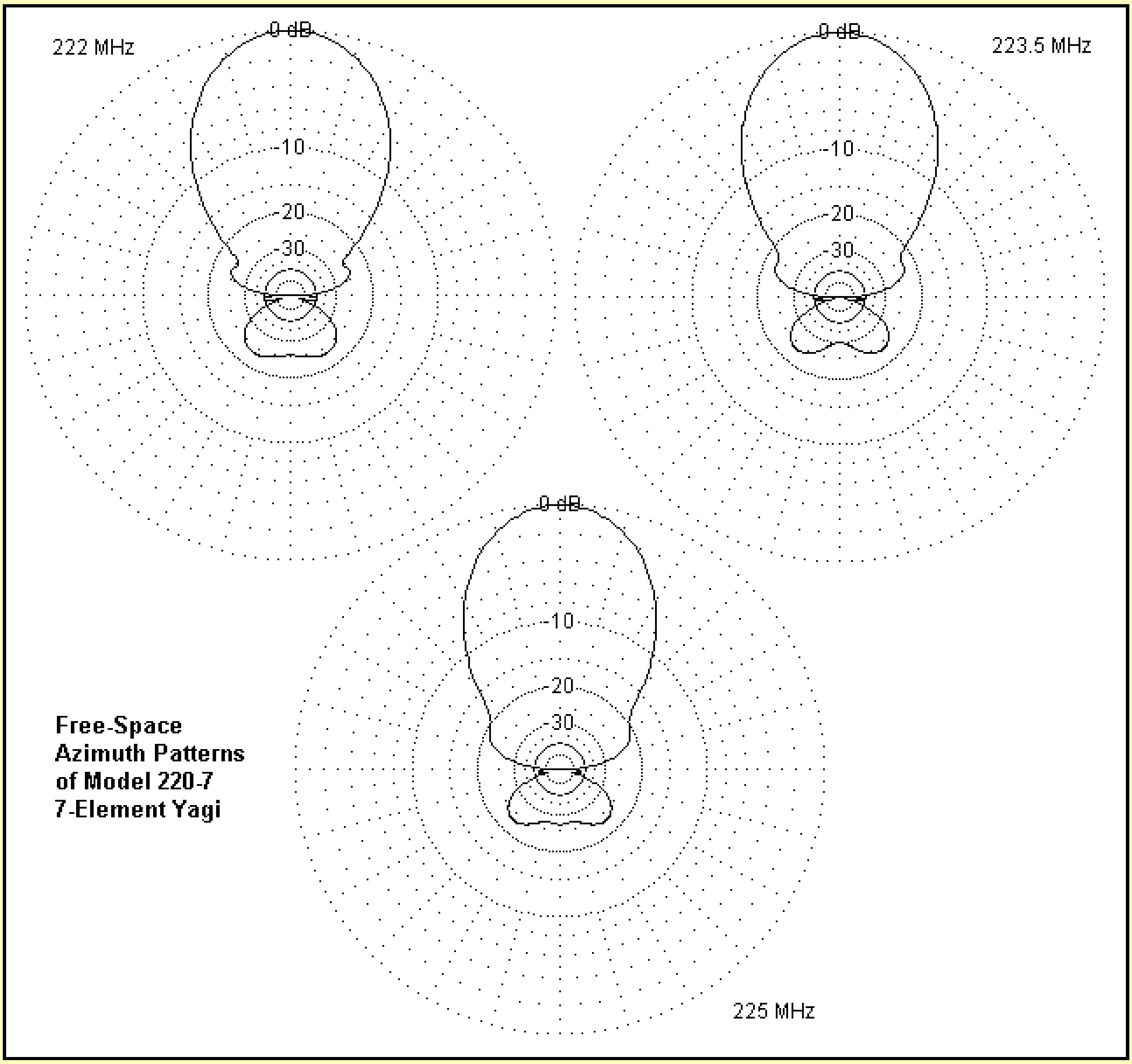
Also scaled from a 2-meter design is a 7-element OWA Yagi on a 4.5' boom. The extra boom length adds about 1.3 dB of gain, with other parameters sustained. The original design used quarter-inch elements, so for 220, 3/16" elements worked best in the adaptation. As in the 6-element design, directors 2 and 3 have the same length, with the forward 2 directors returning to a normal set of tapered lengths. As a personal aside, note the incipient secondary forward lobes in the azimuth patterns. Although almost all designers would considered them insignificant, I continue to believe that a "perfect" Yagi design would eliminate them.

Model 220-7 Dimensions (in inches): Element Diameter 0.125"

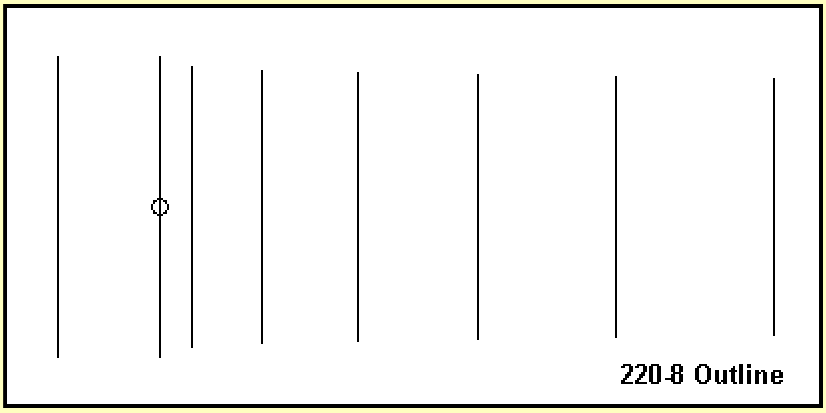
Element	Length	Space from Reflector
Reflector	26.79	----
Driver	25.62	5.82
Director 1	23.93	8.84
Director 2	23.48	16.67
Director 3	23.48	26.59
Director 4	23.35	39.94
Director 5	22.24	54.30

Modeled Performance

Parameter	222 MHz	223.5 MHz	225 MHz
Gain dBi	11.52	11.55	11.51
180-deg F-B	25.34	30.28	27.04
-3dB Beamwidth	47.2	46.2	45.2
Impedance (R+/-jX)	41.6 + j 2.9	44.3 + j 5.2	48.5 + j 3.7
50-Ohm SWR	1.22	1.18	1.09



220-8: An 8-Element Yagi



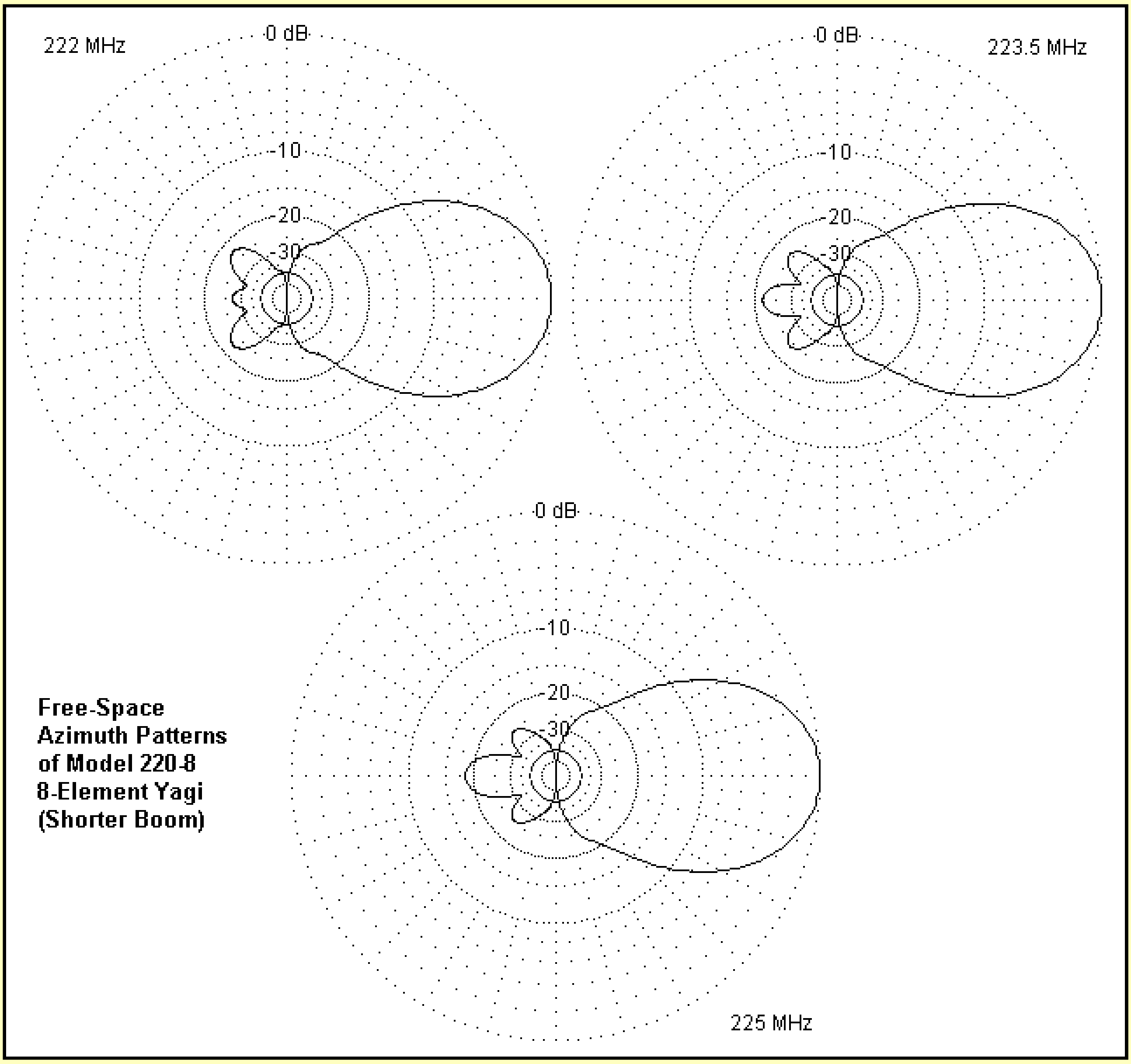
The first of 2 8-element designs uses a relatively short boom, only 7" longer than the 7-element OWA design. As well, it does not use OWA design practices, but derives the source impedance largely by virtue of the spacing between the reflector and the driver. Hence, the SWR curve is steeper than for the OWA design, and the gain is only about 0.4 dB higher. Part of the gain originates in the large (3/8") elements. This design is a scaling of a relatively standard handbook design for 432 MHz. It achieves its pattern largely by the taper of the directors. Note the continuing decrease in the -3 dB horizontal beamwidth as we increase the gain.

Model 220-8 Dimensions (in inches): Element Diameter 0.375"

Element	Length	Space from Reflector
Reflector	25.60	----
Driver	25.50	8.62
Director 1	23.97	11.41
Director 2	23.29	17.35
Director 3	22.76	25.57
Director 4	22.45	35.77
Director 5	22.15	47.64
Director 6	21.90	61.04

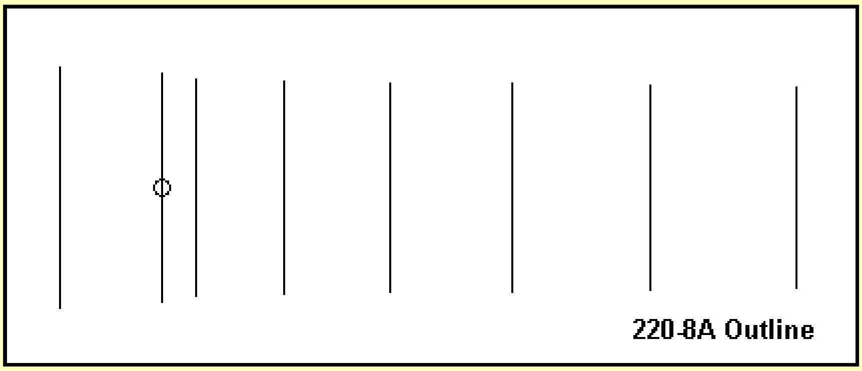
Modeled Performance

Parameter	222 MHz	223.5 MHz	225 MHz
Gain dBi	11.87	11.90	11.88
180-deg F-B	27.21	21.76	18.41
-3dB Beamwidth	45.8	45.2	44.6
Impedance (R+/-jX)	34.9 + j 8.7	42.6 + j 7.4	44.4 - j 2.7
50-Ohm SWR	1.51	1.25	1.14



Free-Space Azimuth Patterns of Model 220-8 8-Element Yagi (Shorter Boom)

220-8A: A Second 8-Element Yagi



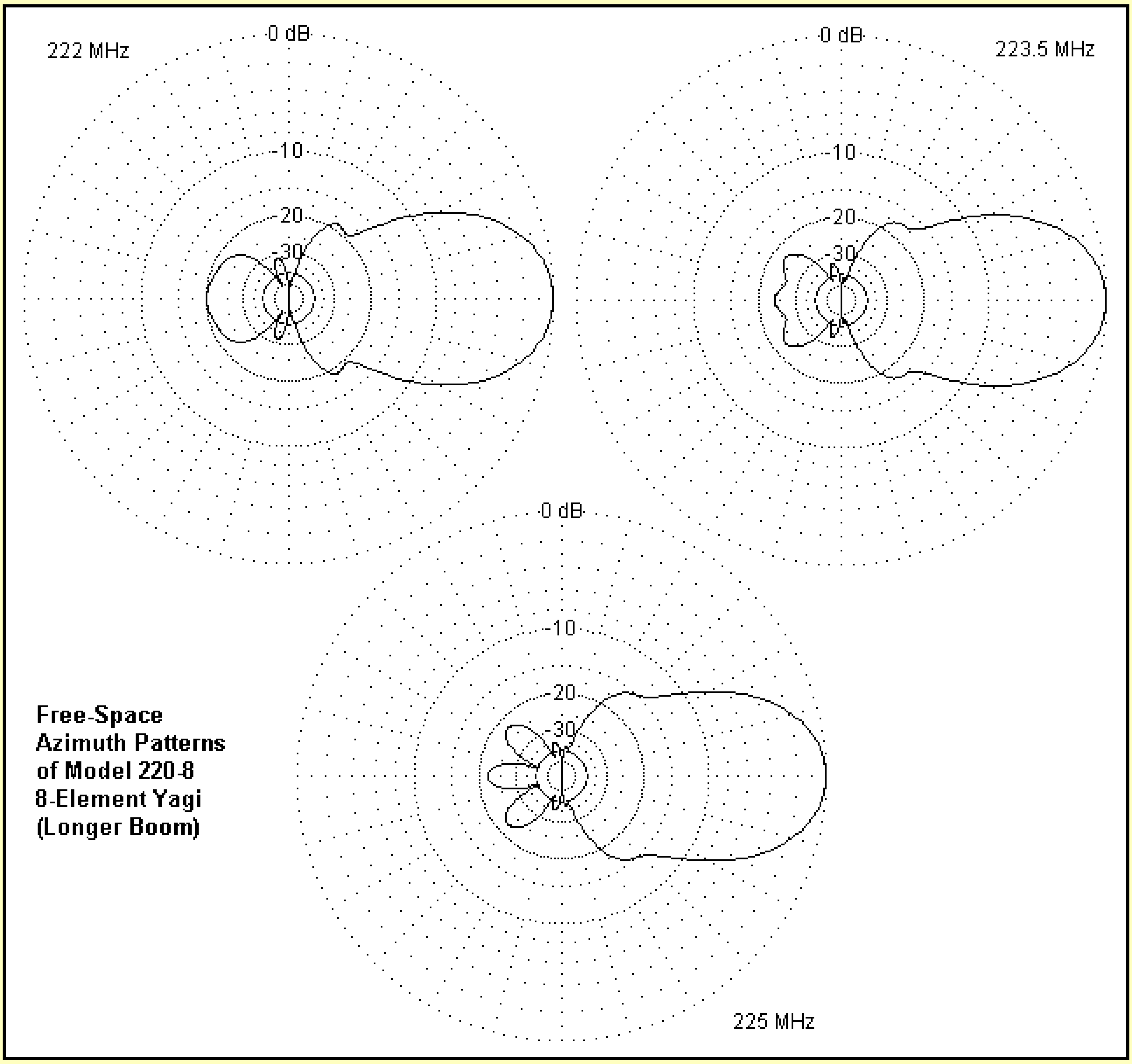
The final Yagi in our utility collection is a scaled derivative from the classic DL6WU designs for 432 MHz. Bringing the frequency downward required the use of 3/8" elements (as the closest correspondent to the 4 mm elements in the higher-frequency original), plus other adjustments. One mark of this design is the 81" boom length and the consequential increase in gain over the shorter 8-element design just reviewed. Guenter Hoch designs are noted for long boom lengths and a sequence of directors such that the full-size original (26 elements in my files) can be broken almost anywhere to yield a fairly well optimized Yagi of the new shorter length. For the best SWR curve, the reflector spacing often needs tweaking. However, DL6WU designs are very broad-banded and can be made to work acceptably over the entire 420-450 MHz band. So the challenge of scaling the design to 222-225 MHz is to align the best front-to-back ratio region of the curve with the flattest SWR for the desired feedpoint impedance. Needless to say, we shall encounter other DL6WU derivatives as we explore arrays for longer booms in succeeding episodes.

Model 220-8A Dimensions (in inches): Element Diameter 0.375"

Element	Length	Space from Reflector
Reflector	26.20	----
Driver	25.20	11.36
Director 1	23.50	14.99
Director 2	23.19	24.68
Director 3	22.91	36.24
Director 4	22.65	49.68
Director 5	22.42	64.75
Director 6	22.00	80.88

Modeled Performance

Parameter	222 MHz	223.5 MHz	225 MHz
Gain dBi	12.75	12.75	12.60
180-deg F-B	20.03	23.58	22.01
-3dB Beamwidth	40.4	39.6	38.8
Impedance (R+/-jX)	35.0 - j 5.7	39.9 + j 5.0	56.4 + j 9.9
50-Ohm SWR	1.46	1.29	1.25



Free-Space Azimuth Patterns of Model 220-8 8-Element Yagi (Longer Boom)

This completes the set of utility 220 Yagis from my files. If I had to select favorites from the list, it would be the OWA designs adapted from various 144 and 432 MHz designs. Despite the seeming sensitivity of the position and length of the first director in obtaining the desired feedpoint impedance, the broad-banded nature of these arrays tends to make them reasonably straightforward to replicate with success. As well, each provides even performance across the band in most categories.

Nevertheless, many applications on 220 require considerably more gain than provided by any of the antennas shown in this utility collection. Therefore, in the next collection, we shall look at beams using boom lengths from about 12' to about 18'. We shall not greatly increase the element count: in fact, we shall stay in the 12-14 element range throughout the exercise. However, a few of the designs will have "something different."

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