



Three Forward-Stagger 5-Band Yagis from ON4ANT



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Part 1: 50' Boom Models, August, 1998

Johan Van de Velde, ON4ANT, shared with me some fascinating designs for a 5-band Yagi. He wished to make the designs more widely available as food for thought by others and asked me if I would place them at my site. Although I normally only place my own work at my site, since there are perhaps better outlets for the original work of others, these designs are worth examining on at least two counts. First, the idea that a 5-band Yagi within a finite boom is not possible is laid to rest. Second, the work is a fine example of the forward stagger principle, noted in some other places at the site.

Here is the brief account Johan shared about how he came to these designs:

"Having a 15 meter boom with a 4" diameter available made me think about the possibility of putting some elements to arrive at a beam that covered the 5 highest HF bands, 10 to 20 meters. The design goal was to achieve a gain for each band comparable to the gain of a 3-element monoband Yagi.

"As I started, I took several designs for monoband beams for 10, 15, and 20 meters and placed them on the boom. Then I added WARC band mono-banders, and the result was very productive.

"The average gain for 3-element mono-banders was 7.0 to 7.3 dBi (free space gain). After placing everything on the boom, the gain increased to over 8 dBi, an average increase of 1 dB per band. The designs looked to perform more like 4-element mono-banders on all bands.

"The designs consist of 3 elements on 20, 3 elements on 17, 2 elements on 15, 2 elements on 12, and 4 elements on 10 meters. The result is an average gain of over 8.0 dBi free space, with excellent front-to-back ratio and good operating bandwidth for 14.0-14.28, 21.0-21.35, 28.0-28.6, and full WARC band coverage."

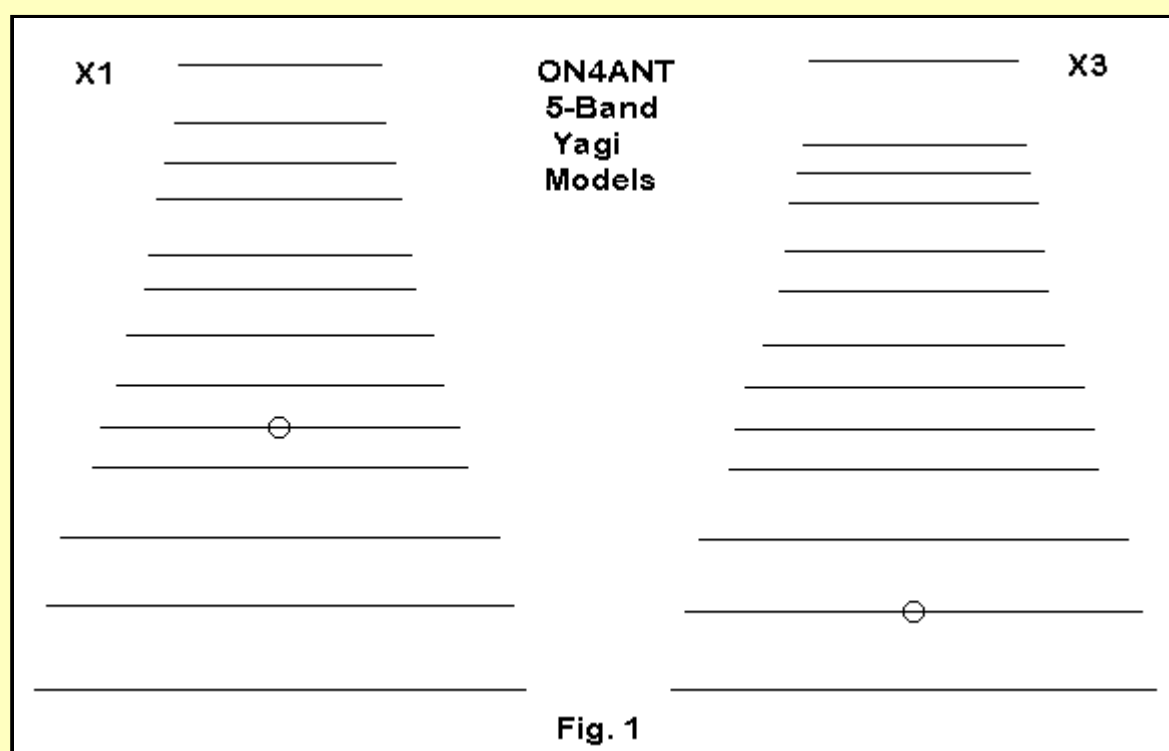


Figure 1 shows the outlines for the two designs. The first is focused on band coverage, while the second focuses on peak gain. At the end of this note are the modeling descriptions of the antennas, given both as AO models and as EZNEC model descriptions. The results of Johan's work have been cross checked on NEC-4, and, as one might expect for these untapered initial designs, the results are in close agreement.

Here are tables of performance figures from NEC-4 for each model, taking the band edges and the band center as markers. For the non-WARC bands, the limits are wider than John set as design goals, but the designs hold up well on almost all bands to the very limits of the wider bands.

14-28 X1

Frequency	Gain dBi	F-B dB	Z (R+/-jX)
14.0	8.07	28.38	32.7 - j 2.5
14.175	8.16	30.48	28.9 + j 5.4
AO	(8.14)	(29.27)	(29.2 + j 5.1)
14.35	8.30	24.17	22.8 + j16.1
18.068	8.08	21.70	19.8 + j 3.5
18.118	8.09	22.08	21.1 + j 5.7
AO	(8.11)	(23.75)	(23.7 - j 0.5)
18.168	8.11	22.52	22.8 + j 8.2
21.0	8.22	22.04	20.0 - j 0.8
21.225	8.29	21.78	32.0 + j 7.9
AO	(8.21)	(20.96)	(34.8 + j 5.7)
21.45	8.39	21.60	34.5 + j16.2
24.89	8.59	25.08	12.9 + j 6.8
24.94	8.62	24.50	13.2 + j 8.7

AO	(8.64)	(25.82)	(10.8 + j 4.0)
24.99	8.65	23.96	13.4 + j10.6
28.0	7.90	34.52	22.3 + j 0.6
28.5	8.15	24.59	23.0 + j16.2
AO	(8.22)	(22.56)	(26.9 + j13.8)
29.0	8.42	19.98	23.4 + j33.2

Reference AO values for center band are included to show the agreement. Only the lowest end of 10 meters shows a gain lower than 8.0 dBi, and only the upper end of 10 meters shows a 180-degree front-to-back ratio under 20 dB (just barely). The lower source impedance of the 12-meter run is inevitable, given the nearness in length of the 10- and 12-meter elements, making almost all of the 10-meter elements added directors that increase 12-meter gain. On 10, the 12-meter elements function as added reflectors and have little influence on the 10-meter performance.

14-28 X3

Frequency	Gain dBi	F-B dB	Z (R+/-jX)
14.0	8.11	24.43	31.4 - j 5.3
14.175	8.18	23.45	31.5 + j 2.8
14.35	8.30	22.09	29.1 + j11.6
18.068	8.16	22.21	24.6 - j 1.3
18.118	8.18	22.80	25.3 - j 0.7
18.168	8.20	23.55	25.7 + j 0.1
21.0	8.39	19.78	26.2 - j 4.4
21.225	8.50	19.41	27.9 + j 5.2
21.45	8.61	19.10	29.5 + j14.8
24.89	8.65	25.90	13.2 + j 2.5
24.94	8.67	25.16	13.2 + j 4.3
24.99	8.70	24.50	13.1 + j 6.2
28.0	8.42	23.08	31.1 - j 1.0
28.5	8.57	21.57	20.0 + j 2.3
29.0	7.90	26.62	3.9 + j25.9

The X3 design achieves some added low band-end gain on some of the bands, especially 15-10 meters. However, there is some small sacrifice of front-to-back ratio on 15 and a narrower operating bandwidth on 10 meters. For some operating situations, these gain and sacrifices may be in order; for other operating situations, the broader X1 design may be favored.

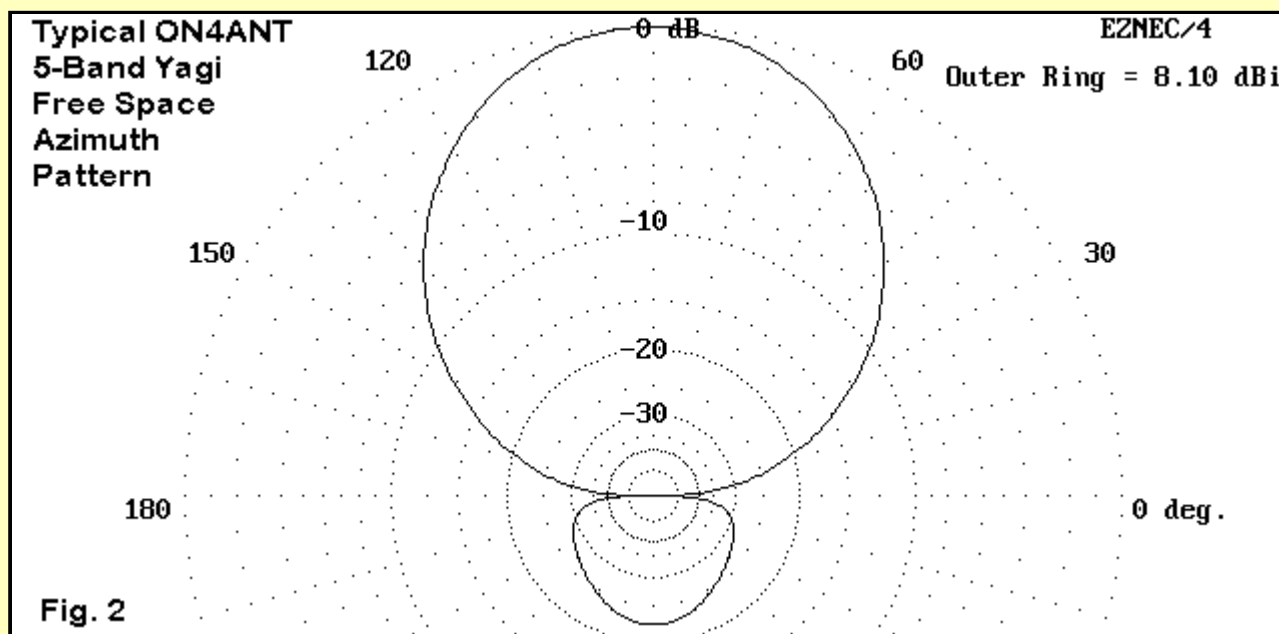


Figure 2 shows a typical pattern, with its very small rearward "ball" of gain. This pattern holds for almost all bands on both designs and is more typical of 4-element designs than of 3-element Yagis. Those who wish to model either or both of these antennas will benefit from examining the current tables to discover which elements are active to a significant degree as each band is fed.

The designs call for separate feeds, with the feed elements indicated in the AO models. All dimensions are in meters. US readers who model the antenna in EZNEC can convert the dimensions to feet or inches within the program. Incidentally, the 15-meter boom translates to about 49.2' long. The boom is similar to the boom length of a long 20-meter mono-bander, whose free space gain would be about 10.0 to 10.2 dBi for a well-designed 5-element version. See the note on the comparative performance of six 5/6-element 20 meter mono-banders in another note in this series for further details. However, in the same space, Johan has packed 5 bands of 3+ element performance.

These designs are worth study and further experimentation.

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AO model

14-28X1.ANT

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114-18-21-24-28 yagi
;Over real ground
Free space
;14.150 MHz
;18.118 MHz
;21.200 MHz

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;24.940 MHz
;28.300 MHz
14.175 MHz
13 wires, meters
r = 5.45 ;reflector20
s = 5.2 ;driver20
t = 4.9 ;dir 20
a = 4.15 ;reflector 17 + director2 20
b = 4.02 ;driver 17
d = 3.8 ;dir 17 + refl 15
e = 3.395 ;driver 15
f = 3.02 ;dir 15 + refl 12
g = 2.91 ;driver 12
h = 2.78 ;dir 12 + refl 12
i = 2.55 ;driver 10
j = 2.355 ;dir1 10
k = 2.265 ;dir2 10
;
pr = 0 ;refl 20
ps = 2 ;driver 20
pt = 3.6 ;dir 20
pa = 5.25 ;refl 17 -dir 20
pb = 6.2 ;driver 17
pd = 7.2 ;dir 17 - refl 15
pe = 8.4 ;driver 15
pf = 9.5 ;dir 15 - refl 12
pg = 10.3 ;driver 12
ph = 11.6 ;dir 12 - refl 10
pi = 12.45 ;driver 10
pj = 13.4 ;dir 10
pk = 15 ;dir2 10
dia = .02 ;tubing diameter --> must be tapered
shift z 24
;
1 pr -r 0 pr r 0 dia ;14 refl
1 ps -s 0 ps s 0 dia ;14 driven
1 pt -t 0 pt t 0 dia ;14 dir1
1 pa -a 0 pa a 0 dia ;18 refl - 14 dir2
1 pb -b 0 pb b 0 dia ;18 driven
1 pd -d 0 pd d 0 dia ;18 dir2 - 21 refl
1 pe -e 0 pe e 0 dia ;21 driven
1 pf -f 0 pf f 0 dia ;21 dir1 - 24 refl
1 pg -g 0 pg g 0 dia ;24 driven
1 ph -h 0 ph h 0 dia ;24 dir1 - 28 refl
1 pi -i 0 pi i 0 dia ;28 driven
1 pj -j 0 pj j 0 dia ;28 dir1
1 pk -k 0 pk k 0 dia ;28 dir2
1 source
Wire 2, center ; driver 20
;Wire 5, center ; driver 18
;Wire 7, center ; driver 15
;Wire 9, center ; driver 12
;Wire 11, center ; driver 10

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EZNEC model description

EZNEC/4 ver. 2.5

ON4ANT 5-b Yagi: 14-28xl 08-28-1998 20:11:19

Frequency = 14.175 MHz.

Wire Loss: Aluminum -- Resistivity = 4E-08 ohm-m, Rel. Perm. = 1

----- WIRES -----

Wire Conn. --- End 1 (x,y,z : m) Conn. --- End 2 (x,y,z : m) Dia(mm) Segs

1	-5.450, 0.000, 0.000	5.450, 0.000, 0.000	2.00E+01	37
2	-5.200, 2.000, 0.000	5.200, 2.000, 0.000	2.00E+01	35
3	-4.900, 3.600, 0.000	4.900, 3.600, 0.000	2.00E+01	34
4	-4.150, 5.250, 0.000	4.150, 5.250, 0.000	2.00E+01	28
5	-4.000, 6.200, 0.000	4.000, 6.200, 0.000	2.00E+01	27
6	-3.640, 7.200, 0.000	3.640, 7.200, 0.000	2.00E+01	25
7	-3.395, 8.400, 0.000	3.395, 8.400, 0.000	2.00E+01	23
8	-3.020, 9.500, 0.000	3.020, 9.500, 0.000	2.00E+01	21
9	-2.910, 10.300, 0.000	2.910, 10.300, 0.000	2.00E+01	21
10	-2.720, 11.600, 0.000	2.720, 11.600, 0.000	2.00E+01	19
11	-2.560, 12.450, 0.000	2.560, 12.450, 0.000	2.00E+01	19
12	-2.355, 13.400, 0.000	2.355, 13.400, 0.000	2.00E+01	17

13 -2.265, 14.800, 0.000 2.265, 14.800, 0.000 2.00E+01 16

----- SOURCES -----

Source Wire Wire #/Pct From End 1 Ampl.(V, A) Phase(Deg.) Type
Seg. Actual (Specified)

1 18 2 / 50.00 (2 / 50.00) 1.000 0.000 V

No loads specified

No transmission lines specified

Ground type is Free Space

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AO Model

14-28X3.ANT

14-18-21-24-28 yagi

;Over real ground

Free space

;14.150 MHz

;18.118 MHz

;21.200 MHz

;24.940 MHz

28.300 MHz

13 wires, meters

;r = 5.450 ;reflector20

;s = 5.152 ;driver20

;t = 4.892 ;dir 20

;a = 4.148 ;reflector 17 + director2 20

;b = 4.021 ;driver 17

;d = 3.802 ;dir 17 + refl 15

e = 3.375 ;driver 15

f = 3.019 ;dir 15 + refl 12

g = 2.905 ;driver 12

h = 2.781 ;dir 12 + refl 10

i = 2.6 ;driver 10

j = 2.498 ;dir1 10

k = 2.35 ;dir2 10

;

;pr = 0 ;refl 20

ps = 1.874 ;driver 20

pt = 3.6 ;dir 20

pa = 5.25 ;refl 17 -dir 20

pb = 6.194 ;driver 17

pd = 7.2 ;dir 17 - refl 15

pe = 8.21 ;driver 15

pf = 9.5 ;dir 15 - refl 12

pg = 10.487 ;driver 12

ph = 11.6 ;dir 12 - refl 10

pi = 12.34 ;driver 10

pj = 13.02 ;dir 10

pk = 15 ;dir2 10

dia = .02 ;tubing diameter --> must be tapered

;

1 0 -5.450 0 0 5.450 0 dia ;14 refl

1 ps -5.142 0 ps 5.142 0 dia ;14 driven

1 pt -4.820 0 pt 4.820 0 dia ;14 dir1

1 pa -4.148 0 pa 4.148 0 dia ;18 refl - 14 dir2

1 pb -4.021 0 pb 4.021 0 dia ;18 driven

1 pd -3.802 0 pd 3.802 0 dia ;18 dir2 - 21 refl

1 pe -e 0 pe e 0 dia ;21 driven

1 pf -f 0 pf f 0 dia ;21 dir1 - 24 refl

1 pg -g 0 pg g 0 dia ;24 driven

1 ph -h 0 ph h 0 dia ;24 dir1 - 28 refl

1 pi -i 0 pi i 0 dia ;28 driven

1 pj -j 0 pj j 0 dia ;28 dir1

1 pk -k 0 pk k 0 dia ;28 dir2

1 source

;Wire 2, center ; driver 20

;Wire 5, center ; driver 18

;Wire 7, center ; driver 15

;Wire 9, center ; driver 12

Wire 11, center ; driver 10

=====

EZNEC/4 ver. 2.5

Frequency = 14.175 MHz.

Wire Loss: Aluminum -- Resistivity = 4E-08 ohm-m, Rel. Perm. = 1

----- WIRES -----

Wire Conn. --- End 1 (x,y,z : m) Conn. --- End 2 (x,y,z : m) Dia(mm) Segs

1	-5.450, 0.000, 0.000	5.450, 0.000, 0.000	2.00E+01	37
2	-5.142, 1.874, 0.000	5.142, 1.874, 0.000	2.00E+01	35
3	-4.820, 3.600, 0.000	4.820, 3.600, 0.000	2.00E+01	34
4	-4.148, 5.250, 0.000	4.148, 5.250, 0.000	2.00E+01	28
5	-4.021, 6.194, 0.000	4.021, 6.194, 0.000	2.00E+01	27
6	-3.802, 7.200, 0.000	3.802, 7.200, 0.000	2.00E+01	25
7	-3.375, 8.210, 0.000	3.375, 8.210, 0.000	2.00E+01	23
8	-3.019, 9.500, 0.000	3.019, 9.500, 0.000	2.00E+01	21
9	-2.905, 10.487, 0.000	2.905, 10.487, 0.000	2.00E+01	21
10	-2.781, 11.600, 0.000	2.781, 11.600, 0.000	2.00E+01	19
11	-2.600, 12.340, 0.000	2.600, 12.340, 0.000	2.00E+01	19
12	-2.498, 13.020, 0.000	2.498, 13.020, 0.000	2.00E+01	17
13	-2.350, 15.000, 0.000	2.350, 15.000, 0.000	2.00E+01	16

----- SOURCES -----

Source	Wire Seg.	Wire #/Pct From End 1 Actual (Specified)	Ampl.(V, A)	Phase(Deg.)	Type
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1	18	2 / 50.00 (2 / 50.00)	1.000	0.000	V
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No loads specified

No transmission lines specified

Ground type is Free Space



Part 2: 60' Boom Model, April, 1999

Johan has sent me his latest design--a 14-element forward stagger 5-band Yagi design. By giving himself an extra 10' of boom (now up to 60' long), he has improved performance throughout, but especially on the upper bands. Johan intends to use a gamma match for each driven element.

The following table gives the NEC-4 readouts of potential performance for the design frequency in each band, with data in () for the band edges. The numbers confirm the modeling results Johan derived from AO.

Freq. MHz	Gain dBi	F-B dB	Feed Impedance R +/- jX Ohms
20			
(14.0	8.16	30.80	32.4 - j 2.4)
14.15	8.26	30.20	28.7 + j 5.7
(14.35	8.40	23.03	22.8 + j16.4)
17			
18.118	8.26	21.29	30.5 + j 6.9
15			
(21.0	8.70	23.13	29.5 + j 2.5)
21.2	8.79	23.33	32.4 + j10.5
(21.45	8.92	23.45	35.4 + j20.1)
12			
24.89	9.57	36.73	24.4 + j 9.3
10			
(27.6	9.58	21.86	20.4 - j17.1)
28.0	9.79	26.48	22.0 - j 7.1)
28.35	9.88	38.14	23.3 + j 3.2
(28.8	9.50	31.15	24.8 + j 1.0)
28.9	9.29	31.34	15.8 + j 1.1)
(29.0	8.90	31.07	7.8 + j 7.4)

Band edge data for 10 meters includes extra checks, which show that the operating cut-off is about 28.85 MHz, although some "surplus" performance and matchable feedpoint impedance exist below the lower end of 10-meters.

The AO and EZNEC descriptions are appended for those wishing to model this extraordinary design. The two models correspond wire for wire, so that the driven element locations for each band listed in the AO model also apply to the EZNEC model.

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AO Model

14->28 yagi

;gain & F/B is 8.2/30 8.2/21 8.7/23 9.4/31 9.85/27

Free space

14.150 MHz

;18.118 MHz

;21.200 MHz

;24.940 MHz

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;28.350 MHz
14 wires, meters
r = 5.45 ;refl 20
s = 5.2 ;driver20
t = 4.9 ;dir 20
a = 4.15 ;refl 17
b = 4 ;driver17
d = 3.64 ;refl 15
e = 3.4 ;driver15
f = 3.02 ;refl 12
g = 2.9 ;driver12
h = 2.68 ;refl 10
i = 2.55 ;driver10
j = 2.47 ;dir1 10
k = 2.44 ;dir2 10
l = 2.31 ;dir3 10
;
pr = 0 ;refl 20
ps = 2 ;driver20
pt = 3.6 ;dir 20
pa = 5.25 ;refl 17 - dir 20
pb = 6.4 ;driver17
pd = 7.2 ;dir 17 - refl 15
pe = 8.4 ;driver15
pf = 9.5 ;dir 15 - refl 12
pg = 10.8 ;driver12
ph = 12 ;dir 12 - refl 10
pi = 12.914 ;driver10
pj = 13.829 ;dir 10
pk = 15.556 ;dir2 10
pl = 17.944 ;dir3 10
dia = .02
1 pr -r 0 pr r 0 dia ;14 refl
1 ps -s 0 ps s 0 dia ;14 driven
1 pt -t 0 pt t 0 dia ;14 dir
1 pa -a 0 pa a 0 dia ;18 refl
1 pb -b 0 pb b 0 dia ;18 driven
1 pd -d 0 pd d 0 dia ;18 dir2 - 21 refl
1 pe -e 0 pe e 0 dia ;21 driven
1 pf -f 0 pf f 0 dia ;21 dir1 - 24 refl
1 pg -g 0 pg g 0 dia ;24 driven
1 ph -h 0 ph h 0 dia ;24 dir1 - 28 refl
1 pi -i 0 pi i 0 dia ;28 driven
1 pj -j 0 pj j 0 dia ;28 dir
1 pk -k 0 pk k 0 dia ;28 dir 2
1 pl -l 0 pl l 0 dia ;28 dir 3
1 source
Wire 2, center ; driver 20
;Wire 5, center ; driver 17
;Wire 7, center ; driver 15
;Wire 9, center ; driver 12
;Wire 11,center ; driver 10

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EZNEC/4 ver. 2.5

ON4ANT 5-b Yagi: 14-28X2 04-18-1999 17:55:29

Frequency = 14.175 MHz.

Wire Loss: Aluminum -- Resistivity = 4E-08 ohm-m, Rel. Perm. = 1

----- WIRES -----

Wire Conn. --- End 1 (x,y,z : m) Conn. --- End 2 (x,y,z : m) Dia(mm) Segs

1	-5.450, 0.000, 0.000	5.450, 0.000, 0.000	2.00E+01	37
2	-5.200, 2.000, 0.000	5.200, 2.000, 0.000	2.00E+01	35
3	-4.900, 3.600, 0.000	4.900, 3.600, 0.000	2.00E+01	34
4	-4.150, 5.250, 0.000	4.150, 5.250, 0.000	2.00E+01	28
5	-4.000, 6.400, 0.000	4.000, 6.400, 0.000	2.00E+01	27
6	-3.640, 7.200, 0.000	3.640, 7.200, 0.000	2.00E+01	25
7	-3.400, 8.400, 0.000	3.400, 8.400, 0.000	2.00E+01	23
8	-3.020, 9.500, 0.000	3.020, 9.500, 0.000	2.00E+01	21
9	-2.900, 10.800, 0.000	2.900, 10.800, 0.000	2.00E+01	21
10	-2.680, 12.000, 0.000	2.680, 12.000, 0.000	2.00E+01	19
11	-2.550, 12.914, 0.000	2.550, 12.914, 0.000	2.00E+01	19
12	-2.470, 13.829, 0.000	2.470, 13.829, 0.000	2.00E+01	17
13	-2.440, 15.556, 0.000	2.440, 15.556, 0.000	2.00E+01	16
14	-2.310, 17.994, 0.000	2.310, 17.994, 0.000	2.00E+01	16

----- SOURCES -----

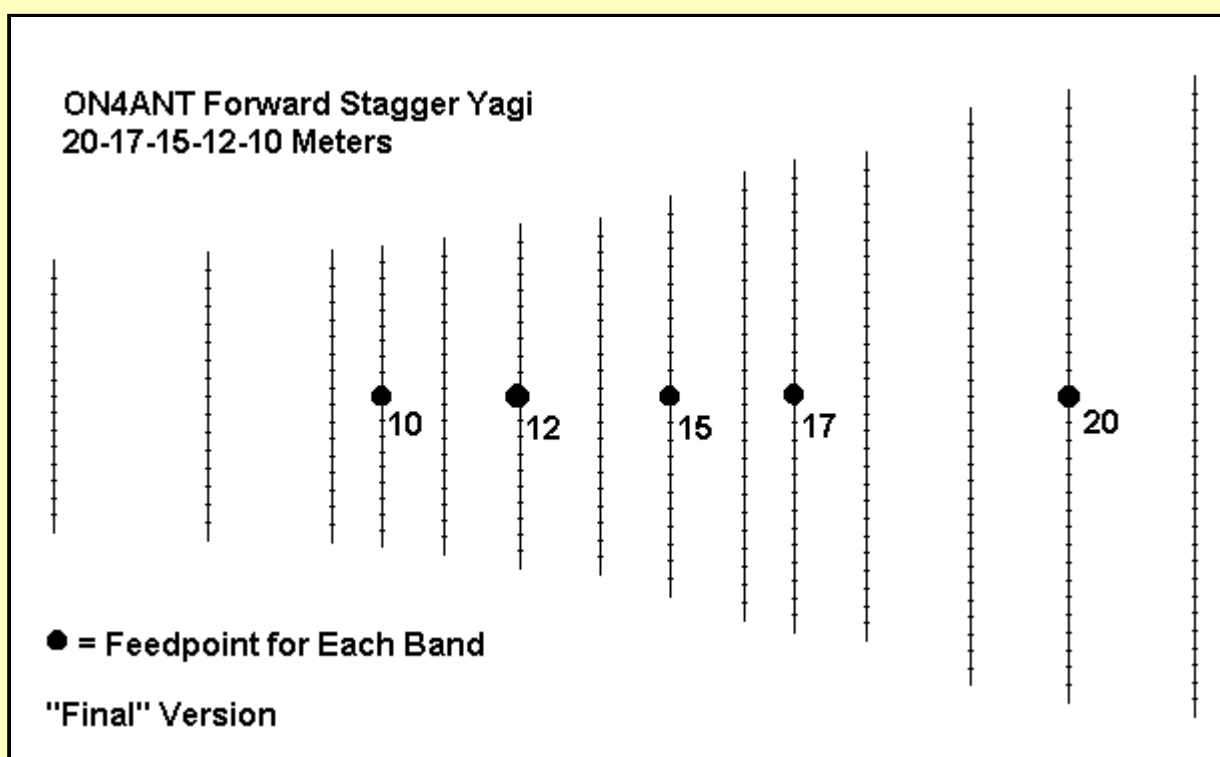
Source	Wire Seg.	Wire #/Pct Actual	Wire #/Pct From End 1 (Specified)	Ampl.(V, A)	Phase(Deg.)	Type
1	18	2 / 50.00	(2 / 50.00)	1.000	0.000	I

No loads specified
 No transmission lines specified
 Ground type is Free Space

Part 3: 18.25 m Boom Model, July, 1999



Johan has sent me the "final" or constructed version of his 5-band forward stagger Yagi. He has made a few changes in structure to improve 10-meter performance, especially at the lower end of the band. The result was a 0.25-m lengthening of the boom, plus some spacing changes and some minor element length changes. The model he sent me now uses non-tapered elements, but of different diameters that increase as the frequency decreases. This technique allowed him to better approximate the behavior of the beam when the tapered-diameter element schedule was added before construction. The photograph attests to both the size and the construction quality of the antenna.



The sketch, taken from an EZNEC antenna view, better shows the final proportions and the location of the feedpoints. The following table shows the modeled performance of the antenna as forecast by NEC-4.

Freq. MHz	Gain dBi	F-B dB	Feed Impedance R +/- jX Ohms
20			
14.0	8.30	36.74	28.8 - j 0.4
14.175	8.41	27.35	24.7 + j 7.9
14.35	8.55	20.57	19.0 + j18.8
17			
18.118	8.35	23.06	31.7 - j 4.9
15			
21.0	8.73	23.12	34.1 + j 2.0
21.225	8.86	23.15	35.9 + j10.3
21.45	8.99	23.04	37.4 + j18.6
12			
24.94	9.70	37.50	23.4 + j14.6
10			
28.0	9.92	26.58	30.0 - j 8.8

28.35 9.99 39.15 33.5 - j 4.7
28.7 9.69 34.30 20.3 - j12.2

Gain figures are up a bit, with the F-B ratio maintained and good coverage across all of four bands and the portion of the 10-meter band of interest to Johan. He reports that gamma matches for each band were easily set up for most bands, with only a couple that he would like to tweak up a bit. His initial tests against a neighbor's large commercial multi-band Yagi at the same height and over similar terrain give the forward-stagger design a considerable advantage--something over an S-unit on his rig. For reference, I am adding Johan's AO file and the EZNEC model description I used to obtain the projected free space operating parameters. Johan's design work will appear in an issue of the Belgian national amateur radio society journal. It will include extensive construction details.

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AO File:

14->28 yagi
; gain calculated is 8.3/34 8.3/21 8.7/23 9.6/38.4 10.0/29.0 in free space

Free space

14.150 MHz
;18.118 MHz
;21.200 MHz
;24.940 MHz
;28.350 MHz

14 wires, meters

r = 5.45 ;refl 20
s = 5.2 ;driver20
t = 4.9 ;dir 20
a = 4.15 ;refl 17
b = 4.02 ;driver17
d = 3.8 ;refl 15
e = 3.395 ;driver15
f = 3.02 ;refl 12
g = 2.91 ;driver12
h = 2.68 ;refl 10
i = 2.55 ;driver10
j = 2.47 ;dir1 10
k = 2.44 ;dir2 10
l = 2.31 ;dir3 10

;
pr = 0 ;refl 20 32mm
ps = 2.0 ;driver20 32mm
pt = 3.6 ;dir 20 32mm
pa = 5.25 ;refl 17 -dir 20 32mm
pb = 6.4 ;driver17 25mm
pd = 7.2 ;dir 17 - refl 15 25mm
pe = 8.4 ;driver15 25mm
pf = 9.5 ;dir 15 - refl 12 25mm
pg = 10.8 ;driver12 25mm
ph = 12.0 ;dir 12 - refl 10 23mm
pi = 13.014 ;driver10 23mm
pj = 13.816 ;dir 10 23mm
pk = 15.775 ;dir2 10 23mm
pl = 18.25 ;dir3 10 23mm

dia = .023
diam = .032
dian = .025

;I use different element diameters for the different bands
;it makes things easier afterwards, when you want to taper
shift Z 24

1 pr -r 0 pr r 0 diam ;14 refl
1 ps -s 0 ps s 0 diam ;14 driven
1 pt -t 0 pt t 0 diam ;14 dir1
1 pa -a 0 pa a 0 diam ;14 dir2 - 18 refl
1 pb -b 0 pb b 0 diam ;18 driven
1 pd -d 0 pd d 0 diam ;18 dir2 - 21 refl
1 pe -e 0 pe e 0 diam ;21 driven
1 pf -f 0 pf f 0 diam ;21 dir1 - 24 refl
1 pg -g 0 pg g 0 diam ;24 driven
1 ph -h 0 ph h 0 dia ;24 dir1 - 28 refl
1 pi -i 0 pi i 0 dia ;28 driven
1 pj -j 0 pj j 0 dia ;28 dir1
1 pk -k 0 pk k 0 dia ;28 dir2
1 pl -l 0 pl l 0 dia ;28 dir3

1 source
Wire 2, center ; driver 20
;Wire 5, center ; driver 18
;Wire 7, center ; driver 15
;Wire 9, center ; driver 12
;Wire 11,center ; driver 10
;

;Important note: Those wishing to increase gain on 20m can easily do this without
;too much sacrifice, making the 18Mhz reflector longer will increase the gain with 0.5 db
;Given the fact I use a gamma match and wanted to avoid nasty surprises like freq shift
;when putting the antenna on top of a 80ft tower, I preferred the wide bandwidth.

=====

Frequency = 14.175 MHz.

Wire Loss: Aluminum -- Resistivity = 4E-08 ohm-m, Rel. Perm. = 1

----- WIRES -----

Wire Conn. --- End 1 (x,y,z : m) Conn. --- End 2 (x,y,z : m) Dia(mm) Segs

1	-5.450, 0.000, 0.000	5.450, 0.000, 0.000	3.20E+01	37
2	-5.200, 2.000, 0.000	5.200, 2.000, 0.000	3.20E+01	35
3	-4.900, 3.600, 0.000	4.900, 3.600, 0.000	3.20E+01	34
4	-4.150, 5.250, 0.000	4.150, 5.250, 0.000	2.50E+01	28
5	-4.020, 6.400, 0.000	4.020, 6.400, 0.000	2.50E+01	27
6	-3.800, 7.200, 0.000	3.800, 7.200, 0.000	2.50E+01	25
7	-3.395, 8.400, 0.000	3.395, 8.400, 0.000	2.50E+01	23
8	-3.020, 9.500, 0.000	3.020, 9.500, 0.000	2.50E+01	21
9	-2.910, 10.800, 0.000	2.910, 10.800, 0.000	2.50E+01	21
10	-2.680, 12.000, 0.000	2.680, 12.000, 0.000	2.30E+01	19
11	-2.550, 13.014, 0.000	2.550, 13.014, 0.000	2.30E+01	19
12	-2.470, 13.816, 0.000	2.470, 13.816, 0.000	2.30E+01	17
13	-2.440, 15.775, 0.000	2.440, 15.775, 0.000	2.30E+01	16
14	-2.310, 18.250, 0.000	2.310, 18.250, 0.000	2.30E+01	16

----- SOURCES -----

Source	Wire Seg.	Wire Actual	Wire #/Pct From End 1 (Specified)	Ampl.(V, A)	Phase(Deg.)	Type
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1	18	2 / 50.00	(2 / 50.00)	1.000	0.000	I
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No loads specified
 No transmission lines specified
 Ground type is Free Space



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