Modeling an 80/40/20M Fan Dipole for DX

New Station – New Antennas!
- Installation and SWR Response
- Where is the DX?
- How do these Dipoles "Play?" (EZNEC)

What about Terrain?
- HFTA and Terrain
- The effect on these Dipoles

Potential Improvements
- Higher Dipoles?
- Different Types of Antennas?

Appendix
Effect of Sea Water
Other HF Bands

Larry Banks, W1DYJ

First licensed: 1962 as KN1VFX (Novice)

W1DYJ since 1966 – Amateur Extra

10 Matthews Way Harpswell ME

33 Blueberry Hill Road Woburn MA

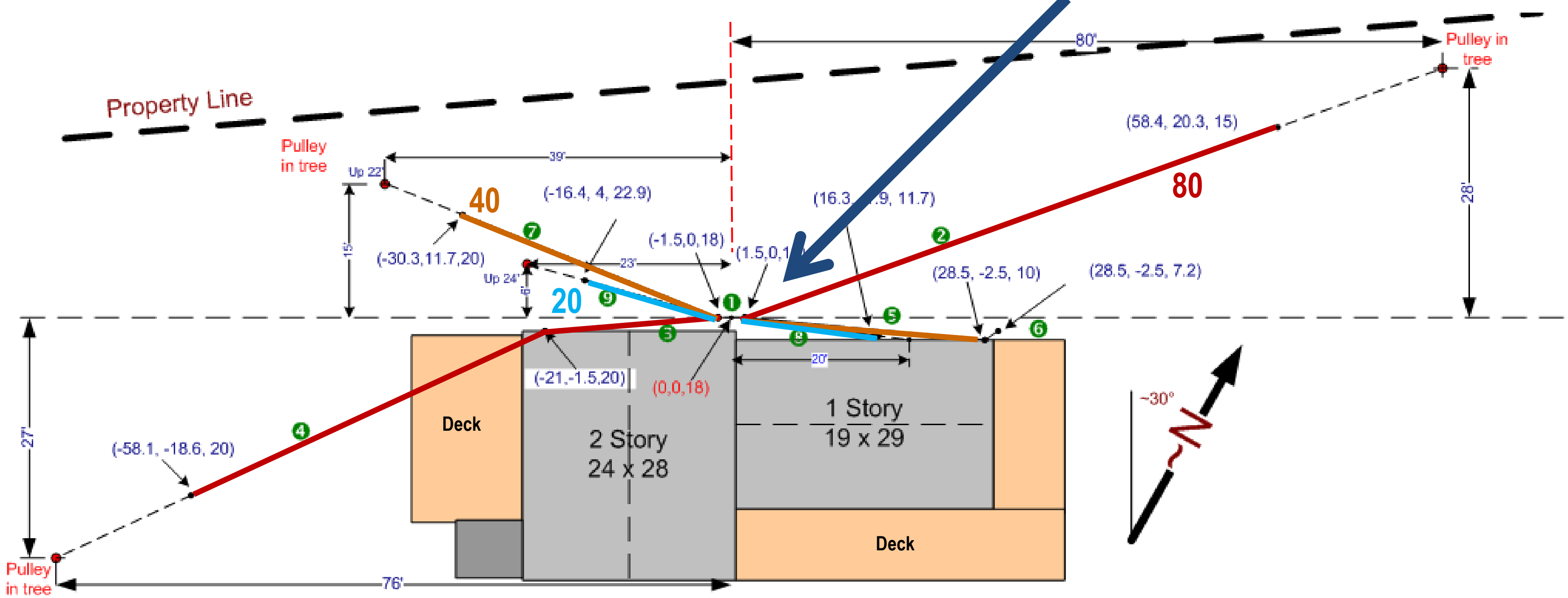
New Station ~ New Antennas!

- Bought a 2nd home in Harpswell, ME, in 2008
- Need HF antennas on 80/40/20 to understand local conditions
- No tall trees -- did not want a tower
- Low band verticals make sense – but radials are a lot of work
  - → Simple Dipoles for now: 80, 40, 20 in a "Fan"
    - Use a corner of the house as the center point
      - (Yes – too low!)
    - Build Them – Understand Them – Improve Them
- Add 160, 60, 30, 17, 12, 10, 6 in the future

Modeling an 80/40/20M Fan Dipole for DX

Simple Dipoles for now: 80, 40, 20 Fan

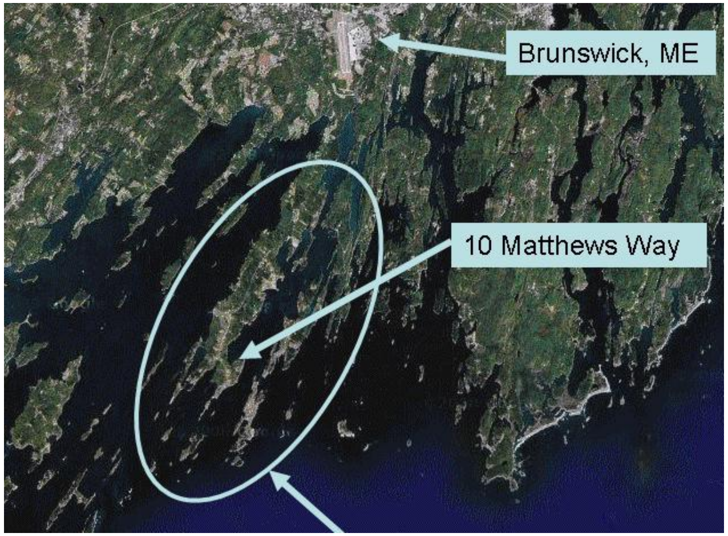
Use a corner of the house as the center point

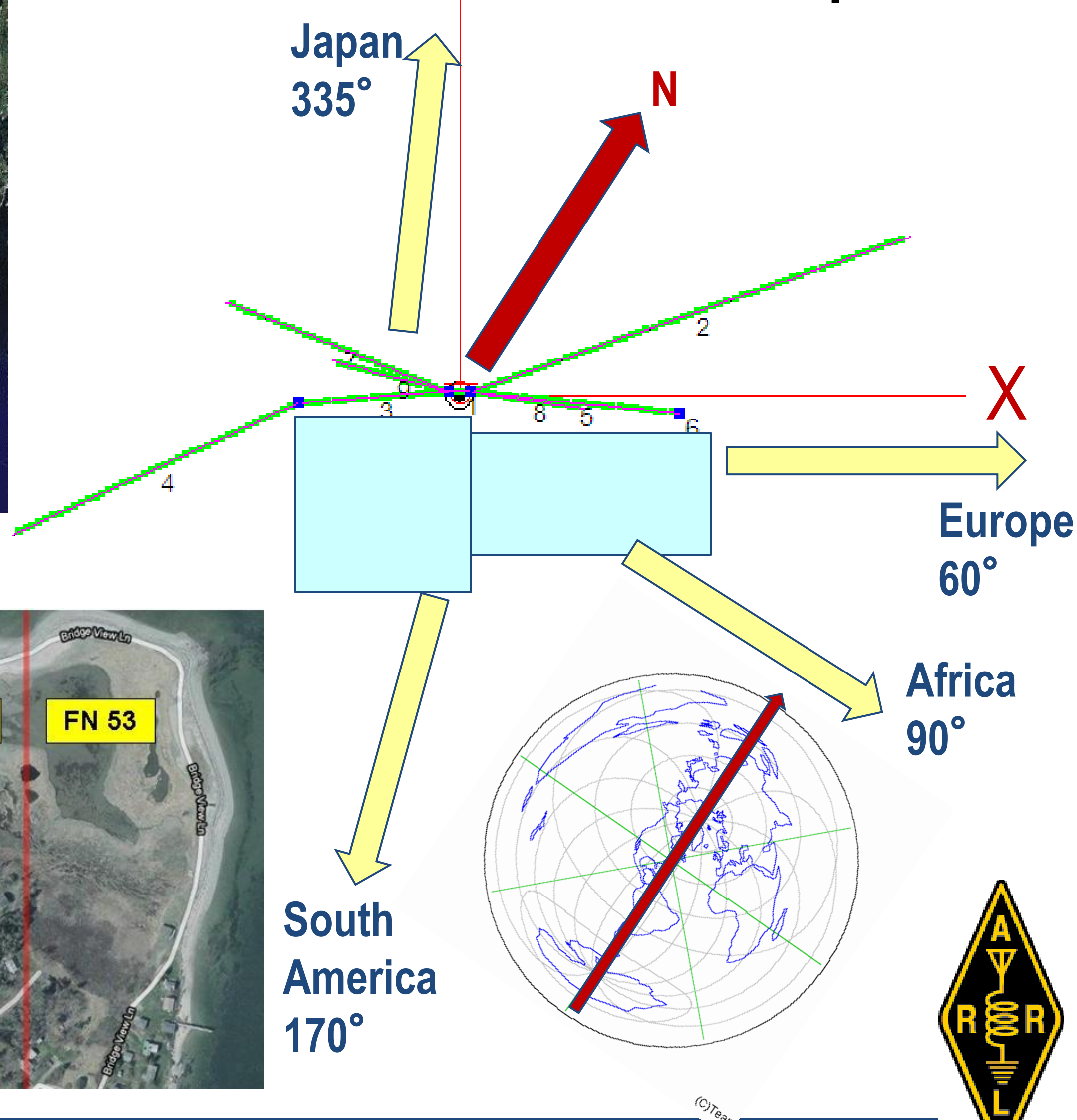


(The numbers on the wires are for use with EZNEC.)

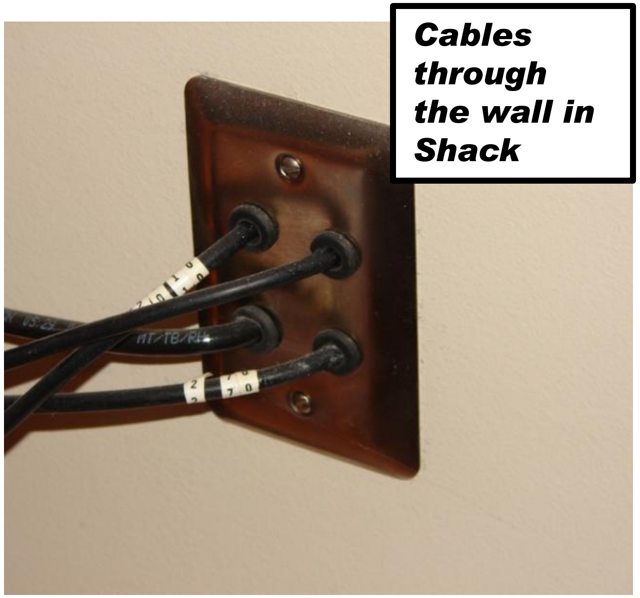
Antenna Orientation

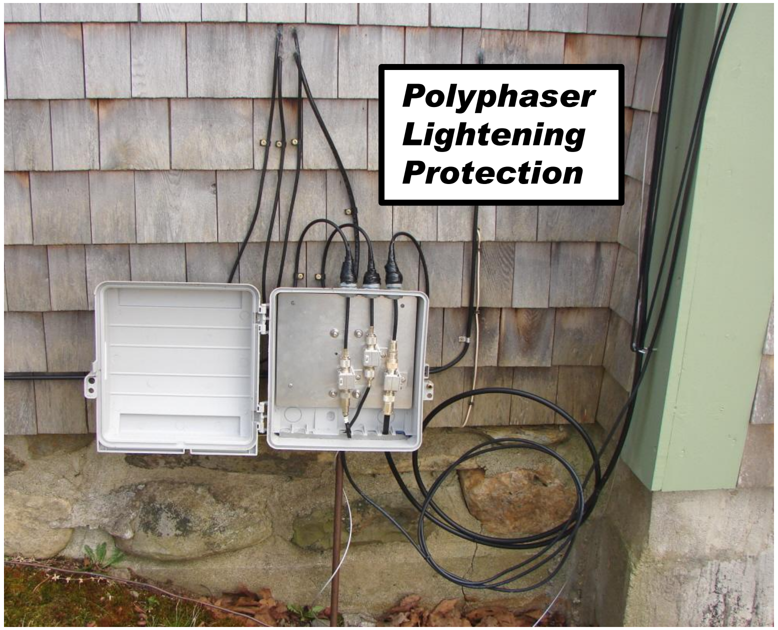
Modeling an 80/40/20M Fan Dipole for DX

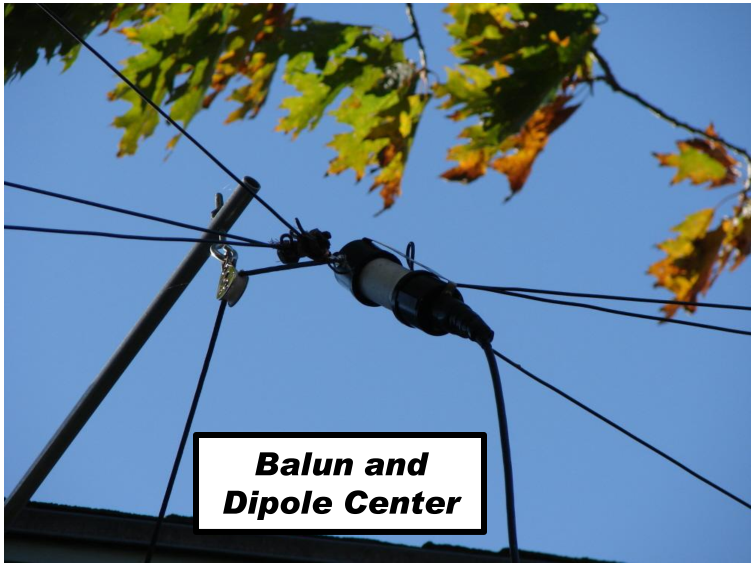


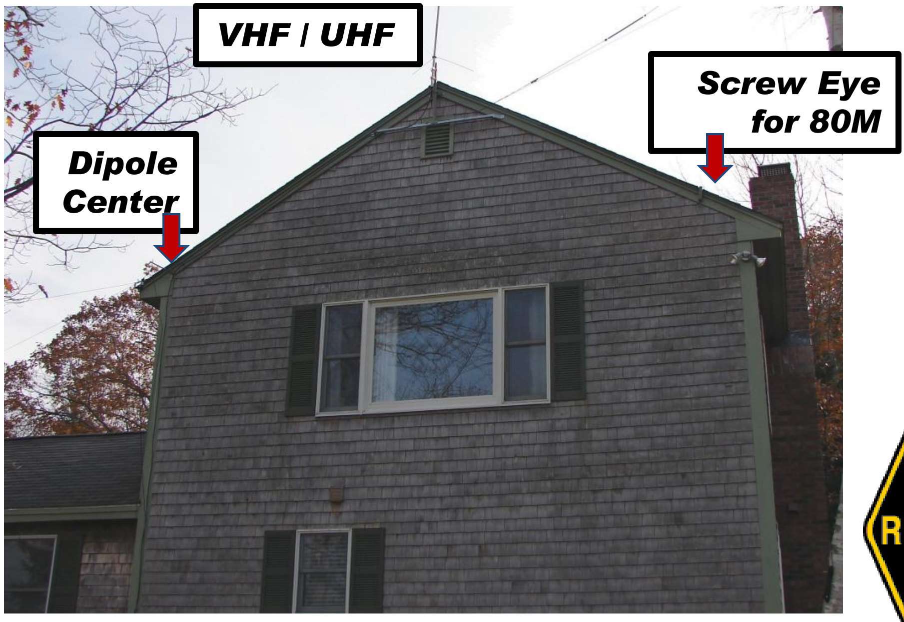


Actual Installation

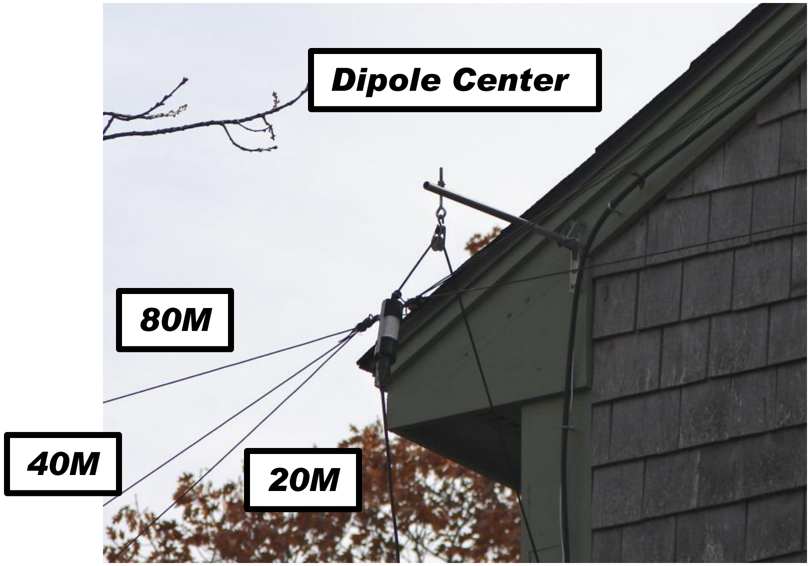


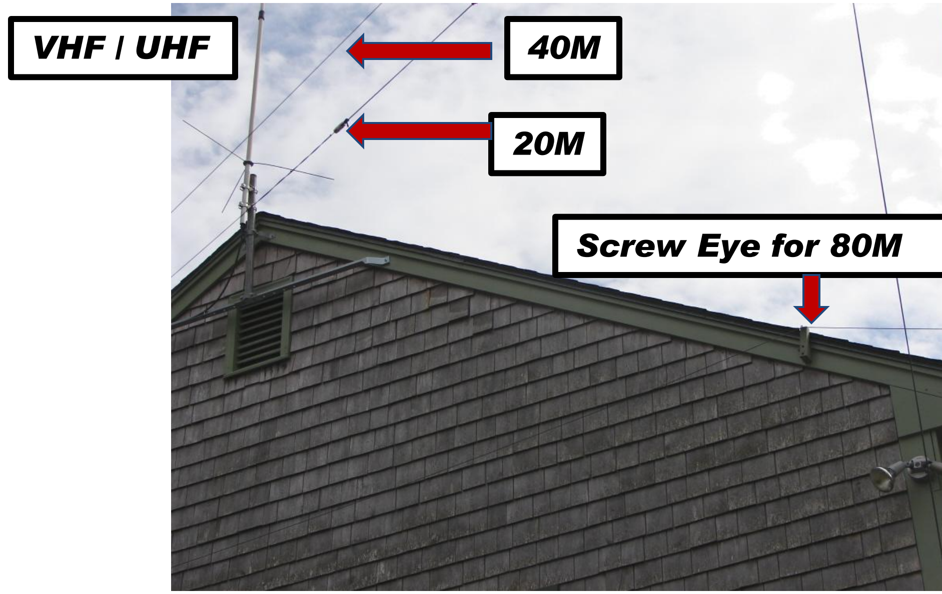


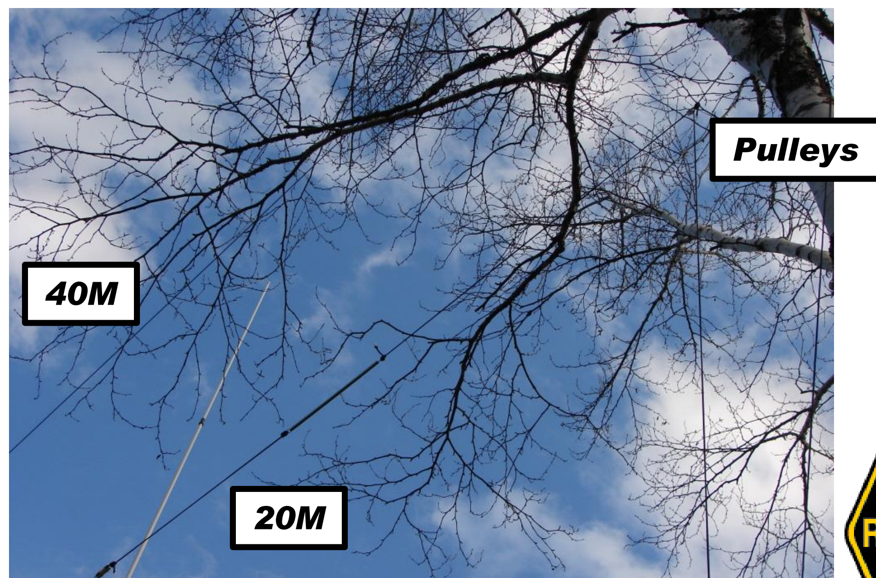




Actual installation

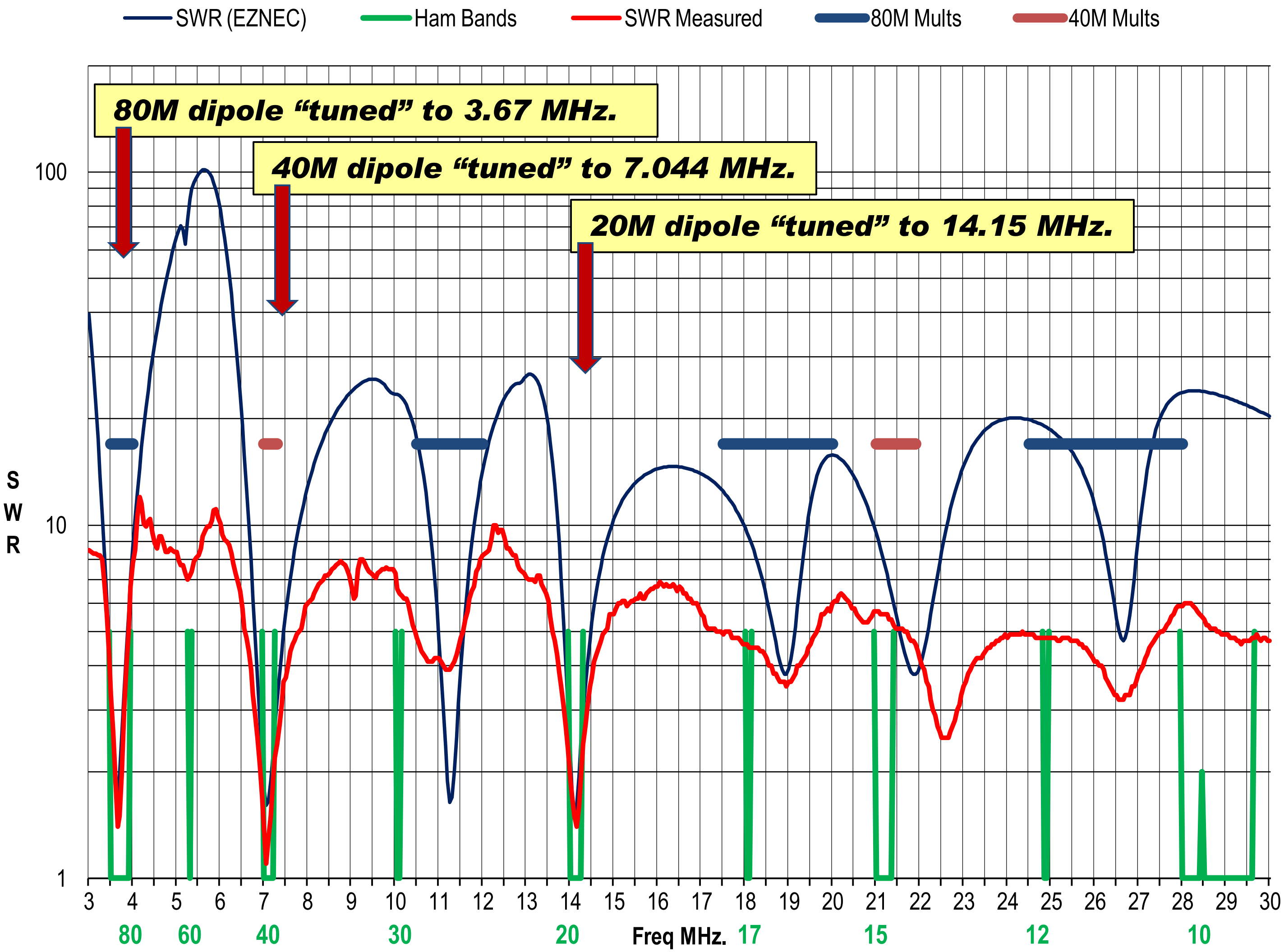






Modeling an 80/40/20M Fan Dipole for DX

SWR Response



	Freq (MHz.)	SWR
80M	3.67	1.3
60M	5.30	7.2
40M	7.044	1.1
30M	10.10	6.4
	11.20	3.9
20M	14.15	1.4
17M	18.10	4.5
	18.95	3.5
15M	21.20	5.6
	22.55	2.5
12M	24.95	4.8
	26.60	3.2
10M	28.30	5.8

The SWR is measured at the transceiver. The attenuation of the 30 ft. of RG-8X coax feeding the antenna can account for most of the difference between measured and theoretical SWR.

Modeling an 80/40/20M
Fan Dipole for DX

Where is the DX?

At what angle (from the horizon) does the RF arrive?

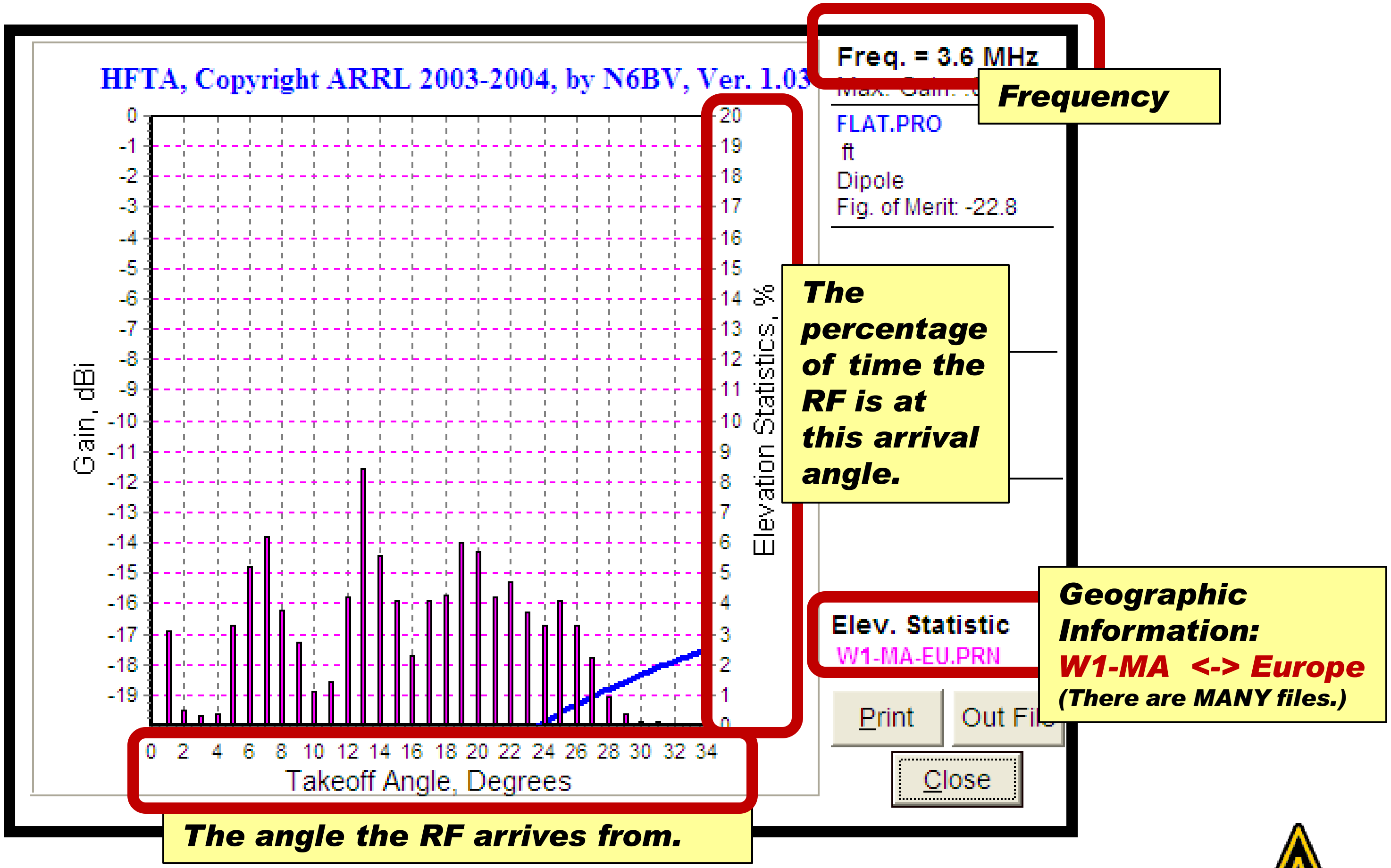
We must always remember this simple truth:
The ionosphere controls the elevation angles of the RF we see at our location, not our antenna!

Data from the ARRL Antenna Book , Dean Straw N6BV editor.

Information available as tables: the statistical distribution of elevation angles that are necessary for communication via the ionosphere from one location to another.

Also part of the software program **HFTA** (High Frequency Terrain Analysis)

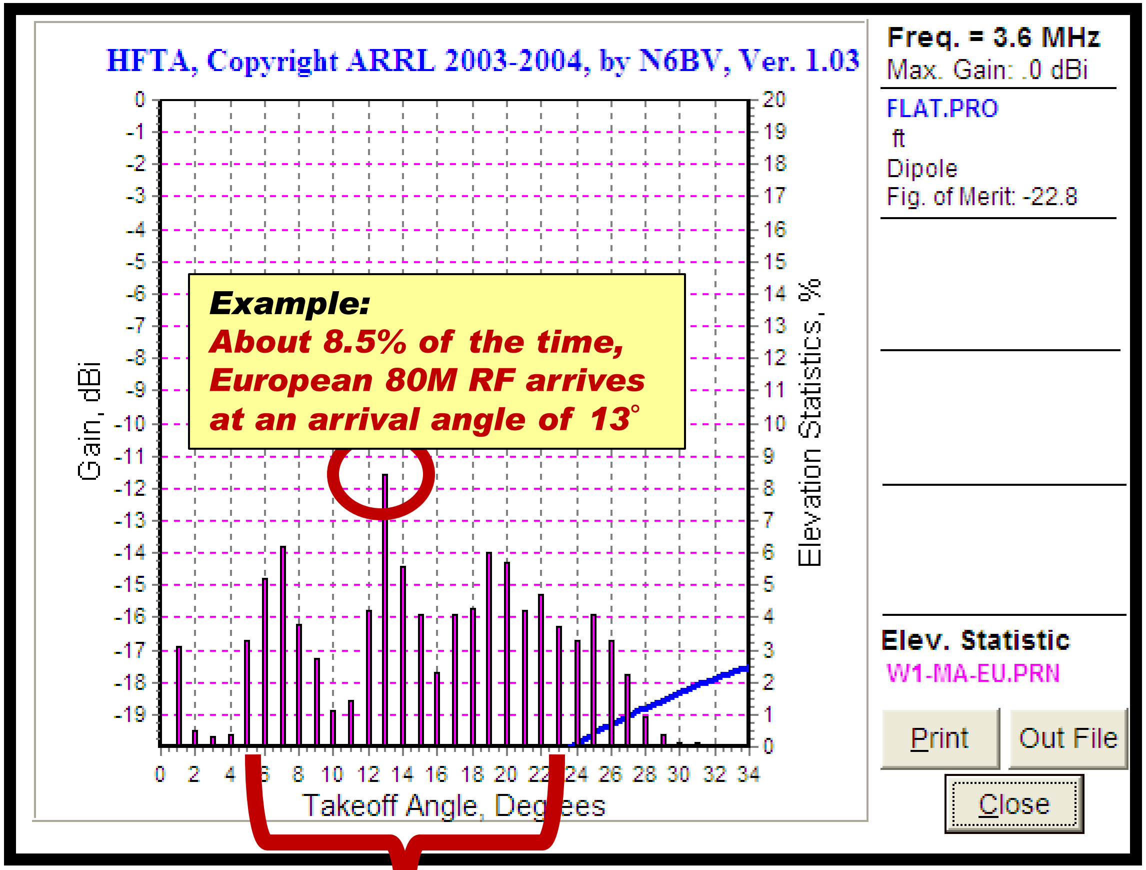
Primer on HFTA's "Elevation-Statistics" Models



Primer on HFTA's "Elevation-Statistics" Models

Note:
The statistical data is an overall average of all time; i.e. for any time, any day, any season, any part of the 11-year sunspot cycle.

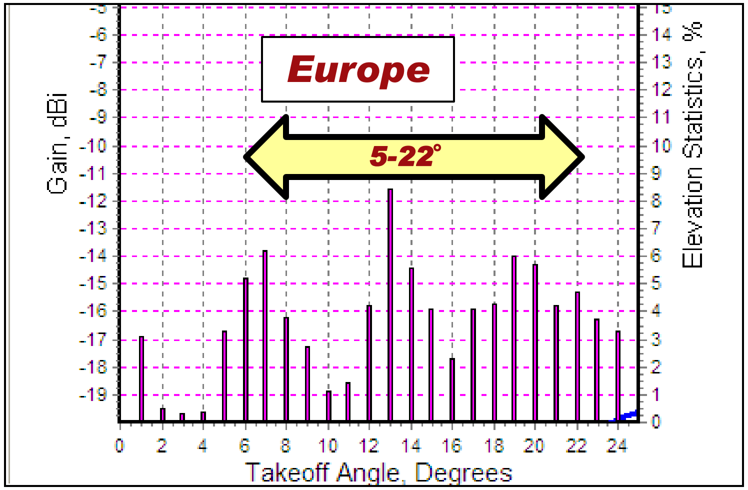
Specific propagation "today" will be very limited in angle.

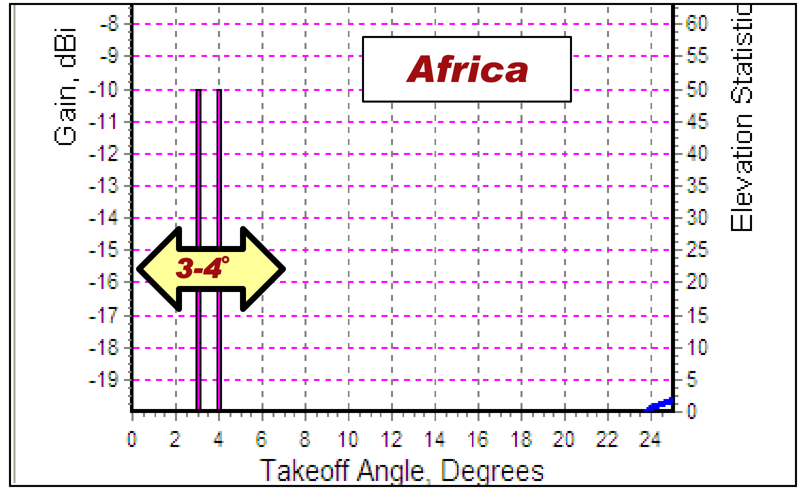


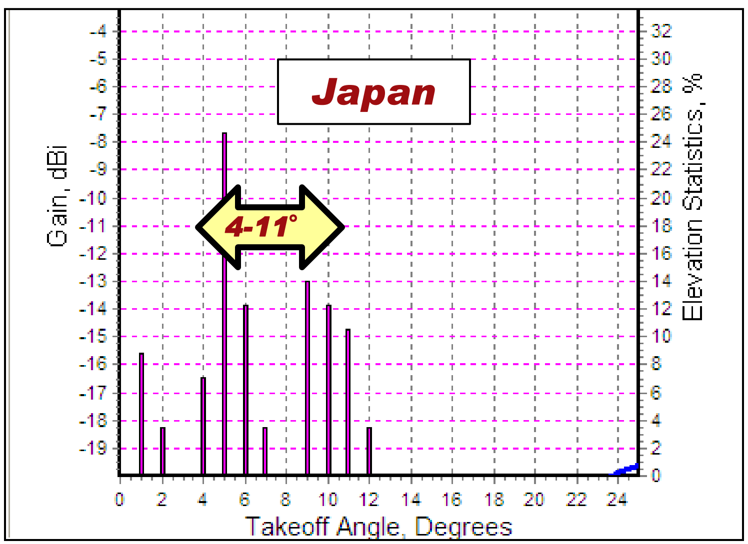
Conclusion, <u>from this one graph</u>:
About 80% of the time, European 80M RF arrives at arrival angles between 5 → 22°

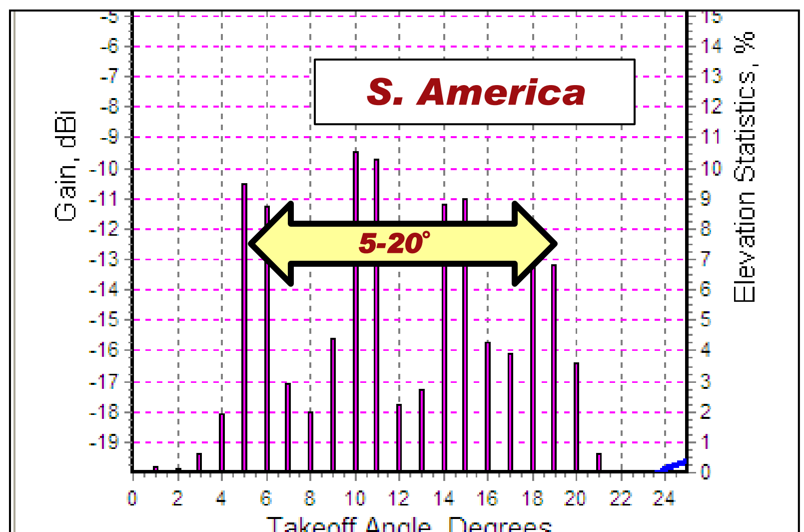
Elevation Statistics for New England – 80M

3-22°
GOAL





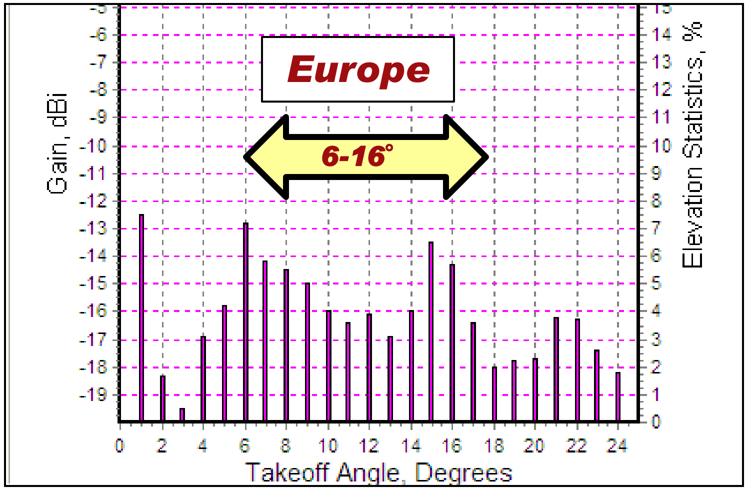


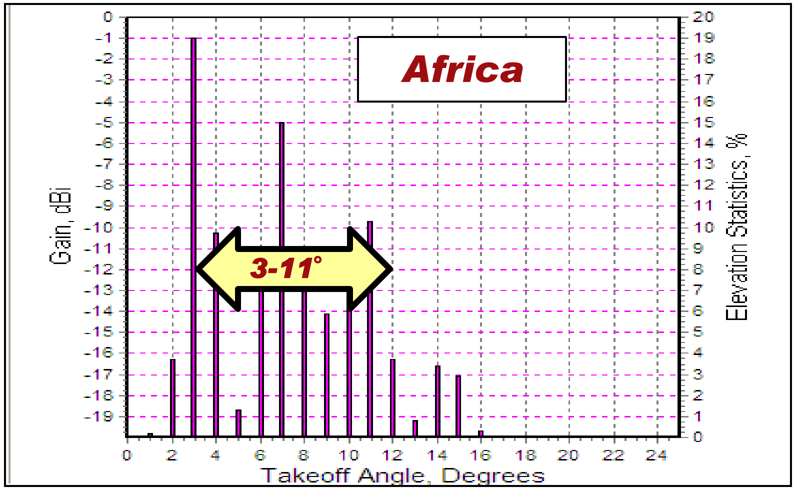


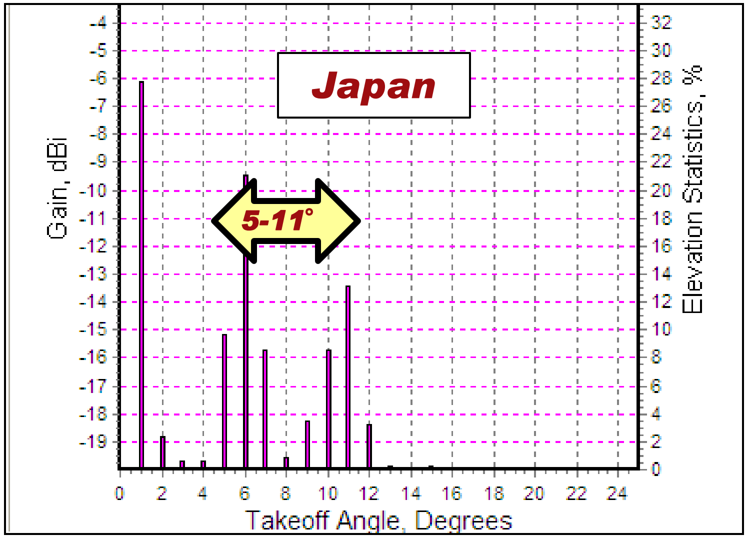
Elevation Statistics for New England – 40M

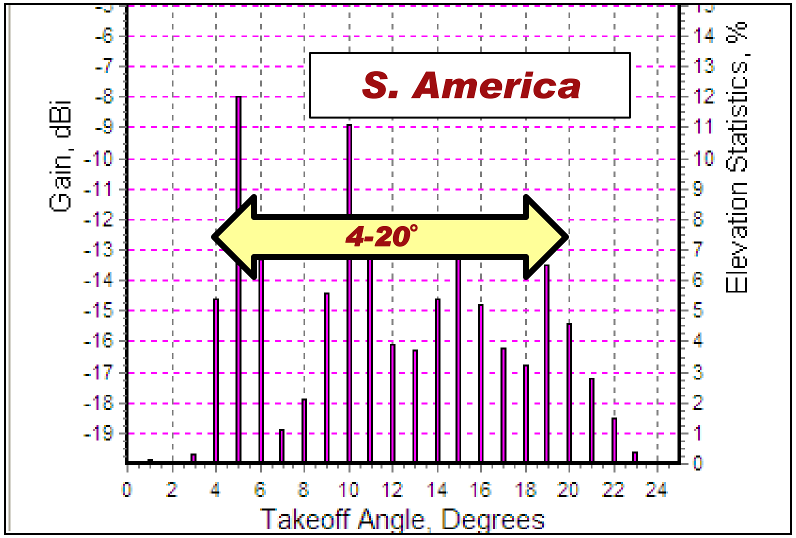
3-20°

GOAL





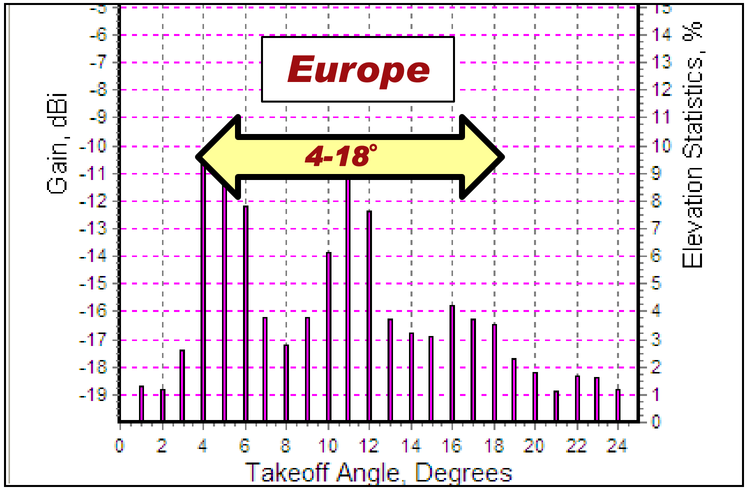


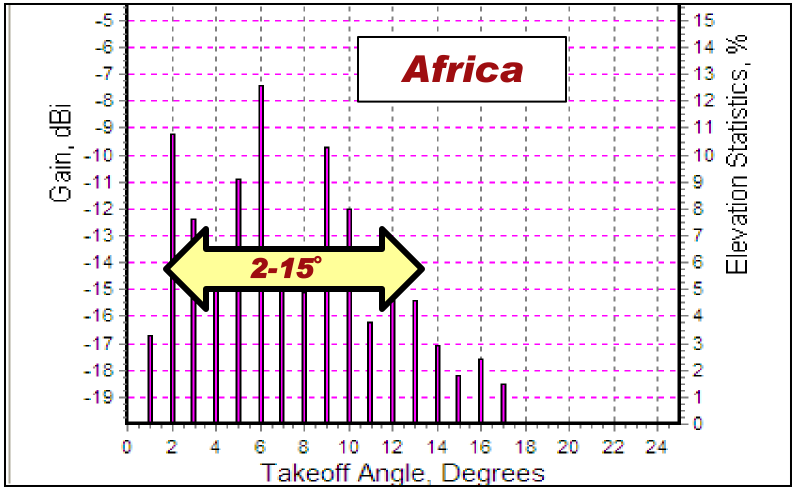


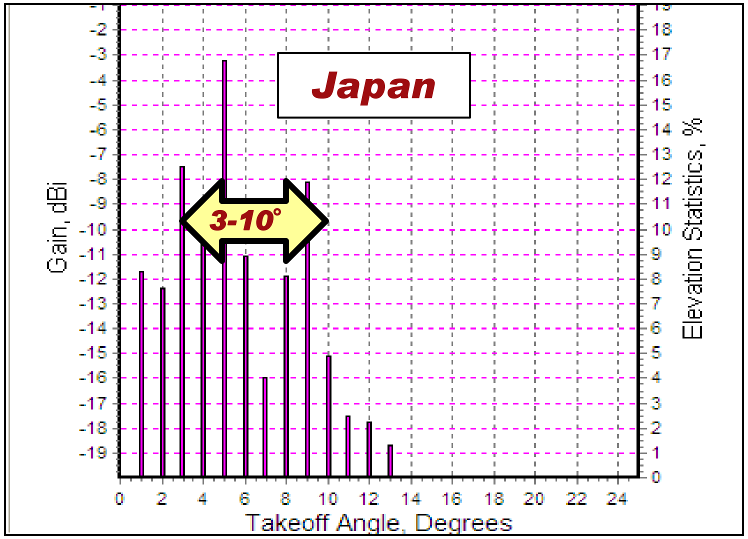
Elevation Statistics for New England – 20M

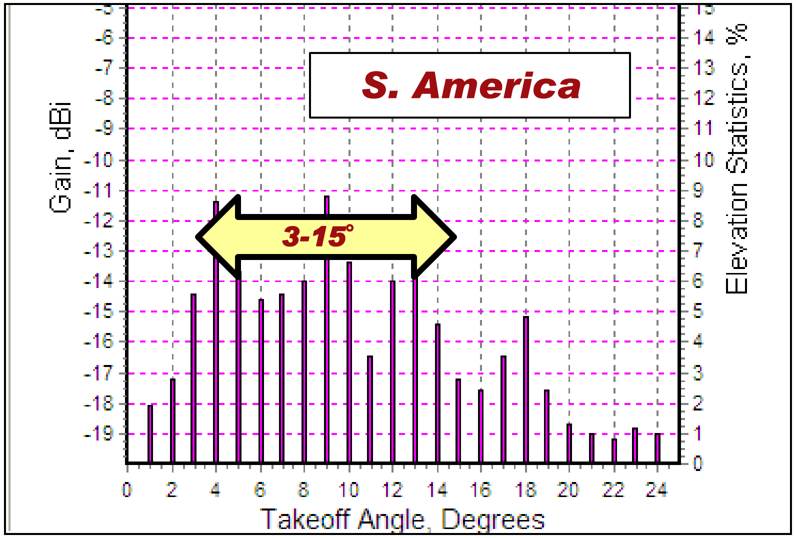
3-18°

GOAL









Modeling an 80/40/20M Fan Dipole for DX

The previous slides show where the DX comes from, so…

How do these dipoles "play" from 3-22°

using EZNEC:

EZNEC is a powerful but easy-to-use program for modeling and analyzing nearly any kind of antenna *in its actual operating environment*.

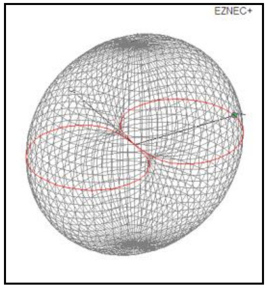
EZNEC:

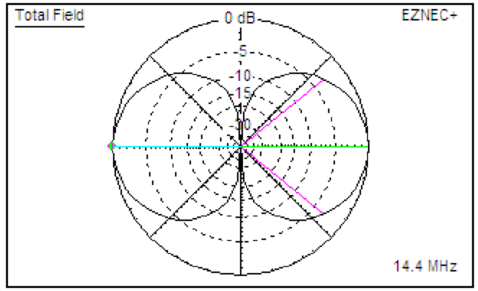
- plots azimuth and elevation patterns
- tells you gain, feedpoint impedance, SWR, and current distribution
- reports beamwidth, 3-dB pattern points, f/b ratio, takeoff angle
- …and more.

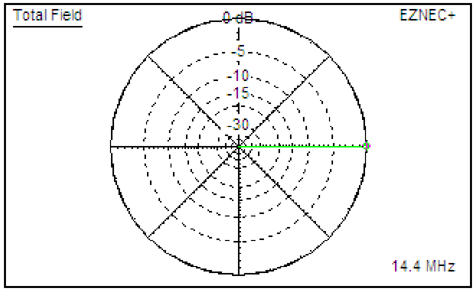
REVIEW ~ Ideal EZNEC Dipole Patterns

	3D	Azimuth	Elevation

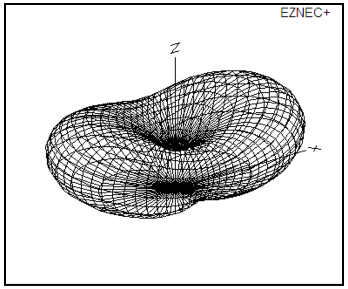
Free Space

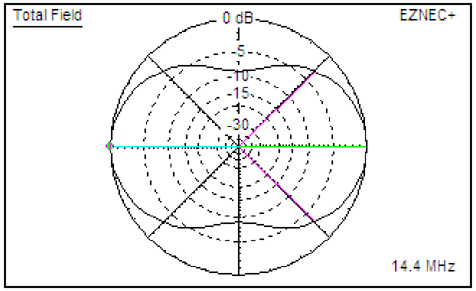


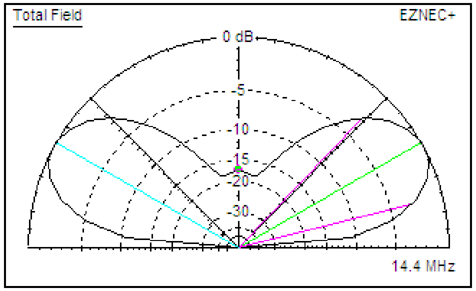




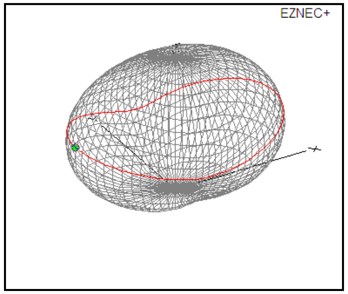
1/2 λ above real ground

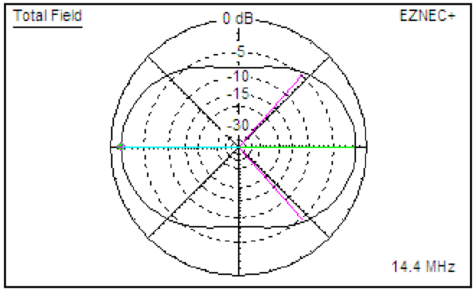


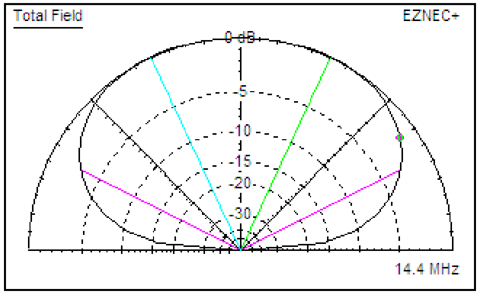




1/4 λ above real ground



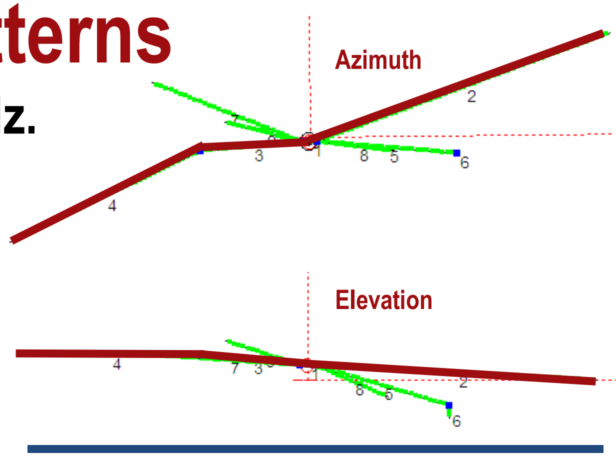


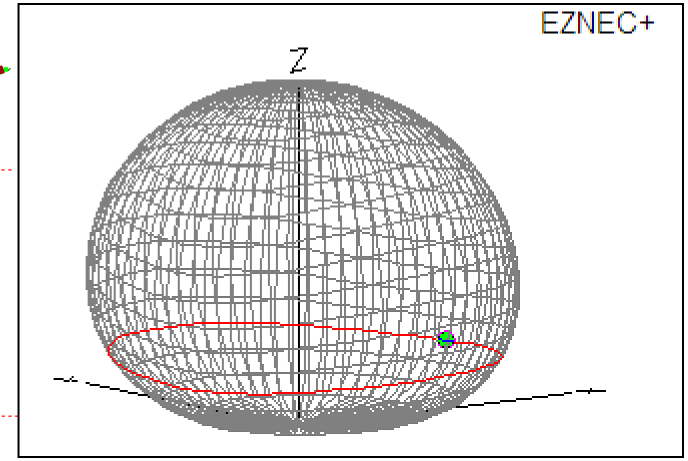


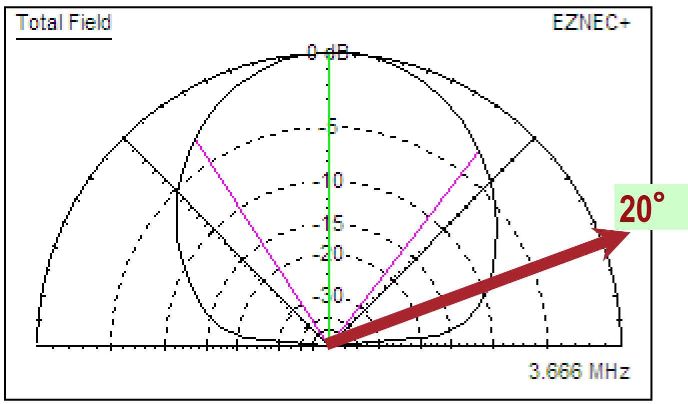
80M EZNEC patterns

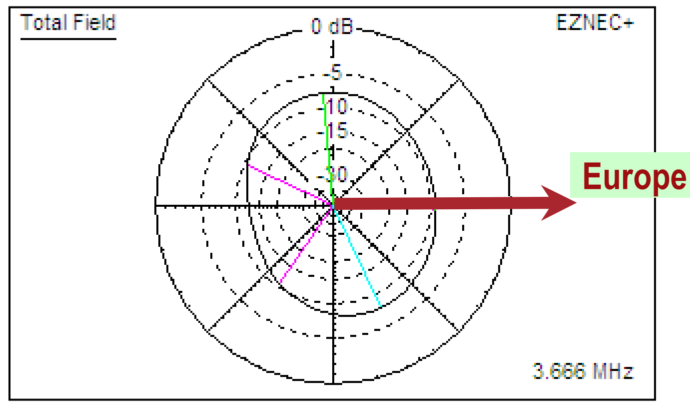
Data shown for 3.666 MHz.

Height = ~1/14 λ









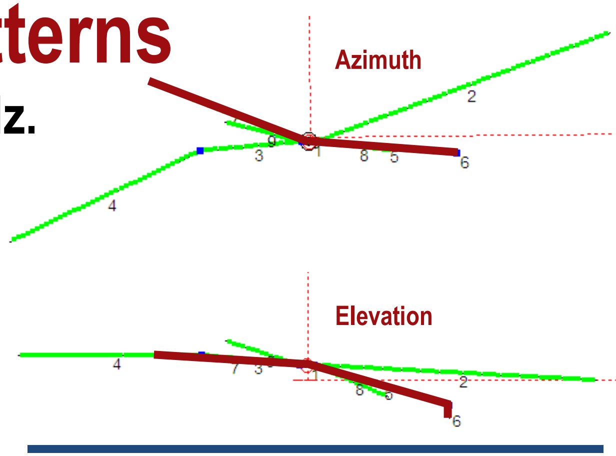
Elevation °	Gain (dBi) @ 60°	Azimuth
90	3.9 dBi	△
20	- 5.6	- 9.5 dB
10	- 8.9	-12.8
5	-12.8	-16.7

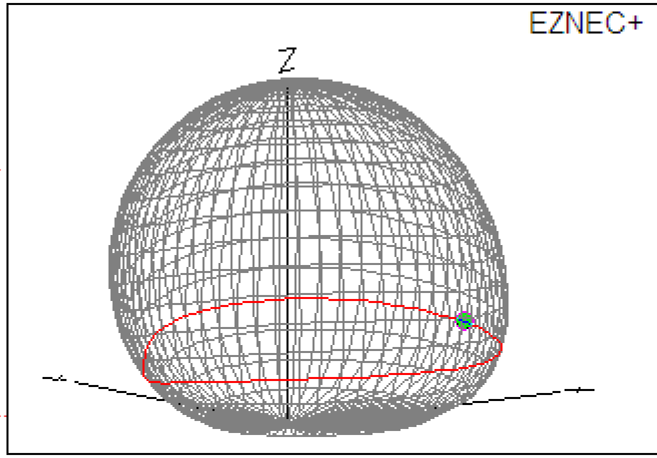
Azimuth °	Gain (dBi) @ 20° Elevation	
60 (Europe)	-5.6 dBi	-4.9±0.9 dB
90 (Africa)	-4.7	
170 (S. America)	-5.8	
335 (Japan)	-4.0	

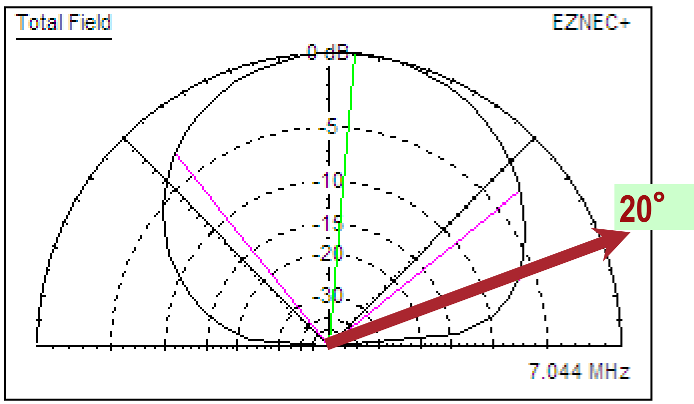
40M EZNEC patterns

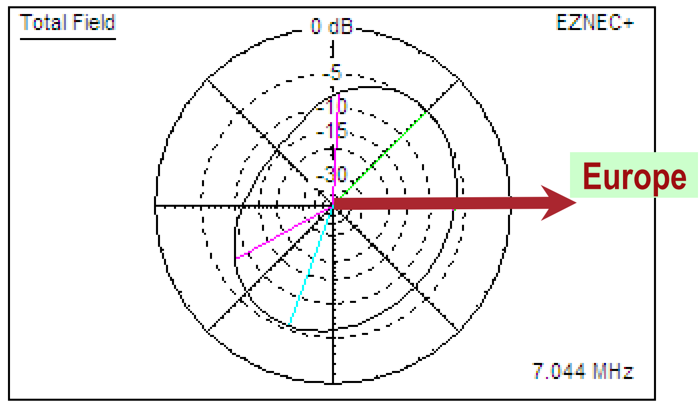
Data shown for 7.044 MHz.

Height = ~1/7 λ









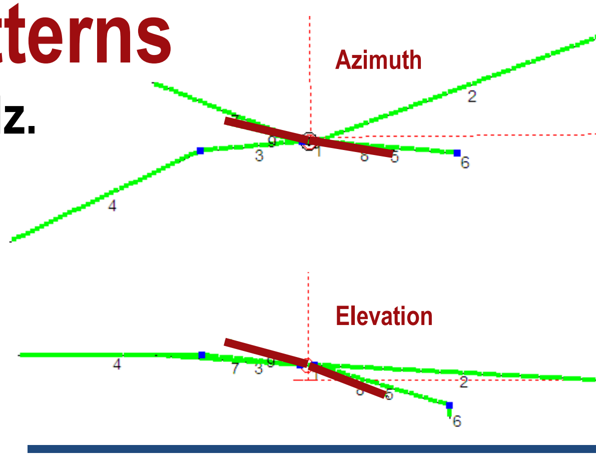
Elevation °	Gain (dBi) @ 60°	Azimuth
90	4.8 dBi	△
20	- 1.6	- 6.4 dB
10	- 5.0	- 9.8
5	- 9.1	-13.9

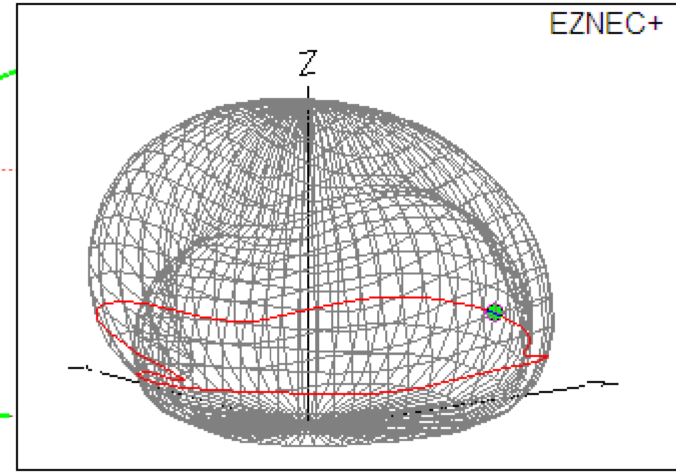
Azimuth °	Gain (dBi) @ 20° Elevation	
60 (Europe)	-1.6 dBi	-2.1±1.6 dB
90 (Africa)	-2.4	
170 (S. America)	-0.8	
335 (Japan)	-3.6	

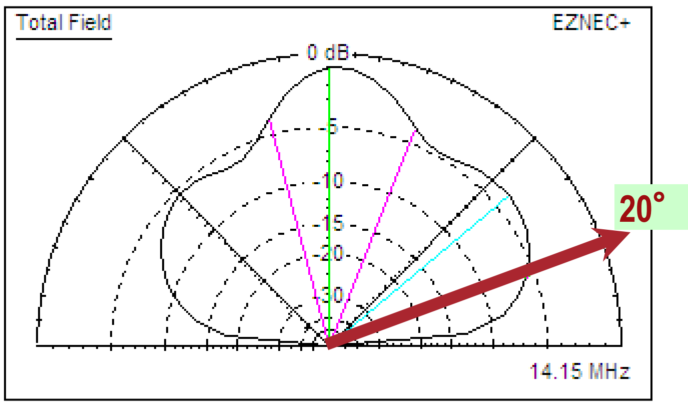
20M EZNEC patterns

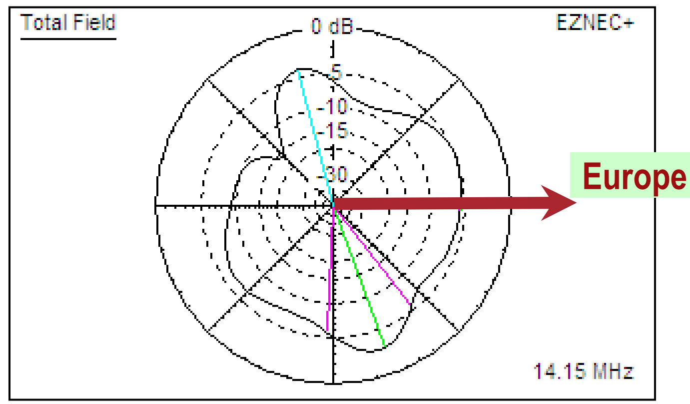
Data shown for 14.15 MHz.

Height = ~ 0.27 λ









Elevation °	Gain (dBi) @ 60° Azimuth	△
90	6.0 dBi	△
20	1.3	- 4.7 dB
10	- 1.8	- 7.8
5	- 5.9	-11.9

Azimuth °	Gain (dBi) @ 20° Elevation
60 (Europe)	1.3 dBi
90 (Africa)	0.3
170 (S. America)	-0.5
335 (Japan)	0.8

0.4±0.9 dB

Modeling an 80/40/20M
Fan Dipole for DX

Conclusions

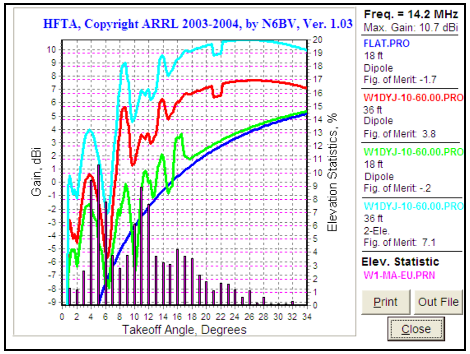
- We want our DX antennas to "play" from 3° to 22° and be omnidirectional

- These dipoles are "OK" for Azimuth → ± ~ 1½ dB
  - In this case low is good!

- These dipoles are not so good for Elevation
  - Gain straight up at 90° : 4 – 6 dBi
  - Gain where we want it, <20° is not so good: - 5 to -17 dB

What about the effect of local terrain? → Next

Modeling an 80/40/20M Fan Dipole for DX



The Effect of Terrain

HFTA (High Frequency Terrain Analysis)

- We have looked at where the Qs come from… (3-22°)
- We know these antennas aren't great for DX… (-5 → -17 dB)
- But how does the local terrain in Harpswell, ME, effect the RF?

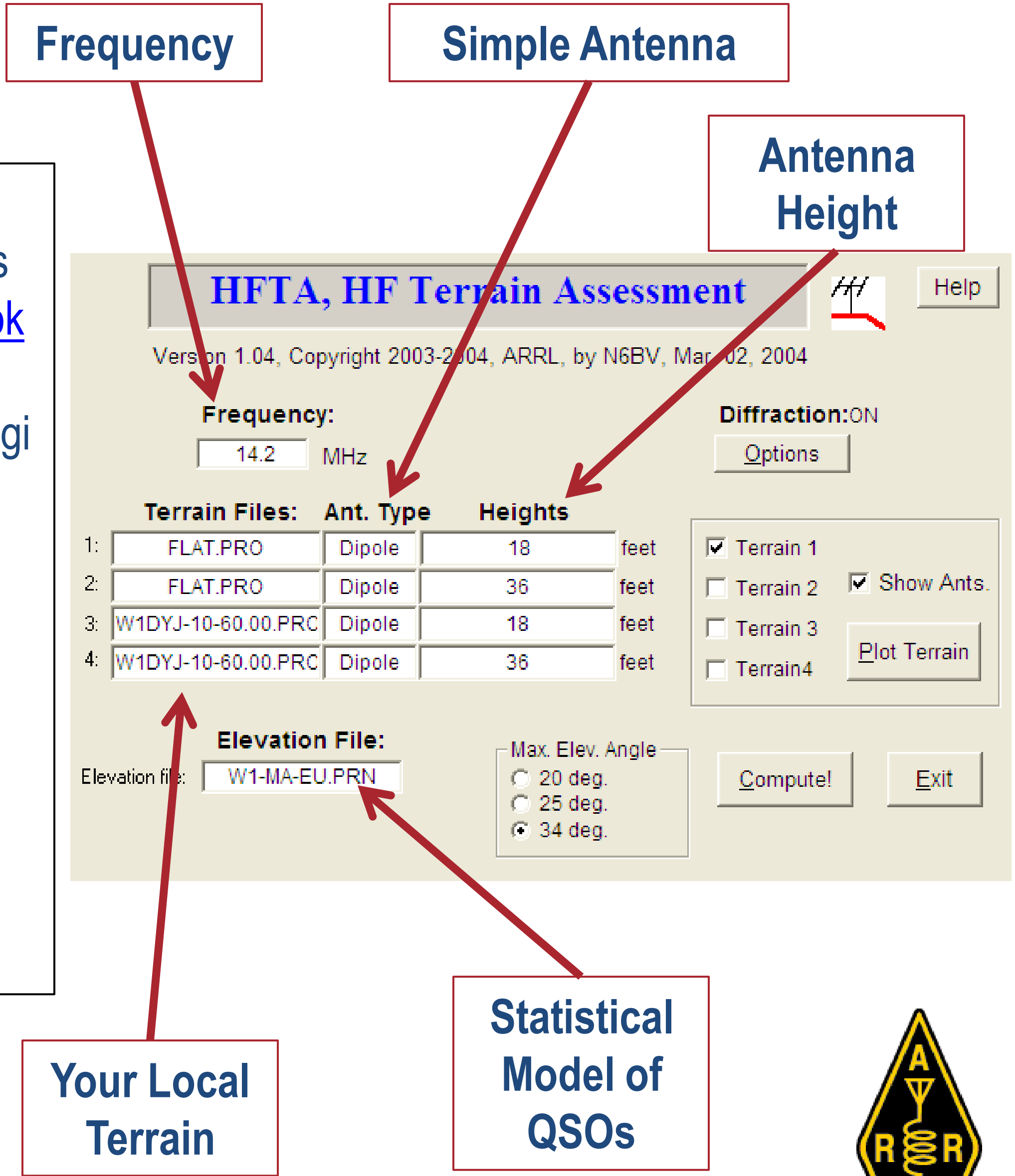
Remember this simple truth:

The ionosphere controls the elevation angles, not our transmitting antenna – *but the local terrain affects it!*

HFTA

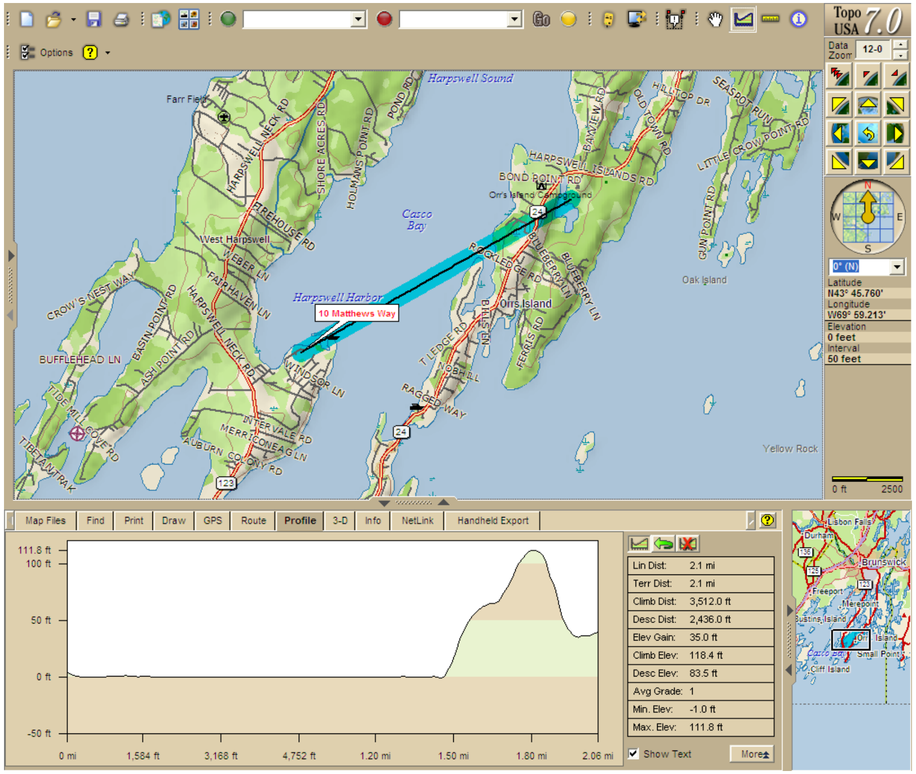
HFTA (**HF Terrain Assessment**), developed by **Dean Straw N6BV**. HFTA is available on the latest ARRL Antenna Book CD-ROM. HFTA shows visually how the elevation angles of a horizontal dipole, Yagi or stacked Yagis cover the statistical distribution of elevation angles that are necessary for communication via the ionosphere from one location to another.

We must always remember this simple truth:
The ionosphere controls the elevation angles, not our transmitting antenna!



HFTA ~ the Local Terrain to Europe

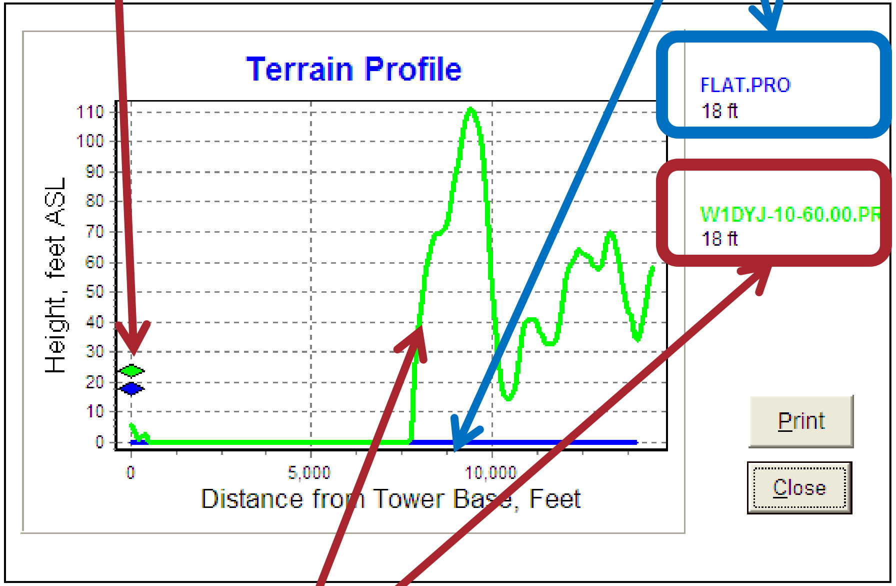
DeLorme Topo USA 7.0



Antenna Height

HFTA

Flat (EZNEC)

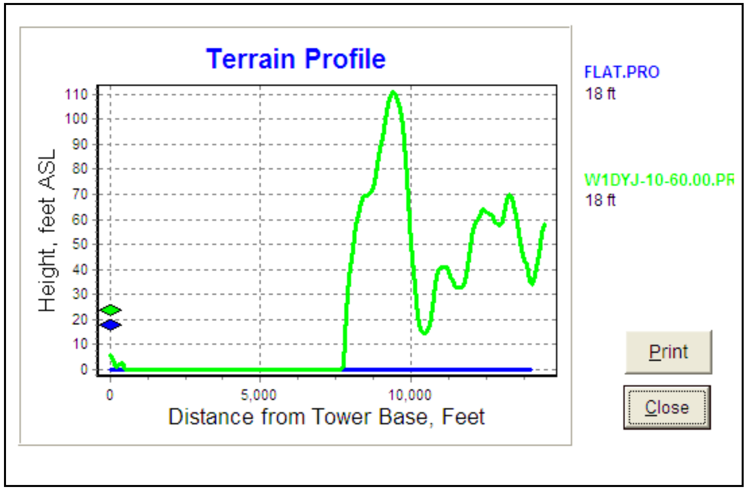


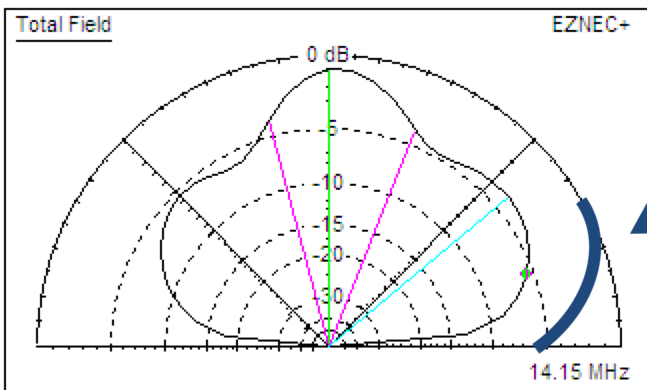
From "MicoDEM" USGS

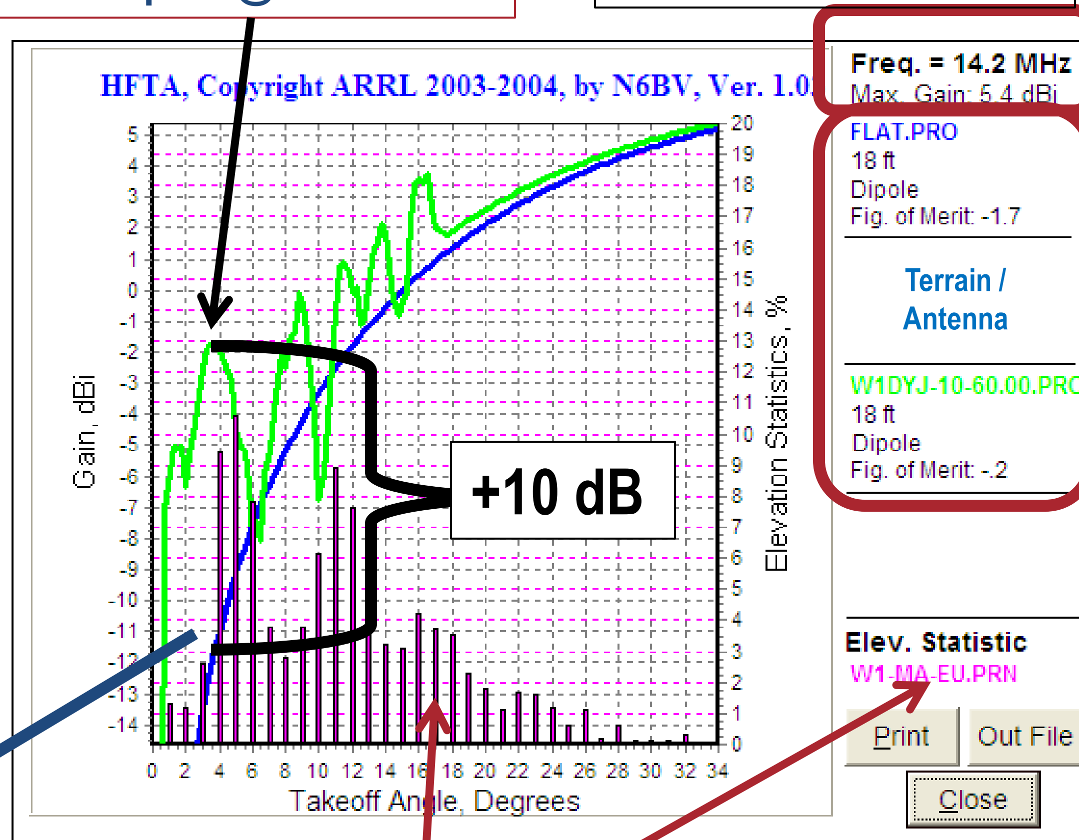
HFTA ~ "Primer"

Effect of the terrain on this dipole @ 4º: +10 dB

Frequency of Analysis



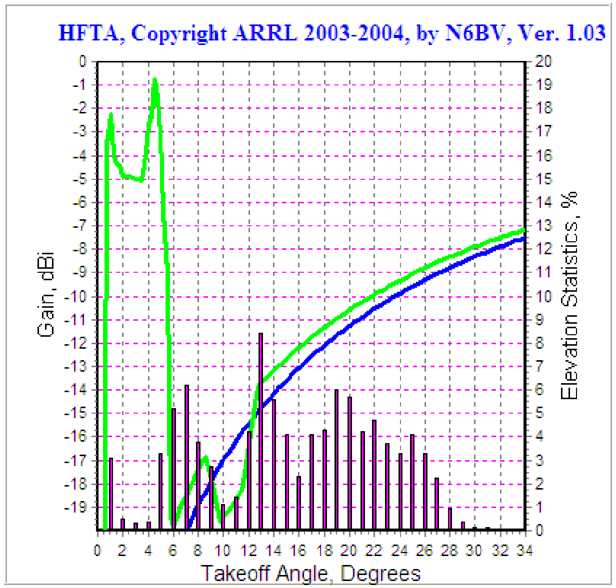




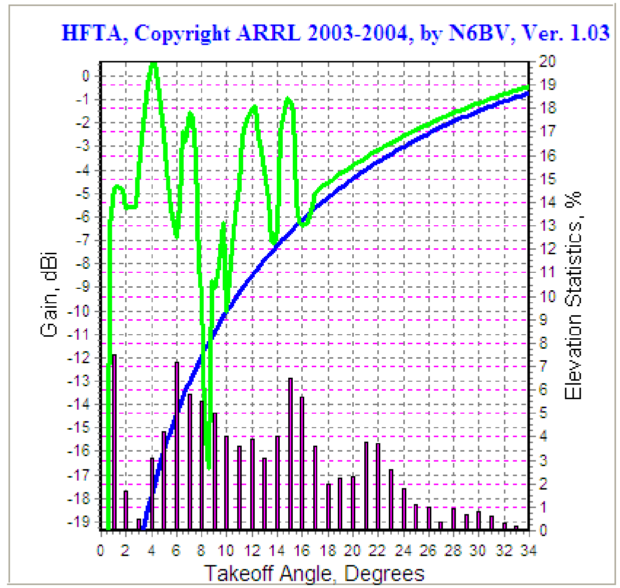
From W1 → Europe: % QSOs vs. Takeoff Angle

HFTA: Europe ~ 60°

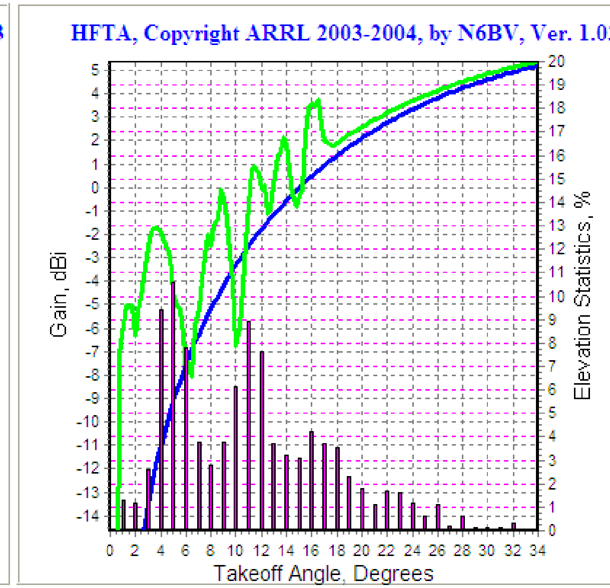
80M (3.666 MHz)

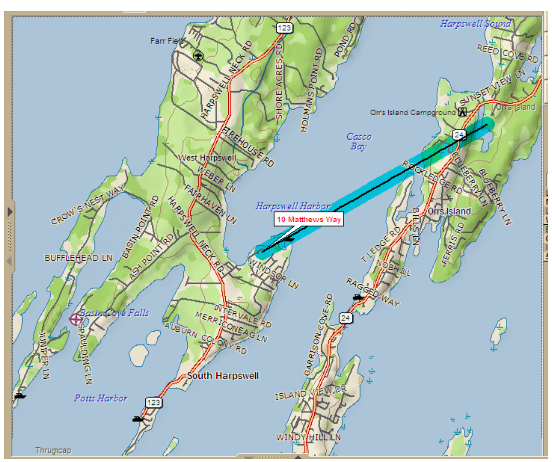


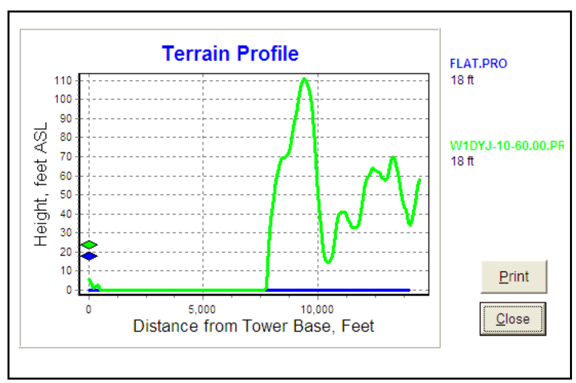
40M (7.044 MHz)

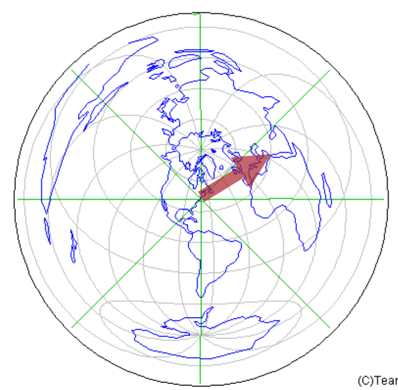


20M (14.15 MHz)



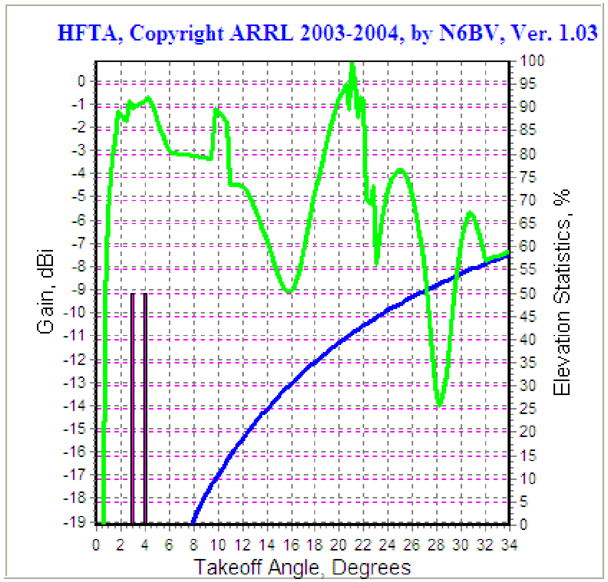




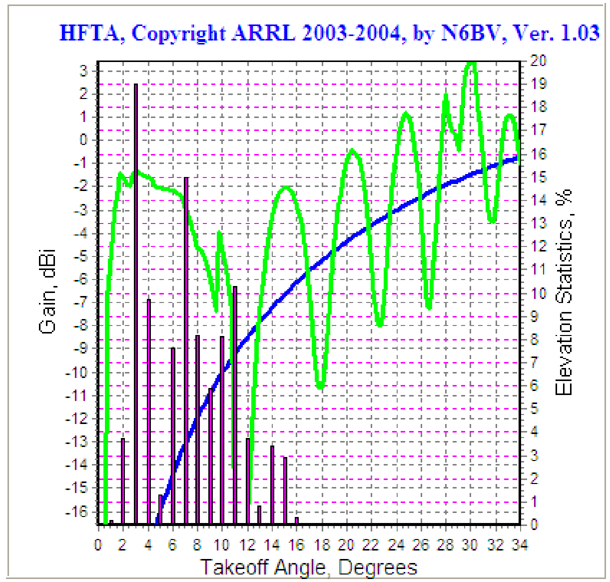


HFTA: Africa ~ 90°

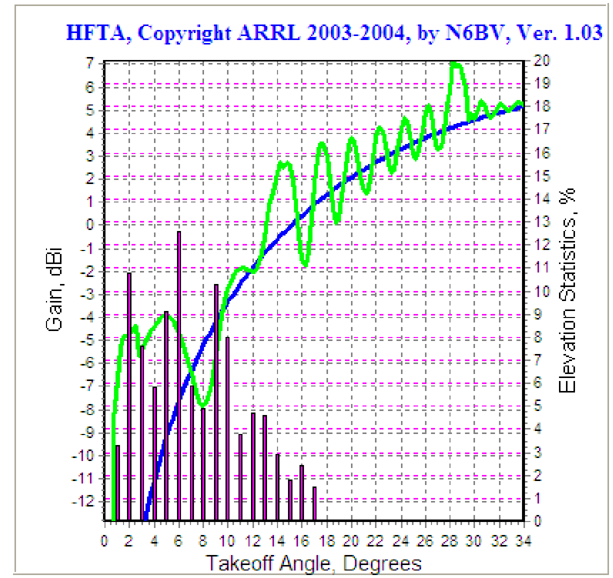
80M (3.666 MHz)

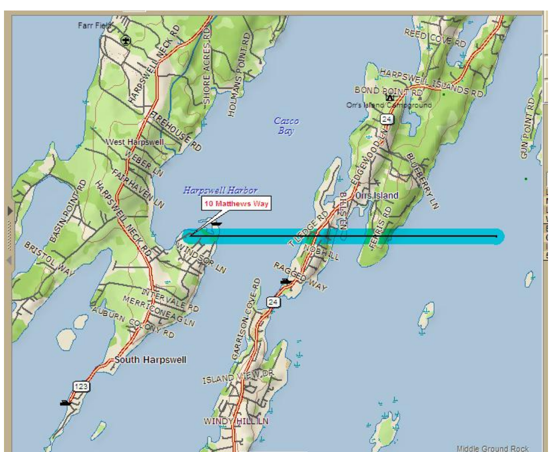


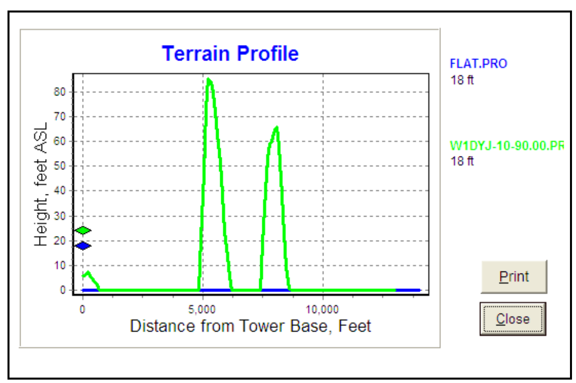
40M (7.044 MHz)

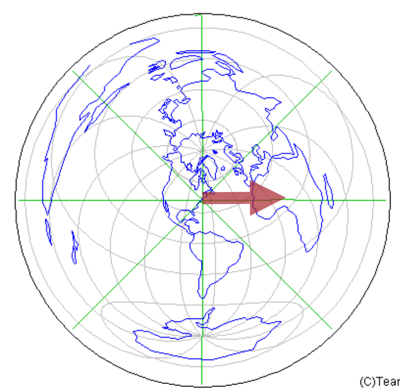


20M (14.15 MHz)



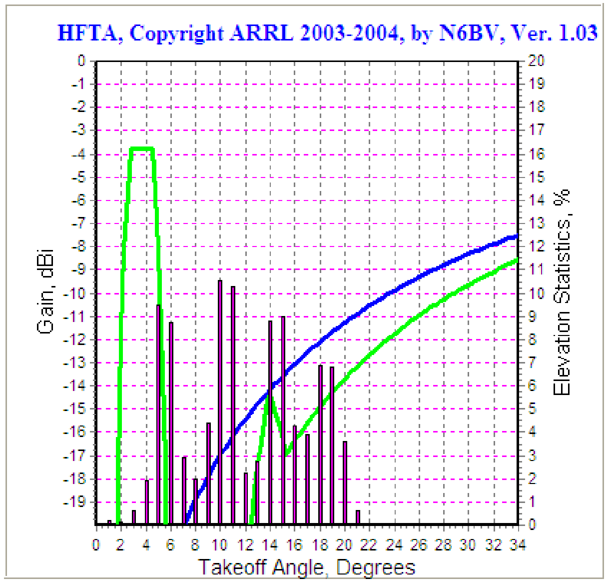




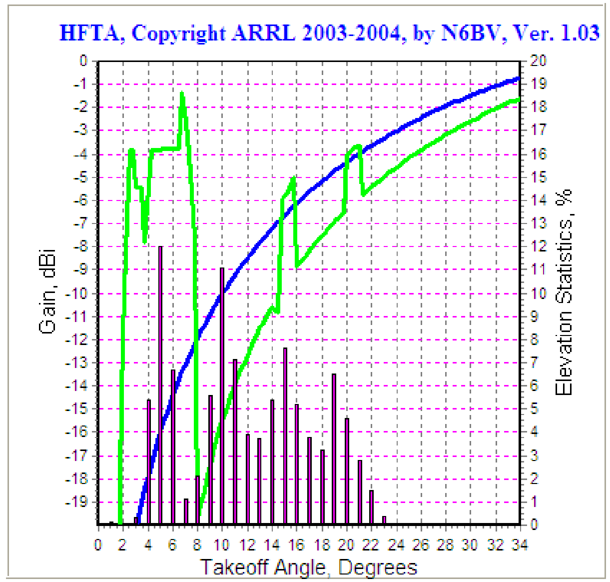


HFTA: South America ~ 170°

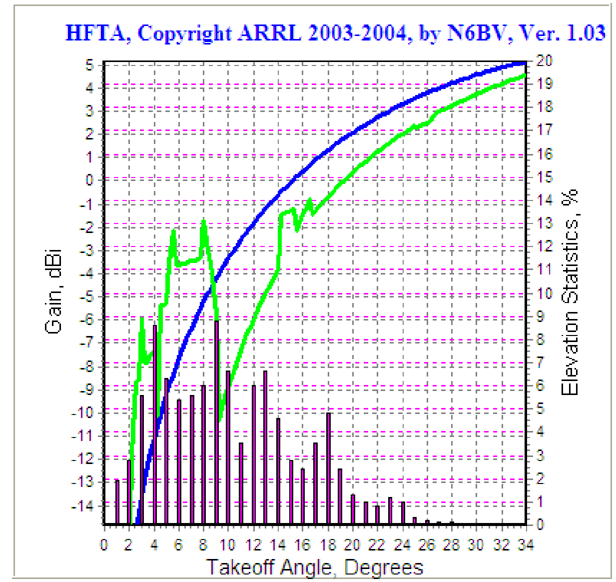
80M (3.666 MHz.)

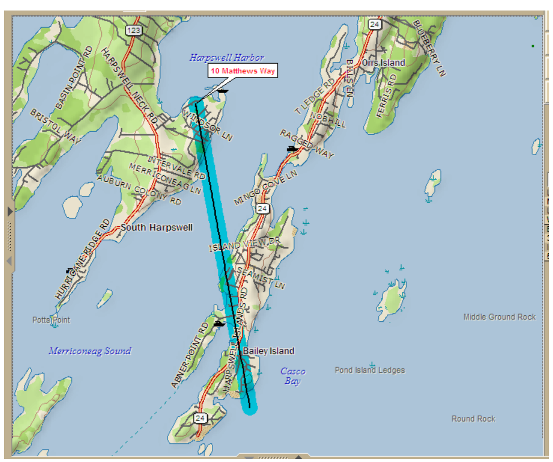


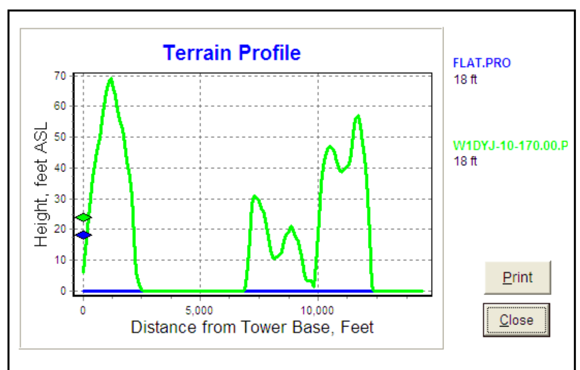
40M (7.044 MHz.)

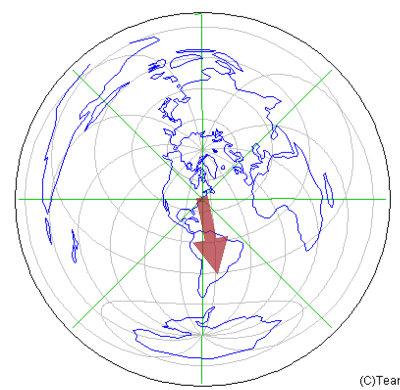


20M (14.15 MHz.)



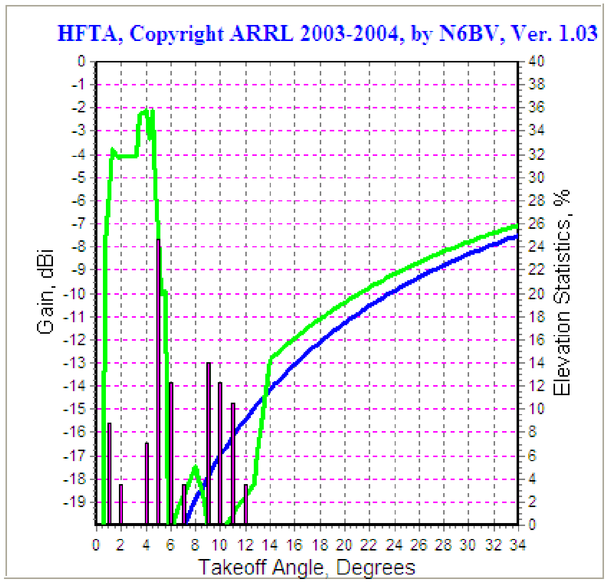




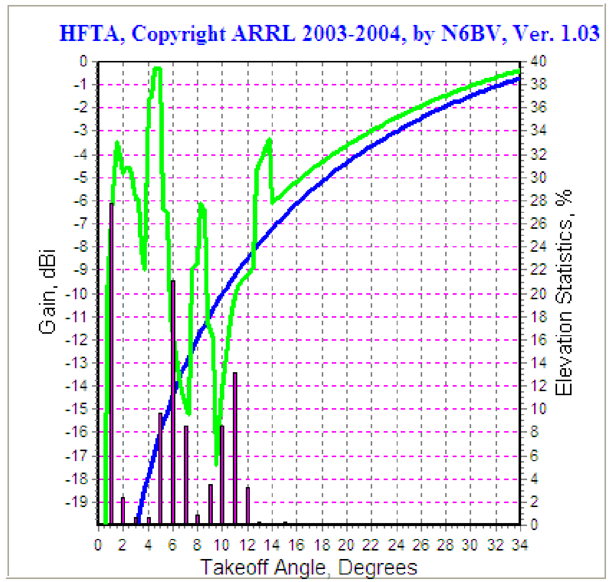


HFTA: Japan ~ 336°

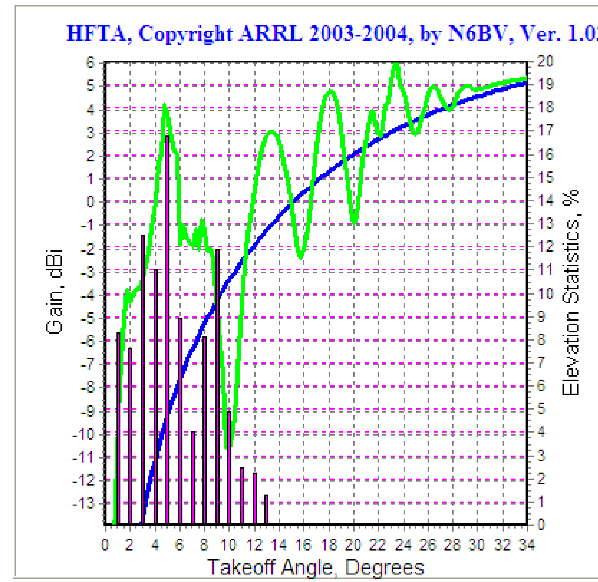
80M (3.666 MHz.)

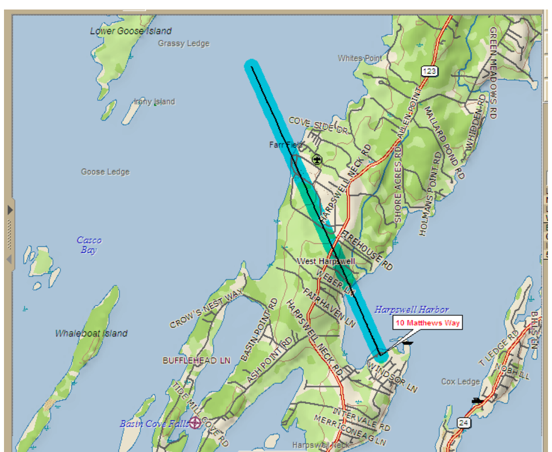


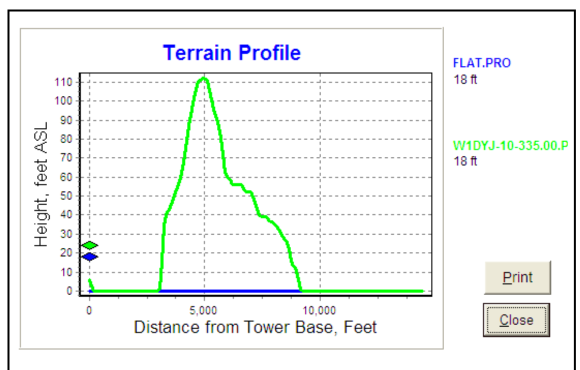
40M (7.044 MHz.)

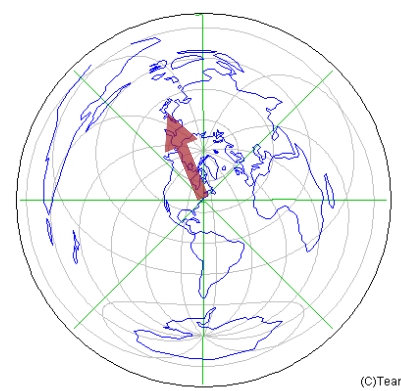


20M (14.15 MHz.)









Modeling an 80/40/20M
Fan Dipole for DX

Summarize: Effect of Terrain

The Effect of the Local Terrain

	Europe	Africa	S. America	Japan
80M	0	++	—	+/-
40M	++	++	+/-	0
20M	+	+	+/-	++

How can I improve on these dipoles? → Next

Potential Improvements

→ Will making them higher help much?

- **EZNEC** with dipole centers @ 36' (rather than 18')
- **HFTA** with 20M dipole center = 18' & 36'

→ What about a different antenna on 20M?

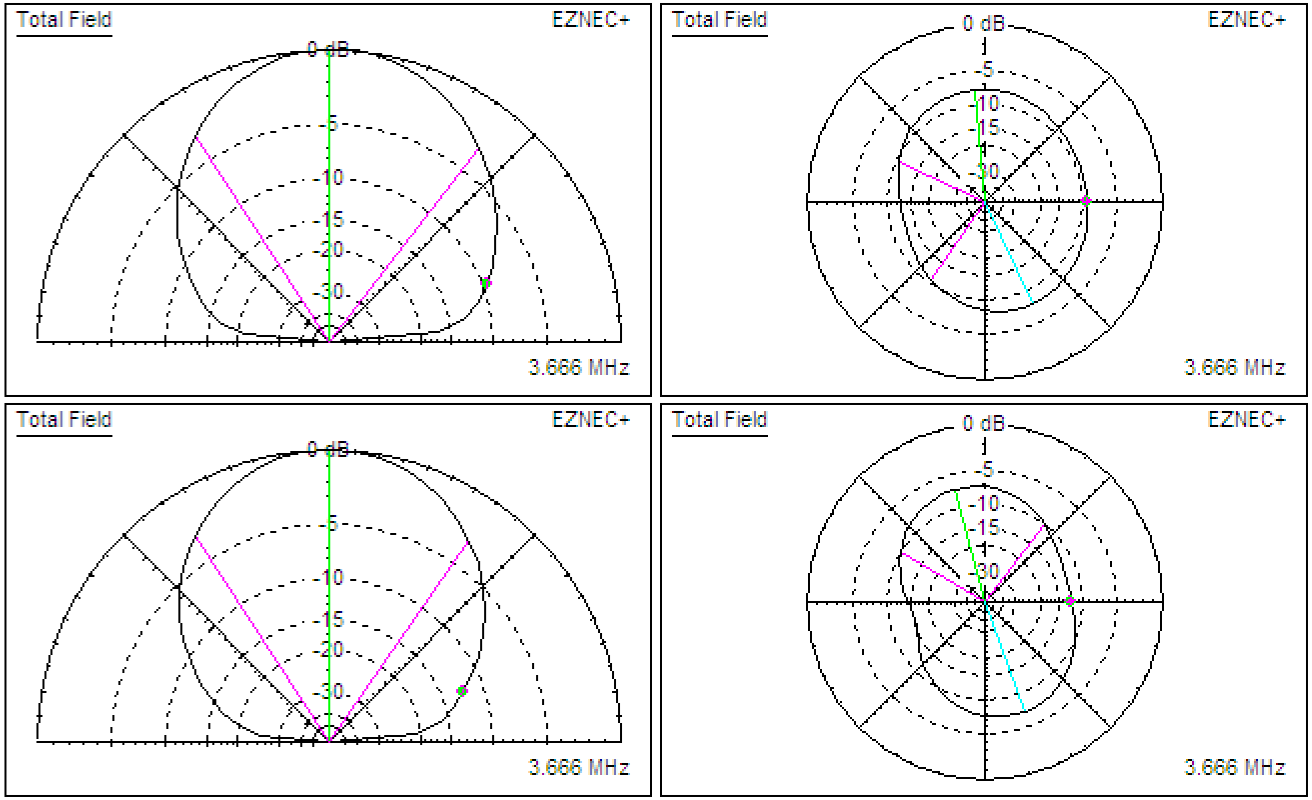
- **HFTA**: Dipole 2 18' vs. 2 el Yagi & 3 el Yagi @ 32'

Potential Improvement? 80M ~ 3.666 MHz.

Original
@ 18' center
~ 1/14 λ

@ 36' center
~1/7 λ

@ Azimuth = 60°



Elevation °	Gain @ 18' Elevation		@ 36' Elevation		△
90	3.9 dBi	△	7.0 dBi	△	
20	- 5.6	- 9.5 dB	- 5.2	-12.2 dB	- 2.7 dB
10	- 8.9	-12.8	- 9.3	-16.3	- 3.5
5	-12.8	-16.7	-13.4	-20.4	- 3.7

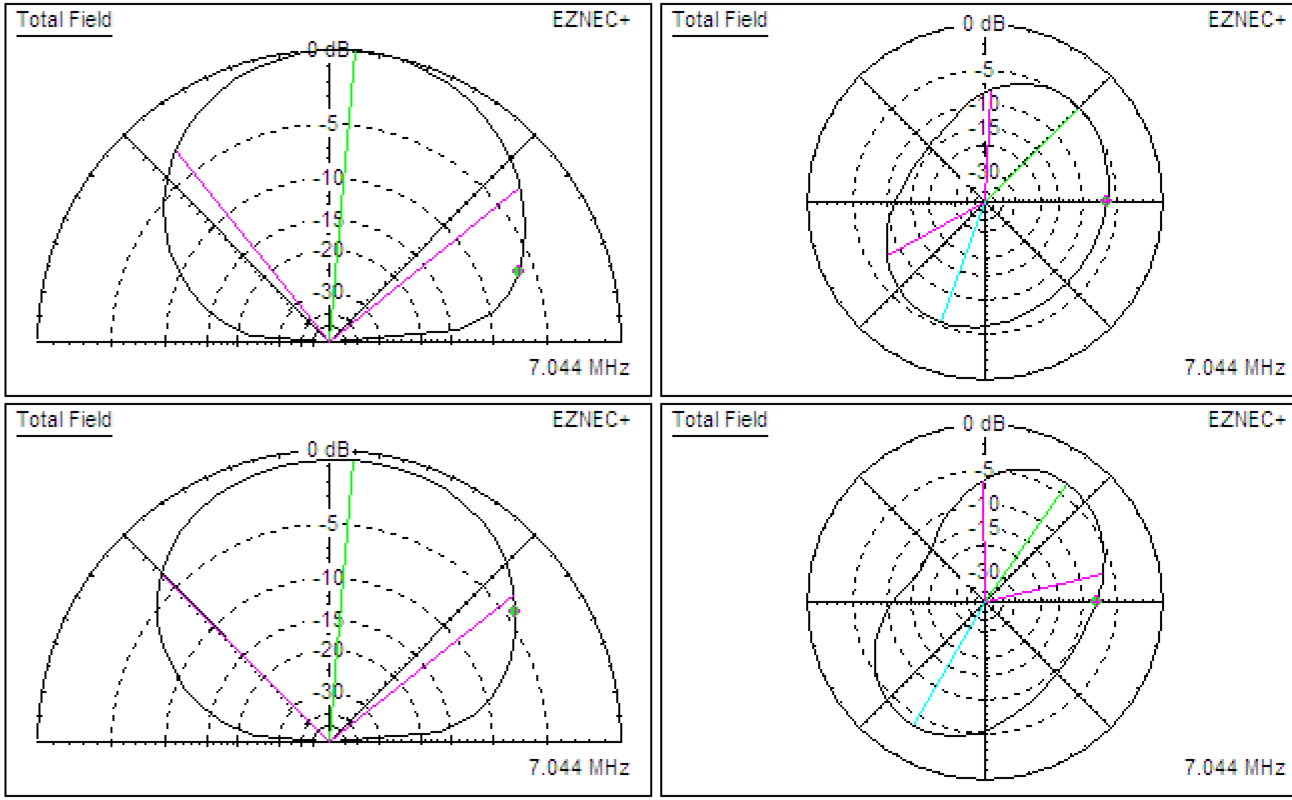
Potential Improvement?

40M ~ 7.044 MHz.

Original
@ 18' center
~ 1/7 λ

@ 36' center
~1/4 λ

@ Azimuth = 60°



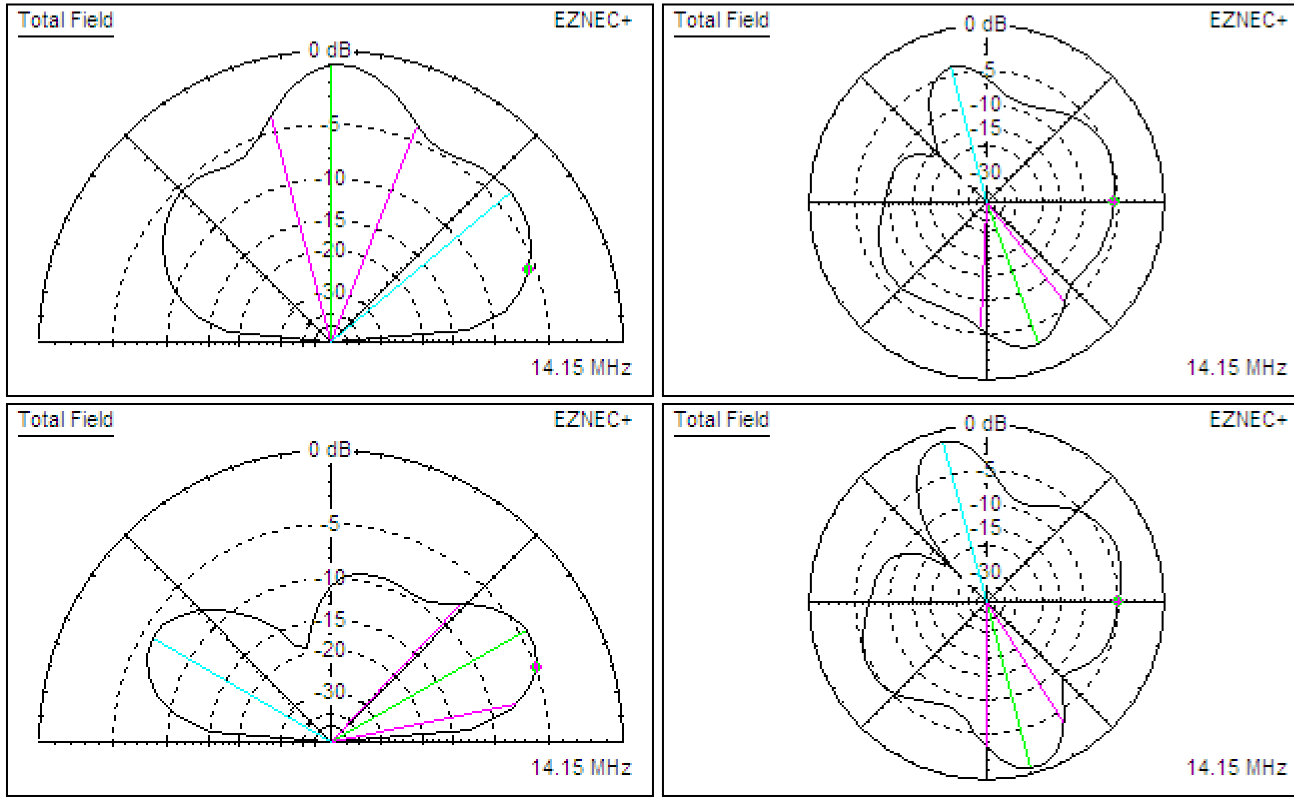
Elevation °	Gain @ 18' Elevation		@ 36' Elevation		△
90	4.8 dBi	△	6.3 dBi	△	
20	- 1.6	- 6.4 dB	-1.1	- 7.4 dB	-1.0 dB
10	- 5.0	- 9.8	-5.2	-11.5	-1.7
5	- 9.1	-13.9	-9.6	-15.2	-1.3

Potential Improvement? 20M ~ 14.15 MHz.

Original
@ 18' center
~ 1/4 λ

@ 36' center
~1/2 λ

@ Azimuth = 60°



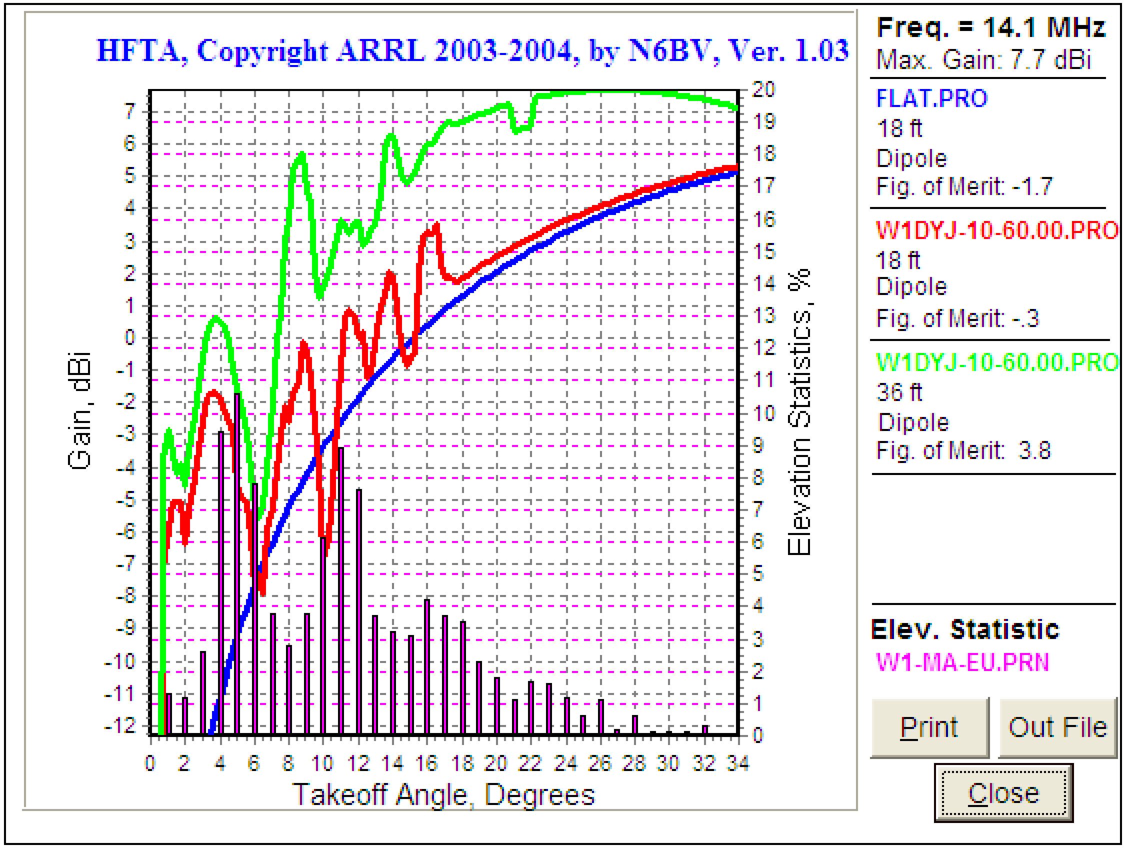
Elevation °	Gain @ 18' Elevation		@ 36' Elevation		△
90	6.0 dBi	△	-0.1 dBi	△	
20	1.3	- 4.7 dB	+4.0	+4.1 dB	+8.7 dB
10	- 1.8	- 7.8	+0.8	+0.9	+8.7
5	- 5.9	-11.9	- 3.5	-3.4	+8.5

Potential Improvement? 20M ~ 14.15 MHz.

HFTA – 20M

Dipoles @ 18' & 36'

(To Europe)



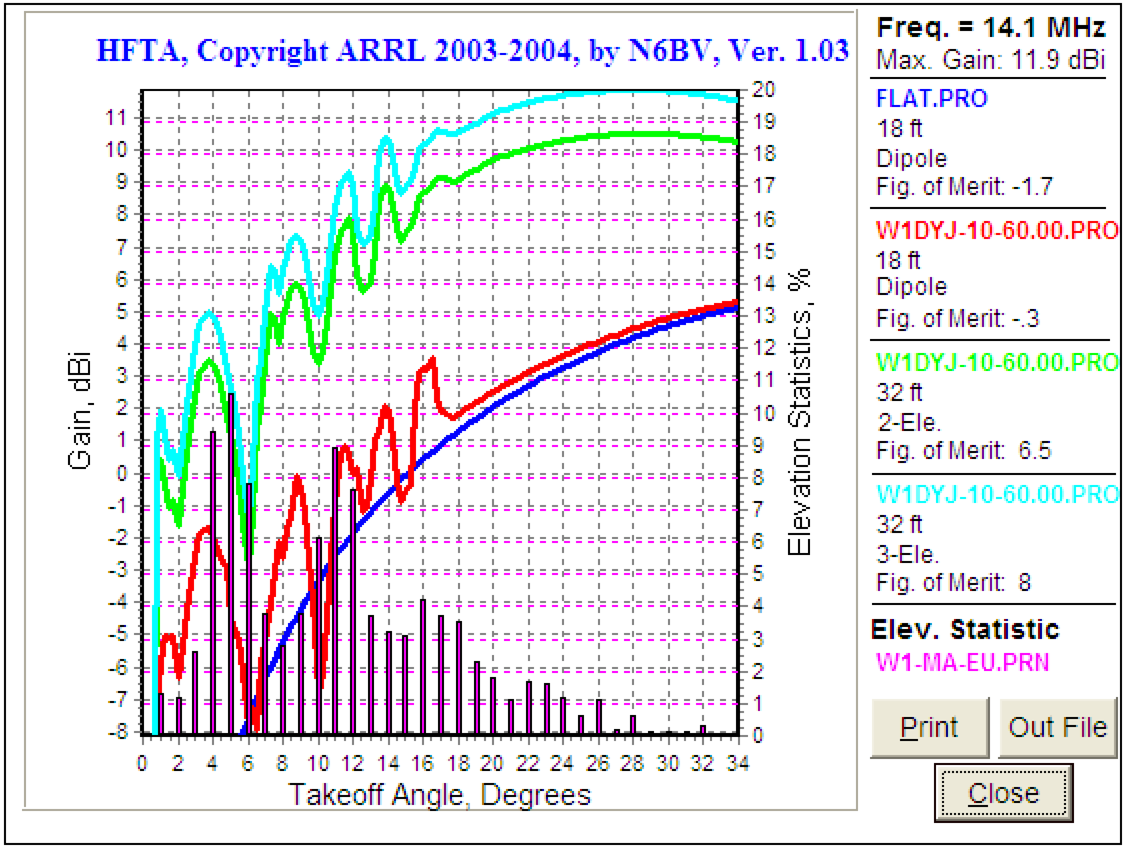
Potential Improvement?

20M ~ 14.15 MHz.

HFTA – 20M

Dipole @ 18'
2 El Yagi @ 32'
3 El Yagi @ 32'

(To Europe)



Potential Improvement?

Conclusions

Dipoles: raise center from 18' to 36'

- **80M: doubling the height hurts some >> but ½ λ is 135'!**
- **40M: doubling the height is a wash >> ½ λ is 66'**
- **20M: helps by better than an S-Unit!**

20M: need a "real" antenna

- **Homebrew? Hexx Beam? Spiderbeam? SteppIR?**

Modeling an 80/40/20M Fan Dipole for DX

Appendix

- Saltwater Analysis
- Other HF Bands

Modeling an 80/40/20M Fan Dipole for DX

Salt Water Analysis

Effect of Location – what about the cove? Does it help low angle radiation?

Theory: Salt water affects vertical antennas more than horizontals.

Effect of Salt Water– what about the cove?

Theory: Salt water affects vertical antennas more than horizontals.

Cond (S/m)	Diel Const	
0.005	13	Direct Entry
0.001	3	Extremely Poor: cities, high bldgs
0.001	5	Very Poor: cities, industrial
0.002	10	Sandy, dry
0.002	13	Poor: rocky, mountainous
0.005	**13**	**Average: pastoral, heavy clay**
0.006	13	Pastoral, med hills and forestation
0.0075	12	Flat, marshy, densely wooded
0.01	14	Pastoral, rich soil, US Midwest
0.0303	20	Very Good: pastoral, rich, central US
0.001	80	Fresh water
5	81	Salt water

Ok Cancel

Previous plots assumed average soil:
- Conductivity = 0.005 Siemens/meter
- Dielectric Constant = 13

Actual location:
- Salt water ~400' to the North West
- ~1000' to the East

For Salt Water:
- Conductivity = 5 Siemens/meter
- Dielectric Constant = 81

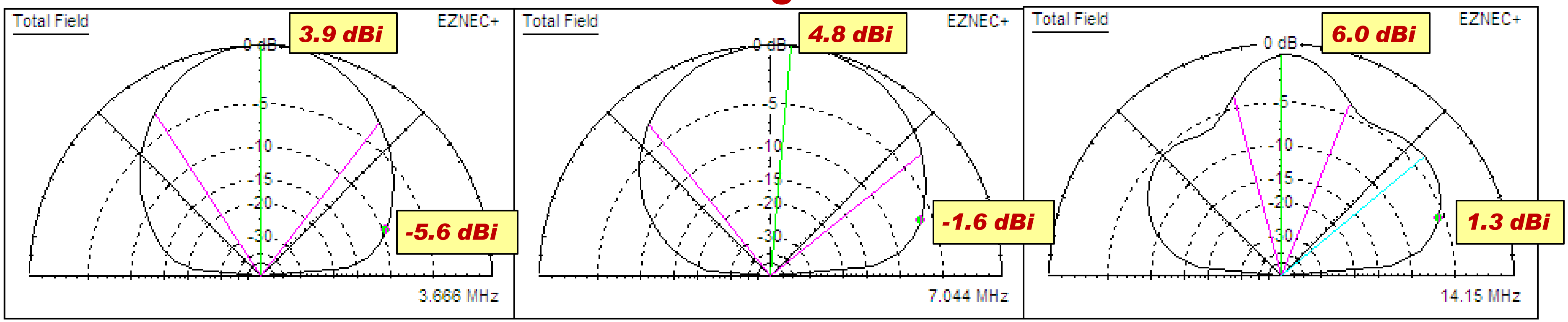
Experiment:
- "Average" soil for 400' circle
- Salt Water beyond that

EZNEC can have two different "soils" in a radial pattern:

400 ft

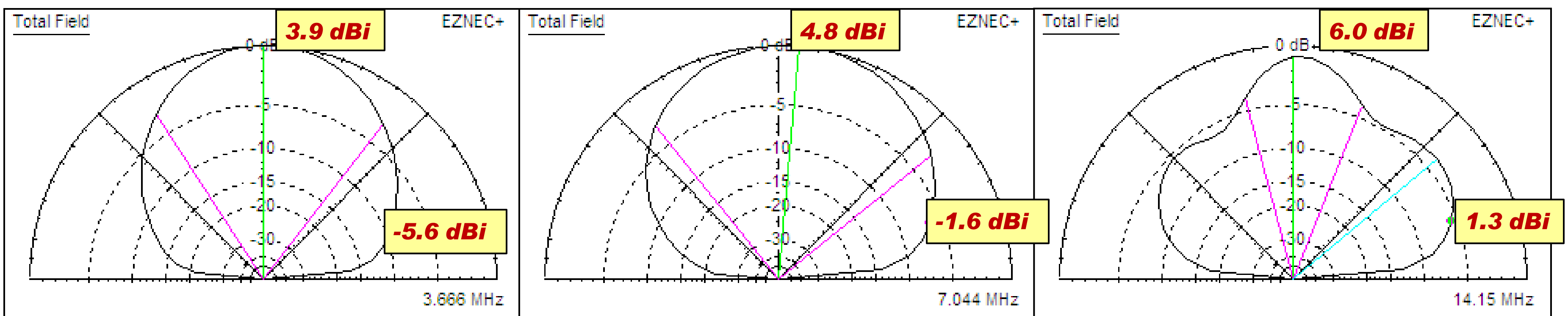
Effect of Salt Water→ Europe @ Elevation = 20°

“Average” Soil



80M: Δ = -9.5 dBi **40M: Δ= -6.4 dBi** **20M: Δ = -4.7 dBi**

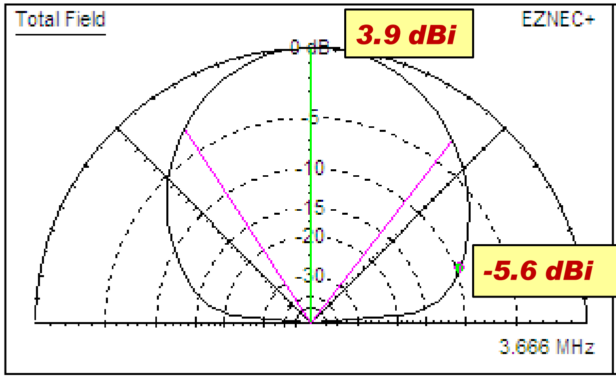
Salt Water at 400’ radius

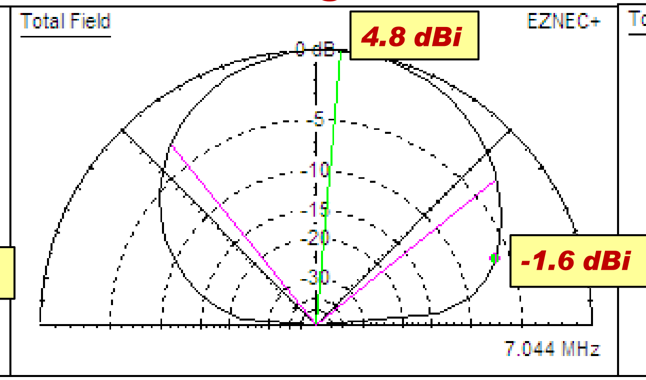


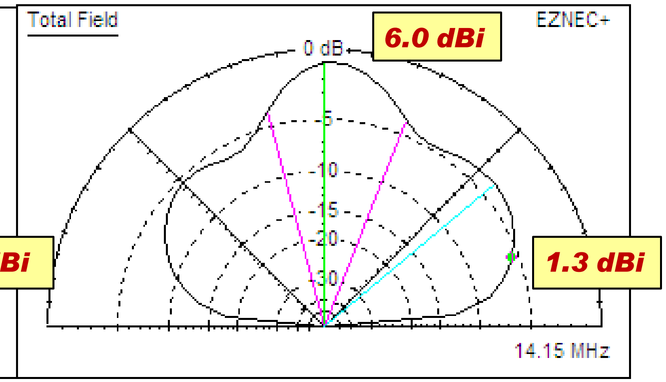
There is no difference!

Effect of Salt Water→ Europe @ Elevation = 20° A Test of the Method

"Average" Soil

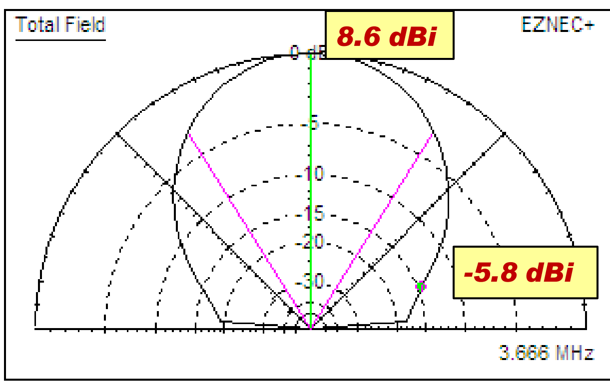


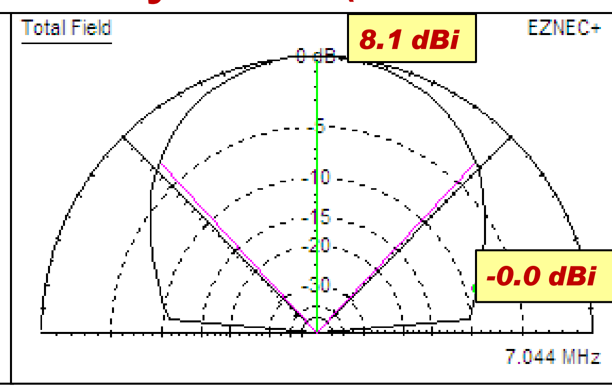


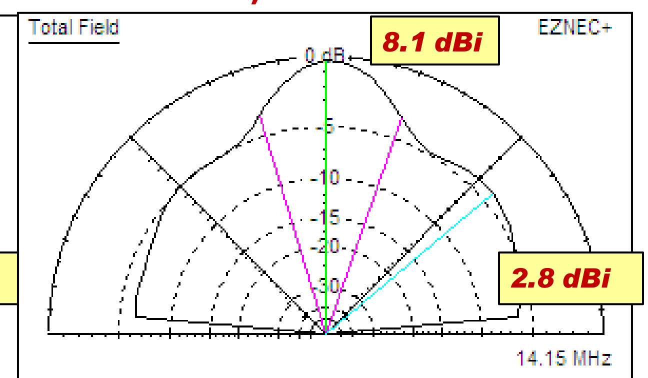


80M: Δ = -9.5 dBi 40M: Δ= -6.4 dBi 20M: Δ = -4.7 dBi

Salt Water everywhere (but house doesn't float!)





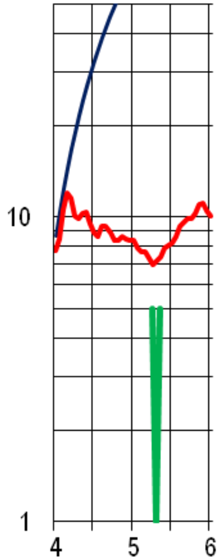


80M: Δ = -14.4 dBi 40M: Δ= -8.1 dBi 20M: Δ = -5.3 dBi

Don't use horizontal dipoles on a houseboat!

Modeling an 80/40/20M Fan Dipole for DX

Other HF Bands

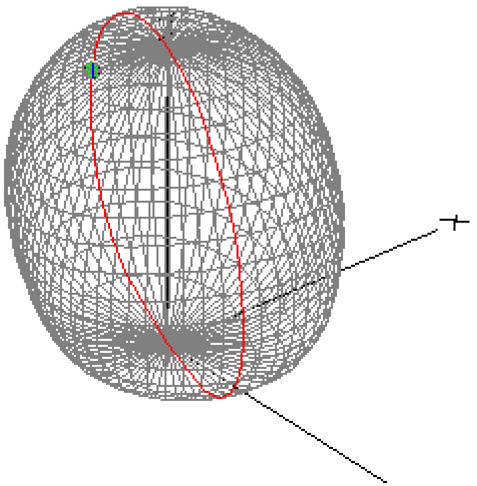


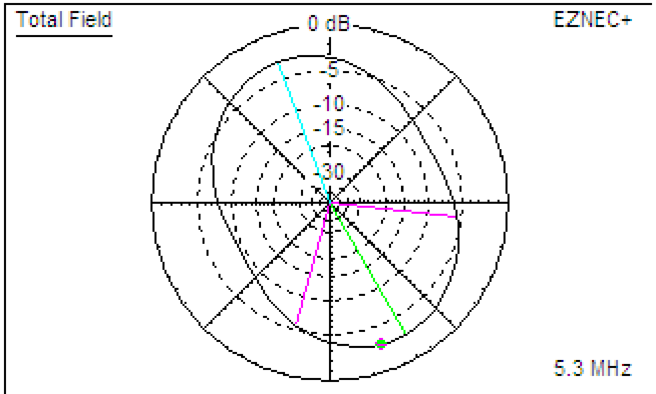
EZNEC patterns

60M ~ 5.3 MHz.

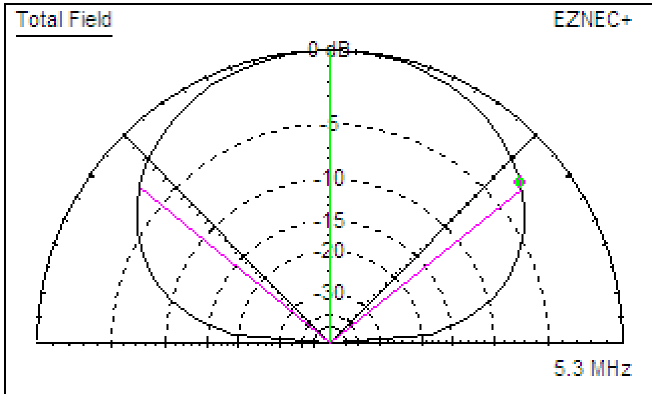
Height = ±0.09λ

SWR ~ 7.2:1

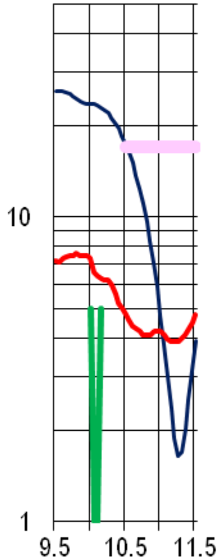




Azimuth Plot		Cursor Az	290.0 deg.
Elevation Angle	40.0 deg.	Gain	3.55 dBi
Outer Ring	6.4 dBi		-0.15 dBmax
			-2.85 dBmax3D
3D Max Gain	6.4 dBi		
Slice Max Gain	3.7 dBi @ Az Angle = 300.0 deg.		
Front/Back	0.4 dB		
Beamwidth	99.3 deg.; -3dB @ 254.2, 353.5 deg.		
Sidelobe Gain	3.47 dBi @ Az Angle = 110.0 deg.		
Front/Sidelobe	0.23 dB		

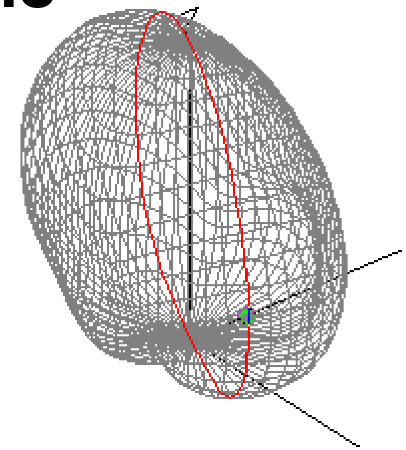


Elevation Plot		Cursor Elev	40.0 deg.
Azimuth Angle	290.0 deg.	Gain	3.55 dBi
Outer Ring	6.4 dBi		-2.81 dBmax
			-2.85 dBmax3D
3D Max Gain	6.4 dBi		
Slice Max Gain	6.36 dBi @ Elev Angle = 90.0 deg.		
Beamwidth	101.9 deg.; -3dB @ 38.8, 140.7 deg.		
Sidelobe Gain	< -100 dBi		
Front/Sidelobe	> 100 dB		

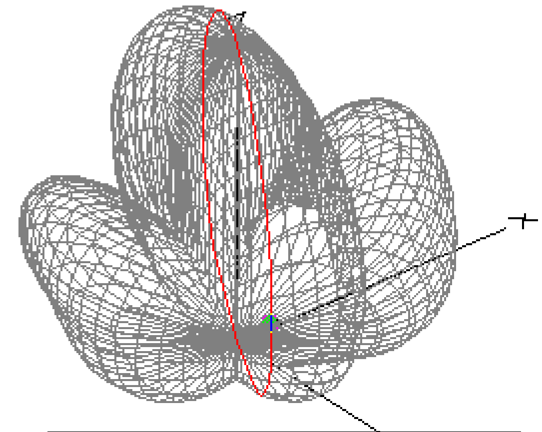


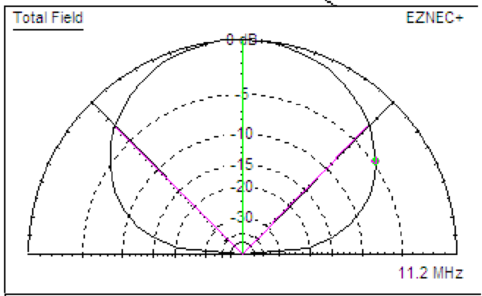
EZNEC patterns

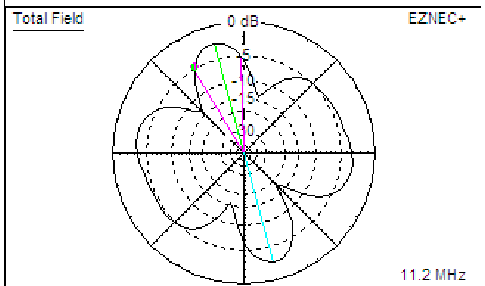
30M ~ 10.1 MHz
Height = ±0.18λ
SWR ~ 6.4:1

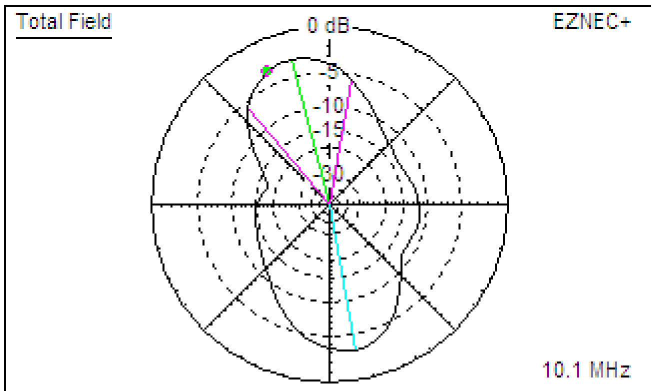


11.2 MHz.
3.9:1

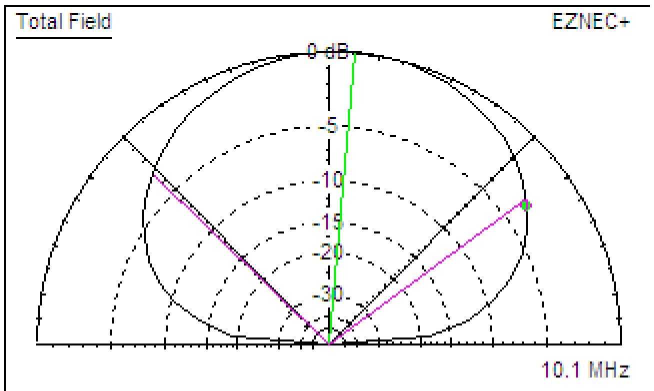




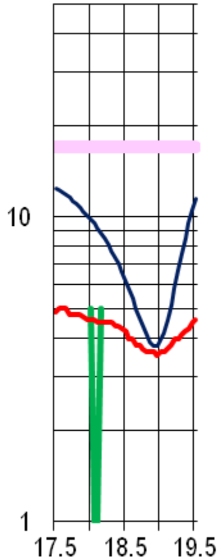




Azimuth Plot		Cursor Az	115.0 deg.
Elevation Angle	35.0 deg.	Gain	5.89 dBi
Outer Ring	9.14 dBi		-0.38 dBmax
			-3.25 dBmax3D
3D Max Gain	9.14 dBi		
Slice Max Gain	6.26 dBi @ Az Angle = 105.0 deg.		
Front/Back	0.42 dB		
Beamwidth	50.5 deg.; -3dB @ 79.6, 130.1 deg.		
Sidelobe Gain	6.02 dBi @ Az Angle = 280.0 deg.		
Front/Sidelobe	0.24 dB		

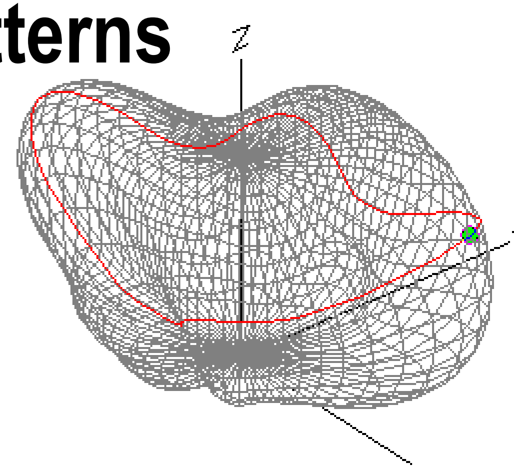


Elevation Plot		Cursor Elev	35.0 deg.
Azimuth Angle	115.0 deg.	Gain	5.89 dBi
Outer Ring	9.14 dBi		-3.24 dBmax
			-3.25 dBmax3D
3D Max Gain	9.14 dBi		
Slice Max Gain	9.12 dBi @ Elev Angle = 85.0 deg.		
Beamwidth	99.5 deg.; -3dB @ 36.5, 136.0 deg.		
Sidelobe Gain	< -100 dBi		
Front/Sidelobe	> 100 dB		

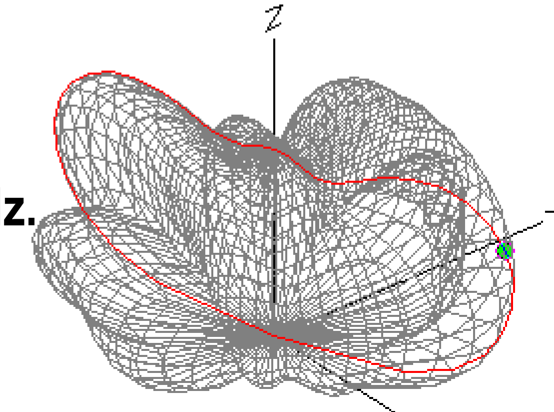


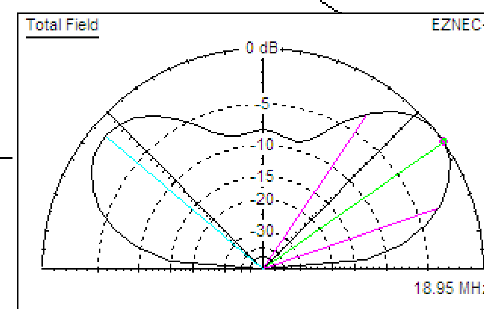
EZNEC patterns

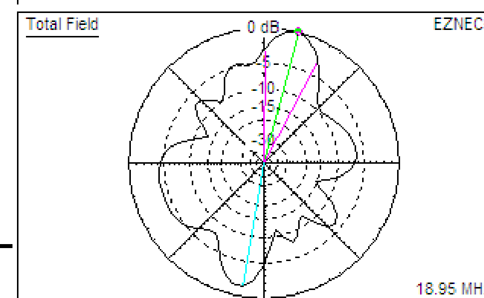
17M ~ 18.1 MHz
Height = ±0.32λ
SWR ~ 4.5:1

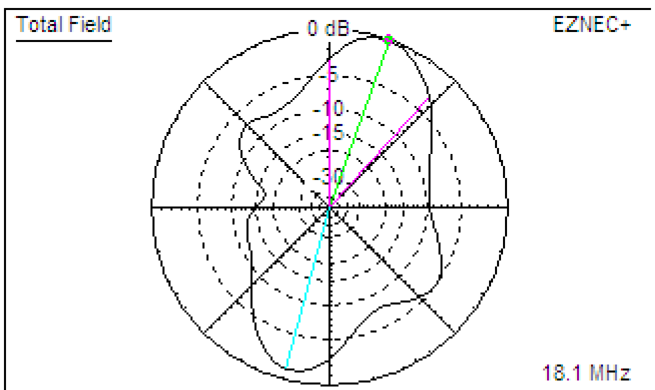


18.95 MHz.
3.5:1

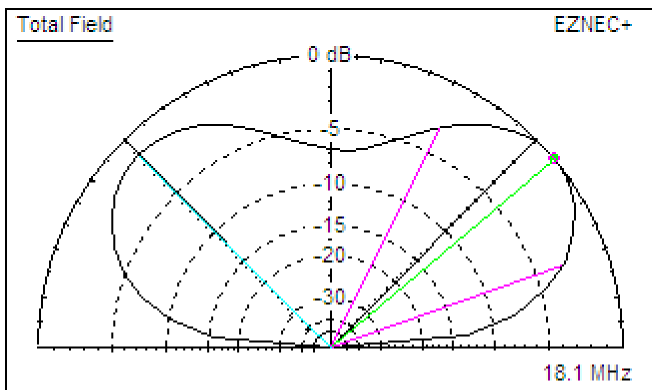








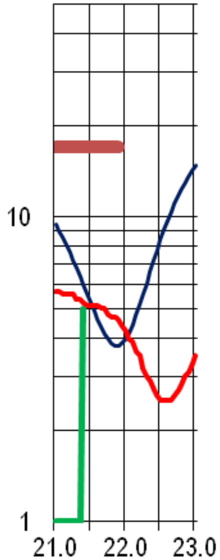
Azimuth Plot		Cursor Az	70.0 deg.
Elevation Angle	40.0 deg.	Gain	9.85 dBi
Outer Ring	9.85 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	9.85 dBi		
Slice Max Gain	9.85 dBi @ Az Angle = 70.0 deg.		
Front/Back	1.45 dB		
Beamwidth	42.2 deg.; -3dB @ 47.8, 90.0 deg.		
Sidelobe Gain	8.8 dBi @ Az Angle = 255.0 deg.		
Front/Sidelobe	1.05 dB		

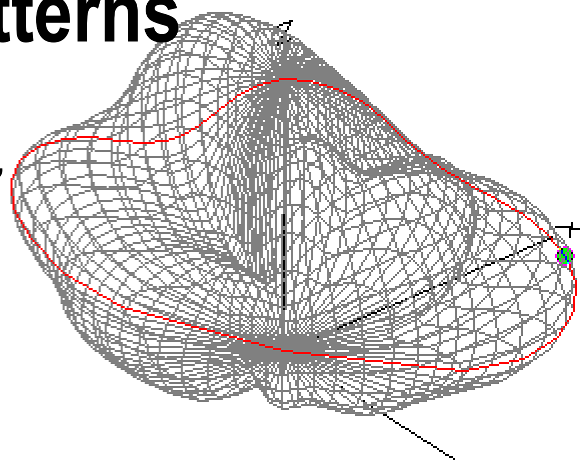


Elevation Plot		Cursor Elev	40.0 deg.
Azimuth Angle	70.0 deg.	Gain	9.85 dBi
Outer Ring	9.85 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	9.85 dBi		
Slice Max Gain	9.85 dBi @ Elev Angle = 40.0 deg.		
Beamwidth	43.7 deg.; -3dB @ 19.5, 63.2 deg.		
Sidelobe Gain	8.56 dBi @ Elev Angle = 135.0 deg.		
Front/Sidelobe	1.29 dB		

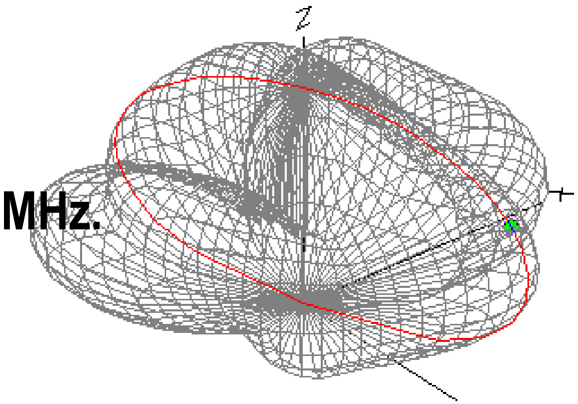
EZNEC patterns

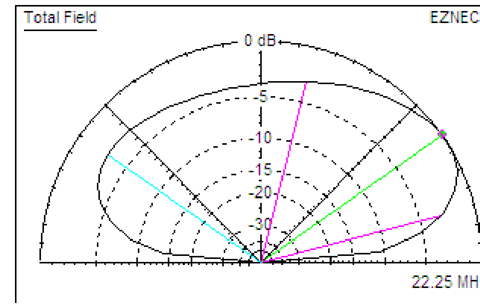
15M ~ 21.2 MHz
Height = ±0.37λ
SWR ~ 5.6:1

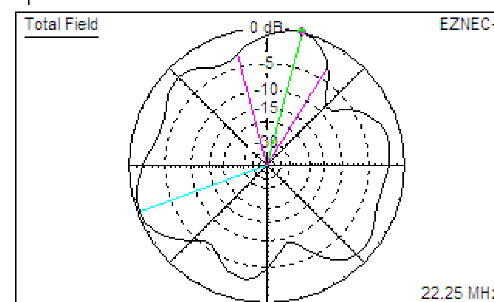


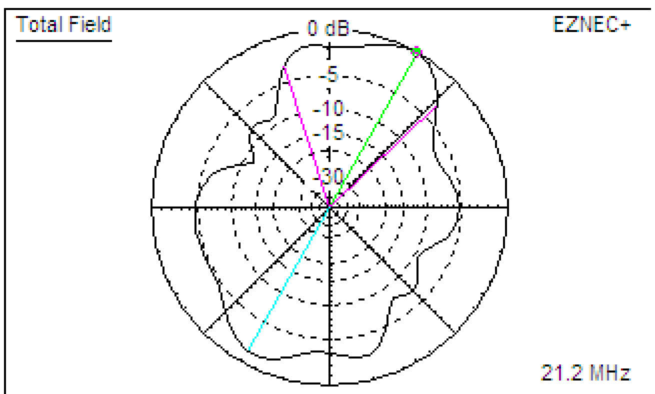


22.25 MHz.
2.5:1

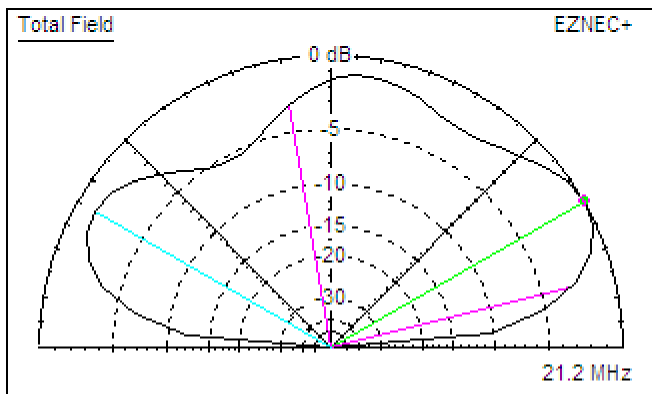








Azimuth Plot		Cursor Az	60.0 deg.
Elevation Angle	30.0 deg.	Gain	8.2 dBi
Outer Ring	8.2 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	8.2 dBi		
Slice Max Gain	8.2 dBi @ Az Angle = 60.0 deg.		
Front/Back	1.17 dB		
Beamwidth	64.0 deg.; -3dB @ 43.7, 107.7 deg.		
Sidelobe Gain	7.03 dBi @ Az Angle = 240.0 deg.		
Front/Sidelobe	1.17 dB		

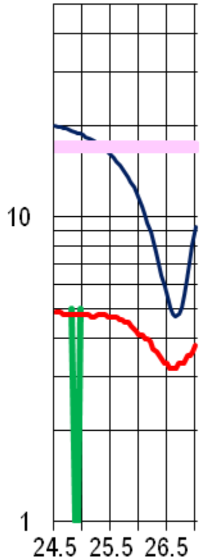


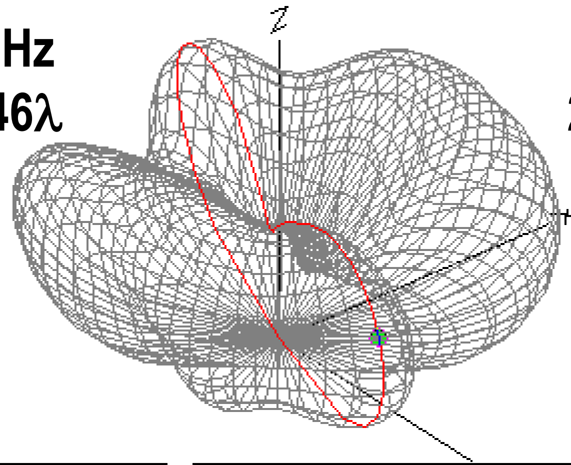
Elevation Plot		Cursor Elev	30.0 deg.
Azimuth Angle	60.0 deg.	Gain	8.2 dBi
Outer Ring	8.2 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	8.2 dBi		
Slice Max Gain	8.2 dBi @ Elev Angle = 30.0 deg.		
Beamwidth	85.9 deg.; -3dB @ 13.9, 99.8 deg.		
Sidelobe Gain	7.03 dBi @ Elev Angle = 150.0 deg.		
Front/Sidelobe	1.17 dB		

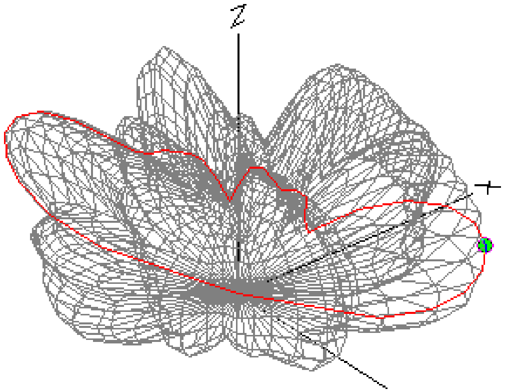
EZNEC patterns

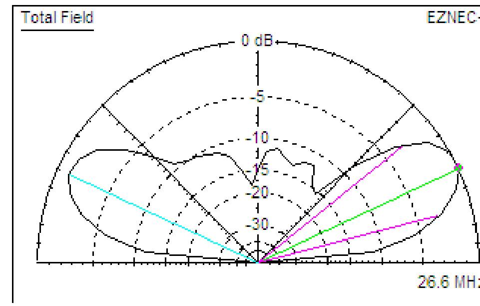
12M ~ 24.95 MHz
Height = ±0.46λ
SWR ~ 4.8:1

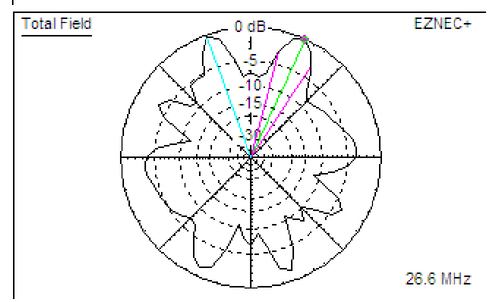
26.6 MHz.
3.2:1

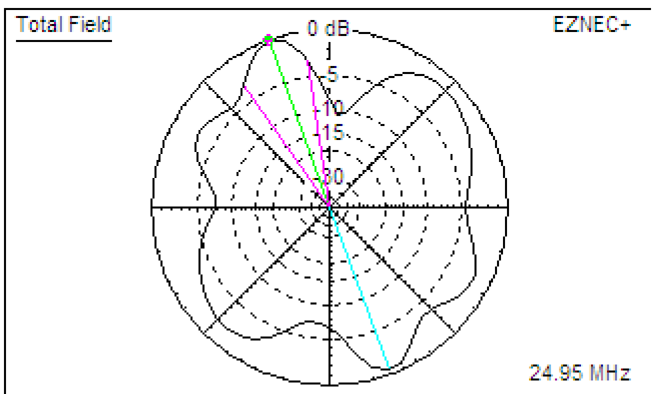






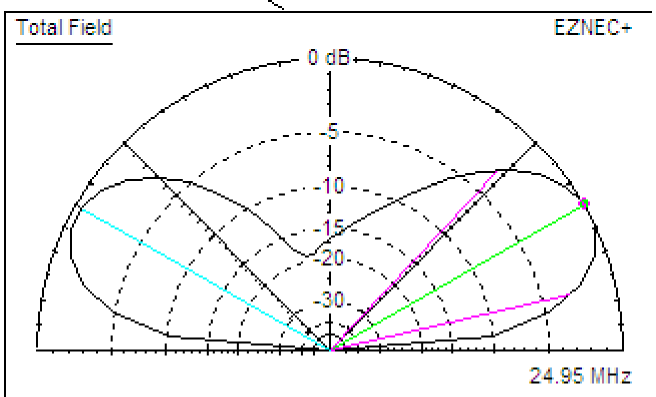






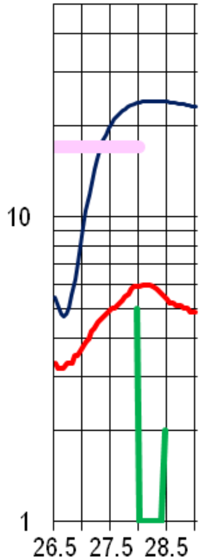
Azimuth Plot — Cursor Az 110.0 deg.
Elevation Angle 30.0 deg. — Gain 8.51 dBi
Outer Ring 8.51 dBi — 0.0 dBmax
0.0 dBmax3D

3D Max Gain 8.51 dBi
Slice Max Gain 8.51 dBi @ Az Angle = 110.0 deg.
Front/Back 0.42 dB
Beamwidth 26.3 deg.; -3dB @ 98.8, 125.1 deg.
Sidelobe Gain 8.09 dBi @ Az Angle = 290.0 deg.
Front/Sidelobe 0.42 dB



Elevation Plot — Cursor Elev 30.0 deg.
Azimuth Angle 110.0 deg. — Gain 8.51 dBi
Outer Ring 8.51 dBi — 0.0 dBmax
0.0 dBmax3D

3D Max Gain 8.51 dBi
Slice Max Gain 8.51 dBi @ Elev Angle = 30.0 deg.
Beamwidth 33.5 deg.; -3dB @ 13.4, 46.9 deg.
Sidelobe Gain 8.09 dBi @ Elev Angle = 150.0 deg.
Front/Sidelobe 0.42 dB

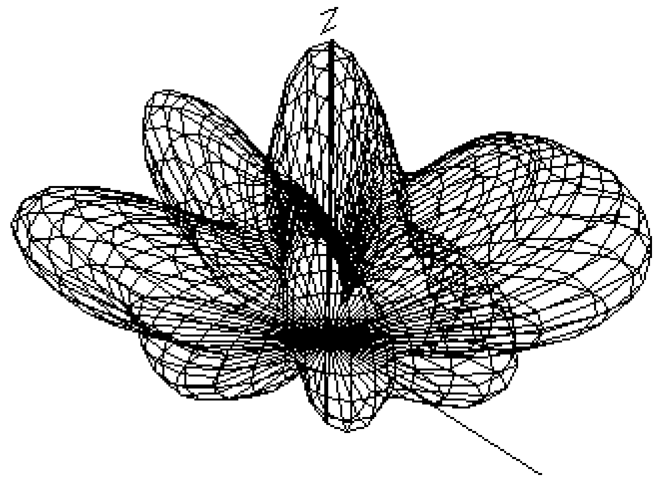


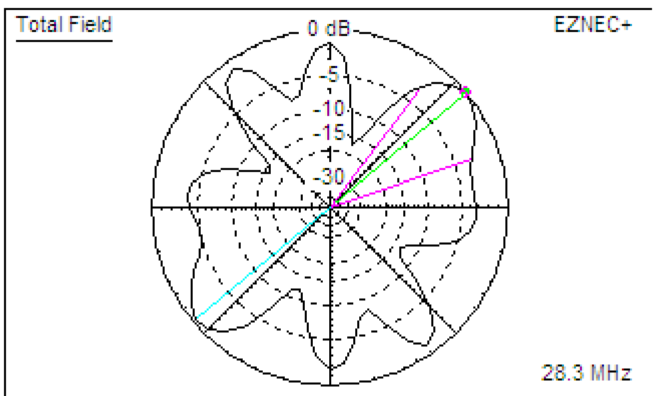
EZNEC patterns

10M ~ 28.3 MHz

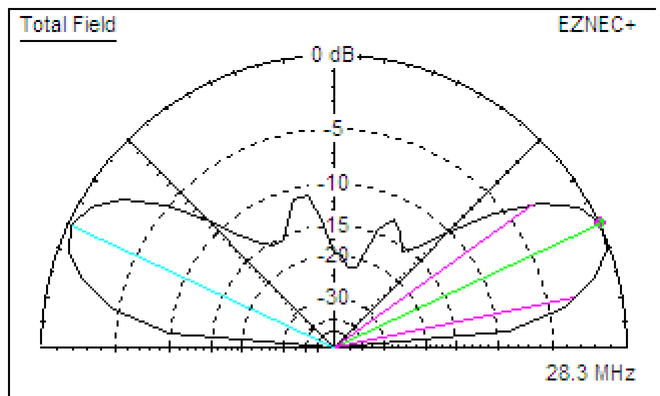
Height = ±0.55λ

SWR ~ 5.8:1





Azimuth Plot		Cursor Az	40.0 deg.
Elevation Angle	25.0 deg.	Gain	9.59 dBi
Outer Ring	9.59 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	9.59 dBi		
Slice Max Gain	9.59 dBi @ Az Angle = 40.0 deg.		
Front/Back	0.27 dB		
Beamwidth	34.5 deg.; -3dB @ 18.5, 53.0 deg.		
Sidelobe Gain	9.32 dBi @ Az Angle = 220.0 deg.		
Front/Sidelobe	0.27 dB		



Elevation Plot		Cursor Elev	25.0 deg.
Azimuth Angle	40.0 deg.	Gain	9.59 dBi
Outer Ring	9.59 dBi		0.0 dBmax
			0.0 dBmax3D
3D Max Gain	9.59 dBi		
Slice Max Gain	9.59 dBi @ Elev Angle = 25.0 deg.		
Beamwidth	24.0 deg.; -3dB @ 11.7, 35.7 deg.		
Sidelobe Gain	9.32 dBi @ Elev Angle = 155.0 deg.		
Front/Sidelobe	0.27 dB		

Modeling an 80/40/20M Fan Dipole for DX

Thank You

www.qsl.net/w1dyj