Terrain Assessment for HF Contesting

Higher isn't necessarily better…

By Dean Straw, N6BV

at Sea-Pac, Friday, June 6, 2014

Sunset at N6RO acres

A few feathered friends on one of N6RO’s 10-meter Yagis

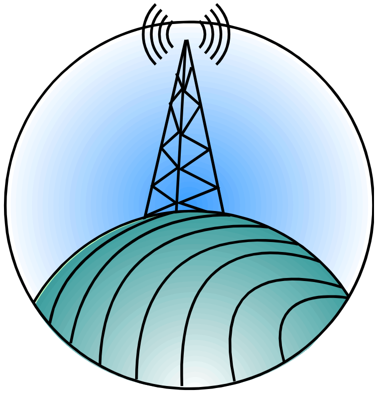
"The subject of how to choose a QTH for working DX has fascinated hams since the beginning of amateur operations. No doubt, Marconi spent a lot of time wandering around Newfoundland looking for a great radio QTH before making the first transatlantic transmission."

The ARRL Antenna Book, 22st Ed.

Scientifically Planning a Station

There are three elements needed to plan an HF station *scientifically*:

- The range of elevation angles needed.



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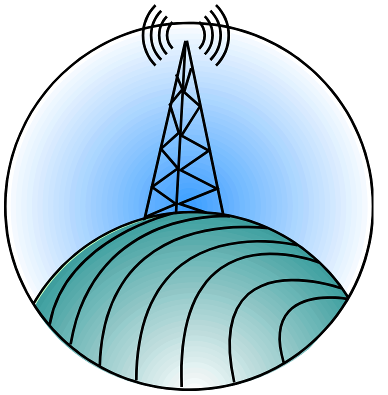

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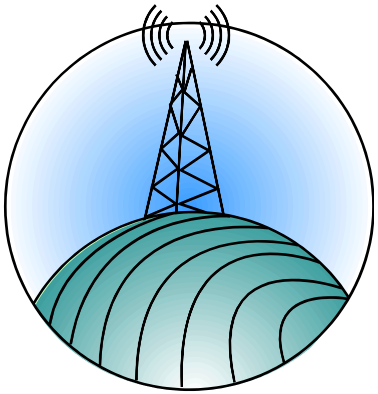

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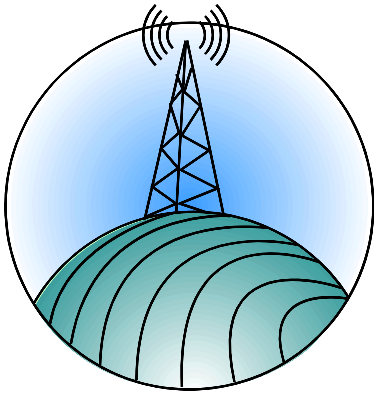
Which is most important? … Terrain!



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- I used the *IONCAP* program (now upgraded to *VOACAP*), along with some proprietary software I wrote.
- Later, I upgraded the statistics using corrected *IONCAP* loss tables in the latest version of *VOACAP*, plus more receiver QTHs.

Statistical Range of Elevation Angles Needed, by Band

Boston, Ma to Europe

Elev	80m	40m	30m	20m	17m	15m	12m	10m
1	3.6	5.5	4.4	2.5	2.7	3.5	4.7	5.1
2	3.7	3.1	5.2	3.0	2.9	3.6	3.9	3.8
3	1.3	1.1	3.8	5.3	4.6	3.8	4.5	8.0
4	2.4	2.8	6.5	9.3	10.8	10.6	8.2	5.8
5	3.6	4.9	6.7	8.7	11.0	10.9	12.0	10.9
6	6.4	6.3	5.4	6.8	7.0	9.6	10.3	9.9
7	5.5	7.8	4.7	4.6	5.5	6.4	7.9	6.0
8	3.7	4.5	4.0	3.6	4.8	5.5	6.5	6.9
9	2.3	4.8	6.6	5.4	6.1	6.3	6.4	10.4
10	1.5	4.0	6.4	6.8	5.3	5.0	3.8	5.1
11	2.5	4.0	6.8	7.4	6.5	5.0	4.9	4.6
12	4.2	4.4	5.2	5.4	5.9	5.5	4.7	5.8
13	6.3	5.1	3.8	4.6	4.1	3.9	3.6	2.7
14	4.9	3.8	3.6	3.2	3.4	3.5	3.9	4.0
15	3.5	4.4	2.9	3.1	2.2	2.5	1.7	1.6
16	3.1	5.2	3.7	3.6	3.2	2.0	2.9	2.0
17	4.1	4.3	3.2	3.1	2.4	2.4	1.8	0.7
18	4.3	2.9	2.2	2.6	2.8	2.1	2.4	2.2
19	4.6	3.0	2.3	1.8	1.4	1.3	0.7	0.4
20	4.9	3.1	2.2	1.6	1.8	2.0	2.0	2.4
21	4.3	2.8	2.6	1.5	0.7	0.8	1.2	0.4
22	4.3	2.5	2.4	1.8	1.0	1.1	1.1	1.1
23	3.5	2.1	1.7	1.2	0.6	0.4	0.1	0.0
24	2.5	2.0	1.1	0.9	0.8	0.3	0.3	0.0
25	2.3	1.3	0.7	0.7	0.5	0.2	0.1	0.0
26	2.7	1.1	0.6	0.5	0.6	0.6	0.1	0.0
27	1.9	0.5	0.4	0.2	0.2	0.2	0.2	0.0
28	0.8	0.6	0.3	0.2	0.3	0.4	0.0	0.0
29	0.5	0.4	0.2	0.1	0.2	0.3	0.0	0.0
30	0.2	0.4	0.2	0.1	0.3	0.1	0.0	0.0

Example: elevation angles from Boston to Europe on 20m.

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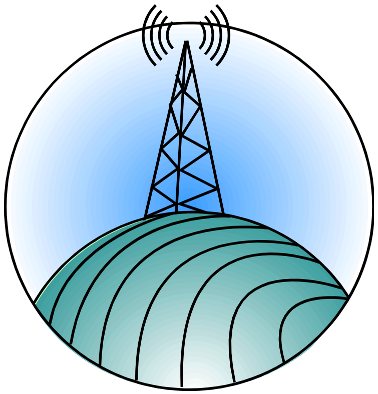

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- Most modern modeling programs, such as *EZNEC*, are derived from *NEC-2* FORTRAN code.
- *NEC-2* works fine over flat ground or in free space — it doesn't do so well, however, when *diffractions* occur over real-world ground terrain.

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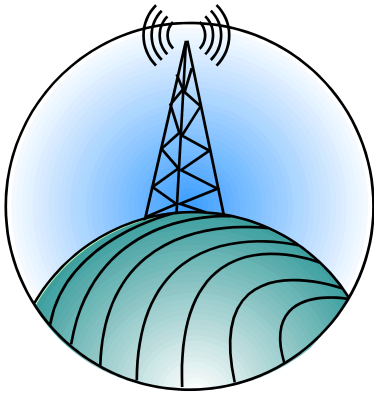

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- In other presentations and Webinars, I've dealt in great detail with how to get digital terrain data to use within *HFTA*. (I won't dwell on getting terrain data here, but do conduct a search for *HFTA.pdf* on the ARRL Web site.)

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- In other presentations and Webinars, I've dealt in great detail with how to get digital terrain data to use within *HFTA*. (I won't dwell on getting terrain data here.)
- Instead, this presentation is about how you can interpret *HFTA* results so that you can optimize your HF antenna system.

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- Back about 1991, Bill Myers, K1GQ, shared with me some computer code that ray-traced reflections across real-world terrain.
- Bill inspired me to add the ability to take diffractions into account — thus was born the DOS program *YT (Yagi Terrain Analysis)*, and eventually the *HFTA* program.

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The *HFTA* Program

- *HFTA* stands for “High Frequency Terrain Assessment.”
- *HFTA* is a ray-tracing program.
- Consider it like a rifle, shooting bullets in steps of 1/4° from +45 ° to –45°, and watching how the bullets interact with the ground terrain.
- *HFTA* calculates reflections and diffractions over the terrain.

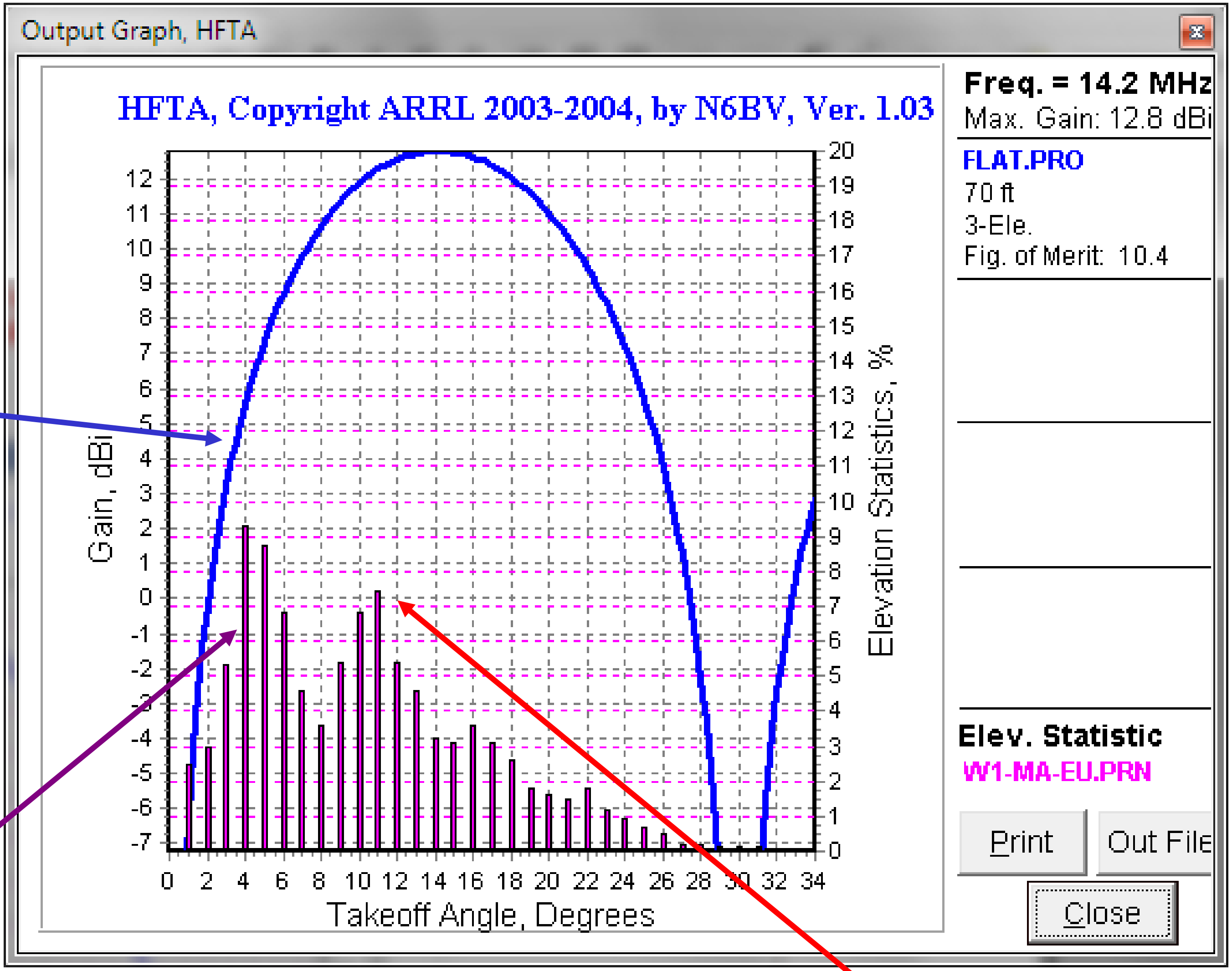
The *HFTA* Program

- *HFTA* integrates the computed elevation response of an antenna array with the elevation angles statistically necessary to launch HF signals into the ionosphere.

Gain & Elevation-Angle Statistics

Elevation response of 3-element Yagi at 70' over flat ground

Elevation-angle stats

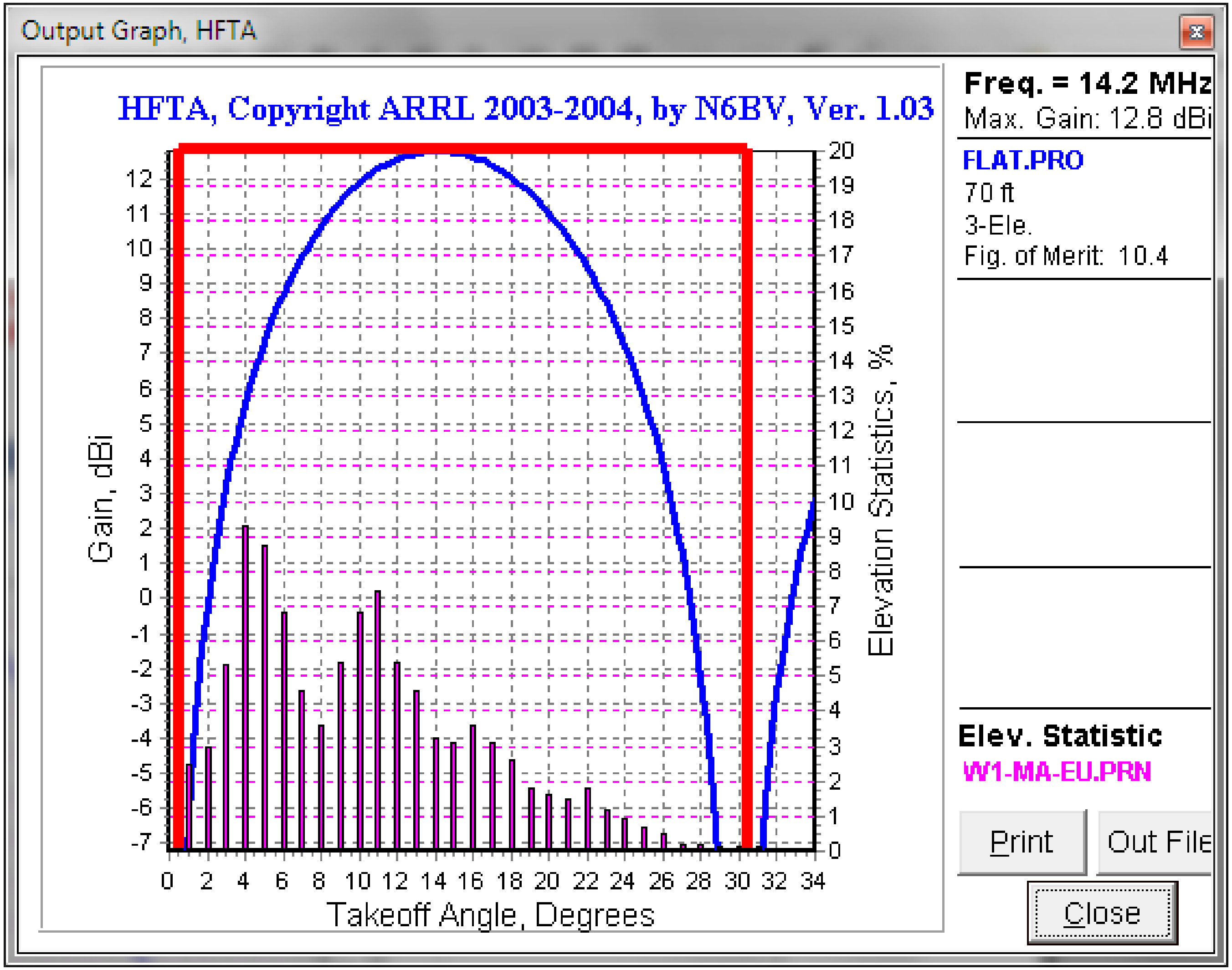


7.4% of all the times 20 m is open to EU from W1, the angle is 11º

The *HFTA* Program

- *HFTA* integrates the computed elevation response of an antenna array with the elevation angles statistically necessary to launch HF signals into the ionosphere.
- *HFTA* shows what angles you need and what gain you get over a particular terrain.

Covering All the Angles…

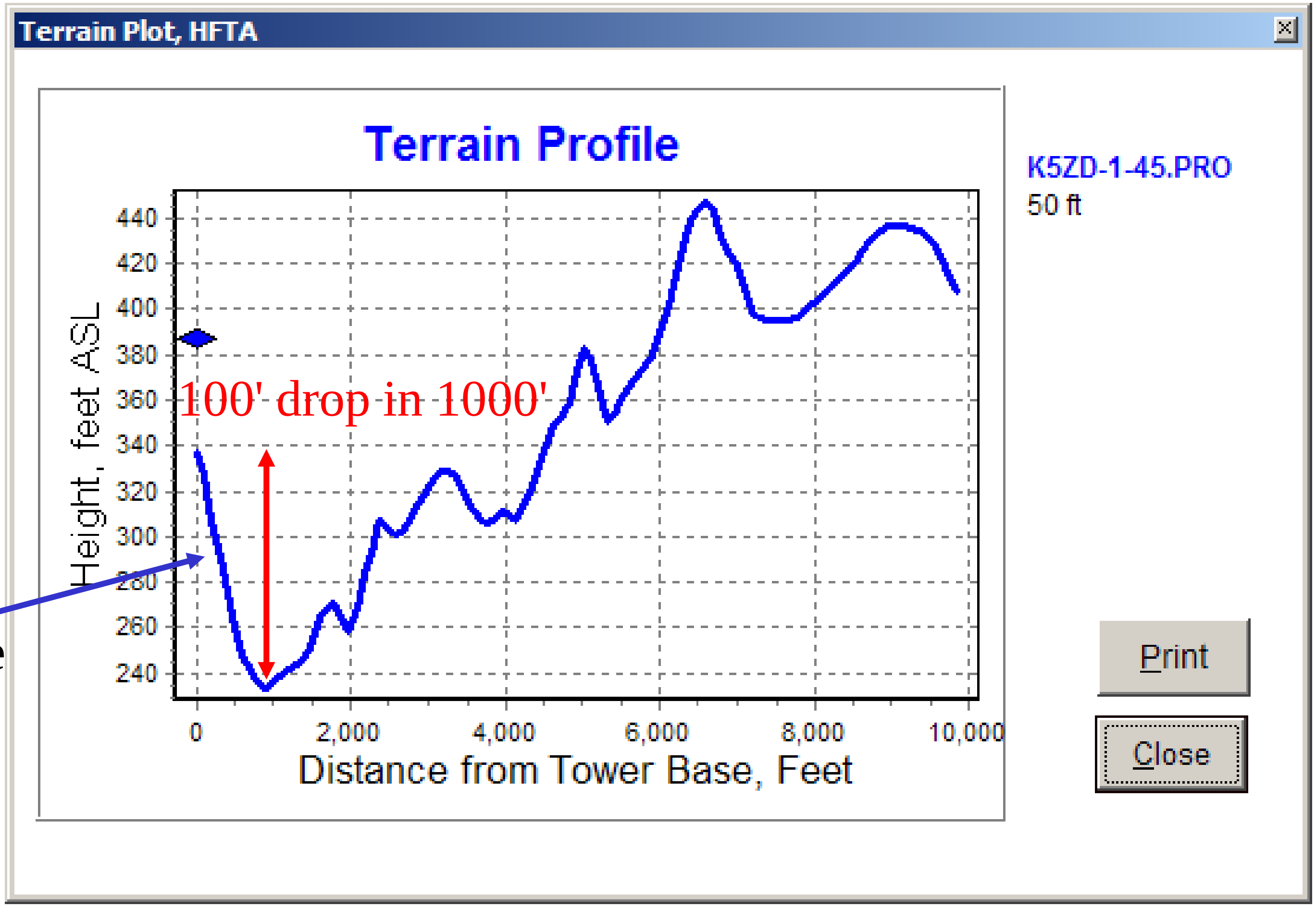


"Perfect" response to cover all the necessary angles

The *HFTA* Program

- *HFTA* integrates the computed elevation response of an antenna array with the elevation angles statistically necessary to launch HF signals into the ionosphere.
- *HFTA* shows what angles you need and what gain you get over a particular terrain.
- As usual, several pictures are worth at least a thousand words.

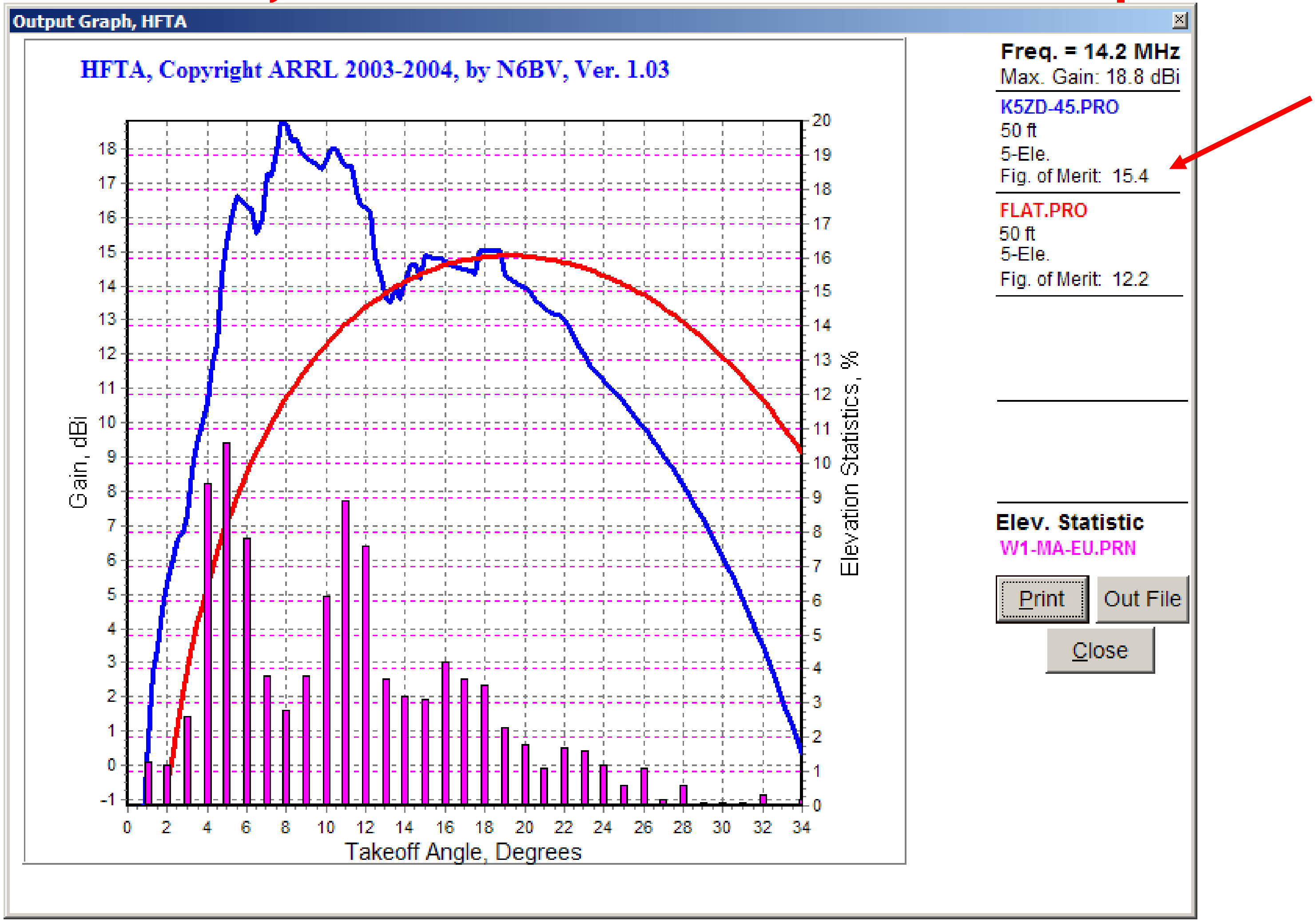
Local Terrain, an Example



Slope nearest tower base is most important

Terrain at K5ZD/1 in Massachusetts, towards Europe.

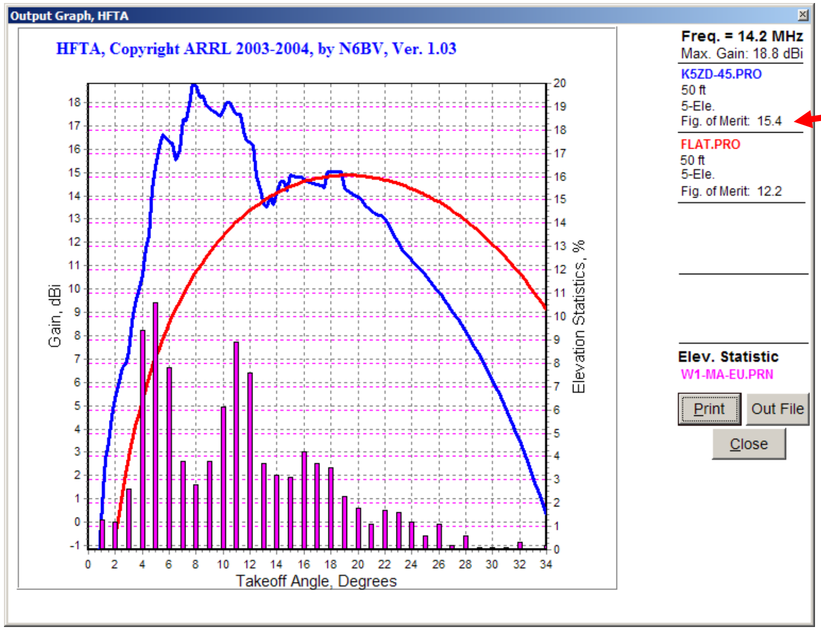
Results, K5ZD Towards Europe



K5ZD's steep terrain has a major effect compared to a flatland antenna. Note "Fig. of Merit" (FOM).

The *Figure of Merit* in *HFTA*

• The Fig. of Merit (FOM) shown in *HFTA* is the gain at each elevation angle multiplied by the elevation-angle percentage for that angle for a particular path, summed and averaged over all angles from 1 to 35°.

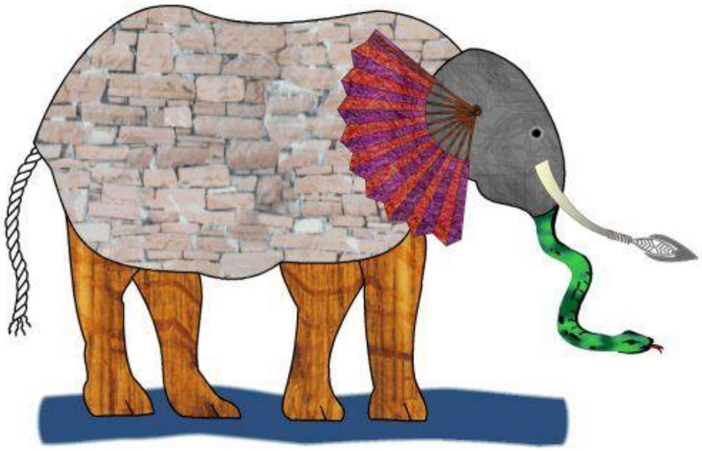


FOM

The *Figure of Merit* in *HFTA*

- FOM is a statistical "weighted gain," calibrated in dBi. It is a "snapshot" of performance. Like any snapshot, FOM must be used carefully.

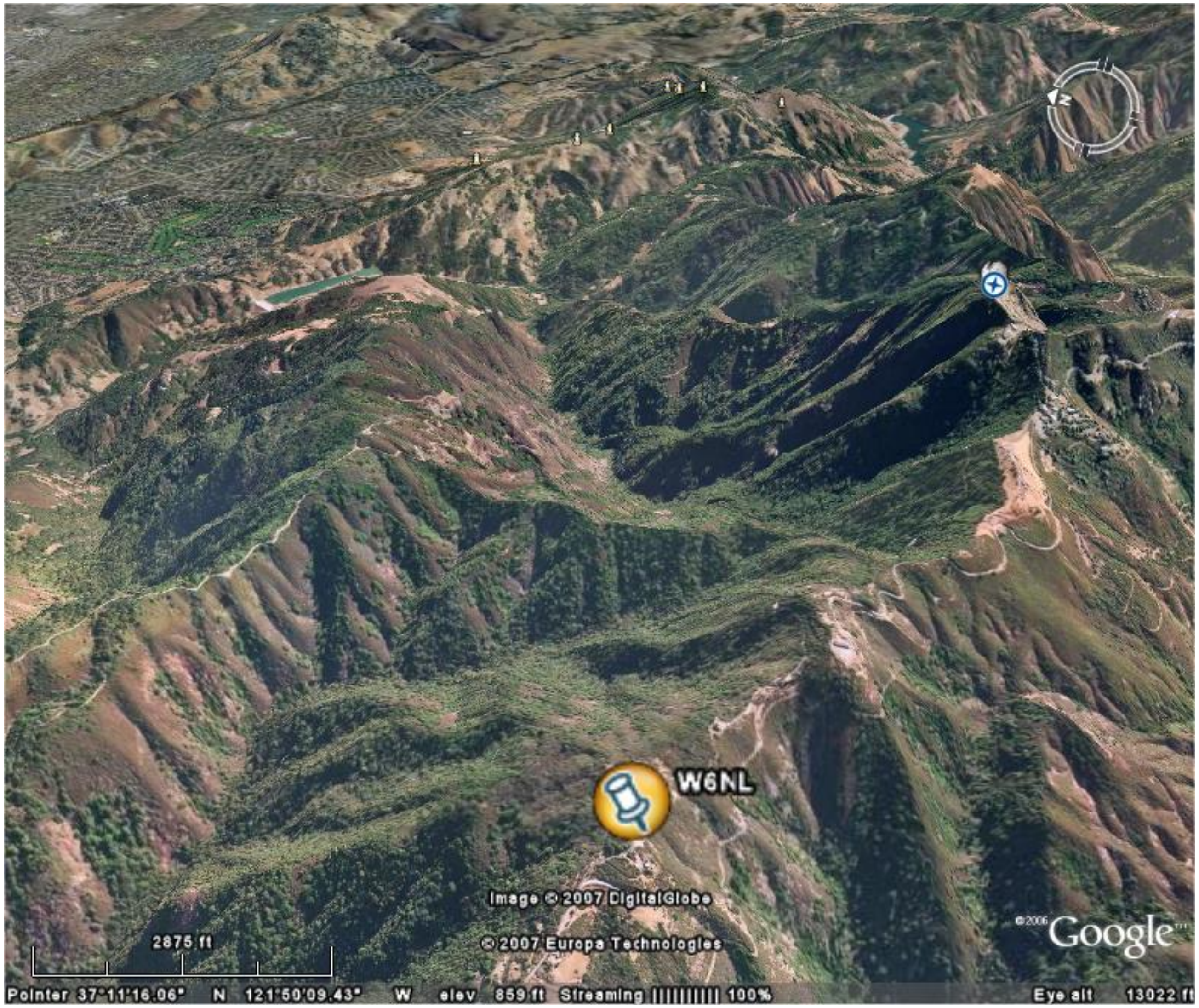
Remember the story of the three blind men and the elephant?



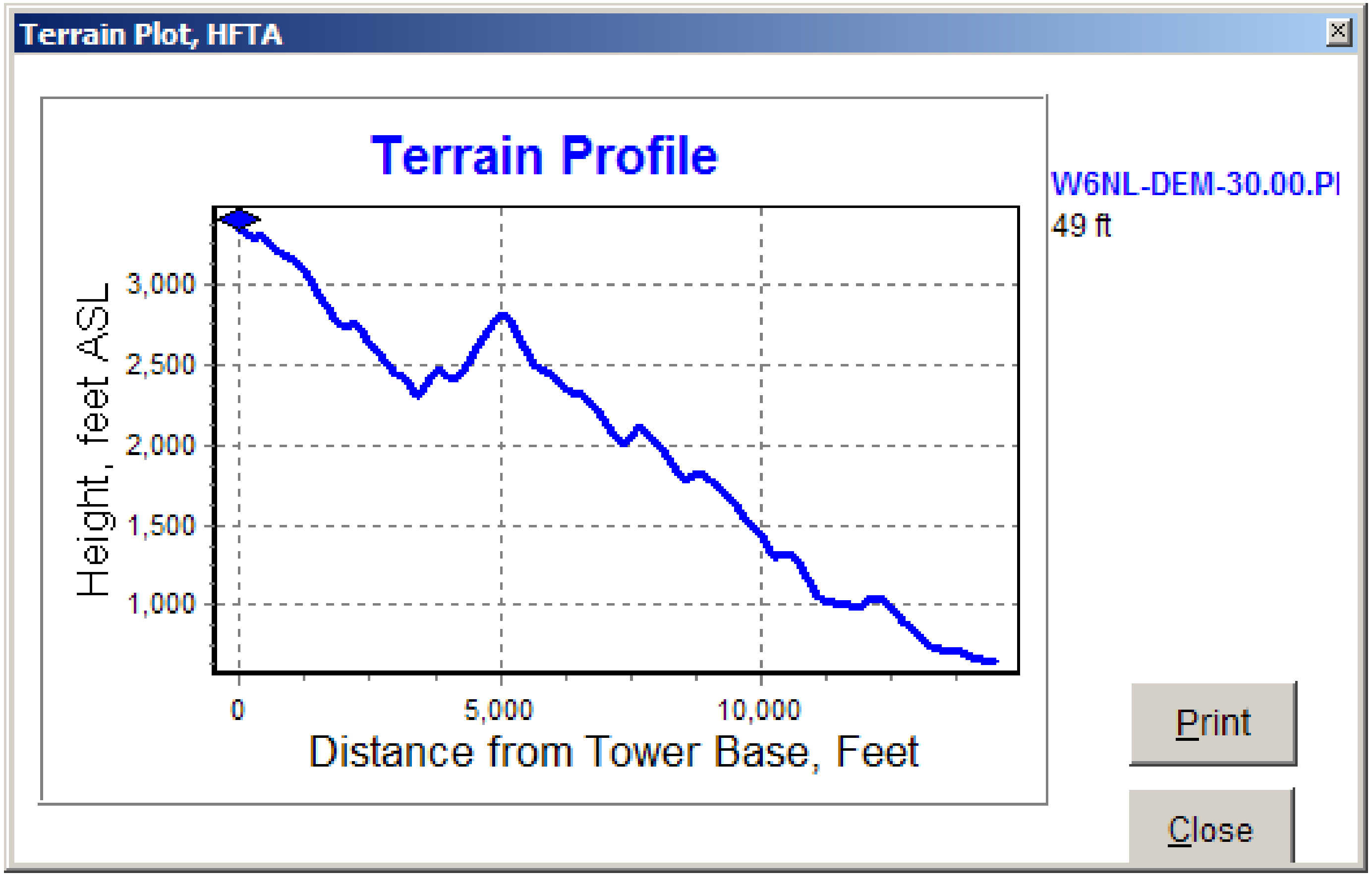
The *Figure of Merit* in *HFTA*

- FOM is a statistical "weighted gain," calibrated in dBi. It is a "snapshot" of performance. Like any snapshot, FOM must be used carefully.
- FOMs change depending on the terrain in direction of the target receiving area and on the frequency.

W6NL Towards the USA

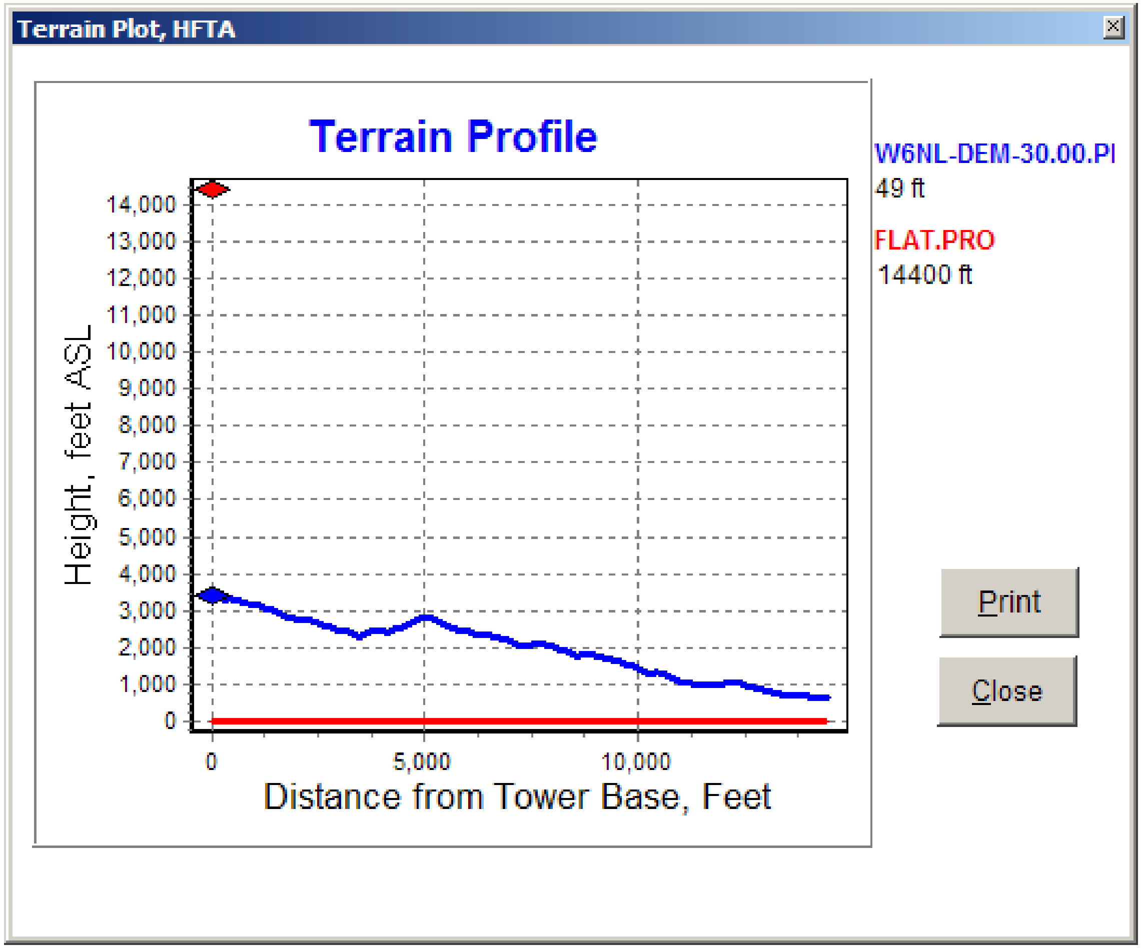


First, Some Perspective on Terrain



Scaling for x- and y-axes is set automatically in *HFTA* to show terrain changes most vividly.

True Perspective



Using same scales for x- and y-axes. (Note my trick of placing antenna 14,400 feet above flat terrain.)

What Can I Change Using *HFTA*?

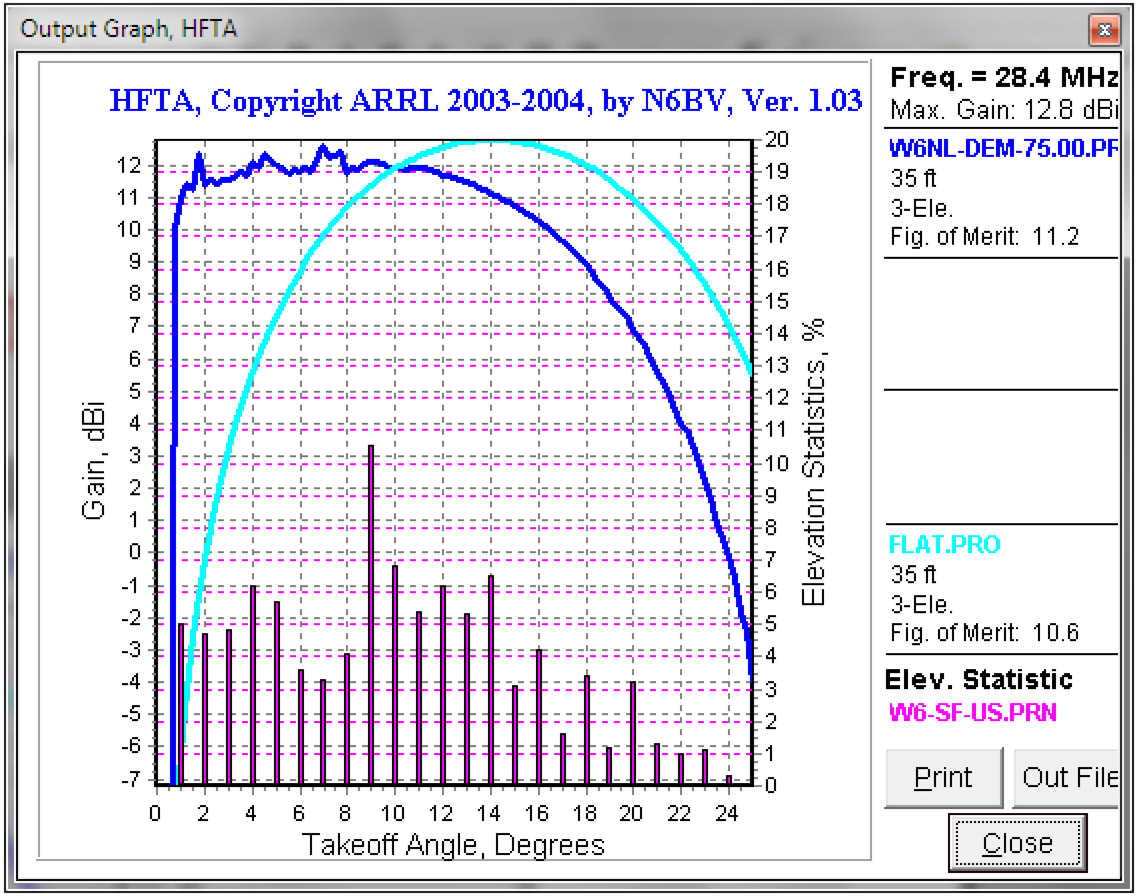
1. Antenna height above ground.
2. Select gain (number of elements for a Yagi).
3. Stack two (or more) Yagis.
4. Change spacing between stacked Yagis.
5. Move tower back from a cliff (or a hill).
6. Do BIP/BOP (Both In-Phase/Both Out-of-Phase).

Let's examine each of these.

What Can I Change Using *HFTA*?

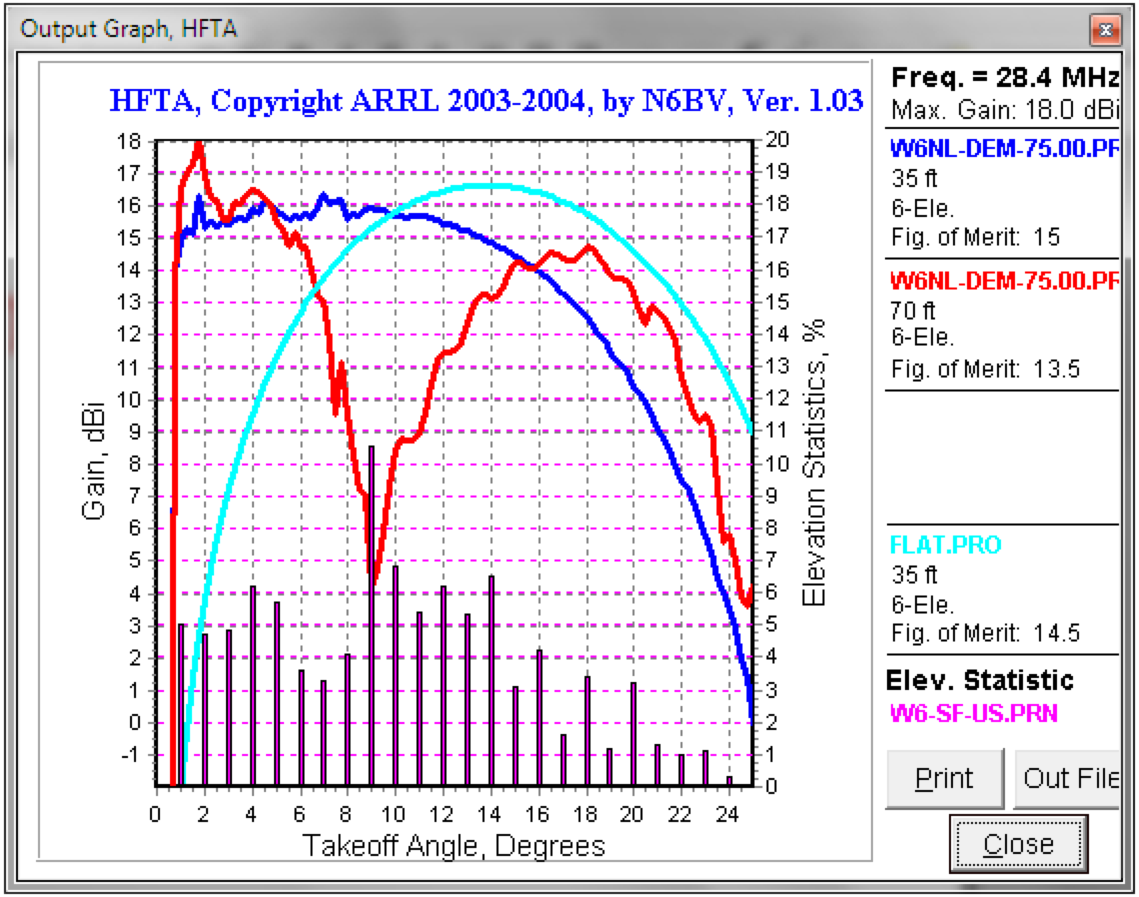
1. Antenna height above ground.

The Effect of Antenna Height



Because of the steep slope at W6NL, a 35-foot high 20-meter antenna can cover both low and high angles well. Note the reference antenna at 35 feet over flat ground.

High Tower on a Steep Hill?



A 70-foot high 20-meter antenna has a big null at 9º, the highest-percentage elevation angle. 70 feet is too high!

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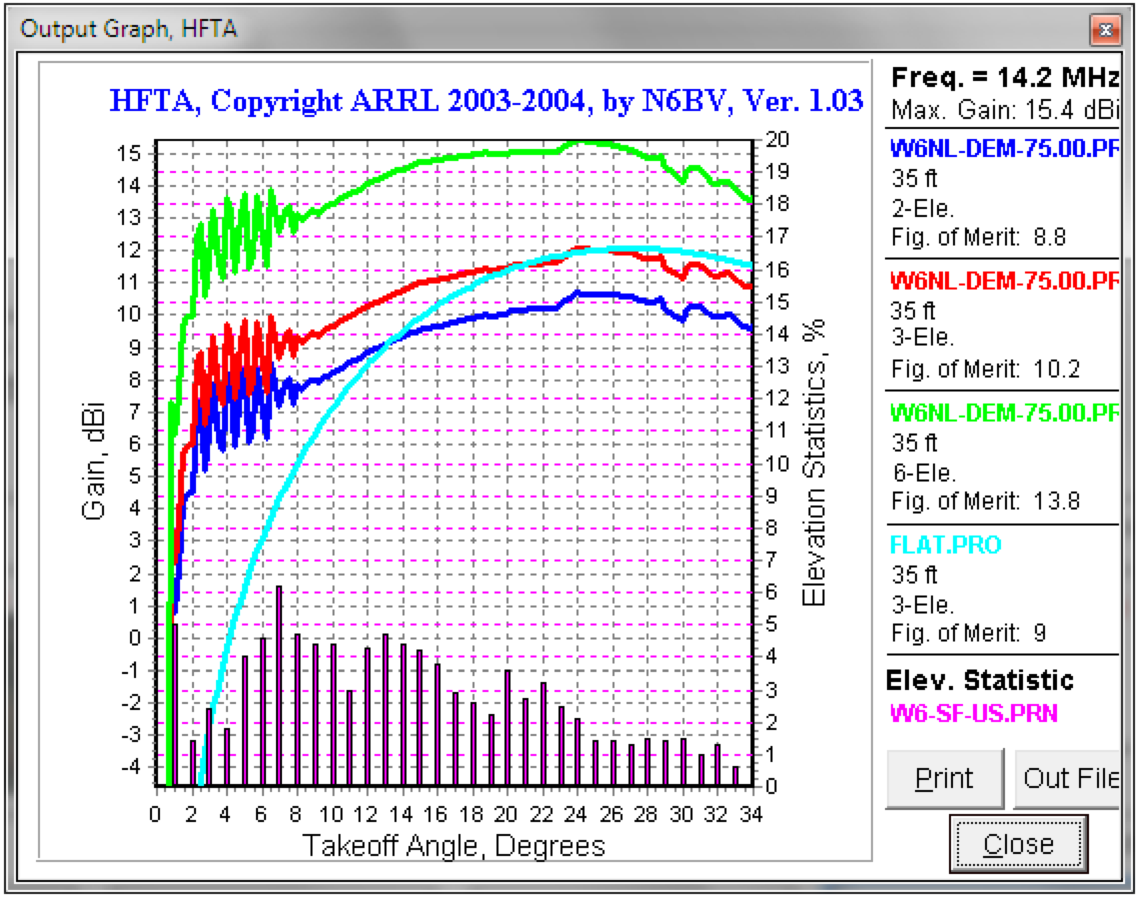
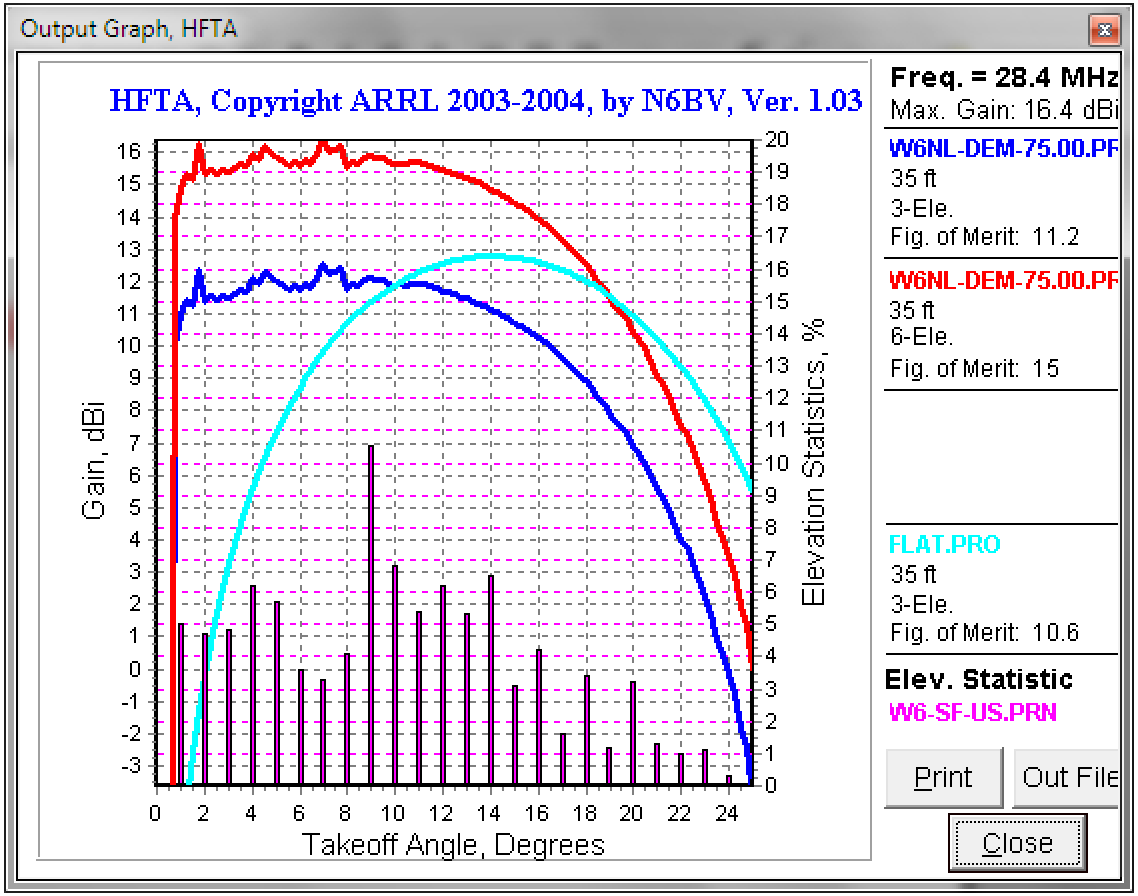
Antenna Gain —No. of Elements



Note the shape of the responses over real terrain compared to flat ground.

Need More Gain?



With six elements the gain increases, but the shape of the elevation pattern doesn’t change. The response shape is set by the terrain and the antenna height.

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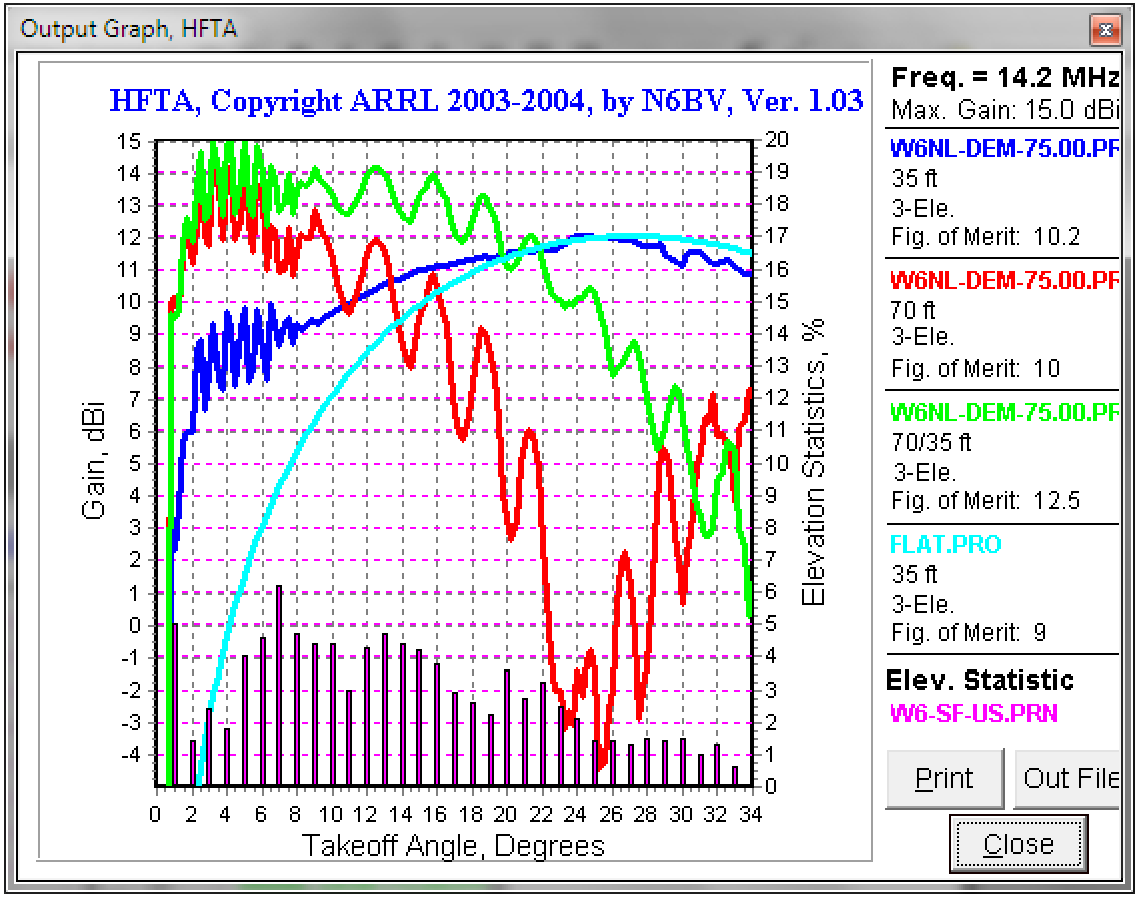
3. Stack two (or more) Yagis.

Stacking 3L/3L at W6NL



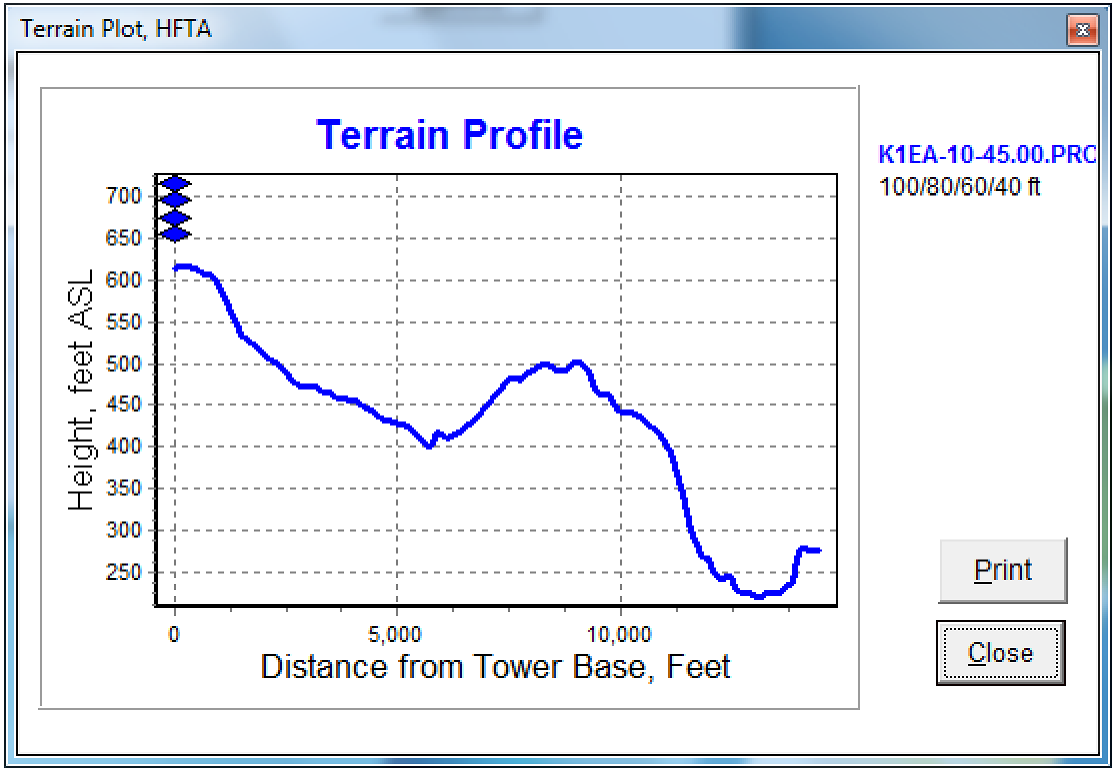
The 70'/35' stack covers a greater range of angles

Another Example, K1EA

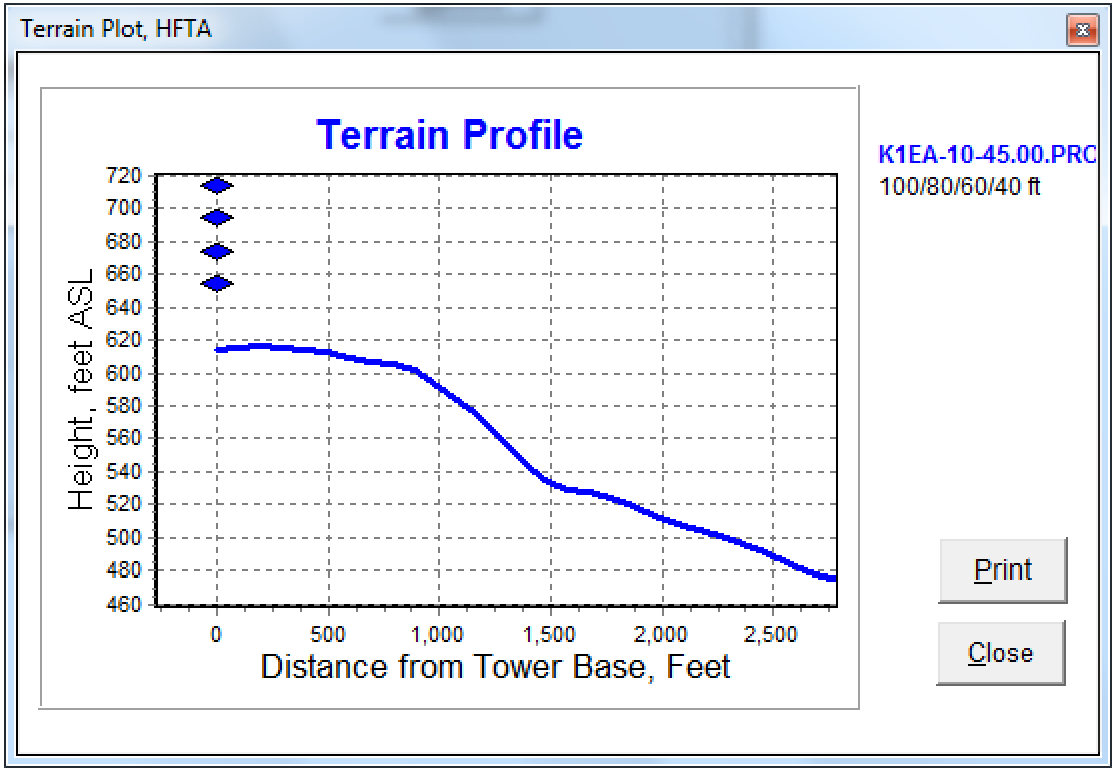
15/20

10/40

Hilltop at K1EA Towards Europe



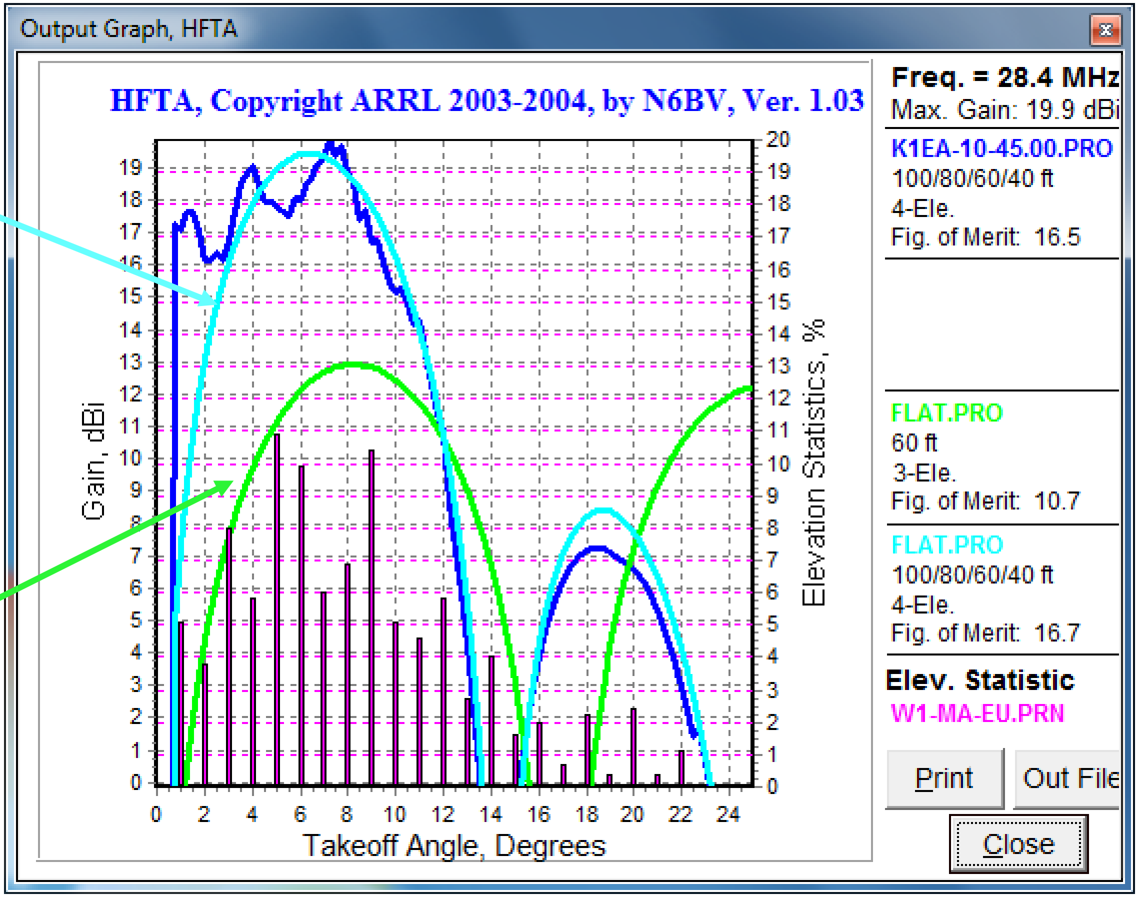
Zooming in Close to Tower



Stacking 4L/4L/4L/4L on 10m at K1EA

Main reference: stack over flat ground

Another "reference": a Little Gun with a tribander at 60'



Pretty close to flat-ground response — almost moon-bounce gain!

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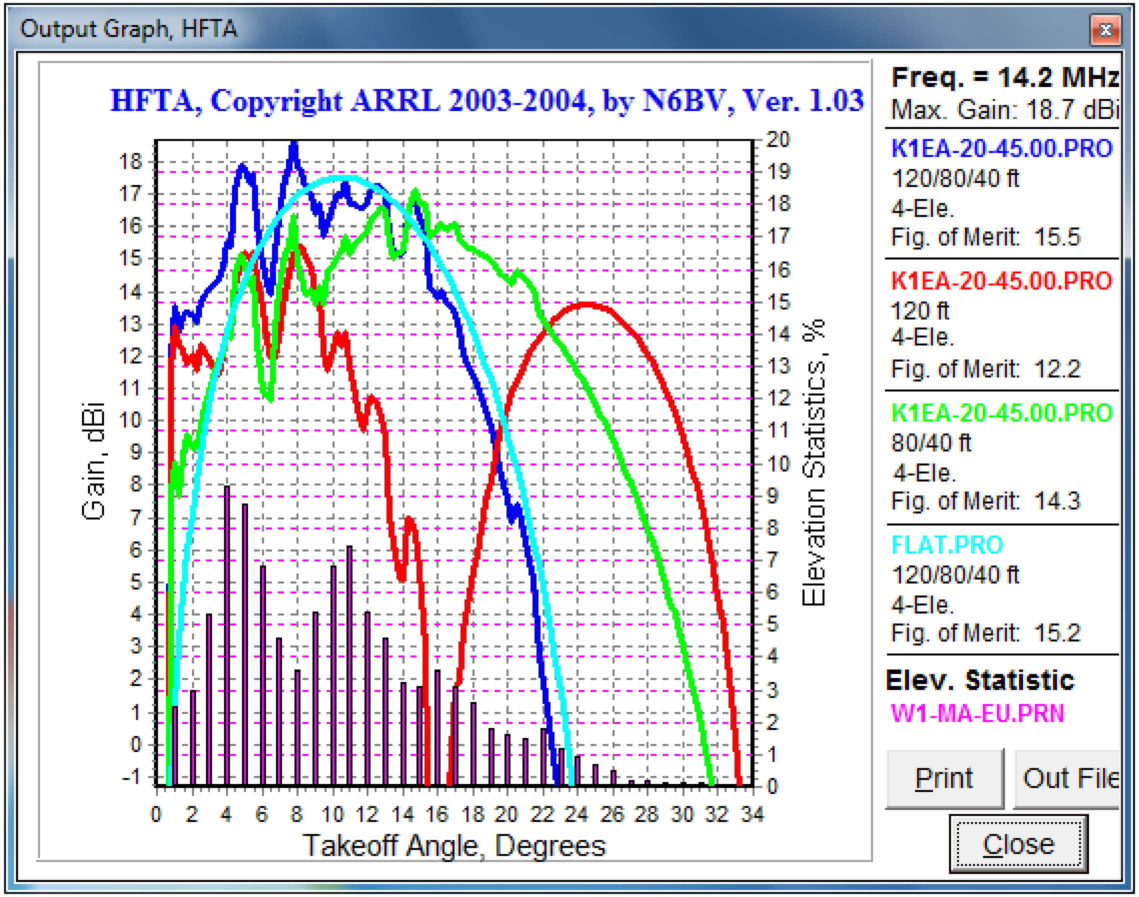
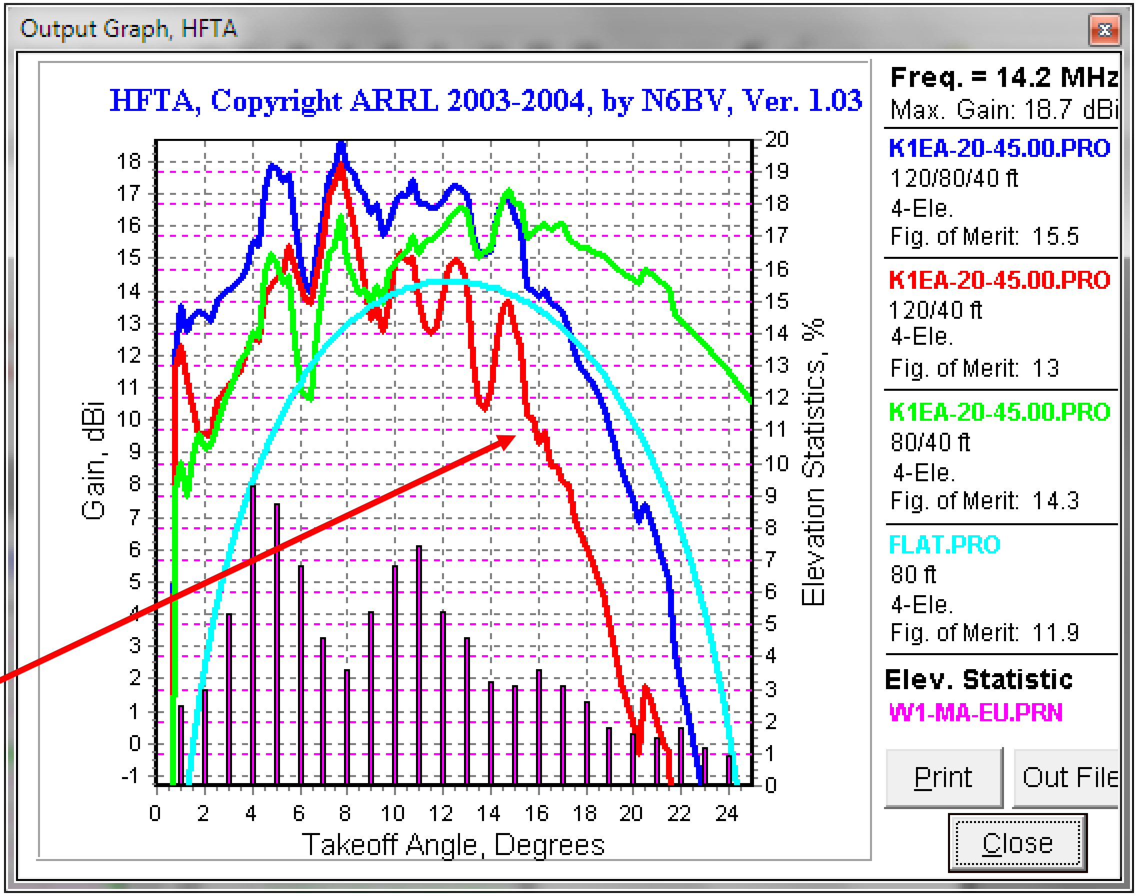
Normal Spacings in Stacks



Spacing Too Wide



Too wide
at 120'/40'

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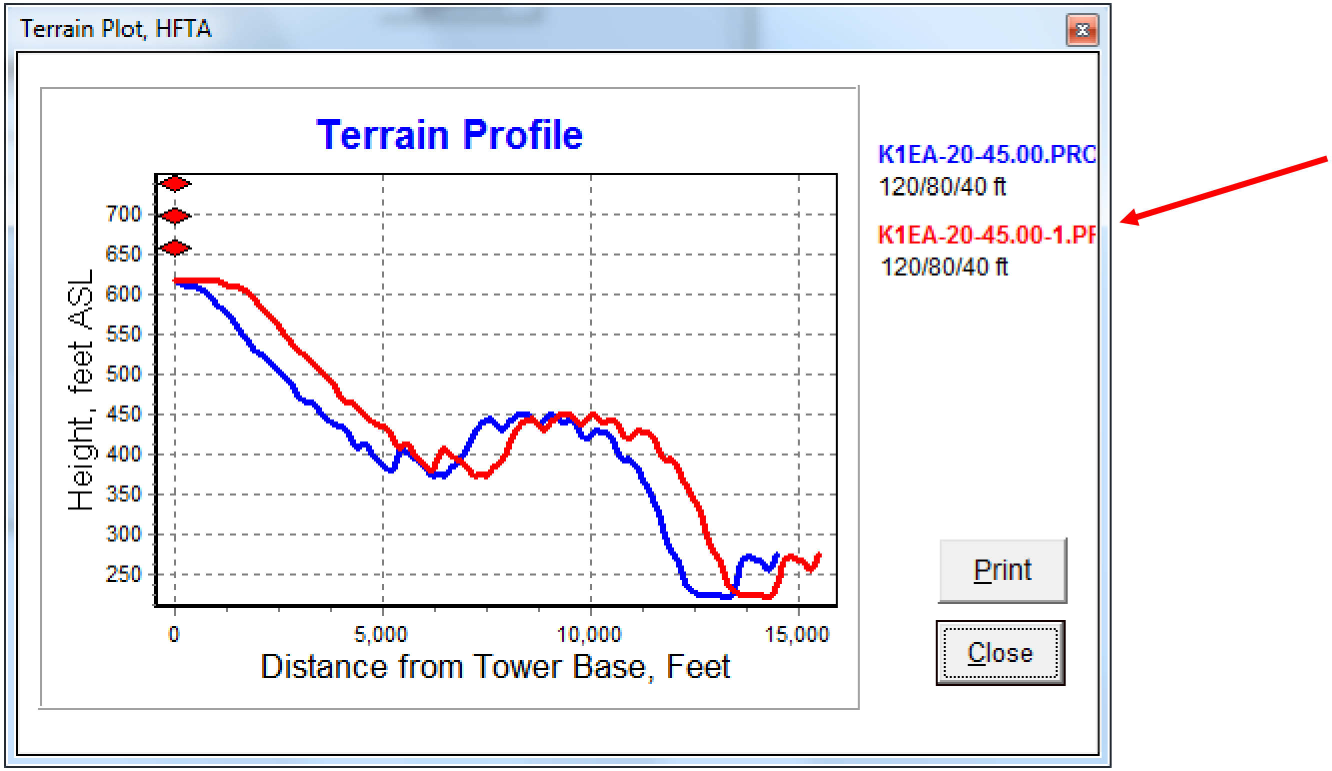
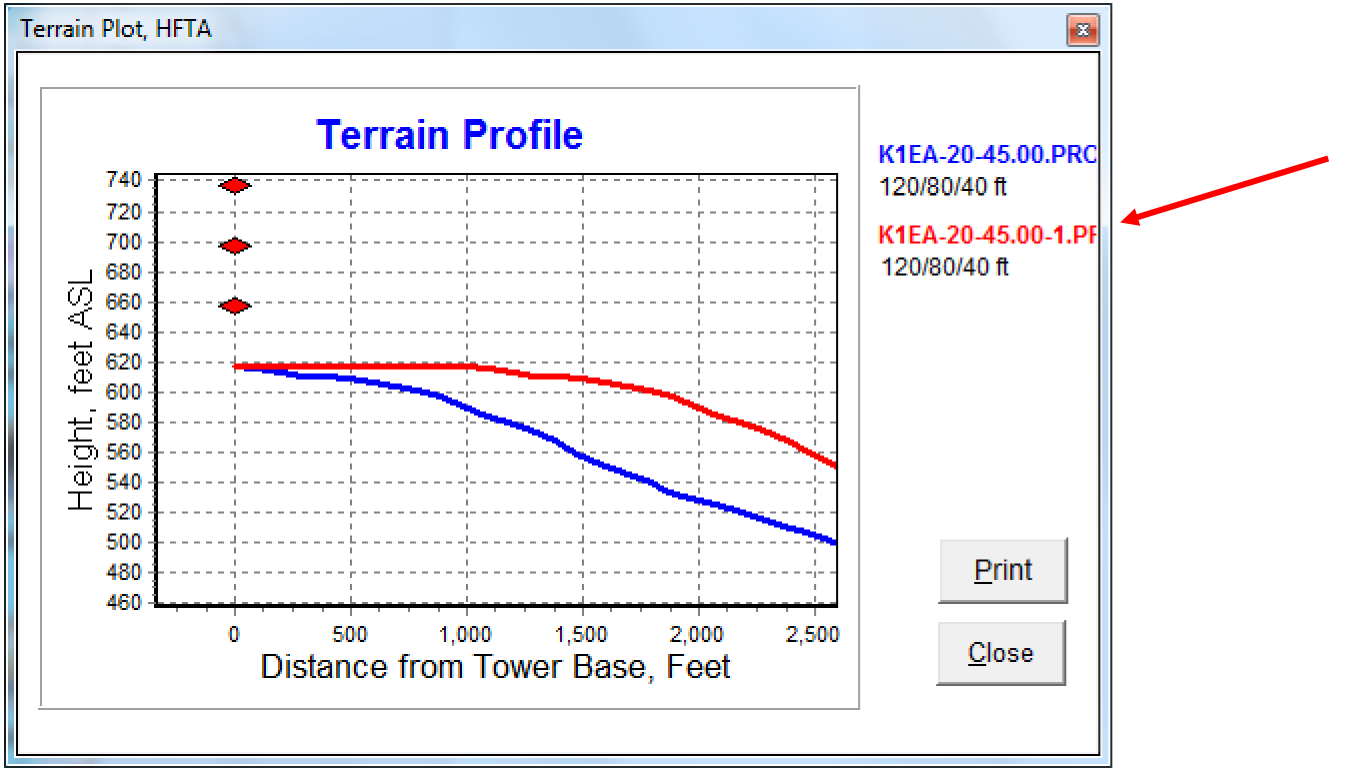
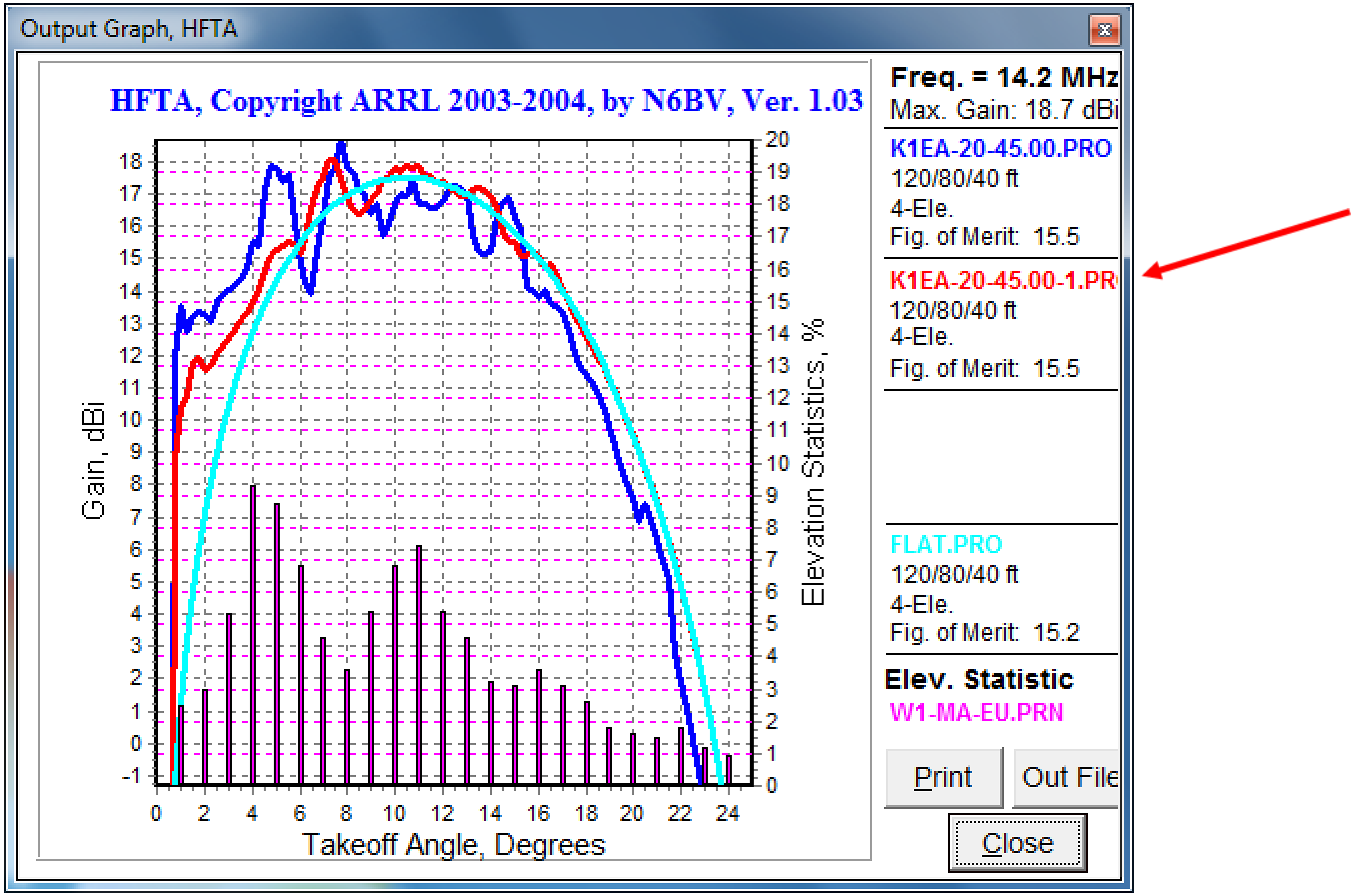
Tower Moved Back 1000 Feet



Zoomed-in: Tower Moved Back 1000 Feet



Tower Moved Back 1000 Feet



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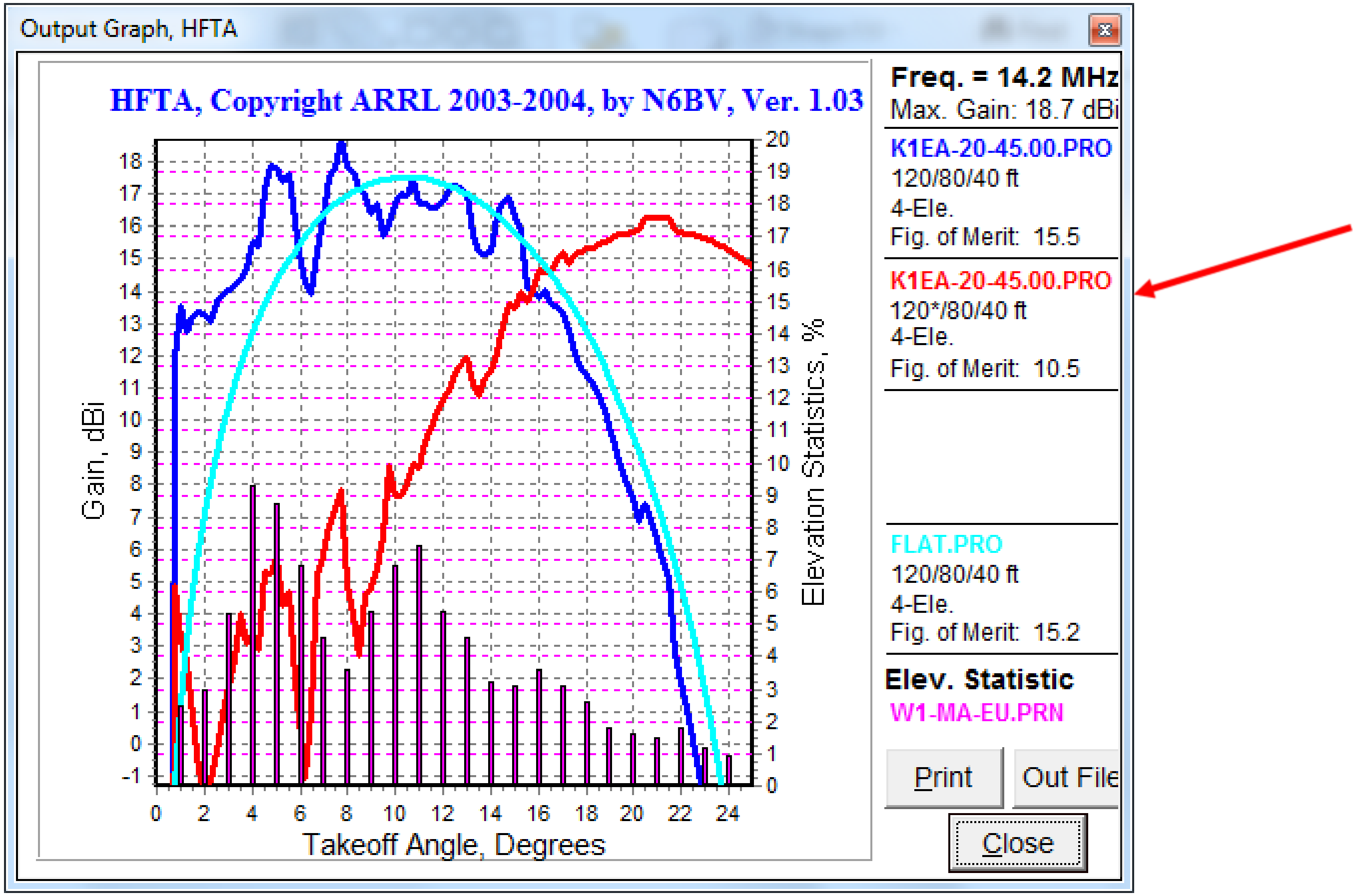
Top Yagi 180° Out-of-Phase



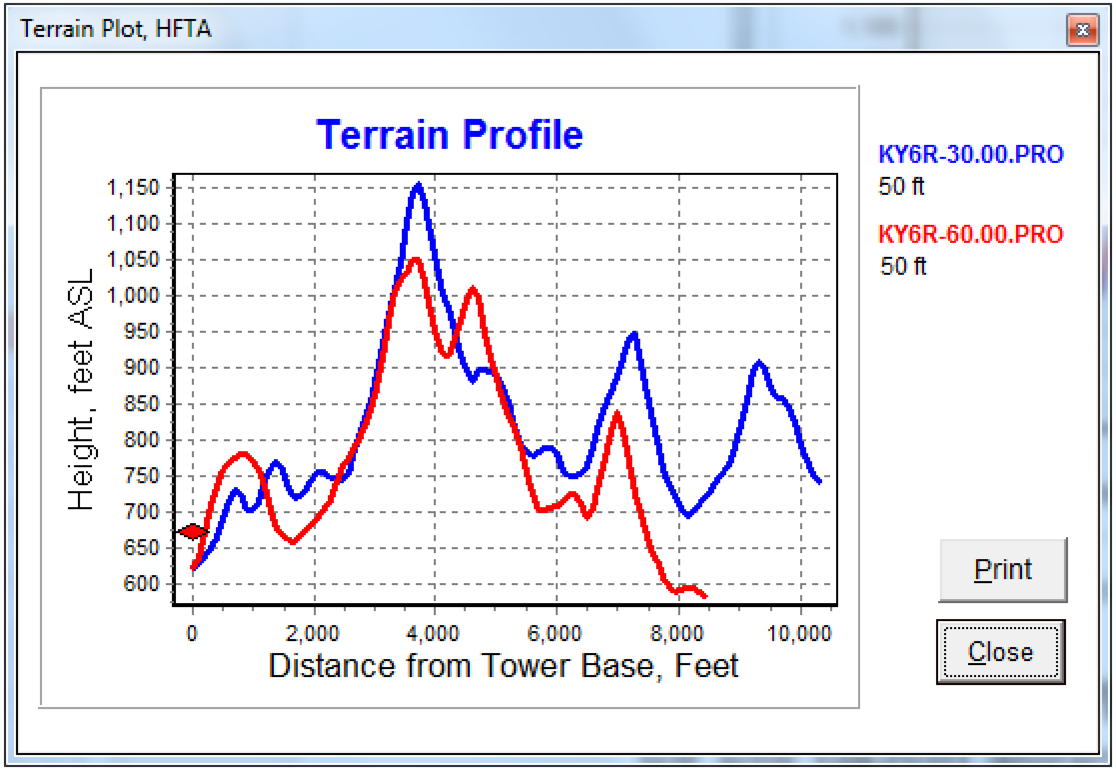
Difficult Terrains

- Shooting uphill
- Saddlebacks
- Peeking over a hump
- Terrain is too steep (too much of a good thing?)
- Distant mountains
- Vastly different terrain shapes at different azimuths

Let's examine these one-by-one.

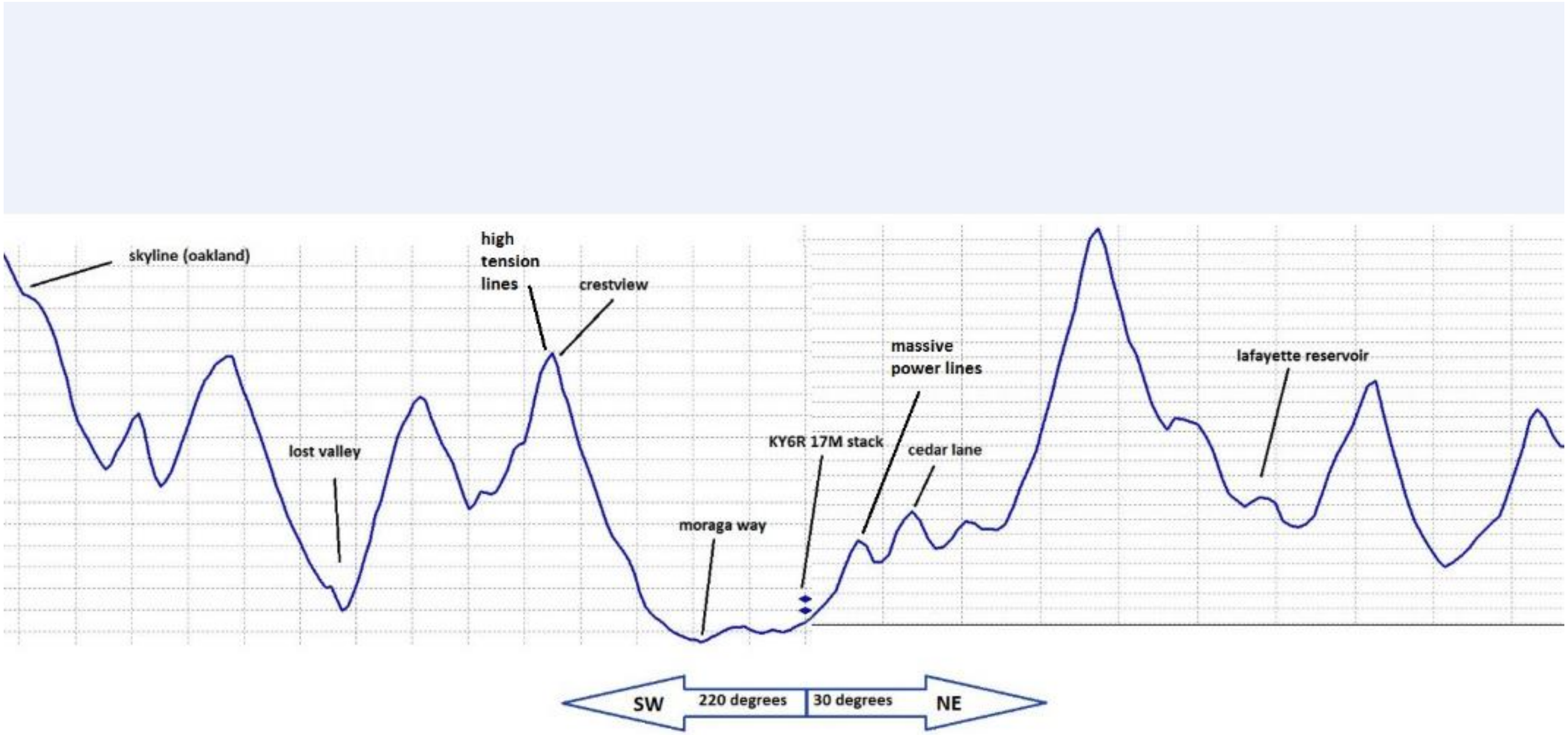
Difficult Terrains

- Shooting uphill — KY6R to Europe and Mid-East



The early part of the upwards slope is the most challenging for low takeoff angles.

KY6R, Deep in a Valley



Courtesy: KY6R

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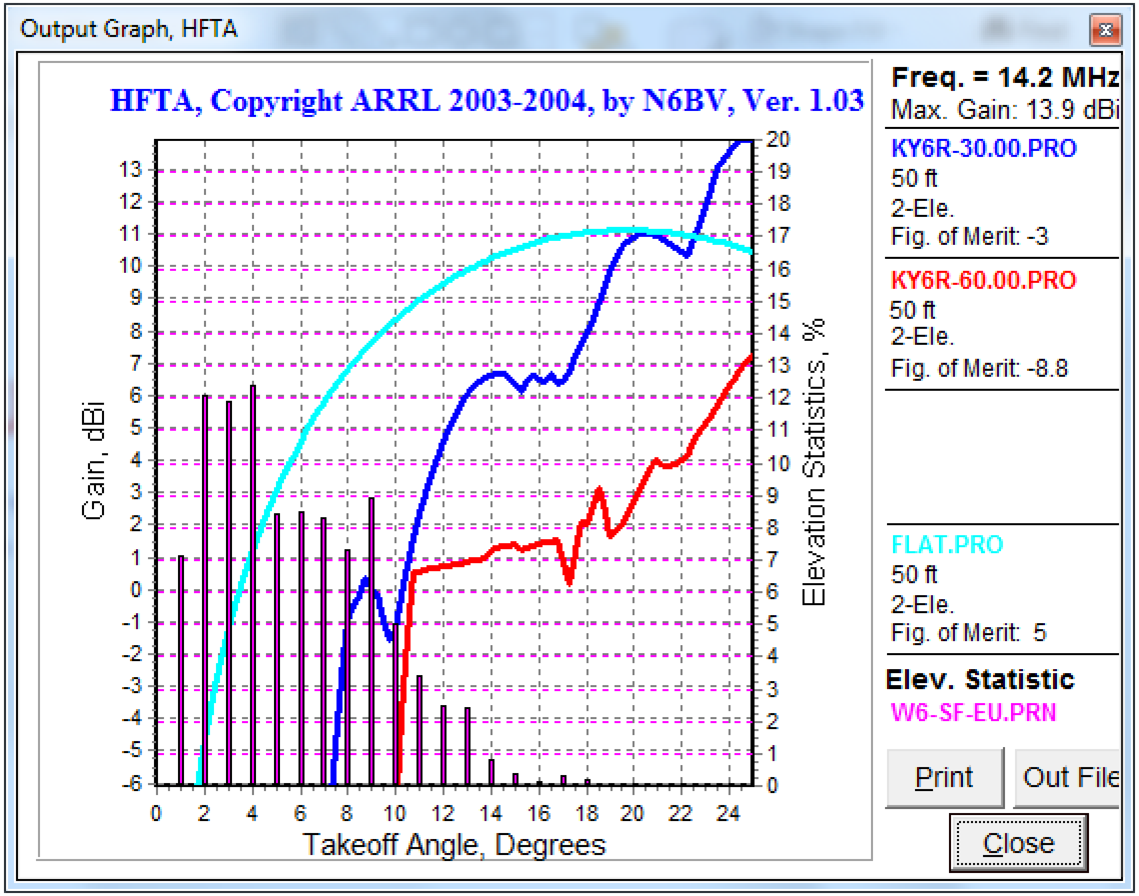

"Extreme DXing"? Rich finally made the Honor Roll.

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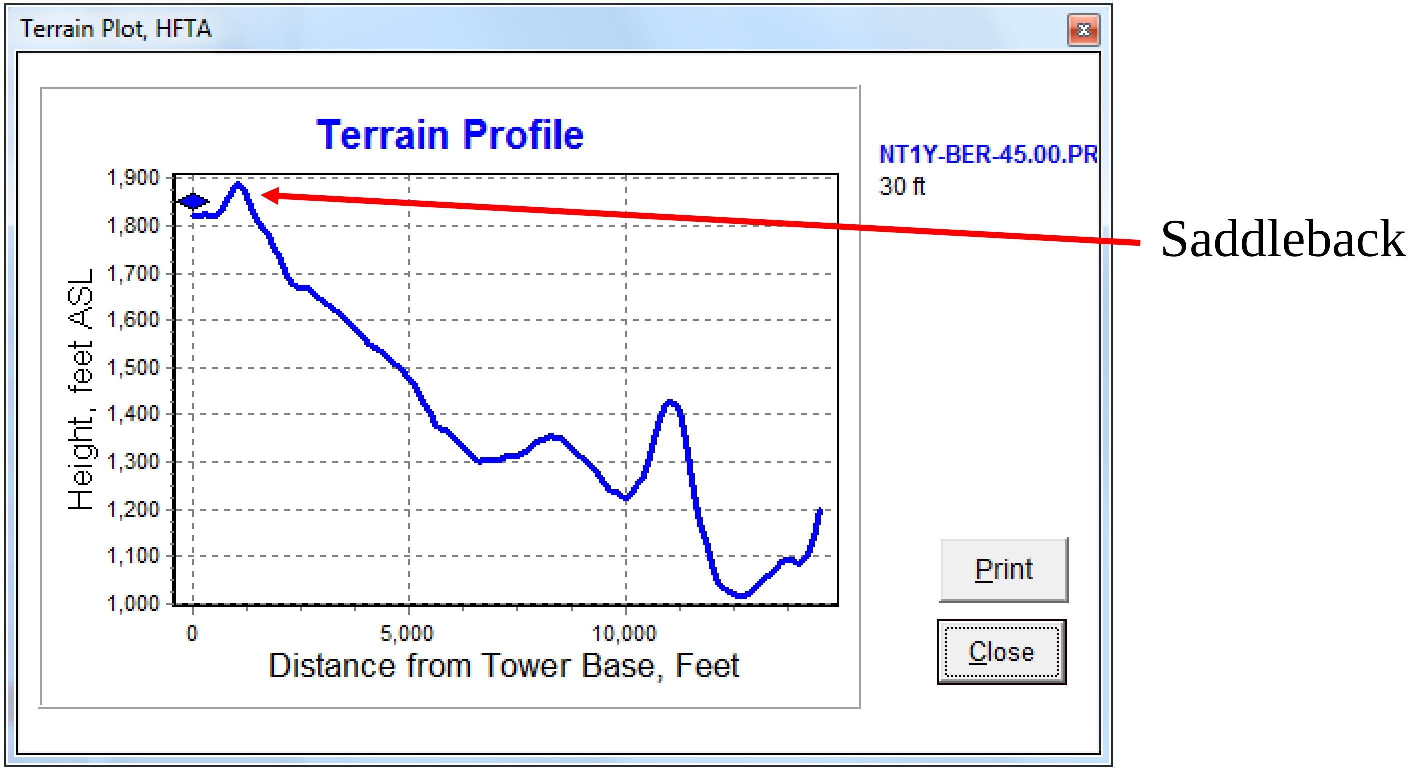
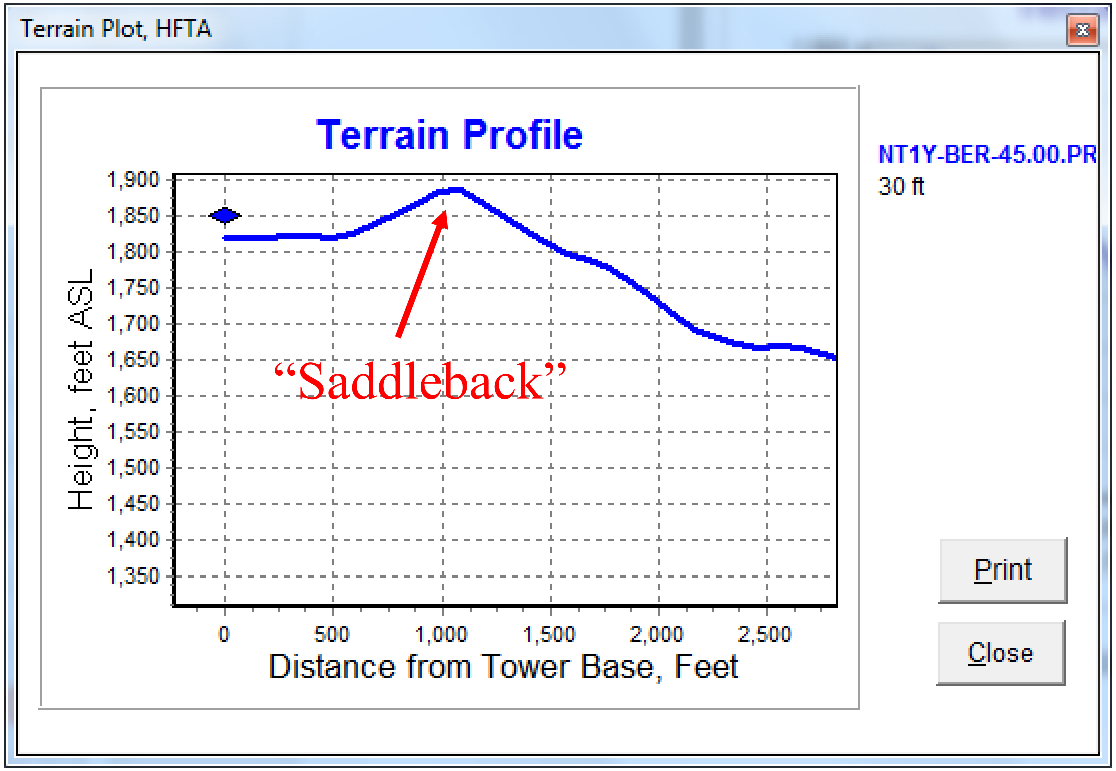
Difficult Terrains

- Saddlebacks

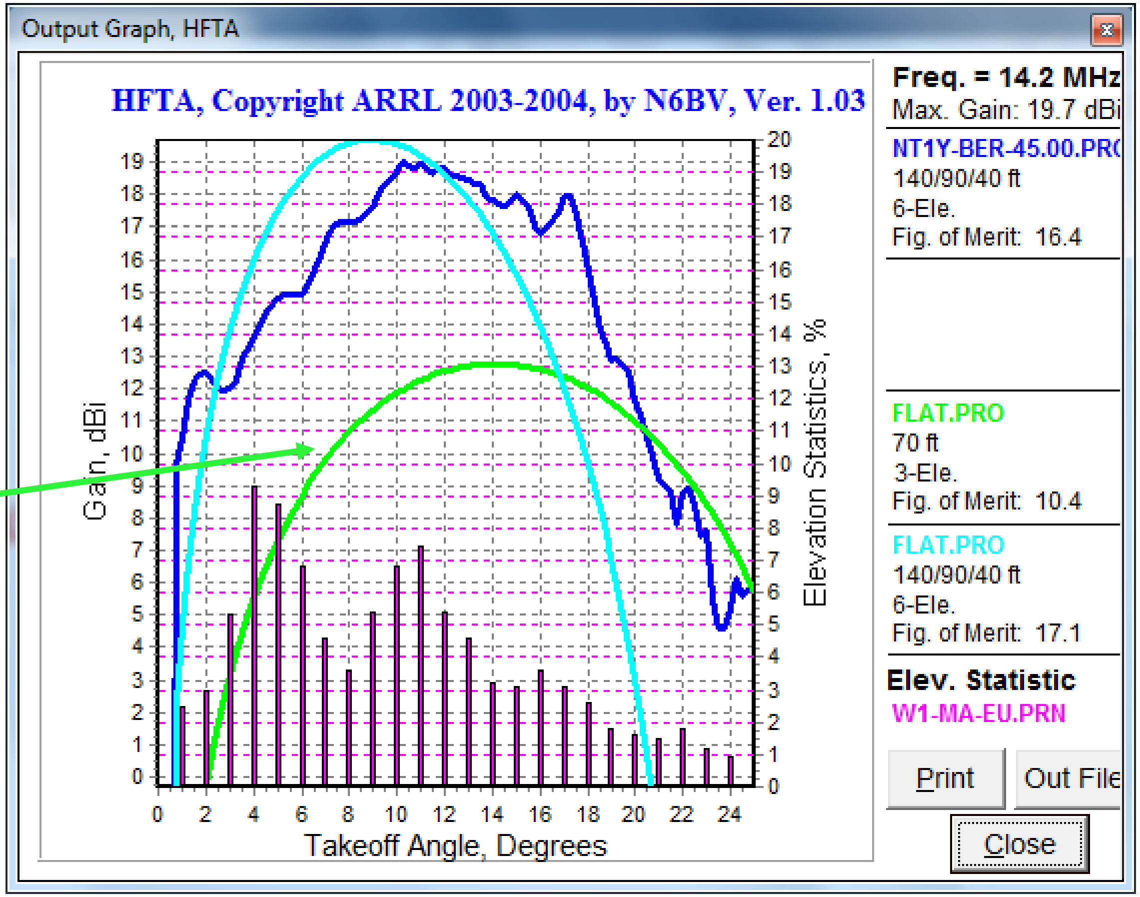


Zoomed-in View of NT1Y Terrain



We Shouldn't Feel Too Bad for NT1Y…

A typical Tribander at 70' over flat ground, for comparison



Bill was still *very* competitive, in spite of that saddleback.

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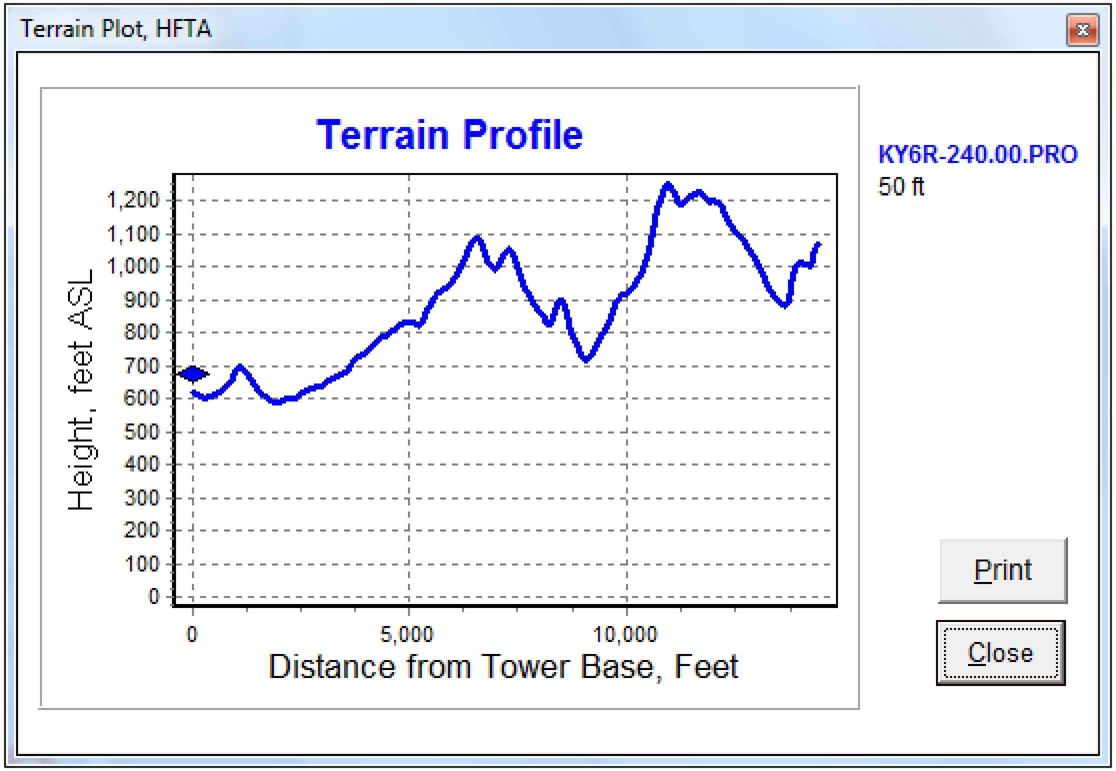
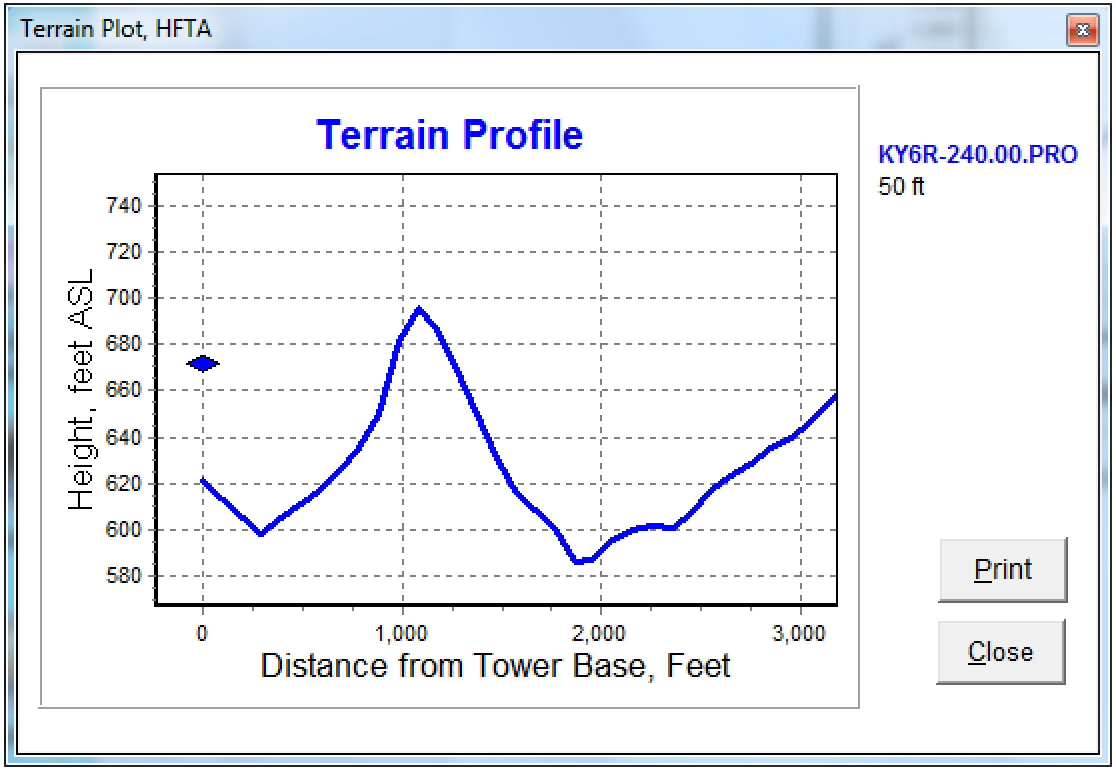
Difficult Terrains

- Peeking over a hump to ZL



Difficult Terrains

- Peeking over a hump to ZL zoomed-in



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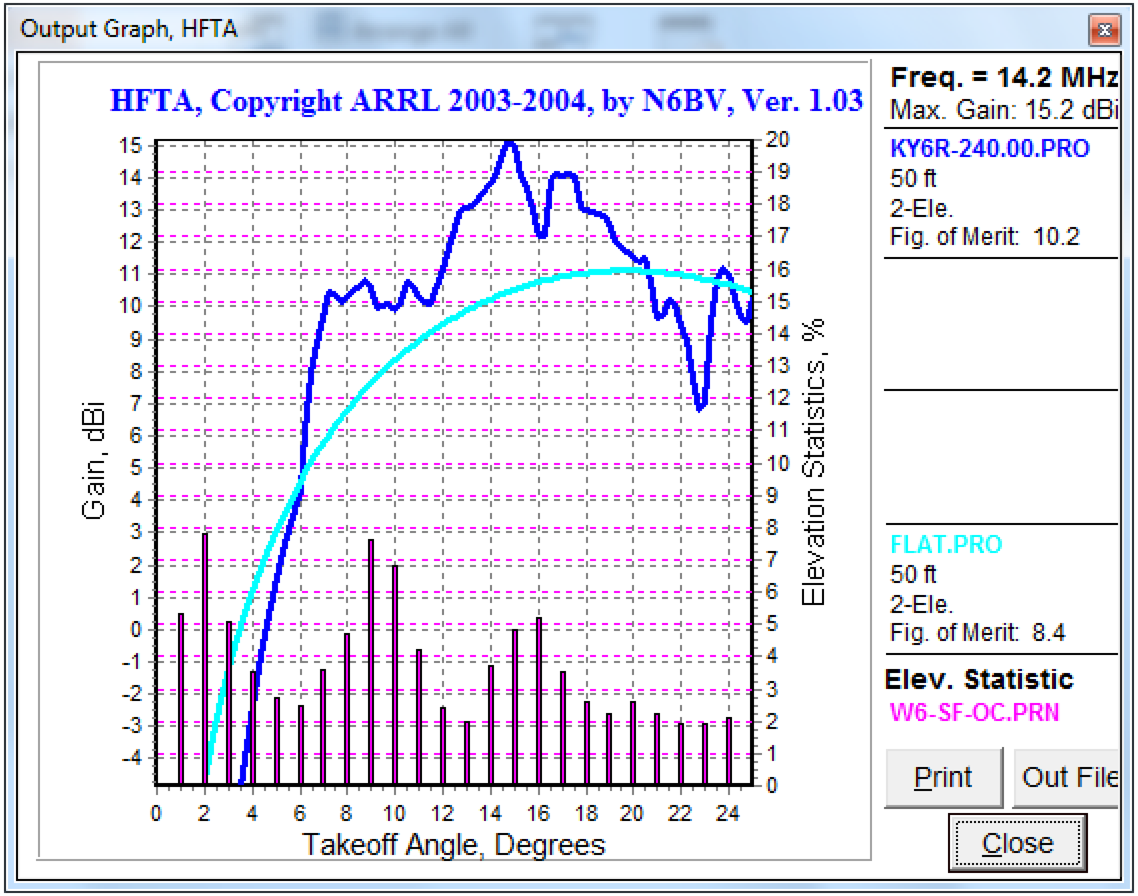

Difficult Terrains

- Shooting uphill
- Saddlebacks
- Peeking over a hump
- Terrain is too steep (too much of a good thing?)
- Distant mountains
- Vastly different terrain shapes at different azimuths

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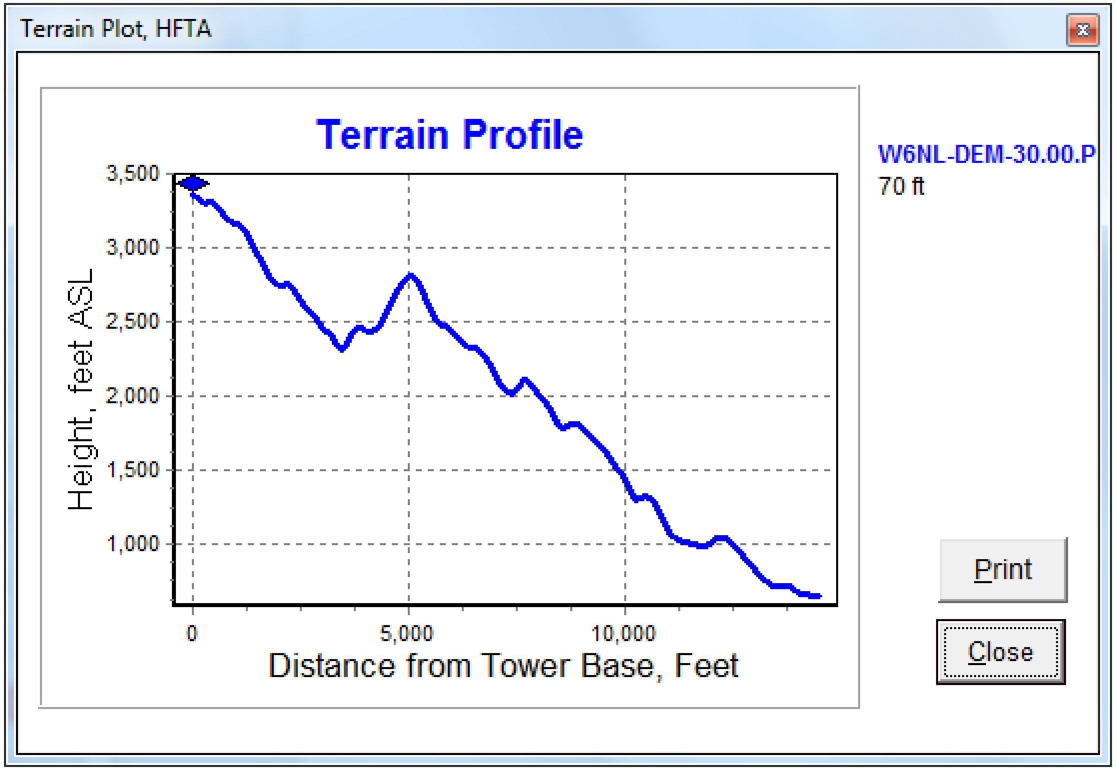
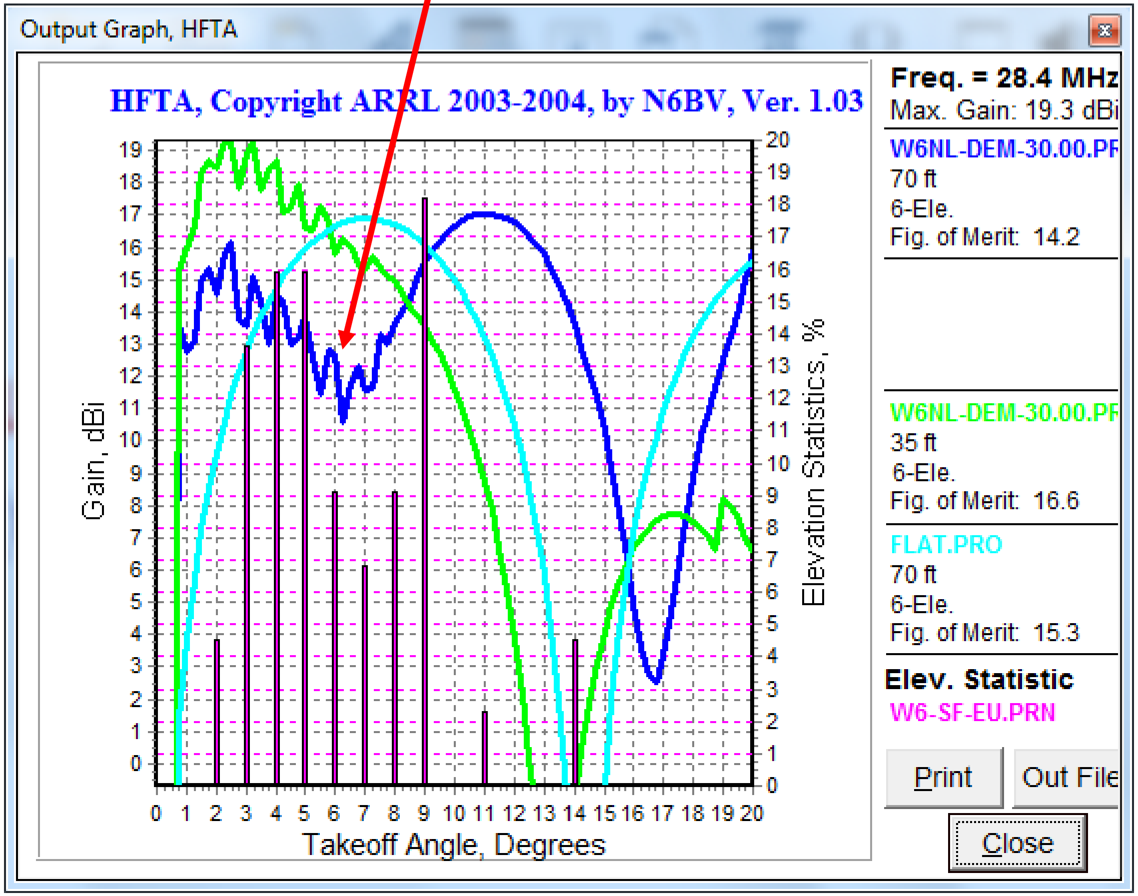


Difficult Terrains

- Terrain is too steep (too much of a good thing?)

Is terrain too steep or is antenna too high for that terrain?



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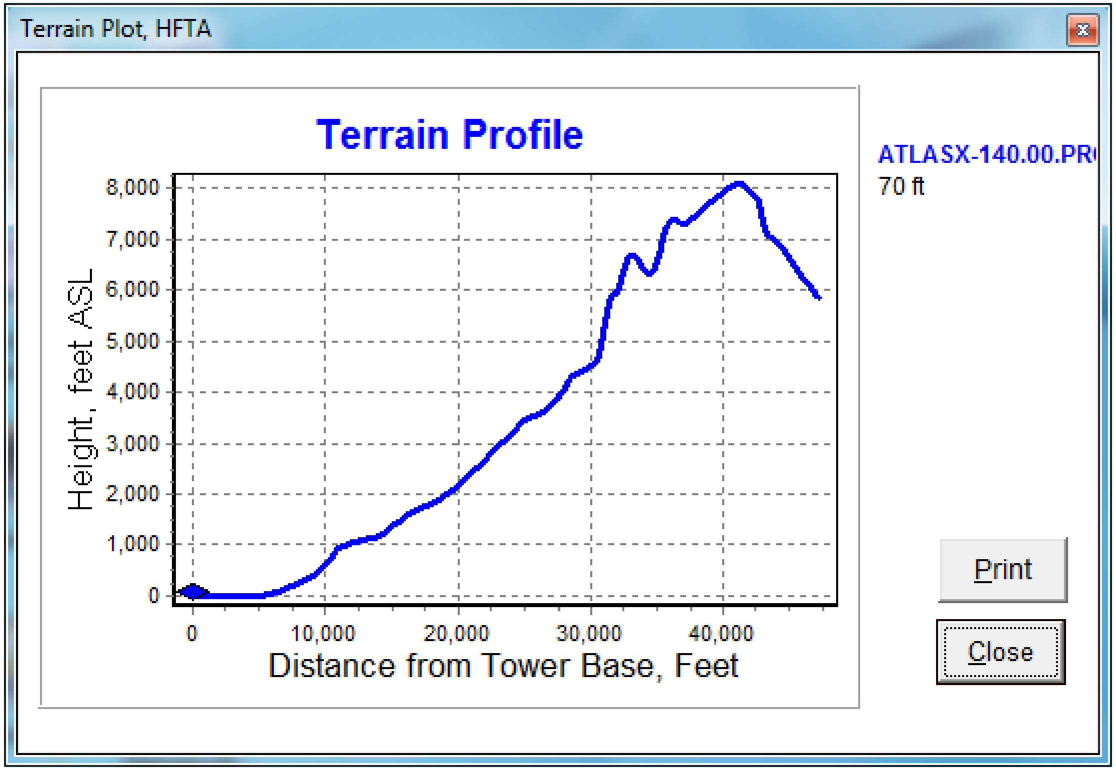
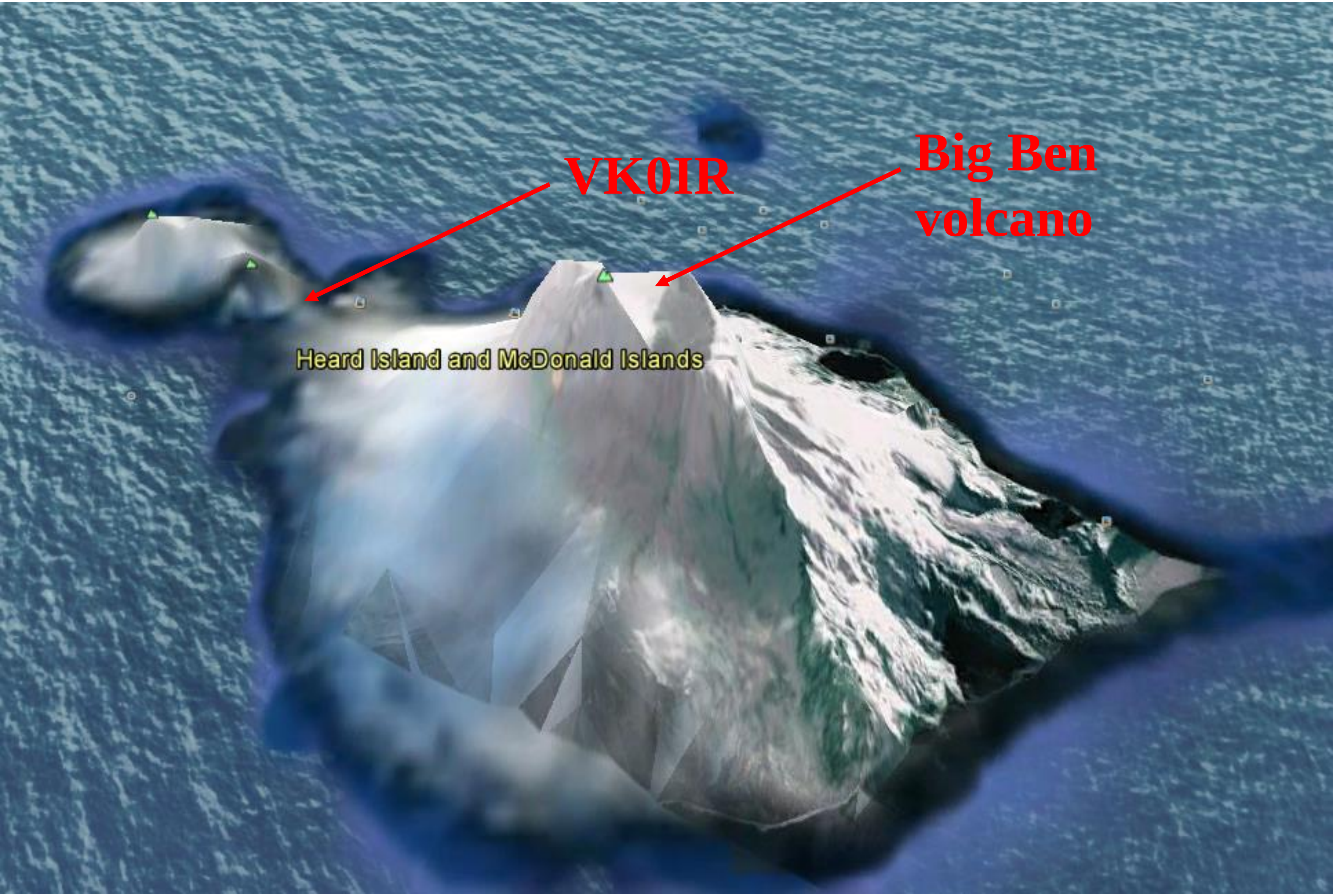
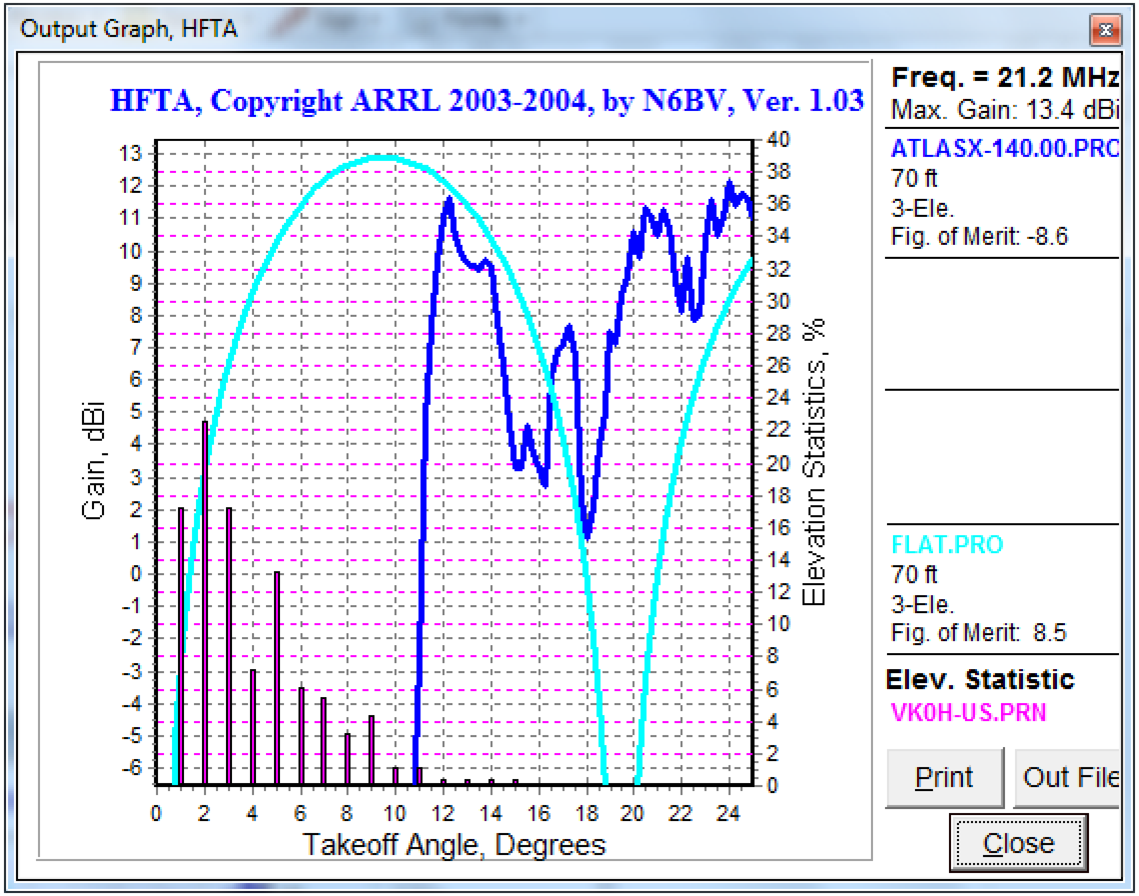


Short-path to W6 from Heard Island


VK0IR
Big Ben
volcano
Heard Island and McDonald Islands

Difficult Terrains

- Distant mountains



Good luck, California…

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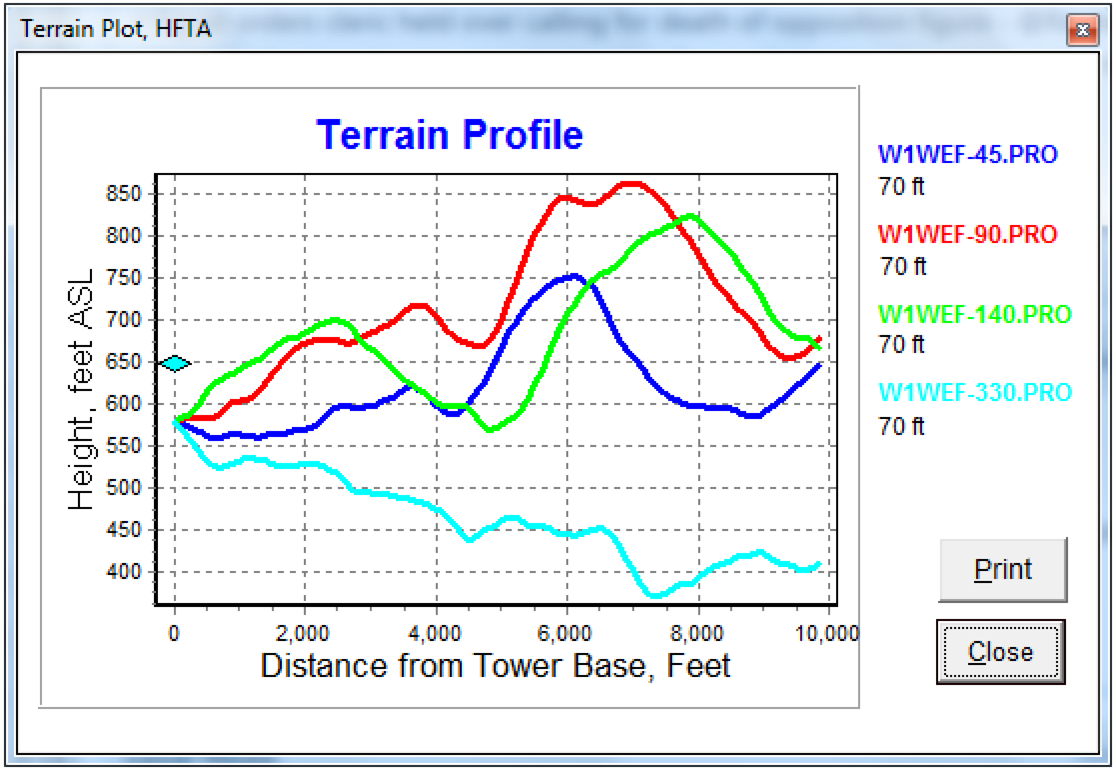
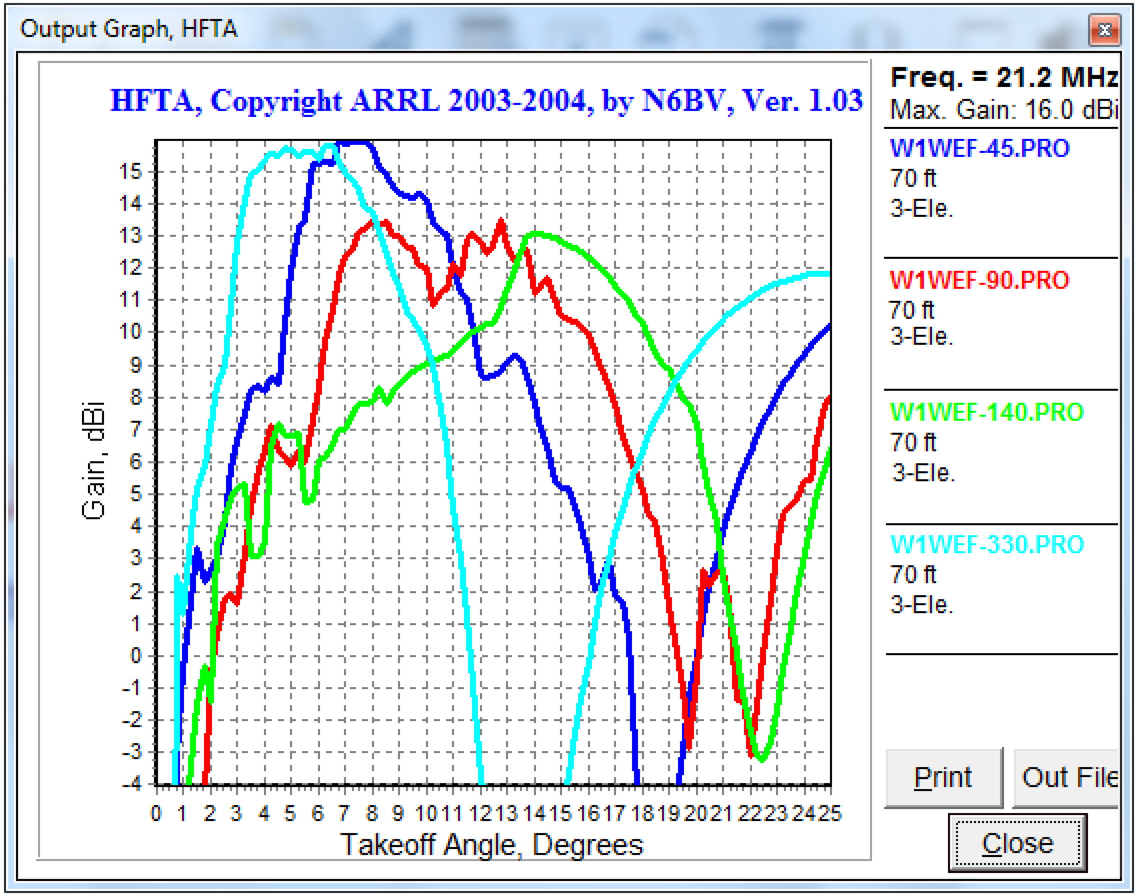


Difficult Terrains

- Vastly different terrain shapes at different azimuths

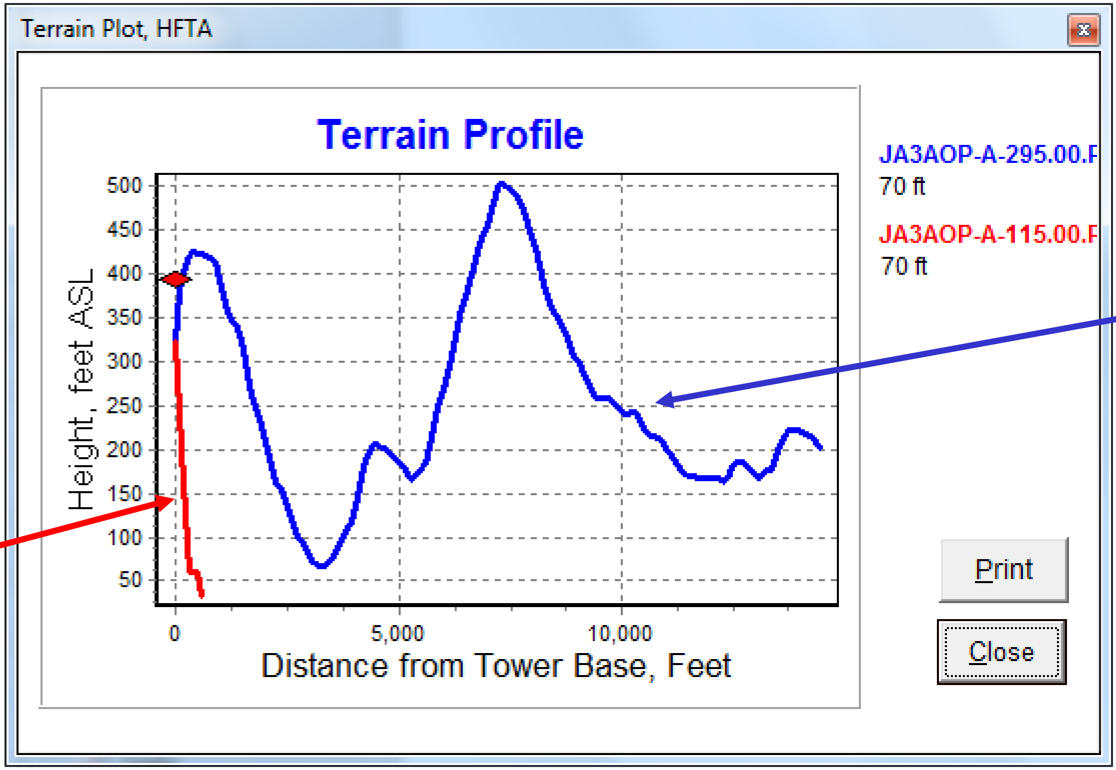


For a single tower, you choose the optimal height for your most important direction — probably Europe for a W1.

Miscellaneous Observations

- Short-path or long-path?

Long path to TR8



Short path to TR8

JA3AOP's QTH


JA3AOP Long-Path to Africa

Miscellaneous Observations

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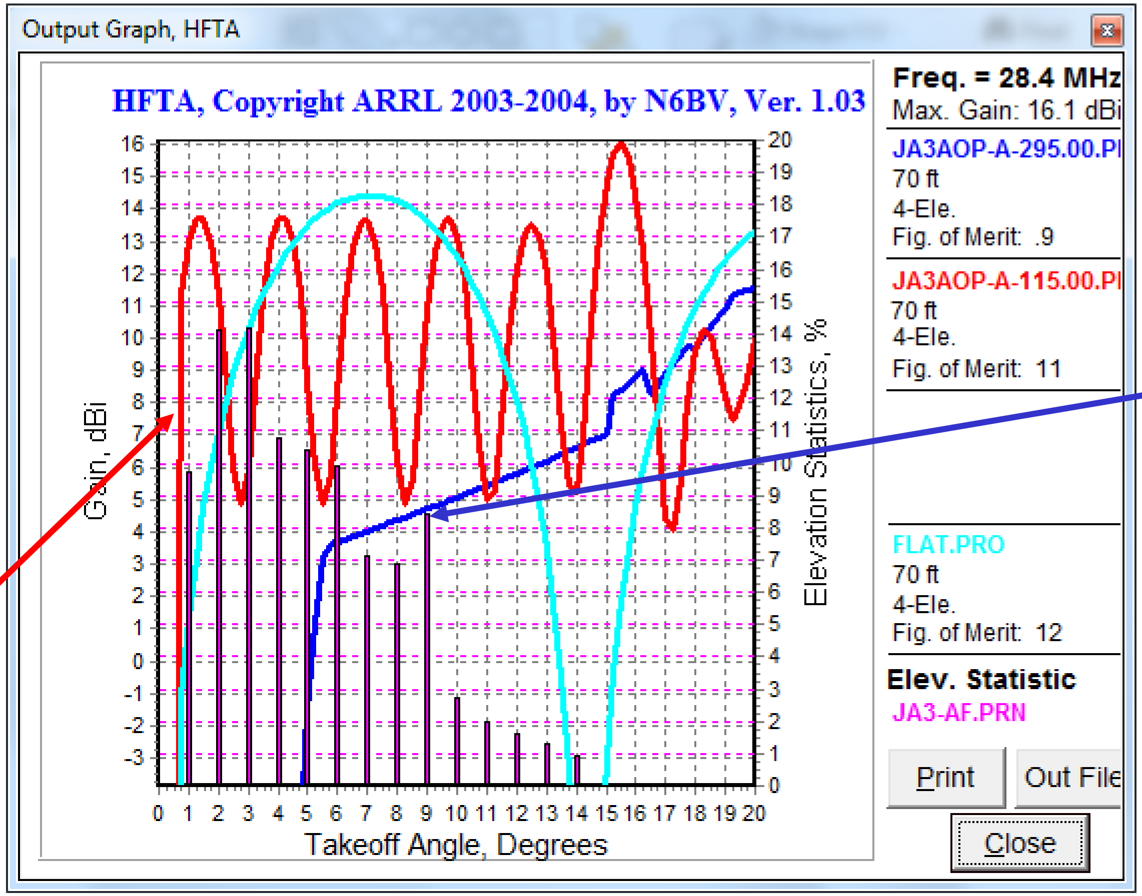
Long-path to TR8

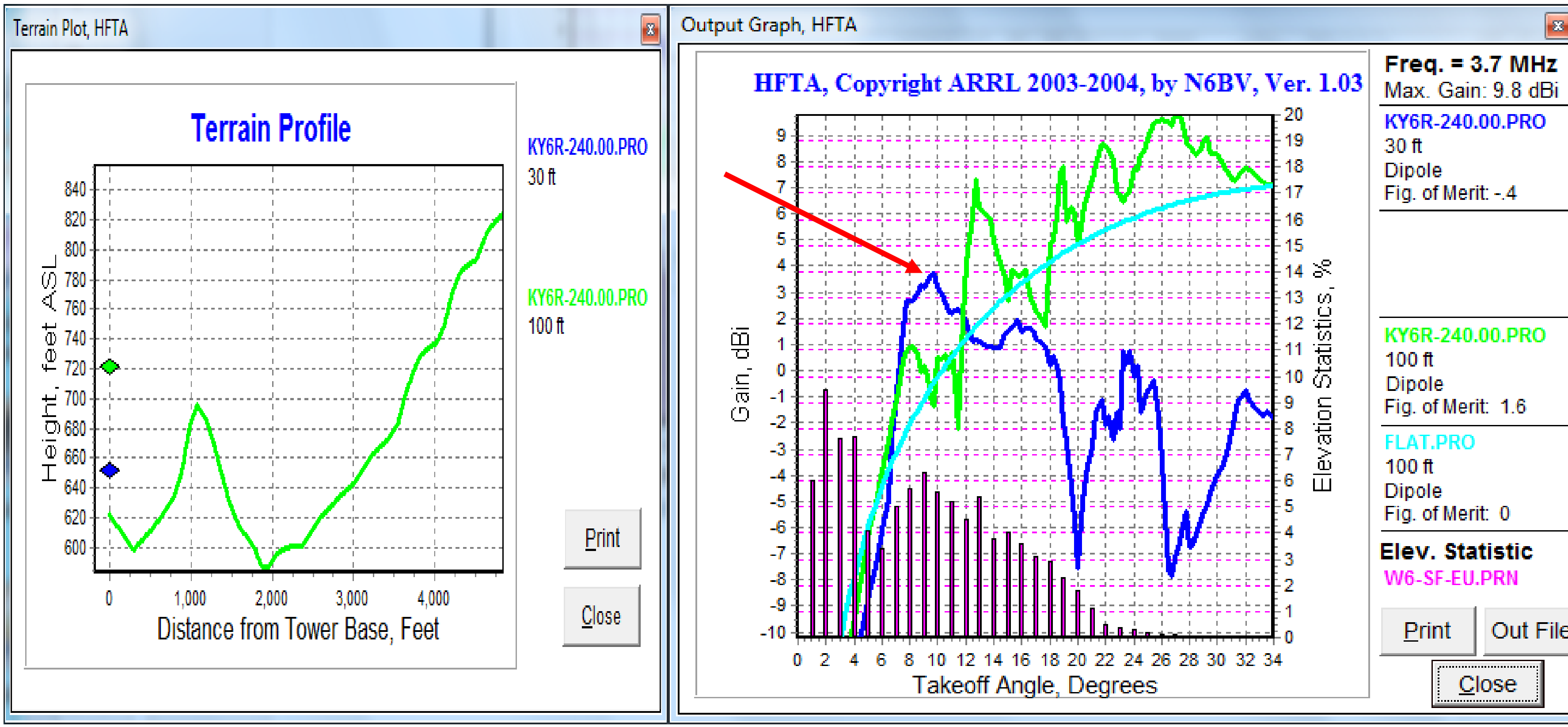


Short-path to TR8

JA3AOP's QTH

“Hurricane Strap”— the winds are merciless on JA3AOP’s hill

Anomaly
Low Frequency; Low Height; Steep Upslope

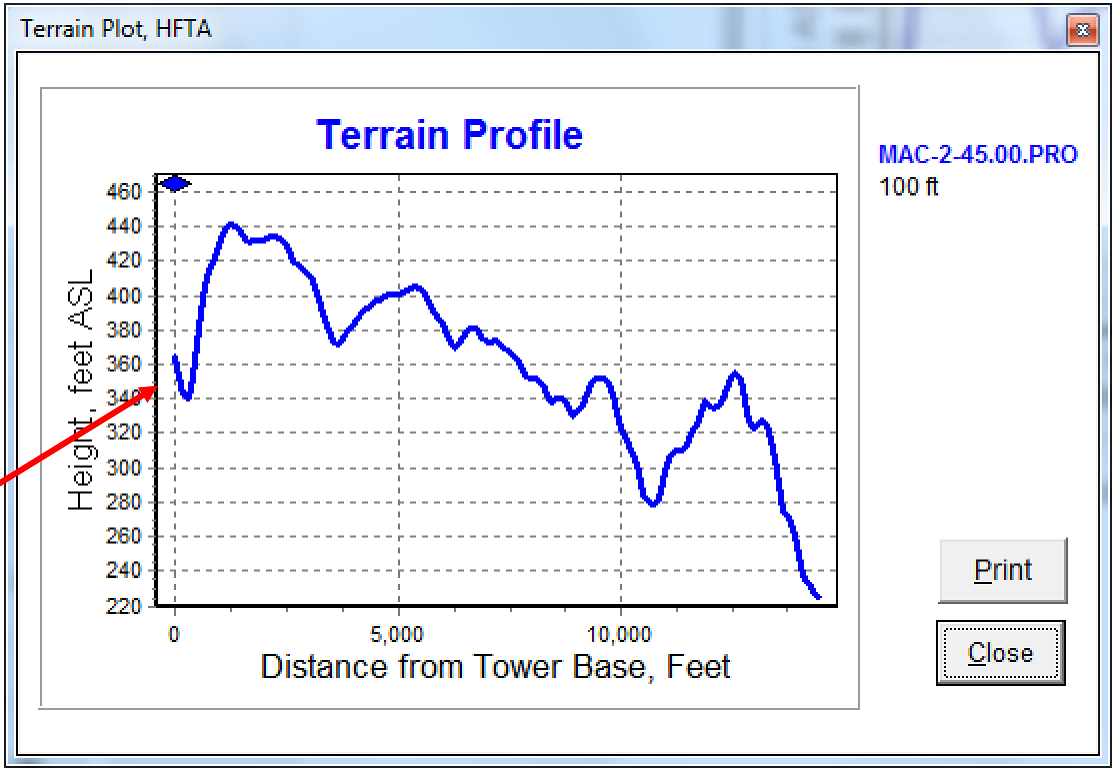


A 30' high dipole is not stronger at 10° than a 100' dipole!
A diffraction aliasing spike is at work here…

JA3USA

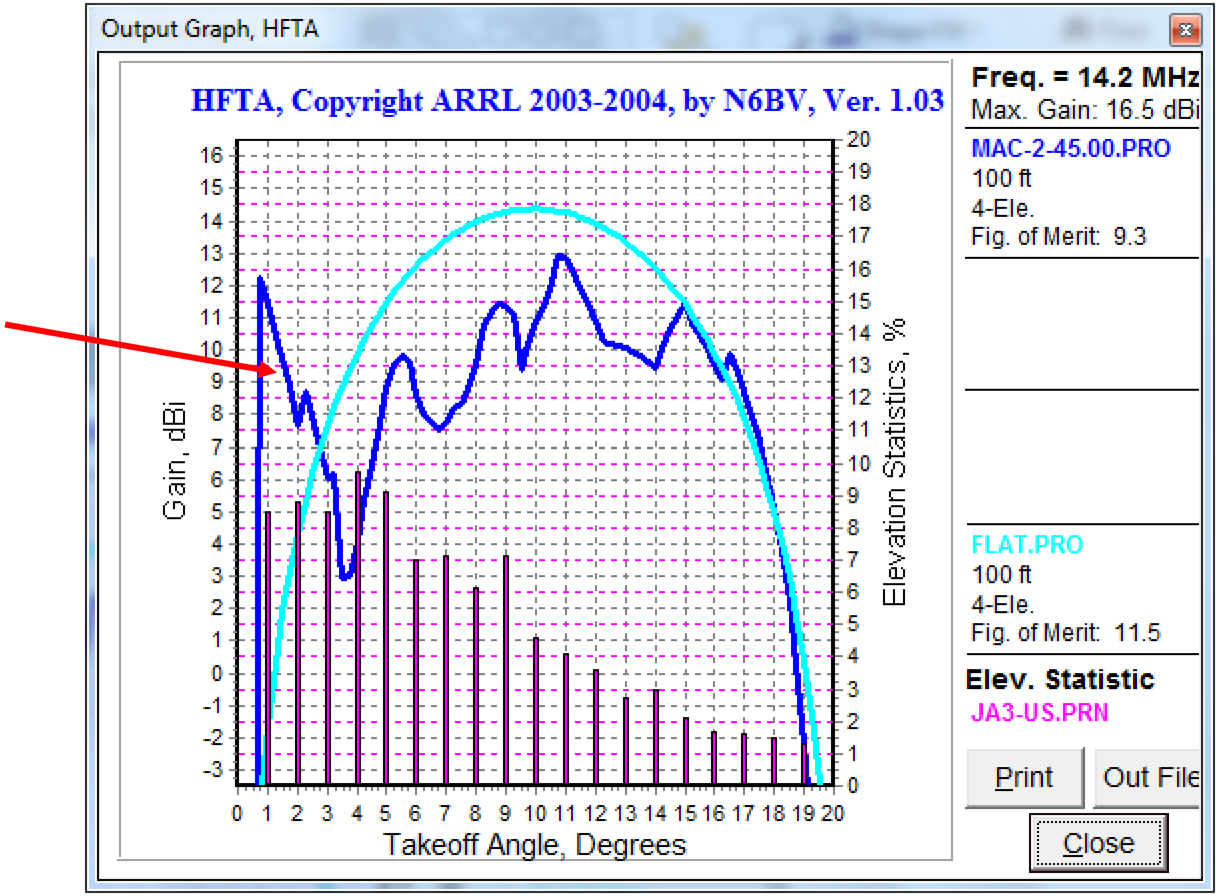
N
JA3USA
© 2012 ZENRIN
Google earth
Imagery Date: 1/31/2007
2005
34°44'00.96" N 135°44'45.62" E elev 420 ft
Eye alt 825 ft

JA3USA in Nara



Downslope close to tower

JA3USA in Nara



Not too shabby — especially for very low angles. But response is still not entirely intuitive because of complex diffractions.

Putting It All Together

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- You should know how your antennas work under ideal conditions (free space, or flat ground).
- Then, you can analyze the effects of irregular local terrain and optimize heights, stacks or tower placement on your property.

Finally, Keep Your Perspective!

It’s very easy to get very involved, even consumed, in antenna modeling and terrain analysis.

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Got your bulldozer ready?