" You can observe a lot, just by watching."

Yogi Berra

Metrocrest Amateur Radio Society
Limited Space Antennas

April 8, 2021

Limited Space
Visual Restrictions
or
simply a “no antennas” mandate

directly impact the most influential component of a radio station:

the antenna

When deciding on an antenna to purchase,

we depend mostly on the

manufacturer/seller's claims.

We also seek out anecdotal comments
from friends
and
on the Internet.

Caveat emptor

”Let the buyer beware” Summarizes the concept that a purchaser must examine, judge, and test a product considered for purchase themselves.

Caveat venditor

”Let the seller beware” Although the buyer is still required to make a reasonable inspection of goods upon purchase, increased responsibilities have been placed upon the seller.

There is a legal presumption that a seller makes certain warranties unless the buyer and the seller agree otherwise.

A seller who is in the business of regularly selling a particular type of goods has greater responsibilities in dealing with an average customer, such as a person purchasing antiques from an antique dealer, or jewelry from a jeweler, is justified in his or her reliance on the expertise of the seller.

There is no free lunch

This means that we can get

only what is reasonable for a particular design,

construction and installation;

possibly even less than what we are anticipating.

From our N6BT.com website, the following are basic steps to assist in deciding on your antenna selections:

__1. Available space (and type i.e. ground, roof, etc.)

__2. Bands (practical for available space)

__3. Location

__4. Equipment

__5. Installation and Maintenance

__6. Budget

How can you evaluate an antenna?

What equipment is used as an indicator of how well an antenna is “working?”

A “low VSWR” became a leading indicator of whether or not a particular antenna was a

“killer antenna”

The VSWR matched to the coveted 1:1.

It must be a killer antenna.

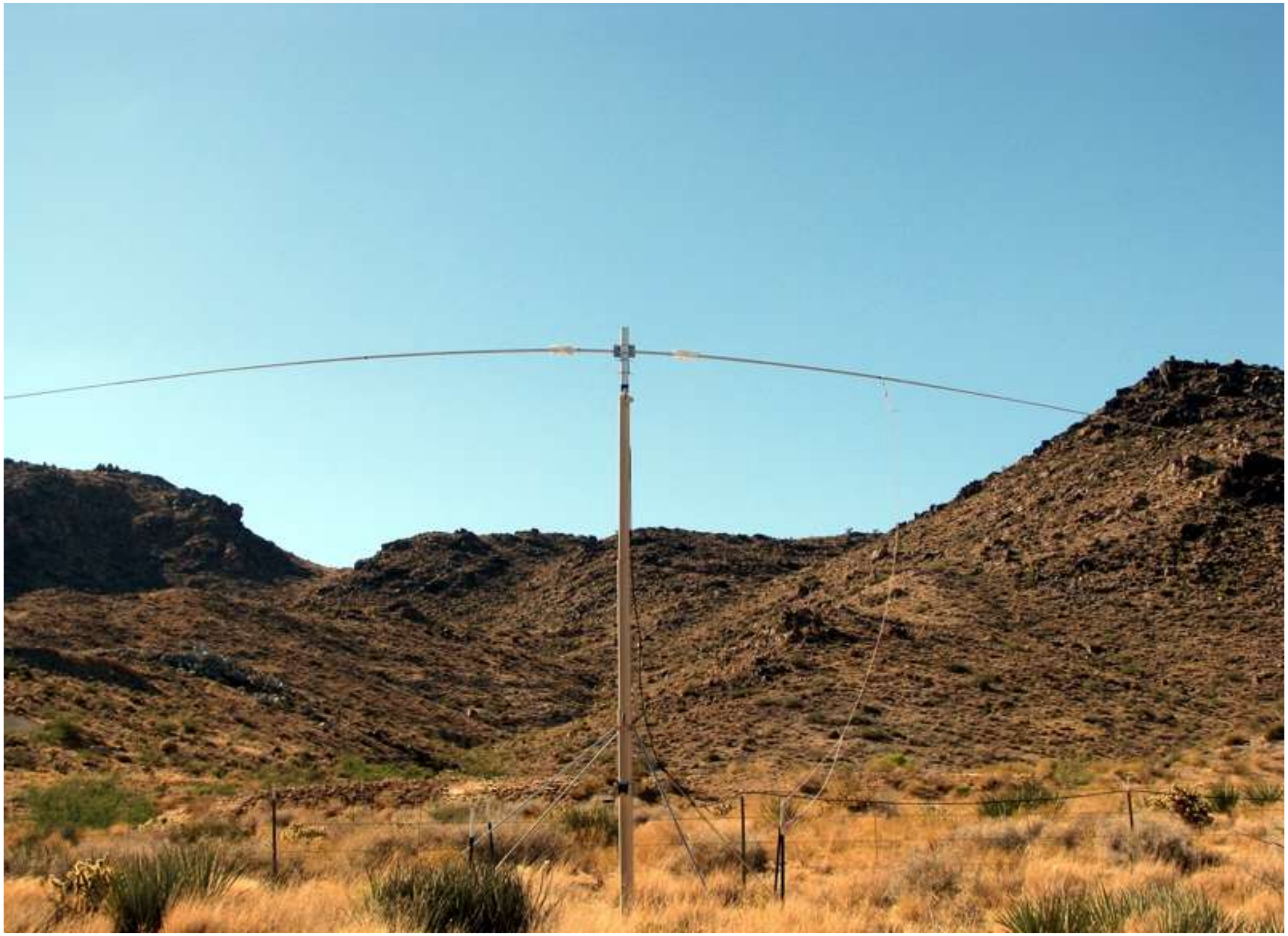
Speaking of categorizing antennas in one way or another,

we could do something like this...

For those who like to operate nets, especially being net control, we have -->

The “Moderator”

…a 40 meter NVIS dipole at 18’



For those who enjoy getting into high-band pile-ups, we have -->

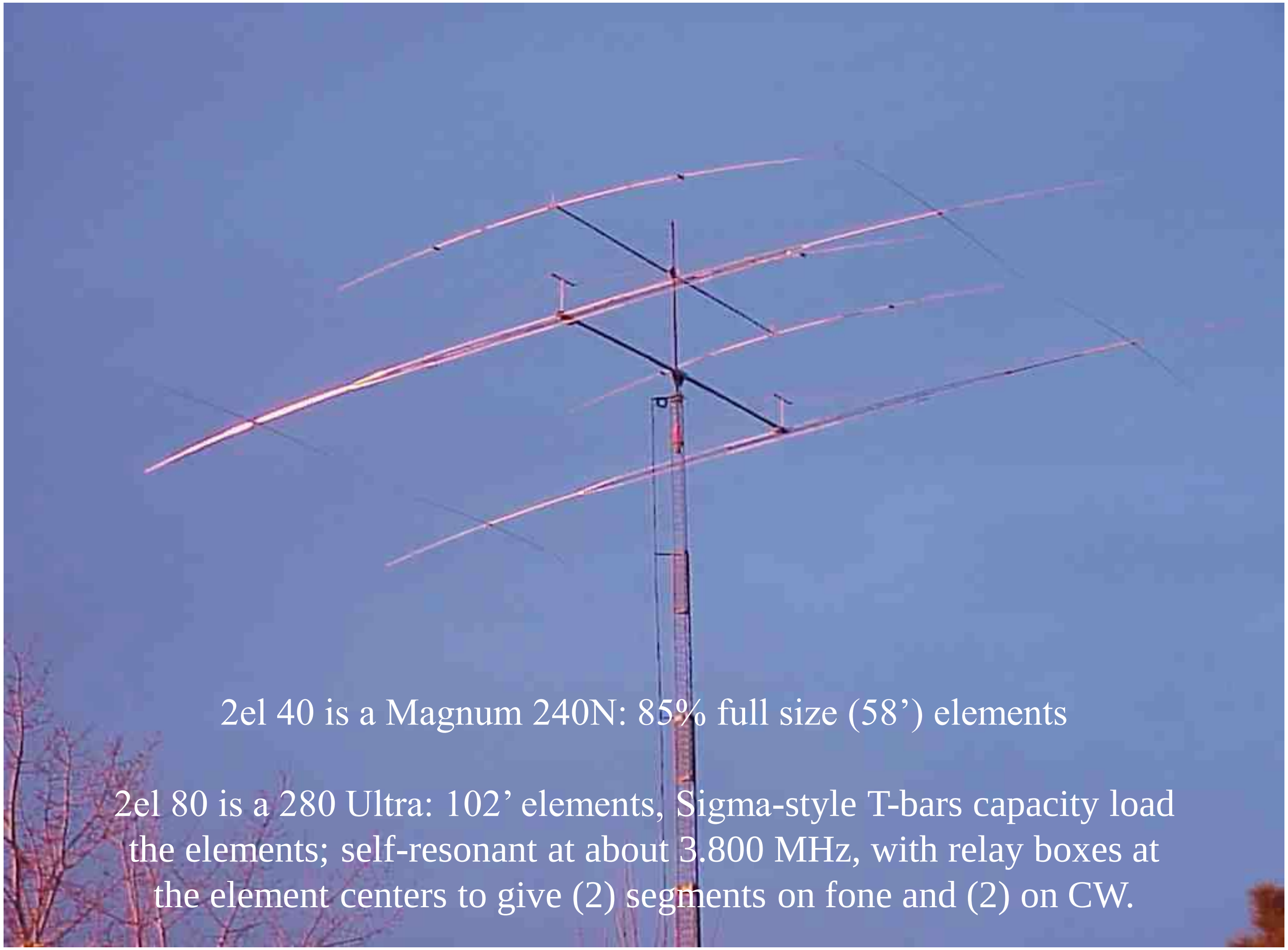
The "Intimidator"

…an tri-bander w/o traps

For those who enjoy getting into low band pile-ups, we have -->

The "Terminator"

…big 2-element 80/75 and 40 mtr Yagis



For those who enjoy getting into BIG pile-ups, we have -->

The "Exterminator"

stacked Yagis on all bands

140' rotating 55G

K0XG rotating guy rings

2el 40 Magnum 240 (58' ele)

C-49XR 20-15-10 (49' boom)

C-49XR 20-15-10 (49' boom)

2el40 Magnum / 2el30 N6BT custom

(both 2el40 Magnum's are phased)

3el17 / 4el12 N6BT custom

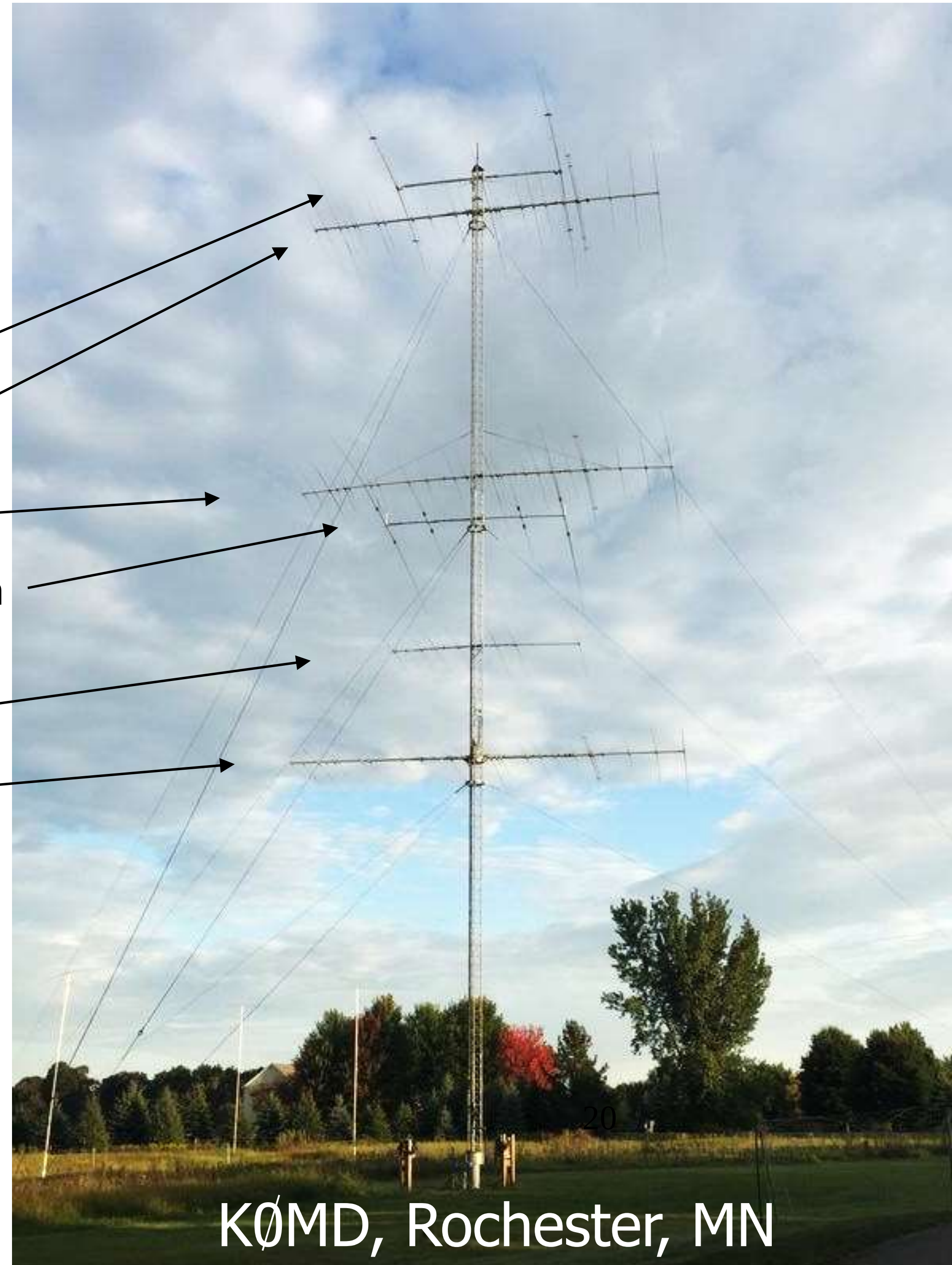
C-49XR 20-15-10 (49' boom)

(all C-49XR's are phased and the bottom C-49XR is on a rotating ring)

_160 vertical (N6BT)

__80/75 4-square (N6BT)

___SS-3e 20-15-10 (N6BT) on a separate tower

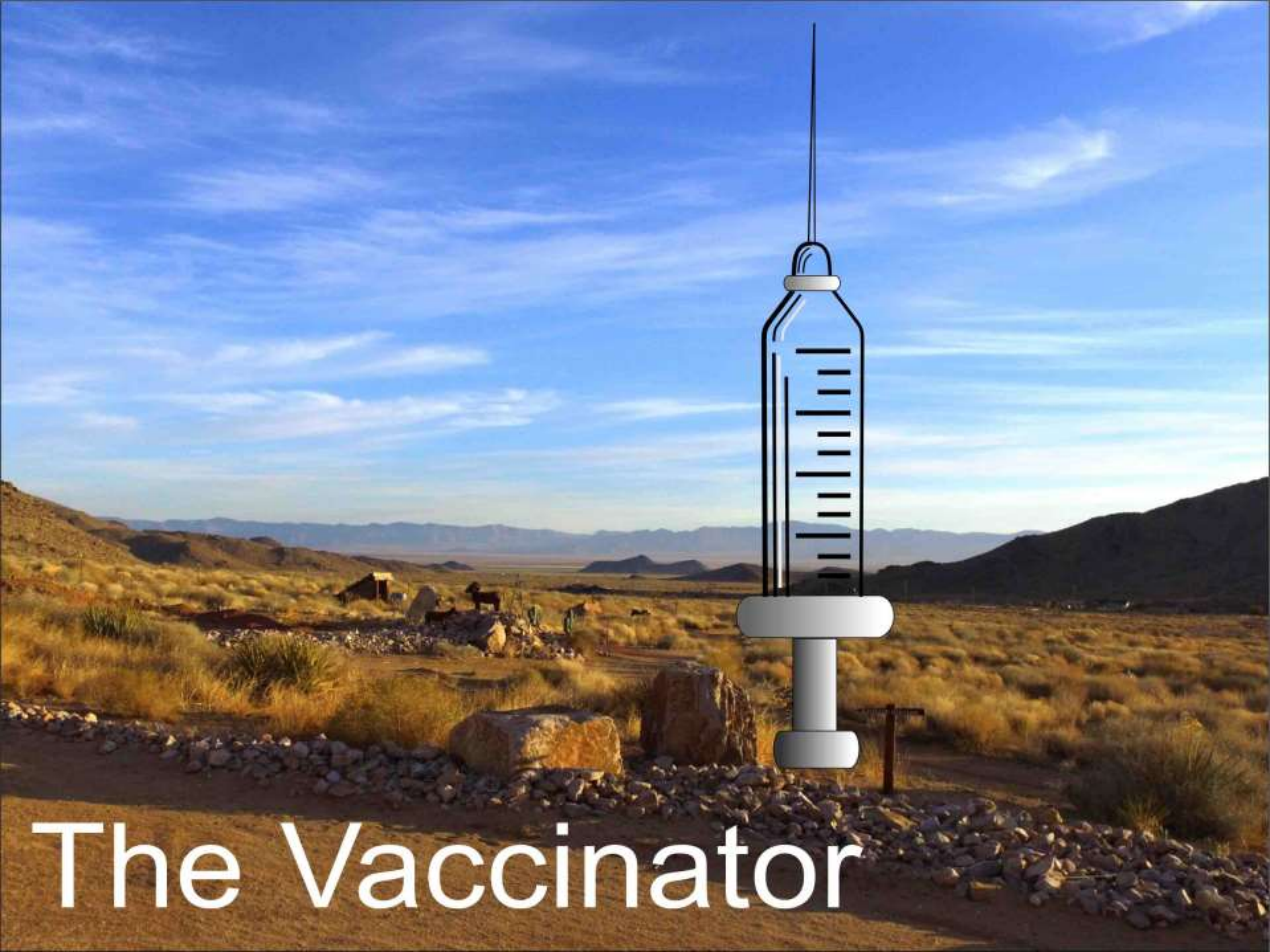


Then

for those who *absolutely* must be the first one through the pile-ups, we have -->

“CU Later”

As a tribute to First Responders, Doctors, Nurses, Vaccine Developers, Manufacturers, those in Transportation, FEMA, National Guard, and especially the nurses who gave me the two Covid-19 shots, → → →


The Vaccinator

The prior slides of stations were all Yagi-based; however, there are others that have vertical arrays on several bands, such as our place in NW Arizona → →


4el on 40 (4-square)
3el 80 mtr triangle phased broadside
2el 160 phased end-fire & broadside
No ground radials – all use the VOR (vertical open ring)
More on this later

“I have never let my schooling interfere with my education.”

Mark Twain

What is the purpose of the antenna?

1. Get on the air to work someone, anyone.

2. Be able to work locals and friends.

3. Chase DX.

What is a common issue for all 3?

length

as in wavelength

Unless there is a specific prohibition on outdoor antennas,

this is probably the major factor to be considered.

What kind of lengths are we looking at?

Length depends on the band(s) we are interested in using.

A half-wave in free space,

is calculated using

492/f (MHz)

...but...
this would maybe be for a wire dipole,
so it will be shorter.

½ wavelength dipole

	Free space	Wire approx 468/f
10 mtrs =	17.4'	16.6'
12 mtrs =	19.7'	18.8'
15 mtrs =	23.2'	22.1'
17 mtrs =	27.1'	25.9'
20 mtrs =	34.6'	33.0'
30 mtrs =	48.7'	46.3'
40 mtrs =	69.2'	66.0'
80 mtrs =	129.5'	123.1'
160 mtrs =	269.5'	260.0'

Why include free space length?

Useful for spacing phased elements, as

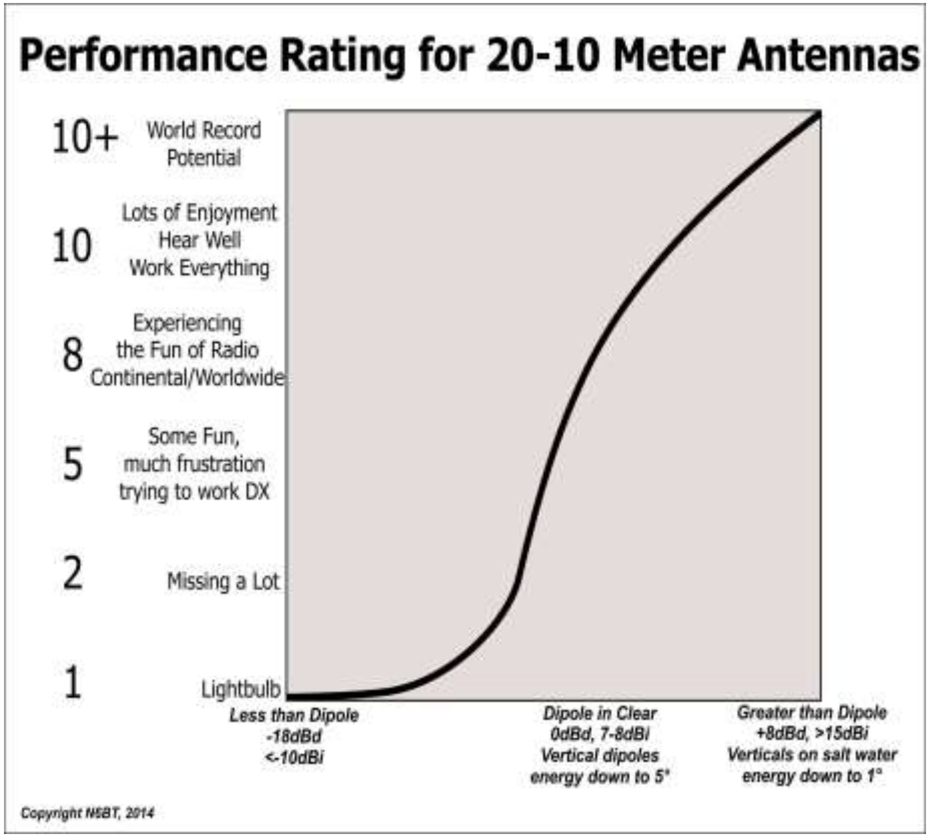
the are coupling through air, not through a physical conductor (e.g. wire).

For a given small area to work with, which bands are “reasonable” to consider?

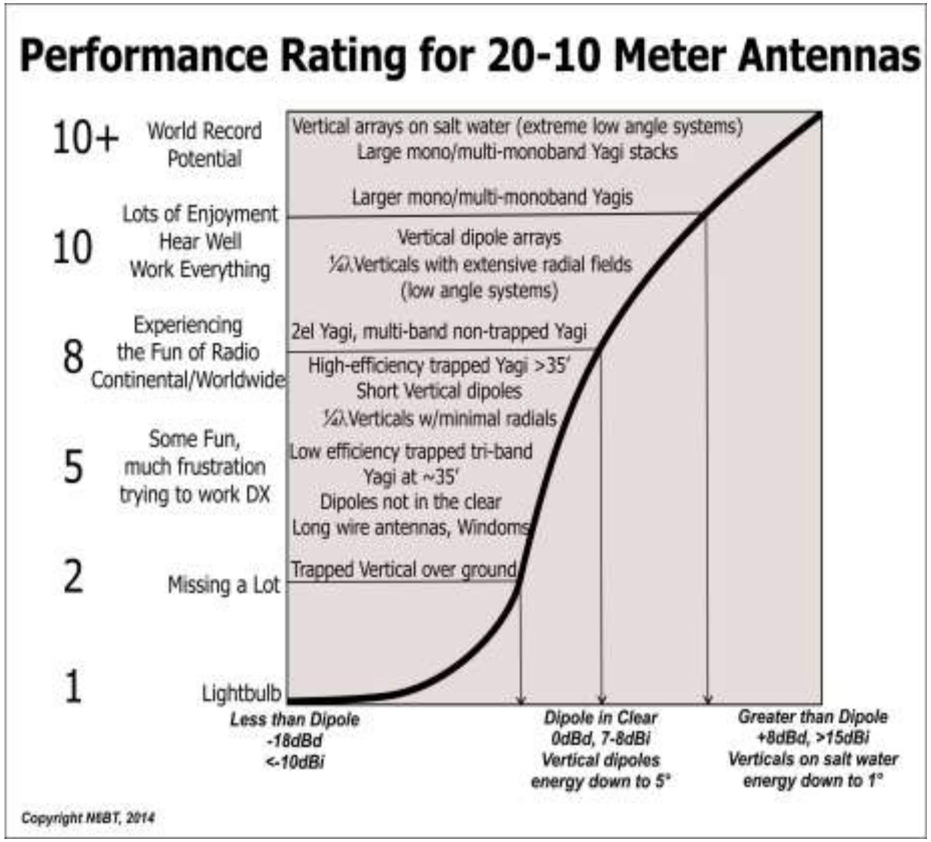
	Free space	Wire approx 468/f
10 mtrs =	17.4'	16.6'
12 mtrs =	19.7'	18.8'
15 mtrs =	23.2'	22.1'
17 mtrs =	27.1'	25.9'
20 mtrs =	34.6'	33.0' ←
30 mtrs =	48.7'	46.3'
40 mtrs =	69.2'	66.0' ←
80 mtrs =	129.5'	123.1'
160 mtrs =	269.5'	260.0'

With our current low sunspot conditions, the best choices are 20 for daytime operating and 40 for nighttime and nets.

Those who have limited space -- I would like to change the length formula so to you could fit a 160 antenna on your property; however, I simply don’t have the authority.

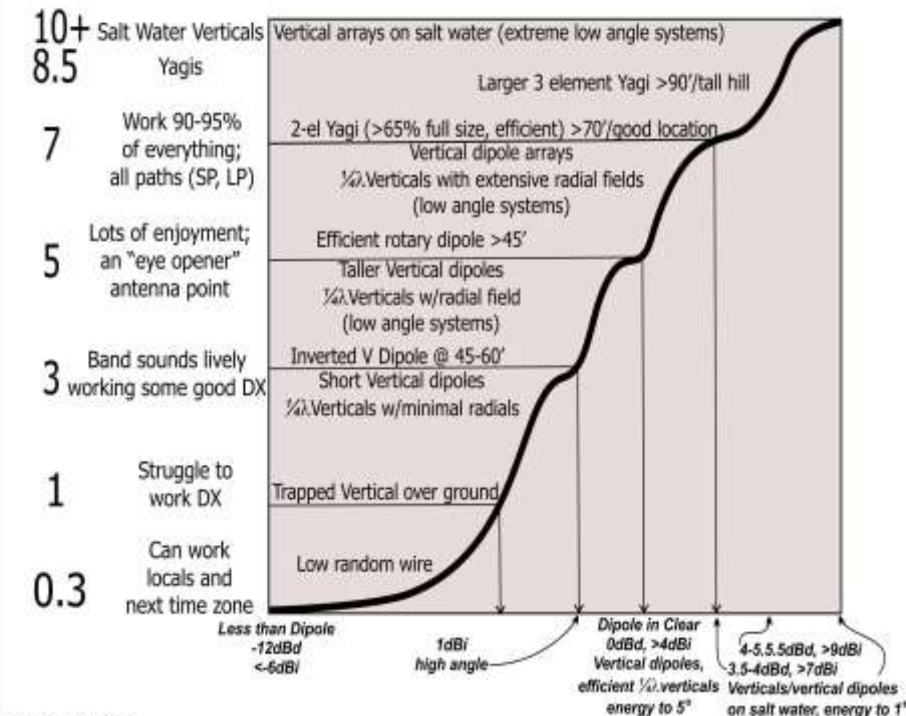


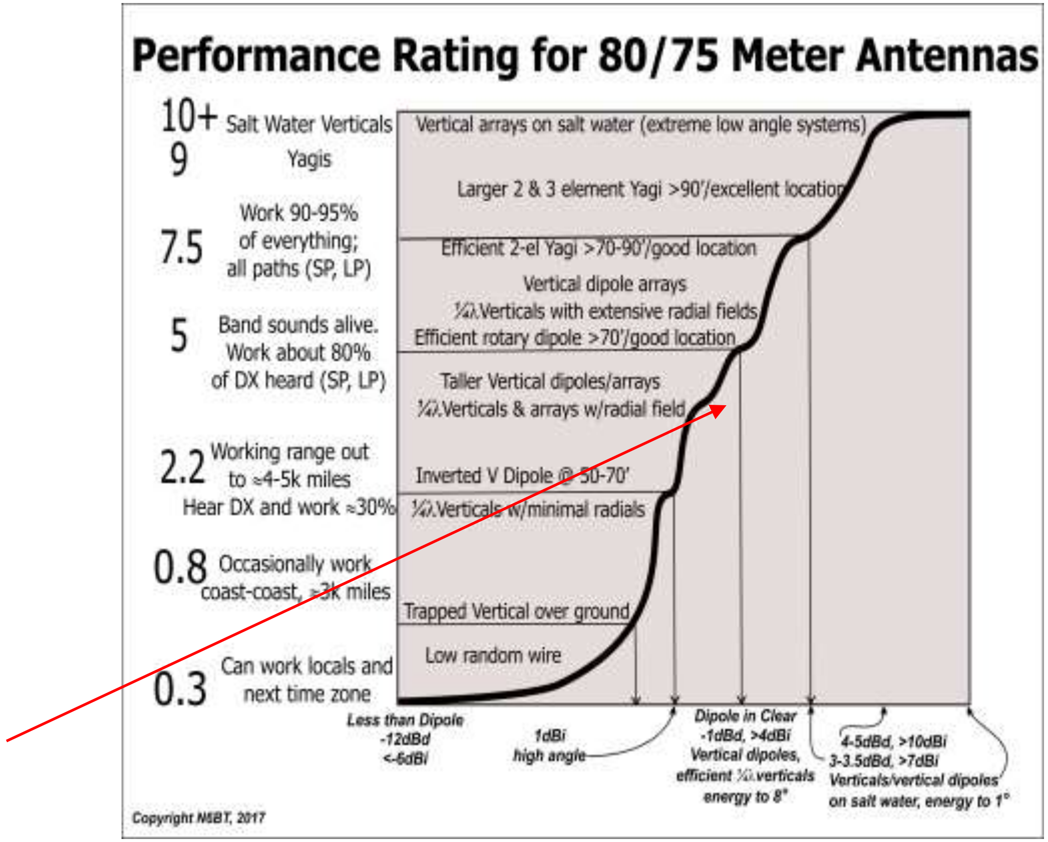
Enjoyment of radio to antenna performance

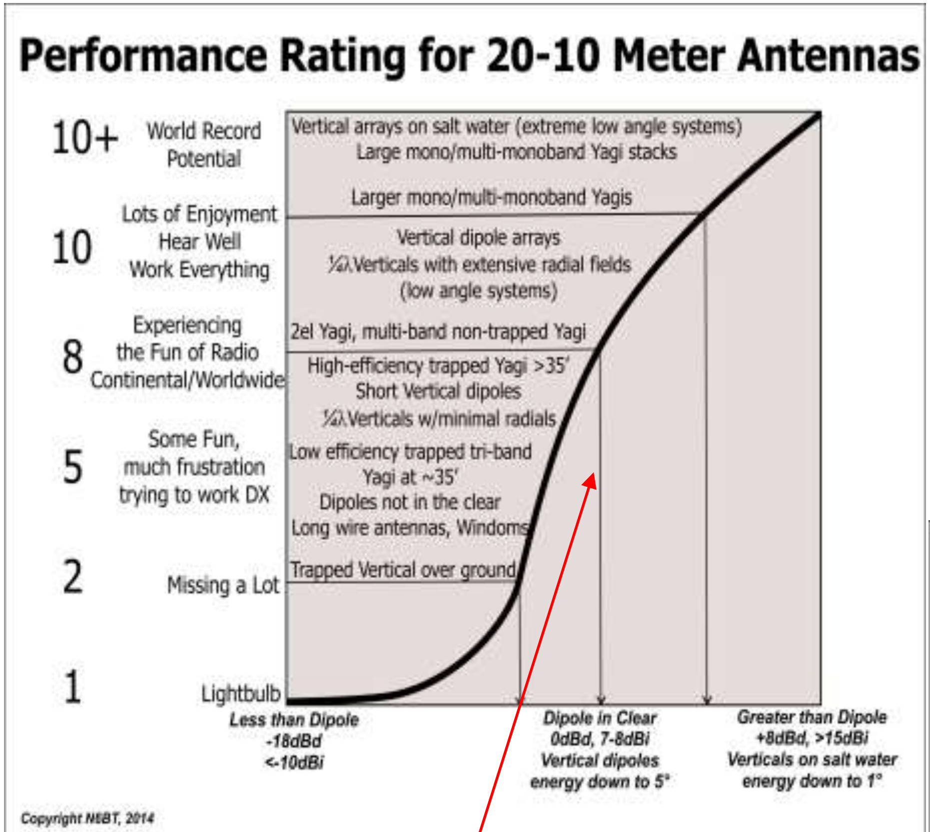


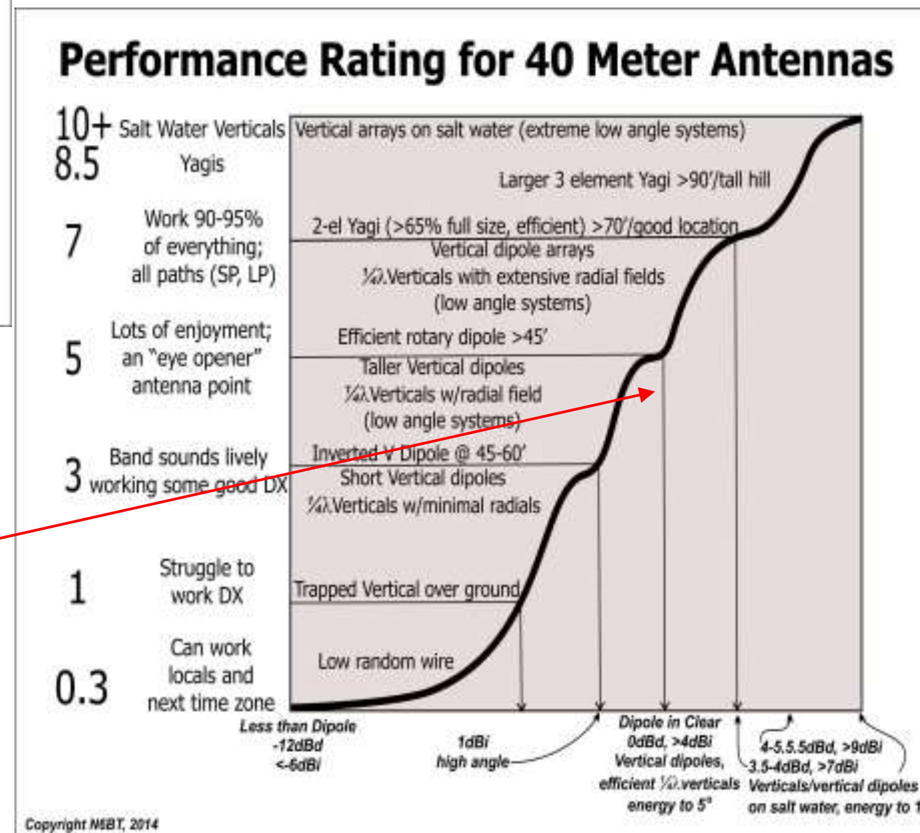
Enjoyment of radio to antenna performance

Performance Rating for 40 Meter Antennas




Performance Rating for 80/75 Meter Antennas
10+ Salt Water Verticals
9 Yagis
7.5 Work 90-95% of everything; all paths (SP, LP)
5 Band sounds alive. Work about 80% of DX heard (SP, LP)
2.2 Working range out to ≈4-5k miles
Hear DX and work ≈30%
0.8 Occasionally work coast-coast, >3k miles
0.3 Can work locals and next time zone
Vertical arrays on salt water (extreme low angle systems)
Larger 2 & 3 element Yagi >90'/excellent location
Efficient 2-el Yagi >70-90'/good location
Vertical dipole arrays
¼λ Verticals with extensive radial fields
Efficient rotary dipole >70'/good location
Taller Vertical dipoles/arrays
¼λ Verticals & arrays w/radial field
Inverted V Dipole @ 50-70'
¼λ Verticals w/minimal radials
Trapped Vertical over ground
Low random wire
Less than Dipole -12dBd <-6dBi
1dBi high angle
Dipole in Clear -1dBd, >4dBi Vertical dipoles, efficient ¼λ verticals energy to 8°
4-5dBd, >10dBi
3-3.5dBd, >7dBi
Verticals/vertical dipoles on salt water, energy to 1°
Copyright N6BT, 2017


Performance Rating for 20-10 Meter Antennas
10+ World Record Potential
10 Lots of Enjoyment Hear Well Work Everything
8 Experiencing the Fun of Radio Continental/Worldwide
5 Some Fun, much frustration trying to work DX
2 Missing a Lot
1 Lightbulb
Vertical arrays on salt water (extreme low angle systems)
Large mono/multi-monoband Yagi stacks
Larger mono/multi-monoband Yagis
Vertical dipole arrays
¼λ Verticals with extensive radial fields
(low angle systems)
2el Yagi, multi-band non-trapped Yagi
High-efficiency trapped Yagi >35'
Short Vertical dipoles
¼λ Verticals w/minimal radials
Low efficiency trapped tri-band Yagi at ~35'
Dipoles not in the clear
Long wire antennas, Windoms
Trapped Vertical over ground
Less than Dipole -18dBd <-10dBi
Dipole in Clear 0dBd, 7-8dBi Vertical dipoles energy down to 5°
Greater than Dipole +8dBd, >15dBi Verticals on salt water energy down to 1°
Copyright N6BT, 2014


Performance Rating for 40 Meter Antennas
10+ Salt Water Verticals
8.5 Yagis
7 Work 90-95% of everything; all paths (SP, LP)
5 Lots of enjoyment; an "eye opener" antenna point
3 Band sounds lively working some good DX
1 Struggle to work DX
0.3 Can work locals and next time zone
Vertical arrays on salt water (extreme low angle systems)
Larger 3 element Yagi >90'/tall hill
2-el Yagi (>65% full size, efficient) >70'/good location
Vertical dipole arrays
¼λ Verticals with extensive radial fields
(low angle systems)
Efficient rotary dipole >45'
Taller Vertical dipoles
¼λ Verticals w/radial field
(low angle systems)
Inverted V Dipole @ 45-60'
Short Vertical dipoles
¼λ Verticals w/minimal radials
Trapped Vertical over ground
Low random wire
Less than Dipole -12dBd <-6dBi
1dBi high angle
Dipole in Clear 0dBd, >4dBi Vertical dipoles, efficient ¼λ verticals energy to 5°
4-5.5.5dBd, >9dBi
3.5-4dBd, >7dBi
Verticals/vertical dipoles on salt water, energy to 1°
Copyright N6BT, 2014

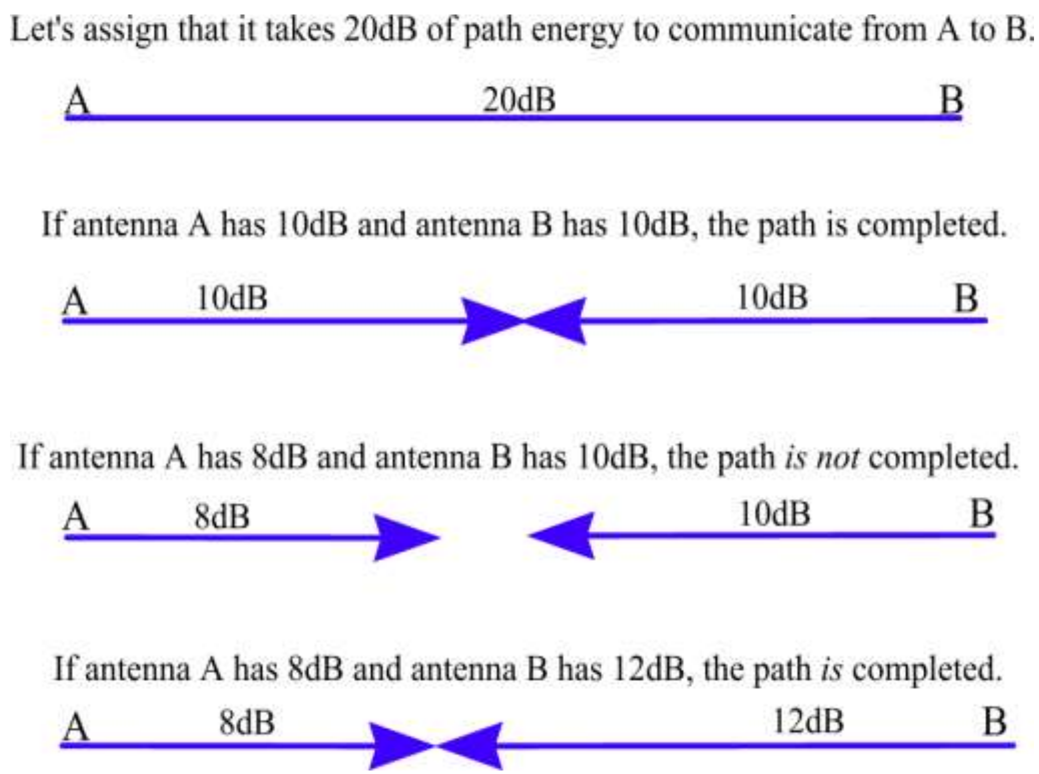
These charts indicate that a dipole or a good vertical will provide lots of enjoyment from radio.

Nothing particularly fancy,

only efficient.

Why is it that some think their antenna works really well?

Example path



Answer – there are enough stations with larger antennas that make up the "missing dBs" to enable a QSO. They do the "heavy lifting", so to speak.

The “Illuminator”

28 countries and W.A.C. in one weekend

120 watts (ARRL DX CW)

QST July, 2000

3 element phased light bulb array

(select any 2 elements in phased broadside)

34 countries and W.A.C. in one weekend

1,200 watts (ARRL DX SSB)

estimated gain is 3dBslb

Used 300 watt bulbs; blew them all out, but it worked the same.

Although we worked a fair number of countries,

the light bulb antennas really did NOT work very well.

A few basics..............

We have limited real estate,

__limited horizontal length,

___limited vertical height,

____visual limitations.

We might also -

__be all inside (condo),

___have a balcony,

____have access to ground.

My “off the top” thoughts for an antenna:

__be all inside _______________magnetic loop

___have a balcony ____________mag loop, compressed vertical or dipole

____have access to ground ____many more options

The magnetic loop is a low profile antenna you can either make, or purchase.

They have been around almost a hundred years.

The magnetic loop is a low profile antenna you can either make, or purchase.

They have been around almost a hundred years.

Seem to be popular today; what is the main issue with most of the new mag loops?

Very narrow VSWR operating bandwidth (a few kHz)

Power handling

The voltages opposite the feed point are extremely high

Many are limited to around 15-25 watts.

My (limited) experience is that mag loops are less sensitive to immediate surroundings and, based on many tests of our ZR vertical antenna, can perform well inside buildings.

Several companies have produced magnetic loops since the early '90's.

Early model ISOLOOP by AEA.

Icom AL-705 40-10M Magnetic Loop Antenna

40-10 meters 20 watts SSB and 10 CW/Digital

Retail $230

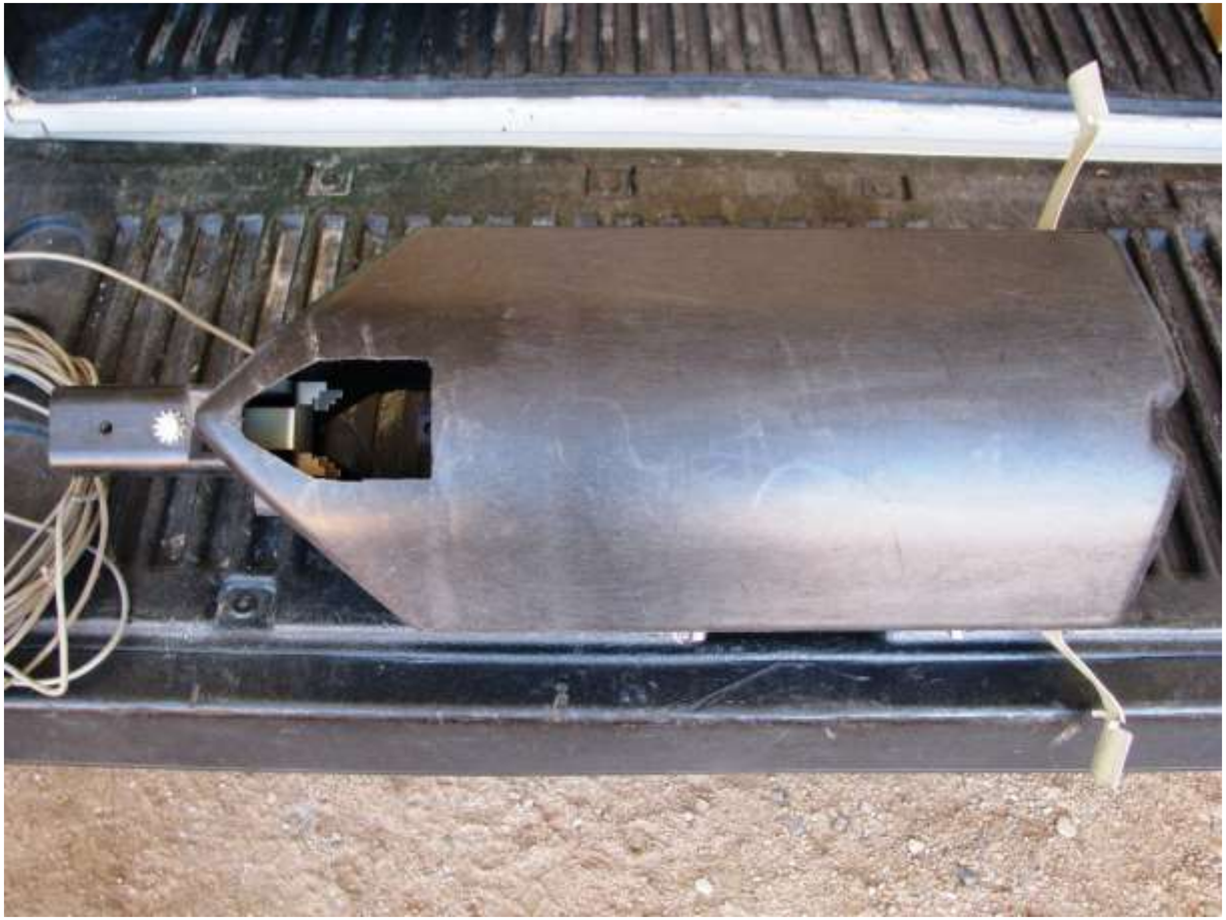
Current MFJ available in several models, including down to 40 meters and still a small footprint of about 3’ diameter.

150 watts

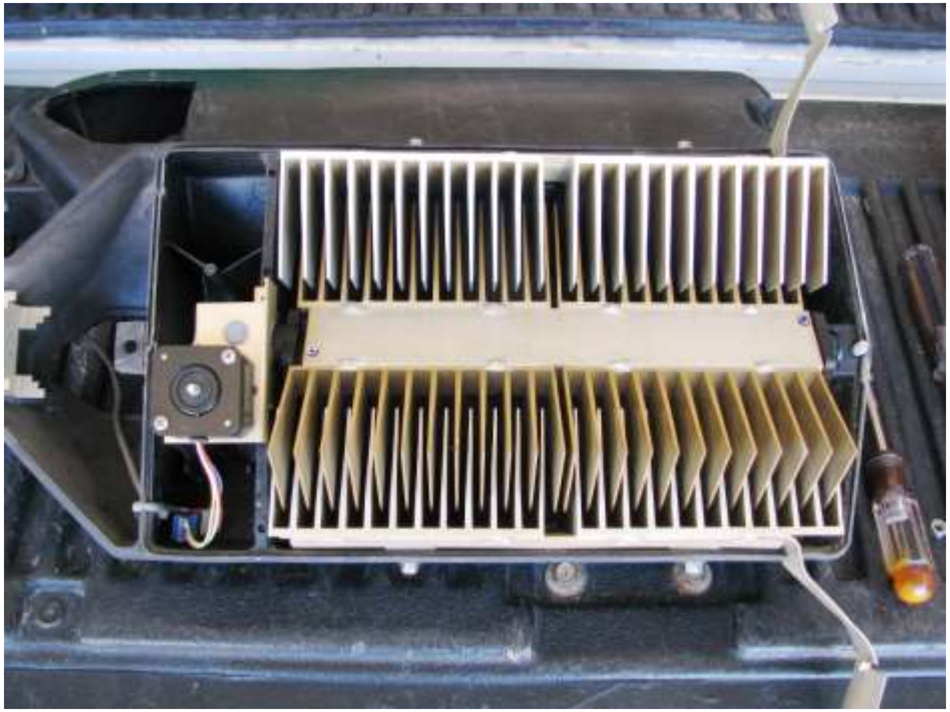
→ Notice the large enclosure

Retail $560

The difference is mainly the capacitor to handle higher power



From an old AEA that could handle power
(motor drive tuning)



Wide spacing on butterfly capacitor plates to handle high voltage

A surplus vacuum capacitor will also work well.

(few hundred $$, plus mount, drive unit, etc.)

one octave

means doubling or halving the frequency

10 to 20

20 to 40

40 to 80

80 to 160

why is this important?

A (fixed length) antenna for a particular band can be loaded for one octave lower while maintaining good efficiency.

The length for the lower frequency is only half what it should be, which makes the selection of the loading device very important.

10 meter dipole is ~16.5’

and the octave lower 20 meter dipole should be ~33’

Now you want to also use it on 40?

10 meter dipole is ~16.5’

and the octave lower 20 meter dipole should be ~33’

the 2 octave lower 40 meter dipole wants to see ~66’,
but all we have is 16.5’

which is 1/4 size.

Want it to work on 80/75?
it will be 1/8 size

but

we can make everything work

to some degree.

Why is it important that we can make an antenna that can cover one octave with good efficiency?

1. Efficiency is the key

2. A full size 20 can be reasonably efficient on 40

A full size 20 mtr dipole can be loaded slightly off center on each half with easy-to-make air core inductors and the efficiency on 40 will be >90%.

The pattern of a dipole is the classic figure 8 and the take-off angle is determined by the elevation of the antenna above ground.

At 35' over flat ground, the take-off angle on 20 is 29° and on 40 mtrs, it is 76°.

If you have a 10-meter vertical,
(or any vertical)
make an inductor enclosure
and extend the frequency coverage.

29° on 20 meters is not too bad for all around operating, both domestic and DX.

76° on 40 meters is alright for domestic, particularly out to 700-1000 miles, as this is almost an NVIS antenna (because it is at a fairly low height).

The main issue is that this dipole is at 35' high and for most areas with restrictions, this is probably not feasible.

A typical take-off angle for a ground-mounted vertical that is elevated above ground (no ground radials) is about 12° and lower over very good ground (so says our drones).

Back to the main concern:

the 20/40 dipole is 35' high.

With HOAs, a 35' tower or mast is not possible.

A mast is not necessarily a major project,

but a 35' tower can be.

We need something lower, or at least an antenna

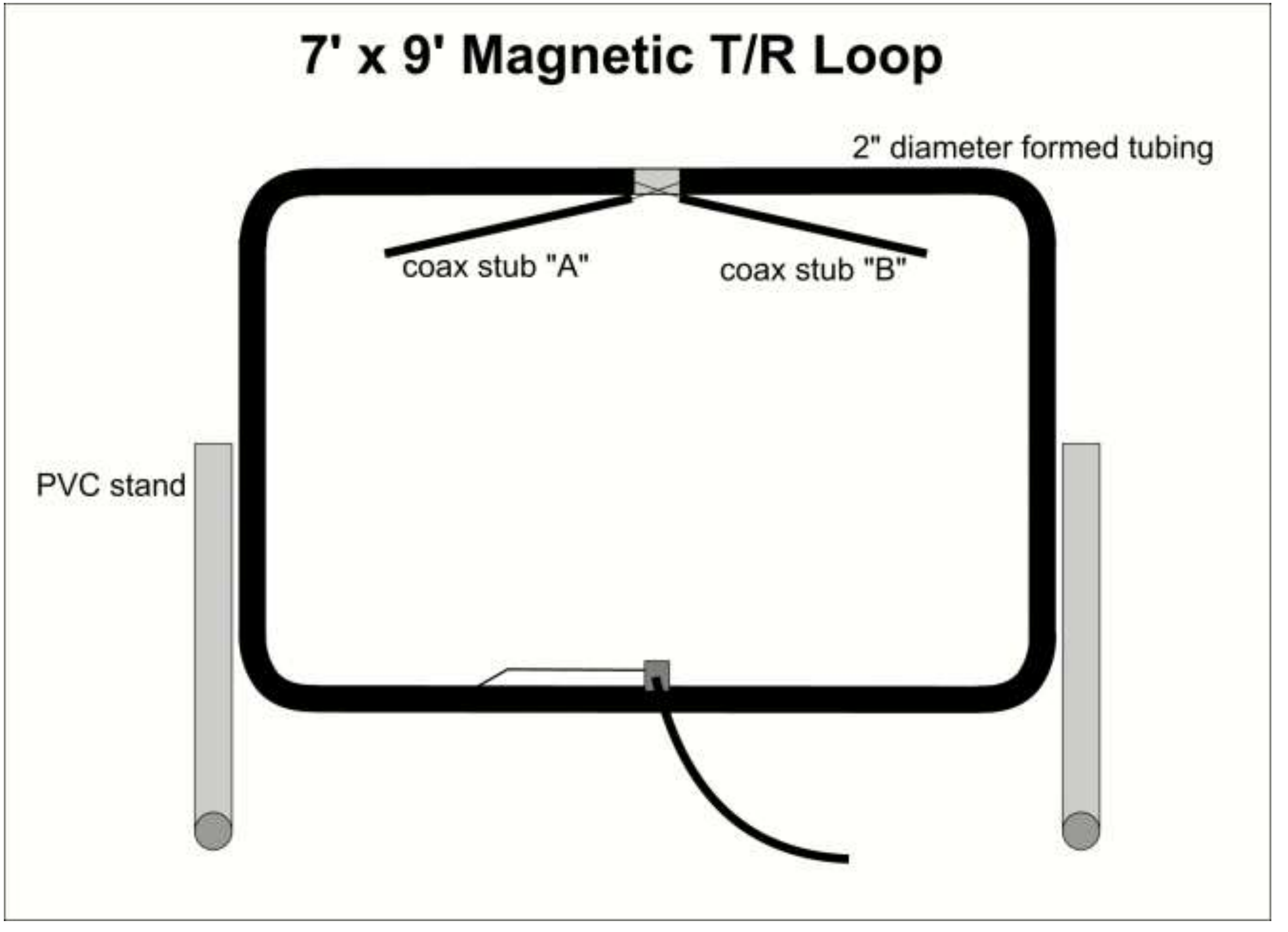
that can be “made lower” when not in use.

A lower profile antenna for 40 meters,

although narrow banded and power-limited

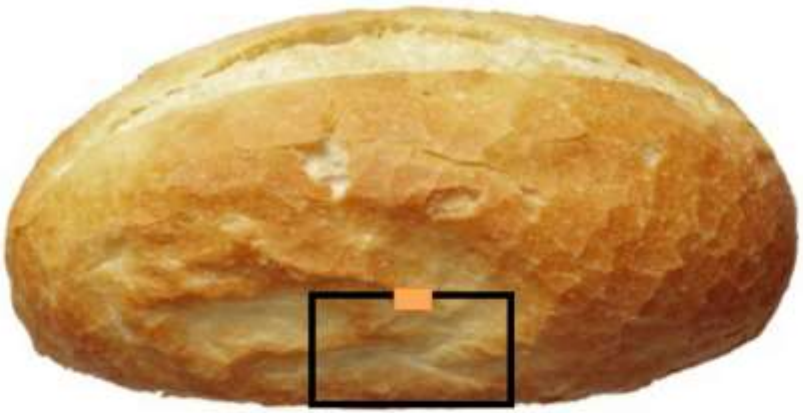
(maybe 100-150 watts, keeping within budget)

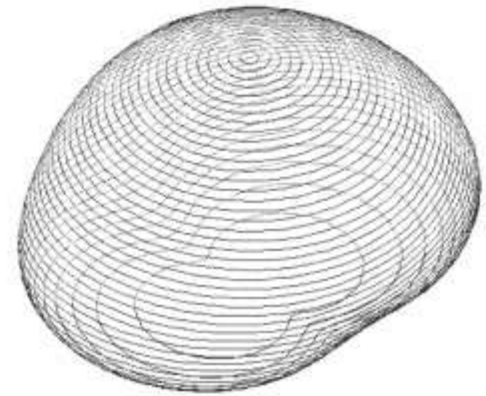
is a well-designed magnetic loop.



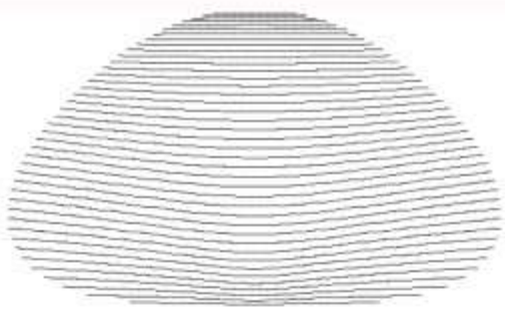
This can rotate in the stand to horizontal when not in use.

40-meter magnetic loop for NVIS
6’ tall x 8’ long at 2’ high



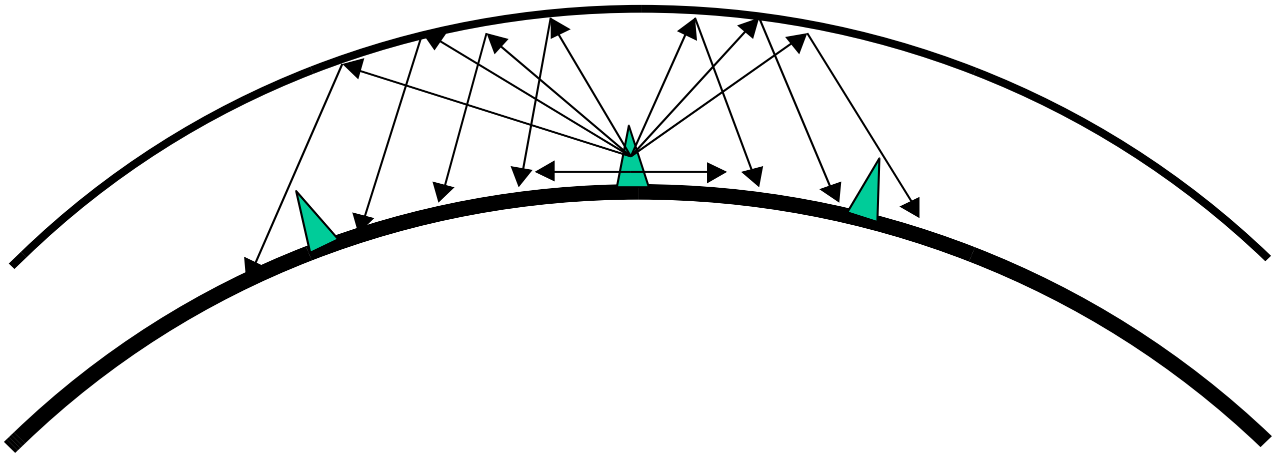


NVIS 3/4 view of pattern



NVIS side view of pattern

NVIS end view of pattern



NVIS antennas

The energy is emitted at angles from about zero to straight up. There are no nulls in the pattern, resulting in contiguous coverage out several hundred miles.

The frequency of operation is between the amateur 75 and 40 meter bands.

What about simply putting up a wire – something?

Dipole…

what kind of wire?

Stranded or solid?

My preference is solid.

__#1 is solid copper.

____Next is alum-o-weld or copper-weld, which are aluminum or copper clad steel. They are less expensive than solid copper and stronger, especially for long dipoles for the low bands. This is not plated wire, which can be very thin and not thick enough for the skin depth, allowing the RF to penetrate into the lossy steel core.

The standard for cladding is ASTM B415-92 fixed at 25% of the cross-sectional area.

Why solid?

Over time, wire ends become corroded, often way back underneath the jacket. Solid wire can easily be buffed/burnished back to the original shiny copper.

Copper hairpin after many years. Easy to maintain.

Stranded wire is very difficult to clean the strands to attach a new connector.

Stranded balun leads after many years.

Difficult to replace lugs and the strands are both corroded and broken from flexing in the wind countless times over the years.

The connection to the lug(s) will eventually fracture.

BTW – stranded, very flexible copper/steel wire for antennas is a potential risk. Often, the twist rate is too tight and the copper has micro-fractures. The result is that rain will get into the steel core and it will rust with the eventual disintegration of the antenna.

If you want to get on HF and work folks, sometimes long distances, but you have limited space and restrictions,

there are some antennas you can make.

You probably will be running low power (200 watts or less) and my suggestion is ***<u>not</u>*** to run QRP (5 watts).

“Life’s too short for QRP”

Bruce, N6TU (late ‘70’s)

General rules:

the lower power you run, the more important the antenna;

and,

your antenna is directly related to your enjoyment of radio.

The most restricted HOA I've ever worked with

and

we got him on the air 40 through 10.

Two of the guy lines

on his wx station tripod

are a 40 mtr dipole.

Then we used an old trapped dipole and mounted it

so that it wasn't visible as he walked down the street.

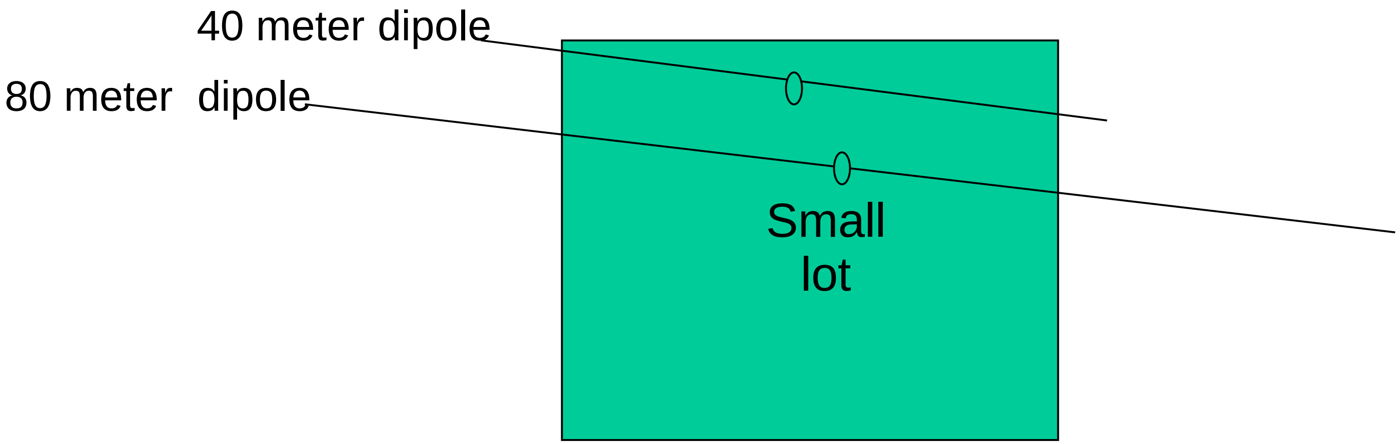
The concrete blocks sit in welded aluminum trays.

The tips were adjusted, along with a little on trap spacing until it had a reasonable match. He runs an ICOM transceiver and KW solid state amplifier (40-10). Optional listening on 40 is a small loop, about 5' in diameter.

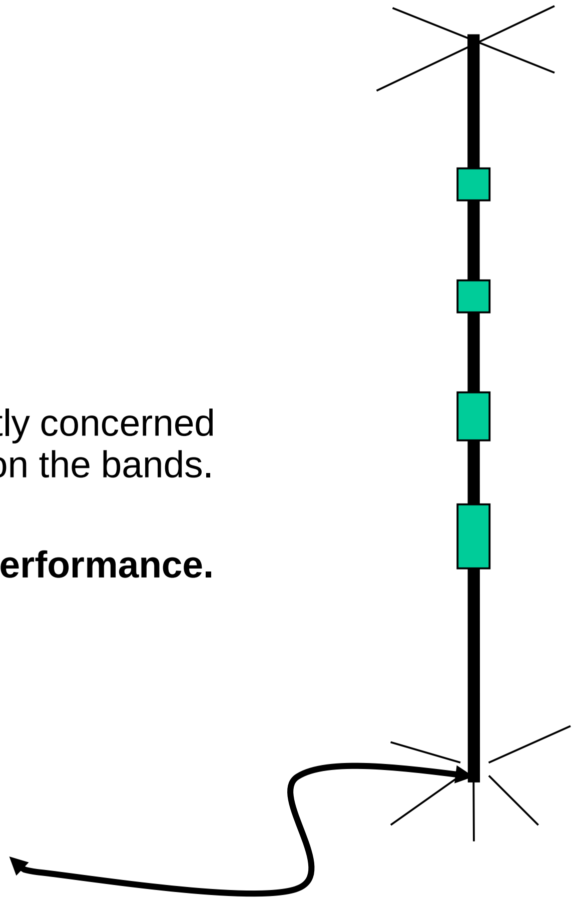
Important to notice the antenna is outside, barely, but outside.

Knowing that a full-size dipole is very effective, but too long and won’t fit in the available space, maybe we can go up instead of horizontally for smaller locations.

(Yes, the dipole ends can be bent, so this can be tried, too.)



“Going up” implies a vertical for our band of choice, or perhaps some method of the antenna “working” on several bands.



Trapped verticals appear mostly concerned about having a low VSWR on the bands.

My primary concern is performance.

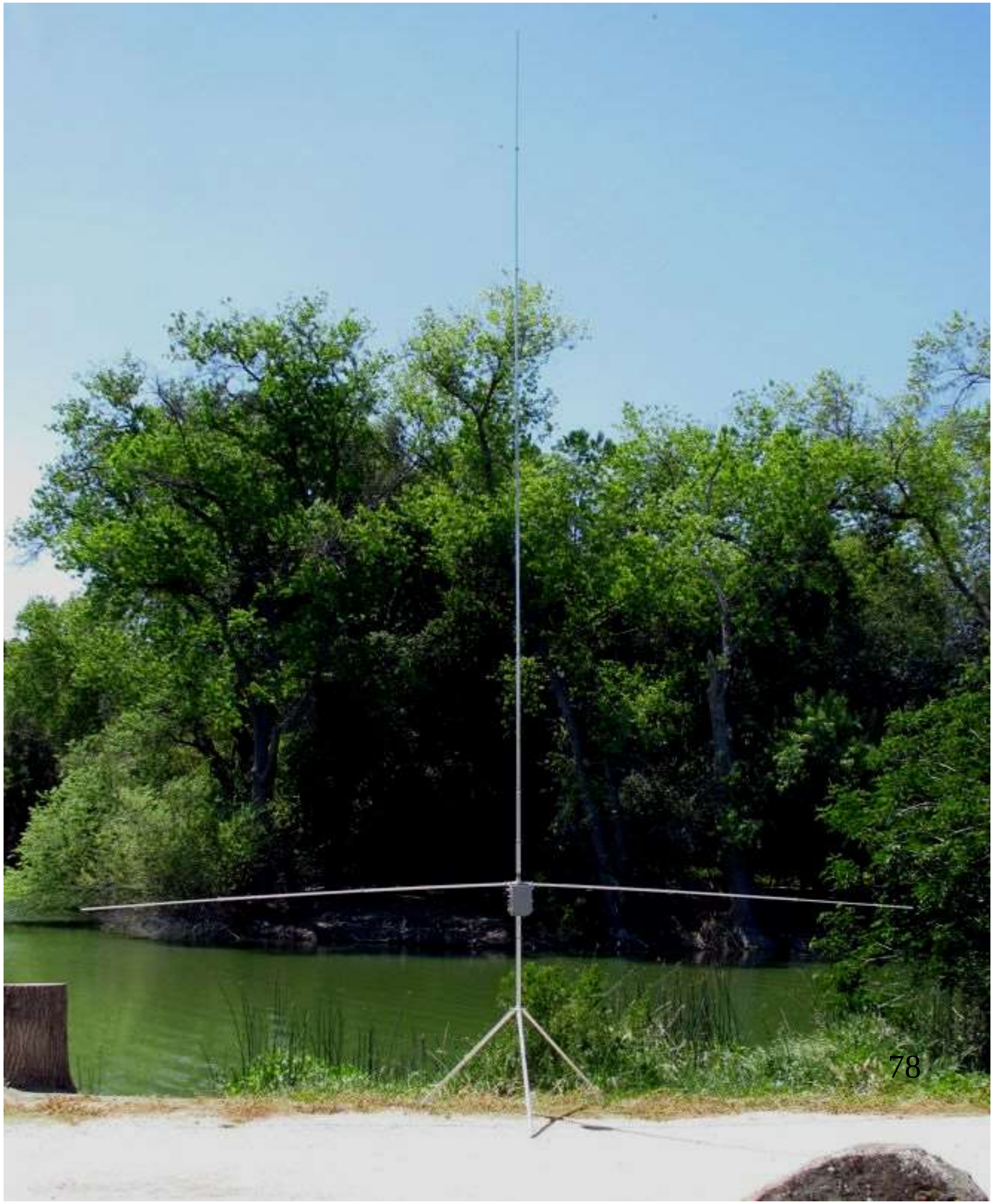
Typical

Bravo Series

(40-10 mtr)

Since 2010, the Bravo has been produced in many models from 80 meters on up: single band, 2 and 3 band, 5-band, manual and relay switching.

Originally developed for Team Vertical on Eleuthera, Bahamas.



EV Series

2el rotatable

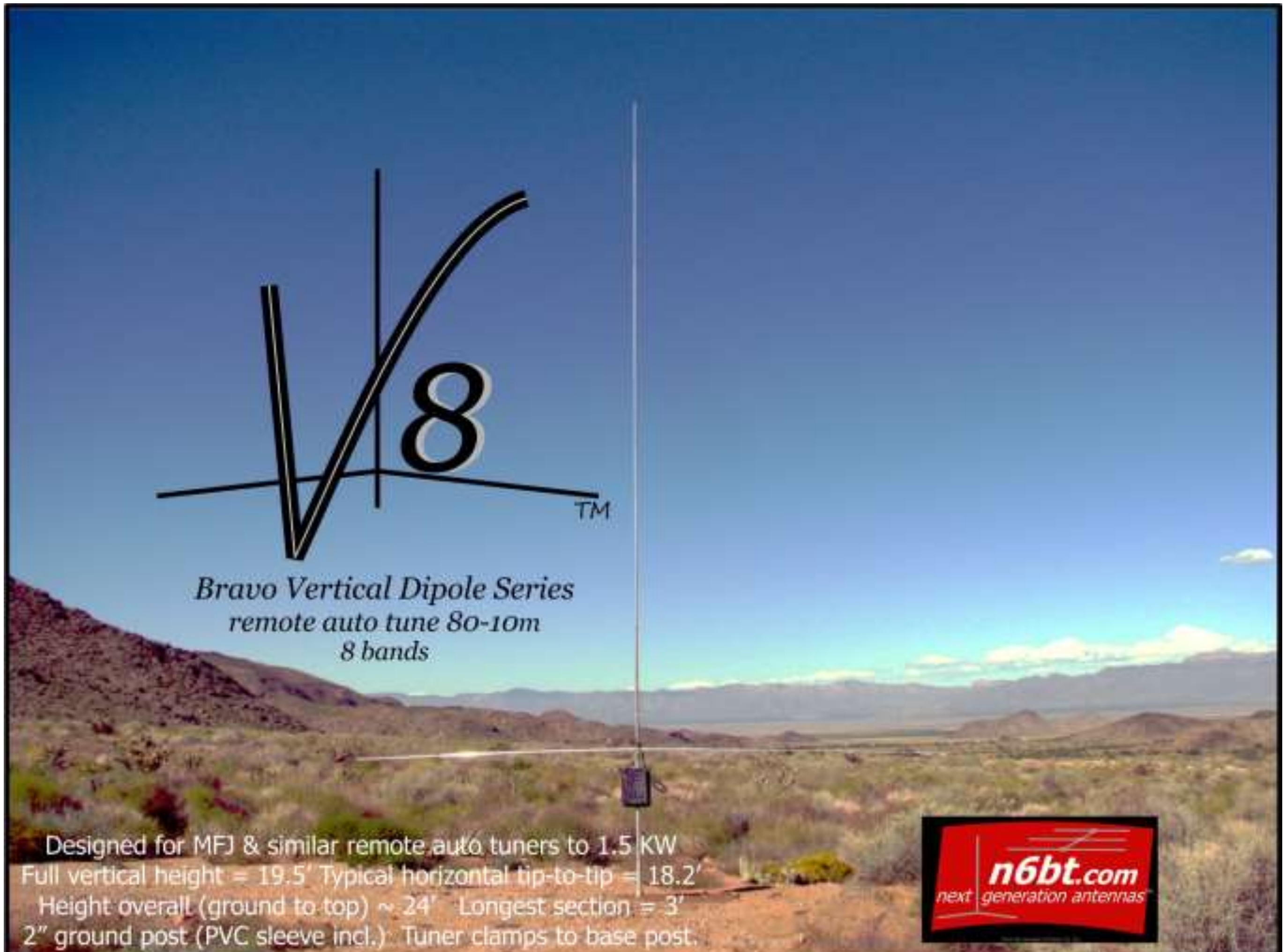
Without ground contact and no horizontal sections, multi-band vertical dipoles can be paired for a low profile, rotatable gain array.

This 2 element is manual band change for 20-17-15-12-10 meters.

This Bravo was made into the **V-8** for use with a remote tuner to cover 80-10.

Reviewed in QST January 2020; drops into 2" PVC in ground; horizontal is about 4' above ground.

The vertical sections can easily pull out to lay on the ground, out of sight. Everything telescopes.



A new look at verticals

2014 began empirical testing using drones

Discoveries to date about vertical antennas

1. The ground is not your friend - keep the vertical and horizontal components off the ground;

2. Linear loaded verticals are highly efficient;

3. 1/4 wave ground radials are actually ~25-30% too long, which places the maximum current in the ground, rather than in the vertical;

4. Verticals using 1/4-wave ground radials usually get shortened, ensuring that the maximum current is in the ground (shorten the radials, instead);

5. A "classic vertical" will be 7dB down from a vertical with elevated, tubing radials;

6. The take-off angles for vertical antennas have been measured to be substantially lower than the computer model indicates;

7. Verticals by salt water have energy down to the water (<1°);

8. Verticals adjacent to sloping ground have energy that follows the slope and measurements on sloping ground of 8-12º show that the vertical has energy at and below the horizon;

9. Measurements comparing full size (asymmetric) vertical dipoles to full size horizontal dipoles shows them to be within the margin of error in field strength, meaning that the often-quoted 6dB of ground reflection gain for the horizontal is not seen;

Discoveries to date about vertical antennas

10. The most efficient vertical is a full-size vertical dipole (90 ohms);

11. The most efficient compressed size vertical is the ZR design, because it is an electrically full size, half-wave element;

12. A full size Sigma is almost identical to the ZR, but shares the same awkward feed point in the middle of the vertical element;

13. Asymmetric vertical dipoles are user friendly with the feed point at (or close) to the bottom;

14. Asymmetric vertical dipoles can be built as rotatable beams (no tower);

15 A 2el broadside vertical array has reasonable (~4dB) gain to a single and a narrow beam pattern, making it quiet on receive and broad-banded;

16. Asymmetric vertical dipoles, as well as other verticals that are asymmetric, have a current imbalance that causes balun heating and a loss of energy;

17. The 2017 Gen-7 vertical design is a balanced current, physically asymmetric vertical dipole that does not heat up the balun;

18. VOR is as effective as (2) full length Gull-Wing radials (modeled within 0.1dB) and takes up less space.

19. Verticals do not necessarily need to look like an antenna.

Discoveries to date about vertical antennas

** main items **

5. A “classic vertical” will be 7dB down from a vertical with elevated, tubing radials;

6. The take-off angles for verticals have been measured to be substantially lower than the computer model indicates;

7. Verticals by salt water have energy down to the water;

8. Verticals adjacent to sloping ground have energy that follows the slope and measurements on sloping ground of 8-12º show that the vertical has energy at and below the horizon;

9. Measurements comparing full size (asymmetric) vertical dipoles to full size horizontal dipoles shows them to be within the margin of error in field strength, meaning that the often-quoted 6dB of ground reflection gain for the horizontal is not seen;

18. VOR is as effective as (2) full length Gull-Wing radials (modeled within 0.1dB) and takes up less space.

19. Verticals do not necessarily need to look like an antenna.

What can you make that will work well?

Specifically – how to make an efficient vertical without buried radials

An initial assessment to make might be to:

__think about the possibilities of your property and,

___to recognize your limitations.

A vertical <u>does need </u>"something" for a current return and with limited space and various restrictions, this can be a difficult task.

Some “wisdom” from the Internet to grounding for vertical antennas

These masses of metal act as a giant counterpoise as well as a metallic path for ground currents to supplement soil conductivity. Plus since they are buried in the ground. they have good ground contact over a very large surface area for many wavelengths.

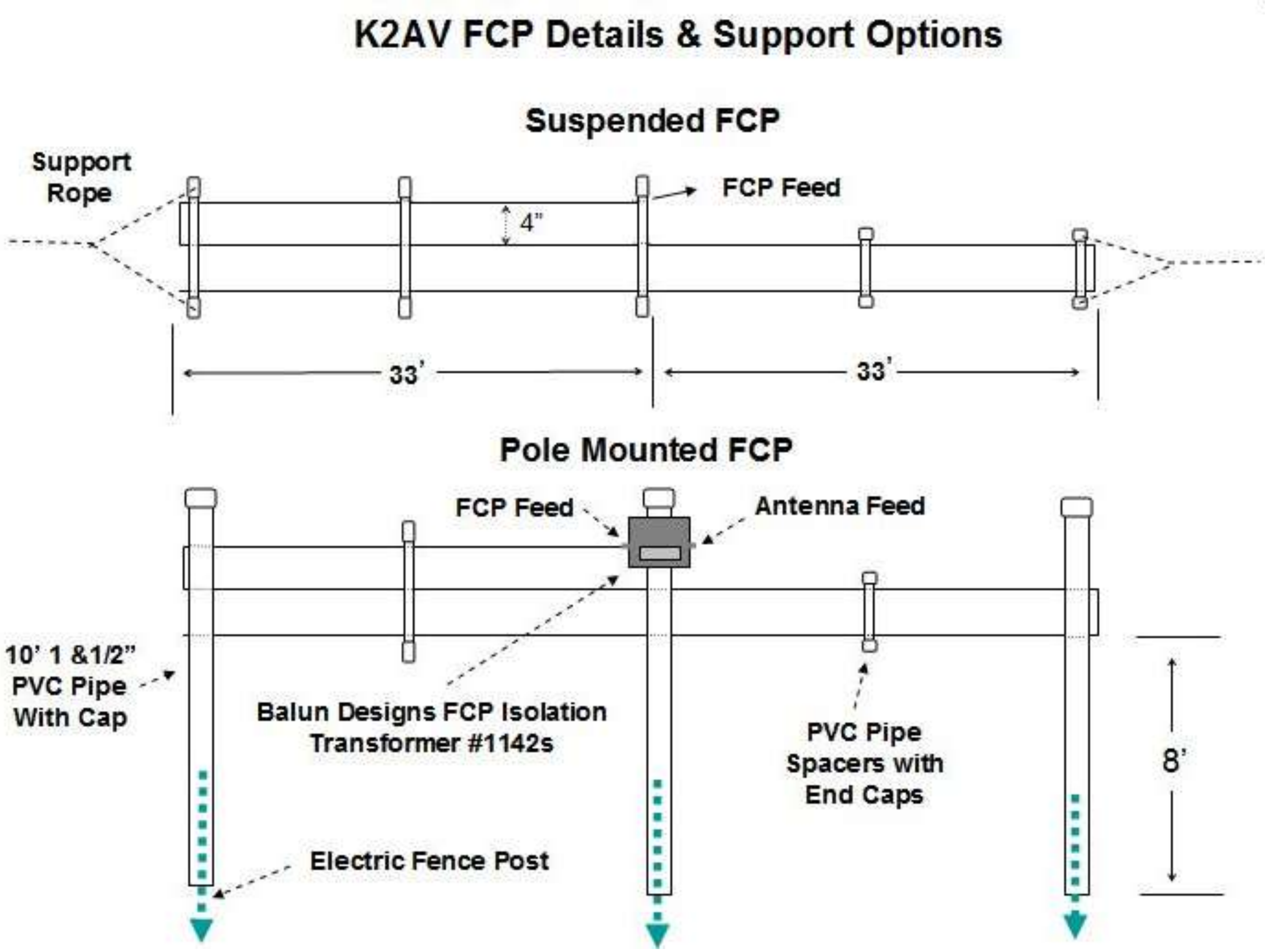
Fire hydrants near trees are an ideal combination
and
have proven to work very, very well.


1162

Limited space, high efficiency
“radials”, “counterpoise”, “current return” for verticals.

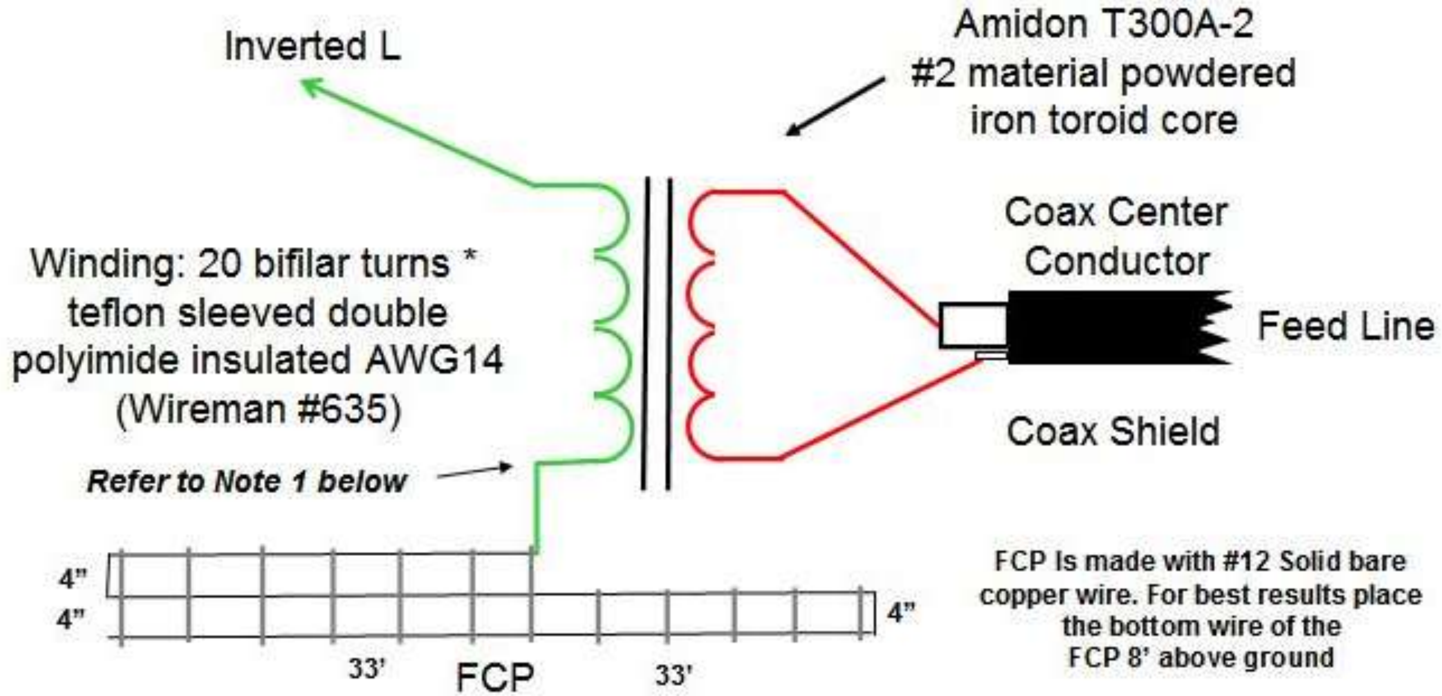
One design that many use is the FCP by K2AV...

Guy Olinger,K2AV, has created an alternative - the folded counterpoise (FCP). An FCP is not magic. It has no gain. An FCP improves an antenna system by replacing more loss with less loss. Some have been able to erect better wires in the air because the small size of the FCP allowed better placement of the antenna. Such a multiple factor improvement project sometimes produces startling changes. Of course, the biggest improvement is that the FCP made possible the first 160 antenna on my property. Detailed construction information for an FCP:



It is fed by a special isolation transformer...

K2AV 33 x 33 160m Folded Counterpoise (FCP) and Isolation Transformer



* Bifilar turns: Instead of the two windings kept separate, one wire on one side of the toroid and one wire on the other side, the two wires are kept in a pair like a length of zip cord. The PAIR of wires is wound around the toroid twenty times. For this application 15 feet of wire and teflon sleeve, cut in half, provides the required PAIR length of 7.5 feet.

Approximate space required for a vertical using the FCP:

Horizontal is 66′ for 160 + end supports

34′ for 80 + end supports

18′ for 40 + end supports

The space for the FCP was still too large for many installations, so we continued developing a smaller footprint, high efficiency current return.

The VOR - Vertical, Open Ring*

__Late '90's Team Vertical used "Gull Wing", elevated 1/4λ radials. This was adapted from a new I.E.E.E. article about AM broadcast stations using elevated wire to replace aging, buried radials. Their empirical testing showed that (4) elevated wires equaled 120 buried ground radials.

__Gull Wing radials are excellent; however, they require a lot of horizontal space and supports at each end.

__2010, our location in the Bahamas had limited space on the beach. We developed a new design employing shortened, elevated tubing resonators (aka "radials"). Tubing is self-supporting and kept the efficiency high. A common air-core inductor fed both equal-length resonators. This was based on my earlier Sigma series developed in 1999 and used by Team Vertical in 2001. The new, shortened design became the commercial "Bravo" series of verticals.

__Not the Gull Wing, FCP, Sigma, or Bravo were the answer for our smallest, efficient footprint, especially for 80 and 160.

Bravo vertical

Sigma vertical

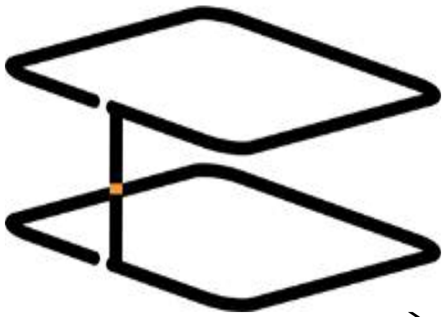
like a large letter "I"

__Our search for a minimal space, high efficiency current return continued and went back before the Bravo and Sigma to the early ‘90 design by Dr. Boyer, the ZR, which uses an open ring at each end of the vertical to complete the electrical length.

__The ZR is originally a full-length dipole that has its ends made into an open-ended square.

__The resulting design is the “Vertical Open Ring” - VOR

VOR development went back to the original ZR from 1995-96



20 mtr proto-type

(1995)

ZR-3

20-15-10 mtrs

6' tall, one feed line

No loading or traps

2017-18
Open Ring on a 40 vertical

Comparative computer models are as follows

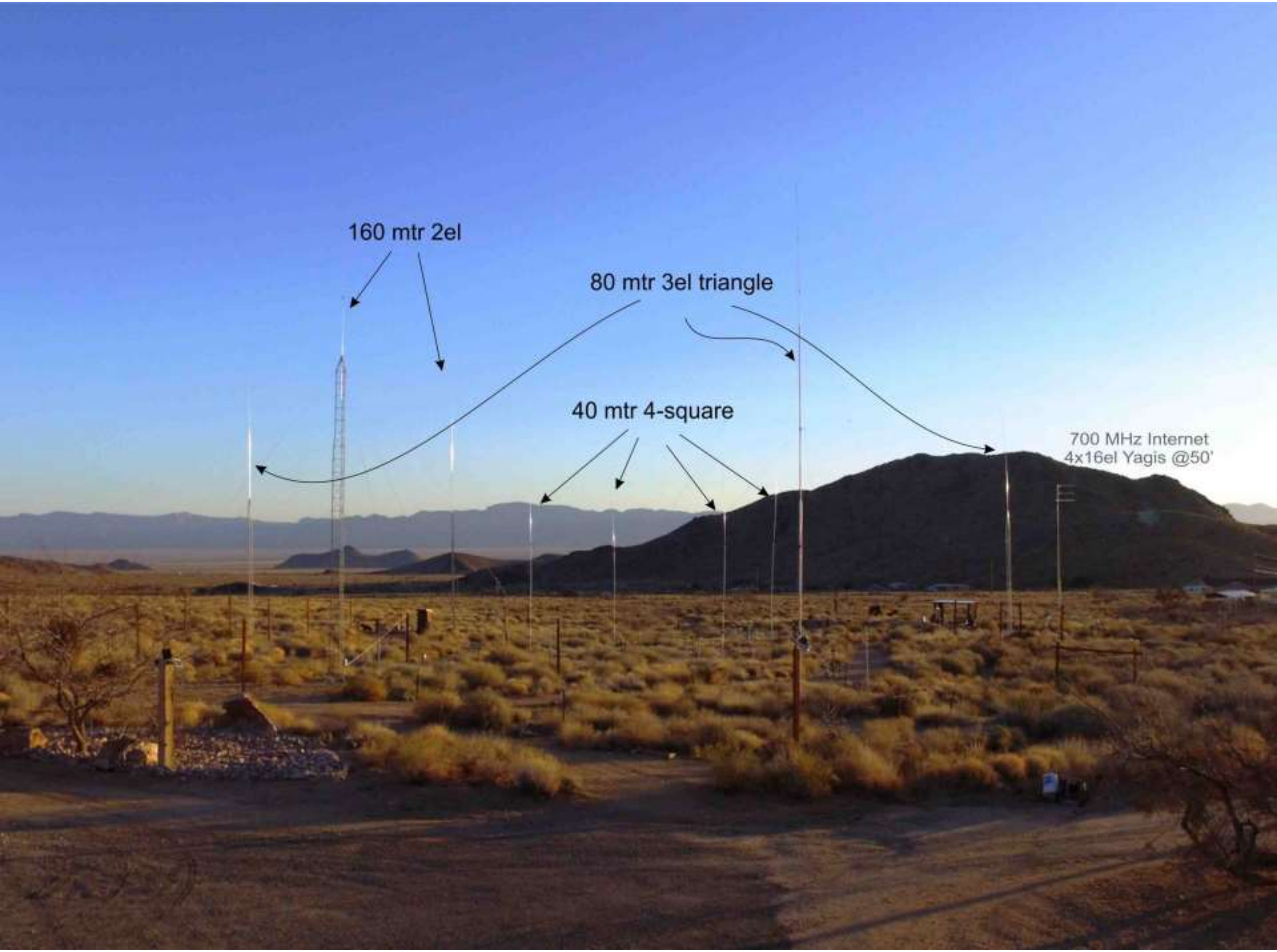
(vertical system is over salt water; however, efficiency is the same for other ground types)

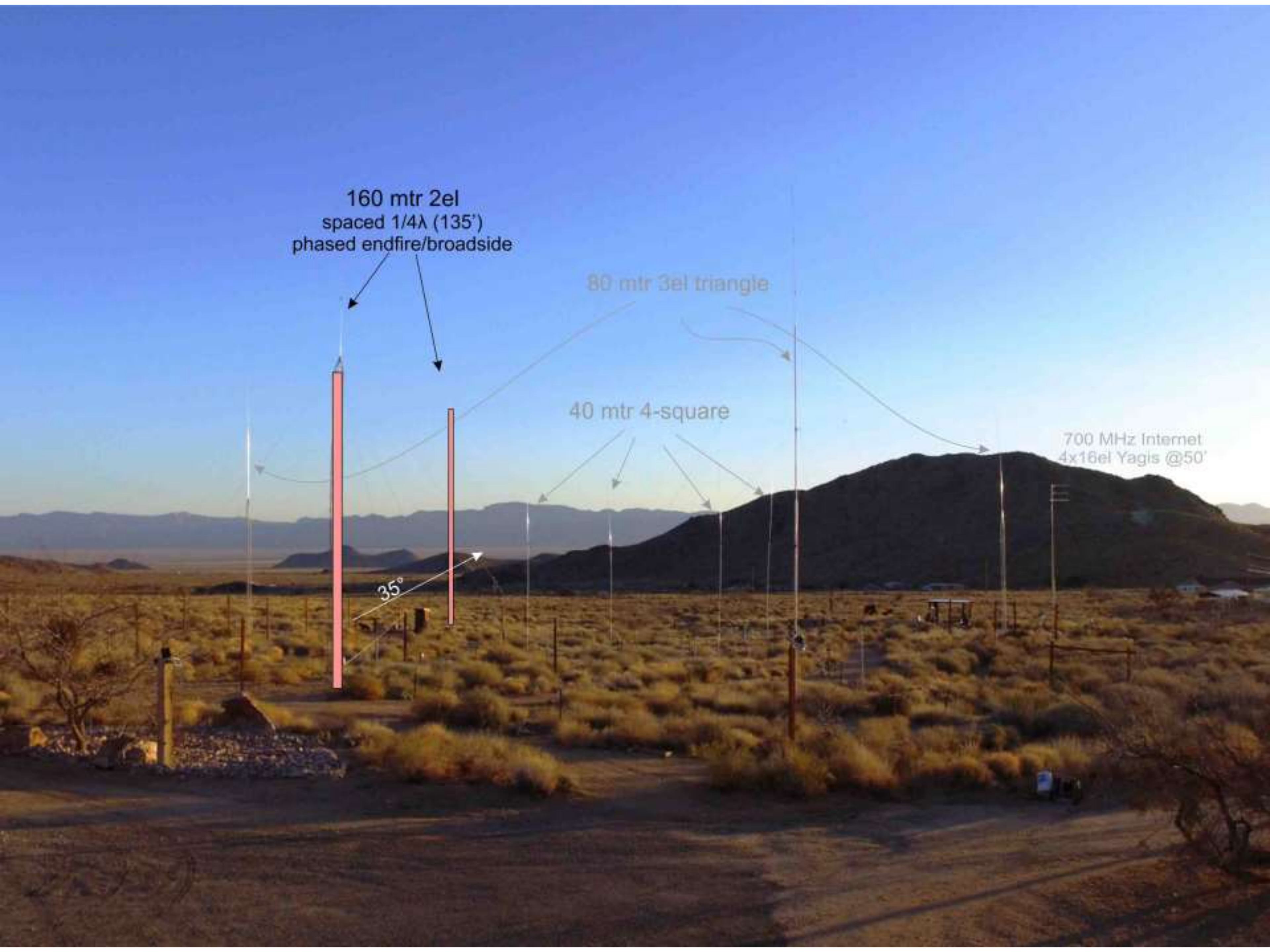
		Efficiency		
Full size vertical	#14 Gull Wing radials @8’	95.2%	-0.21dB loss	4.68dBi @8°, 4.55dBi@5°
Full size vertical	FCP (8' away, ~36' long)	86.1%	-0.65dB loss	4.08dBi @8°, 3.95dBi@5°
Full size vertical	VOR-4 sides (#14 wire) @7'	94.0%	-0.27dB loss	4.47dBi @8°, 4.34dBi@5°
Full size vertical	VOR-3 sides (#14 wire) @7'	94.5%	-0.25dB loss	4.50dBi @8°, 4.37dBi@5°
Full size vertical	VOR-4 sides (.3” tubing) @7'	97.5%	-0.11dB loss	4.63dBi @8°, 4.50dBi@5°

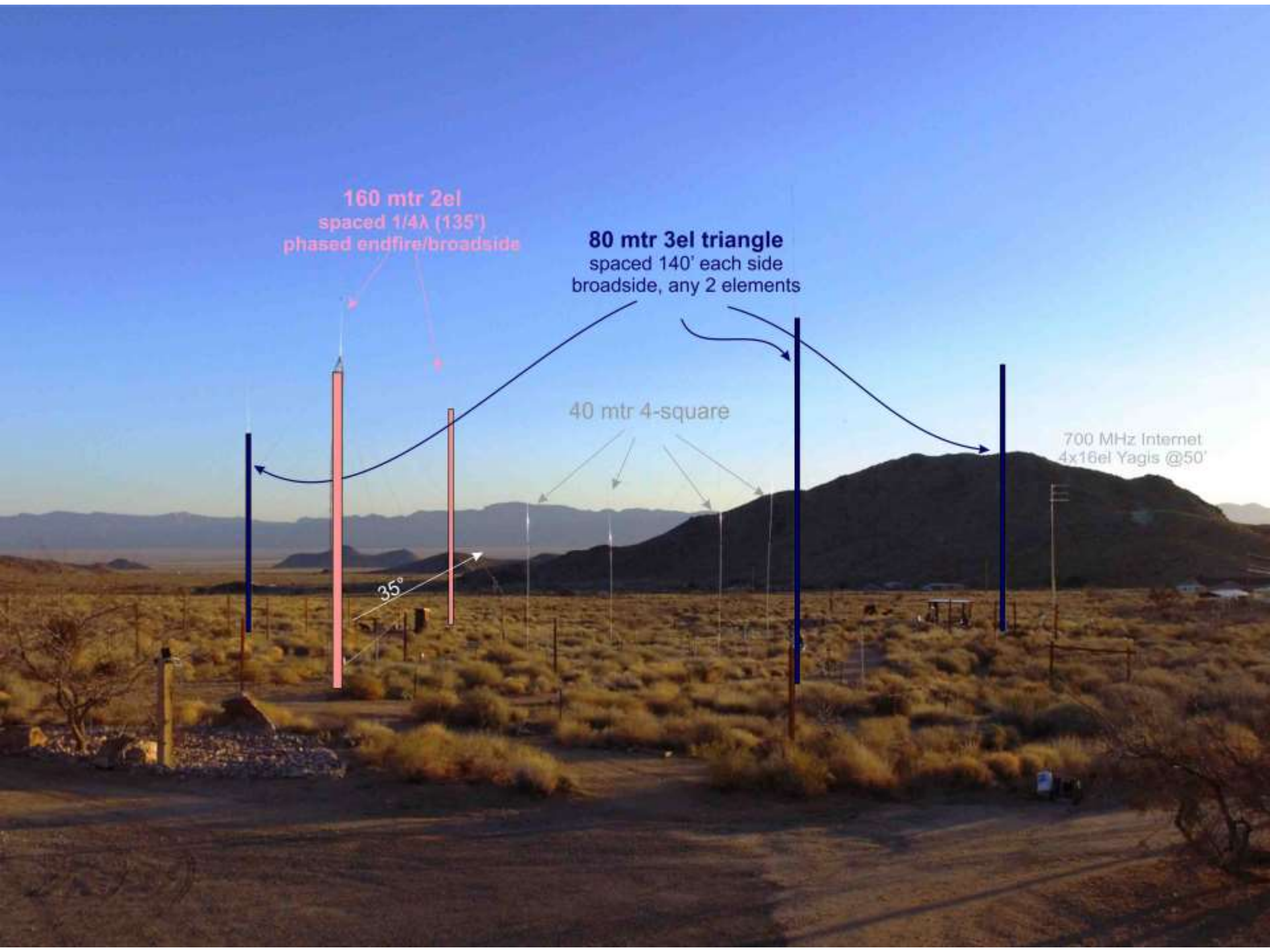
Earlier in this presentation, there was a photo of our verticals in NW Arizona.

Here are the details →

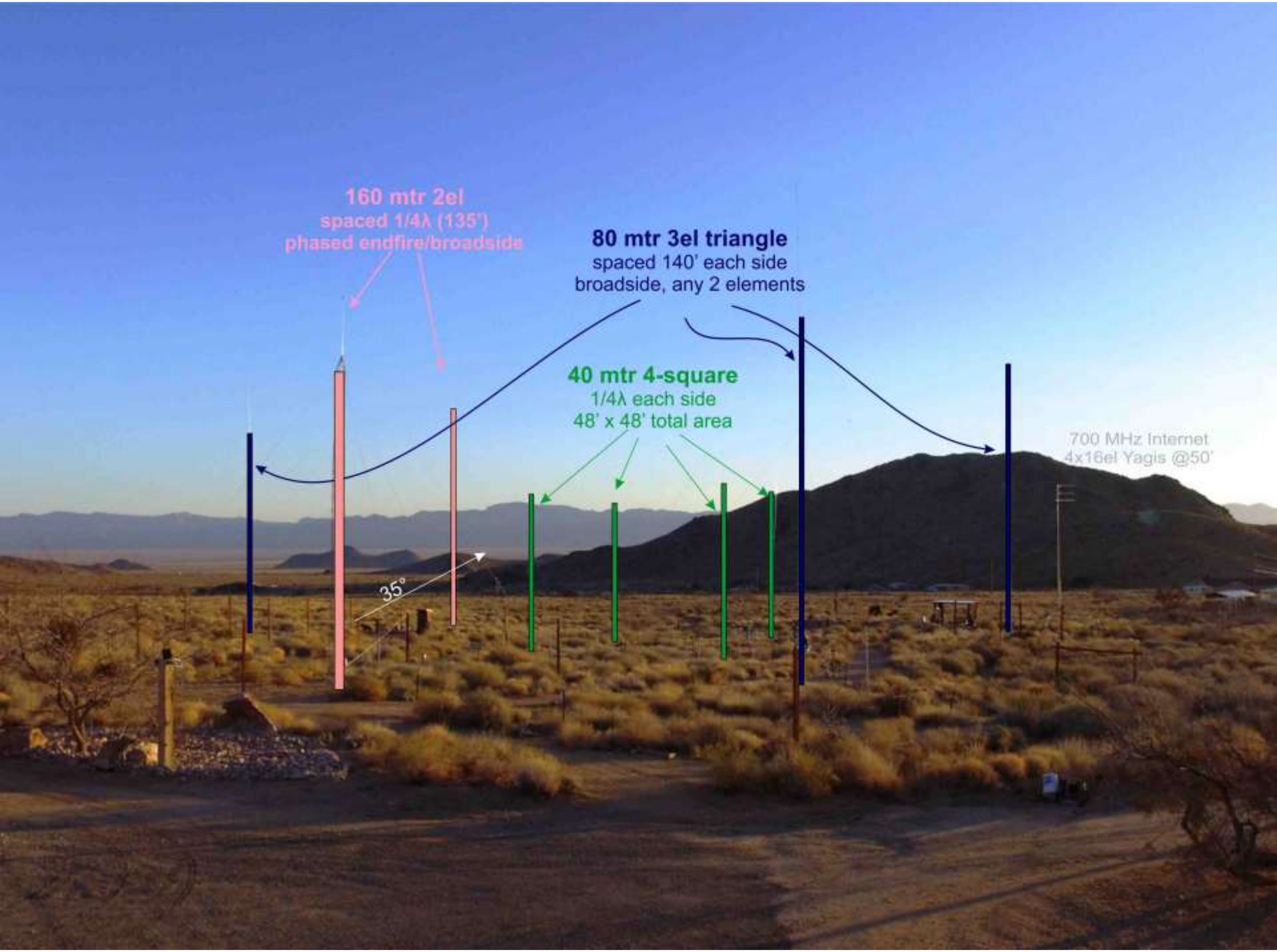

4el on 40 (4-square)
3el 80 mtr triangle phased broadside
2el 160 phased end-fire & broadside
No ground radials – all use the VOR (vertical open ring)
More on this later

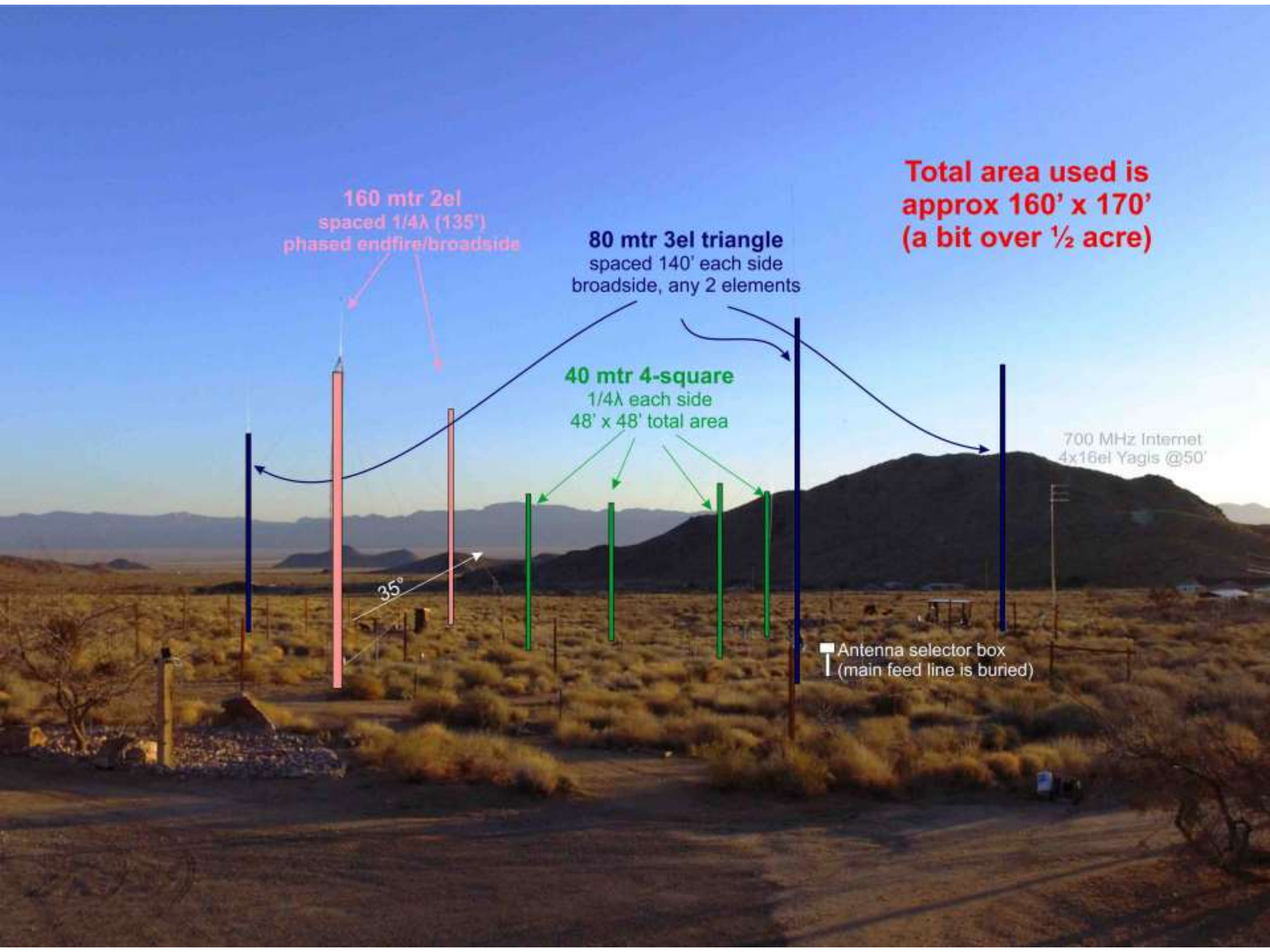

160 mtr 2el
80 mtr 3el triangle
40 mtr 4-square
700 MHz Internet
4x16el Yagis @50'

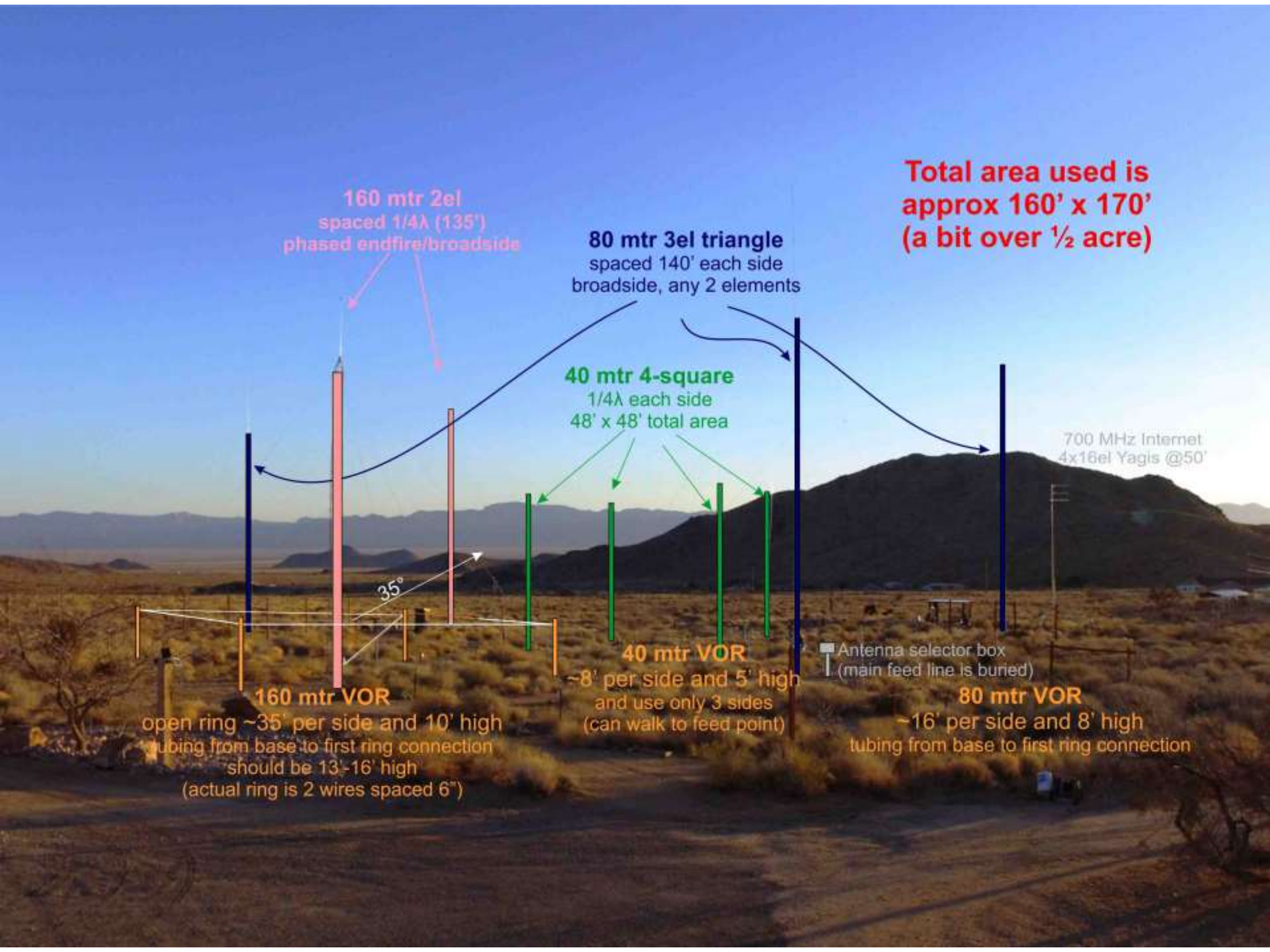

160 mtr 2el
spaced 1/4λ (135')
phased endfire/broadside
80 mtr 3el triangle
40 mtr 4-square
700 MHz Internet
4x16el Yagis @50'
35°



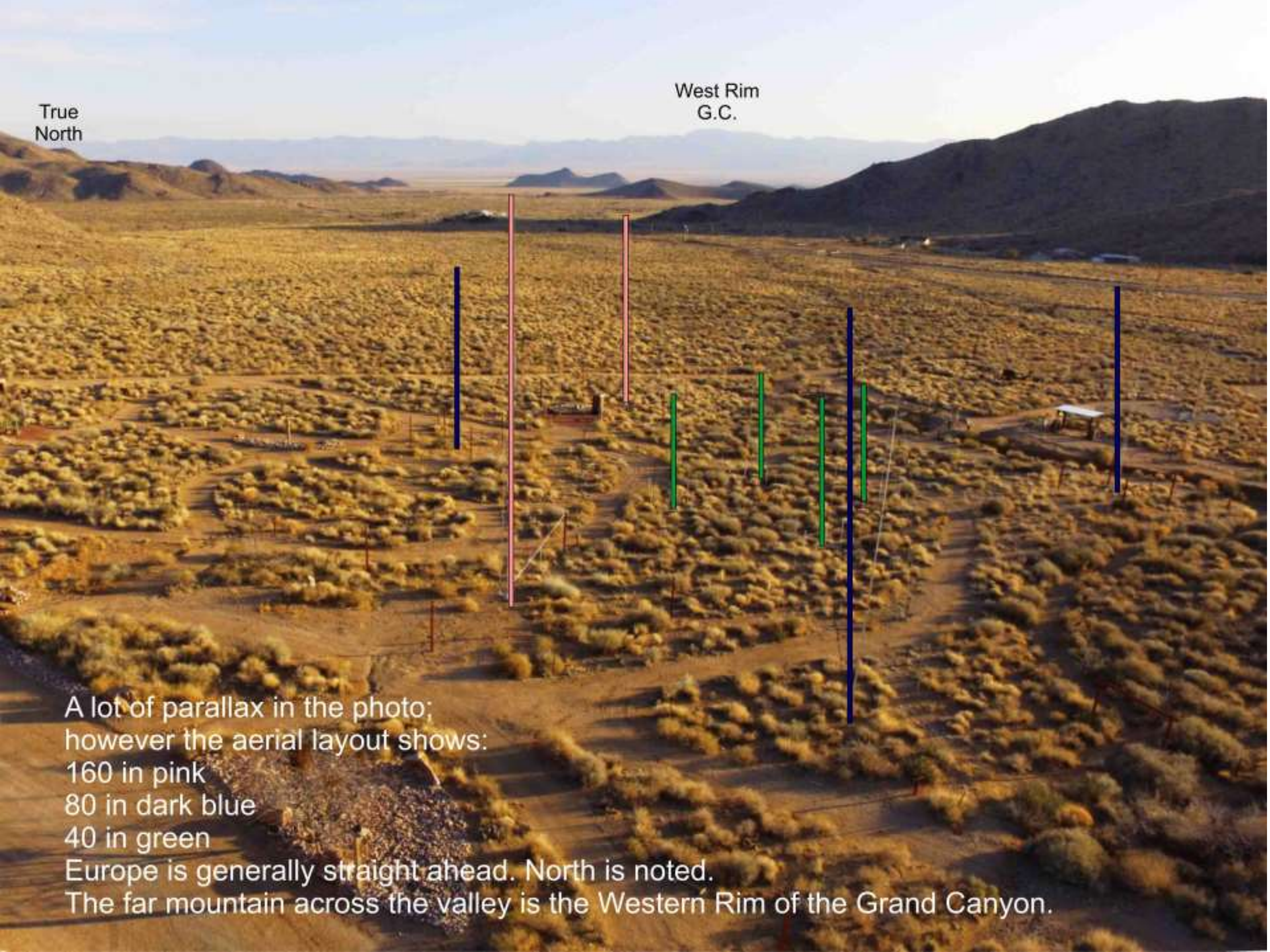
160 mtr 2el
spaced 1/4λ (135')
phased endfire/broadside
80 mtr 3el triangle
spaced 140' each side
broadside, any 2 elements
40 mtr 4-square
700 MHz Internet
4x16el Yagis @50'
35°


160 mtr 2el
spaced 1/4λ (135')
phased endfire/broadside
80 mtr 3el triangle
spaced 140' each side
broadside, any 2 elements
40 mtr 4-square
1/4λ each side
48' x 48' total area
700 MHz Internet
4x16el Yagis @50'
35°

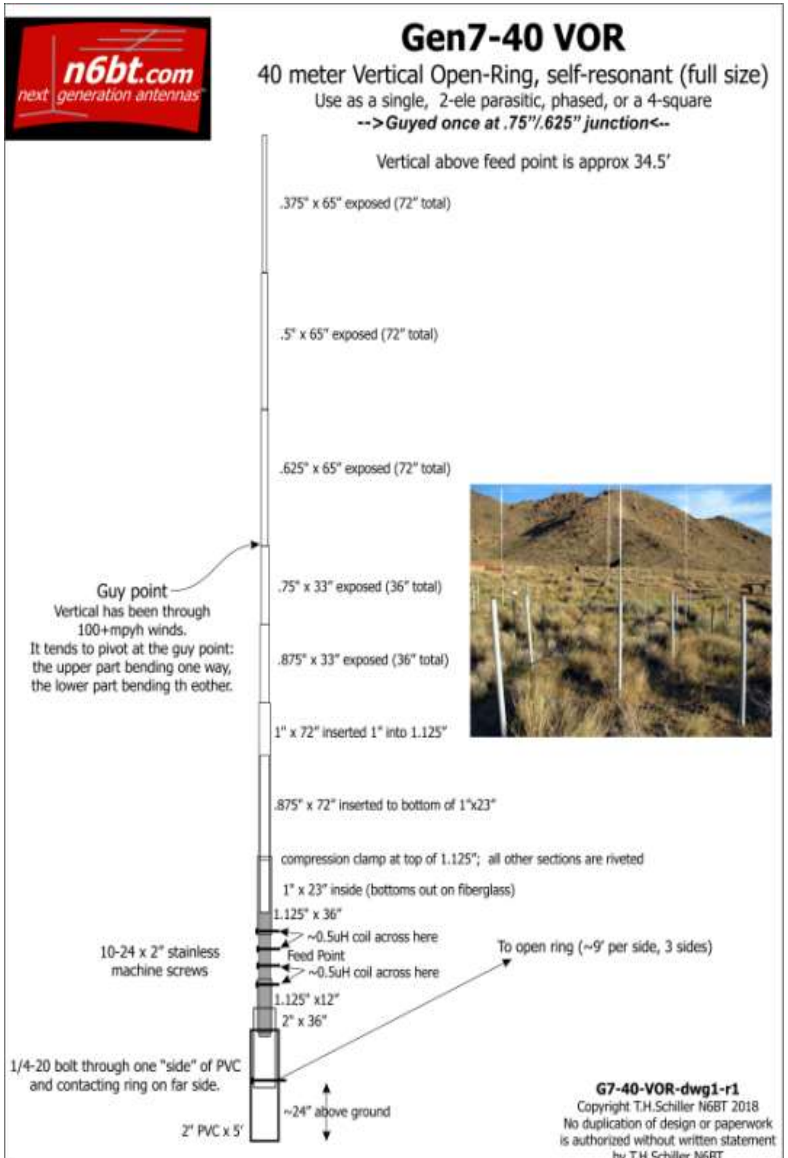

160 mtr 2el
spaced 1/4λ (135')
phased endfire/broadside
80 mtr 3el triangle
spaced 140' each side
broadside, any 2 elements
Total area used is
approx 160' x 170'
(a bit over ½ acre)
40 mtr 4-square
1/4λ each side
48' x 48' total area
700 MHz Internet
4x16el Yagis @50'
35°
Antenna selector box
(main feed line is buried)

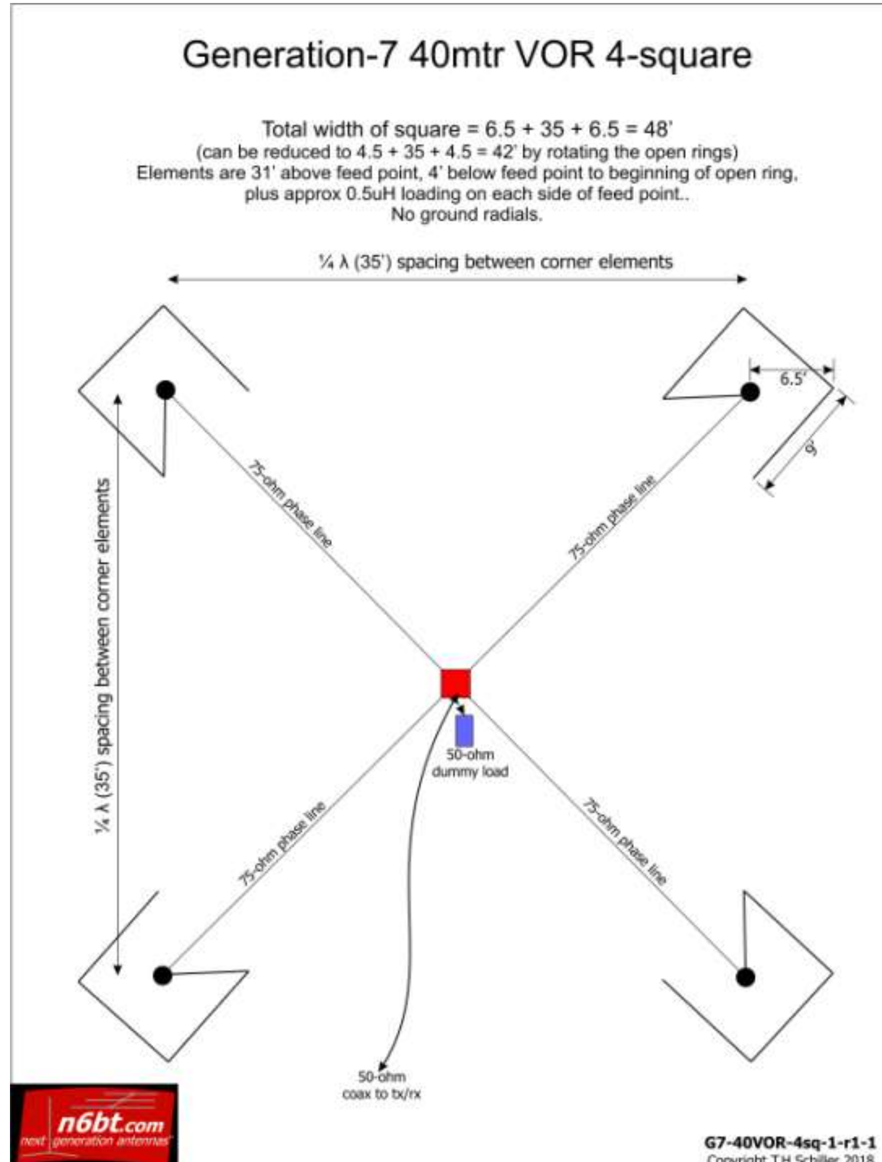


160 mtr 2el
spaced 1/4λ (135')
phased endfire/broadside
80 mtr 3el triangle
spaced 140' each side
broadside, any 2 elements
Total area used is
approx 160' x 170'
(a bit over ½ acre)
40 mtr 4-square
1/4λ each side
48' x 48' total area
700 MHz Internet
4x16el Yagis @50'
35°
40 mtr VOR
~8' per side and 5' high
and use only 3 sides
(can walk to feed point)
Antenna selector box
(main feed line is buried)
160 mtr VOR
open ring ~35' per side and 10' high
tubing from base to first ring connection
should be 13'-16' high
(actual ring is 2 wires spaced 6")
80 mtr VOR
~16' per side and 8' high
tubing from base to first ring connection


True
North
West Rim
G.C.
A lot of parallax in the photo;
however the aerial layout shows:
160 in pink
80 in dark blue
40 in green
Europe is generally straight ahead. North is noted.
The far mountain across the valley is the Western Rim of the Grand Canyon.

40 meter vertical (8'x8') and 4-square (48'x48')





75% full size 40-meter vertical using the VOR (3-sided)

n6bt.com
next generation antennas

VOR-40s

40 mtr monoband vertical dipole
vertical-open-ring design*
75% full size, no radials
vertical radiator is 24'
>95% efficient
open ring is all tube and 7'/side
integrated 2-core ferrite balun
enclosure is NEMA4, outdoor rated
gasket and snap-lock fasteners

VOR-40s-dwg1-r1

* Patent Pending

n6bt.com
next generation antennas

G7-3B

20-17-15 Mtr Generation-7 Vertical

Vertical-Open-Ring balanced design
3-band relay-controlled, no radials
integrated ferrite balun

Low profile, small footprint, strong design.
Vertical above ring is ~10’9” of tapering tubing.
3-sided open ring is tubing, 34” per side.
Relay enclosure is NEMA-4 outdoor rated,
with latches and weather seal.
Internal ferrite core balun.
SO-239 coax connector.
3’ base post (can be taller).
3-wire control cable (12VDC).
Full size 15, air-core inductors for 17 and 20.
20 mtrs is ~300kHz 2:1.

G7-3B-dwg1-r1

20-17-15 mtr

relay switched

Full size for 15 mtrs;

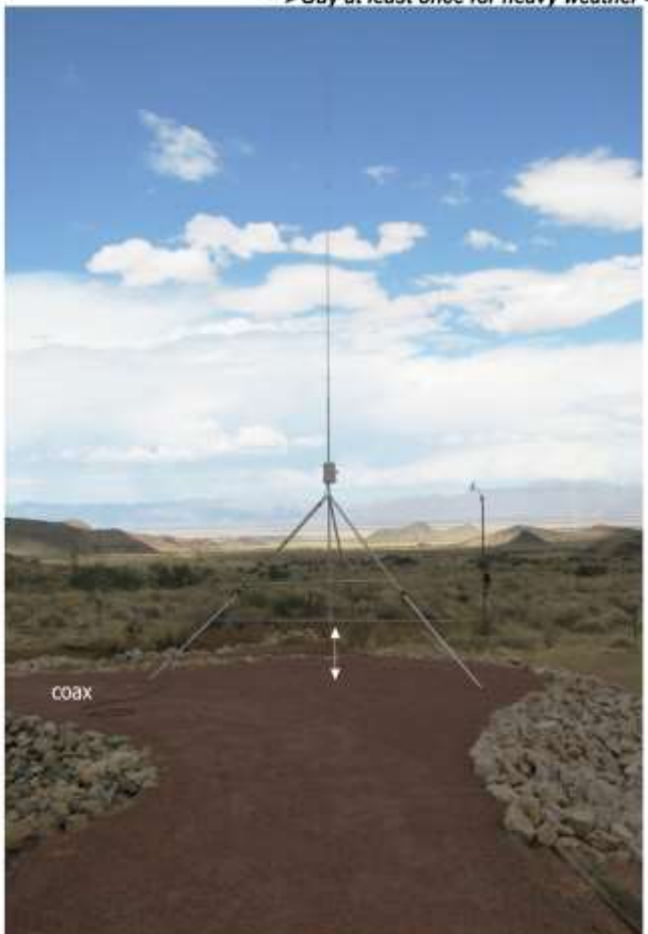
loaded for 17 and 20 mtrs

n6bt.com next generation antennas

Gen7-40

40 meter vertical antenna
for permanent installations, DXpedition, portable
Use as a single vertical, in a 2-element parasitic,
or in phased arrays, such as a 4-square

-->Guy at least once for heavy weather<--

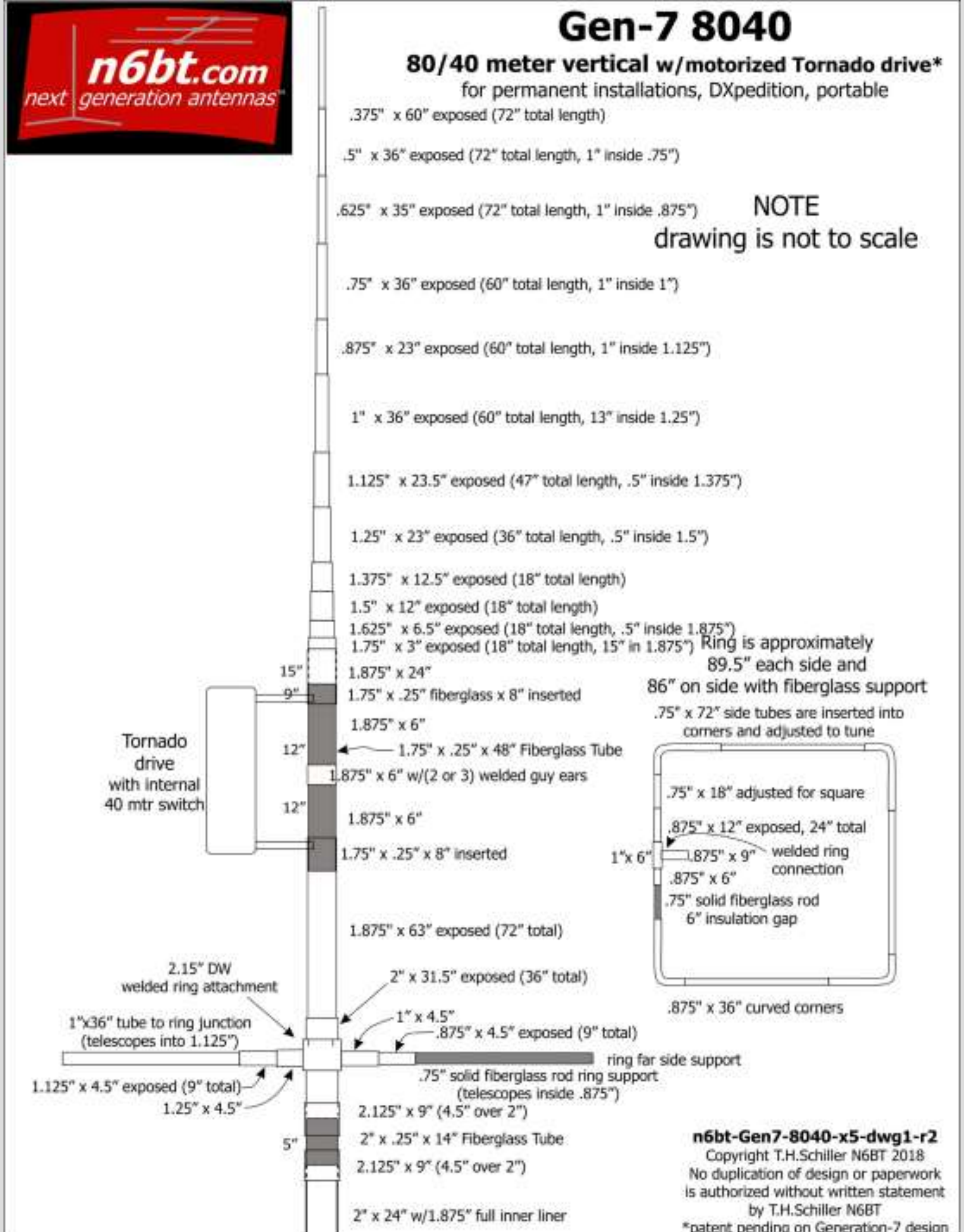


___main method to adjust frequency: adjust height of lower section above ground. This is using the capacity (coupling) to the ground, rather than changing the physical lengths.
___alternate method, if the above is insufficient: adjust the lengths of the horizontal bars.

n6bt-Gen7-40-x5-dwg8-r1

This is a full size 20, then loaded for 40, so it can be a 2-band antenna.

The tri-pod legs are telescoping painter's poles (available from Home Depot), making this fast and easy to install and then take-down.



2-Band 80/40 Vertical

Full size 40 with open ring;

loaded to 80/75 using motorized Tornado Drive.

Total footprint is approximately 7'x7',

which is the open ring

dimension (~full size 40)

plus guy attachment points which can be very close,

or use (2) rigid guys that attach at approx 8' from center.

80/40

A full size vertical for 40 with an full size 40 mtr open ring, making a full length vertical dipole on 40.

A Tornado drive (motorized inductor pair) is added at the feed point for full coverage on 80/75 meters.

This can be tilted over and the ring hinged to stay parallel to the ground.

Several types of flagpole verticals

Some use a tuner at the base,

some use tuner at the rig,

Most use buried radials;

The OCF does not.

Where is the best location for a tuner when we are using a non-resonant antenna on multiple bands?

__A. At the rig

__B. Where the coax enters the house

__C. At the antenna feed point

Should we use a balun on a non-resonant antenna like a flagpole??

__A. Yes – at the feed point, in front of the tuner at the antenna

__B. Yes – at the feed point, after the tuner at the antenna

__C. Yes – at the feed point and using the rig's tuner

__D. Yes – at the point where the coax enters the house, using the rig's tuner

__E. No – makes no difference

__F. Yes – it depends

How much loss is there in a vertical with unbalanced current and no balun?

Def: an unbalanced vertical is one that is asymmetrical

15 mtr vertical dipole offset 30” = -0.9dB (drone measure & VSWR matched to 1:1)

1/4λ vertical w/(4) 1/4λ radials on ground = -7dB to elevated w/(2) radials
(maximum current was in the ground)

…therefore, always feed a vertical with a balun to force current and isolate the coax feed line.
The balun will get heat up with power and imbalance.

When we cut a radial to the "specified" ¼ wavelength, how long is it when it is laid on the ground?

__A. It is still the same

__B. It is almost the same, within a few percent

__C. It is way too long, maybe up to 30% too long

What happens when ¼ wavelength radials are placed on/in the ground, as the classic designs show (figure a few radials)?

__A. The frequency of the antenna moves down

__B. The frequency of the antenna moves up

__C. No big deal, adjust the vertical to put it on frequency

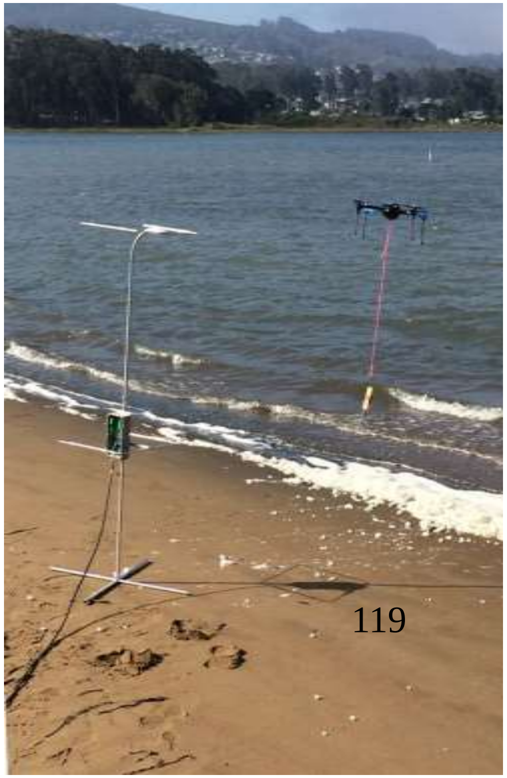
__D. The take-off angle is lowered

__E. Can lose several dB

If possible, try to utilize terrain to your advantage.

For verticals, place them adjacent to sloping ground, or even right at the top of a hill.

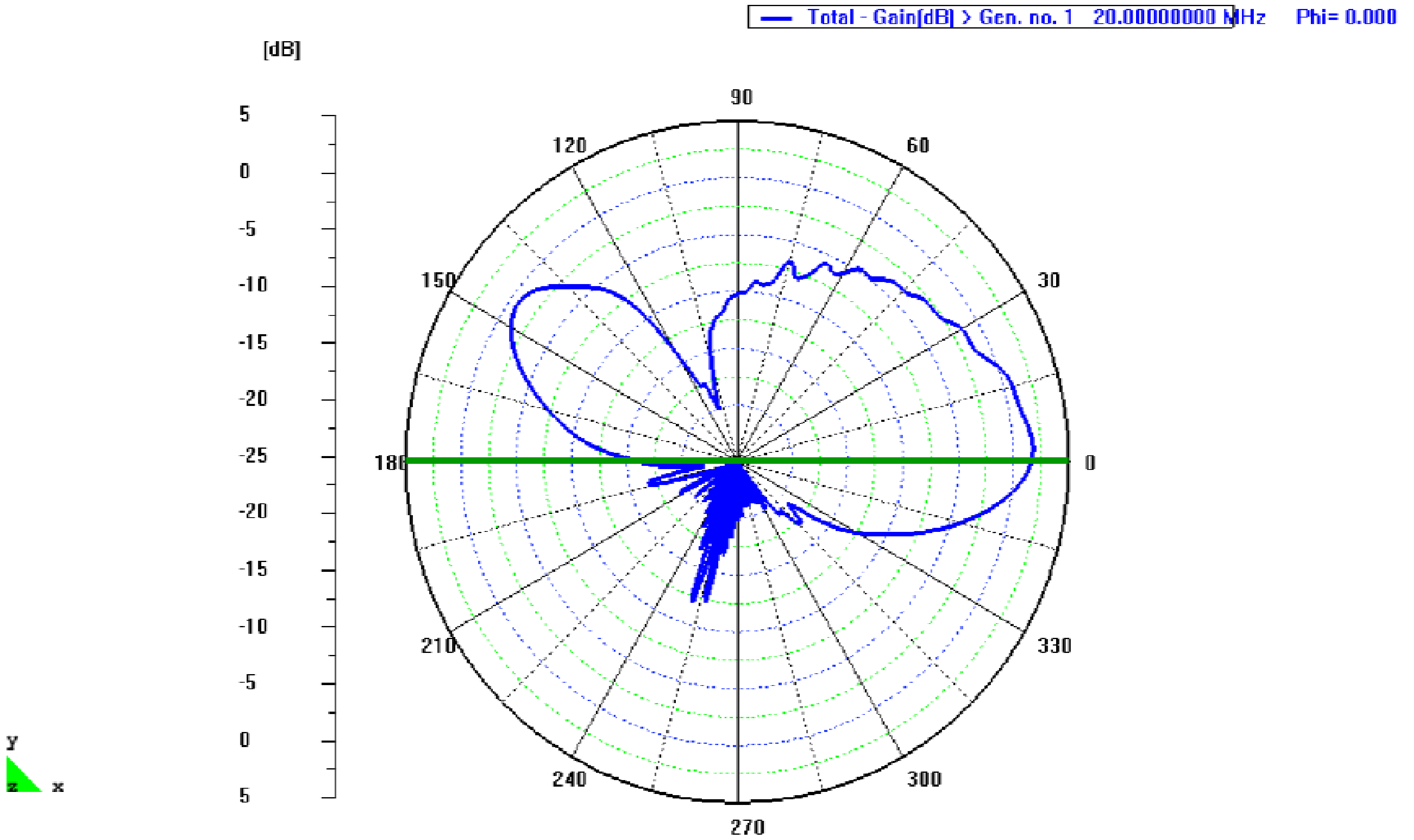
Since 2014, have performed empirical tests of verticals (and dipoles) over several types of ground, flat ground, sloping ground and salt water using helium balloons first, then (3) drones.



Effect of Ground Tilt on Vertical Antenna Radiation Pattern

Steve Stearns, K6OIK

January 3, 2018



New software confirms that a vertical adjacent to sloping ground will have the take-off angle lowered a bit over 1° for each degree of slope.

Perhaps you can locate a vertical adjacent to sloping ground!

Remember that HOA and the trapped dipole on the roof?

The most restricted HOA I've ever worked with

and

we got him on the air 40 through 10.

Two of the guy lines

on his wx station tripod

are a 40 mtr dipole.

Then we used an old trapped dipole and mounted it

so that it wasn't visible as he walked down the street.

The concrete blocks sit in welded aluminum trays.

The tips were adjusted, along with a little on trap spacing until it had a reasonable match. He runs an ICOM transceiver and KW solid state amplifier (40-10). Optional listening on 40 is a small loop, about 5' in diameter.

Was that dipole very effective, or efficient?

Whichever, it did one thing → it got him on the air.

Just how efficient is a trapped dipole?

Let's fly through the pattern and see what we find…..


Yuneec Typhoon H with horizontally polarized
XG-3 test oscillator


Drone ready table down range

Step 1 - measure the trapped driver element to a full size dipole

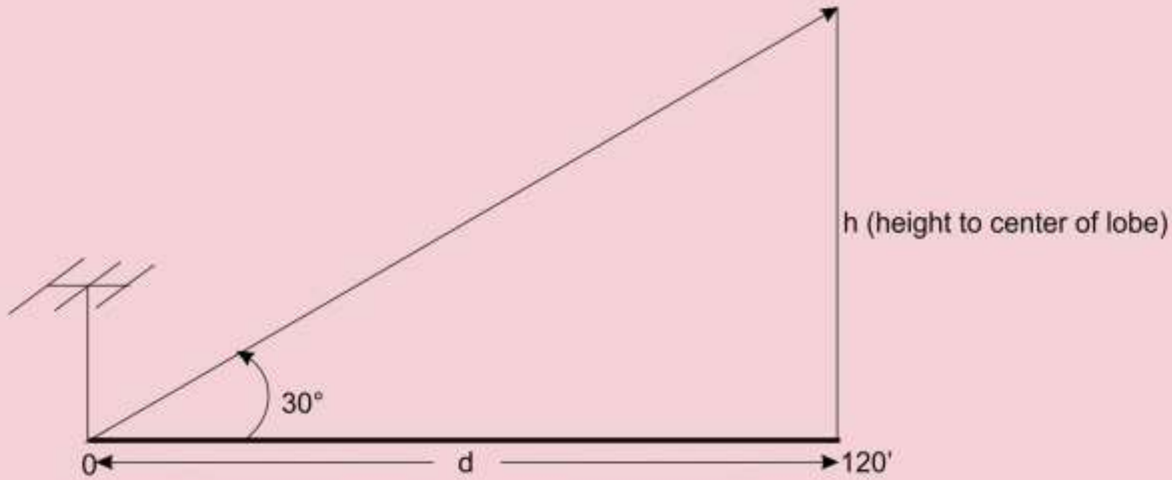
_All joints were cleaned
__Dipole center was separated inside the traps for full size
___Full size dipole in same position as trapped dipole
____Full size has the same balun/feed point/center as the trapped dipole, then added telescoping sections


Feed point: 2-ferrite core with teflon coax balun

The candle (reference) antenna is 6" above ground, horizontally polarized, 1½ wavelength distant to the side and rear.

n6bt.com next generation antennas

How high do we need to fly the drone to measure at the main lobe of our antenna under test?
The test antenna is on 20 meters at a height of 35', which is 0.5 wavelengths (0.5λ);
therefore, the antenna should have a single lobe centered at 30°.



_Distance from antenna to measurement point is >1.5λ (end of near field).
__At 20 meters, one wavelength = 70', so we need at least 70 x 1.5 = 105'.
___Let's go a bit farther to 120', so how high do we need to fly to be at 30°?

From the Pythagorean Theorem, opposite side/adjacent = tangent of unknown angle=> h/d = tan30°

We know d (120') and tan30°, so we then use h = tan30° x 120' (trig table shows tan30° = .577)
h = .577 x 120'
h = 69.28'

We want to go past the expected peak (at 70'), so let's fly to at least 45°, which is 120'.

tan45° = h/d; tan45°= 1, so then h/d = 1 or, rewriting, h = 1 x d h = 1 x 120; therefore 45° = 120' flight height

n6bt-pyth-flt-ht-r2

Step 1a - measure the trapped driver element to a full size dipole

Spectrum analyzer with dual inputs:
“candle” and antenna under test

_Drone flown to 150’ height on each pass.

__Analyzer was in MAX HOLD for each pass.

___Pass of up/down/up/down was within 0.1dB each cycle.

____Candle antenna was to ensure XG-3 source was constant.

_____Over all the passes, the dipole was 0.75 to 0.84dB below the full size dipole; therefore, the trapped dipole measured an average of **-0.79dB to full size**.

Step 2 - measure the tri-bander with all 3 elements

_Measurements are taken between the trapped driver alone and with the reflector and director in place
__Parasitic elements are rotated to horizontal from vertical after measuring the trapped driver alone
___Drone flown to 150' height on each pass.
____Analyzer was in MAX HOLD for each pass (max gain for 3el is at a lower angle than the dipole).
_____Passes ranged from 3.27dB to 3.52dB increase, averaging 3.42dBtd (3.42dB to the trapped driver)
______Compared to the full size dipole, the tribander has -0.79 (trapped driver)

+ 3.42 (gain from 2 elements)

Actual gain to a full size dipole = 2.63 dBd

Notes: 1. the max gain on the 3el Yagi was at a lower angle (by several degrees) than the dipole due to lobe compression for Yagis (gain antennas) lower than 1λ high; this Yagi was at ~1/2λ
2. what makes this antenna also "feel" like it has more gain is that it has pattern (i.e. F/B)
3. having a good 2.5dB over a dipole nonetheless is a noticeable improvement

n6bt.com
next generation antennas

Step 3 - measure the added gain from the director

_Several measurements are taken between the 2el using the driver/reflector and then adding the director.
__The wind had come up, making it difficult to stabilize the airborne signal source.
___The drone was still flown up to 150’ with both Yagi configurations.
____Analyzer was in MAX HOLD for each pass - six (6) passes were made..
_____The median improvement from adding the director was +0.42dB
______The 3el Yagi with 2.6dBd gain, the 0.42dB from the director is ~16% of the overall gain, which is in line with the incremental improvement typically found in full size element Yagis.

n6bt.com next generation antennas

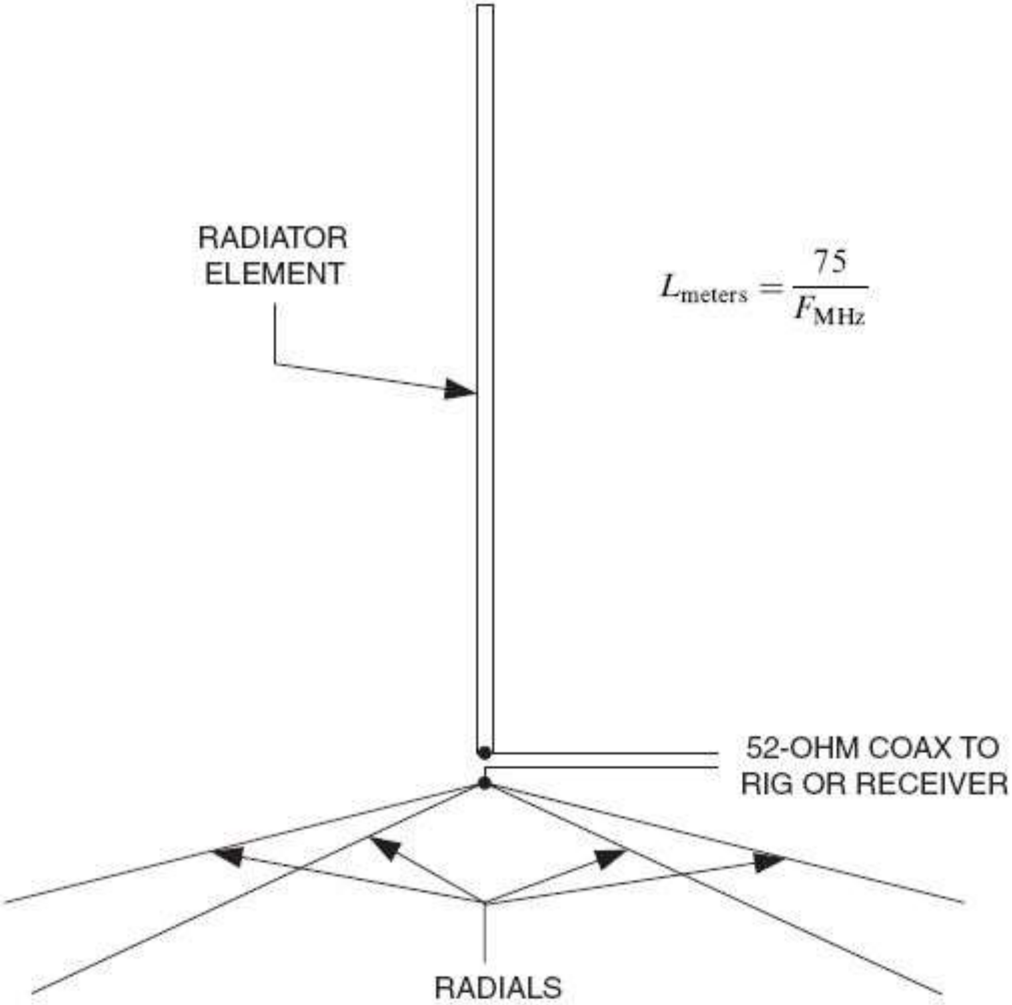
Overall, the trapped dipole being down even 1dB from full size on 20 provided a way to get on the air with an antenna that was fairly efficient, albeit the difficult installation.

It is also important that although the dipole is only a foot or so above the roof, it is outside.

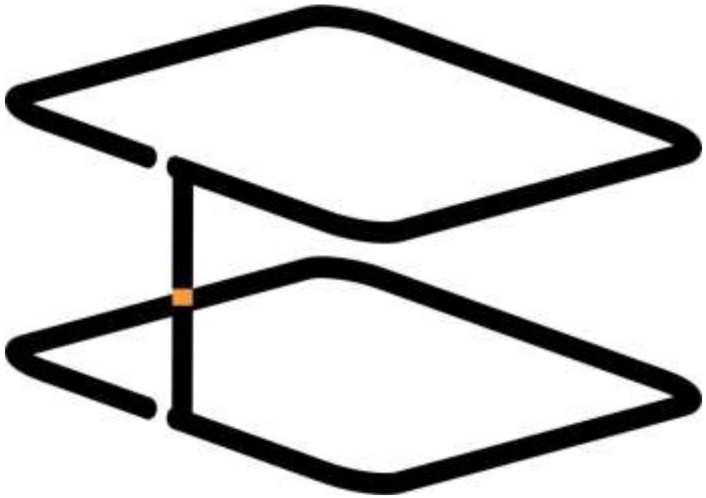
Back to…

what can you make that will work well?

Classic vertical design that we followed for years and it left a lot on the table.



If you can work with aluminum tubing and can do some computer modeling, you can make a ZR design for any band.



Dr. Joe Boyer's 20-mtr proto-type
3' tall vertical radiator
approximately 1/2 wavelength of **copper tubing**,
fed at the center of the vertical and matched using a hairpin.

The 3-band ZR-3 for 20-15-10 meters.

The vertical sections total 6’ and the rings make up the remaining length for a full-size dipole.

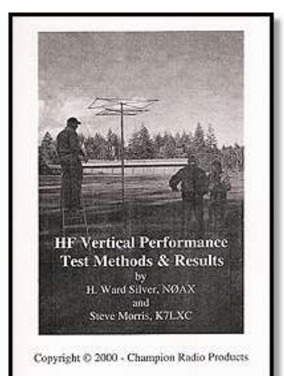
___No loading coils, no traps
_____High efficiency
_______Hairpin match and fed with a 1:1 balun at about a 45º angle to the vertical.

Monoband could be modeled, but not the 3-bander, so 15 and 10 were done real-time
(thanks to Ken, K6HPX for his great assistance).

It is technically magnetic on 20, as the radiator is less than 10% of a wavelength.
It is very quiet and a great performer.

Reviewed in QST, March 1998

and also by K7LXC and N0AX and N0AX



If the ZR is too complex to build,
you can make a Sigma style.

The Sigma is also a center-fed vertical dipole like the ZR, but the open-ended rings are replaced with “T-bars” (top and bottom)

Easy to model and can be full size with the vertical section lengths adjusted for a feed point of 50 ohms. It can also be shorter and center loaded with a feed point of less than 50 ohms and matched with a simple hairpin.

High efficiency and excellent performer.

Feed point, hairpin matched

This is a 2-element parasitic array: driver on left, reflector on right, aimed at Asia, Western USA.

Note: the reflector also has a hairpin match across the feed point. This is used to tune it to the right frequency using a balun. After the balun is removed, the hairpin remains across the parasitic element feed.

Jamaica 2001, Sigma 40XK

Simple mounting made from ABS for adding coils at the center and also a hairpin match with a 1:1 ferrite bead balun.

The Sigma can be made multi-band by setting the lengths for the highest frequency and equally loading each half at the center (for the bands desired). One hairpin matching the lowest band will work for all the bands.

Simple to make - equal vertical sections and equal T-bars. Needs to be a couple feet above ground - more is fine, up to 3/8λ.

In 2′ sections, it is excellent for portable.

Enclosures

https://www.polycase.com/all-products

Loading coils - the best are air core.

Many coils are wound on PVC, or some kind of plastic (black) material; consequently, are you sure what it is?

Black might contain graphite = conductor (albeit poor)

Many products (e.g. PVC) come from Asia and the content is unknown.

Be cautious of using bungee cords for securing things at the bottom of an antenna, such as loading coils or capacitors for matching a tower. They are black and contain something that will conduct, then get hot, creating smoke and eventually melt/burn.

Sample air-core coil for verticals and Yagi elements

Solid fiberglass rod at the center,

coil is 1/4″ aluminum tubing (“EZ-bend”, annealed), 3″ diameter form,

through aluminum stand-offs to aluminum tubing element sections on both ends.

Long machine screws are 10-24 stainless with Loctite.

Standoff is 3/8″ tubing cut to 1″ and filed concave on the tubing end.

Coils can also be 1/8″ copper refrigeration tubing with soldered-on lugs at each end.

NOTE – “soft” tubing (al & cu) will work harden, so be sure the diameter is right the first time.

Where is the best location for coils?

Close to the center/feed point:

It is the highest current, lowest voltage,

requires the lowest inductance for resonance.

Moving coils farther away from the center/feed point:

current decreases, voltage increases, and

the inductance increases to maintain resonance.

Coil location can be determined so that the element is not resonant on other bands that might be near by.

When do you begin to consider the pattern, or when does it become important?

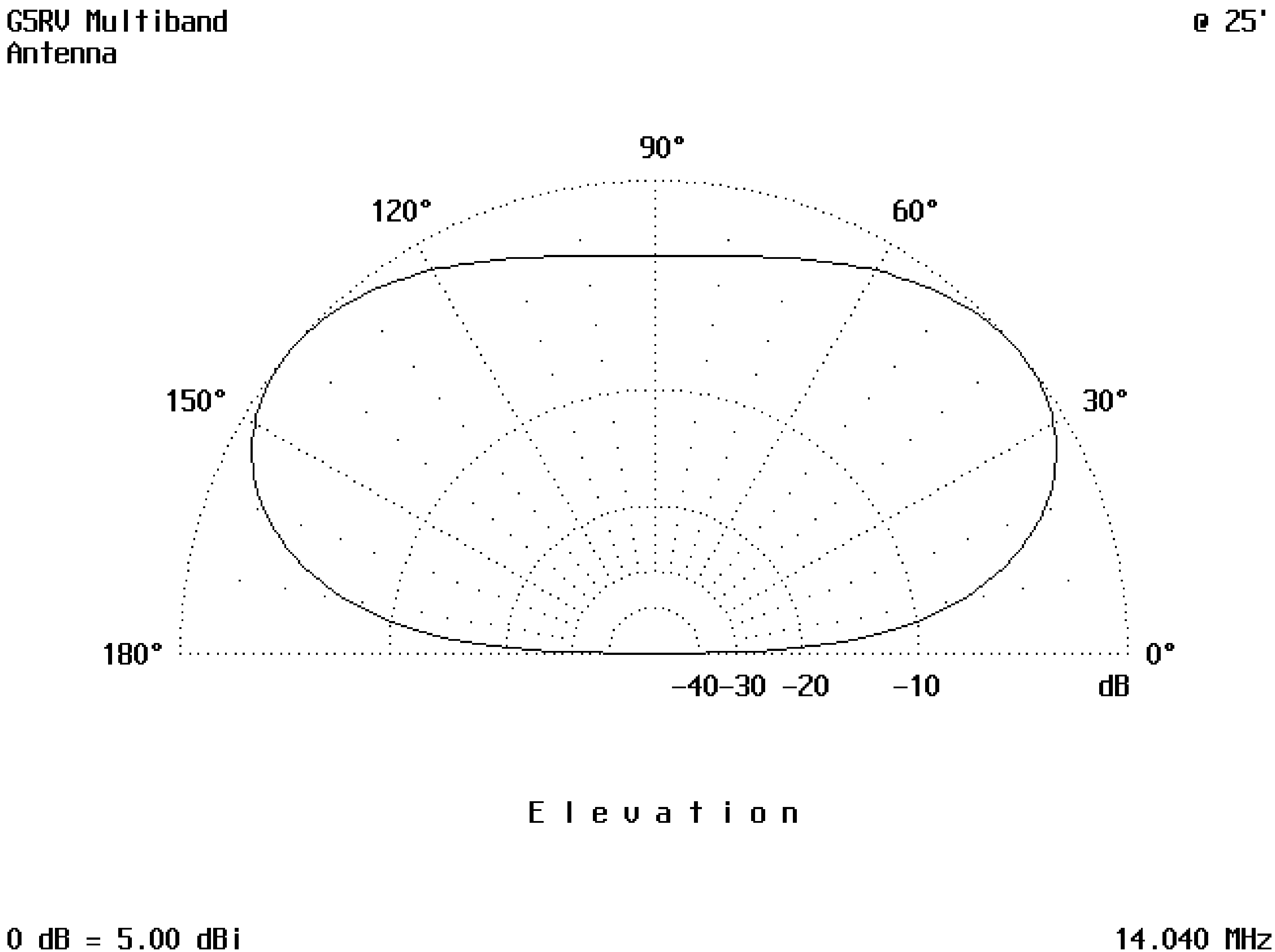
__Getting on the air with “something” implies that the pattern is most likely not much of a concern.

__Chasing DX, or contesting implies the pattern is important - the target zone of the antenna is the primary objective and rejection of other directions might also be important.

How do you get directivity?

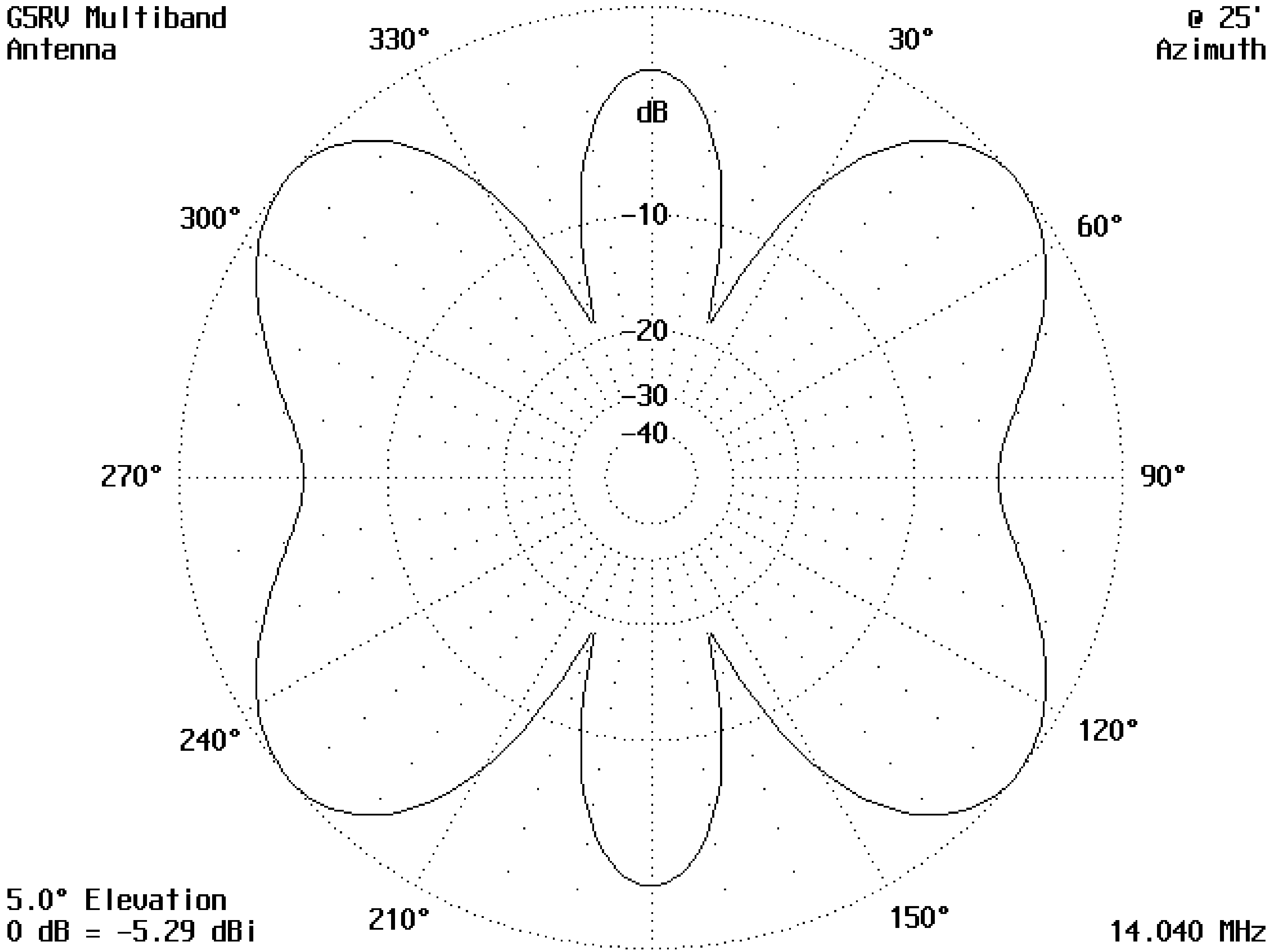
Sometimes unknowingly!

Quick look at the popular a G5RV at
a typical smaller installation height of 25′.



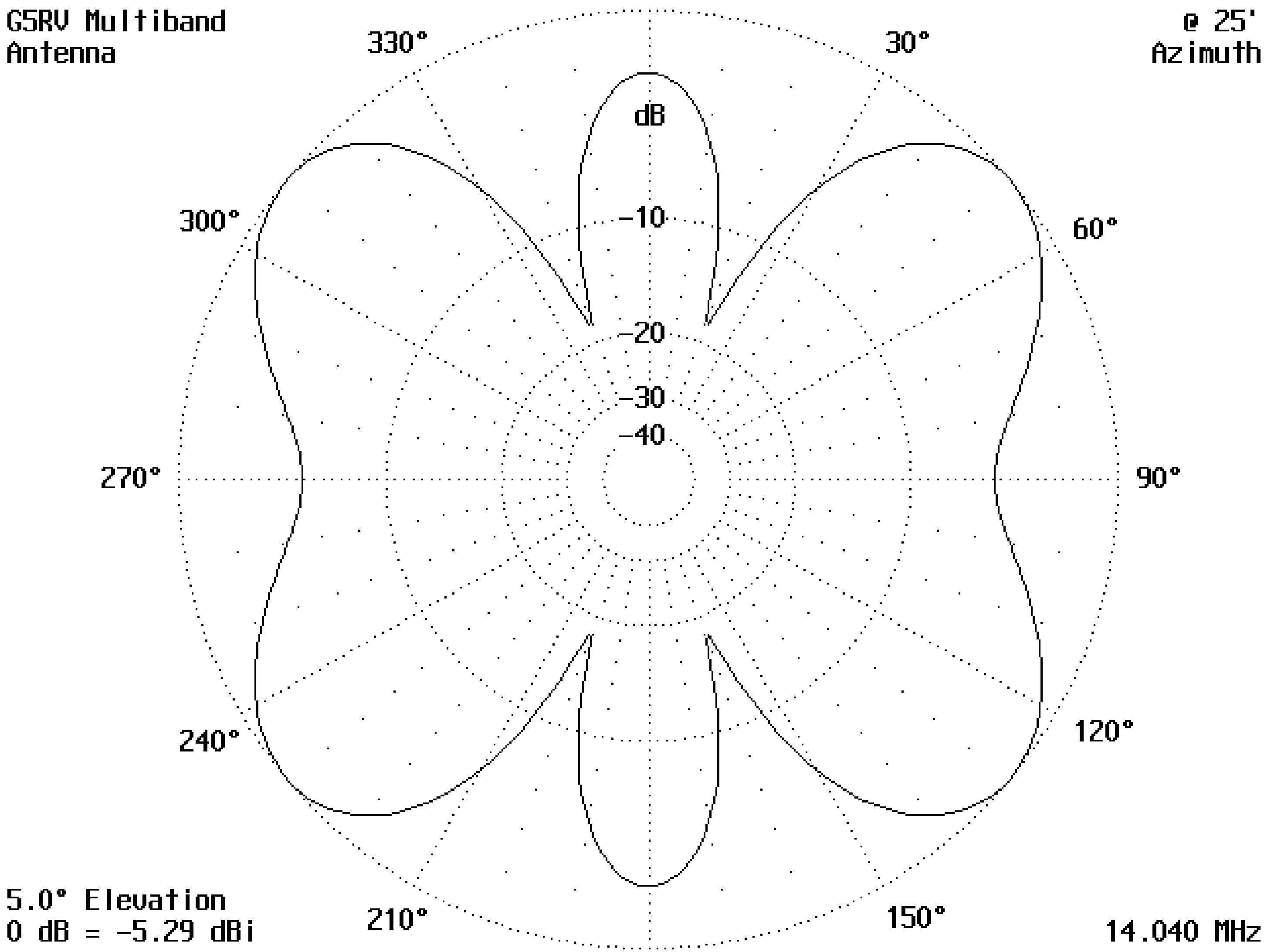
Take-off angle looks reasonable on 20 meters…

(looking end-on to the antenna, broadside view)



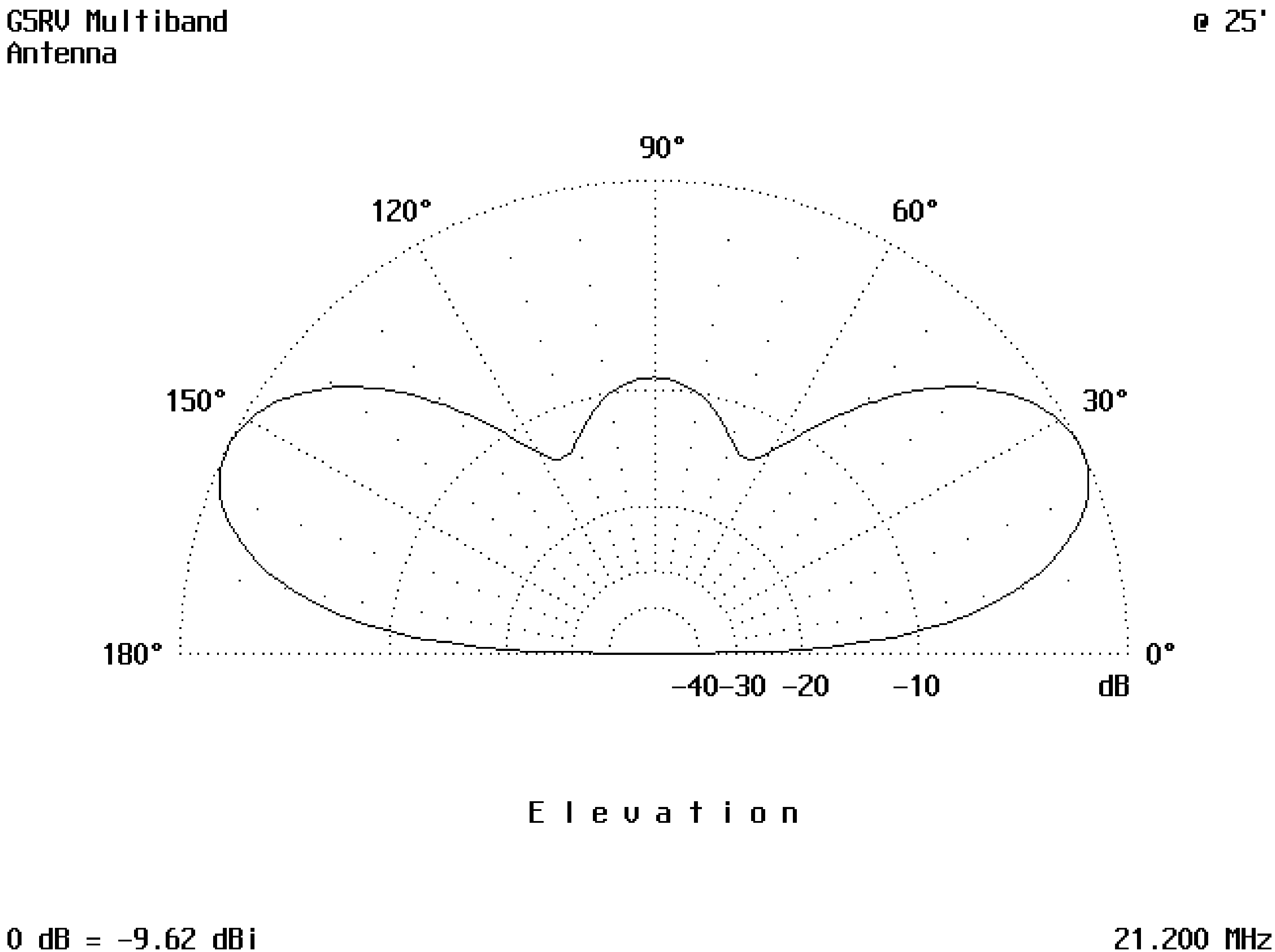
...until we look at the directivity.

(looking down on the antenna, azimuth view)

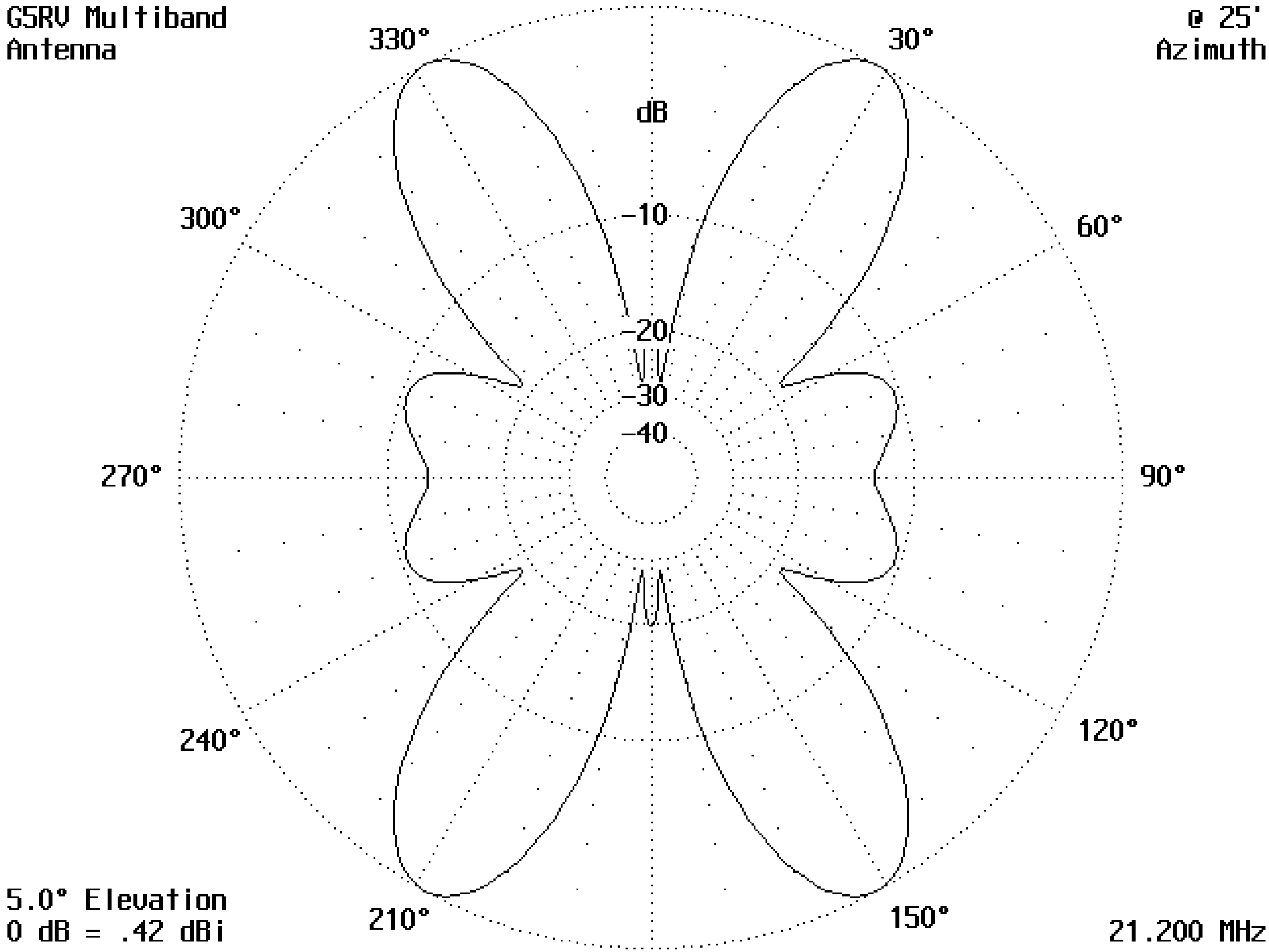


Makes on-air performance assessment difficult at best.

How about on 15 meters?

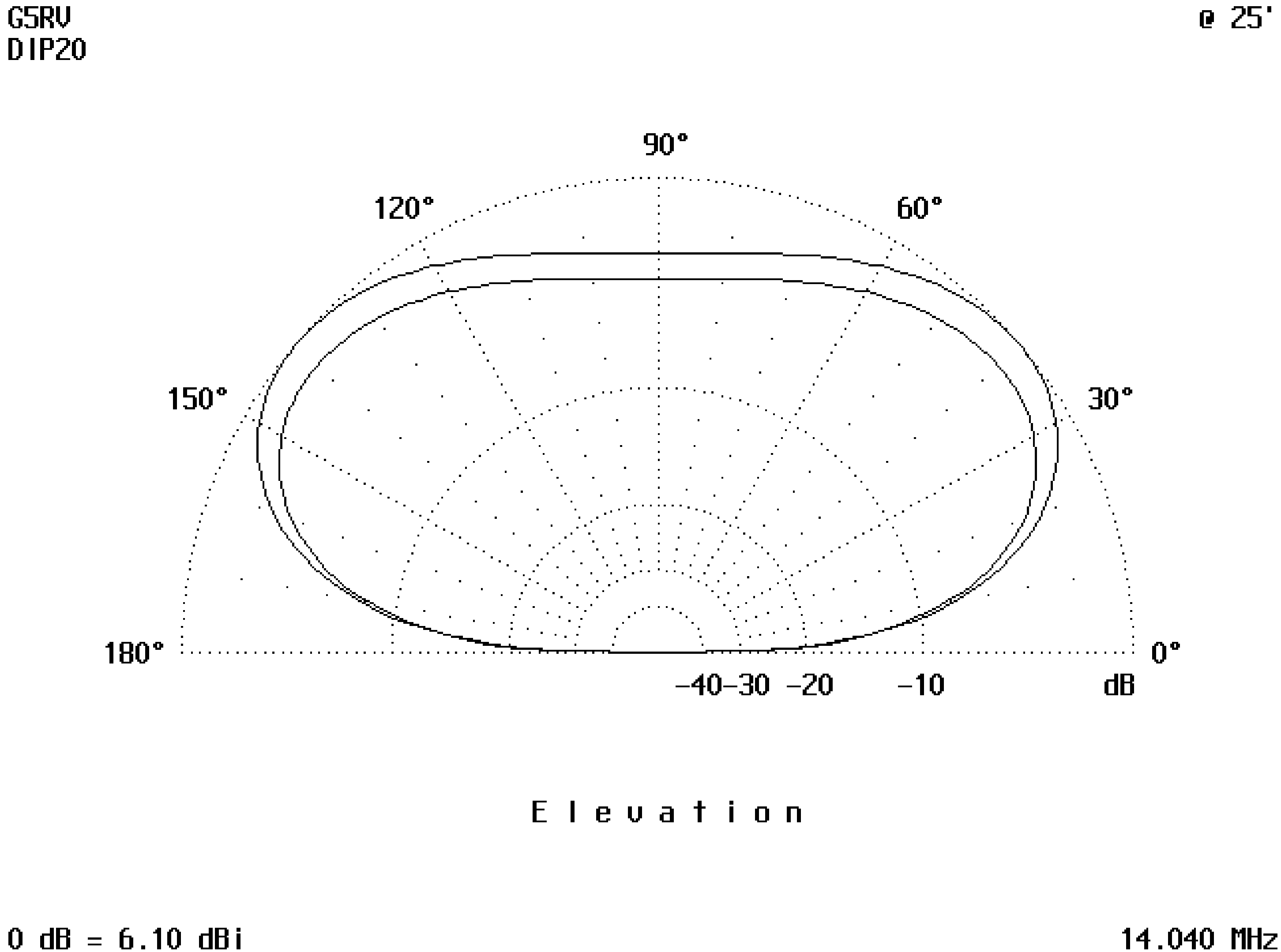


Take-off angle looks fine...

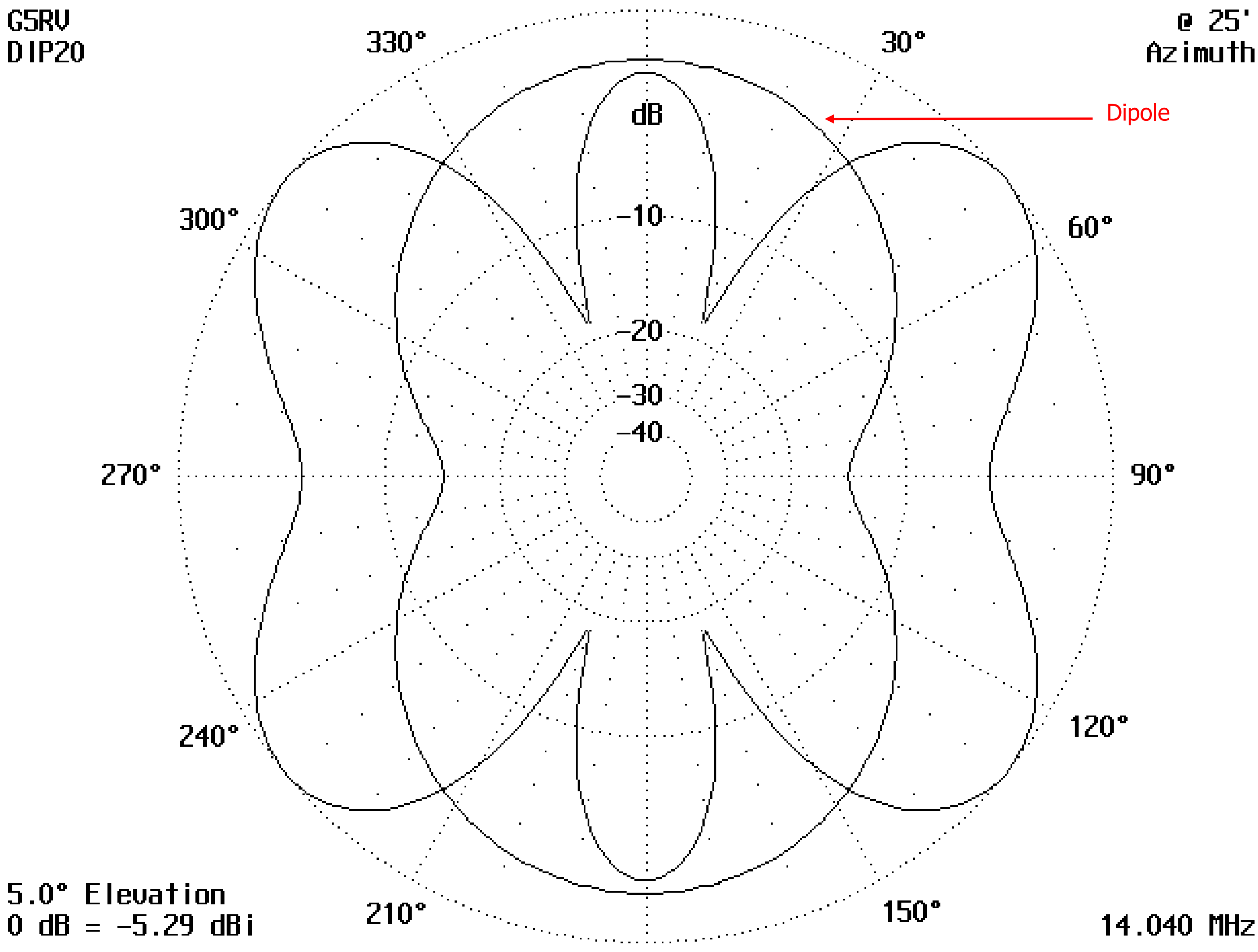


…but the directivity is probably not what you would want.

How does the G5RV compare to a 20-meter dipole at 25′?



…the dipole is ahead by a good 1dB in elevation and even more--



...in azimuth, it is much more predictable.

MAPS and Aliens

In general,

we study antenna patterns and

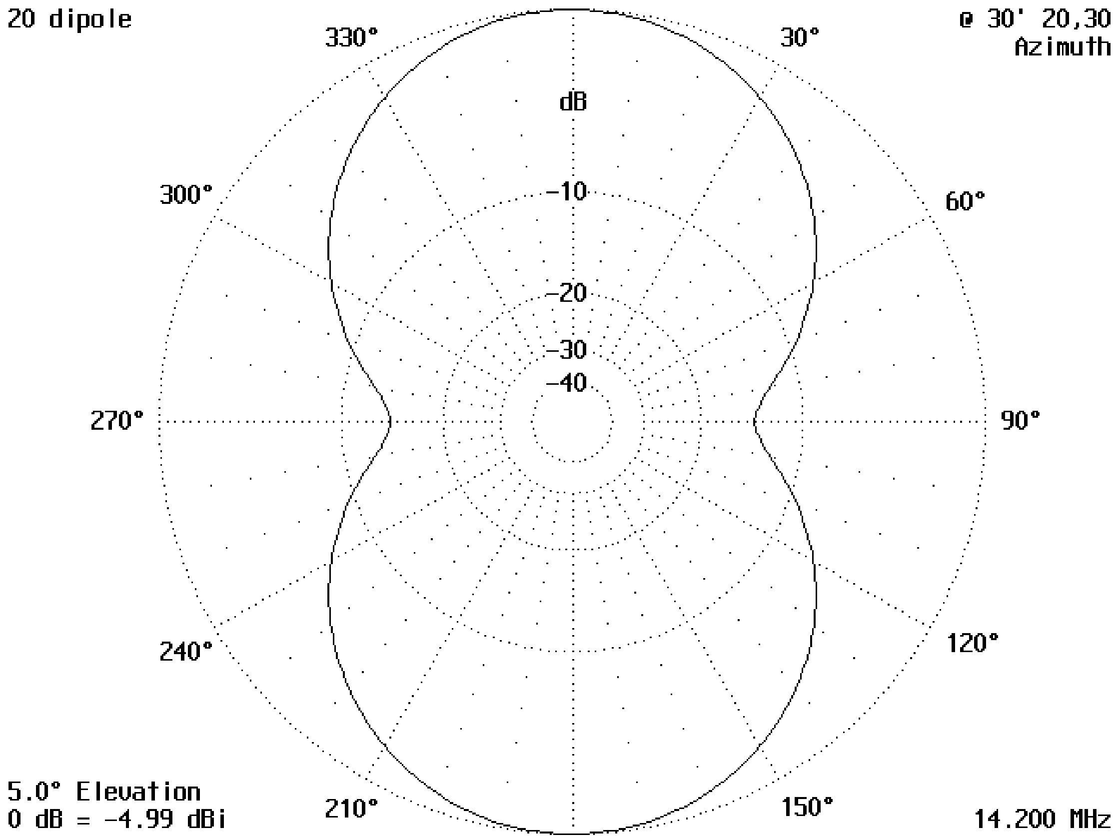
expect the antenna

to perform like we see in the plots.

If we put up a dipole, we expect it to have the classic figure-8 pattern:

Is this what we always get?

Why not?



The plots presume the antenna is “all alone”

but…what if it isn’t?

What if --

there is a house nearby,
trees in the yard,
wires along the property
and other antennas up, too?

What happens?

Every antenna will “see” other objects within a certain distance from it.

Remember - although an antenna is a mechanical structure,

it is first and foremost, an electrical device.

To operate as we expect,
(like the plots in books)

an antenna needs to be in the clear
by a certain distance,
depending on the frequency of the antenna.

Let's introduce a new term:

"Stand-off Distance"

This is how far the antenna is from any other surface or structure, including
ground, roofs, walls
and other antennas or feed lines.

Can you test if the stand-off distance is adequate?

Thanks to Ward Silver, N0AX for his assistance with this material.

M.A.P.S.

My Antenna's Personal Space

PROXIMITY

How far away might this be?

(stand-off distance)

A starting point for a practical answer can be derived from:

how far can we space elements in a Yagi
and still have it be effective?

At least a 1/4 wavelength.

40m = 35′

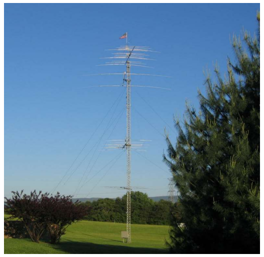
20m = 18′

15m = 12′

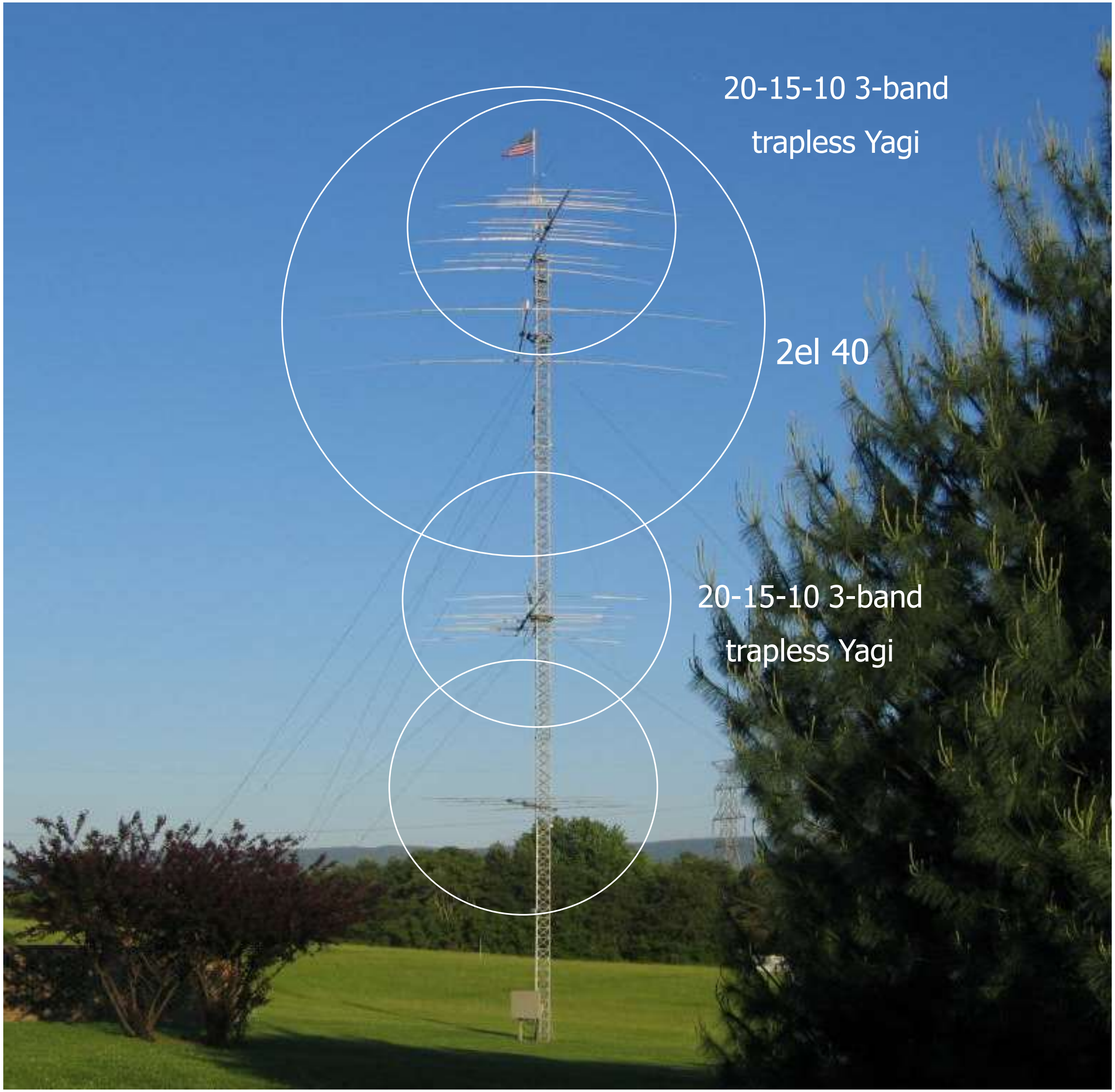
10m = 9′

The catch is that this is in all directions - all 3 dimensions (x,y,z)

a sphere around every antenna.



HOA Stack


20-15-10 3-band
trapless Yagi
2el 40
20-15-10 3-band
trapless Yagi

This installation uses known stand-off distances,

with single-boom 20-15-10 trapless tribanders
on the same tower with the 2el 40 Yagi.

(Thank modeling software for the assistance.)

Now that we know antennas need “personal space” around them to operate properly,

and that we can also design around this “space”,

we can do some planning for our station.

In essence, we “know” what we are dealing with.

A good question to always ask, of course, is,

“What don’t we know?”

When we put up an antenna and there is an object within the antenna’s stand-off distance,

a) we know that that object
will interact in some manner with the antenna,

or, putting it a different way,

b) we know that the antenna we just put up
will “see” that object in some way.

“What does our antenna (actually) look like?”

Any guesses?

Our actual antenna is composed of the physical antenna we put up,
PLUS
everything within its stand-off distance.

We have an **"Alien Antenna"**

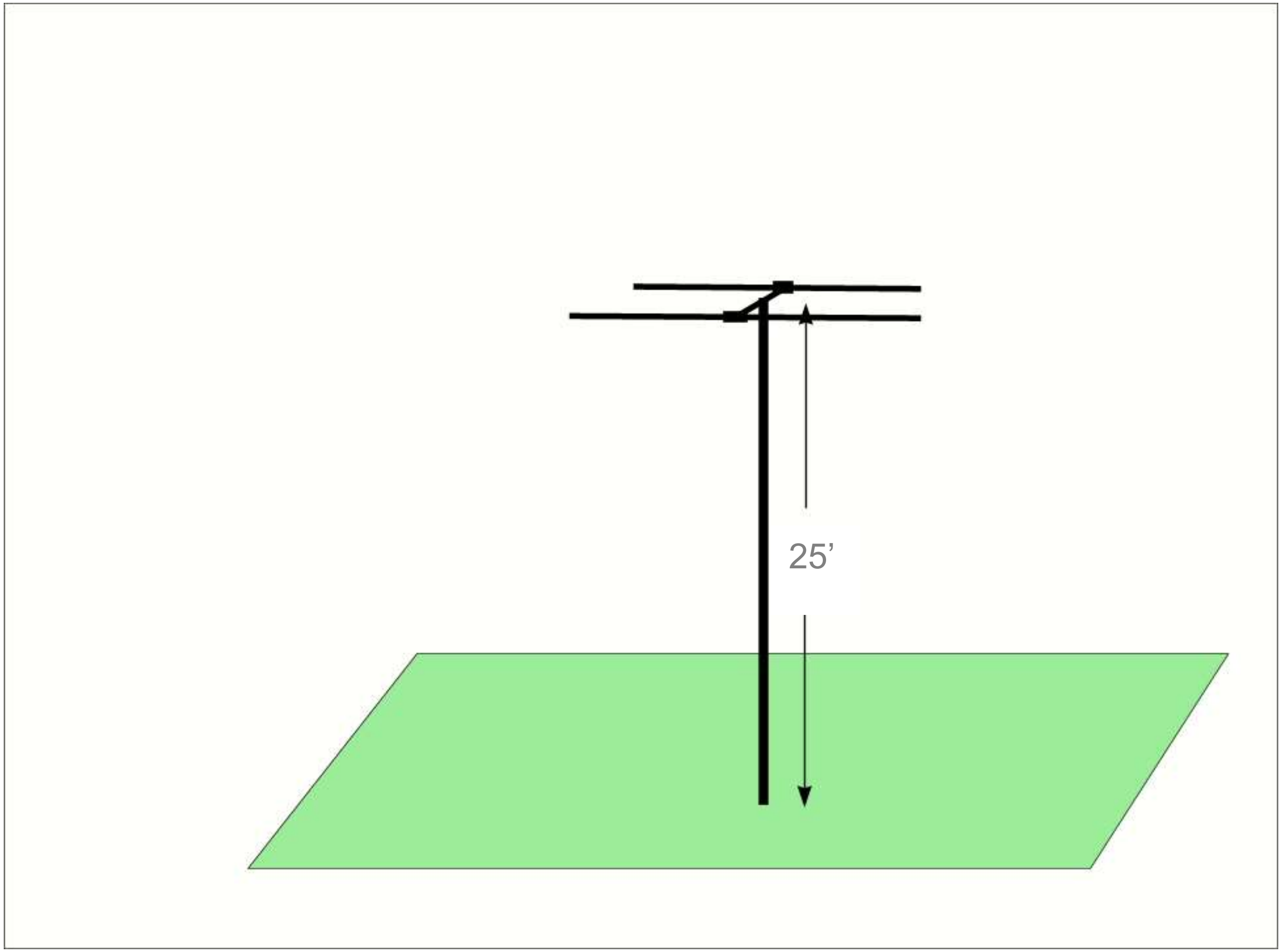
It is unknown.

It is partly what we put up and part other things.

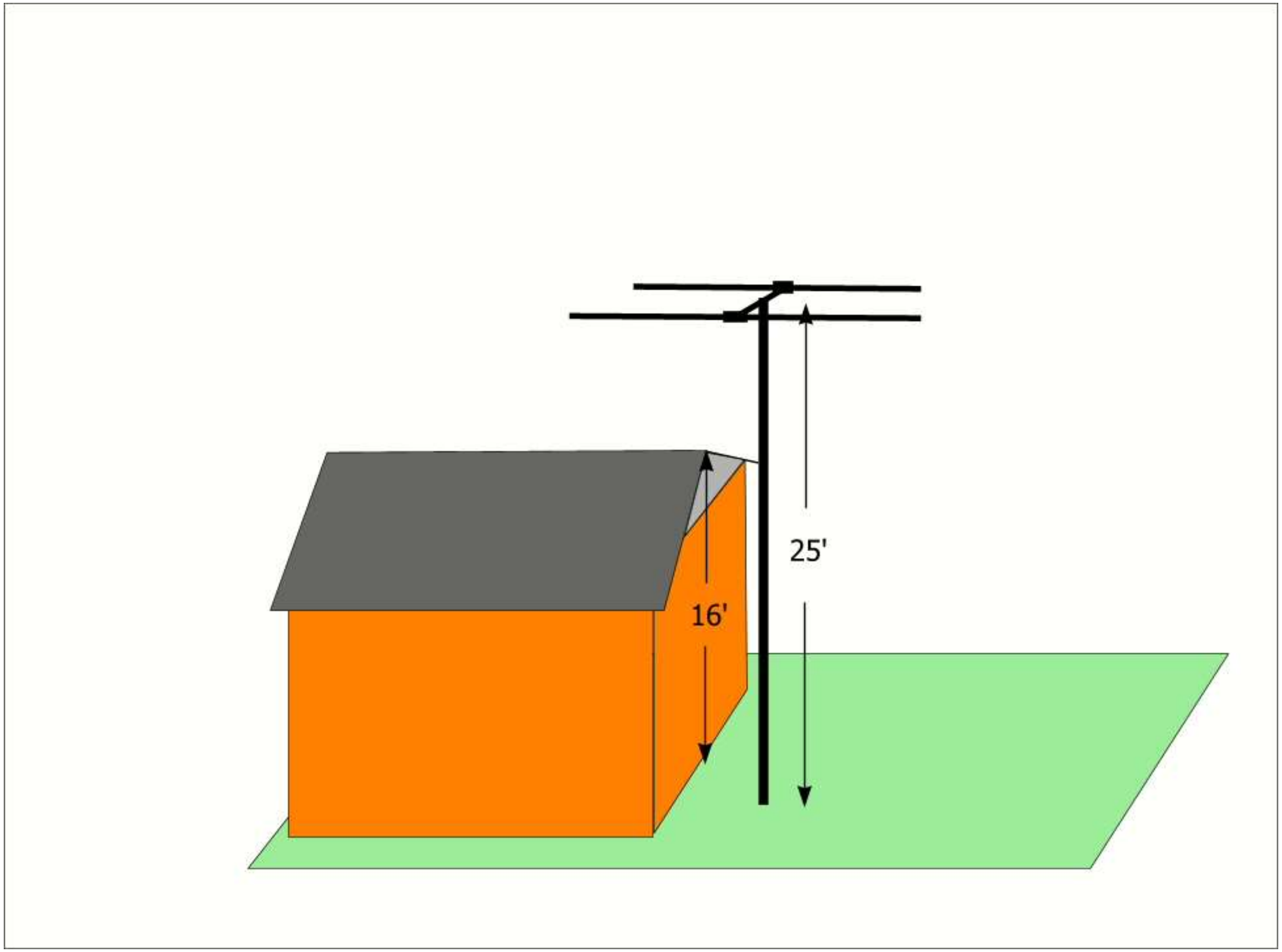
Example:

Height above ground

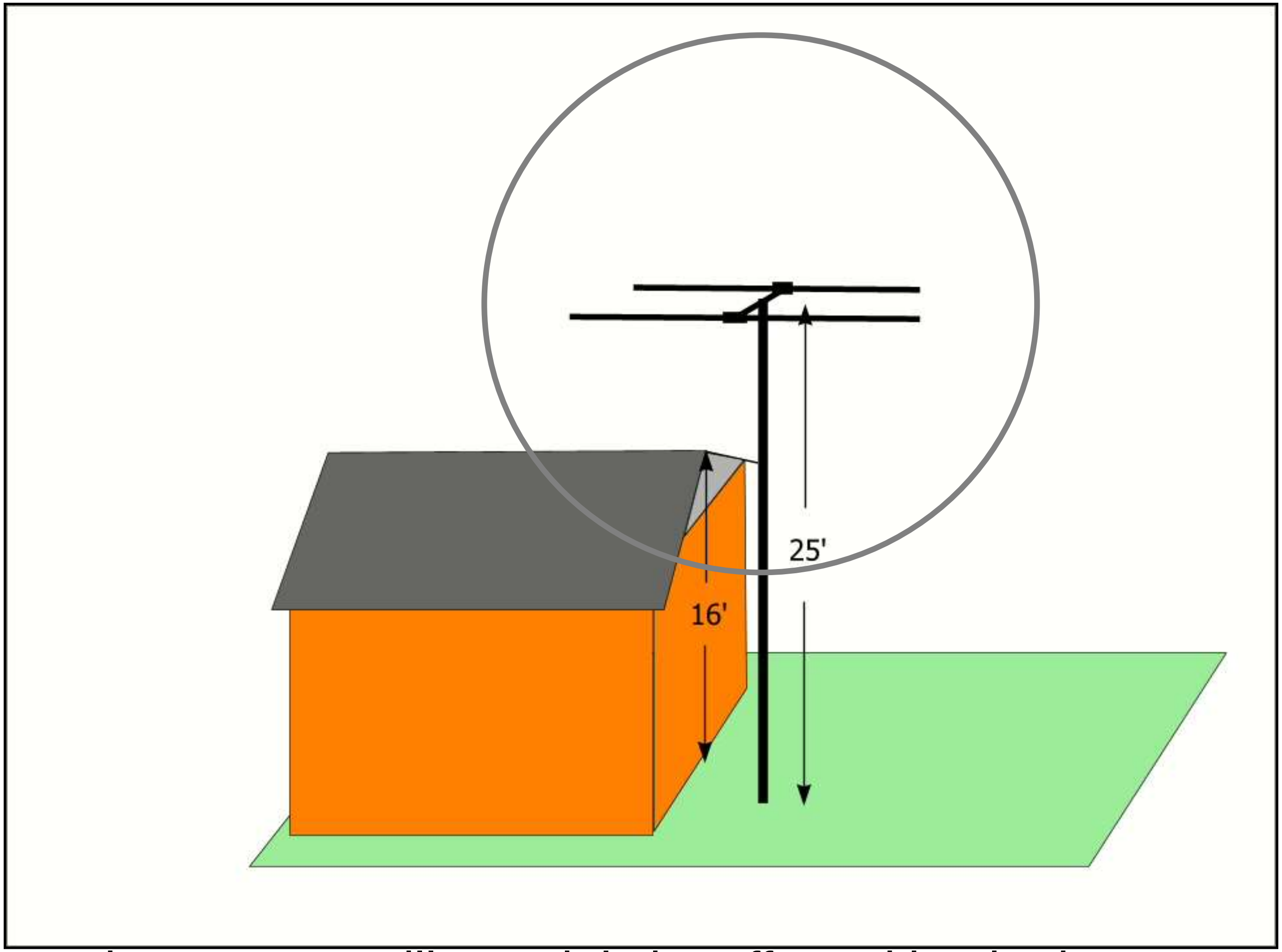
The antenna's height above ground is_____?



The antenna's height above ground is_____?



The house is well within the stand-off distance from the antenna.

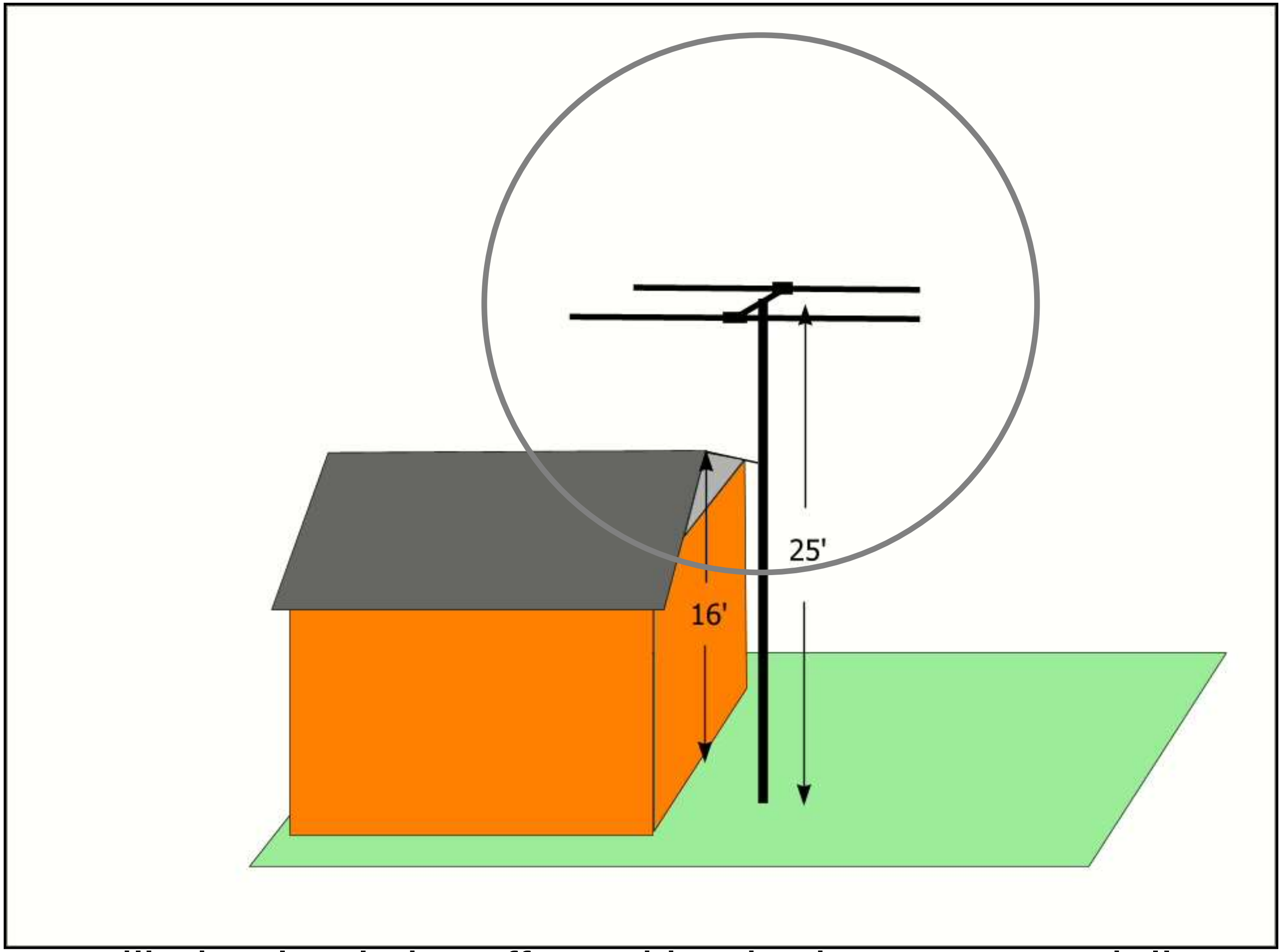


The antenna will certainly be affected by the house.

What typically happens when an antenna is in close proximity like this?

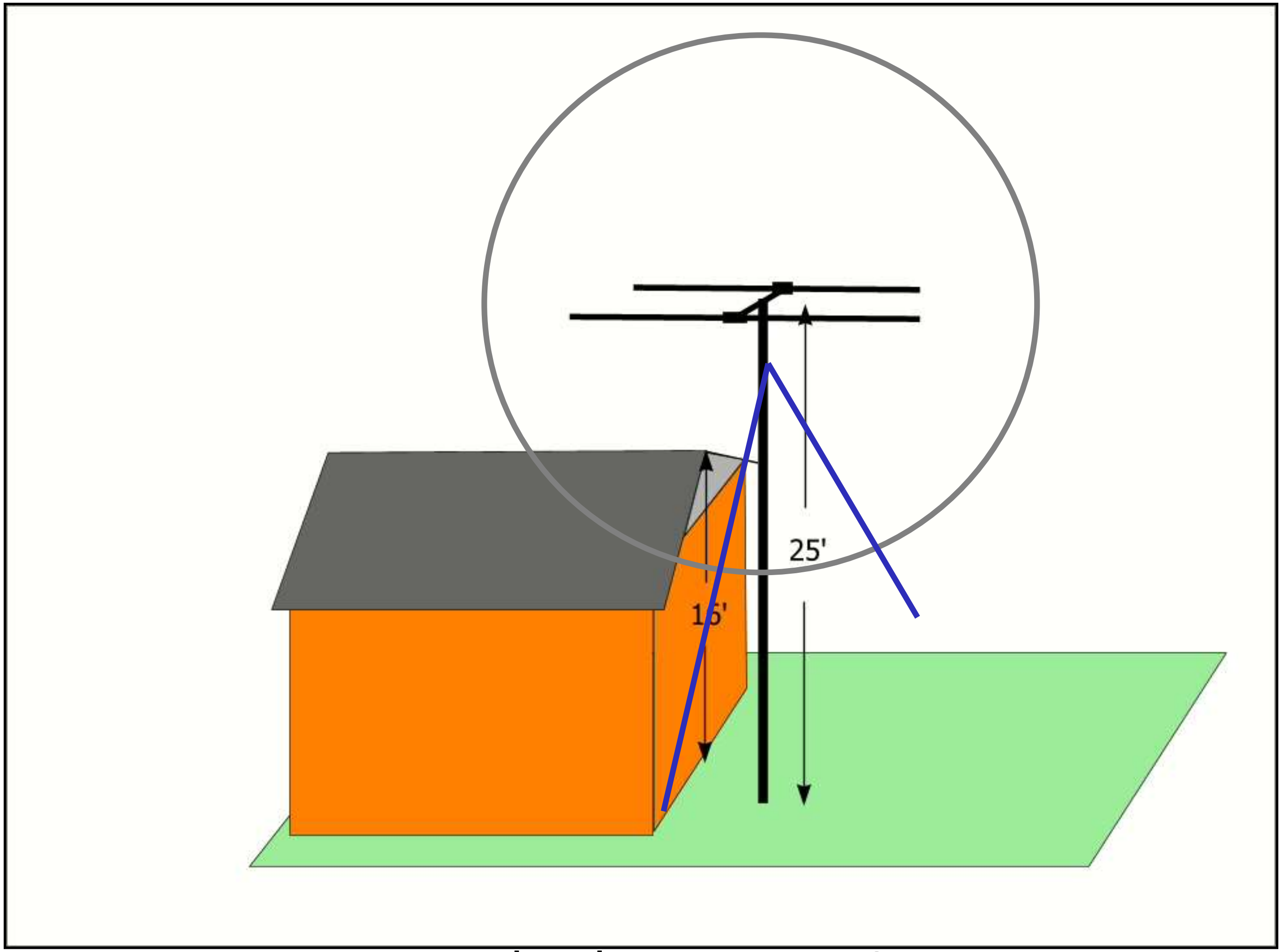
The frequency is pulled low
and
the feed point is also affected.

This is a simple example of an alien antenna, which includes the intended antenna, plus the affects of the roof (its composition), AC wiring, duct work, gutters, security wiring, etc.



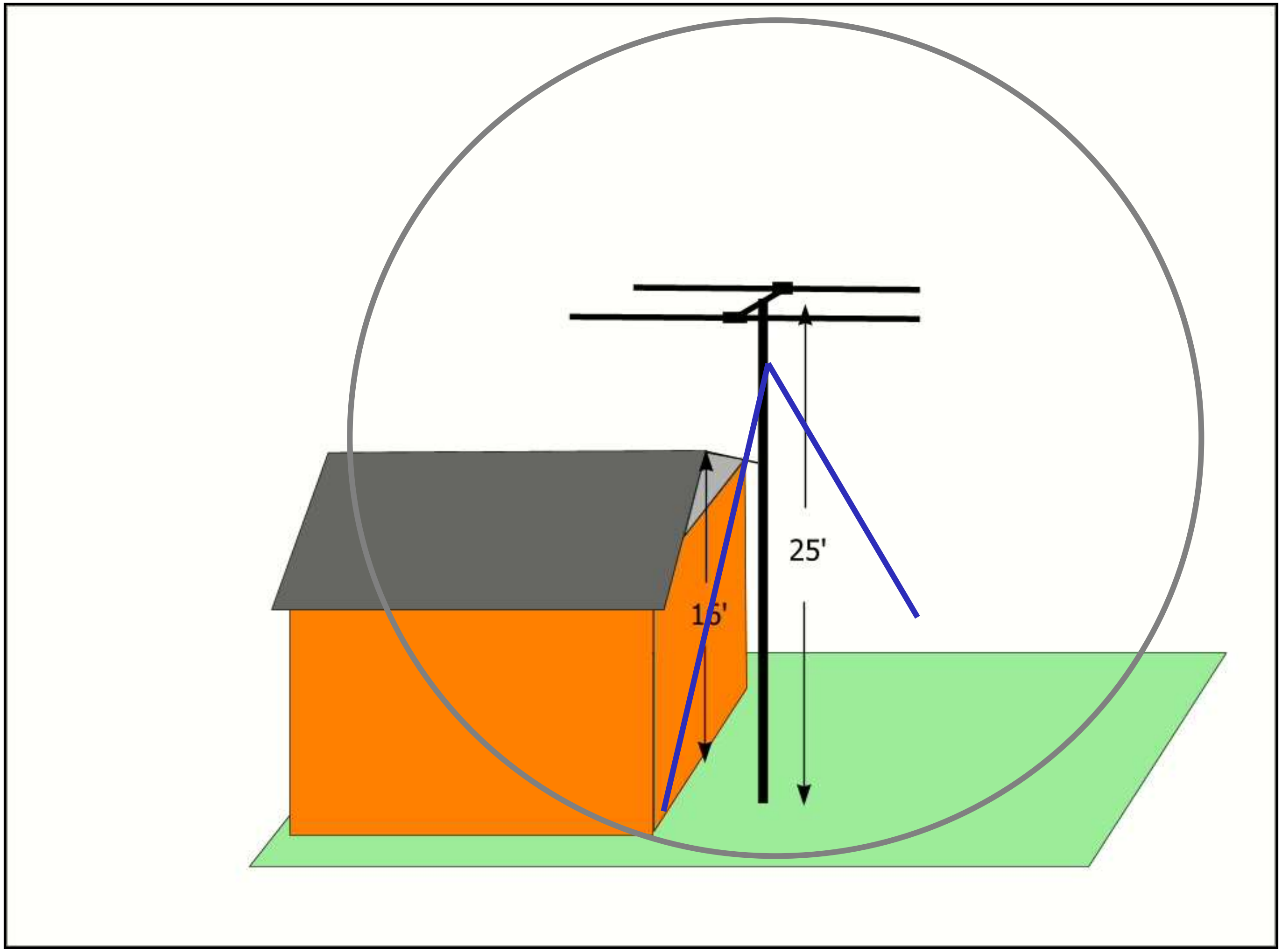
The antenna will absolutely be affected by the house, especially on 20 mtrs.

Let’s add a 40-meter inverted Vee...

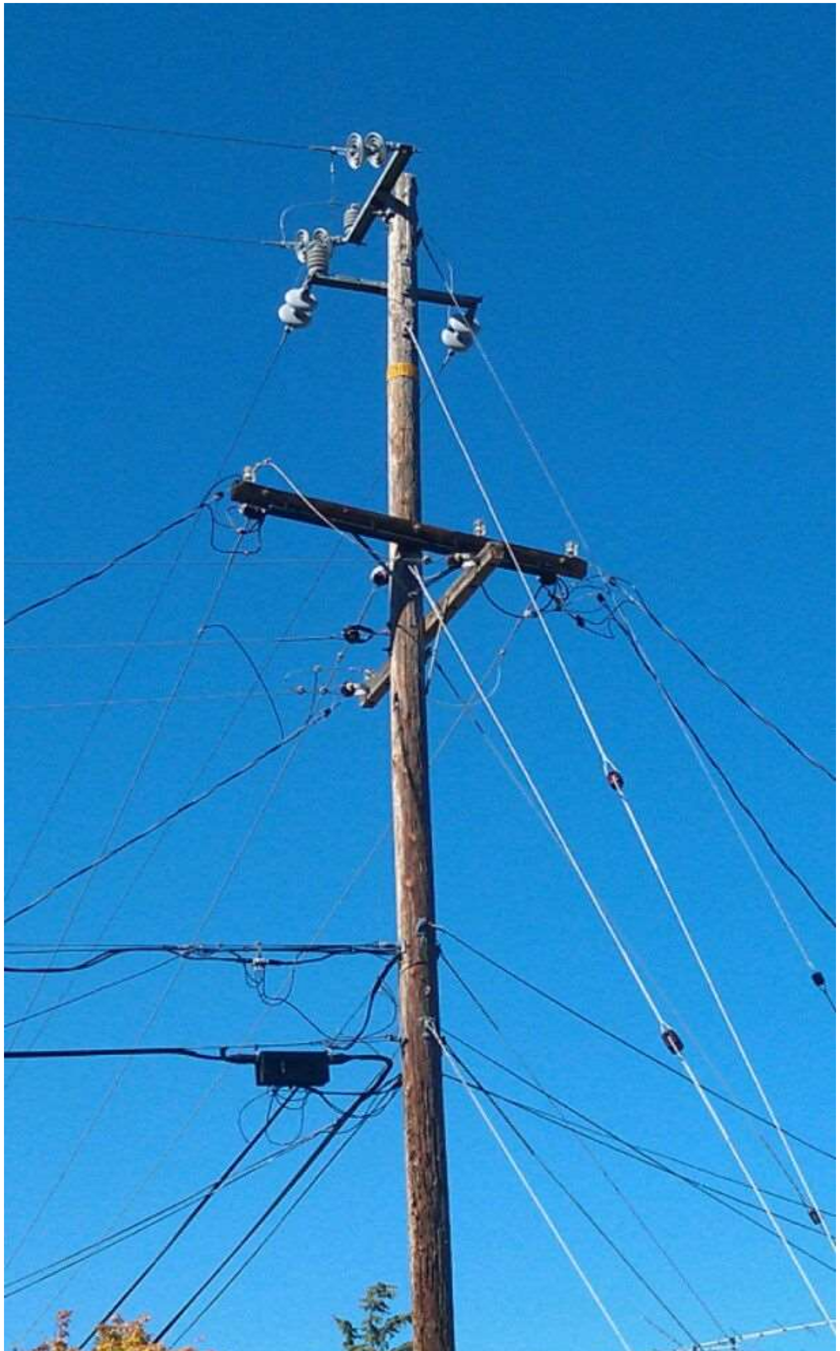


Now what have we got?

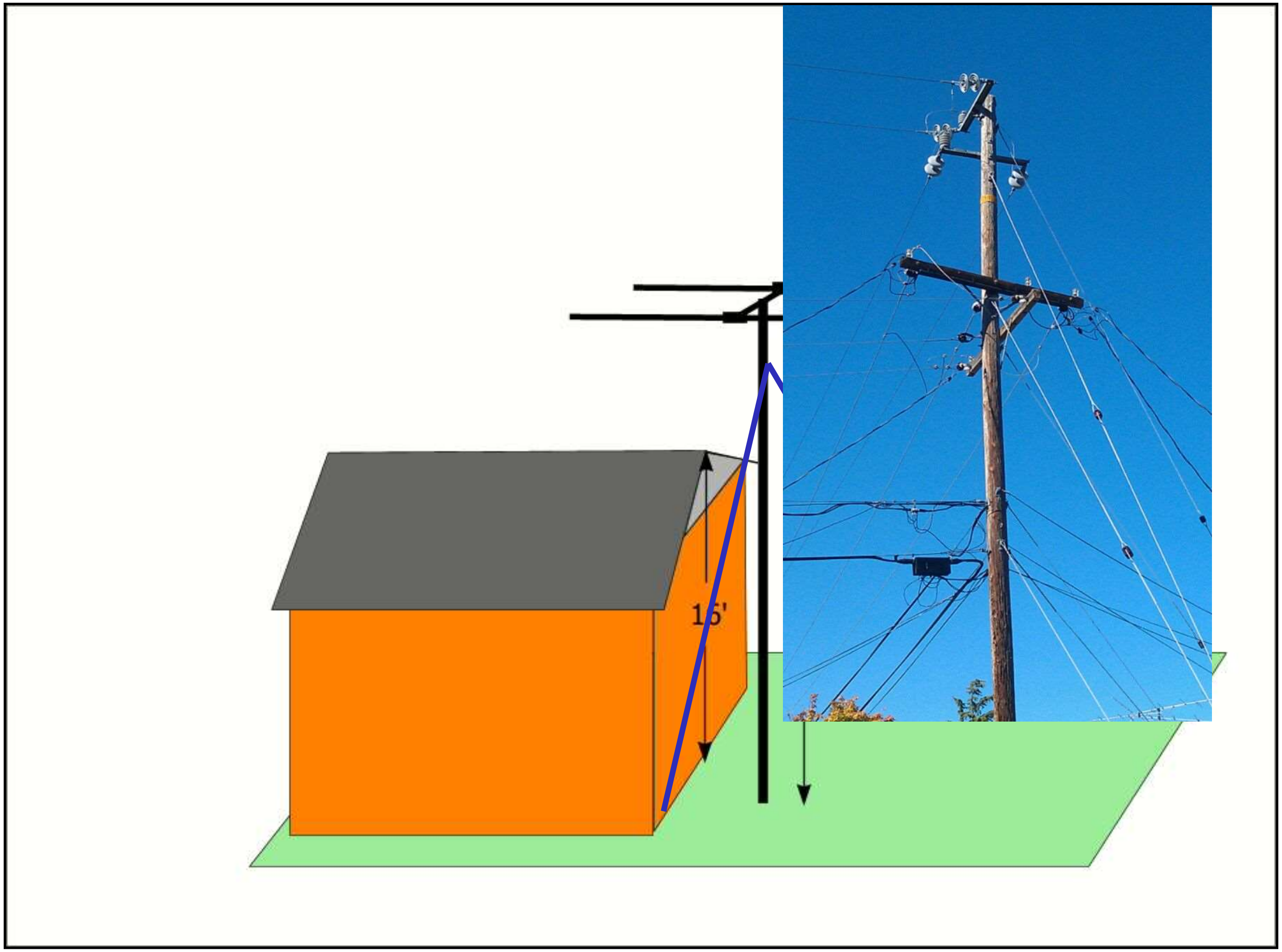
Just about the whole house and everything inside, plus sprinklers.



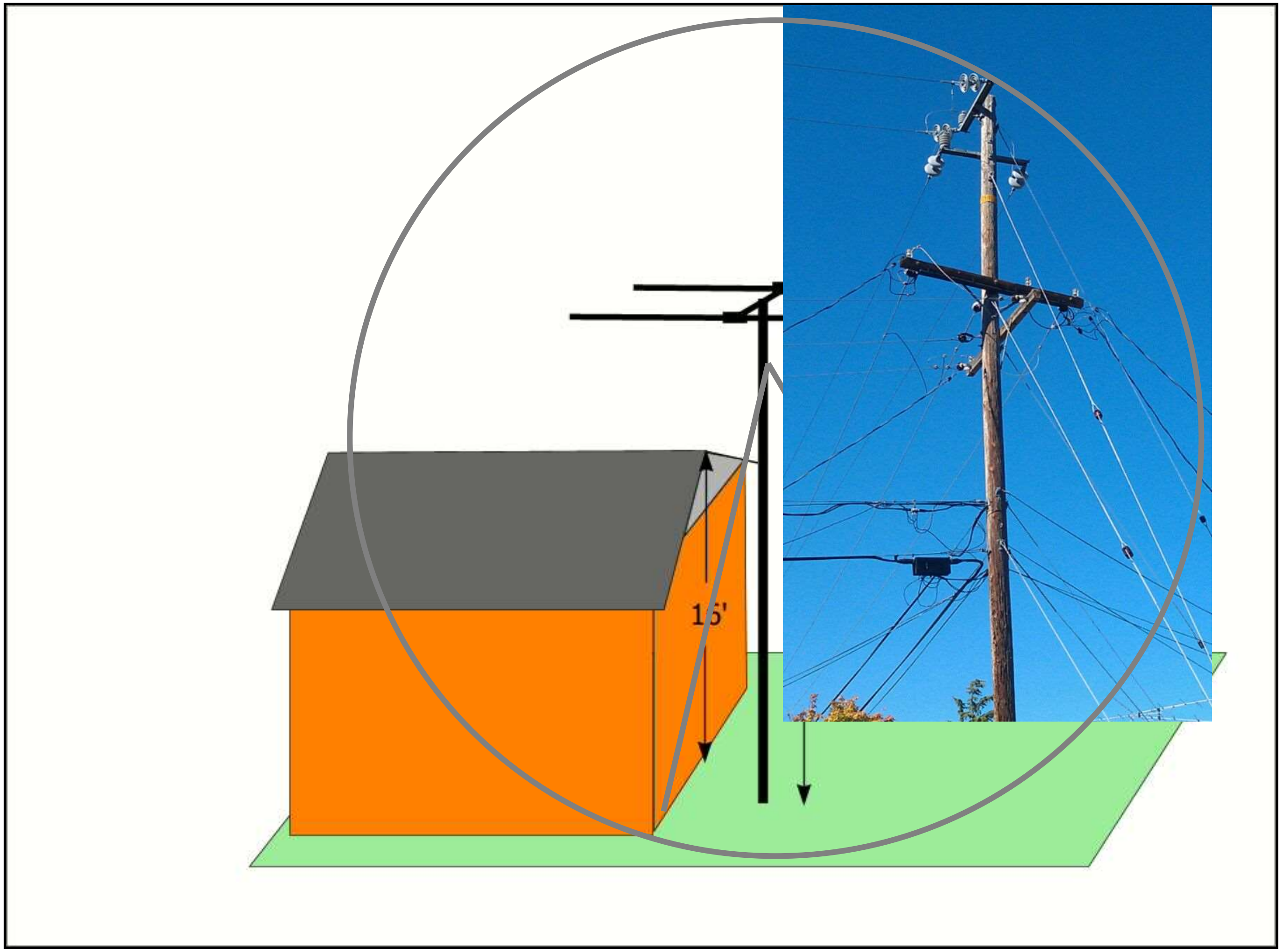
Let’s add a typical power pole into the back yard...



Now to add the stand-off distance for 40...

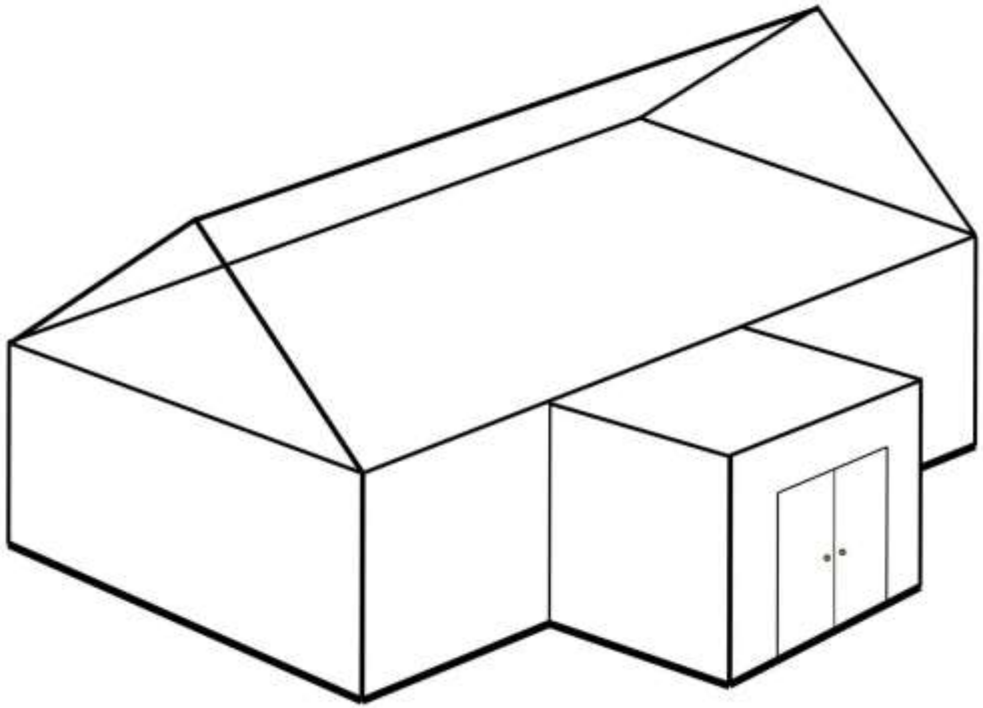


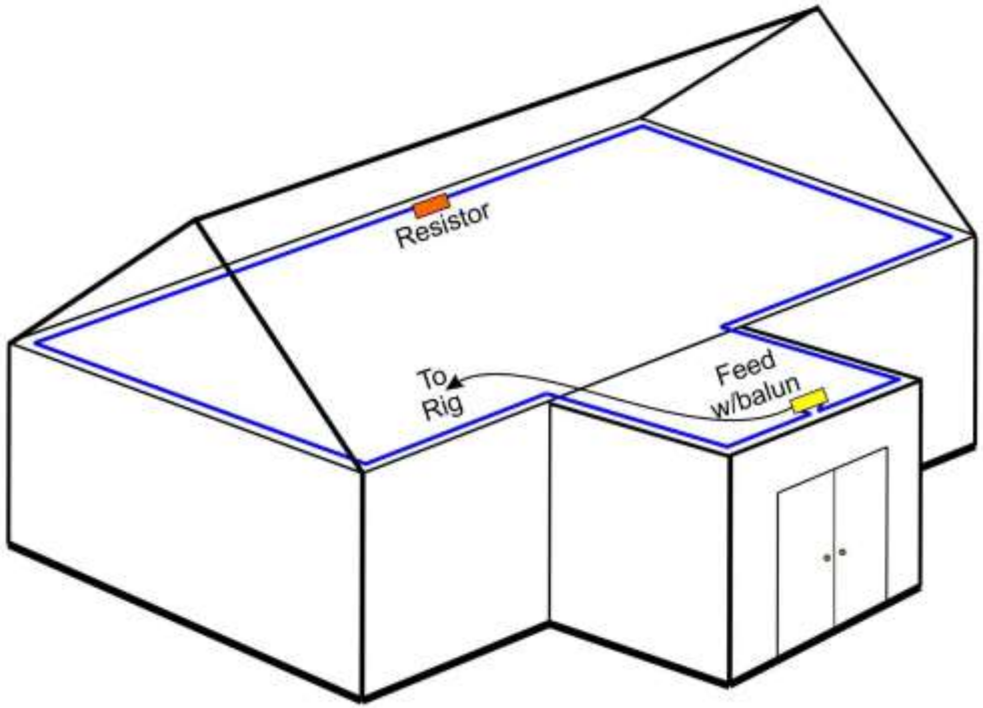
This is a real problem, as our antenna is truly an alien:
it includes the antenna, power pole and house.



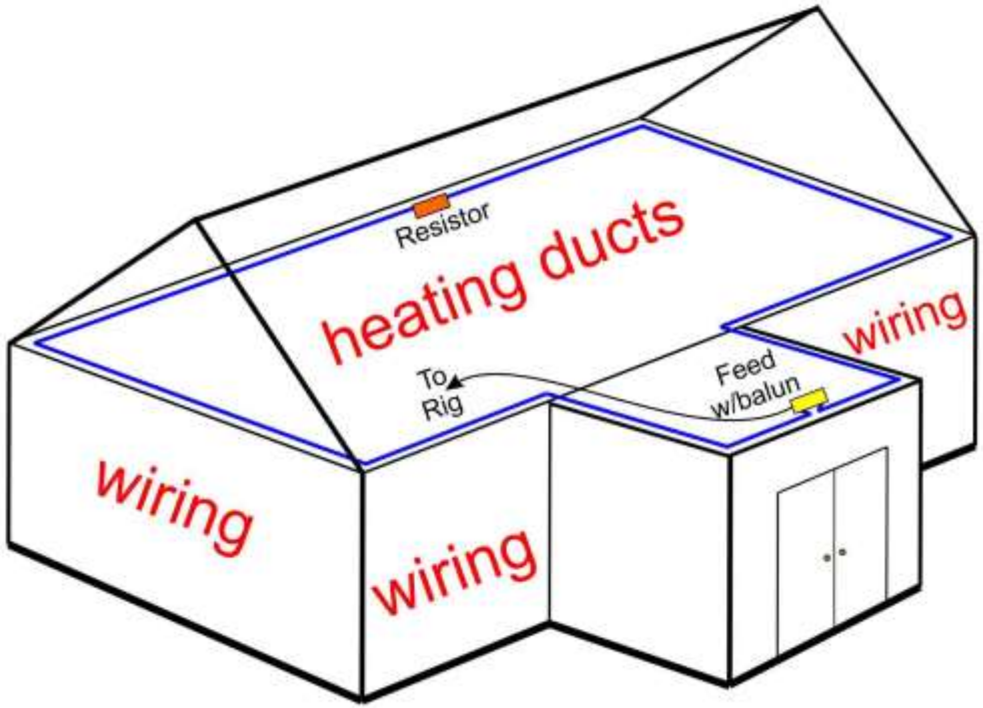
**One can find several suggestions on-line for “home” antennas,
along with various claims.**

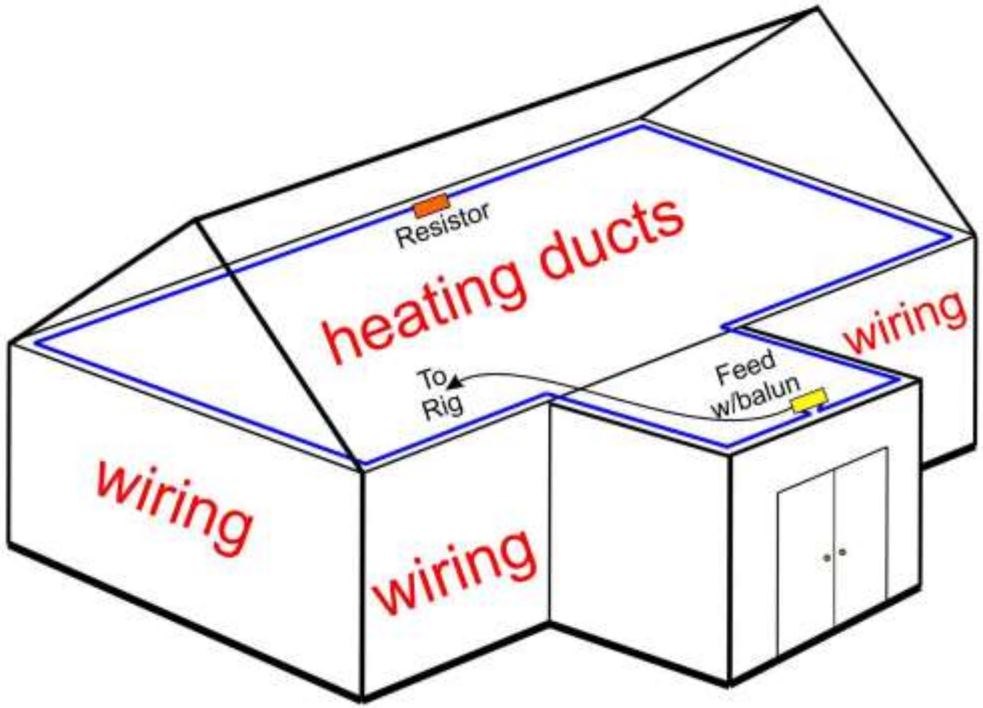
One is the following…





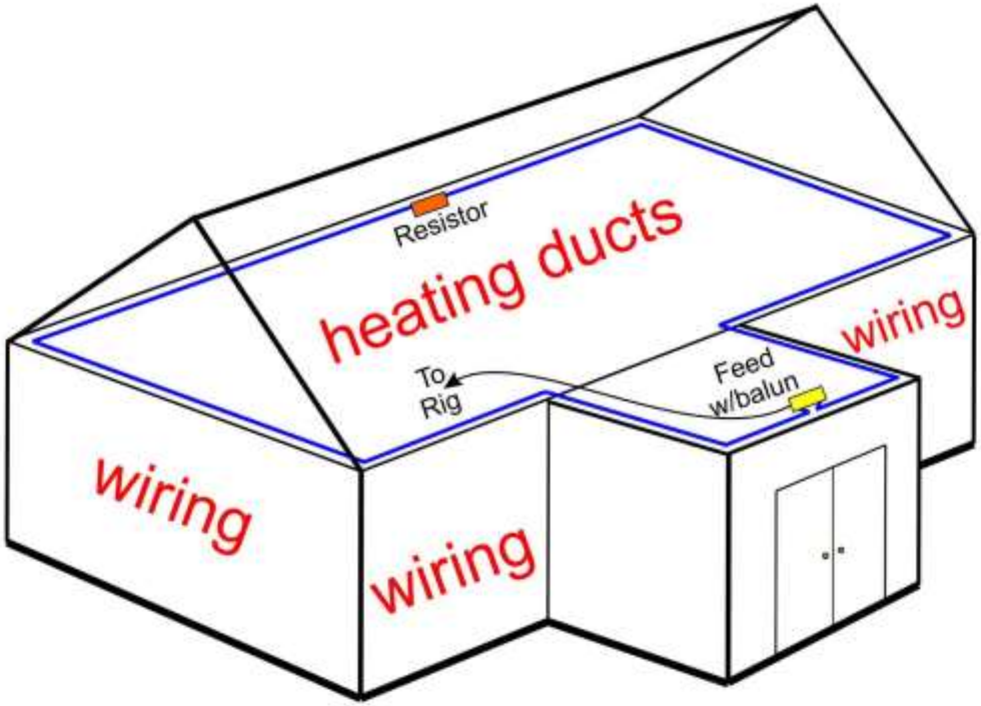
Resistor
To
Rig
Feed
w/balun


Resistor
heating ducts
wiring
To Rig
Feed w/balun
wiring
wiring



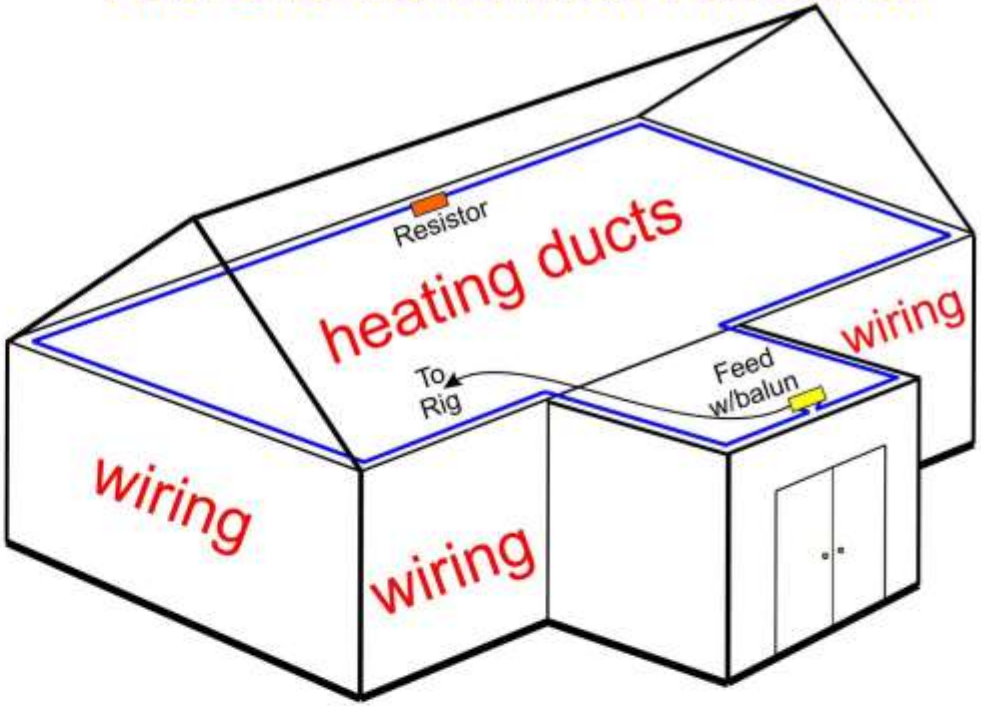
House metal siding, or stucco
Gutters and down spouts
Security and sensors
Computer ethernet
Telephone lines

The Perimeter Antenna
Lights up the entire house with RF



House metal siding, or stucco
Gutters and down spouts
Security and sensors
Computer ethernet
Telephone lines

The Perimeter Antenna
Lights up the entire house with RF
"The Ultimate Alien Antenna"



House metal siding, or stucco
Gutters and down spouts
Security and sensors
Computer ethernet
Telephone lines

A word of CAUTION

Antenna High Voltage

Attic dipoles: → high voltage is at the ends can start a fire
→ ends of all dipoles are high voltage

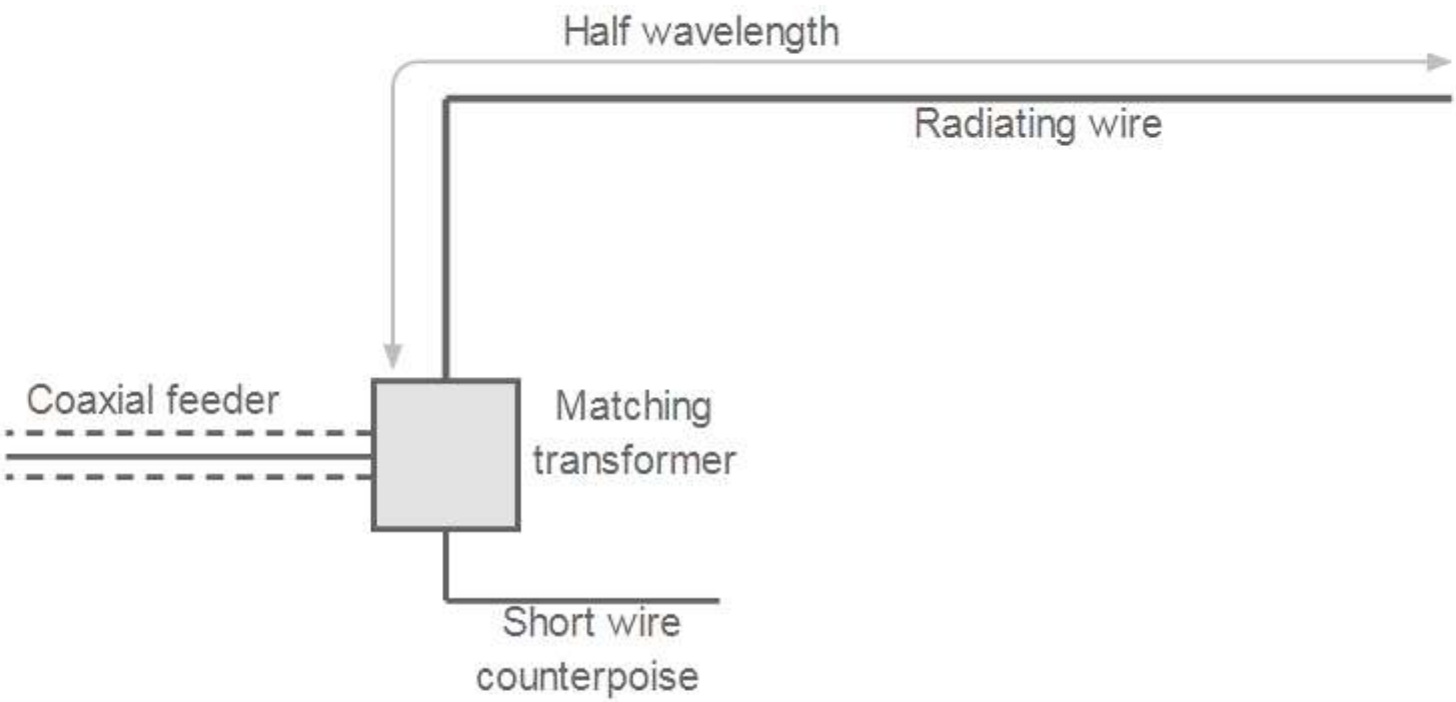
Verticals: → roof-top radials can have high enough voltage to ignite wood shingles
→ horizontal resonators (like on a Bravo), high voltage is at the tips

Magnetic Loops: → high voltage is opposite the feed point and is very high

"Perimeter wires": → can have multiple voltage maxima, depending on the length

Another is the EFHW:

end-fed, half wave



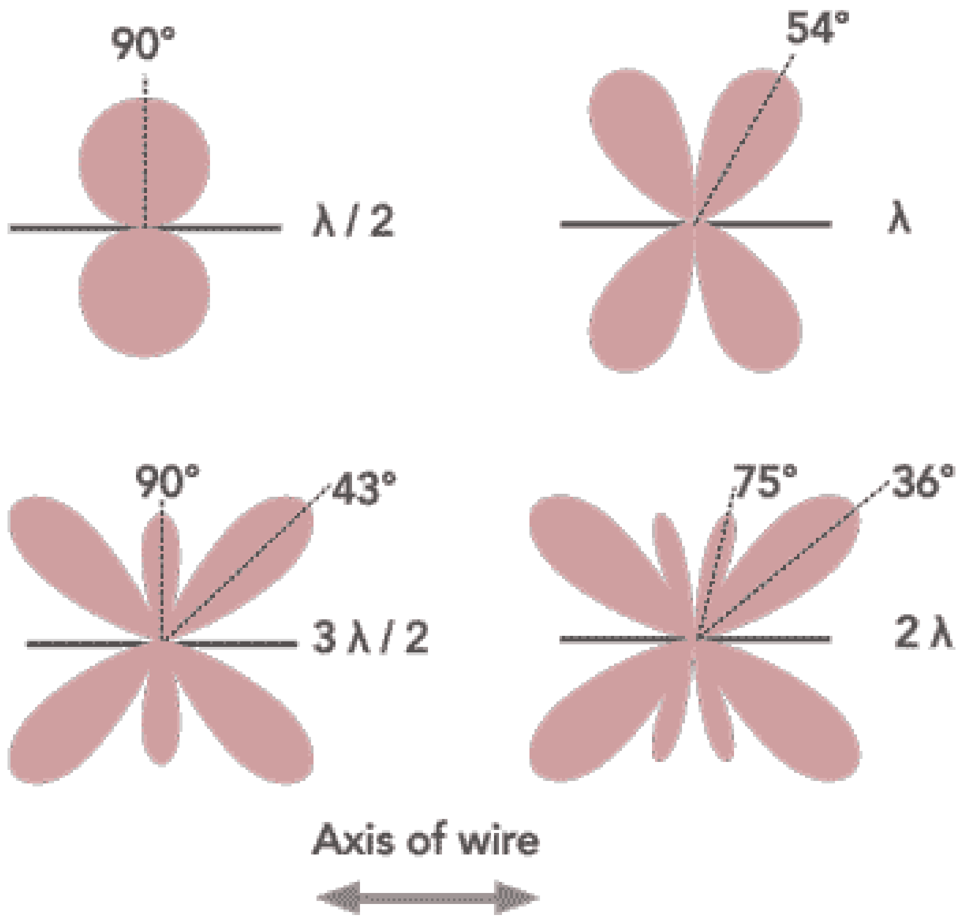
If the EHFW is installed correctly with an elevated far end:

1) the pattern will change according to the band on which it operates (the number of ½λ's it uses);

2) As a half wave radiator = same way as a half wave dipole (figure 8 pattern, 90° to wire axis);

3) As the length increases, the pattern changes with additional lobes forming.

Examples……………………….



…..depending on frequency of operation, it might or might not perform to your expectations

A simple test for an antenna that is rotatable

is to carefully plot the VSWR at the rig at four (4) compass points,

90° apart, such at N-E-S-W.

VSWR is not a perfect indicator,
but is pretty good to show if coupling is present.

What we need to do is to carefully plan
which antenna(s) to choose,
where to place them

and have reasonable expectations of the results.

Adding lots of antennas, particularly wires, will not result in an effective system.

In general, less is better.

Many times there have been 40-meter dipoles installed at low heights and they performed exceptionally well.

Terrain is often the reason.

A dipole installed parallel to a slope will have the advantage of the hill behind it (a pseudo reflector), plus the slope in the foreground will increase its effective height above ground.

How do you *intentionally* get directivity?

By re-distributing/re-directing the energy.

Start with an “isotropic radiator”

It is located in free space – not anywhere near ground – and is far enough away from the earth so that the earth (ground) has no effect upon the emitted energy.

There is a point source at the center that is emitting energy equally in all directions, which ends at the skin of the balloon.

Grab the “isotropic radiator” at the middle and squeeze.

We now have a dipole in free space.

It has a figure-8 pattern at right angles to the wire.

It also has 2.14 more dB than the isotropic radiator in the directions of the figure-8.

The dipole in free space, therefore, has <u>2.14dBi gain</u>

(the trailing “i” means compared to the isotropic radiator).

Can we get more gain?

Yes!

We can add one or more elements to further re-distribute the energy.

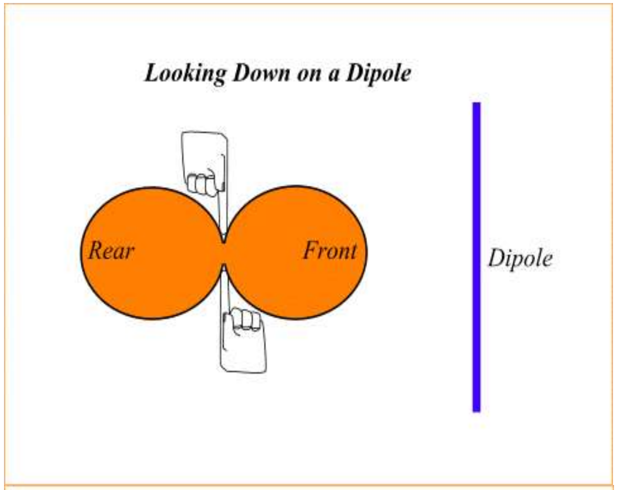
We are not creating energy, only pushing it in a particular direction at the expense of other directions.

If we make a 3-element Yagi, it would be something like this:

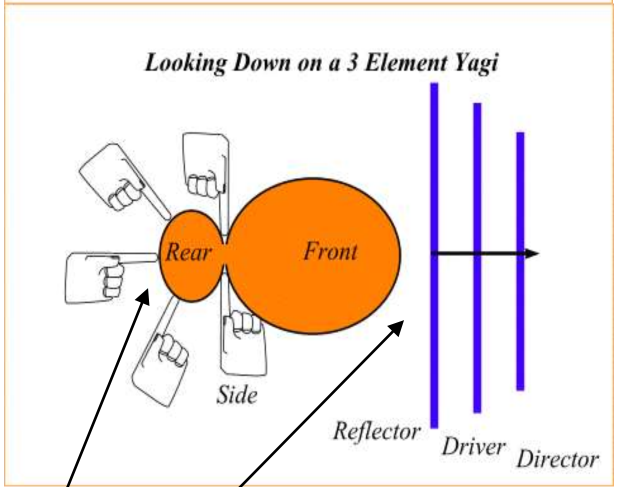
The pattern is now directive, favoring one direction

at the expense of other directions.

Original dipole.



3-element Yagi



It will have gain over a dipole, or dBd

(the trailing “d” means dipole).

Computer modeling designs of Yagis are straightforward; however, be sure to include:

A. The equivalent of the mounting plate as the first section of each half-length

B. The actual taper schedule on each element.

C. Try not to squeeze out that 0.1dB of gain (keep the design “low Q”)

Efficiency (gain / loss)
Practical, realistic gain figures

At 1 wavelength over ground, full size elements

Horizontal dipole,	7.7dBi	(0 dBd)
2 ele Yagi 8' boom,	12.3dBi	(4.5dBd)
3 ele Yagi 18' boom,	13.3dBi	(5.5dBd)
4 ele Yagi 30' boom,	14.2dBi	(6.4dBd)
6 ele Yagi 44' boom,	15.6dBi	(7.8dBd)

Note what it takes to increase 1 or 2dB!!

Consider the mechanical increase vs. gain increase.

The lower power we run, the more important our antenna.

Especially true on the low bands.

What's the most improvement (for the smallest investment)?

Adding one more element:

Either phased or parasitic,

this will add between 3 and 4.5dB over the single element.

Team Vertical will all affirm that 2dB is a "ton."

Whenever we could find 2dB, we would do it, because:

it adds another layer of stations to work.

If you want to lay down an antenna when it is not in use,

This vertical has a base with a wireless actuator that raises and lowers it.

A serious suggestion for anyone wanting to use a drone as a test vehicle.

Our drones weigh several pounds, can fly over 40-50mph and the carbon-fiber blades are very sharp. Getting hit by one of these will ruin your day of fun flying.

Even with sophisticated control systems, drones can do unexpected things.

Suggestion

Practice with an inexpensive quadcopter before launching a large, heavy unit - regardless of what the marketing material says about it being able to "fly itself."

SYMA X5C-1 $45 - 55

6 gyros (not GPS)

2MP camera (pix+video)

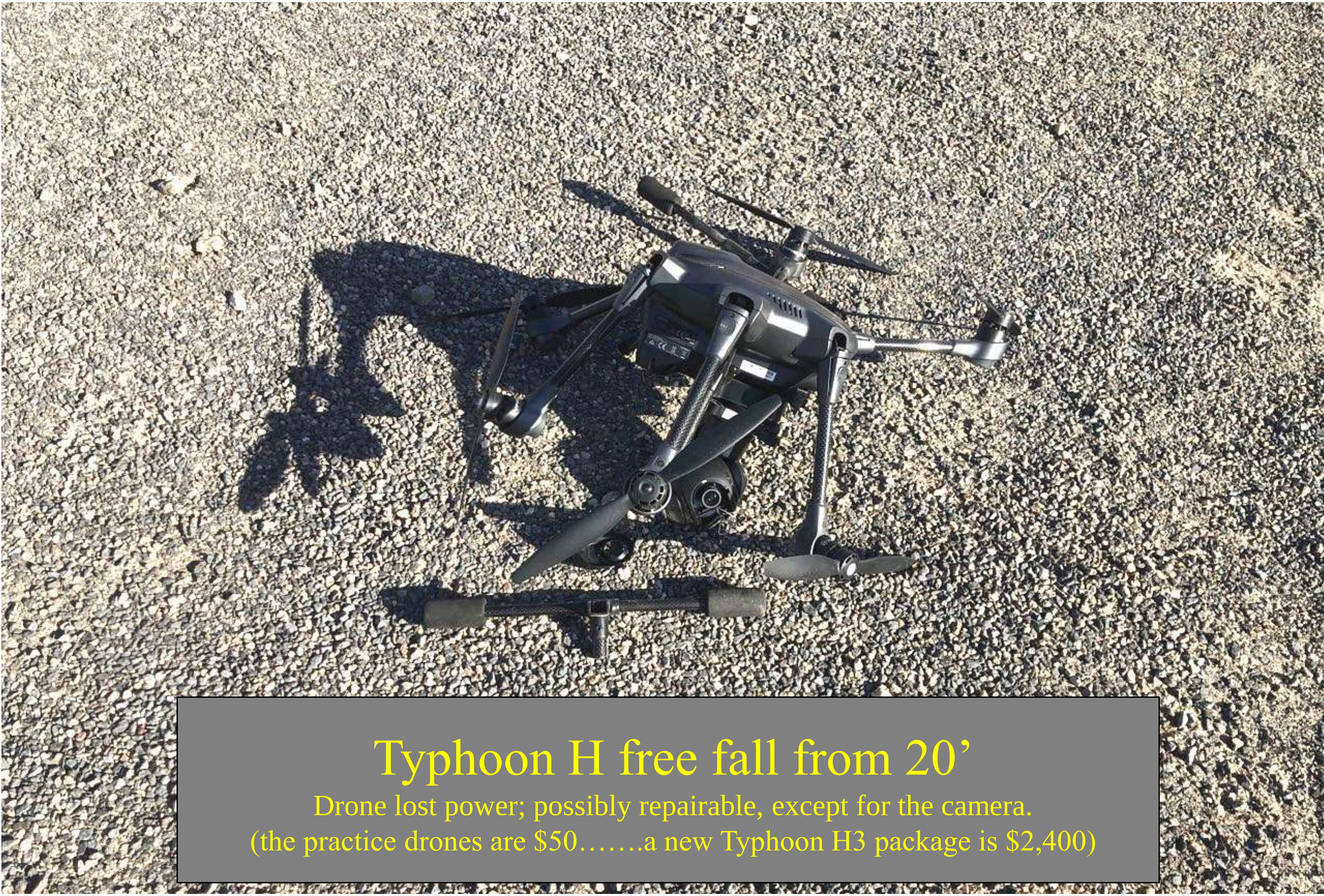
shown with prop guards

Green lights are towards you

"Forward" is the other way

Why do I mention this?

Not everything goes as planned →



Typhoon H free fall from 20’

Drone lost power; possibly repairable, except for the camera.

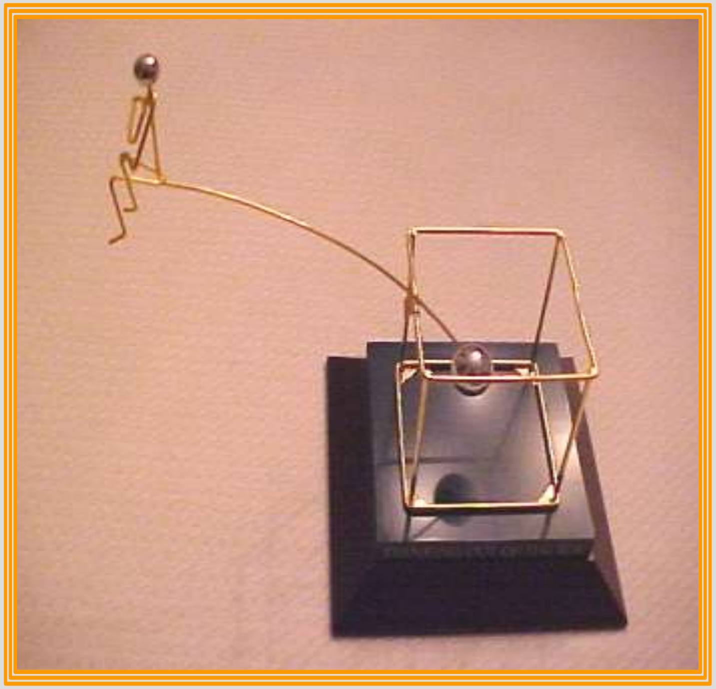
(the practice drones are $50…….a new Typhoon H3 package is $2,400)

Thoughts for the day:

"Everything Works"

...and...

Nothing's obvious



A parting thought:

With today’s technology, setting up a remote station is feasible and sharing an existing one is, too.

Thanks for your attention

Tom N6BT

n6bt.com
next generation antennas™
from the founder of Force 12, Inc.