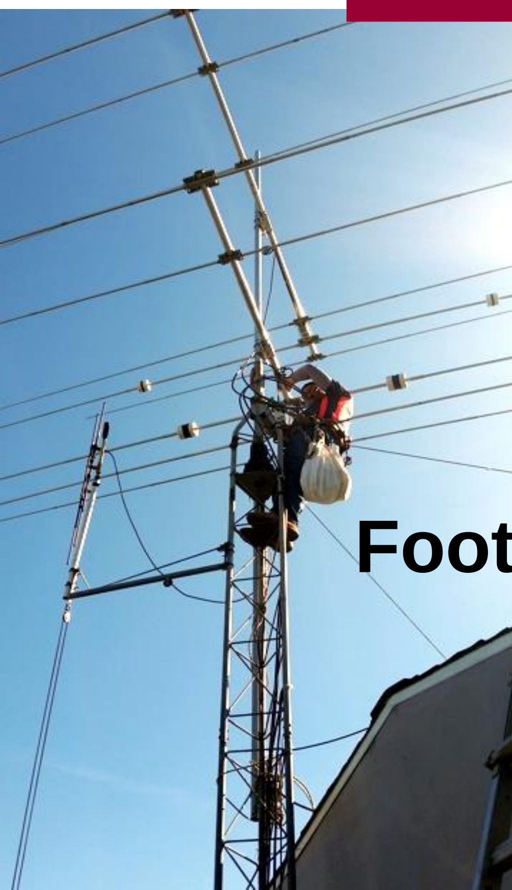


# Foothills Amateur Radio Society

Feb 26, 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;

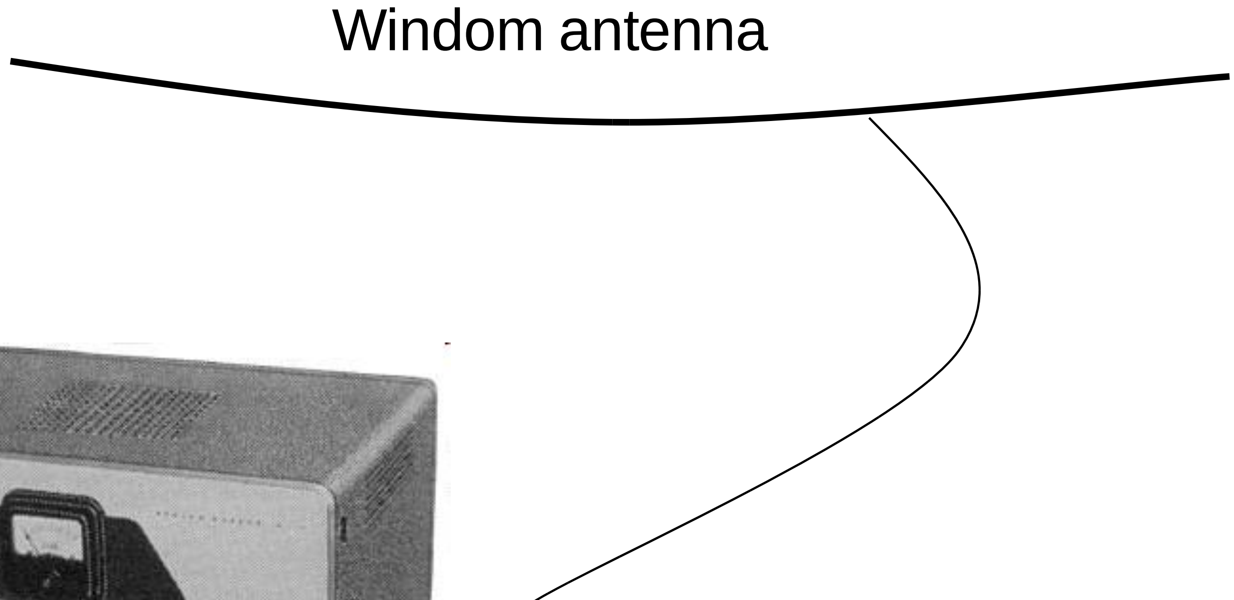
possibly even less than what we are anticipating.

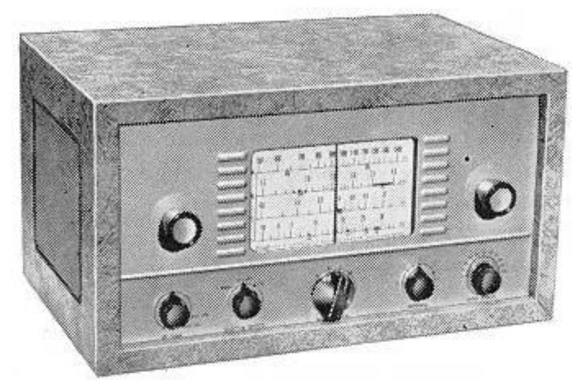
How can you evaluate an antenna?

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


TYPE
Z-2
PR
QUARTZ CRYSTAL
FREQ-KC
7100
PETERSEN RADIO CO
COUNCIL BLUFFS IOWA
MADE IN U.S.A.


JAN
CRC-6AG7
VT-247

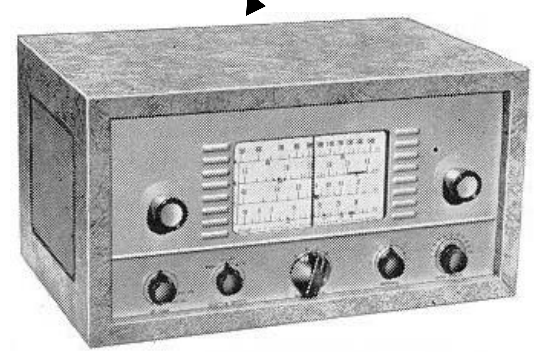


**VF-1** VFO
**DX-35** Transmitter
Phone or CW—80 through 10 meters
65 watts CW—50 watts peak on phone 6146 final amplifier
Pi network output to match various antenna impedances

Windom antenna

**QF-1** “Q” multiplier



**VF-1** VFO
**DX-35** Transmitter
Phone or CW—80 through 10 meters
65 watts CW—50 watts peak on phone 6146 final amplifier
Pi network output to match various antenna impedances

**AR-3** Communications Receiver
HF Communications receiver

# What’s missing?

(that is “required” in today’s stations)

**AM-2** Reflected power meter

# Why has VSWR become a primary factor in antennas?

**AM-2** Reflected power meter

Transmitters/transceivers (and now many amplifiers) with solid state final stages.

In the days with such transmitters as the Heathkit DX-35, rigs had tube amplifiers with a pi-network output stage.

Basically, if you could dip and load (increase) the plate current while holding the grid current within limits and peaking the power output via a field strength meter,

the rig didn't really care about the VSWR;

ergo, the antenna system was just fine.

Solid state final amplifier stages changed the playing field, as they did not employ the same output tuning as tube amplifiers.

Heat dissipation is the issue and the early solid state rigs would clamp down on the output of a 100 watt rig to maybe 15 watts with a slight VSWR of even 1.3:1.

A low VSWR became mandatory.

Rigs became available with internal antenna tuners, and VSWR was mistakenly elevated to a primary indicator of “antenna performance.”

**VSWR**

is what everyone can measure with almost any equipment.

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

C-49XR 20-15-10

C-49XR 20-15-10

2el40 / 2el30 N6BT custom

(both 40's are phased)

3el17 / 4el12 N6BT custom

C-49XR 20-15-10

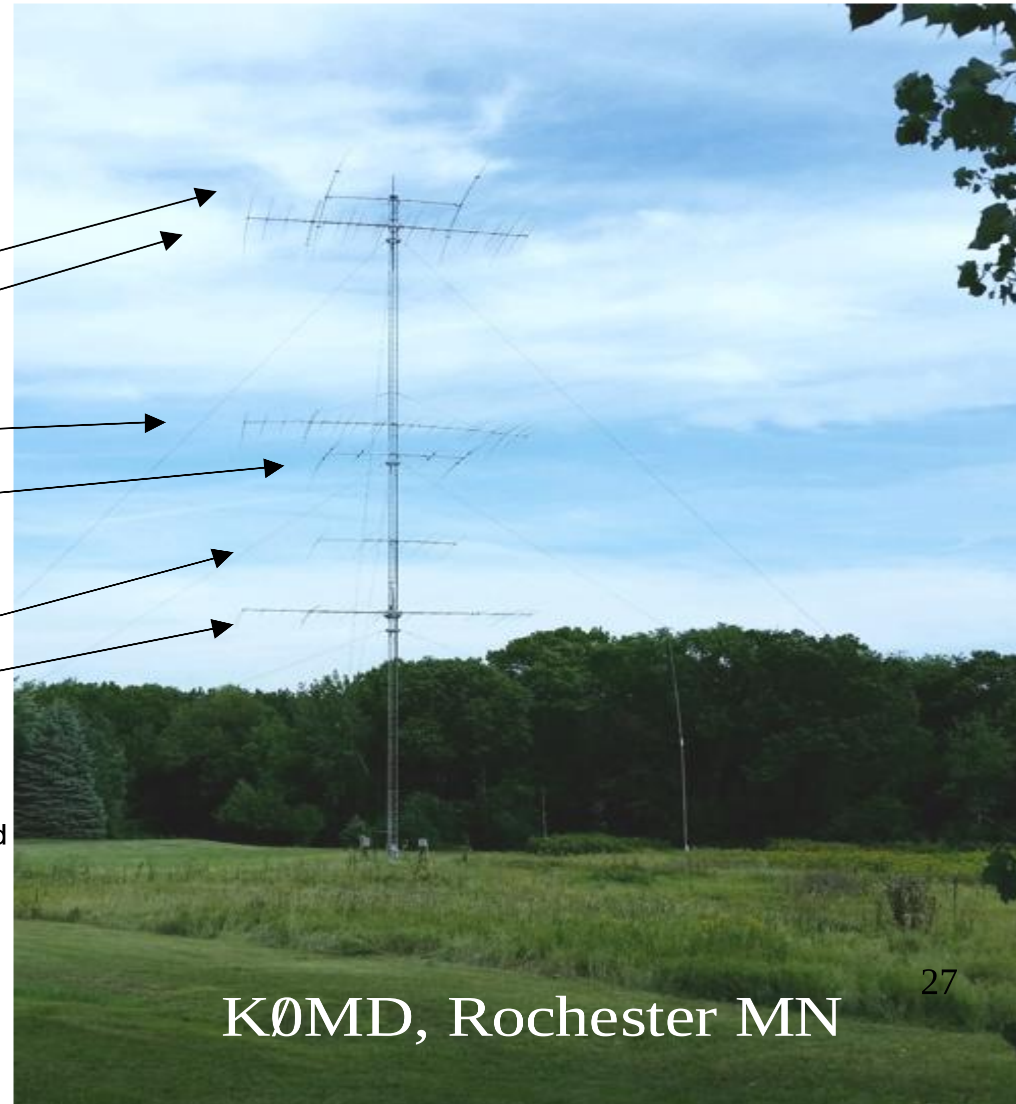
on ring rotator

all 3 C-49XR's and both 2el40's are phased

160 vertical (N6BT)

80/75 4-square (N6BT)

SS-3e 20-15-10 (N6BT)



**Then**

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

"CU 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)

**1/2 λ in free space (air)**

| | |
|---|---|
| 10 meters = | 17.4′ |
| 12 meters = | 19.7′ |
| 15 meters = | 23.2′ |
| 17 meters = | 27.1′ |
| 20 meters = | 34.6′ |
| 30 meters = | 48.7′ |
| 40 meters = | 69.2′ |
| 80 meters = | 129.5′ |
| 160 meters = | 269.5′ |

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

# ½ wavelength dipole

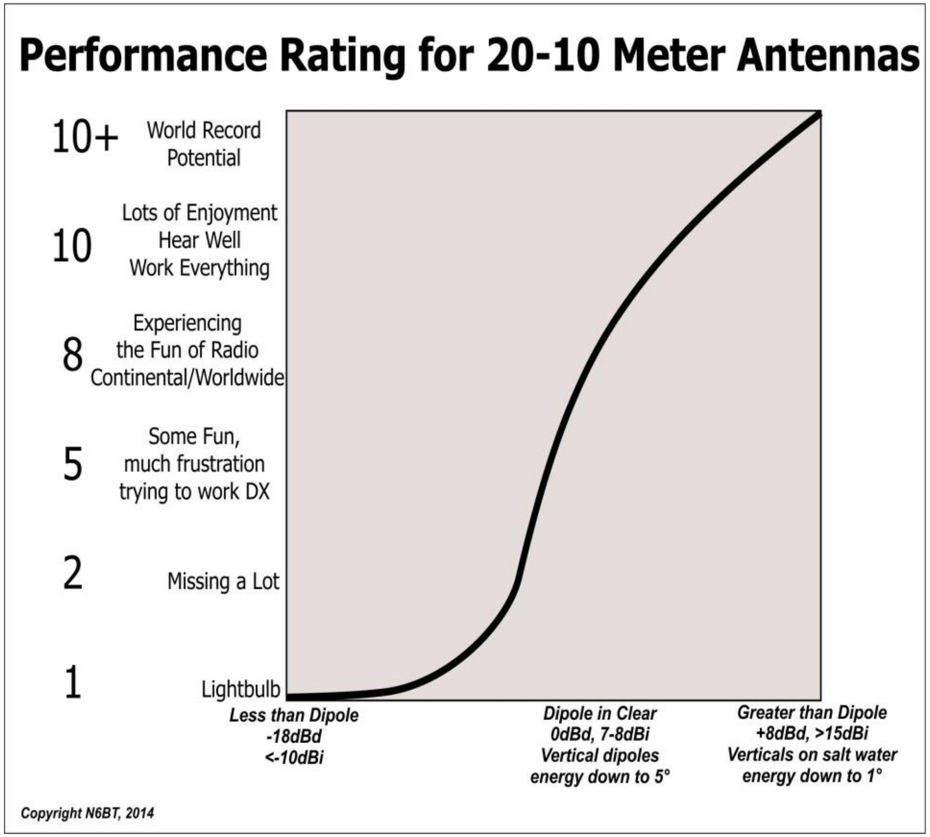
| | Free space | Wire<br>approx 468/f |
|---|---|---|
| 10 mtrs = | 17.4' | 16.6' |
| 12 mtrs = | 19.7' | 18.8' |
| 15 mtrs = | 23.2' | 22.1' |
| 17 mtrs = | 27.1' | 25.9' |
| 20 mtrs = | 34.6' | 33.0' |
| 30 mtrs = | 48.7' | 46.3' |
| 40 mtrs = | 69.2' | 66.0' |
| 80 mtrs = | 129.5' | 123.1' |
| 160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

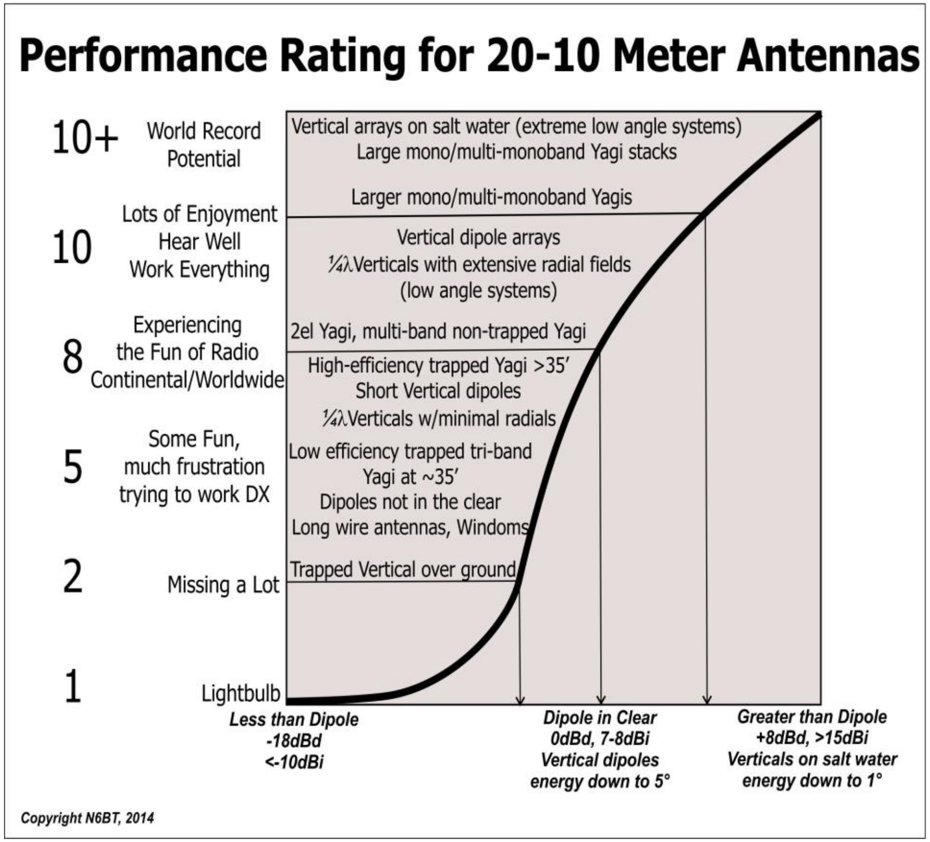
Why include free space length?
Useful for spacing phased elements, as the are coupling through air, not through a physical conductor (e.g. wire).

# For a given small area to work with, which bands are "reasonable" to consider?

| | Free space | Wire<br>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 and 40 for nighttime and nets.


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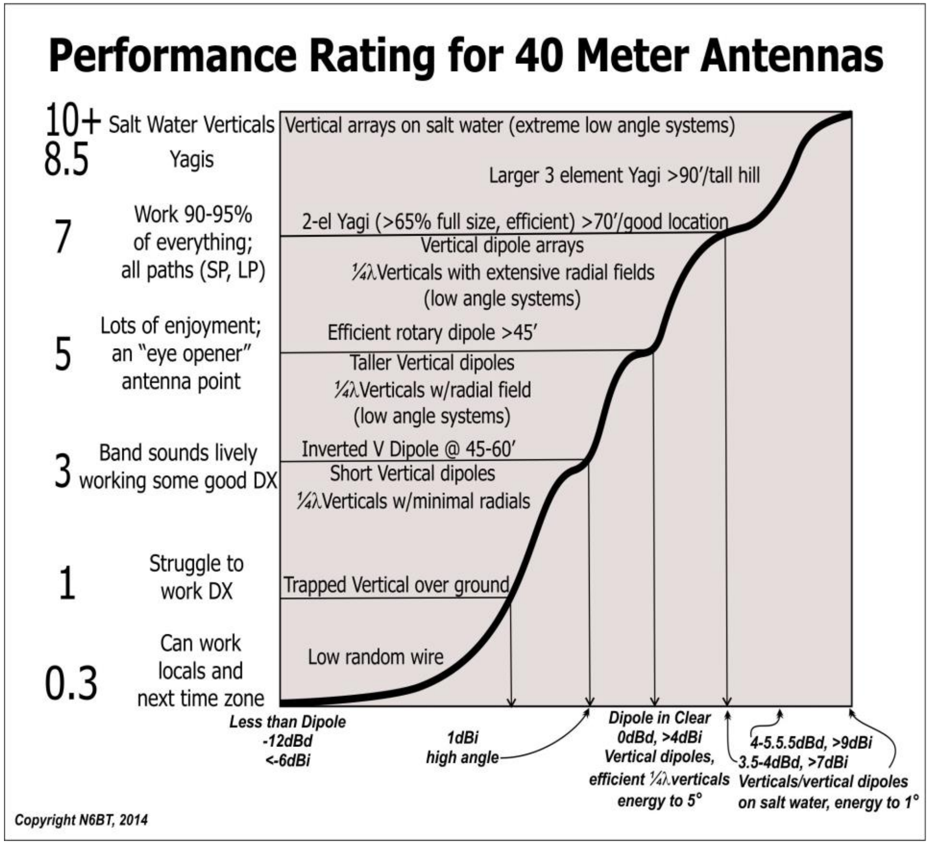
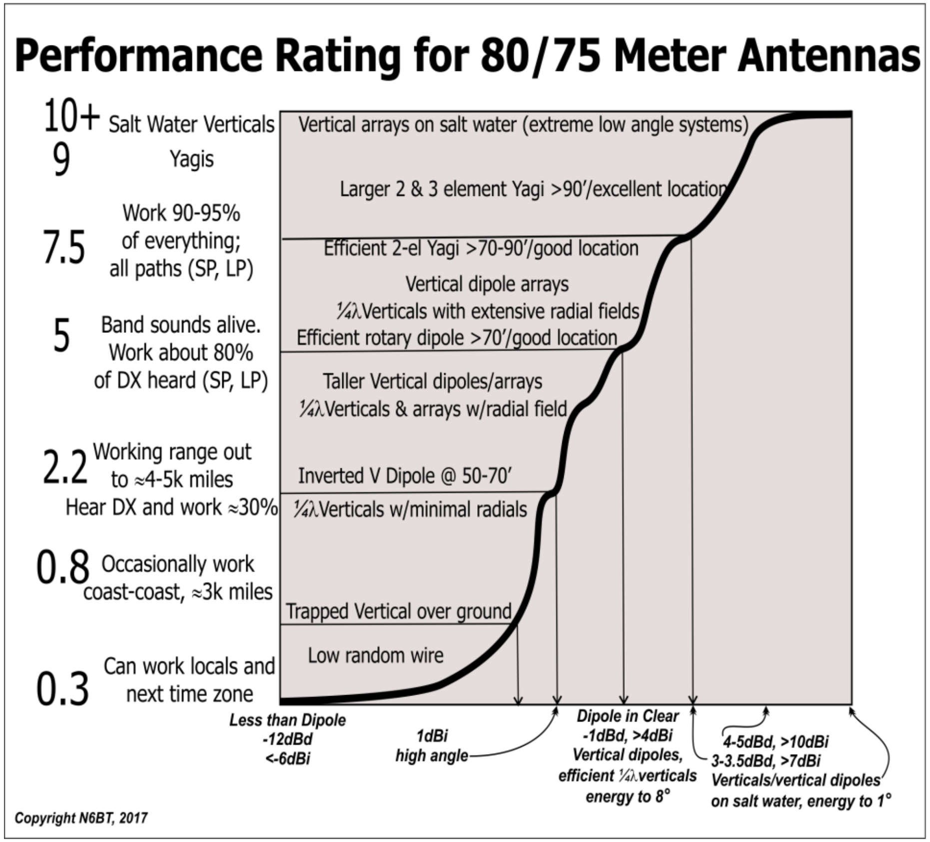


Performance Rating for 40 Meter Antennas
10+ Salt Water Verticals
8.5 Yagis
7 Work 90-95% of everything; all paths (SP, LP)
5 Lots of enjoyment; an "eye opener" antenna point
3 Band sounds lively working some good DX
1 Struggle to work DX
0.3 Can work locals and next time zone
Vertical arrays on salt 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


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°
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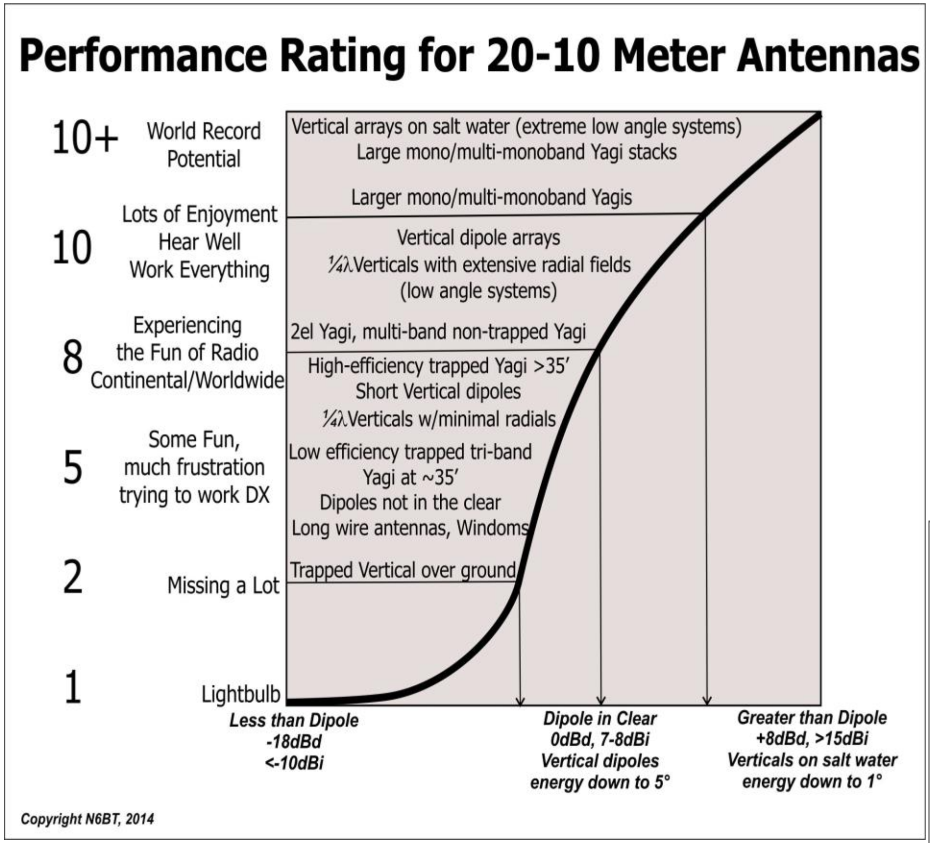
Verticals/vertical dipoles on salt water, energy to 1°
Copyright N6BT, 2017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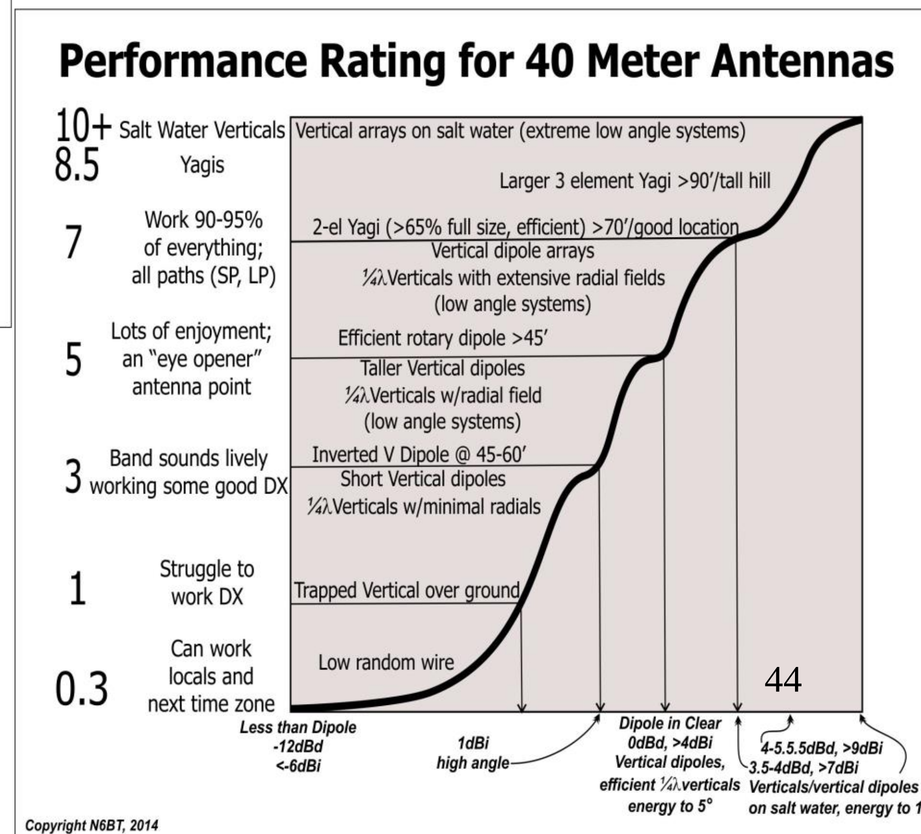
Performance Rating for 40 Meter Antennas
10+
Salt Water Verticals
8.5
Yagis
7
Work 90-95% of everything; all paths (SP, LP)
5
Lots of enjoyment; an "eye opener" antenna point
3
Band sounds lively working some good DX
1
Struggle to work DX
0.3
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<-6dBi
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 <u>efficient</u>.

Before I forget –

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

# Example path

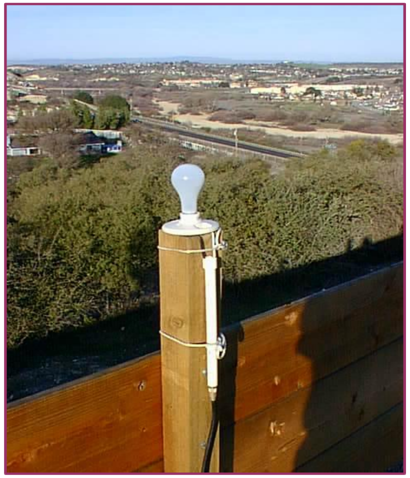
Let's assign that it takes 20dB of path energy to communicate from A to B.


If antenna A has 10dB and antenna B has 10dB, the path is completed.


If antenna A has 8dB and antenna B has 10dB, the path *is not* completed.


If antenna A has 8dB and antenna B has 12dB, the path *is* completed.


**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.

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

We have limited real estate,
__limited horizontal length,
___limited vertical height,
____visual limitations.

# 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

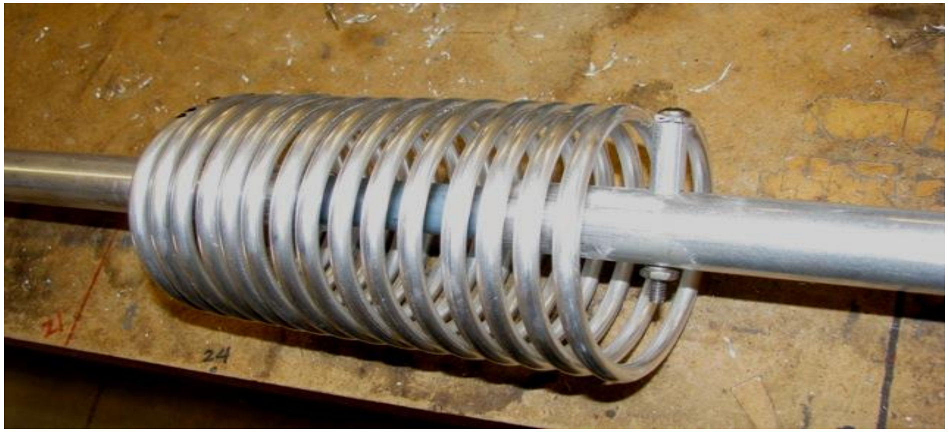
to some degree.

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°.

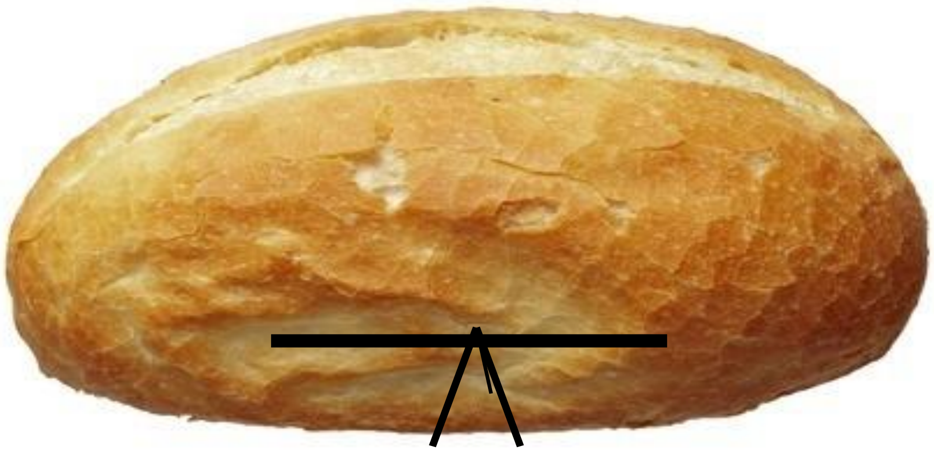
29° on 20 meters is not too bad for all around operating, both domestic and DX.

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.

BTW, an NVIS antenna pattern is easily represented by bakery -->

# A bread roll represents an NVIS pattern



As shown on the "Moderator" slide, this can be accomplished at a height of only 18' on 40 meters, even at a lower height......

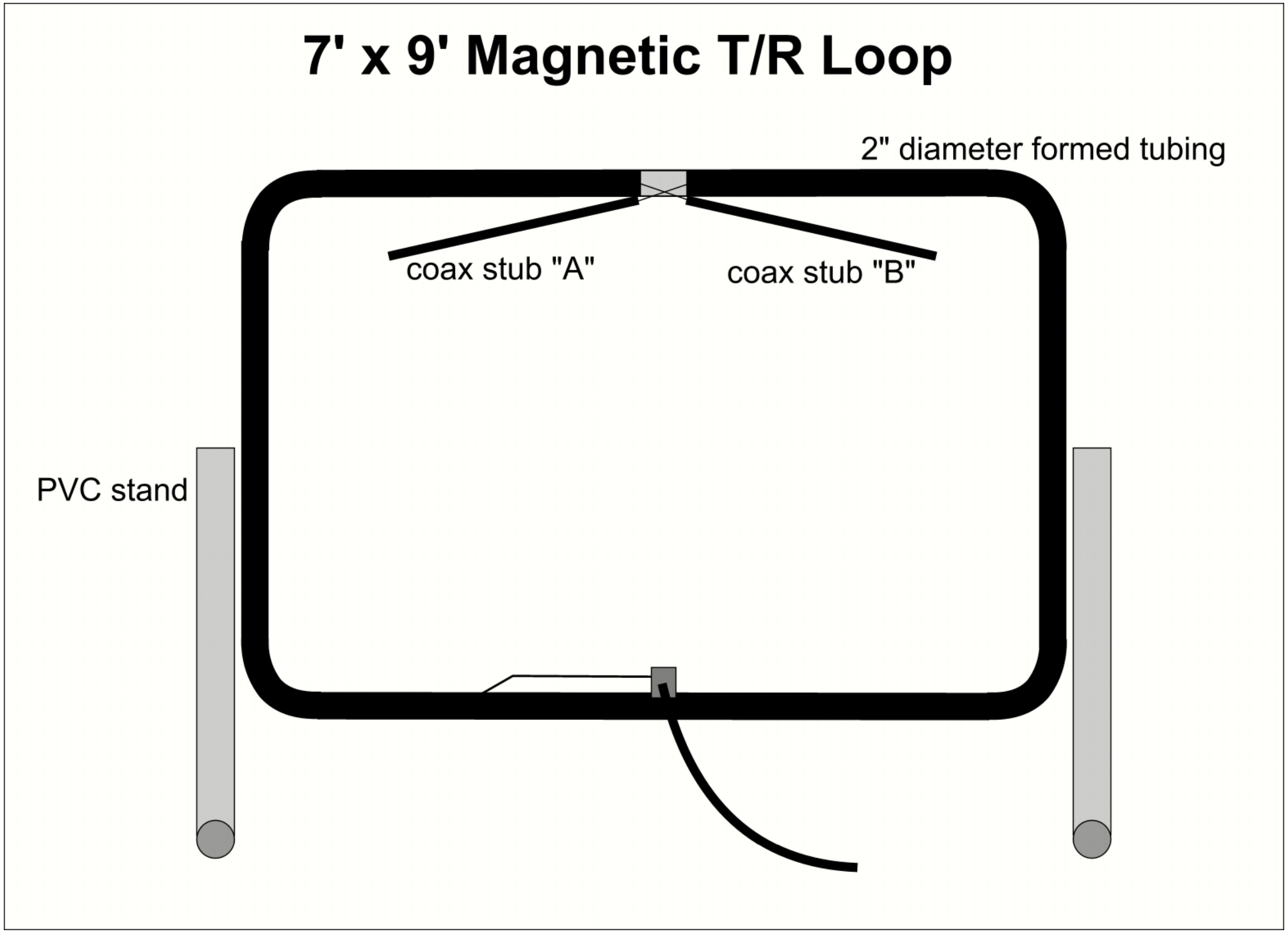
Back to the main concern:
the 20/40 dipole is 35' high.

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.

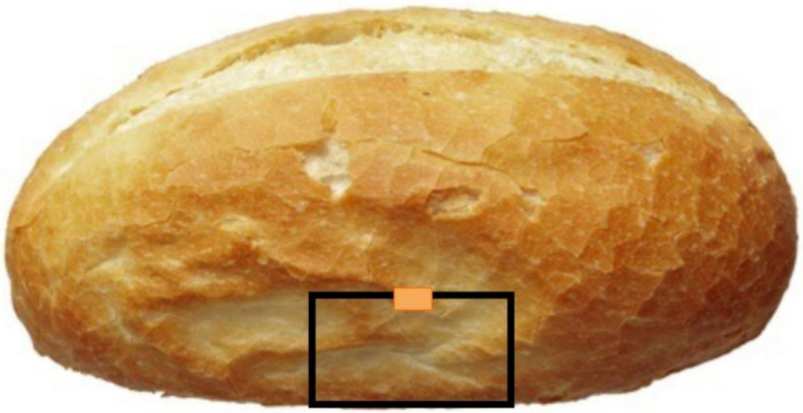
A lower profile antenna for 40 meters, although narrow banded and power-limited (maybe 100 watts or so max) is a well-designed magnetic loop.

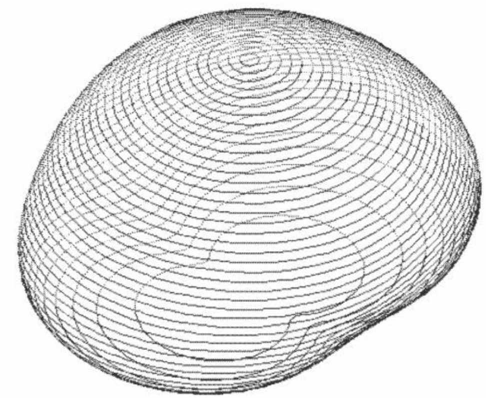




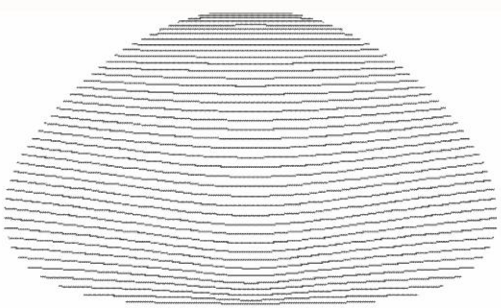

This can rotate in the stand to horizontal when not in use.

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

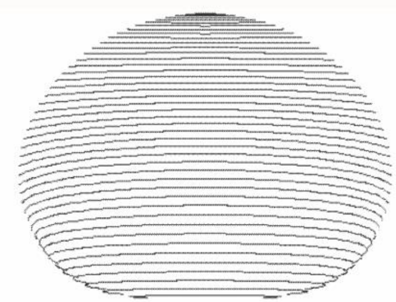




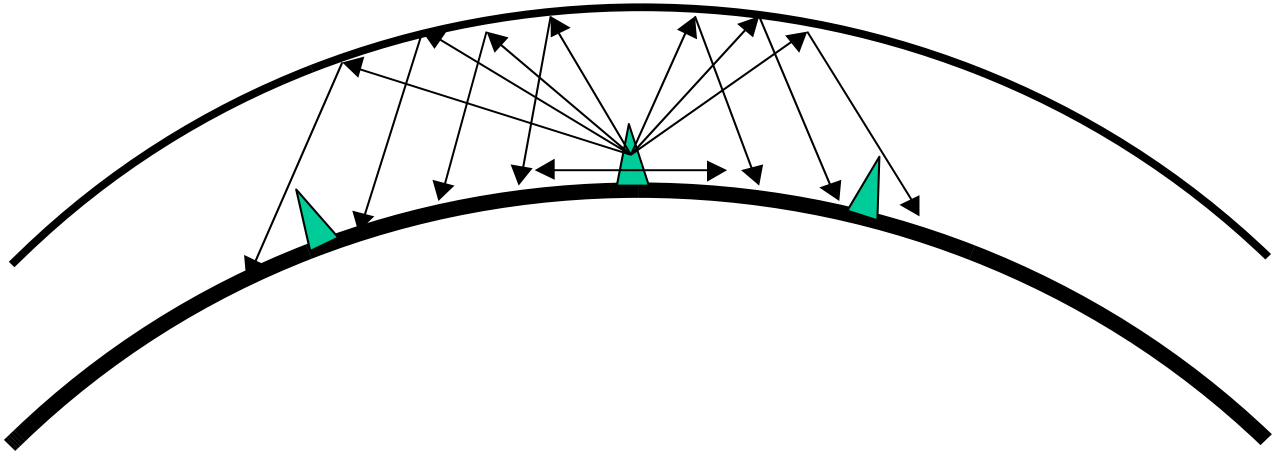
NVIS 3/4 view of pattern



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.

**Wind**

Stranded wire used on baluns, or jumpers on antenna feed points will eventually fracture after moving back and forth countless times in the wind.

# Stainless steel used for a hairpin match on a Yagi. (This was used for only 2 weeks.)

The black discoloring is from heat.
Stainless steel has a lot of loss!

Another example:
a coil made of aluminum wire has a Q of >600.
Making it of stainless steel lowers the Q to <30.

Comments from the tester on the stainless hairpin?
"The antenna was like a piece of wood."

## Wire loops

Horizontally polarized loops share the same take-off angles as other horizontally polarized antennas --> higher is better.

Vertically polarized loops will have a lower take-off angle than horizontally polarized loops at the same height.
This lower angle will be beneficial in your quest for longer range HF communication.

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 ***not*** to run QRP (5 watts).

Quick example -

many years ago, I was on 75 phone listening to a station from Indonesia calling CQ and he was quite strong.

Lots of folks called him, but he came back calling CQ.

This sequence repeated itself several times and finally he said that his line noise was 20 over 9, so unless you thought you were stronger than that in YB, don't bother calling.

As Bruce once said…..

**“Life’s too short for QRP”**

Bruce, N6TU (late ‘70’s)

To clarify my comments about the difficulty making contacts running 5 watts,

I run low power (<100 watts) a lot of the time testing antennas and I also run full power working the low bands 160, 80 and 40;

however,

I have put in my time with QRP in domestic and worldwide DX competitions.

I presently hold two CQWW CW QRP (5 watts) World Records:

80 meters and Top band, 160 meters.

**The keys are an efficient vertical and location** (not from an HOA) →

# CQWW CW QRP 80m High Scores

as of 2019, still #1 (4O4A is new #7)

| Rank | Call | Year | Category | Score | QSOs | Zn | Cty | Operator(s) |
|---|---|---|---|---|---|---|---|---|
| **1** | **6Y8A** | **2002** | **SO QRP 80M** | **207,603** | **1,022** | **23** | **76** | **N6BT** |
| 2 | LY5A | 2005 | SO QRP 80M | 138,575 | 901 | 20 | 95 | LY2ZZ |
| 3 | T43T | 2013 | SO QRP 80M | 121,040 | 758 | 16 | 64 | CO3IT |
| 4 | 5B4AGM | 2000 | SO QRP 80M | 106,596 | 489 | 21 | 73 | |
| 5 | OK2BYW | 2009 | SO QRP 80M | 97,308 | 779 | 18 | 84 | |
| 6 | EU8RZ | 2008 | SO QRP 80M | 79,953 | 801 | 17 | 70 | |
| 7 | SP6GCU | 2004 | SO QRP 80M | 76,608 | 668 | 18 | 78 | |
| 8 | 6Y8A | 2001 | SO QRP 80M | 76,230 | 575 | 14 | 52 | N6BT |
| 9 | UA9CBM | 1994 | SO QRP 80M | 72,051 | 344 | 15 | 58 | |
| 10 | LZ5T | 2005 | SO QRP 80M | 68,464 | 680 | 15 | 73 | LZ3RR |

What was the main difference between 2001 and 2002?
~4dB
2001 used a single vertical and 2002 was a 2el.

# CQWW CW QRP 160m High Scores

as of 2019, still #1 (EU8U is new #5)

| Rank | Call | Year | Category | Score | QSOs | Zn | Cty | Operator(s) |
|---|---|---|---|---|---|---|---|---|
| **1** | **C6ARR** | **2007** | **SO QRP 160M** | **129,480** | **773** | **17** | **66** | **N6BT** |
| 2 | LY5A | 2004 | SO QRP 160M | 37,014 | 570 | 10 | 52 | LY2PAJ |
| 3 | E76C | 2008 | SO QRP 160M | 36,000 | 489 | 14 | 58 | |
| 4 | 6Y0A | 2003 | SO QRP 160M | 35,952 | 448 | 13 | 29 | K2KW |
| 5 | ES1CW | 1996 | SO QRP 160M | 28,670 | 435 | 10 | 51 | |
| 6 | 6Y0A | 2002 | SO QRP 160M | 27,824 | 454 | 11 | 26 | W7CB |
| 7 | UC2WAF | 1992 | SO QRP 160M | 27,280 | 369 | 10 | 52 | |
| 8 | GM4AFF | 2015 | SO QRP 160M | 27,279 | 394 | 11 | 52 | |
| 9 | GW8GT | 2008 | SO QRP 160M | 26,520 | 421 | 10 | 50 | GW3YDX |
| 10 | G4EDG | 2006 | SO QRP 160M | 24,004 | 290 | 9 | 59 | |

Single vertical, but from
a different location in 2007




C6ARR location in 2007
Bahamas (elevated) vs Jamaica (on the beach)


25 12:40AM


22 9:18AM

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

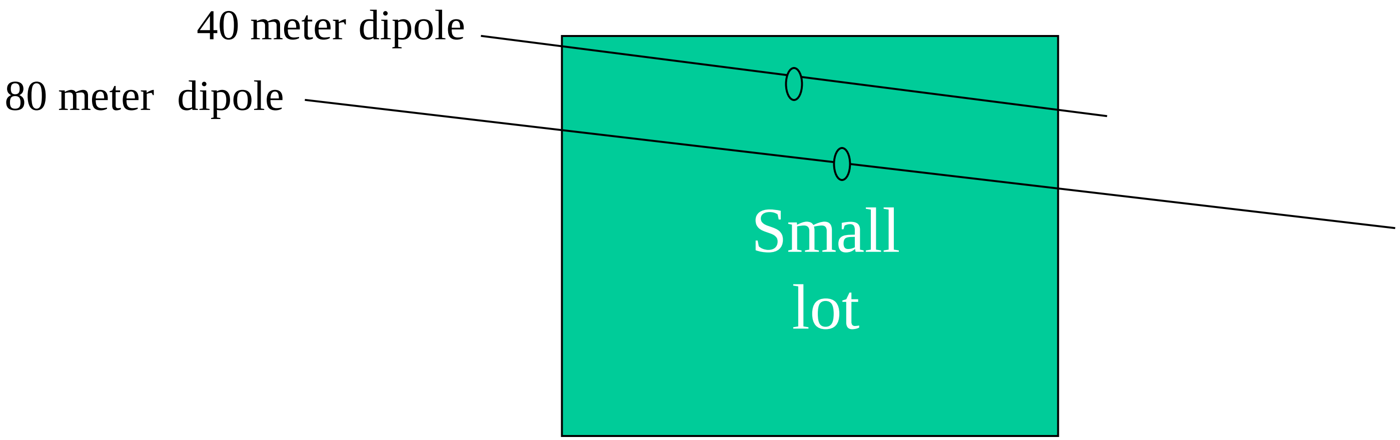
so that it wasn't visible as he walked down the street.

The concrete blocks sit in welded aluminum trays.

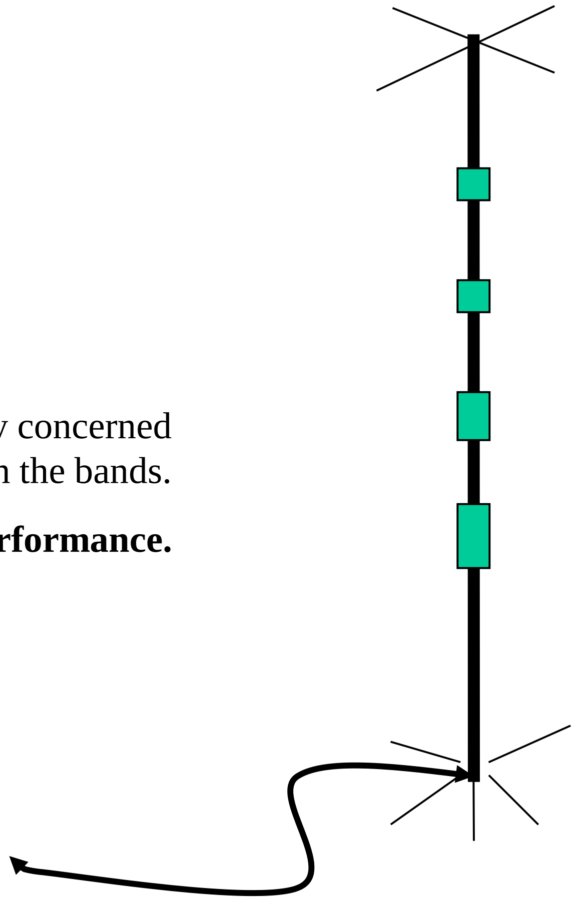
The tips were adjusted, along with a little on trap spacing until it had a reasonable match. He runs an ICOM transceiver and KW solid state amplifier (40-10). Optional listening on 40 is a small loop, about 5' in diameter.

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.**

“Expectations” for me requires
on the air performance utilizing long term, real-time, empirical information, such as Team Vertical, comparative studies and pattern measurement utilizing drones.

2010 - was challenged by Team co-founder Kenny, K2KW to figure out how to fit all of our antennas on the smaller beach front at a new QTH on the island of Eleuthera, Bahamas. Taking many months, the result is this design, which became the “Bravo” series. Walt and I were a bit aggressive in the surf with the pair of 15's.


Walt, N6XG and N6BT - the Atlantic Ocean got us

# More Bahamas Development

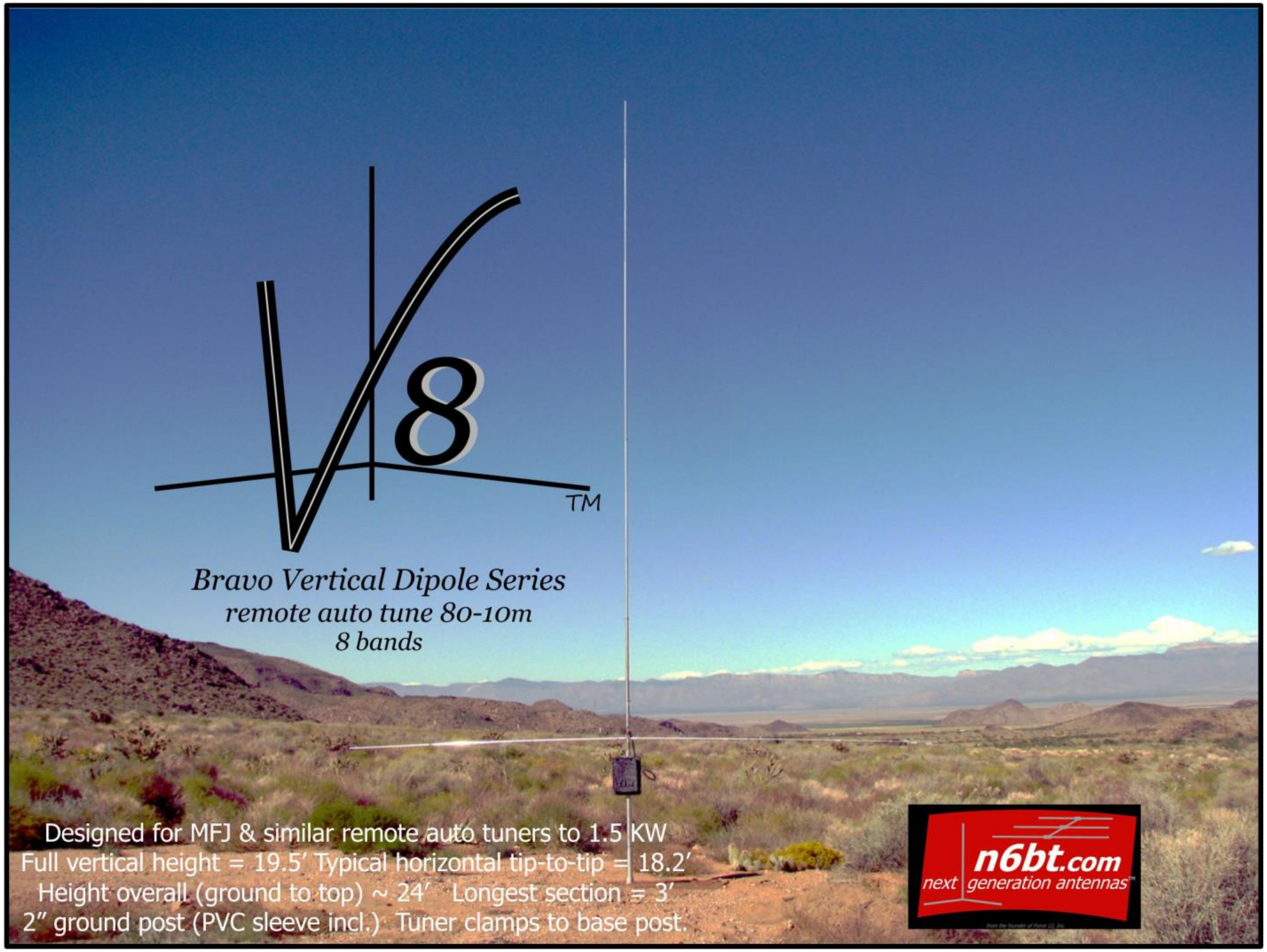
## Foreground, 2el Bravo 5K's on 15, 2el Bravo 40, 2el Bravo 20 and single off-set T-bar 40


Thanks to Fred, KE7X for the photos

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.

This design was made into the **V-8** for use with a remote tuner to cover 80-10.
Reviewed in <u>QST</u> January 2020



## Summary of vertical antenna “discoveries” and developments since 1992:

## 8 Generations of Vertical Development

1992 1 - linear loaded verticals, mainly for 80 and 160

1996 2 - ZR, Z-axis Radiator (full length, not loaded)

2001 3 - Sigma, looks like a big letter "I" (full size and loaded)

2003 4 - SVDA 2el Switchable Vertical Dipole Array (full size)

2010 5 - Bravo (redesigned Sigma, no top T-bar, feed at bottom)

2014 6 - Evolution Vertical (no horizontal components, 2el rotatable)

2017-18 7 - Gen 7 Balanced current, physically asymmetric vertical dipole

2018-20 8 - VOR Vertical Open Ring, single and multi-band, 2el rotatable

1991-2008 is Force 12, Inc. 2010-present is Next Generation Antennas



>140 production antennas and >26,000 HF antennas shipped


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

(continued)

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?

An initial assessment to make might be to:

__think about the possibilities of your property and also,

___to recognize your limitations.

# 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**
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is authorized without written statement
by T.H.Schiller N6BT
* Patent Pending


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**

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20-17-15 mtr

relay switched

Full size for 15 mtrs;

loaded for 17 and 20 mtrs

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next generation antennas™

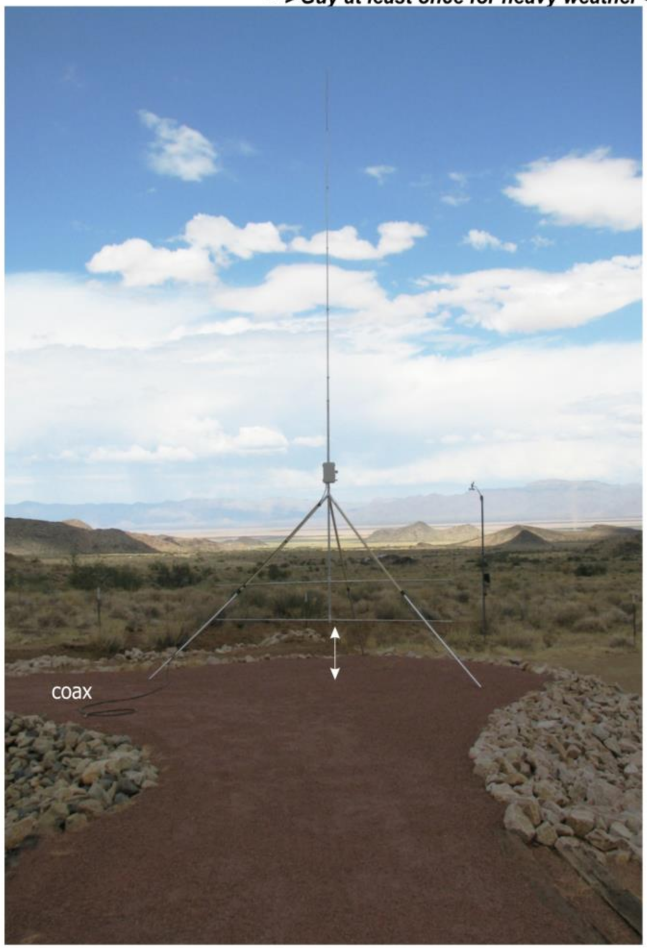
# Gen7-40

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**

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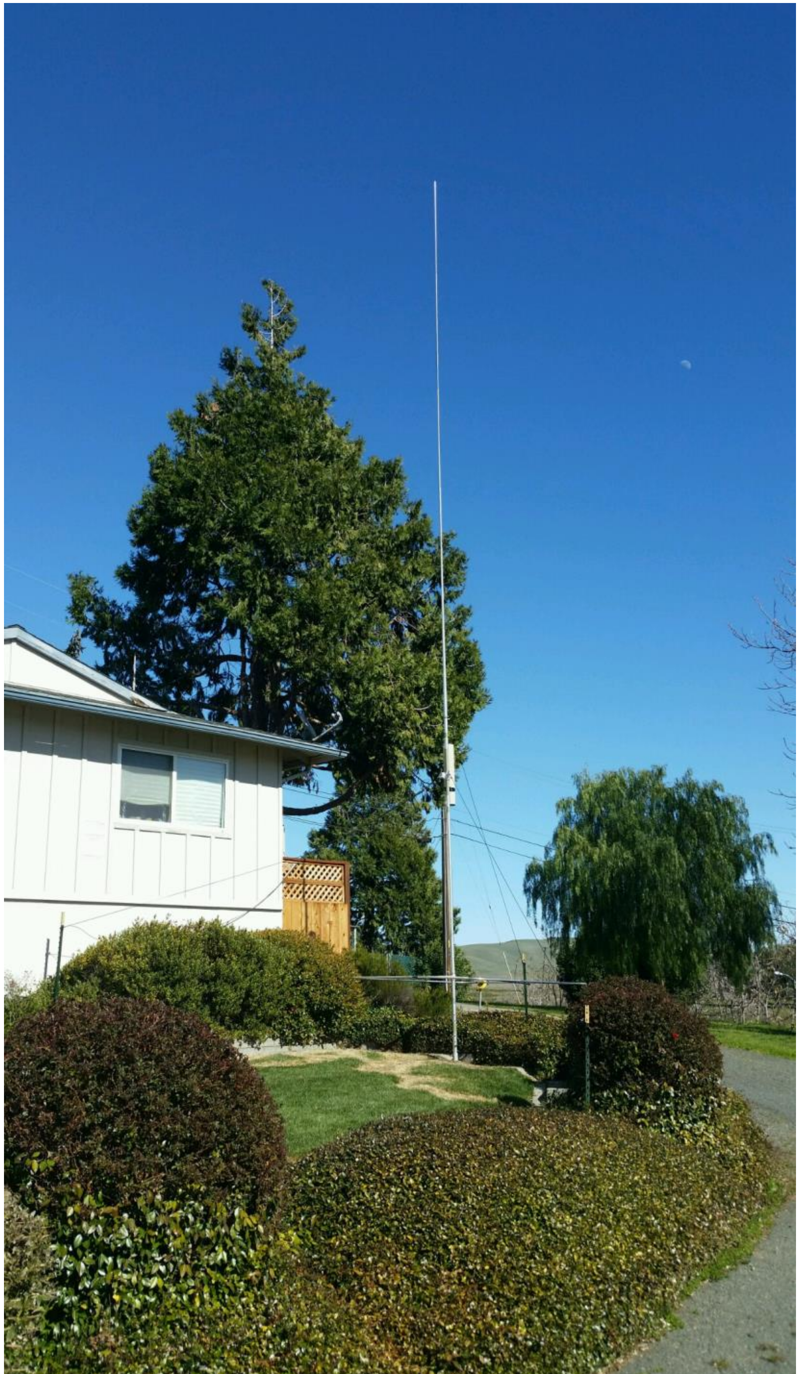
This is actually a full size 20, loaded for 40, so it can also be a 2-band antenna.

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



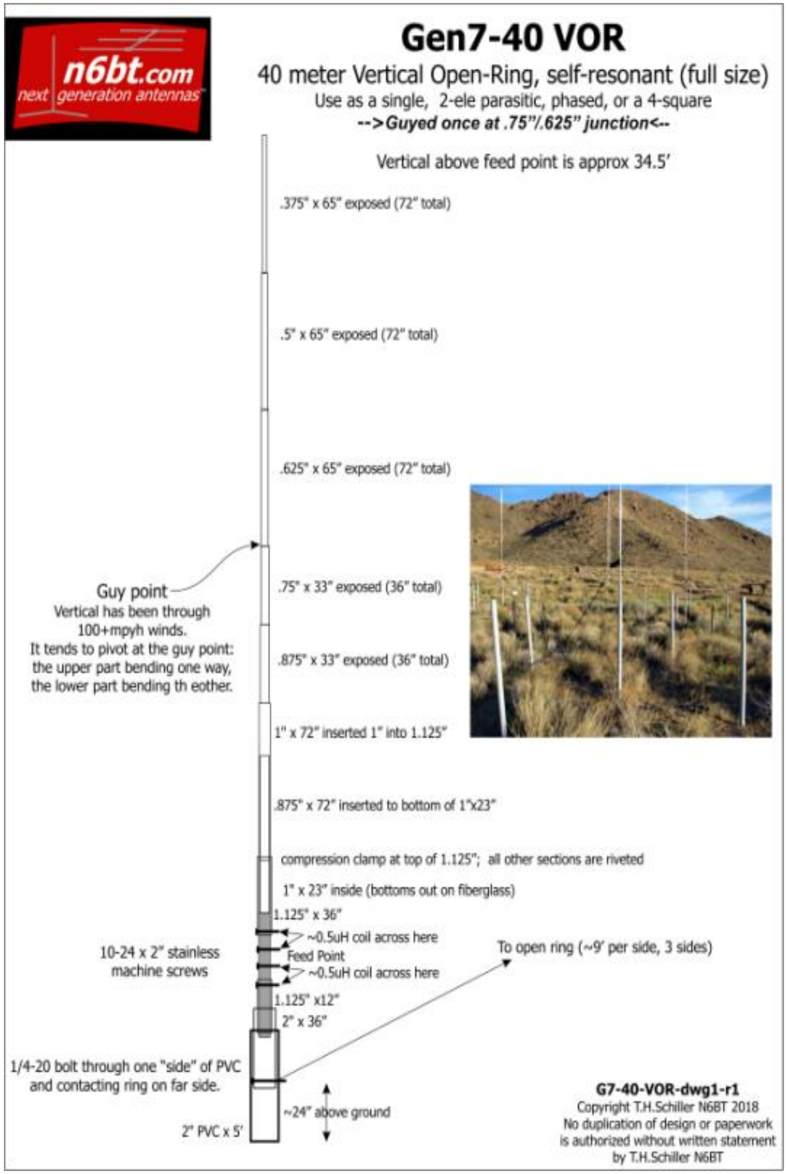
# 80/40

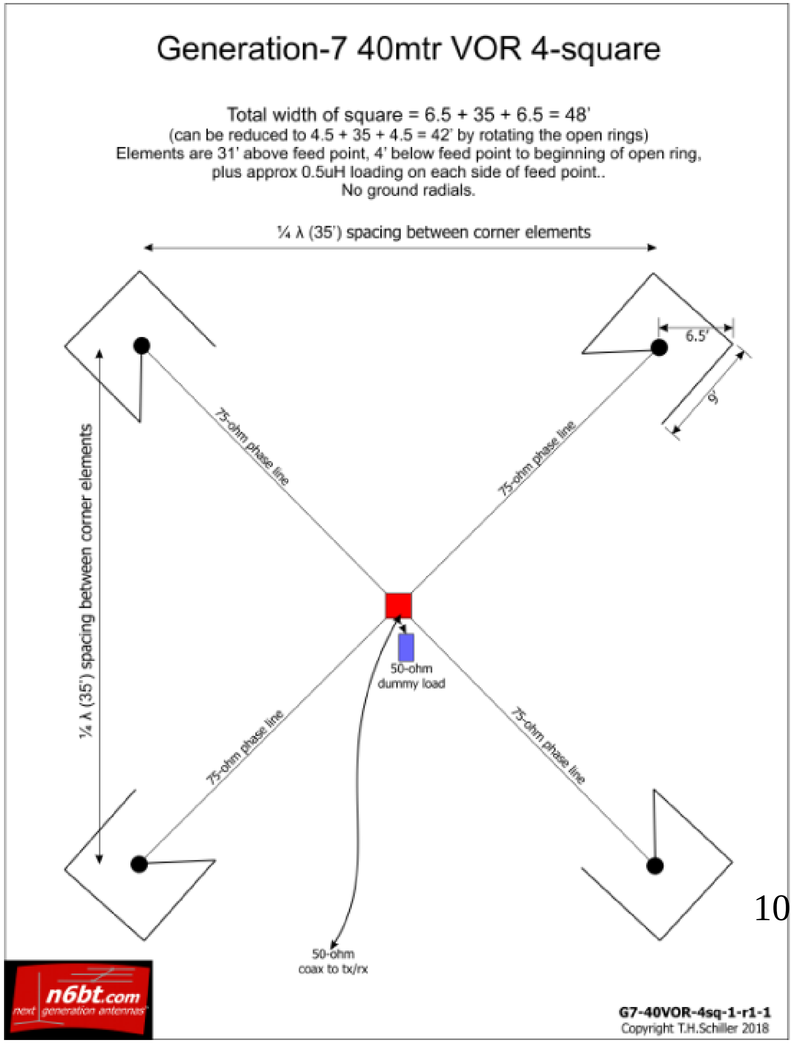
A full size vertical for 40 with an full size 40 mtr open ring, making a full length vertical dipole on 40.

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.

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



# 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

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

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.

## 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;

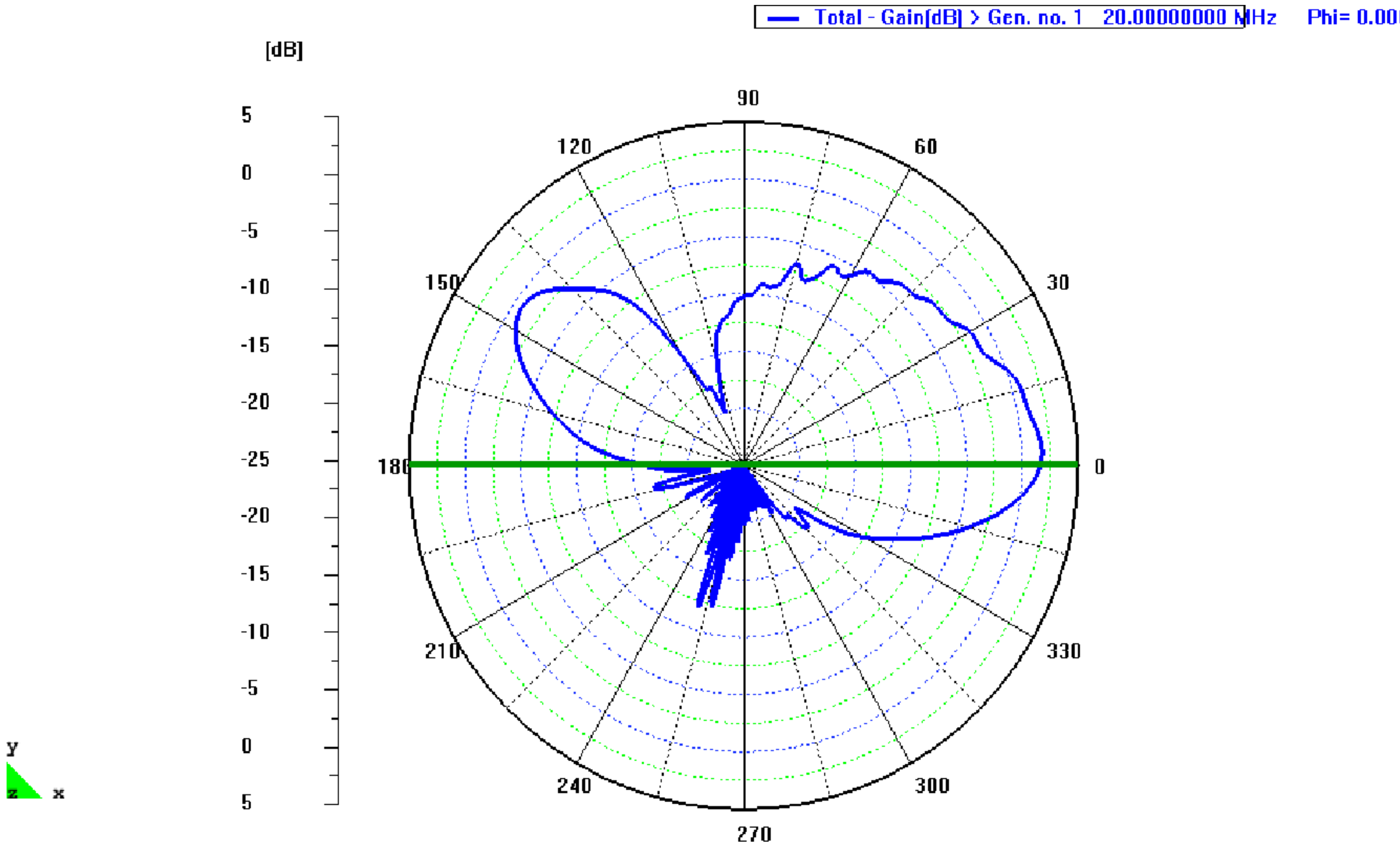
18. VOR is as effective as (2) full length Gull-Wing radials (modeled within 0.1dB) and takes up less space.

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

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

Just how efficient is a trapped dipole?

# 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.



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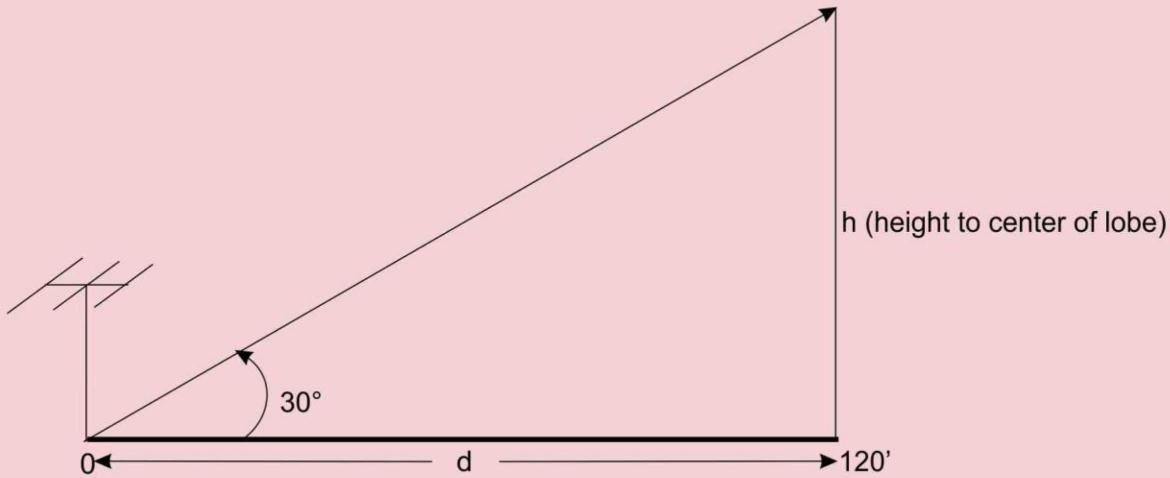
How high do we need to fly the drone to measure at the main lobe of our antenna under test? The test antenna is on 20 meters at a height of 35’, which is 0.5 wavelengths (0.5λ); therefore, the antenna should have a single lobe centered at 30°.




_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**.



20-mtr-dipole-test-step-1a-pic-r1

# 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.

____Passes ranged from 2.39dB to 2.54dB increase, averaging 2.47dBtd (2.47dB to the trapped driver)

_____Compared to the full size dipole, the tribander has -0.79 (trapped driver)

+ 2.47 (gain from 2 elements)

Actual gain to a full size dipole = 1.68 dBd, call it 1.7dBd

**lote:** what makes this antenna "feel" like it has more gain is that it has pattern (i.e. F/B); owever, having 1.7-2dB over a dipole is still a noticeable improvement.



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20-mtr-tribander-test-step2-pic-r2

# 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 1.7dBd gain, the 0.42dB from the director is ~25% of the overall gain, which is a higher incremental improvement than is typically found in full size element Yagis.



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20-mtr-tribander-test-step3-pic-r3

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.

Back to…

what can you make that will work well?

# A new look at verticals

## Measuring take-off angles over flat ground, sloping ground and salt water using drones.

Tom Schiller, N6BT

"Everything Works" is the title of a July, 2000 QST article where I described operating the A.R.R.L. International DX Contest using a light bulb for an antenna, working 28 countries and all continents. The basic concept of the article is that our enjoyment of radio is directly related in large part to our antenna. There is also a story in Array of Light where I recount the moment on Saipan back in the early 1980's while operating a contest with Gary Caldwell, VA7RR, when we were using a trio of TCI-611 curtain antennas owned by Far East Broadcasting Company. Those antennas re-calibrated my mind. Many years later, I founded my first antenna company, Force 12, Inc. In 17 years, we shipped over 24,000 antennas and developed new designs such as the massive C-49XR trap-less tri-bander, but it wasn't until using verticals on the beach with Team Vertical that I discovered an antenna that equaled the Saipan experience, the Team Vertical 2x2 "flame-thrower."

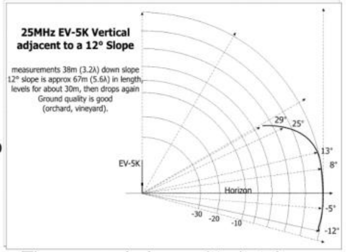
Team Vertical was begun in 1997 and has not only been a contest-oriented group of crack operators, it is also a test facility, using over 300 vertical antennas of varying designs in worldwide competitions. The Team operated out of Jamaica for many years and as the sunspots were going down, co-founder Kenny Silverman, K2KW suggested we move farther east to the island of Eleuthera in the Bahamas. The success of Team Vertical, a 160-meter QRP record and one QSO in 2007, plus several long-term observations have pushed me to research why some verticals work better than others.

The major episodes motivating me over the past 4 years to discover what can make vertical antennas perform well (much better than history would say) are:

1) the success of "Oh, Just Some Verticals on the Beach", as Dean Straw, N6BV entitled his first presentation on Team Vertical;
2) my 2007 CQWW CW 160 meter QRP World Record from Eleuthera, Bahamas (C6ARR) and the QSO during the contest with VK6HD;
3) A.R.R.L. Field Day with the Paso Robles Amateur Radio Club for several years where we alternated between Yagis and verticals;
4) the 2014 CQWW CW where I used a 2-ele vertical beam adjacent to a big slope; and,
5) initial test results of take-off angles for vertical antennas.

Why are take-off angles important? Those who operate HF and especially those who chase DX know that their signals get to distant "point B" using multi-hop propagation, as compared to line-of-site paths for VHF/UHF. An (HF) antenna over ground (not in free space) will launch its energy at some angle to the earth. Presuming the ionosphere is favorable, the signal will then be refracted by the ionosphere at some point and head back to earth, where it will again be launched upwards. The distance between these earth launch points is determined by the take-off angle. As one would expect, the shallower/lower the take-off (launch) angle, the farther the signal travels before returning to earth. Arriving at point B with fewer hops is desirable, because each hop reduces the signal strength by 6-10dB and 6-10dB is a ton. If the signal can arrive in two (2) hops less, that is 12-20dB, which is unattainable to achieve by making the antenna larger. In fact, it is an order of magnitude to increase an antenna system by 6-10dB; therefore, when the take-off angle can be lowered by design and/or location, it is highly beneficial for long-range propagation.

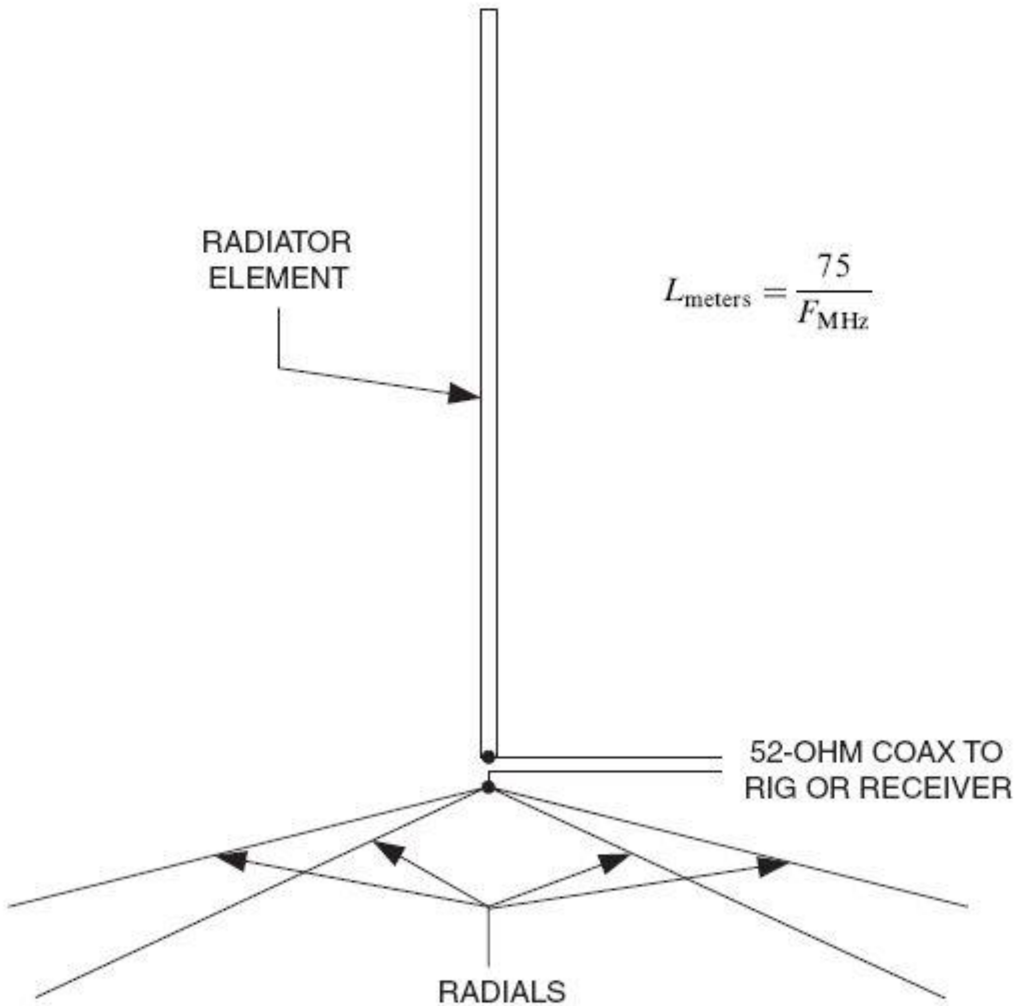
To cut to the chase, the answers are: the actual take-off angles of vertical antennas are much lower than the typical computer model predicts; and, a vertical antenna adjacent to sloping ground has energy that follows down the slope. Yes, that is not a typo – a vertical antenna located adjacent to sloping ground will have energy at the horizon and below the horizon. The plot of a vertical adjacent to a 12° slope:



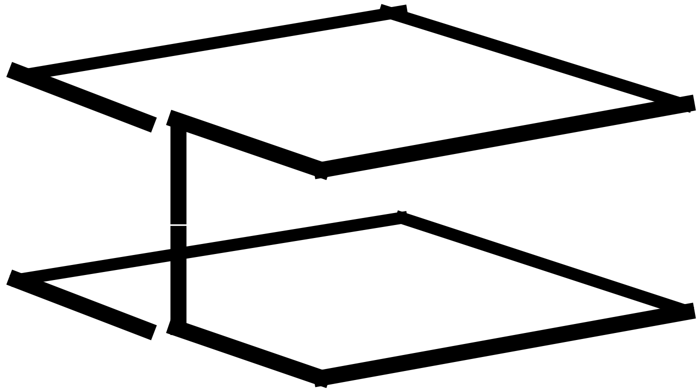

The energy being emitted at the very low angles accounts for the excellent on-air performance. Energy below the horizon might be useful for something!

My 160 vertical in Eleuthera was, for the first time, not on the beach, but elevated 45' above the ocean and adjacent to a steep slope. The combination of energy down to the horizon coupled with salt water for hundreds of miles enabled my 5 watts to

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.

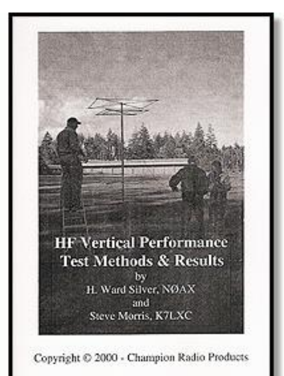
___No loading coils, no traps
_____High efficiency
_______Hairpin match and fed with a 1:1 balun at about a 45º angle to the vertical.

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



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.

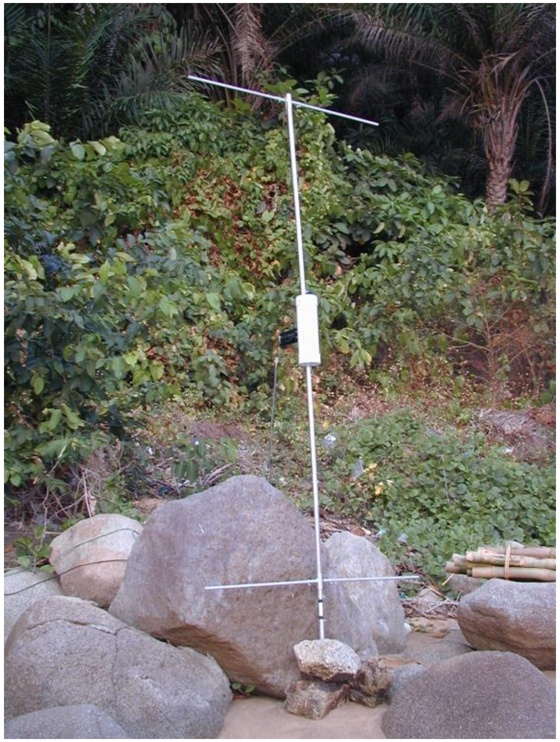
*Note: the reflector also has a hairpin match across the feed point. This is used to tune it to the right frequency using a balun. After the balun is removed, the hairpin remains across the parasitic element feed.*

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.*

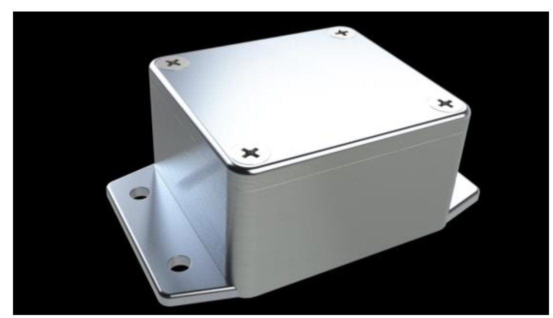




In 2' sections, it is excellent for portable.

# 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?

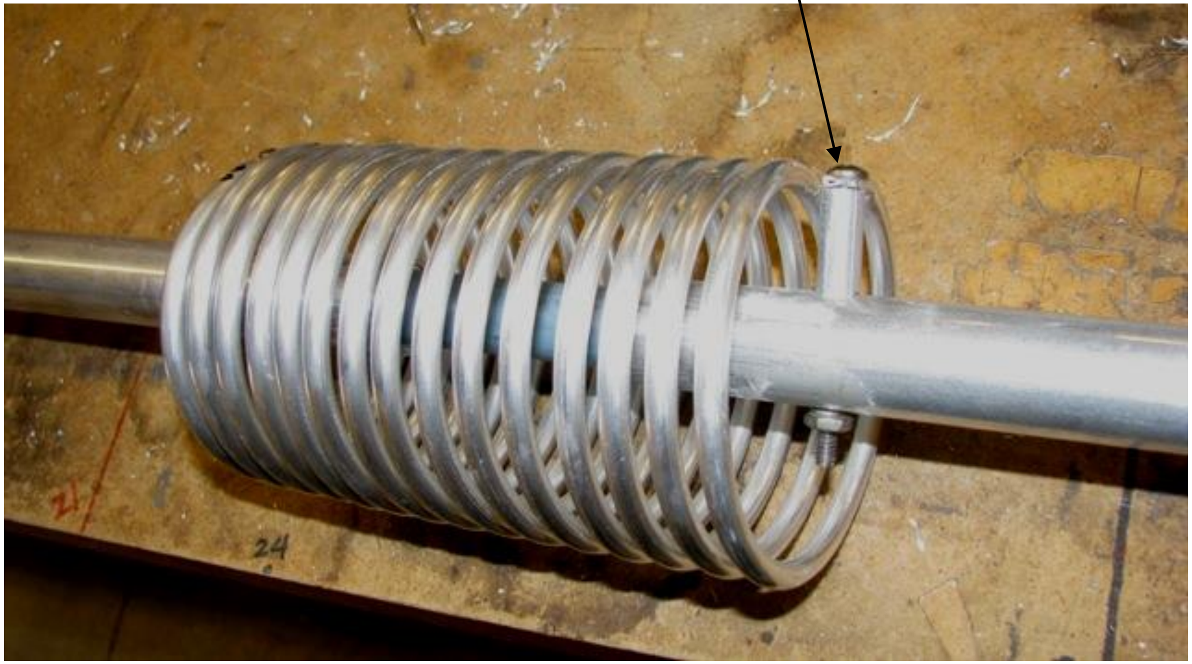
Black might contain graphite = conductor (albeit poor)

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 is:

highest current, lowest voltage,

lowest inductance for resonance.

Moving coils farther away from the center/feed point:

current decreases, voltage increases,

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?

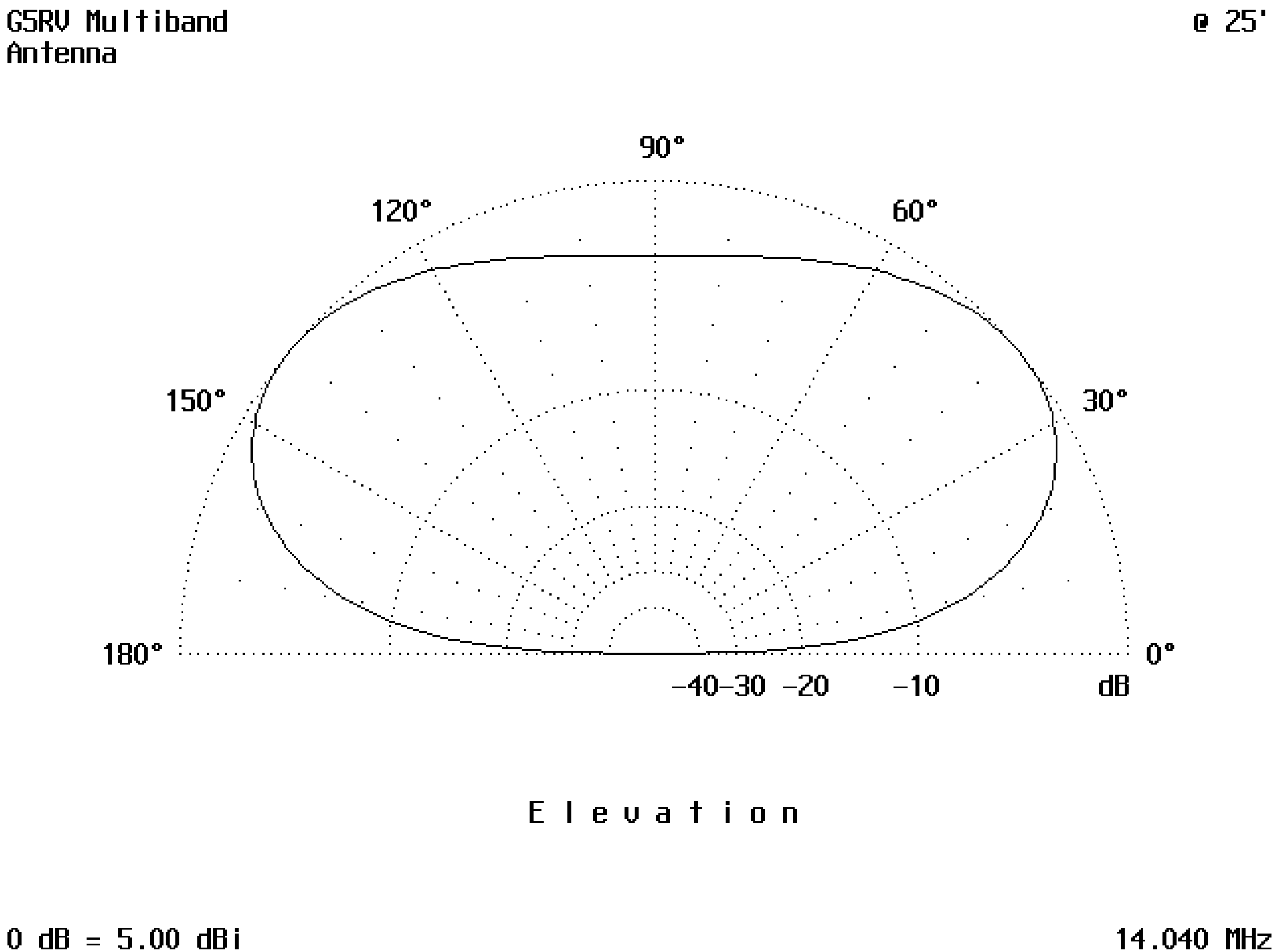
__Getting on the air with “something” implies that the pattern is most likely not much of a concern.

__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!

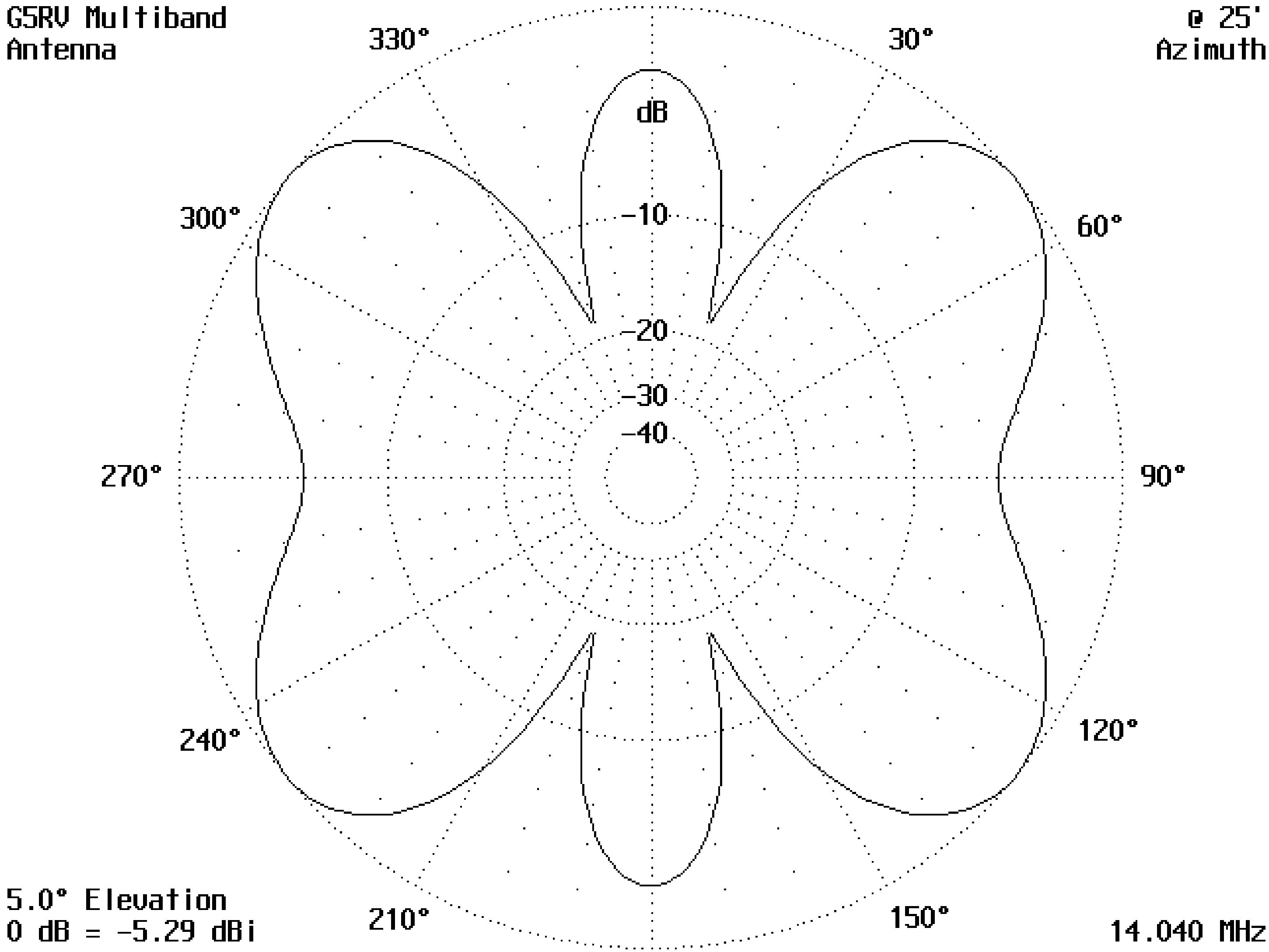
Quick look at the popular a G5RV at
a typical smaller installation height of 25'.






# Take-off angle looks reasonable on 20 meters…

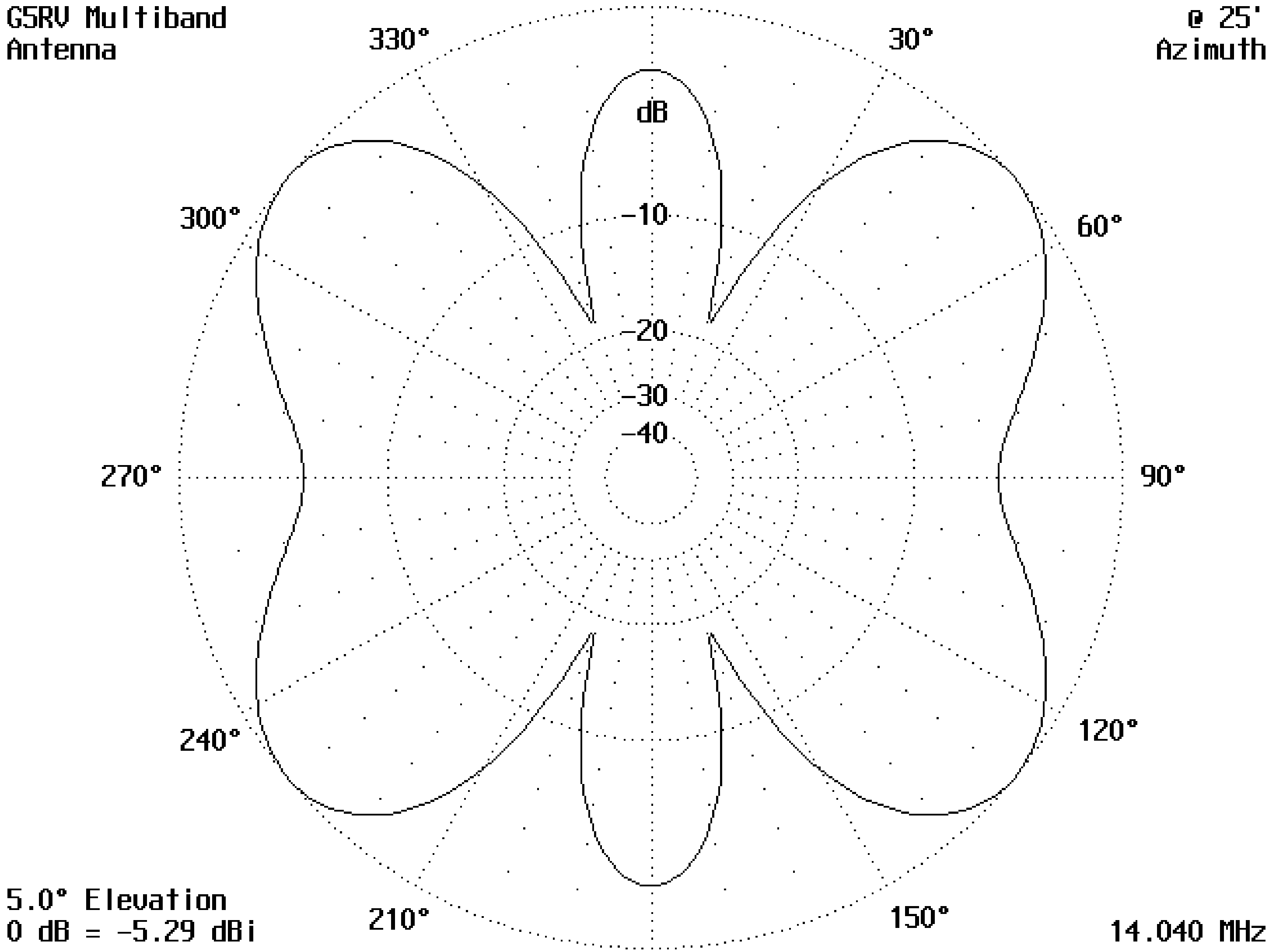
(looking end-on to the antenna, broadside view)






# …until we look at the directivity.

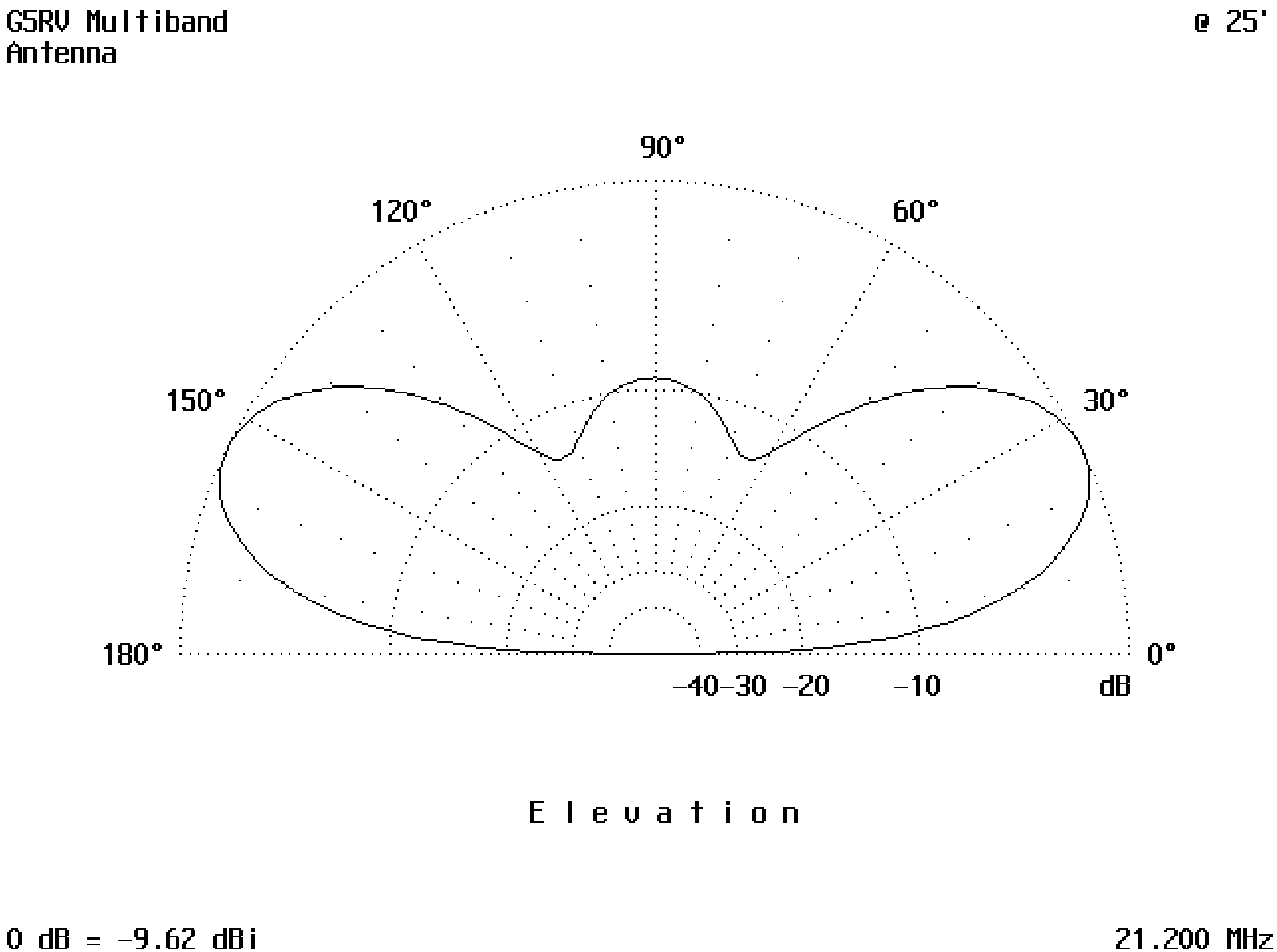
(looking down on the antenna, azimuth view)





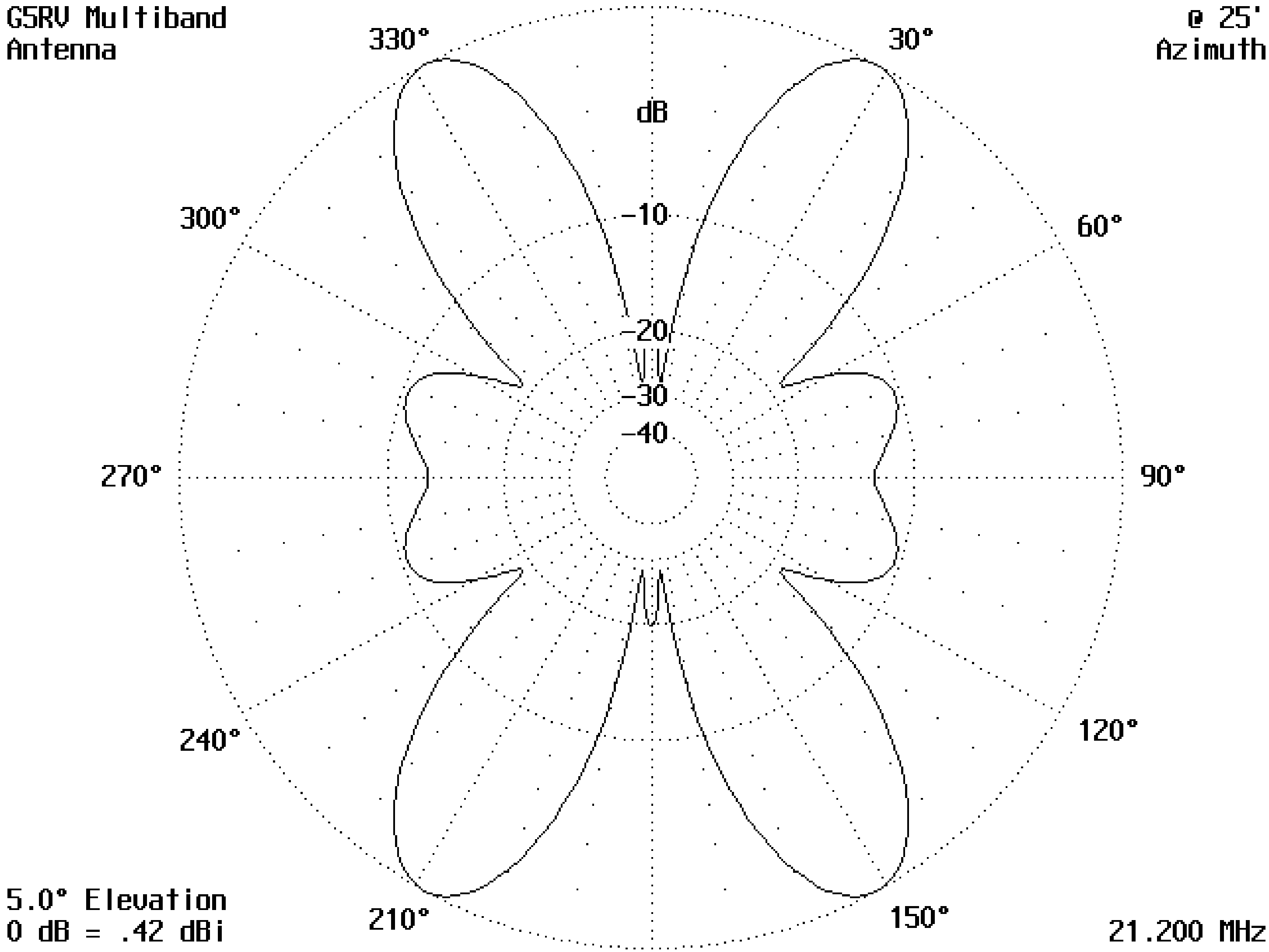

Makes on-air performance assessment difficult at best.

How about on 15 meters?





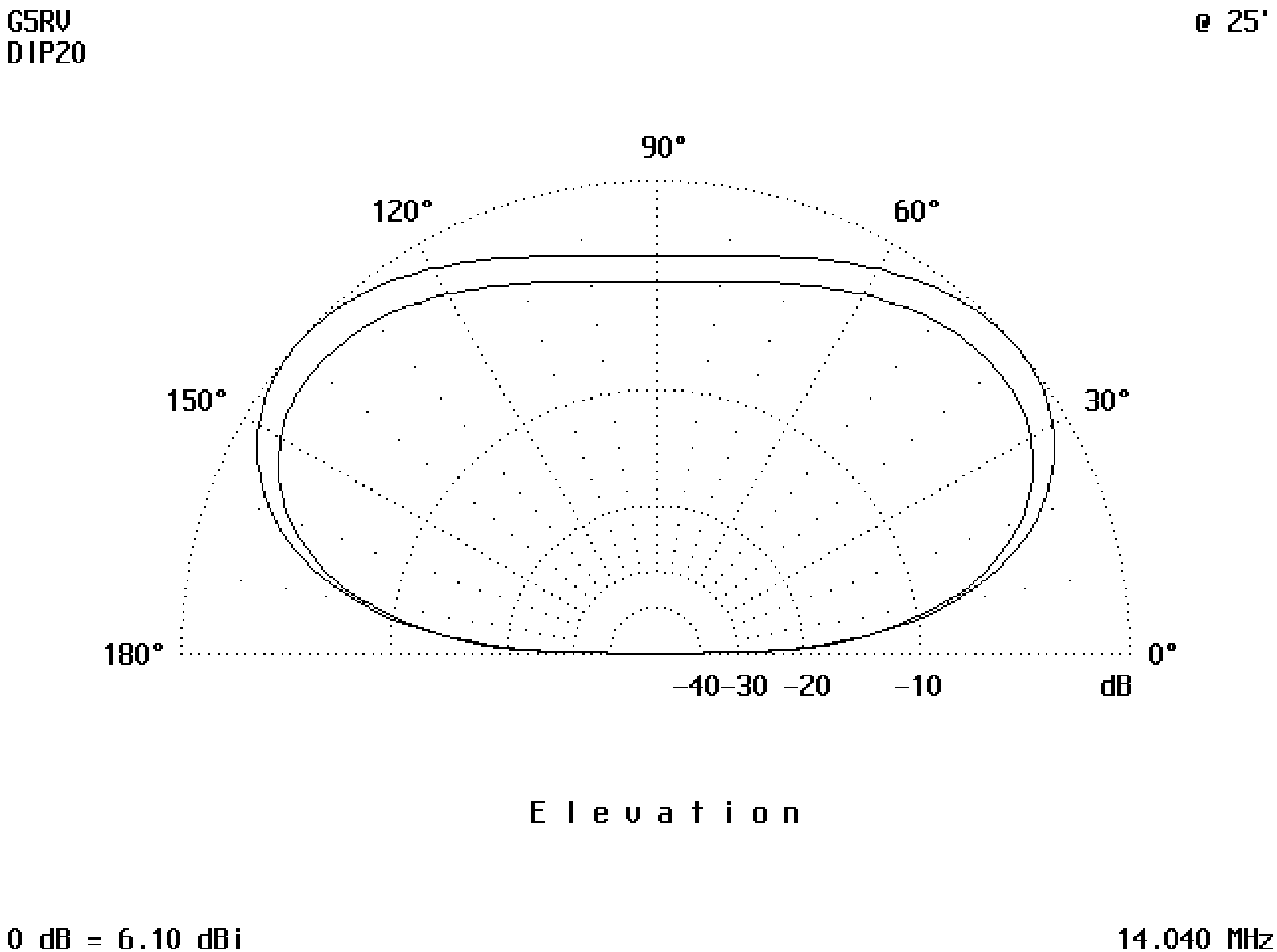

Take-off angle looks fine...





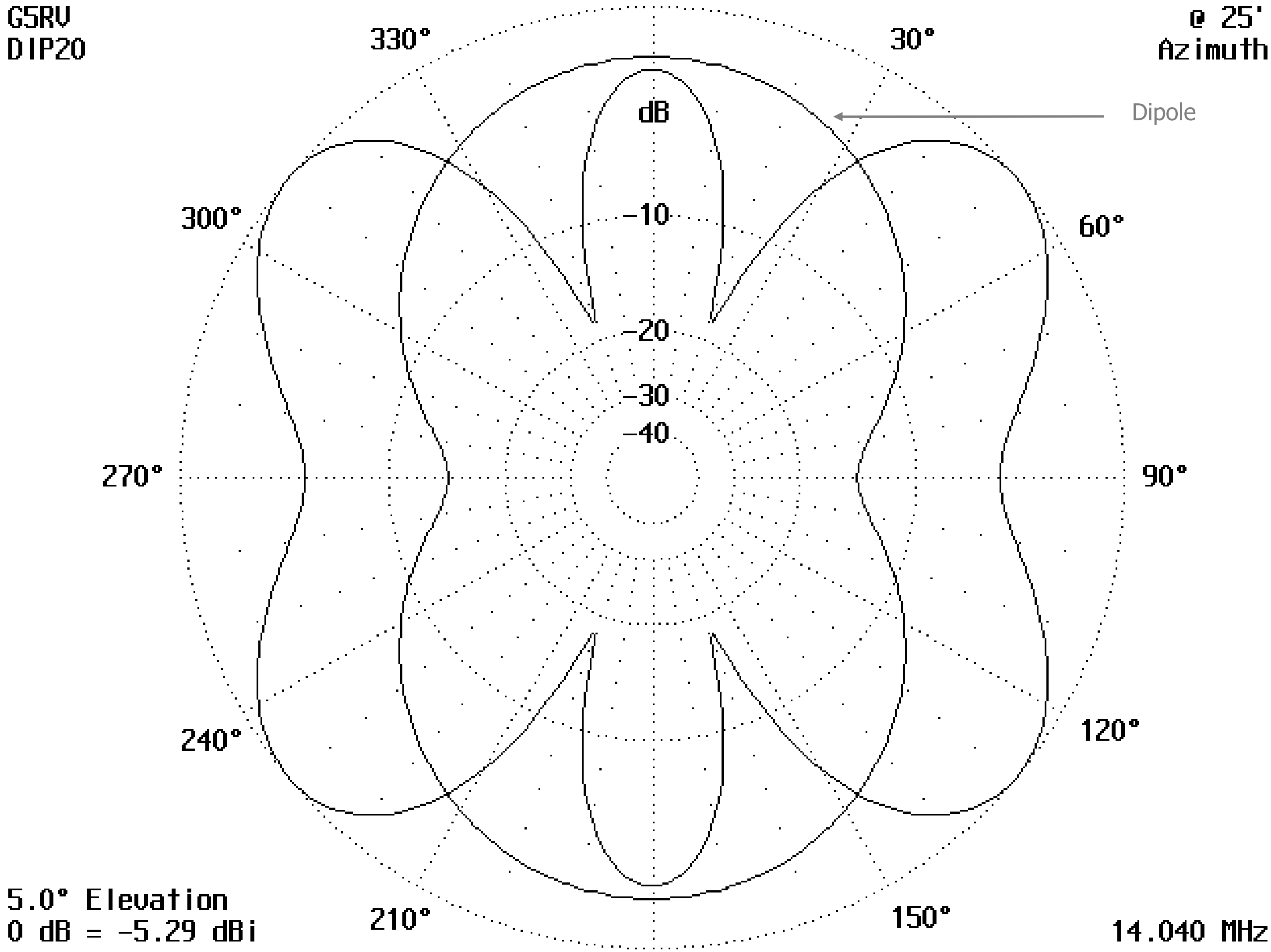

…but the directivity is probably not what you would want.

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.

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.

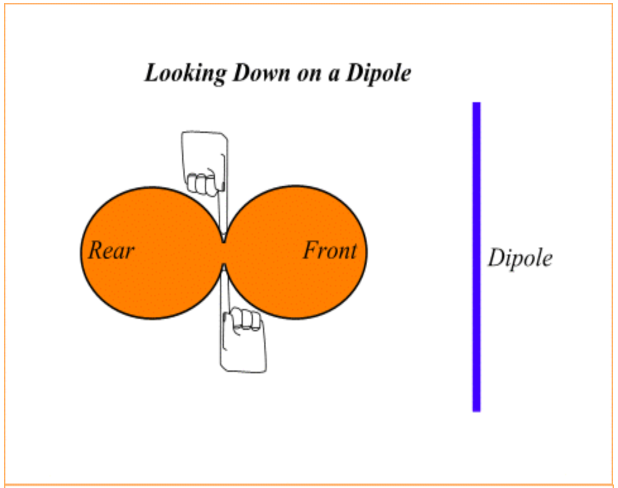
We are not creating energy, only pushing it in a particular direction at the expense of other directions.

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.

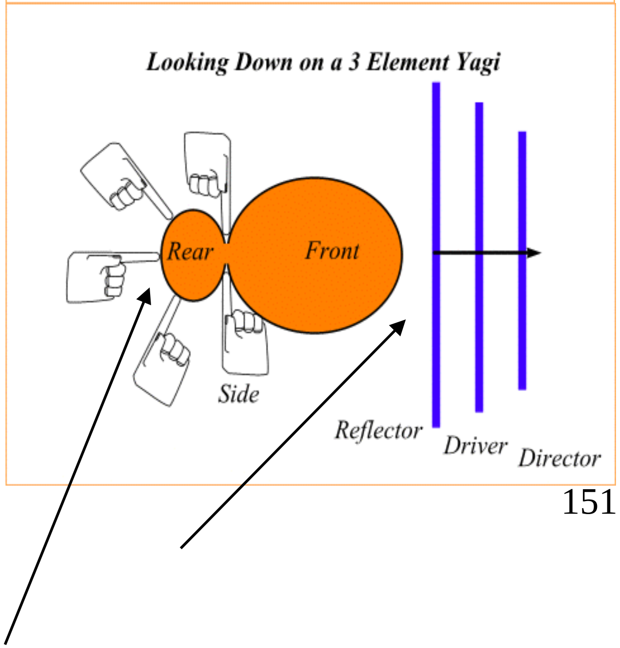
Original dipole.



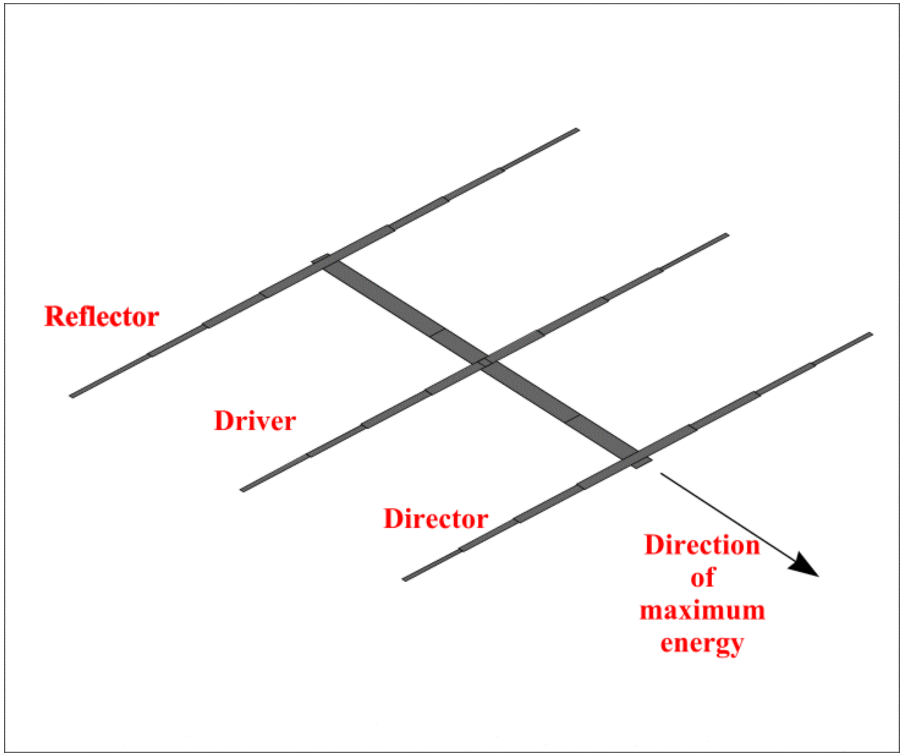

3-element Yagi

It will have gain over a dipole, or dBd

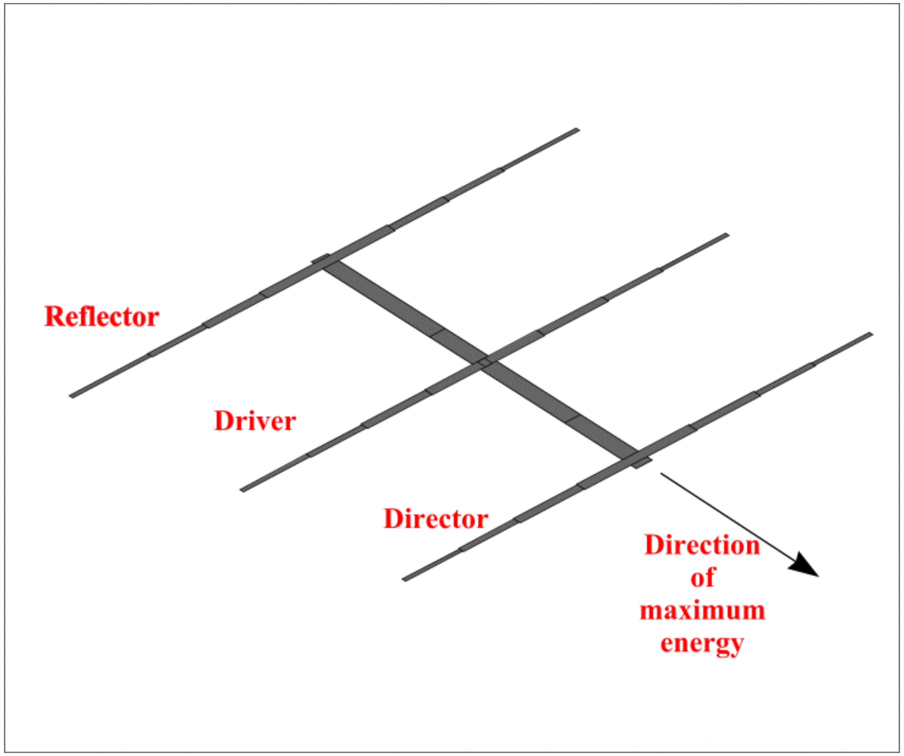
(the trailing “d” means dipole).



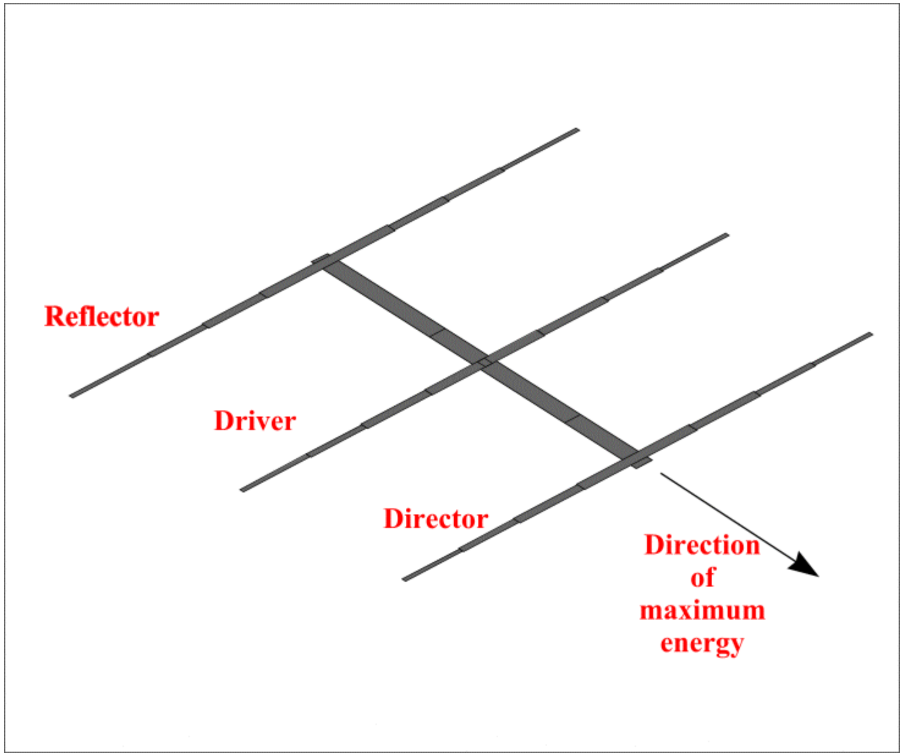
# Typical 3 element Yagi



Purpose of the driver is --
to excite the array



Purpose of the reflector/director is --
to redistribute the energy



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

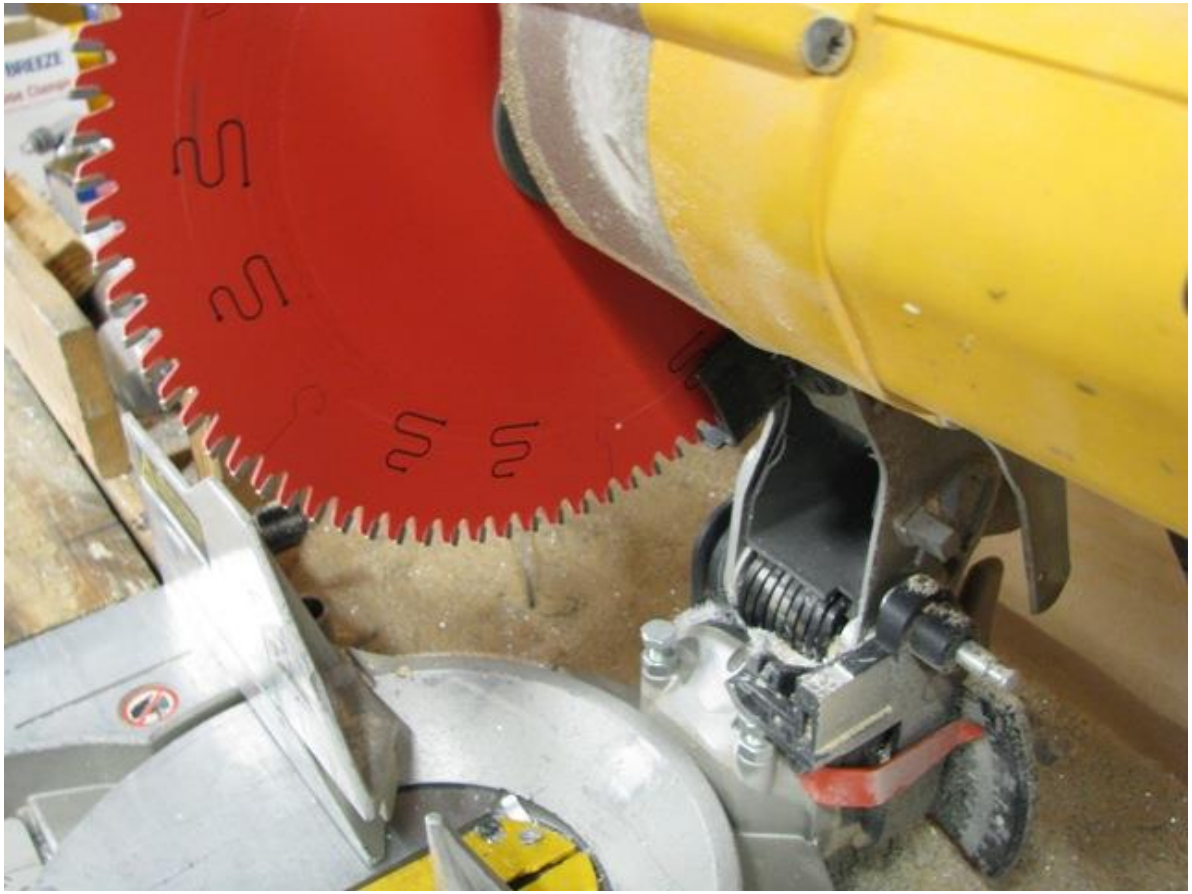
A. The equivalent of the mounting plate as the first section of each half-length

B. The actual taper schedule on each element.

Working with tubing.

How do we cut it?

I use a 10" miter saw



At my original antenna company, Force 12, Inc., we used a 14" with a 100 tooth blade = tons of power.

with an 84-tooth blade for non-ferrous material.

"Regular" blade - for wood.

Blade for non-ferrous material (aluminum).



Note the correct direction of the teeth on the red blade.

# A non-ferrous blade that has been sharpened many times.

# Never cut a “double tube”.

When the blade reaches the inside tube, the teeth will dig into it and try to spin it inside the outer tube.

The result will be a big “BANG” with pieces flying.

The blade is turning 5,000 rpm.



With a 10” diameter blade, the teeth are traveling 157,000 inches per minute, which is 13,083 feet/minute, or 2.48 miles per minute, equaling 148.7mph.

There is a LOT OF KINETIC ENERGY in the blade.

Always keep the blade through the cut until the saw's brake stops the blade.

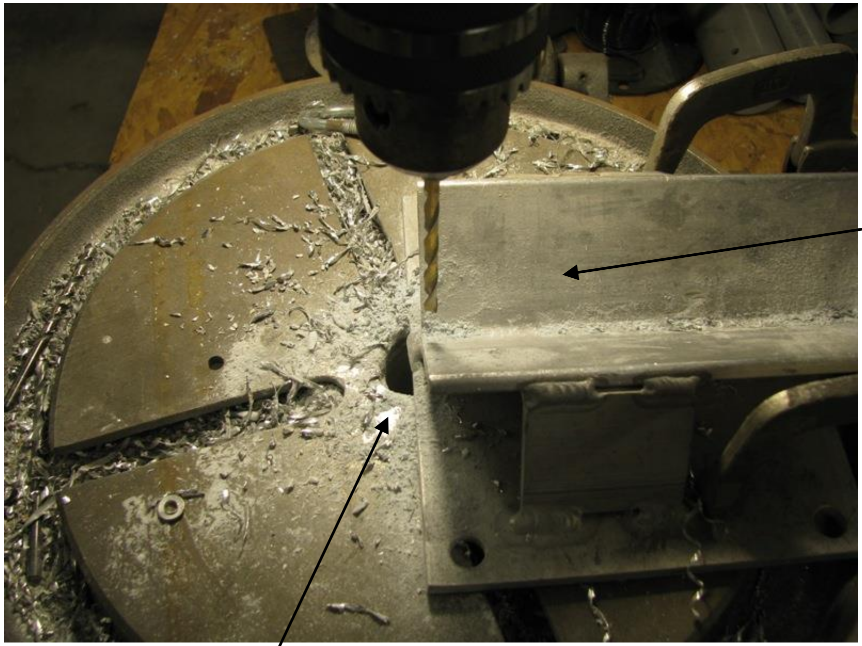
You are holding the left-hand side of the tube, but the cut-off piece is loose.

Lifting the blade too soon can cause a tooth to hook the cut off piece and throw it - usually some place you don’t want.

This is an outer coupler, such as on a boom, and half is riveted in place and the other half will receive 1/4-20 through bolts.

How do you drill on a tube?

# Utilize a V-block on the drill press to drill tube.



V-block

made out of welded aluminum angle stock.

Drill bit is centered in the V and back slightly from the hole

to allow chips to fall away.

# Rivets

An estimate of the number of riveted elements in the field is >150,000.

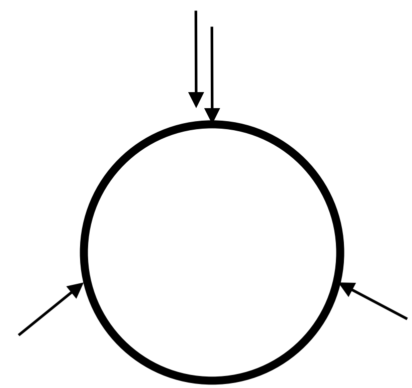
An average of 25 rivets per element calculates to be 3.75 million rivets, plus all those used on booms, inner liners and verticals.

Let's call it 4 million rivets and the elements stay up.

These are "closed end" rivets.

A smaller V-block for smaller tube, such as for drilling rivet holes in element sections.

2 holes ~ 2 ¼″ apart



Note the markings on the V-block to avoid measuring each time for a standard distance.

Markings are 3″ each side of center for a 3″ tubing insertion length.

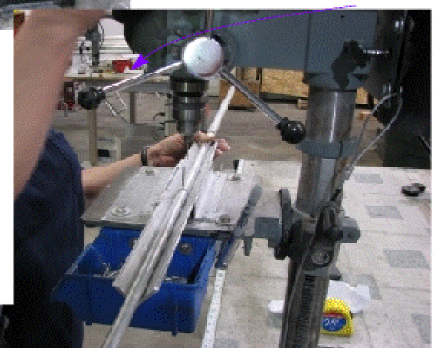
2 holes are drilled in line about 3/8″ in from the ends, plus 2 more holes at about 120º on each "side" of the original 2 holes line.

# Drilling Round Tubing with a V-Block for Rivets

This technique will align the holes between telescoping pieces.

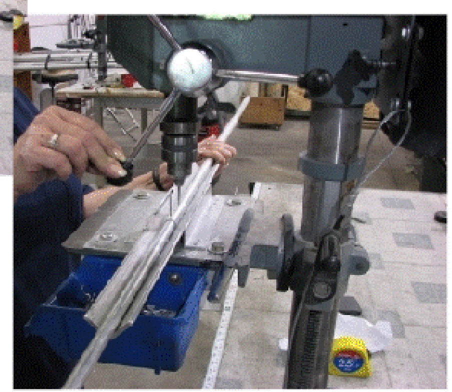
Use a drill bit that is slightly larger in diameter than the rivet body so that the rivet can be pulled into the hole. Rivet specs often give a recommended drill/hole size.

Step 1:
drill first of 3 holes and only go through half-way, not all the way through the tubing.



Step 2:
insert rivet in first hole to maintain alignment

Step 3:
drill second hole



Step 4:
drill remaining rivet holes

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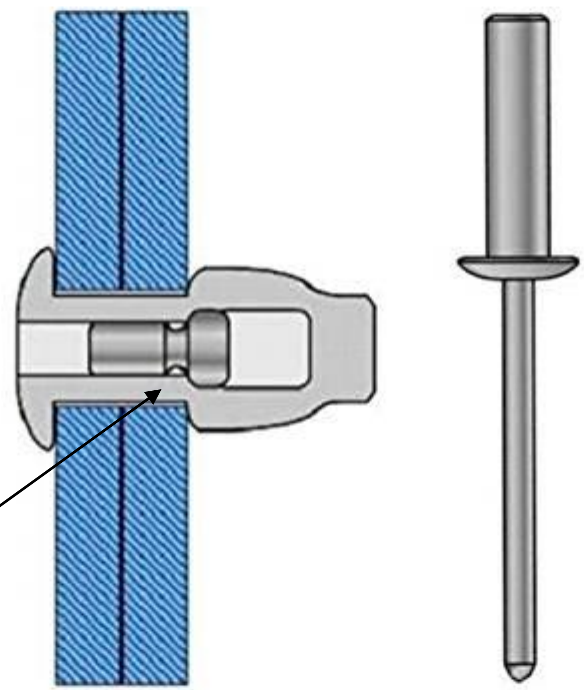
# Common "blind" rivets

Typical rivet, with ball on end.

**These are NOT for antennas!**

# Closed-end Rivets

Steel mandrel is pulled this way until it detaches from inside the aluminum rivet.



Aluminum body -- not stainless.

Steel mandrel pulls harder for strongest joint.

Rivet pulls inner tubing into the outer tubing for solid contact and a secure aluminum-to-aluminum joint.

# Closed-end Rivet tools

Hand rivet tool for 1/8″ rivets (1/8″ rivet body.)


Great pneumatic tool by POP (expensive)

Hand rivet tool for 3/16″ rivets (3/16″ rivet body.)

Inexpensive pneumatic rivet tool that will work for most all projects. Will pull up to 3/16″ rivets.

(Don’t use the rivets that come with it.)

# Where to get closed-end rivets

McMaster-Carr

https://www.mcmaster.com

Olander

http://www.olander.com

Inexpensive rivet tools can be found at many places, including those on the left and also at stores like Lowe's, Home Depot and Harbor Freight.

**In all rivet tools, use the smallest nozzle for the particular size rivet and mandrel.**

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.

# 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!!

Mechanical increase vs. gain increase.

Besides our own line, we perform antenna research, antenna testing and evaluation.

This particular antenna is a SteppIR vertical for 20-10 with their big coil at the base.
It is coupled to a VOR using (4) commercial stanchions and plastic chain with wire weaved through it for the open ring.

The goal is no ground radials and covering down to 40, possibly 80.

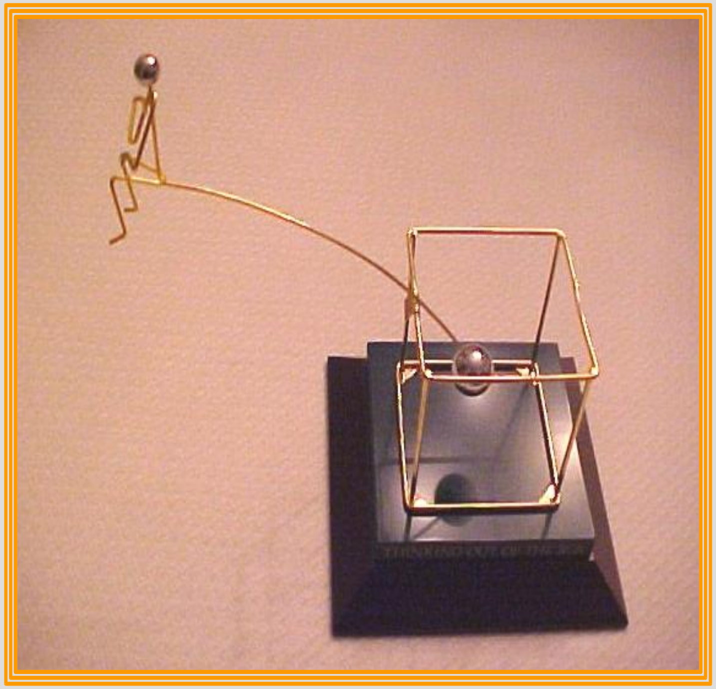
*This vertical also has a proto-type base with a wireless actuator that raises and lowers it.*

Thoughts for the day:

"Everything Works"

...and...

# Nothing's obvious



People will accept your ideas more readily

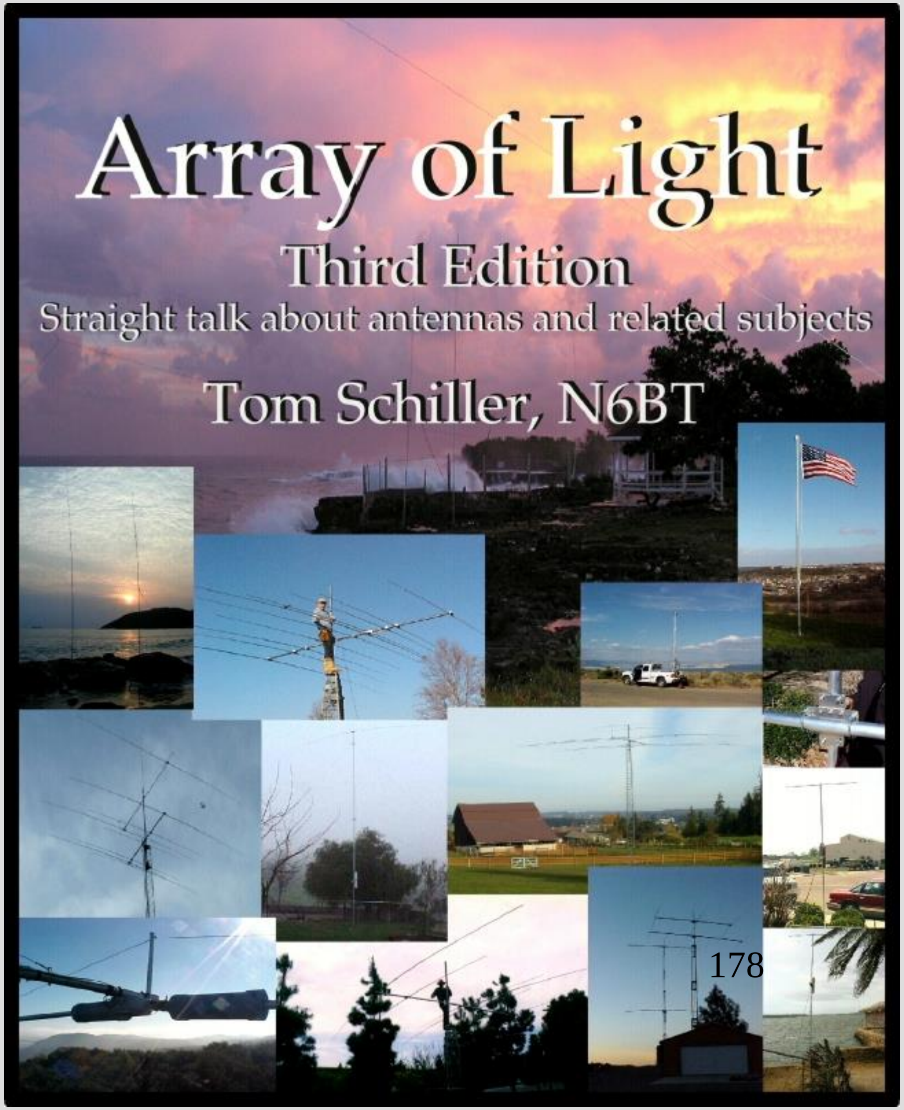
if you tell them:

"Benjamin Franklin said it first."

# *Thanks for your attention*

*Tom N6BT*

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

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