

Fox Hunting

Calvert Amateur Radio Association

July 14, 2022

What is Fox Hunting

(Amateur Radio Direction Finding - ARDF)

- Locating a hidden transmitter using direction finding equipment and skill.
 - typically 2 meters and 80 meters
- Is a recognized sport in Europe
 - not limited to Amateur Radio operators
- Can involve a time constraint
 - points for fastest “finds”
- Can involve elements of “orienteering”
 - compass & map
- Skills apply to finding Emergency Locator Transmitters and interference sources as well

20th World ARDF Championships 2022

(together with World ARDF Cup 2022)

Borovets, Bulgaria



[Web Link](#)

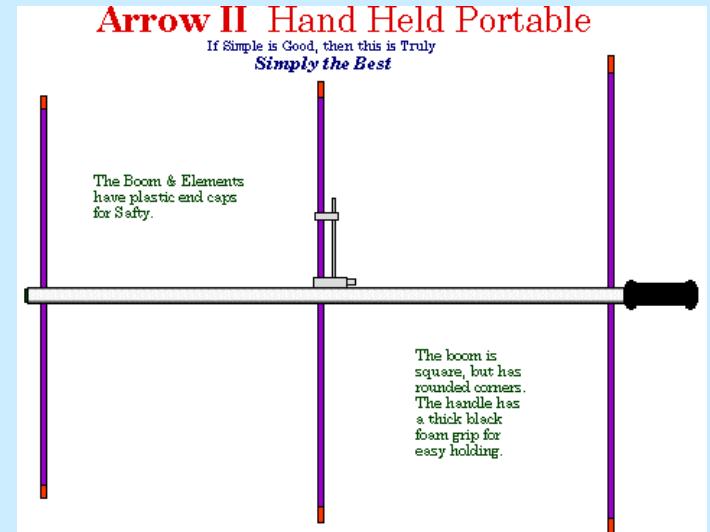
Challenges

- Direction finding in multipath propagation environment
- Multiple transmitters time-shared on same frequency, each on for only a period of time
- Finding a well hidden “fox” in the RF “near field”
 - like geo-caching, people get inventive hiding the transmitter
- Terrain difficulties & search strategy
- Physical condition of the hunter

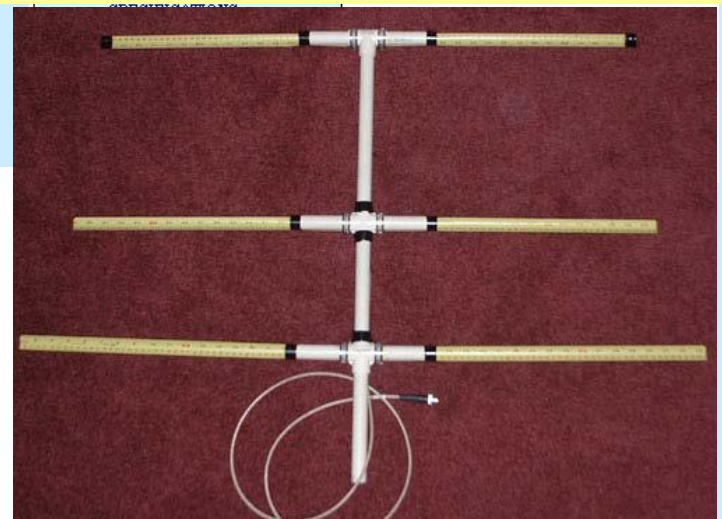
Equipment

(2 Meter)

- Directional Antenna
 - Yagi or Quad
- HT or receiver
- Signal Strength Output
 - meter or bar graph
 - “audio s-meter”
 - tone varies with strength
- Attenuator
 - for “close-in” work

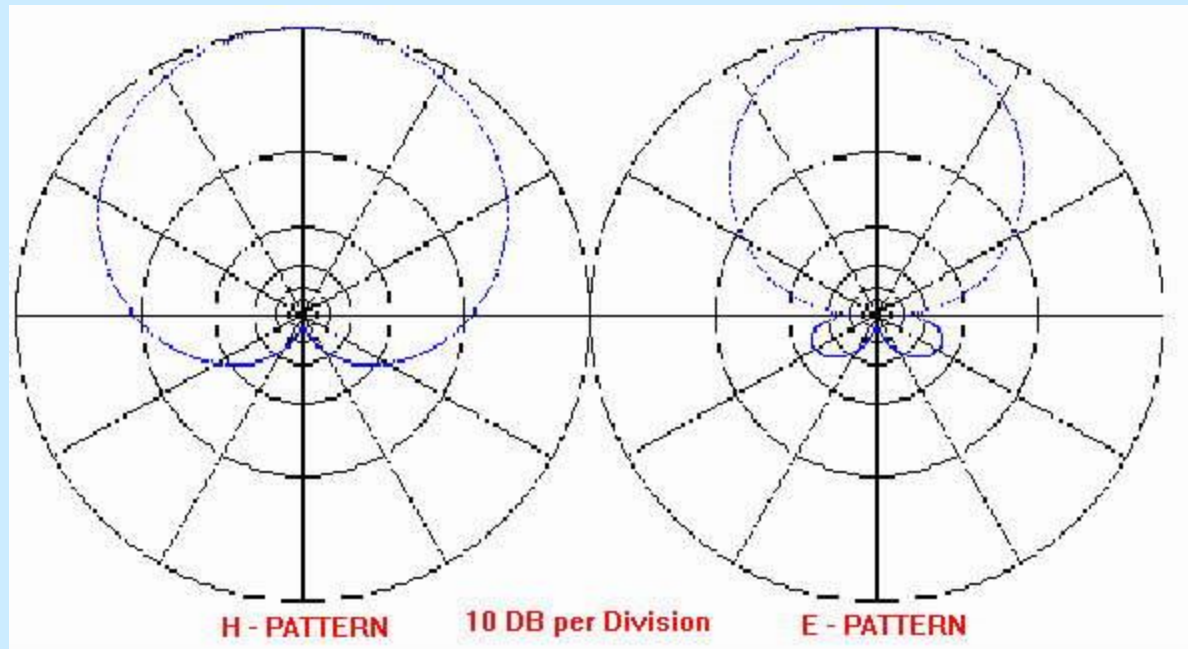


Home brew “tape measure” yagi



Directional Antenna

- Sharp forward lobe with low back and side lobes

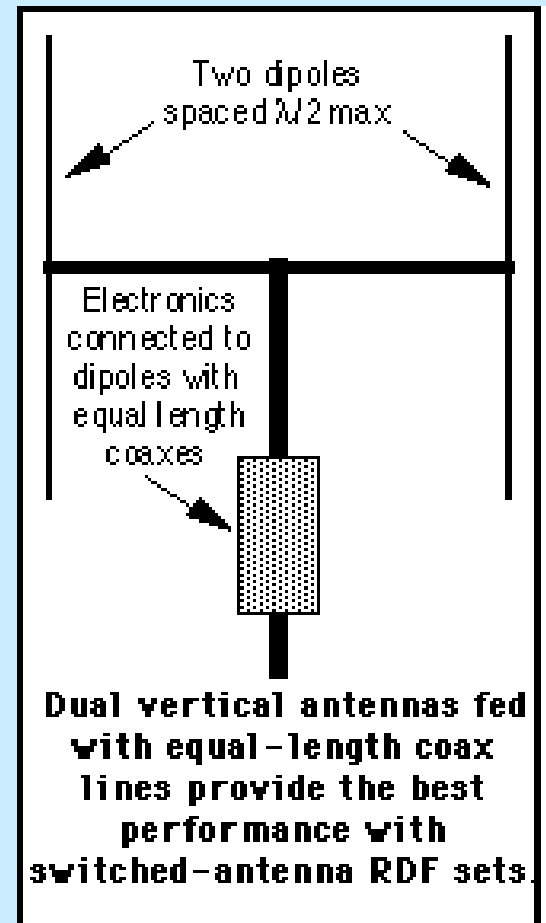


From WB2HOL Optimized Tape Measure Beam for Radio Direction Finding
http://theleggios.net/wb2hol/projects/rdf/tape_bm.htm

Equipment

(2 Meter continued)

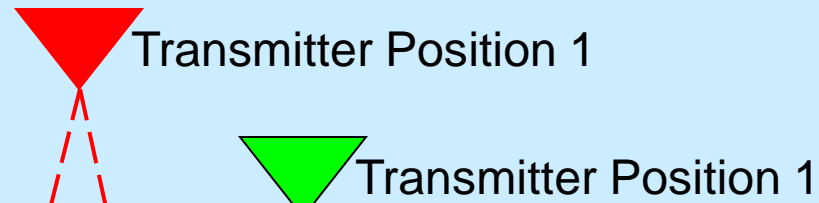
- Time Direction of Arrival (TDOA)
 - Sharp null when plane of antennas at right angle to transmitter
 - Bi-directional unless equipped with a separate sense antenna
 - Fox could be ahead or behind
 - Simple & Inexpensive
 - Good entry level system
 - “Handy Finder Kit”
 - May still be available for \$27.95 at: <http://www.handi-finder.com/>



TDOA

Principle of Operation

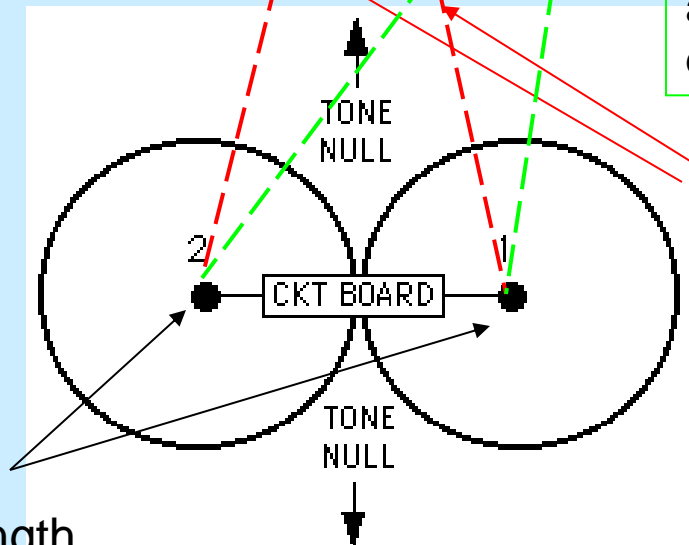
Circuit switches between the two antennas at an audio rate (1 kHz or so). Since most FM demodulators are sensitive to signal phase as well as signal frequency, an audio tone will be generated if the two signals are not in phase. Amplitude of tone depends on how much out of phase. Minimum amplitude for in-phase.



Distance between transmitter and both antennas different if plane of antennas not at right angle to transmitter. Signal arrives at both antennas with phase difference.

Distance between transmitter and both antennas equal if plane of antennas at right angle to transmitter. Signal arrives at both antennas in phase.

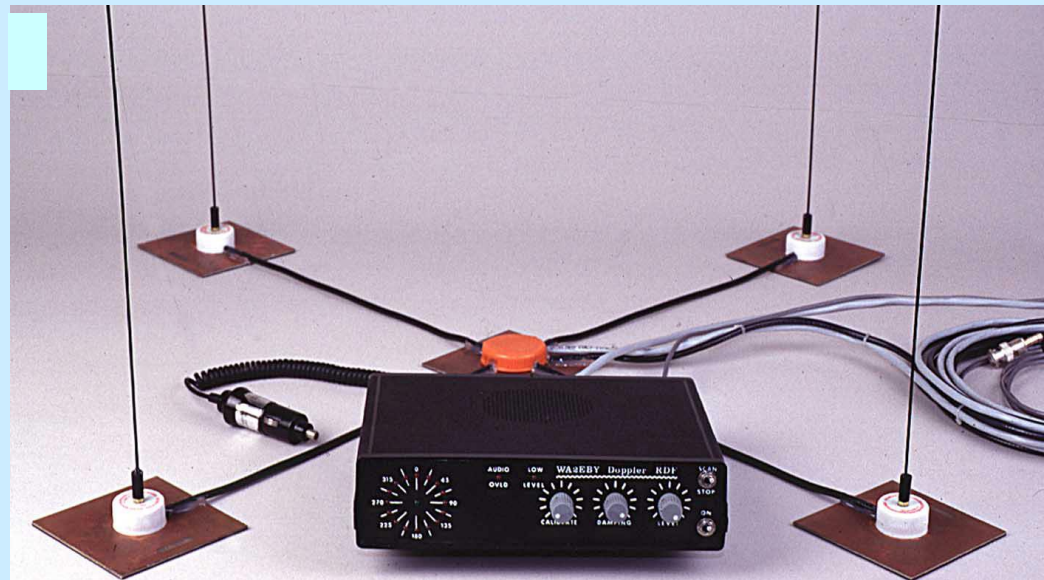
Vertical Dipoles
Spaced $< \frac{1}{4}$ Wavelength



Equipment

(2 Meter continued)

- Doppler Systems
 - typically vehicle mounted
 - Can use sophisticated signal processing
 - Can be tied into GPS and map software



Doppler

Principle of Operation

Doppler Principles (Courtesy of WB6EYV)

PRODUCING DOPPLER SHIFT ON A RECEIVED SIGNAL USING STATIONARY ANTENNAS

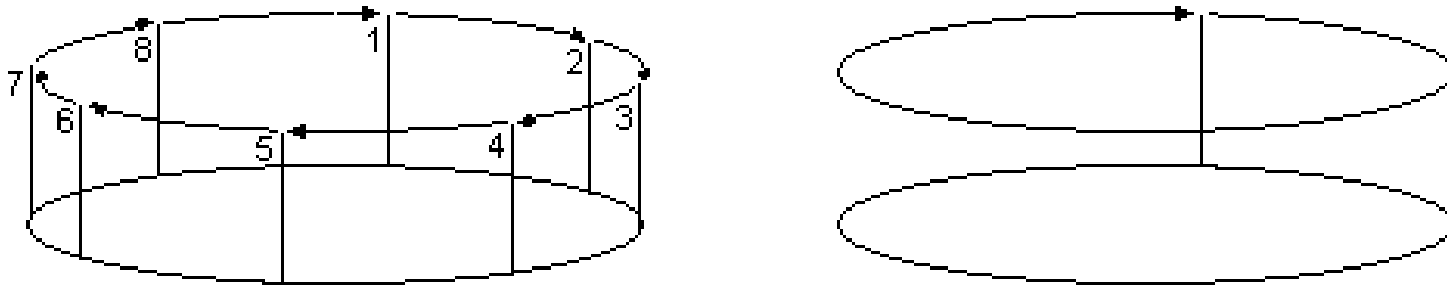


FIGURE 1

Switching a receiver between 8 stationary antennas (arranged in a circle) simulates the action of a single, *hypothetical* antenna, moving in a circle.

Doppler

Principle of Operation

Doppler Shift as System Switches Antennas

DOPPLER SINE WAVE VS. SIGNAL DIRECTION

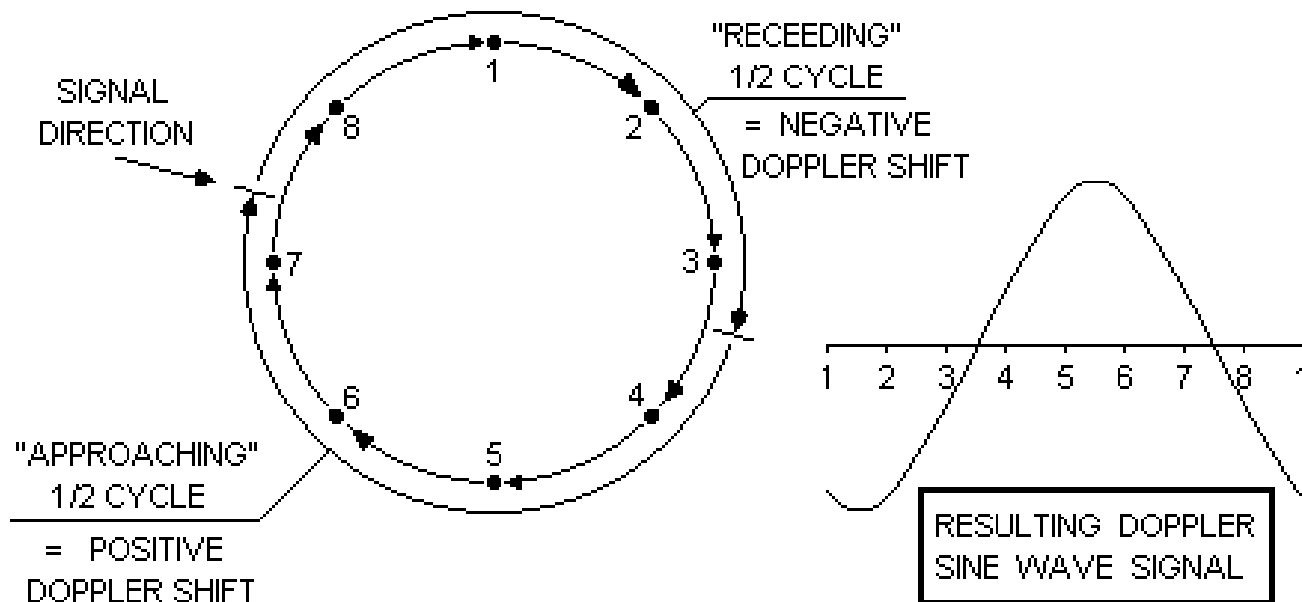


FIGURE 2

The sine wave zero - crossing at the end of the positive half - cycle signals the exact instant when the hypothetical antenna is nearest the signal source

Doppler

Principle of Operation

Doppler Principles (Courtesy of WB6EYV)

To generate a significant amount of Doppler shift, (about 500 Hertz at 144 MHz) the antennas must be switched very fast... about 7.5 KHz in this D/F. With eight antennas, sequentially switched at 7.5 KHz, the rotation rate of the hypothetical antenna is $7500 / 8 =$ (approx.) 470 Hz. If the antennas are arranged in a circle with a two foot diameter, this simulates the movement of a single antenna which is circling at a (tangential) speed of 3000 feet per second.... nearly three times the speed of sound. The antenna switching is achieved with diodes, to deal with the high switching rates.

Audio filtering is required to remove any voice modulation, and to construct a Doppler sine wave with enough waveform quality to be useful. The filtered Doppler sine wave has two zero-crossing "events", which occur when the hypothetical antenna is "nearest to" the signal source, and "farthest from" the signal source. (Figure 2) The "nearest to" zero crossing always occurs at the end of the positive half cycle, ("falling edge" zero - crossing) and it can be detected and used to signal the exact instant when the hypothetical antenna is closest to the transmitter signal.

Equipment

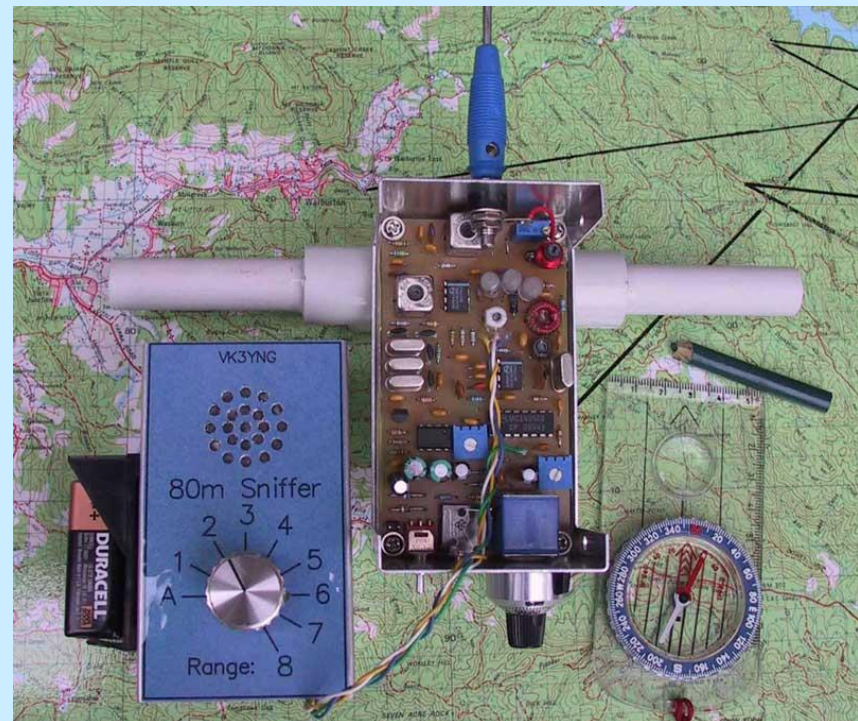
(80 Meter)

- Almost always a magnetic loop antenna or ferrite bar antenna
 - sense antenna to resolve by-directional ambiguity



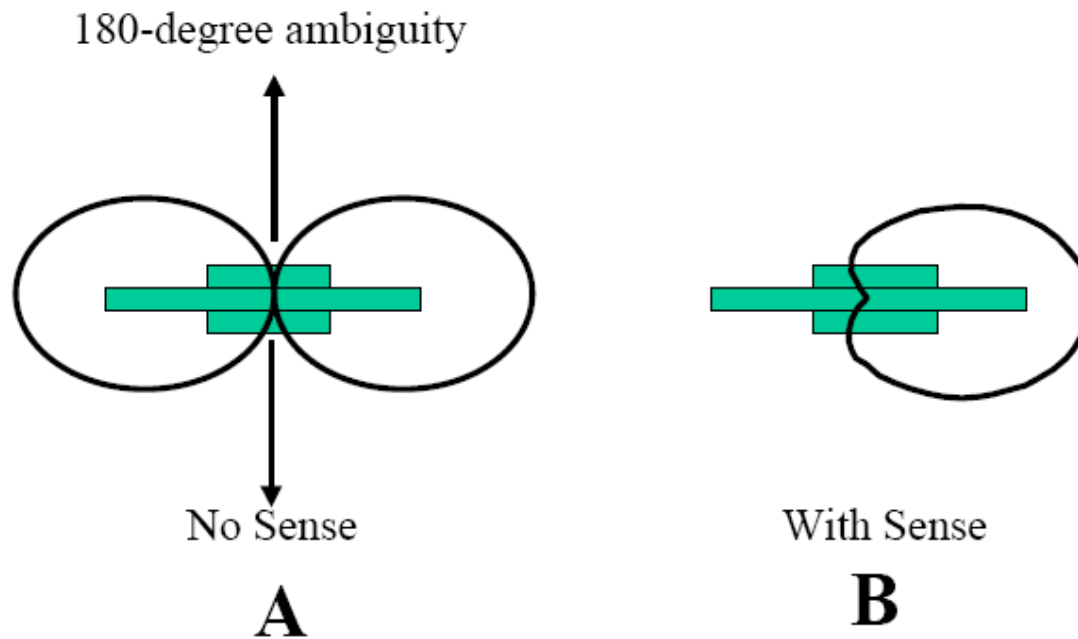
Magnetic (shielded) loop

<http://www.foxhunt.com.au/>



Magnetic Loop Antenna

Principle of Operation

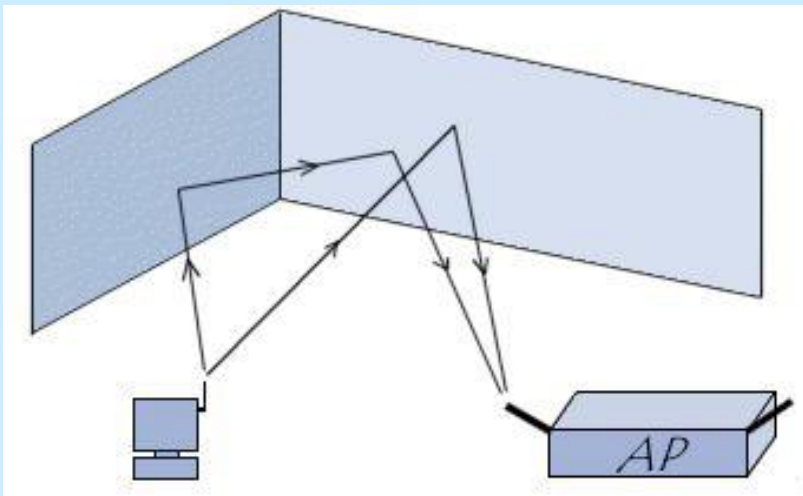
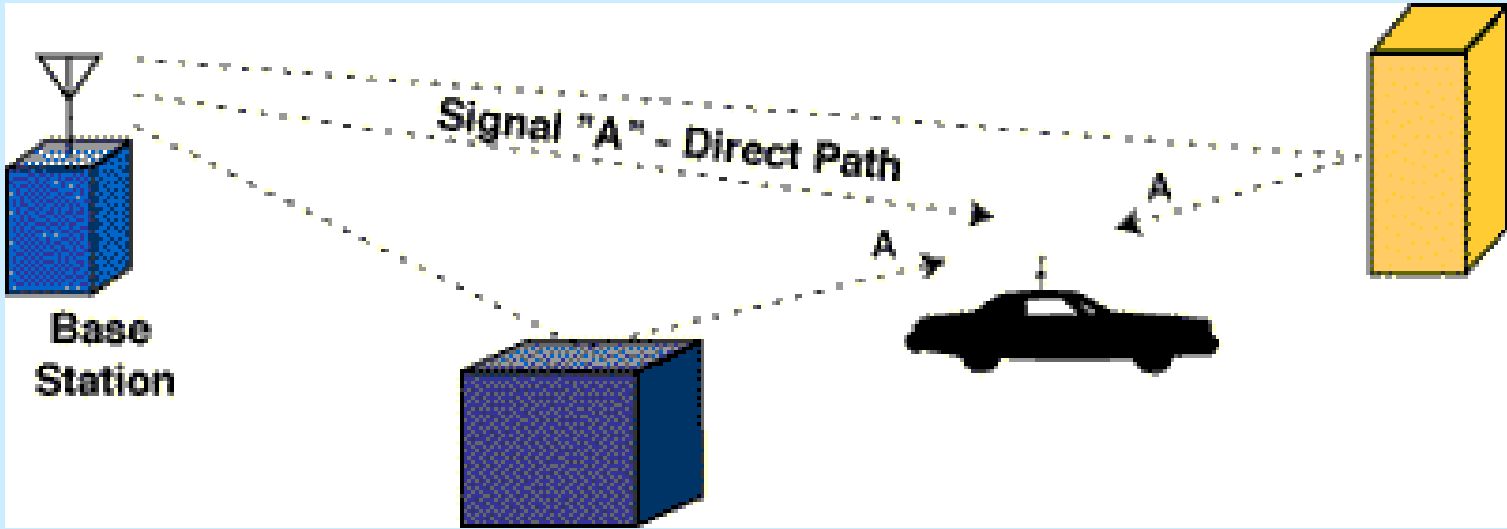


Loop antenna patterns (viewed from above looking down onto receiver)

Multipath

- Problem above ~ 30 MHz
 - object can be a reflector if larger than ~ $\frac{1}{2}$ wavelength
 - $\frac{1}{2}$ wavelength is 3.4 ft
- Not an issue for 80 Meters
 - not many objects big enough to be good reflectors
 - $\frac{1}{2}$ wavelength is 140 ft
- Am I picking up the bearing to transmitter or bearing to a reflection of the transmitter (or a reflection of a reflection, “hall of mirrors”)?

Multipath



APRS and ARDF

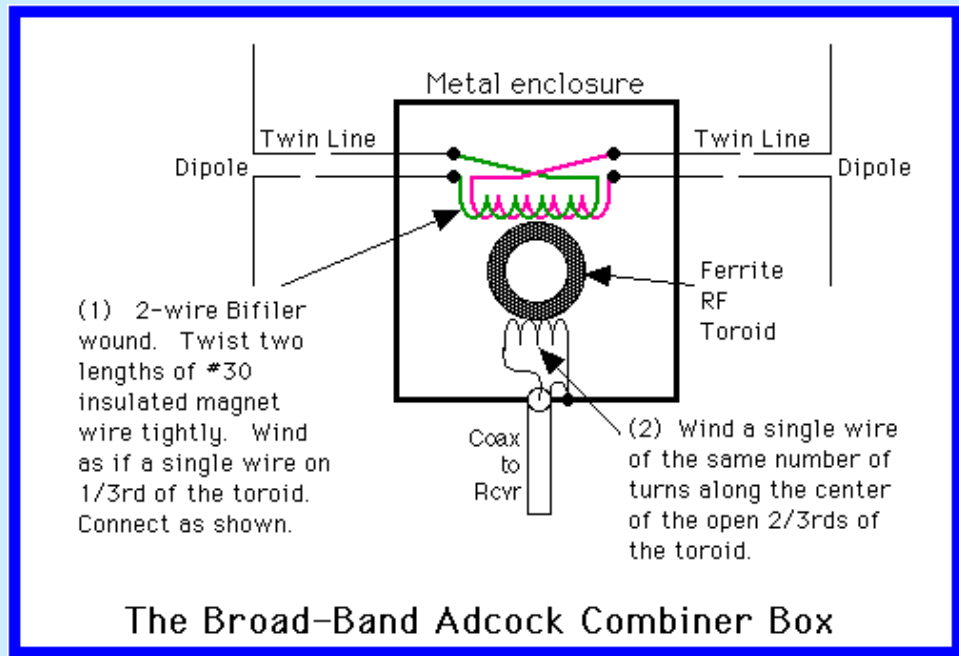
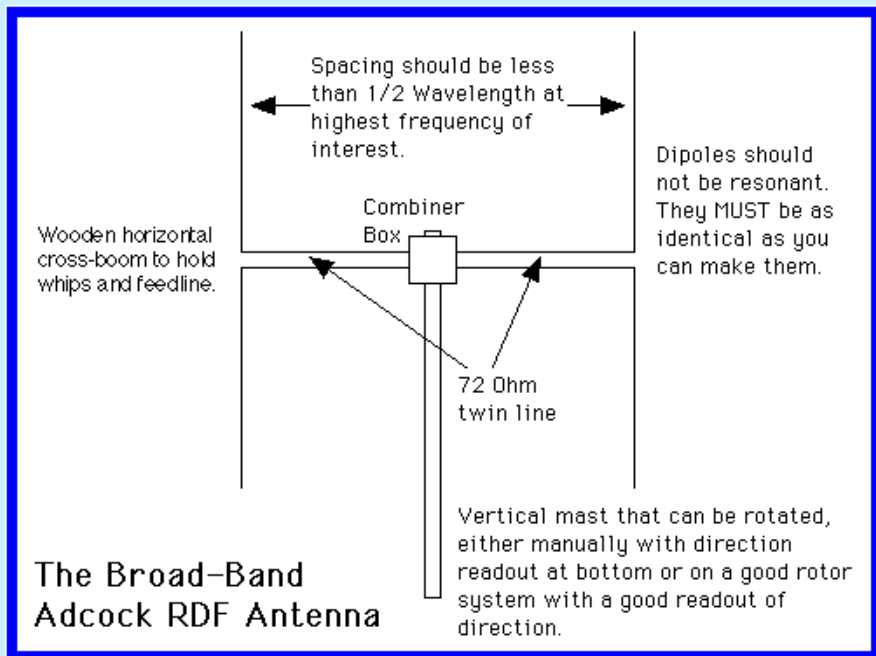
- Some equipment (usually Doppler) has provisions for automatically outputting bearing to an APRS message with the current user location
- Multiple mobile/fixed stations can “share the hunt”

APRS and ARDF



Fixed Station HF RDF

(Adcock Interferometer)



<http://www.iw5edi.com/ham-radio/?the-adcock-hf-rdf-antenna,92>

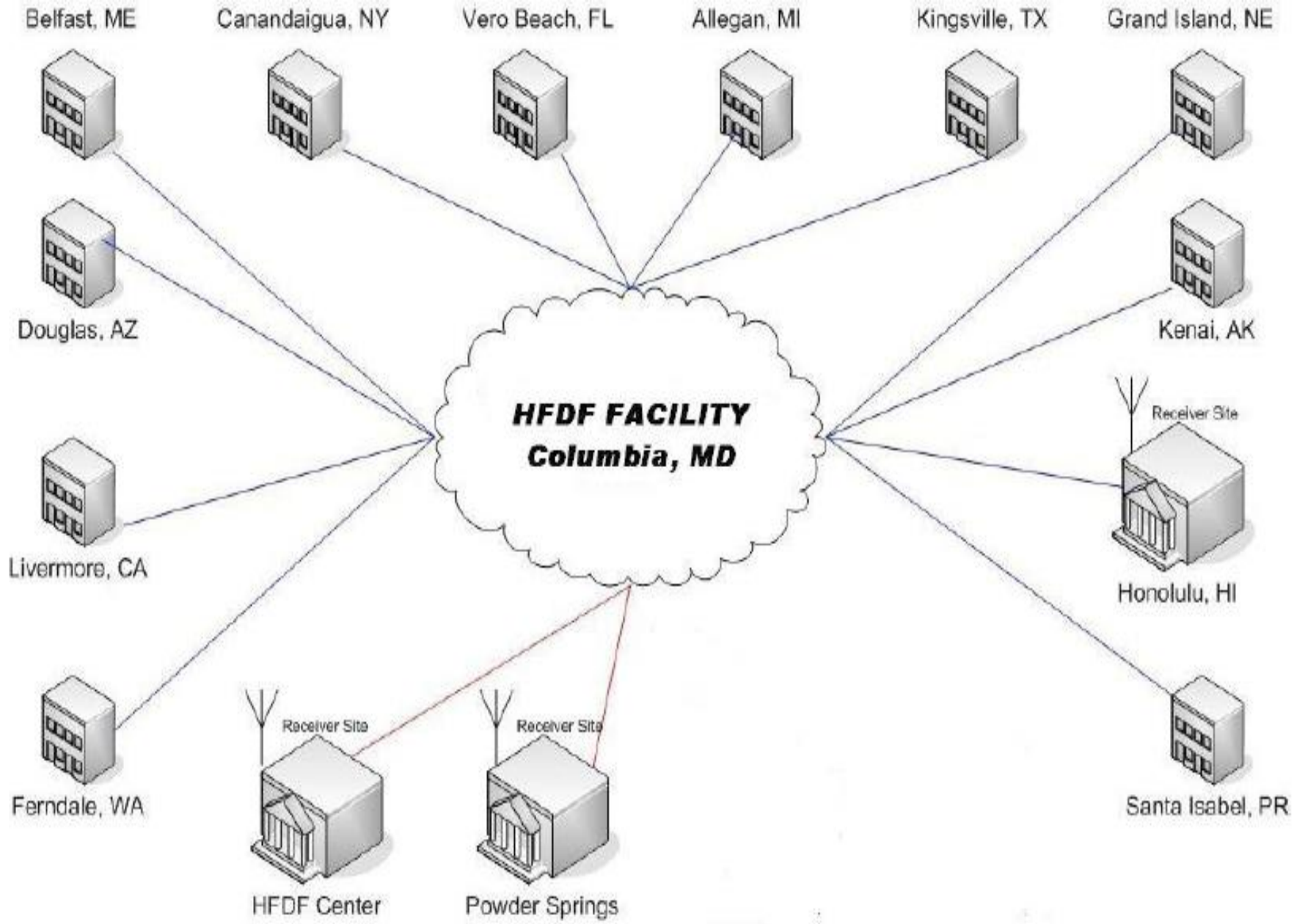
“Professional” Direction Finding

- FCC Columbia Maryland Operations Center
 - multiple remote receiver sites
 - can analyze, fix and report the approximate location of a any high-frequency emitter with a very high level of accuracy, in seconds



<https://www.fcc.gov/general/high-frequency-direction-finding-center>

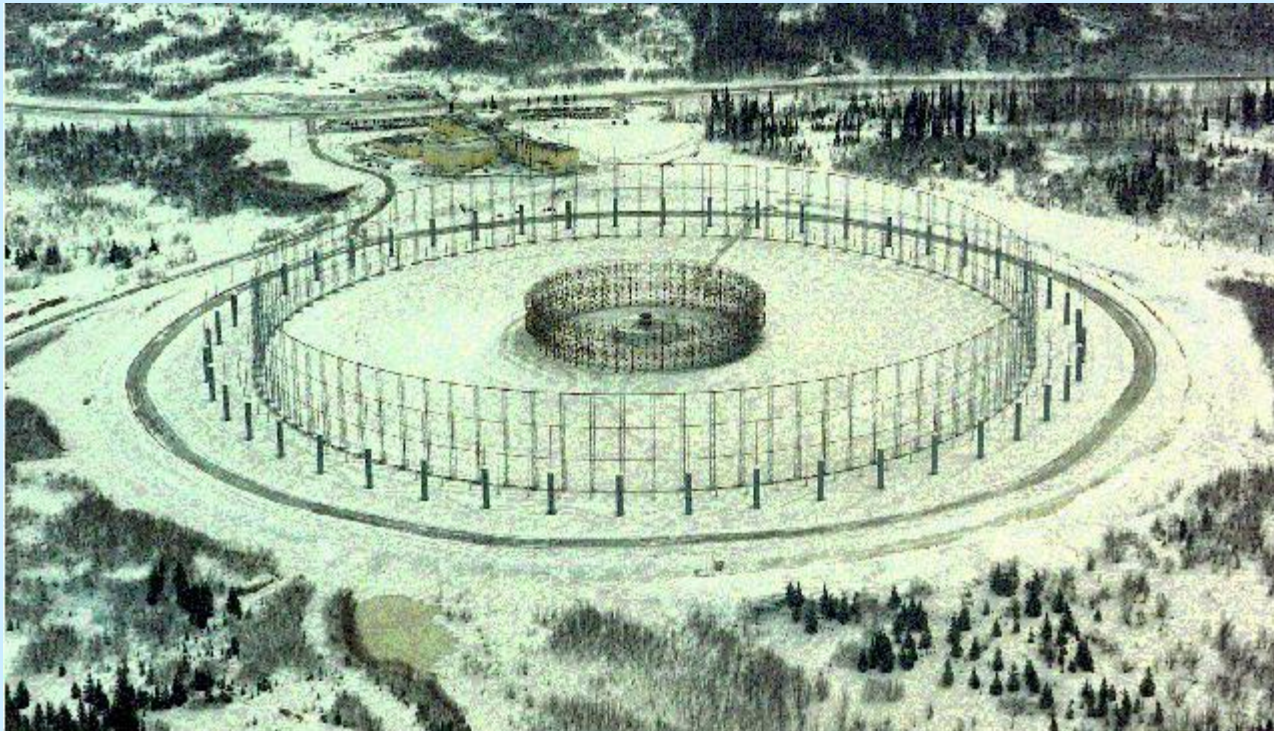
[HFDF Map](#)



From FCC Request for Quote Published On-Line

“Professional” Direction Finding

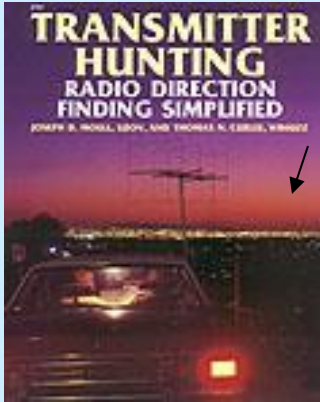
- Military
 - Huge HF direction finding arrays from cold war days
 - AN/FLR-9 Wullenweber (or Wullenwever) circularly disposed antenna array – over 1000 ft diameter
 - Sometimes called an Elephant Cage; now obsolete



ARDF Resources

Joe Moell K0OV

<http://www.homingin.com/THRDFSinfo.html>



Good top level sites with links:

<http://www.homingin.com/>

<http://www.arrl.org/direction-finding>

http://ka7oei.com/ardf_pages.html

Doppler & TDOA Systems

<http://www.qsl.net/ve2emm/index.html#index>

<http://www.kn2c.us/>

<http://www.handi-finder.com>

<http://www.silcom.com/~pelican2/>

<http://www.homingin.com/Sources.html>

APRS & Direction Finding

<http://www.aprs.net/vm/DOS/DF.HTM>