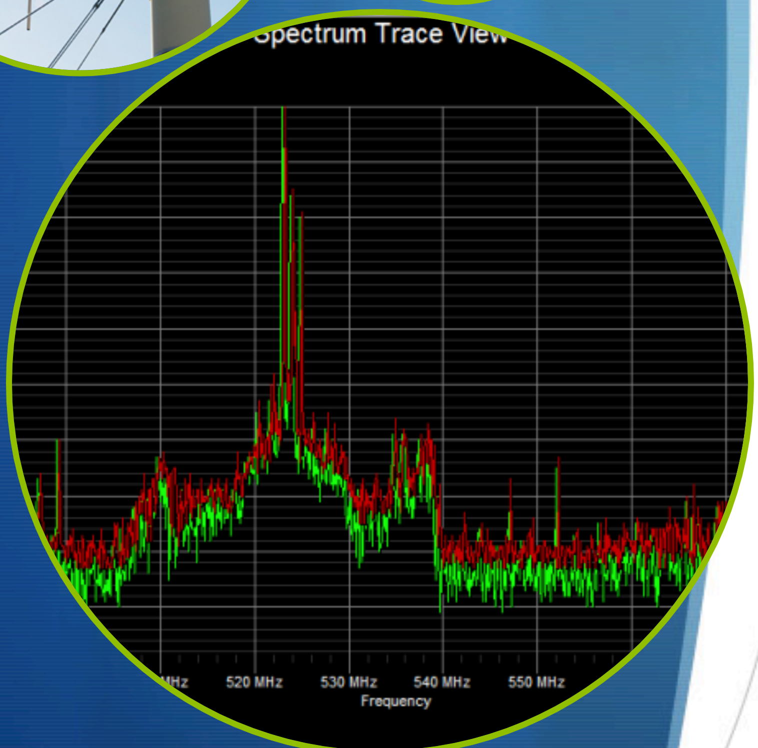
Interference Location

Rocky Mountain Ham University
April 21, 2018

Rocky Mountain Ham Radio

Presenter Info

- John Maxwell, W0VG
- Doug Sharp, K2AD
- Willem Schreuder, AC0KQ
- Dan Meyer, N0PUF – Transmitter Hunt Demo/Learning



Today's Plan

Quick/Basic Theory Lesson

Available tools

Show and tell

- Receiver with Antenna
- Spectrum Analyzer
- Types of Antennas

Field lab transmitter hunt

Wrap up

Direction Finding Theory

- Direction Finding is the process of using directional antennas and receiving equipment to determine the direction to a signal source.
- This class will focus on finding VHF/UHF interference.
- HF Interference was covered in a previous class this year.

- TDOA (Time Differential of Arrival)
  - Measures exact arrival time of jamming signal at multiple receivers
  - Determines position using mathematics great than common core
  - Very expensive and complicated!

Direction Finding Theory

- The antenna can be a yagi for directional gain or a loop for less gain
- Sight down the yagi with a compass to get magnetic bearing
- Remember to correct your bearing from magnetic to true when plotting on a map.
  - Not an exact adjustment – but I subtract 10 degrees to get close.

Available Tools

- Doppler Unit with antenna array

Pictured to the right is the KN2C
Doppler unit with duck antennas.
This unit gives a bearing to any signal
Relative to the receiving location.

Very simple to use, but takes some time
to learn how to properly operate.

Runs much better with laptop and GPS
Interface to plot bearings. Requires
Internet when mobile to plot on map.

Available Tools

- Spectrum Analyzer with Yagi or Loop antenna (dedicated or RTL-SDR)

Available Tools

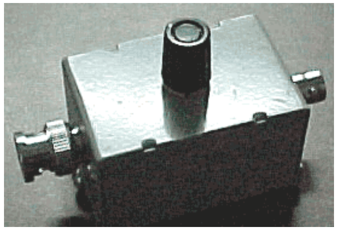
- Handheld with Yagi
- By far the most popular

Direction Finding Tools

- Antenna and Receiver are not your only required tools
- Pads/Attenuators are required to drop excessive signal levels
- Active and offset attenuators are required for close-in work

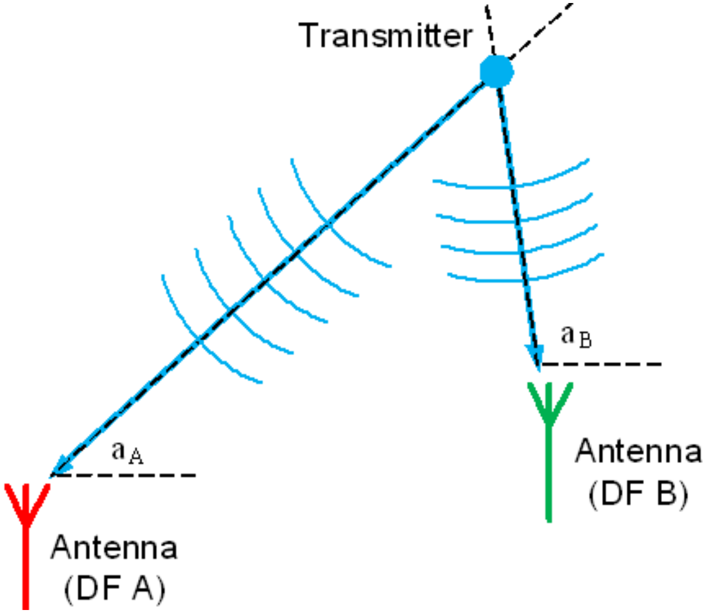
Available Tools

- Fixed attenuators
- Offset Attenuators
- Preamplifiers
- Filters
- Body blocking? What is it?

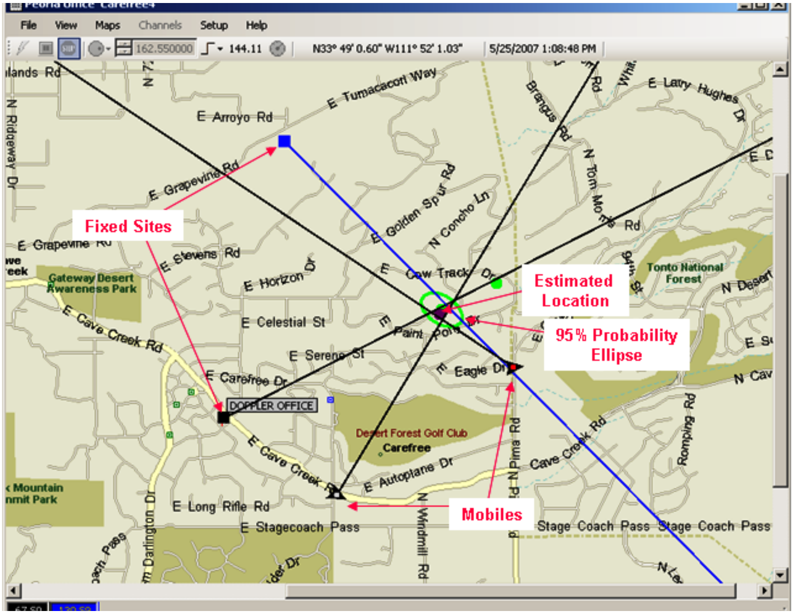


Direction Finding Map

Draw Bearings on a Map



Take multiple readings

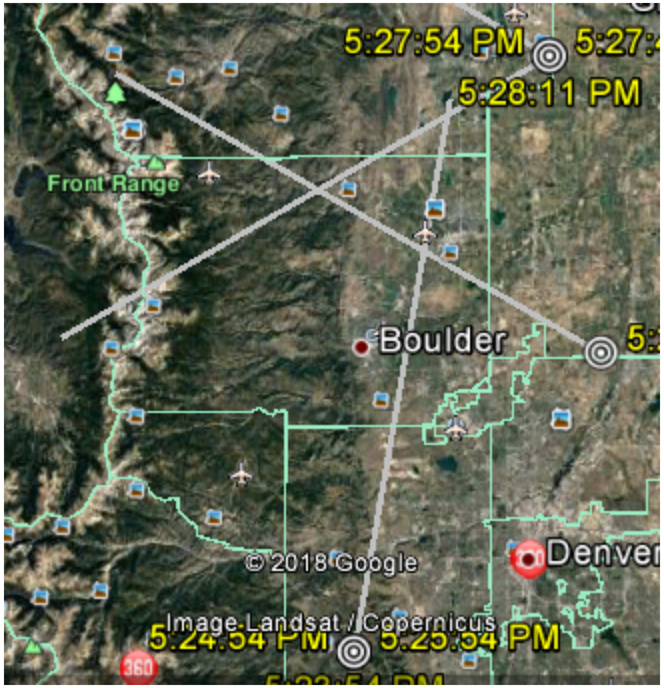


There are tools for mapping

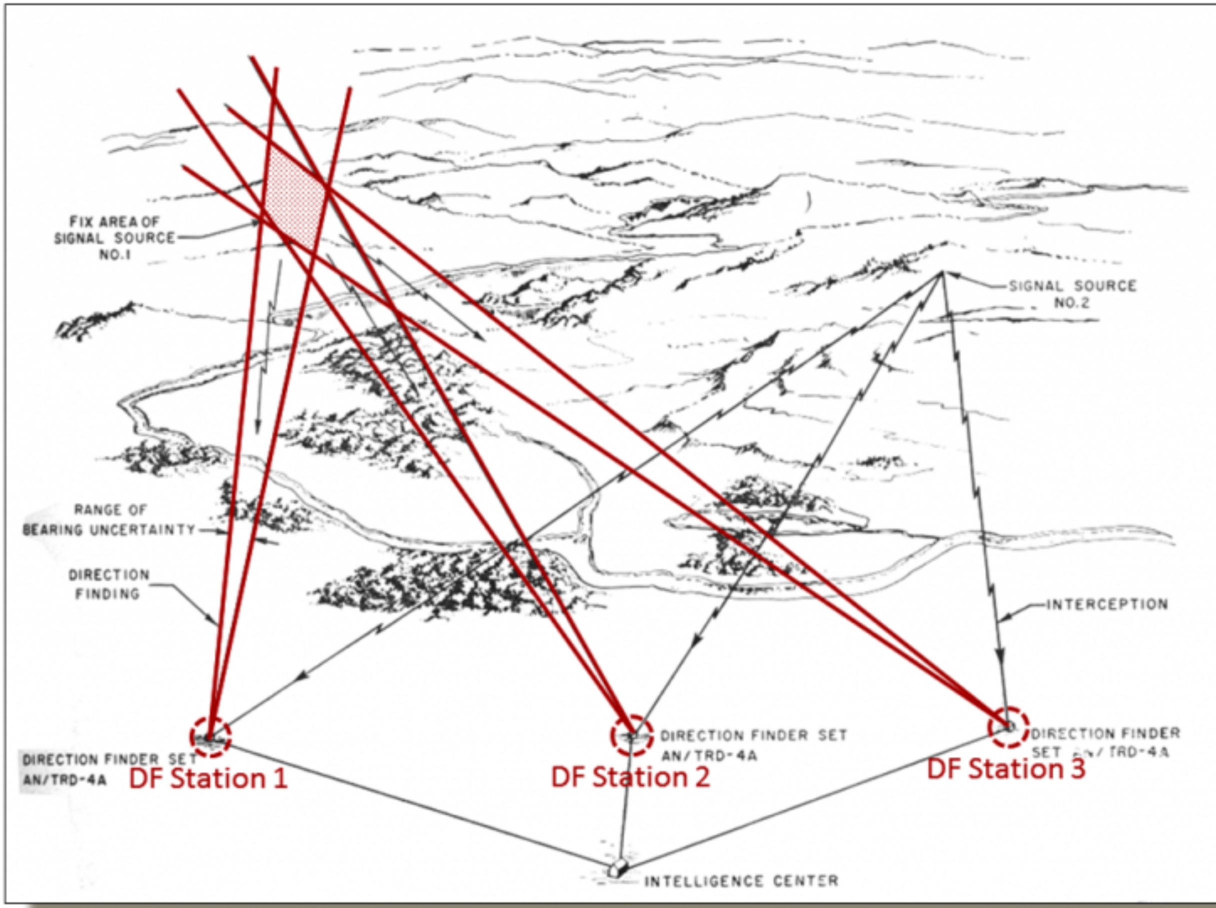
- Google Earth does a fair bit for doing plotting. It's not as nimble as other tools. Free.
- KN2C.US makes doppler units and software that can be used standalone for plotting. NAVI 2020 works quite well for taking a LAT/LON and drawing a plot. Free.
- Most tools require internet access to create maps.

KN2C NAVI 2020 Plotter

- This is a screenshot from NAVI2020 plotter.
- Uses GPS input for beginning
- Uses “bearing” to generate a plot. Overlays on Google Earth.

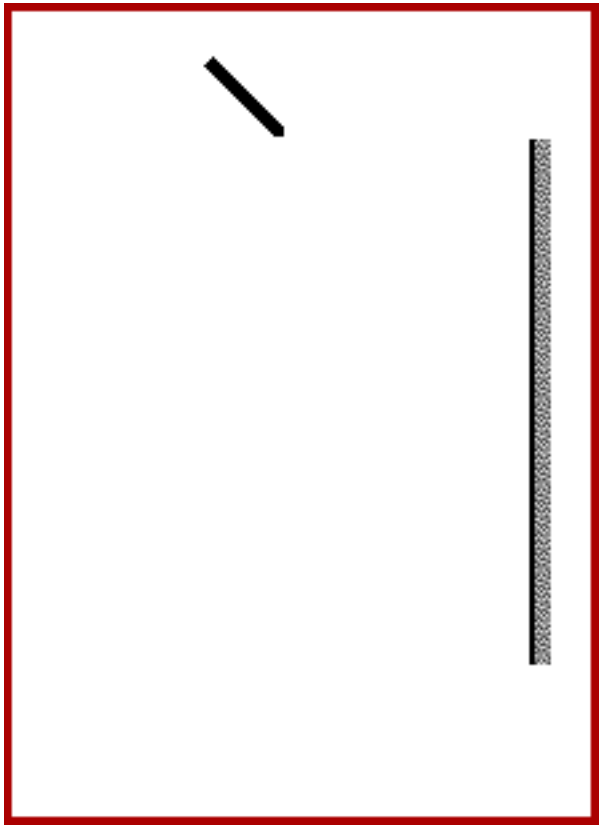


Reflections and Shadows



Reflections

- Any time you're dealing with big objects, buildings, mountains, etc. you have to deal with reflections.
- Angle of incidence equals the angle of reflection
- This will affect you! I promise.



Reflections

Look around

- Look at your bearings, and see if they are pointing at large objects.

Look for your reverse bearing

- When you are DF'ing, make sure you always turn around 180 degrees and look at the signal from the reverse direction to check for a reflection!
- In the case of the CenturyLink building here, the image was "bigger" than the signal from the actual source. The size of the reflector was very much a factor in tricking us.

Fixed or Portable?

- Is my signal source in a fixed location or is it portable?
- How do I tell?

Fading

- Fast Fading – Rayleigh (signal fades of 35 dB across milliseconds)
- Slow Fading – Log Normal Distribution (1-5 dB fades across seconds)

Slow versus fast fading [edit]

The terms *slow* and *fast* fading refer to the rate at which the magnitude and phase change imposed by the channel on the signal changes. The coherence time is a measure of the minimum time required for the magnitude change or phase change of the channel to become uncorrelated from its previous value.

- **Slow fading** arises when the coherence time of the channel is large relative to the delay requirement of the application.[1] In this regime, the amplitude and phase change imposed by the channel can be considered roughly constant over the period of use. Slow fading can be caused by events such as **shadowing**, where a large obstruction such as a hill or large building obscures the main signal path between the transmitter and the receiver. The received power change caused by shadowing is often modeled using a log-normal distribution with a standard deviation according to the log-distance path loss model.
- **Fast fading** occurs when the coherence time of the channel is small relative to the delay requirement of the application. In this case, the amplitude and phase change imposed by the channel varies considerably over the period of use.

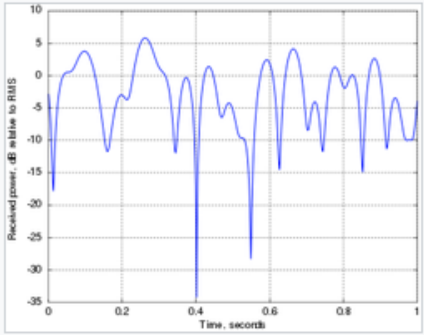
In a fast-fading channel, the transmitter may take advantage of the variations in the channel conditions using time diversity to help increase robustness of the communication to a temporary deep fade. Although a deep fade may temporarily erase some of the information transmitted, use of an error-correcting code coupled with successfully transmitted bits during other time instances (interleaving) can allow for the erased bits to be recovered. In a slow-fading channel, it is not possible to use time diversity because the transmitter sees only a single realization of the channel within its delay constraint. A deep fade therefore lasts the entire duration of transmission and cannot be mitigated using coding.

The coherence time of the channel is related to a quantity known as the **Doppler spread** of the channel. When a user (or reflectors in its environment) is moving, the user's velocity causes a shift in the frequency of the signal transmitted along each signal path. This phenomenon is known as the Doppler shift. Signals traveling along different paths can have different Doppler shifts, corresponding to different rates of change in phase. The difference in Doppler shifts between different signal components contributing to a signal fading channel tap is known as the Doppler spread. Channels with a large Doppler spread have signal components that are each changing independently in phase over time. Since fading depends on whether signal components add constructively or destructively, such channels have a very short coherence time.

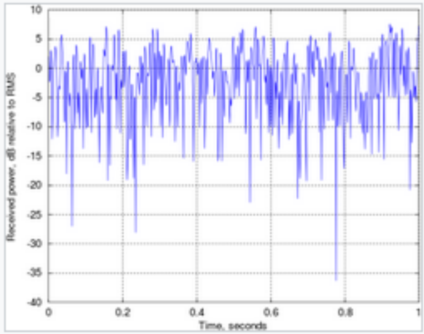
In general, coherence time is inversely related to Doppler spread, typically expressed as

$$T_c \approx \frac{1}{D_s}$$

where T_c is the coherence time, D_s is the Doppler spread. This equation is just an approximation,[2] to be exact, see Coherence time.



One second of Rayleigh fading with a maximum Doppler shift of 10 Hz.



One second of Rayleigh fading with a maximum Doppler shift of 100 Hz.

Case studies for discussion

1. John and Doug tracking down a dead carrier on the RMRL UHF repeater
2. Crossband repeater – repeating Colorado Connection and 446.000 simplex
3. Data interference to W0KU UHF repeater atop Look out Mountain

What comes next?

- Let's go outside and do a demo fox-hunt to see how this stuff works. Dan, N0PUF will be training. Meet outside the front door.