RADIO DIRECTION FINDING "FOXHUNTING"

An Introduction to Radio Direction Finding Equipment and Techniques used by Amateur Radio Operators

(primary focus is VHF and UHF direction finding)

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Topics

- What is Foxhunting? Why would I want to do it?
- Types of Hunts
- Foxhunting Equipment and Techniques
- What do I need to get started?
- Tips and Hints
- Maps and Bearings
- Hiding/Being the Fox
- References

Foxhunting: What/Why/Who

- **Foxhunting, Transmitter Hunting, Radio Direction Finding and ARDF**, all refer to the attempt of tracking and finding the location of a (hidden) transmitter.

- Transmitter hunting can be performed to track down stuck transmitters, find RF noise sources, find malicious operators, save lives (i.e. airplanes, lost hikers), or just for fun/practice.

- As this is primarily a receive only activity, **anyone (even if unlicensed) can participate.**

Types of (organized) “Hunts”

- Transmitter hunts can cover hundreds of miles using vehicles (common in western states).
- Many hunts are city or county wide, initially by vehicle, then with possibly a second (low-power) transmitter to be found on-foot near that same location.
- Many hunts are held (on-foot) in local parks.
- Hunts can be time based (first to find is winner) or mileage based (lowest miles traveled is winner) or just for fun.
  - ***Timed events by vehicle should be avoided!***
- “ARDF” specifically refers to a competitive international sport of searching for multiple transmitters in a large park – using a very detailed (orienteering) map. (Also known as Radio Orienteering).

Technique/Equipment: Body Fade

- One very simple RDF technique is the body fade.
- Body fade can be performed with just your body and a handheld receiver.
- Technique is to **hold the handheld receiver close to the front of your body, and turn in a slow circle to find the direction of the weakest signal strength, (the null) the TX is then behind you.**
- **This technique can be helpful, but is not very efficient.**

Technique/Equipment: Loop Antenna

- A simple loop antenna exhibits a null along its axis
- However there is 180 degree ambiguity
- The loop is functional for RDF work, but more bearings will be needed than with other equipment.
- A “sense” antenna can be used to remove the ambiguity, but with additional size and complexity, and a wider beam width.
- **While a loop may be good for HF RDF, there are many better options for VHF/UHF RDF.**

Technique/Equipment: Directional Antennas

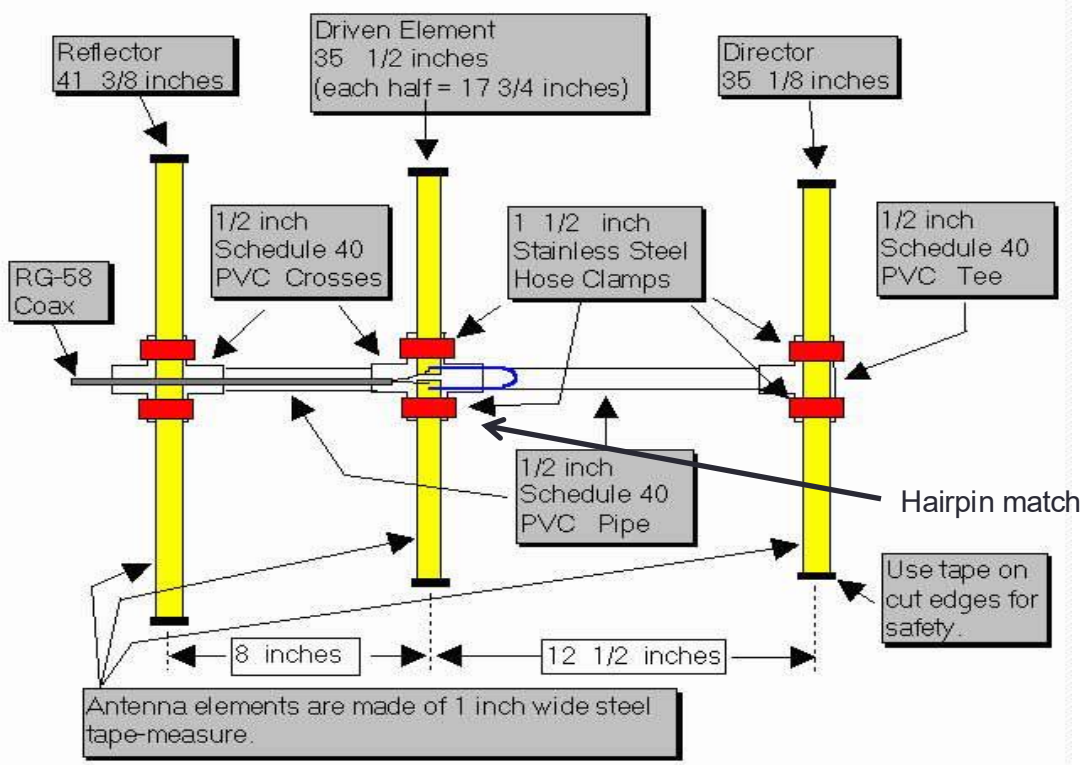
- A directional “Beam” antenna is often used for Transmitter hunting, especially in hunts that cover large areas.
- Provides both signal gain and directivity
- If used on moving vehicle, the user needs a way to turn the antenna from inside the vehicle
  - Typical users will have a 3 or 4 element beam or quad on a short mast protruding through a sunroof or out a window
- **Will often provide too much signal strength when you are close to the transmitter – will likely need to be used with an attenuator when you get close to the TX.**

Technique/Equipment: Directional Antennas – the Tape Measure Beam

- **The Tape Measure beam is a popular antenna for foxhunting** that can also be used for portable or emergency operation.
- **Lightweight, easy to build, low cost**
- **Elements bend so its easy to get in and out of a backseat or trunk**.
- Provides some gain, and (if properly constructed) an excellent Front to Back ratio.
- Build instructions can be found easily with a web search.

Photo by Art Rew

Technique/Equipment: The WB2HOL Tape Measure Beam



From the WB2HOL webpage
http://theleggios.net/wb2hol/projects/rdf/tape_bm.htm

Technique/Equipment: Passive (or "Step") Attenuator

- **Used to reduce the signal strength getting to the receiver to allow more headroom for direction finding.**

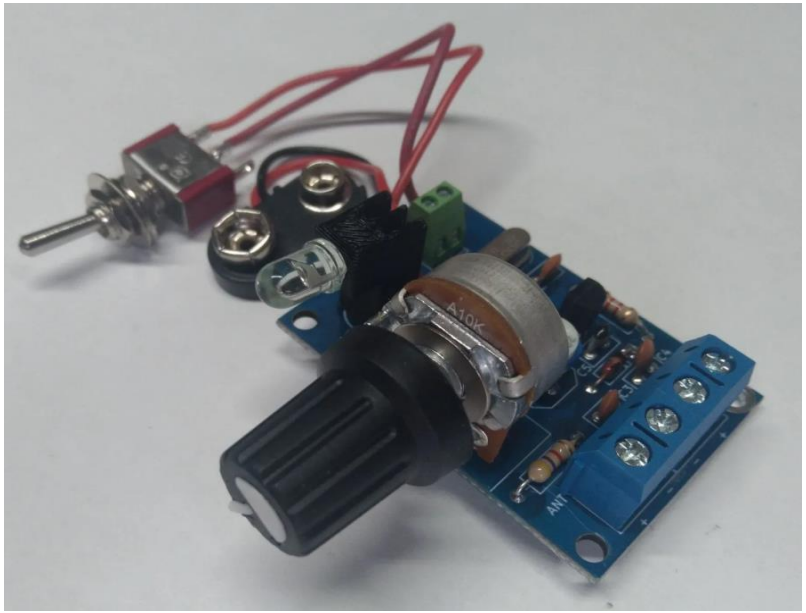
- Has several shielded sections, each with resistors to reduce the RF signal and switches to put each section into and out of the line (adjustable levels).

- The passive attenuator cuts down the RF voltage into the antenna jack, but **strong RF signals may still penetrate the case of the receiver (and/or attenuator), making DF difficult or impossible.**

Technique/Equipment: “Active”, “Mixing”, or “Offset” Attenuator

- **Used to reduce the signal strength getting to the receiver to allow more headroom for direction finding.**
  - **Typically over 80dB of attenuation can be obtained**
- Consists of a Local Oscillator (LO) connected to a diode mixer with an attenuation control.
- **Small and fairly simple to build, or can be purchased.**
- To use, tune your receiver to the frequency of the fox plus (or minus) the LO frequency of the attenuator. I.e. 146.580 MHz + **4 MHz** = 150.58 MHz
- **Easy to use, lightweight, works well, low cost ($10 to $30)**

Technique/Equipment: Offset Attenuator



Offset Attenuator "3rd Planet Solar/KC9ON"
(Kit ~ $10) (Photo used with permission)

Offset Attenuator Photo Art Rew
(Built ~ $35)

Technique/Equipment: Tuning off Frequency / 3rd Harmonic

- Other techniques that can be used when you are close to the transmitter and getting overloaded with RF:
  - Tune 5 kHz or 10 kHz off frequency
  - Tune to the 3rd harmonic of the Transmitter and hunt that signal.
    - Example: If fox frequency is 146.580, x 3 = **439.740 MHz**
    - You will want to test to see if your 2M antenna is directional on 440MHz – or carry a small 440MHz Beam

Technique/Equipment: RSSI Indicators (Accurate Signal Strength)

- Some handheld radios (and some other devices) have an RSSI function (Received Signal Strength Indicator)
- RSSI will provide a much more accurate received signal strength than is shown on most radio “S-meters”
- Readout will typically be in dB, (but may not necessarily be linear or accurately referenced). However this will still be much more useful than a typical S-meter
- **Use of a device with an RSSI indicator may allow you to DF all the way to the device without any attenuation needed.**

Technique/Equipment: RSSI Indicators (Accurate Signal Strength)

- **Quansheng UV-K5 (or UV-K6) Handheld ($30)**
  - Requires a firmware upload to enable the RSSI indicator . (Upload via a “Chirp” cable to the radio).
  - The “F4HWN “ firmware can be set to show an RSSI indication on the display.
  - Easy update - go to firmware web page, plug in CHIRP cable, set radio to upload mode, enable download on web page.
  - The RSSI indicator is fairly linear over a large range of dB.
  - **This may be the simplest/cheapest way to try foxhunting – just this radio and a tape measure Beam**
  - **RSSI readout is small**

RSSI

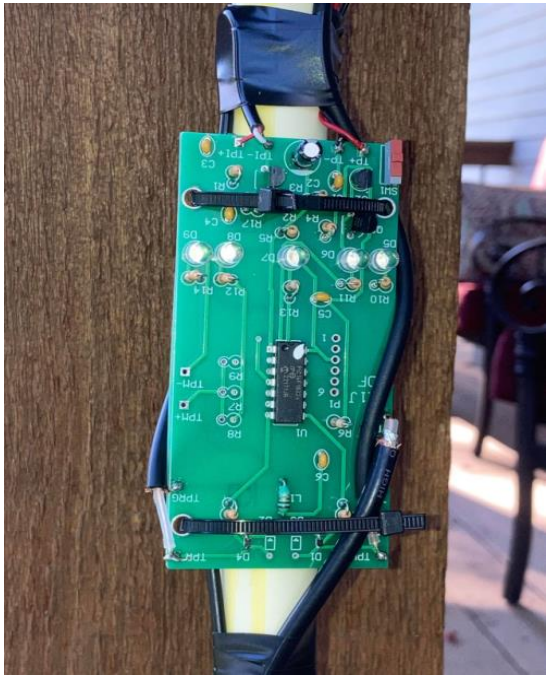
Technique/Equipment: RSSI Indicators (Accurate Signal Strength)

DW-400 RF Field Analyzer

- Receiver and FM demodulator that provides an easy to read RSSI indicator.
- No attenuator needed – can DF right up to (low power) Transmitters.
- Easy to use – good answer for beginners/non-licensed.
- Cost ~ $110 (Alibaba or E-bay)

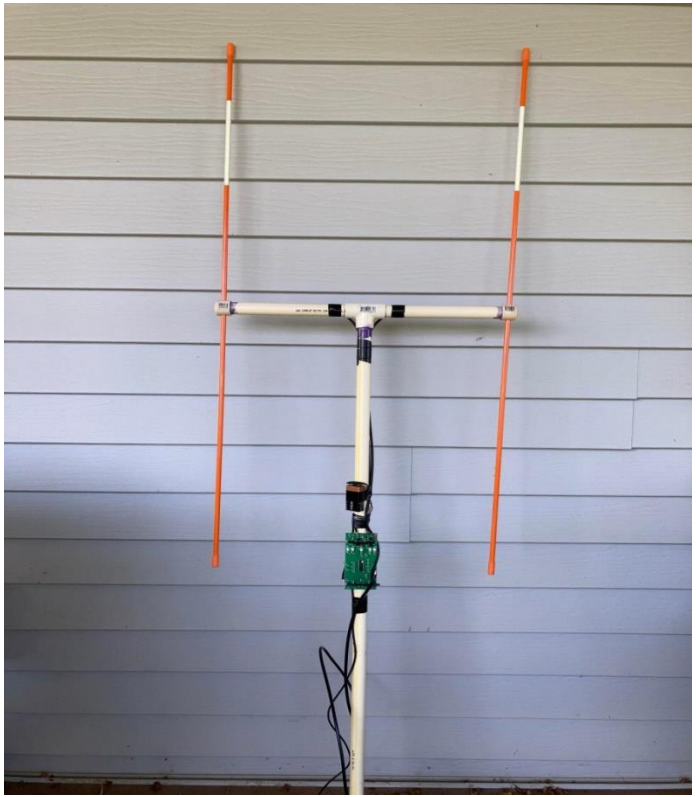
Technique/Equipment: Left/Right Box (Switched Antenna Phase Comparison – or TDOA)

- Paired with a receiver, these RDF units use two receiving antennas, (vertical dipoles) switching rapidly between each**. The phase comparison of the received signal allows the user to determine when the two antennas are equidistant to the transmitter** (via a tone, meter, or display).
- Better units will also provide the user with a Left/Right indication (removing any 180 degree ambiguity)
- Can be used portable or from a vehicle
- **Not typically subject to signal overload (no attenuator needed)**
- **Fairly low cost, or build your own**



NZ1J RDF Photo Art Rew

Technique/Equipment: Left/Right Box
(Switched Antenna Phase Comparison)



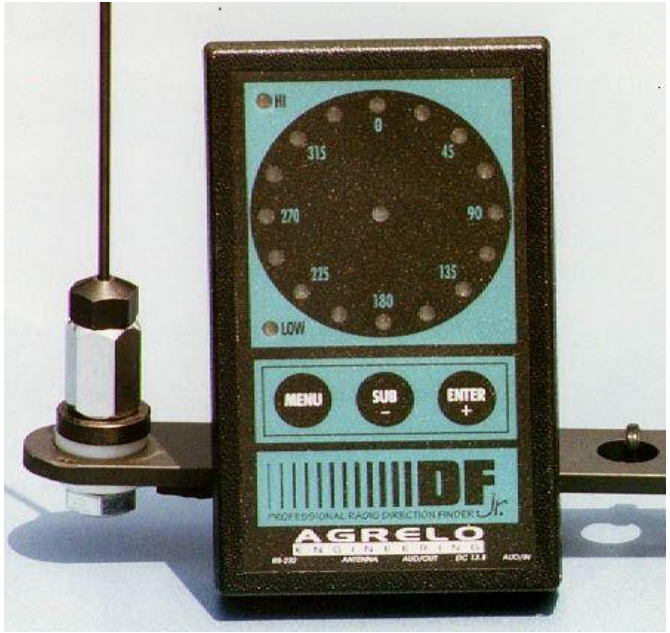
NZ1J RDF and Antenna array Photo Art Rew

NZ1J RDF (repackaged) Photo Art Rew

Technique/Equipment: Doppler

- A Doppler RDF system simulates a “rotating antenna”, which uses the Doppler effect (and some processing) to determine direction to the transmitter.
- Most will use 4 magnetic mount ground-plane antennas attached to roof of vehicle, with the relative direction to the transmitter shown on a display inside the vehicle.
- **Requires no actual mechanical “turning” of antenna**
- Is subject to RF multipath reflections that will reduce accuracy (use while moving). Not typically as accurate as the LED display may indicate.
- **Not typically subject to high signal strength issues (no attenuation needed).**
- **Can be expensive and is not feasible for on-foot/portable use.**

Technique/Equipment: Doppler



Agrelo DFjr Doppler (no longer available)

- PA8W (Netherlands) seems to be the only (ham) currently making RDF units for the amateur radio operator. (PA8Wil@gmail.com)

Technique/Equipment: RF Sniffer

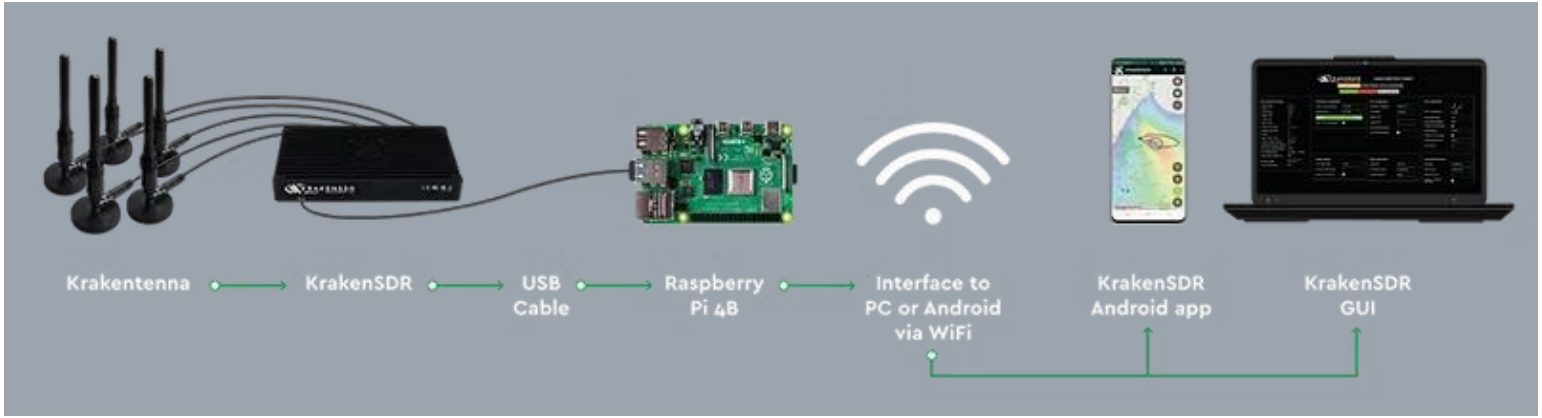
- **A RF Sniffer can be used during the last leg of the search, where there is high signal strength that often overloads other methods.**
- Range may be up to about 1 mile - (depending on sensitivity, TX power, TX antenna, terrain) however it would **typically be used in the last ~ 200 yards of the search.**

- Since it is wideband, it could be subject to sensing other high power transmitters in the area.
- RF Sniffers will typically provide a signal strength (meter) indication, and/or a tone that varies in frequency with signal strength changes.
- **It is fast and intuitive to DF with an Audio tone that changes with RF signal strength.**

N0EX RF Sniffer

Technique/Equipment: Specialized / $$

- **Kracken SDR** https://www.krakenrf.com/
  - Software-defined, coherently operated, five-RX-channel radio based on RTL-SDR. Requires 5 antennas
  - RDF app available for Android devices that displays a map of current location and the calculated transmitter position.
  - Not plug and play. Usually run on a Rasp Pi4. You probably need to be LinuxOS competent for set-up. About $700



Technique/Equipment: Specialized / $$

- **VK3YNG MK4 ARDF Sniffer** http://www.foxhunt.com.au/
  - Auto-ranging RF Sniffer (and receiver) typically used in orienteering type ARDF competitions.
  - Commonly used with Tape Measure Beam
  - Provides audio frequency that varies with RX signal strength
  - No longer produced. $200 - $400

What about the Fox?

- Fox hunts come in many different types, each with its own modified set of rules. Rules will often include start time, start location, defined boundaries, TX antenna polarization, etc.
- The Fox (Transmitter) may be someone in their (parked) vehicle on their mobile rig talking to the hunters, a handheld with a simple timing controller, a standalone programmable module, or a Quansheng UV-K5 with special f/w.
- Typically transmissions will be ON for 30 to 60 seconds, with an OFF time selected to provide a 20% to 50% duty cycle.
- **Select the transmit frequency with care.**
- **If you are hiding a Transmitter in a public area, include a note with what it is and contact information. Also, consider contacting local authorities and notify them of your hunt.**

Transmitter and Label Example

Fox Box and Label Example

Photo Art Rew

What about the Fox?

Byonics Micro Fox (~ $100)
(Transmitter and Controller)
(15mW RF output)
A newer version is available - adjustable 5 to 50 mW

Byonics PicCon Controller (~ $69)
(connect to your Transmitter)

Images from www.byonics.com (used with permission)

What about the Fox? (continued)

- **Build Your Own**
  - If you are an Arduino user/builder, there are many projects you can find on the web as examples if you want to build your own controller.

- **NEW! Use a Quansheng UV-K5 (or UV-K6) Handheld**
  - An Amateur radio operator in Germany has come up with a new firmware release for the UV-K5 that turns it into a standalone Fox Transmitter/Controller.
  - Difficult firmware update. Requires user to manually edit a C program, compile the code, then upload to the radio. Hopefully someone will take the next step and create a version with a menu for the typical selections for a Fox TX.

Setting up the Fox

- **When hiding the Transmitter (or operating as the fox), keep in mind the following recommendations**:

  a) Plenty of signal. If a vehicle hunt, everyone at the start point needs to be able to copy the fox. Run a test of this before the hunt.

  b) Transmit enough. Generally you will want yourself (or the controller) to transmit at least once every two minutes or so for around 0.5 to 1 minute in length. Transmit more to speed up the hunt.

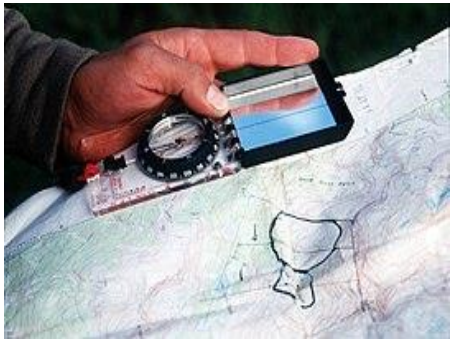
  c) Giving Clues. You can give over the air clues to speed up the hunt, and/or help the last couple of hunters find their way.

  d) Don't make it too hard. If your hunt includes some less experienced hunters, save the hard stuff / funny business for later. Use an omni-directional antenna, vertical antenna polarization, and limit the power output changes. ***The goal is successful hunters having fun!***

  e) Avoid interference. Try not to interfere with the public, and try to make it so the public will not interfere with us – i.e. select areas of low public use. Remember the catch phrase "If you see something, say something"? It would be better if the police are not called during the foxhunt! Avoid busy places. Use public property – stay off of (and away from) private property. Put your name and contact information on the transmitter.

  f) **Consider hunter safety.** Place the fox to try to keep hunters away from un-safe situations.

Maps and Bearings



Public domain, via Wikimedia Commons

Depending on the type of hunt, you may find it advantageous to use a map for plotting bearings.

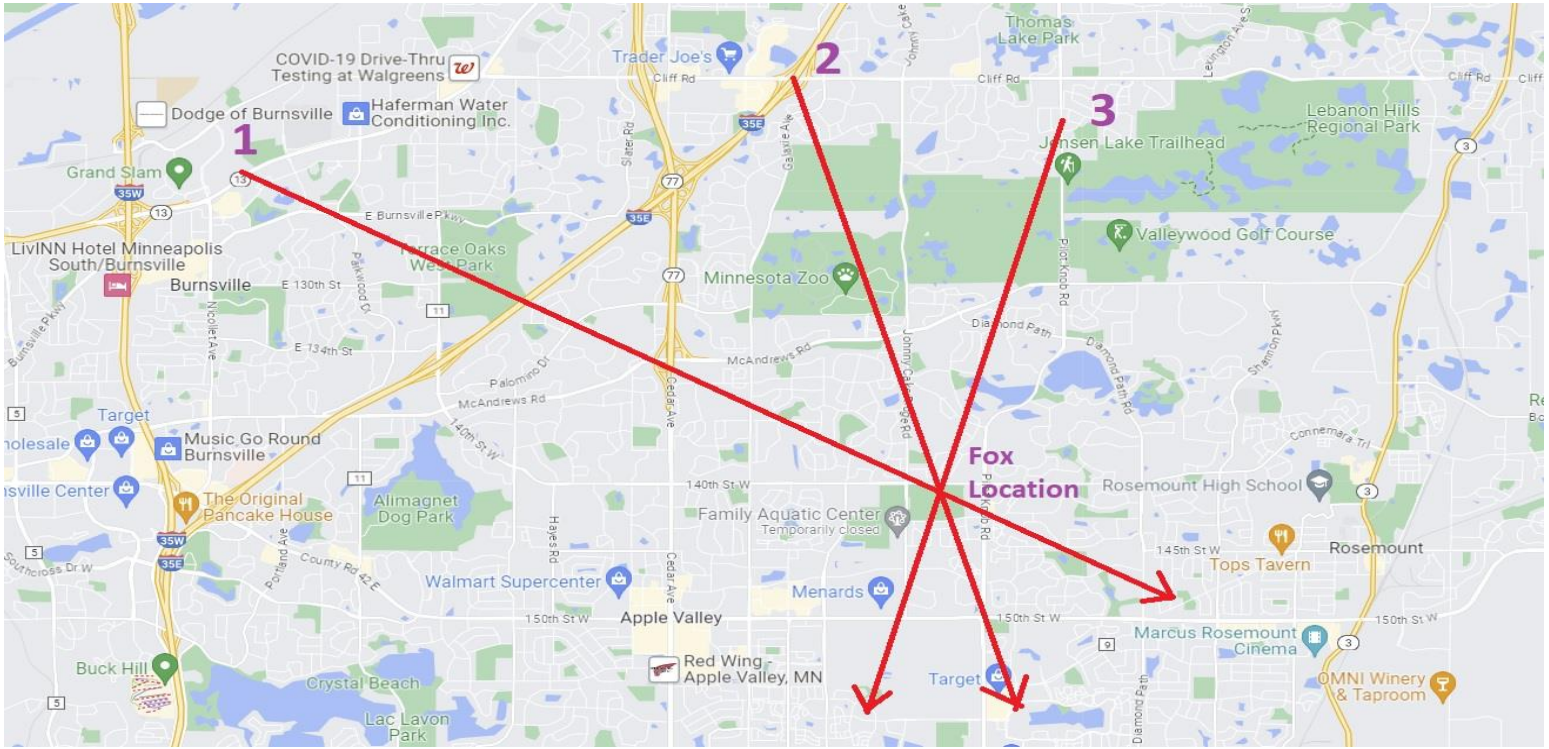
- Will often be helpful for those hunts covering large areas such as a county or larger area. Not usually needed for a short hunt in a park.

Procedure

- Locate yourself on the map
- Use your DF equipment to get best bearing available to the TX
- Draw bearing on map (may need a compass to find your relative direction)
- Two bearings may give you an intersection, but you will likely need 4 or 5 bearings (as you move) to get an idea of the likely TX location.
- Ignore the bearings that do not seem to correlate to the others

Maps and Bearings - continued

Theoretically…..

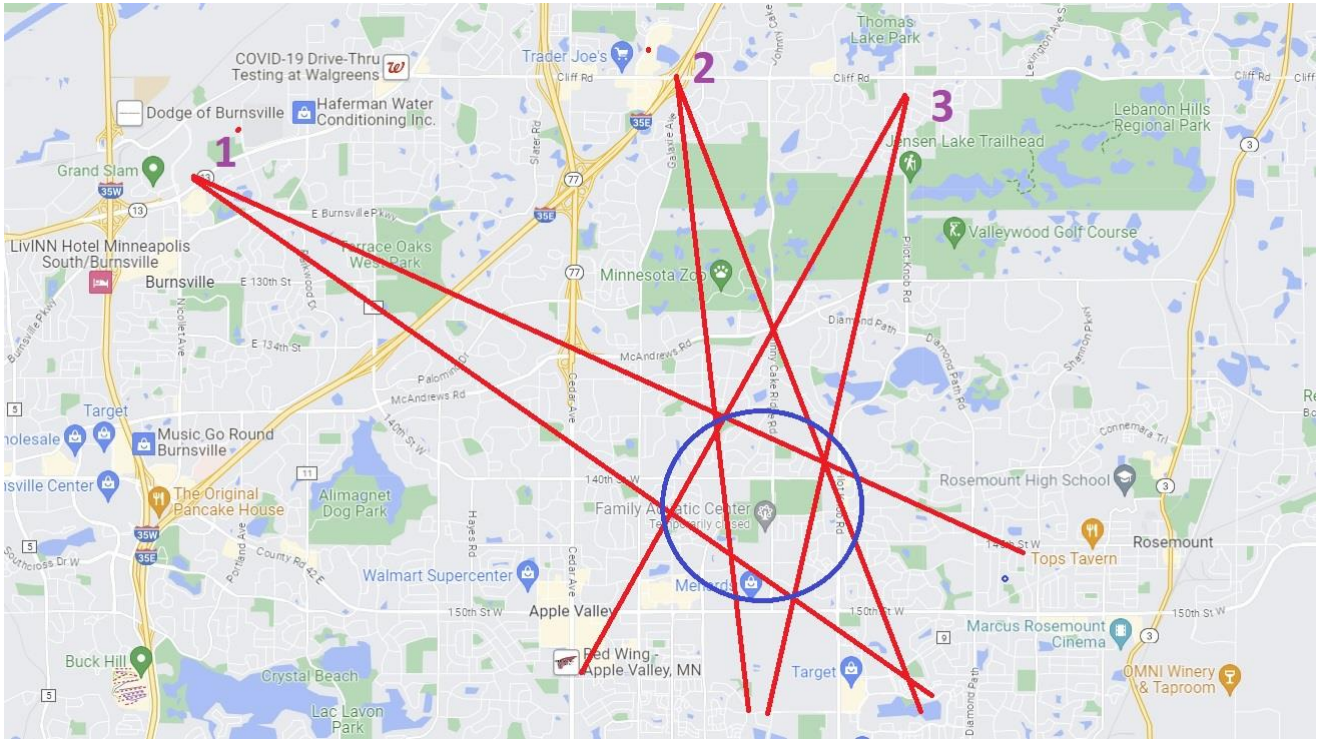


Maps and Bearings - continued

- Bearing (in)accuracy
  - Remember that your bearing is an estimated direction based upon your equipment's accuracy (i.e. beam width of the antenna or the Doppler accuracy), amount of “clean” signal at your exact location, and your accuracy in drawing the bearings on the map.
  - Think of this as narrowing the search to a smaller area, not marking a point on the map and driving right to the Fox.

Maps and Bearings - continued

A bit more realistic…



Maps and Bearings - continued

Automation help - there are apps available for your portable device (Ipad) that can plot your current location, (via GPS) allow you to enter bearings, and it will plot the bearing lines.

- SigTrax – Seems to be the most used. Available for IOS or Android devices.
- Map-n-Compass – Older, not sure if still supported

What do I need to get started? Portable

- For on-foot hunts, or hunts where there is likely only a short drive, a hunter can start with the following:
  1) Handheld receiver
  2) Tape measure beam antenna
  3) Attenuator or RF Sniffer

OR

  1) Quansheng UV-K6 with RSSI firmware mod
  2) Tape measure beam antenna

OR

  1) Handheld receiver
  2) Left/Right phase comparator (TDOA) RDF with dedicated antenna

What do I need to get started? Mobile

- For mobile hunts, a hunter can start with the following:
  1) Quansheng UV-K6 with RSSI firmware mod
     (Or receiver with active attenuator).
  2) Short beam mounted on vehicle that can be safely rotated from inside the vehicle (by a passenger).

OR

  1) Receiver
  2) Left/Right box with dedicated antenna vehicle that can be safely rotated from inside the vehicle (by a passenger).
     - May be advantageous to have a short beam accessible for hunts where there is low signal strength at start.

Foxhunting Hints for Success

Safety. Do not drive a vehicle and operate RDF equipment at the same time!

Scott Davidson, CC2.0, Wikipedia Commons

- **Practice!** Practice with your equipment so you have experience in its operation, understand what its "telling" you, and know how to use it when needed.

- **The effectiveness of most of these types of RDF equipment is enhanced when used "in motion",** as the movement will reduce (average) the effects of RF reflections.

Foxhunting Hints (continued)

- **Transmitter hunting gets more difficult as you get closer and get into very high signal strengths.** Have some way to reduce the RF level into your receiver, (attenuation) or other tools to search for a high strength signal (RF sniffer).

- **Carry a second handheld receiver with you** (in vehicle or on foot) with its antenna removed. This will function as an alert that you are “very close”. (Squelch on, volume up).

- **Don’t burn out your equipment!** When using a transceiver with a Left/Right RDF or Doppler device be sure to **disable the Transmit capability on the radio.**

Where/When are the hunts?

- As of this date, there is no typical “Schedule” of Foxhunts in the Twin Cities metro area (or even Minnesota).
- For at least the past few years, various people (and amateur radio clubs) have put-on a hunt periodically – once/twice per year.
  - Matt (K0LWC) has put on several foxhunts associated with the (no longer active) “MN Ham Radio” Website
  - Bill (AE0EE) has put on several hunts
  - SEMARC - Southeast MN Amateur Radio Club – (primarily Dan, WD0GUP) has typically set-up 2 hunts/year.
  - The RBWMS (Faribault) – has recently tried to get foxhunts going on a monthly basis (after their 3rd Saturday Meeting).
  - Some Hamfests will have a hunt.
  - Other active foxhunters in the area have organized a hunt.

Where/When are the hunts? (continued)

- **Ideas to find local hunts:**
  - Check with your local club and review other clubs on-line newsletters for possible foxhunts.
  - Monitor the MN Ham Radio Discord Fox-Hunting channel for hunt announcements
  - Monitor the “MN Transmitter Hunting” Facebook page for hunt announcements.
  - Monitor (or ask on) local 2M nets for info on upcoming foxhunts
  - **Set-up a hunt for/with your friends and/or local club**

References/Additional Information

- **Homing In (website)** http://homingin.com/
  - Large amount of transmitter hunting information. Good place to start RDF research.
- **Book:** TRANSMITTER HUNTING, Radio Direction Finding Simplified By Joseph D. Moell, KØOV, and Thomas N. Curlee, WB6UZZ (A good reference, the best information in its time, now quite dated)
- **RDF Tips:** http://146970.com/PDFs/RDFing.pdf
  - A short document (17 pages) on Transmitter Hunting by VE3RRD.
- **Byonics** – https://byonics.com/products
  - Foxhunt transmitters, controllers, and offset attenuators for sale.
- **Tape Measure Beam Plans (WB2HOL):** https://wparc.us/hints-sub/hints-pdf/tape_measure_df_antenna.pdf

References/Additional Information (continued)

- **Offset Attenuators:** https://www.tindie.com/products/3rdplanetsolar/fox-hunt-offset-attenuator-kit/

- **NZ1J TDOA unit:** https://www.youtube.com/watch?v=mNqUKYkifOo
  Video demo of a TDOA unit. YouTube description gives Parts list, contact info.

- **RDF Sniffer and TDOA videos: (by the presenter)**
  https://www.youtube.com/@RDFfun Demos of RDF equipment.

- **Facebook Groups:**
  - MN Hidden TX Finders: https://www.facebook.com/groups/1029978110952731
  - **MN Transmitter Hunting:** https://www.facebook.com/groups/373314538221951
  - Amateur Radio DF: https://www.facebook.com/groups/1837252043166688

- **Discord Group:**
  - Minnesota Ham Radio: https://discord.com/channels/961081286443810827

Wrap-up

- Questions?
- Please fill out the Attendee/Interest form

Thanks for your interest – we hope to see you at a FOXHUNT!