# Transmitter Hunting: Tracking Down the Fun

*Part 2*– Now that you've had a taste of T-hunting and how much fun it can be, let's take a look at some more advanced technology and hunting techniques.

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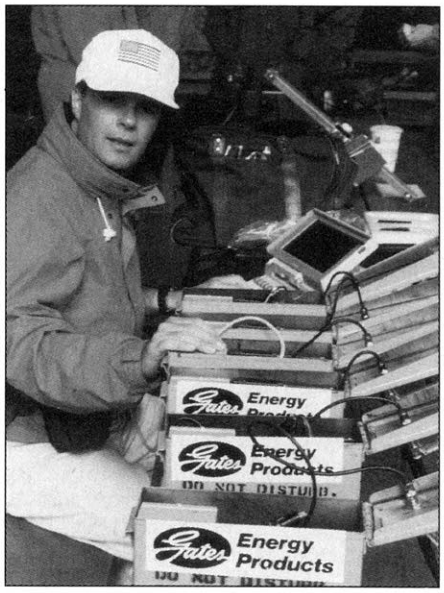
JaMi Smith, KK6CU, shows his ingenuity with this motorized mobile quad for transmitter hunting. It spins at 40 RPM and displays bearings on a storage oscilloscope monitor inside. (*photos by the author*)

### Adding to Your Transmitter Hunting Arsenal

The gain of a mobile beam makes it unexcelled for weak-signal competitive hunts and for locating low-level interference such as TV cable leakage. With an appropriate receiver, you can get bearings on any signal mode, including FM, SSB, CW, TV and noise. For best performance, your receiver should have a sensitive S-meter in an easily seen location.

If signals are arriving from multiple directions (multipath), the meter will show them all as the antenna is manually rotated. You can make educated guesses as to which signal peaks are direct and which are from non-direct paths or scattering. You can even transmit through the beam, if necessary, but use care not to burn out your attenuator.

The 3-dB beamwidth of typical mobile-mount VHF beams is on the order of ±40°, so don't expect to get pinpoint bearing accuracy. Errors of less than 10° are achievable with careful meter reading. In practice, this is not a problem because readings are used primarily to give the general direction of travel to "home in."




When is a fox not a fox? When it's a transmitter built inside a waterproof ammo can! The sealed, all-metal cases protect the hidden transmitters inside from physical damage, the elements and so on. Note the stenciled message on the side (in case a non-foxhunter finds the fox first!).

Your problems with beam foxhunting are greatest when signal levels vary rapidly. The hider may be changing transmitter power, or there may be local influences if the hider's antenna is moving, or is near a well-traveled road or airport. Rapid S-meter movement caused by such motion makes the taking of accurate bearings much more difficult. The process is slow because the antenna must be carefully rotated by hand. Under these conditions, a Doppler or homing RDF set will work better.

### T-Hunting Tips and Techniques

While some mobile hunters prefer to go it alone, most have more success by teaming up and assigning tasks. The driver concentrates on handling the vehicle, while the DFer turns the beam, reads the meters and calls out bearings. The DFer is also responsible for maps and plotting, unless there is a third team member assigned to that task.

Getting a "fix on the fox" with a VHF beam antenna is intuitive and easy. Just rotate the mast and look for the greatest receiver S-meter reading. Note the direction of the beam heading and draw a line of bearing on your map.

If your mobile antenna mast does not have a high-precision indicator, sight along the antenna boom with a compass to get a bearing. Don't forget to correct your compass (magnetic) bearing by the magnetic declination in your area, to give a true (relative to North Pole) bearing for plotting.

Bearings from different locations (taken by you or others) can be triangulated to determine the point of intersection. Triangulation does not provide pinpoint accuracy, but it can give you a good idea of how far you are from the fox. It works best when the bearings are highly accurate and come from widely separated directions.

Since the objective is to proceed to the hidden T with minimum time and mileage, don't go too far out of your way to get off-course bearings for triangulation. It's usually better to take the shortest route along your initial line of bearing and "home in" on the signal. With a little experience, you'll be able to gauge your distance from the fox by noting the amount of attenuation needed to keep the S meter on scale.

### If You Hide It, They Will Come

You say you'd like to go T-hunting, but there are no hunts in your area? No problem—it's easy to get started. Just schedule a hunt and put out the word. Saturday mornings and Sunday afternoons are popular for beginners events. Some groups like to hold hunts on a weekday evening right after a repeater net.

Make the first hunt easy and keep the boundaries small. Encourage everyone to come out, even if they don't have any RDF gear. When they find you using the body fade or hot/cold driving, they will be eager to start work on "real" RDF equipment.

After just a few starter events, you'll have a solid cadre of regular T-hunters, eager for new challenges. Then you can open up the boundaries and increase the level of difficulty.

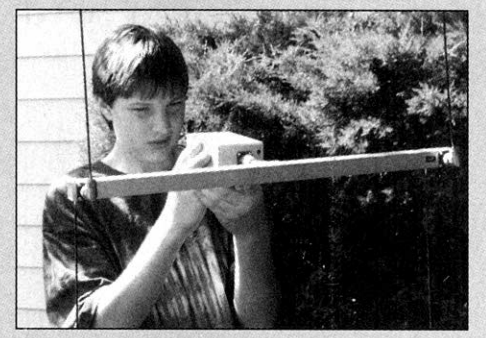
Give careful thought to how the hunt is scored. The obvious way is to award first place to the first team to find the T. Sprint hunts test the hunters' preparation to quickly find jammers or stations in distress. Hunters can start anywhere. But an unlucky traffic break or starting point choice can mean the difference between winning and losing. Newcomers to the area will be at a disadvantage because they're unfamiliar with the territory. It may

## Sniff Better with a Homing Set

Another type of RDF instrument, called the homing or switched-antenna RDF, has its place in the well-equipped T-hunter's bag of tricks. Homing RDF sets feature a pair of vertical antennas and a control box with some sort of left-right indicator, such as a meter or pair of LEDs.

They are easy to use: When the indicator says "left," turn the unit left; when it indicates "right," turn right. There is a sharply defined crossover of the indicator when the unit points toward the signal source direction.

The first homing RDF sets switched the vertical antennas rapidly between two opposing cardioid patterns. These sets required AM detection and RF attenuators. They remain popular among aircraft search/rescue volunteers.[1]



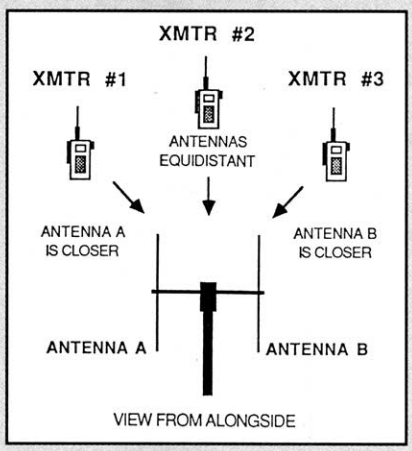
TDOA RDF sets are excellent for on-foot sniffing. They work with all types of VHF-FM handi-talkies and scanners. Eric Jensen of Nebraska City, Nebraska, is learning to follow the left-right LED indicator to find the fox.

### Time Difference of Arrival (TDOA)

Another homing RDF technique makes use of the difference of arrival times of the signal wavefront at the two antennas. It has gained favor with hams because it works with VHF-FM hand-helds and mobiles. No RF attenuator is needed, no matter how close you are to the fox.

The antennas are alternately switched at an audio rate to the receiver input. Differences in the arrival times produce phase changes, readily detected by an FM discriminator. The resulting short pulses are heard as a tone in the receiver output. Polarity of the pulses is a function of which antenna is closer to the source. The display unit processes the pulses and drives the left/right indicators. The tone disappears when the antennas are equidistant from the signal source, giving an audible null.

Three practical designs for home-brew TDOA RDF sets are the Handy Tracker,[2] the W9DUU DF,[3] and the modified Double Ducky.[4,5] The SuperDF, a commercial unit capable of operation from the aircraft band through 70 centimeters, is available from BMG Engineering.[6]




A TDOA RDF set senses which of its antennas is closer to the transmitted signal. The signal from transmitter no. 1 reaches antenna A before it reaches antenna B. When the plane of the antenna is perpendicular to the signal source (transmitter no. 2), the signal arrives at both antennas simultaneously.

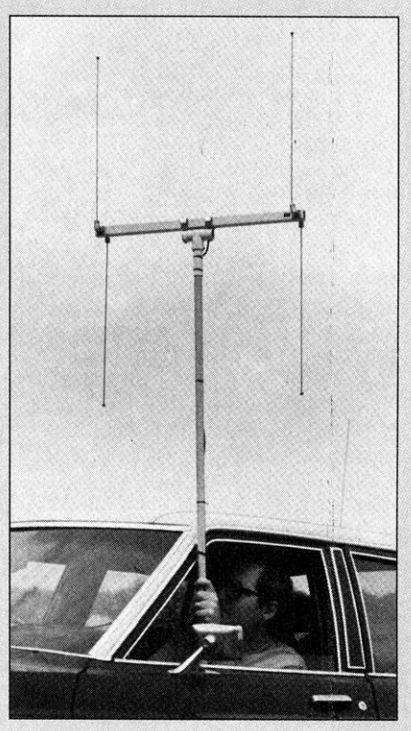
### TDOAs Versus Beams

Dual antenna RDFs make good on-foot sniffing devices. TDOA sets are superior mobile performers when there are rapid amplitude variations in the signal (if the hider is varying power, for example). They are a popular choice for airborne RDF, because it's easy for a pilot to fly to the signal source by following the left-right direction indicators.

Compared to Yagis and quads, TDOA sets give directional performance over a much wider frequency range. Their indications are more precise than those of beams with broad forward lobes. But they frequently give inaccurate bearings in severe multipath situations, because they cannot resolve signals of nearly equal levels from more than one direction.

The best way to overcome multipath with a TDOA set is to take frequent readings while in motion toward the transmitter. This averages out the effects of reflections, making the direct signal more readily discernible.

Switched-antenna RDFs generally do not perform well when the incoming signal is entirely horizontally polarized. In such cases, bearings may be inaccurate or even indeterminate. TDOA units require carrier-type signals such as FM or CW; they usually cannot get bearings on noise or pulsed signals.



A set of TDOA antennas is lightweight and mounts readily through a sedan window without excessive overhang. (*photo by Tom Curlee, WB6UZZ*))

Unless an additional method is employed to measure signal strength, it is easy to overshoot the hidden transmitter location with a TDOA set. I have seen TDOA foxhunters walk over the top of a buried transmitter and walk away, following the opposite 180-degree null. When sniffing with a TDOA set, check your range by removing the antenna connection on your hand-held occasionally. If you can still hear the signal, you may be within a few yards of the fox!—*KØOV*

**Notes:**

[1] The L-Per, a self-contained four-channel, crystal-controlled, switched-pattern RDF set, is available from L-Tronics, 5546 Cathedral Oaks Road, Santa Barbara, CA 93111, 805-967-4859.

[2] J. Moell, "Build the Handy Tracker," *73*, Sep 1989, pp 58-59 and Nov 1989, pp 52-53.

[3] P. Bohrer, "Foxhunt Radio Direction Finder," *73*, Jul 1990, pp 9-11.

[4] D. Geiser, "Double-Ducky Direction Finder," *QST*, Jul 1981, pp 11-14.

[5] D. Geiser, "Updating the Double-Ducky Direction Finder," *QST*, May 1982, pp 15-17.

[6] 9935 Garibaldi Avenue, Temple City, CA 91780, 818-285-6963.

encourage unsafe driving.

In southern California, the winner of most hunts is determined by lowest elapsed mileage, not the shortest time. This encourages safe driving and careful map reading. Occasionally the last, but most careful, team to find the T wins!

All teams must start a mileage hunt from the same point, usually a hilltop, so that odometer readings can be taken. Resolve odometer calibration differences by requesting hunters to obtain a correction factor by driving a standardized course in advance of the hunt, or after.

### World-Class Hiding

As the "hounds" increase their level of expertise, it will become tough for the fox to keep them away. Successfully hiding a trans-

### Dopplers Give Bearings Automatically

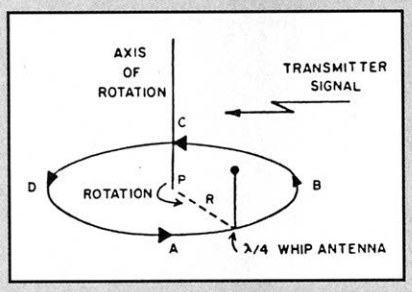
An ideal RDF system would eliminate manual antenna turning. It would take directional readings hundreds of times per second and continue to indicate the direction of bearing after the signal leaves the air. Its antenna would go on top of any car quickly, with no holes to drill.

Doppler RDF sets, though not ideal, fulfill all these wishes. They automate the bearing-taking process. The direction of the signal source relative to the vehicle heading appears on a circular ring of LEDs.

The name comes from the Doppler effect, the same phenomenon you have observed when a car or train goes by with its horn sounding. The horn's apparent pitch rises as the car approaches and falls as the car recedes. Similarly, the perceived radio frequency increases as a receiving antenna moves rapidly toward the emitter, and vice versa.

Dopplers simulate a moving antenna with a set of four or eight whips or vertical dipoles, switched in sequence to the receiver with RF diodes. To the receiver, it appears that the antenna is going around several hundred times per second. Incoming signals are shifted up and down in frequency slightly every rotation, resulting in a sine wave (tone) superimposed on the modulation at the output of the receiver's FM detector. The frequency of this tone equals the pseudo-rotation rate. The relative phase of the tone is detected by the display unit to determine the direction of arrival of the signal.

The Roanoke Doppler[1] and DoppleScAnt[2] are mobile Doppler RDF designs that can be home-brewed inexpensively. Doppler Systems Incorporated[3] manufactures a line of Dopplers featuring optional amenities such as voice and telemetry outputs.




A theoretical Doppler antenna circles around point P, continuously moving toward and away from the signal source at an audio rate. The effect is simulated by sequentially switching whips at points A, B, C and D.

### Up Sides and Down Sides

Dopplers simplify mobile RDF. There are no moving parts and no manual antenna pointing duties. Rapid bearings can be obtained on very short signal bursts. The hidden T's power variations cause no difficulties, as long as the signal remains above the RDF detection threshold. Dopplers excel at chasing foxes that are mobile.

A Doppler does not provide superior performance in some situations, however. If the signal is too weak for detection by the Doppler unit, the hunt advantage goes to teams with high-gain beams. Doppler antennas are too cumbersome for on-foot sniffing. The limitations of other switched-antenna RDFs also apply: poor results with horizontally polarized signals, no indication of distance, detection of carrier-type signals only, and inadvisability of transmitting through the antenna.

Digital readout to the nearest degree is available on some commercial Doppler models, but this does not mean that accuracy is within a degree. A well-designed four-antenna set typically has ±5 degree accuracy on 2 meters under the best conditions (a vertically polarized transmitter signal with no multipath distortion present). "Eyeball" averaging while the vehicle is moving helps counteract multipath.

Is a Doppler the best RDF choice for you? It depends on what you hunt and where you hunt. Because of inferior sensitivity and poor horizontal performance compared to beam setups, Dopplers have not caught on in southern California, the land of the weak-signal horizontal hunt. But in cities such as Phoenix, where hider's signals are always strong and vertically polarized, they are used by most teams. Some Phoenix teams have installed both a beam and a Doppler set.

Many Local Interference Committee members choose Dopplers for tracking malicious QRM because they are inconspicuous (compared to beams) and effective at tracking the strong vertically polarized signals that "jammers" usually emit.—*KØOV*

**Notes:**

[1]Construction plans in *Transmitter Hunting—Radio Direction Finding Simplified*, by J. Moell and T. Curlee, TAB Books, Blue Ridge Summit, PA, pp 123-136.

[2]Rogers, "A DoppleScAnt," *QST*, May 1978, pp 24-28; Feedback: Jul 1978, p 13.

[3] PO Box 2780, Carefree, AZ 85377 602-488-9755.

mitter then becomes as much of a challenge as finding one. But it's worth it when you get to sit back and watch hunters scurrying about trying to find you. Try to select a combination of location and antenna that makes it difficult for the hunters to get reliable bearings. Like a ventriloquist, a good hider can make the signal appear to be coming from some other location.

Good hiders are not content just to see how far away they can be. They delight in finding unusual roads, preferably not on the maps. They look for large terrain features to bounce VHF signals from, and devilish ways to conceal their transmitting setup. They have used such exotic antennas as rhombics and helicals to put "English" on the signal and deceive the searchers.

With careful antenna choice and placement, the signal will cause the hunters to approach the transmitter from the most difficult path, with impassable roads or other obstructions, even though the T is easily accessible from other directions.

Perhaps you can camouflage the setup so well that the hunters won't notice the transmitter unless they literally trip over it. Clever hiders have radiated signals from sprinkler pipes, soda cans (a really tiny transmitter!), baby carriages, shopping carts, survey markers and the ac wiring (it wasn't connected to the mains!) of a home under construction. Unleash your imagination!

You probably have some great ideas for disguised antennas and hiding spots in your area. But in most towns, the only way to get to hide is to win a hunt. So get started on your own RDF setup now, and find out the local foxhunt schedule.

If you're ever in my area (Orange County, California), check the T-hunt frequency: 146.565 MHz. If it's a weekend, a hunt will probably be in progress. If not, give a call. Hunters may be lurking, ready to tell you the latest tall tales. See you on the hunt!

*Joe Moell, KØOV, went on his first hidden transmitter hunt as a Novice in Nebraska at age 11, using the loop from the back of an AM broadcast radio. Almost 20 years later, he and his wife (April, WA6OPS) overheard the start of a southern California 2-meter T-hunt. It sounded like a great "togetherness" activity, so they gave it a try. They have been hunting regularly ever since.*

*Joe has teamed up with Tom Curlee, WB6UZZ, to write a full-length book on RDF. "Transmitter Hunting—Radio Direction Finding Simplified," published by Tab Books and available from the ARRL Bookstore, is the most comprehensive reference available on amateur T-hunting.*

*Joe, a registered Professional Engineer, serves as a Technical Advisor to ARRL Headquarters on RDF. By day, he designs high-power radar transmitters for Hughes Aircraft Company. When not tracking hidden T's, or hiding them, he and April enjoy public service and teaching Amateur Radio classes.*

# Strays

### *QST* congratulates...

◊ Michael "Sparky" Terry, KD4KL, on his election to vice chairman of the Interdepartment Radio Advisory Committee (IRAC). The IRAC is made up of representatives of 20 US government agencies active in telecommunications. It advises the Department of Commerce and the National Telecommunications and Information Administration (NTIA), *inter alia*, on spectrum allocations and planning. Sparky has been the Department of the Interior's IRAC representative for several years.