Your 2 Meter Mobile Antenna – What's the Best Mounting Location?

Where you mount that antenna makes a difference. Antenna modeling gives us some answers.

John Portune, W6NBC

Does it matter where you put a dual band 2 meter and 70 cm antenna on your car? Some may say, "Who cares, I only work local repeaters and rarely do simplex?" Well just the other day I heard a local ham bemoaning, "I wish I could talk to my regular repeater better from this location." Perhaps he could if he'd just move his antenna to a different spot on his car.

Perhaps you haven't thought about it because you never saw a systematic technical comparison of the results of car antenna mounting positions. Hams normally just consider appearance and convenience. But there is a better method. This basic analysis may change your opinion.

This simple, yet systematic, look at antenna placement uses radiation patterns generated by *EZNEC*, a respected PC antenna modeling program that provides a friendly input/output language for the *Numerical Electromagnetic Code*.[1] It is a simple-to-use but powerful tool that has opened my eyes about many antennas over the years.

We'll model a typical 2 meter, 19 inch whip at five popular locations on a car:

1) roof top, dead center,
2) roof top, side,
3) rear window, top, center (glass mount),
4) trunk lid, dead center and
5) trunk lid, side, front.

The relative results are also valid for a higher-gain antenna or a dual band antenna while used on 2 meters.

To evaluate a VHF/UHF antenna on a car, we only need to look at the horizontal (azimuth) radiation patterns. *EZNEC* generates vertical (elevation) patterns as well, but in these cases they are all very similar, indicating little about the best mounting locations.

The Wire-Frame Model

The first step was to construct a wire-frame model of the vehicle to mount the antenna on. It is a rectangular grid of wires in the shape of the car, with wires spaced less than a ¼ wavelength apart. It was built in the WIRES function of *EZNEC*. Note that this model is made of far more than the 25 segments supported by the demo version of *EZNEC*. This requires either of two purchased versions of the program, *EZNEC+* or *EZNEC PRO*. These allow for the large number of wire segments used in the model.

A wire spacing of less than ¼ wavelength makes the wire-frame appear as a solid metal surface to the model. My first model was of a ¾ ton standard pickup truck with a metal toolbox. Here it's for an average sedan measuring 15 × 6 × 5 feet (LWH) and 6 inches off the ground. See Figure 2 (red outline). I simplified the car's shape as shown to make the wire-frame easier to construct (black outline). This causes only tiny differences in the radiation patterns.

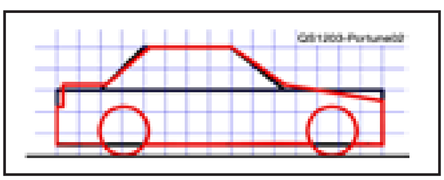

Figure 1 — Side view of *EZNEC* model of sedan. Details of the wire grid are shown in Figure 2.

I mention the pickup truck only because the patterns are quite similar to those of the sedan. This suggests that the results are valid for a wide variety of vehicles. Readers who are familiar with using *EZNEC* may find it enlightening to repeat the process for a van or an RV, either metal skinned or of partially synthetic construction. You may discover that some common antenna mounting maxims need another look.

Top Surfaces Only

While my first version of the sedan's wire-frame included both top and side surfaces, I later I found that the vertical surfaces have almost no effect on the radiation patterns. Therefore, I dropped them from wire frame. This allowed me to use my available segment count to define a closer wire spacing that provides improved accuracy.

The Radiation Patterns

Figure 3 shows the results — the horizontal (azimuth) patterns of a ¼ wave

[1]Several versions of *EZNEC* antenna modeling software are available from developer Roy Lewallen, W7EL, at **www.eznec.com**.

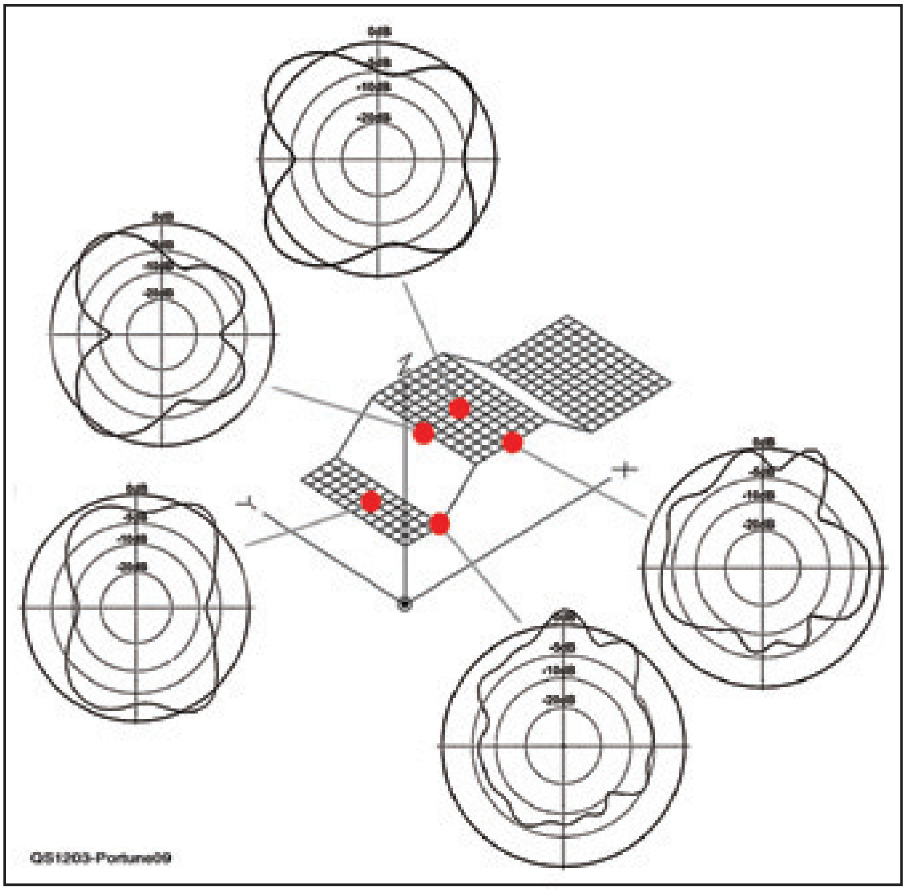

Figure 2 — *EZNEC* azimuth patterns of ¼ wave 2 meter whip antennas mounted at various locations on a wire grid model of the sedan shown in Figure 1. As shown, the center of the top provides the best pattern, followed by the center of the trunk lid.

2 meter whip at the five common locations. They are actual *EZNEC* plots just graphically simplified for clarity. In each plot I've also included a reference antenna. It too is a 19 inch long whip, but mounted over a perfect ground plane, not over the wire frame. As theory predicts, its pattern is omnidirectional (the outer circle). The dotted scales of each figure are in relative dB. (The front of the sedan is to the right.)

The dotted scales are dBi (*EZNEC*'s usual output), that is, gain compared to an isotropic radiator. I adjusted each plot to the same scale to provide a uniform comparison of all five and the reference antenna.

From these plots we can now derive some very useful guidelines for installing a mobile VHF/UHF antenna. Three seem evident to me. If readers see others, I would appreciate hearing from you.

Antenna Mounting Rules of Thumb

■ *There are always lobes*. Even though a car's body is large enough to provide an efficient ground plane for a VHF antenna, the azimuth pattern is never truly omnidirectional, as is evident from the plots. Note the lobes, and in particular notice the 2 S-unit (12 dB) field strength difference, direction to direction.

To give a practical use of this, in a weak signal area of a repeater's coverage, knowing where the gain and loss is relative to your car, can make a big difference. By simply moving your antenna, a troublesome dead spot on a regular commute may vanish without any significant compromise to repeater access in other areas. This is what the ham above needed to know.

■ *Center is better*. Figure 3 illustrates the disadvantage of mounting an antenna off the center line of the vehicle — either side to side or front to back. The reason? Off-center locations always create relative gain, diametrically across the vehicle, and also loss on the same side.

Transmitter hunters, for example, often use this pattern phenomenon. On HF transmitter hunts, directional antennas are much too large to mount on a car. But with only a simple HF whip mounted at an end of the rear bumper — normally the poorest mounting location — they can find the strongest signal direction by simply driving their cars in small circles. For this application, the pattern lobes are an advantage.

For the usual 2 meter/70 cm mobile installation, chose an on-center location if possible.

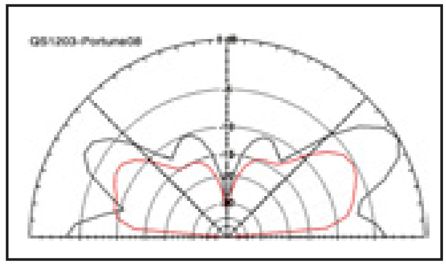

Figure 3 — Elevation plot of a 2 meter whip mounted at the dead center of the roof (red) over average soil, compared to the same configuration over a perfect ground plane (black). Note the loss of low angle radiation — more than a full S-unit.

This can be on any one of your vehicle's large horizontal surfaces, such as the trunk lid or the roof top. Notice the non-symmetry of the patterns from off-center locations. This to me is the most valuable rule of thumb of this little analysis.

■ *Higher is better*. The figures also demonstrate the value of a higher mounting position. Surprisingly, though, it isn't as much of a factor as some hams may believe. Therefore, also using the rule above, a lower on-center position is often better than a higher off-center location. I have not even bothered to show an end of the bumper mount, as the transmitter hunters use. The radiation pattern there has the largest irregularity.

My Own Preference

On my pickup truck, a work vehicle, I located the VHF/UHF antenna in the dead center of the roof top. Here, where appearance is not a big concern, it is the best choice. On my family sedan, I usually prefer dead center of the trunk lid. A magnetic roof mount in the middle of the roof is also good, though less attractive. Alternately on a pickup truck, the center of a metal toolbox is also a reasonable choice. It is similar to the center of the trunk lid on a car. Now that I have done these plots, however, I never mount a VHF/UHF antenna off-center, side to side or front to back.

Finally, here is an interesting observation that came out of this study. I have long known that low angle radiation from an HF mobile antenna is poor over average soil, but I did not expect to see the effect to any degree at VHF. I was therefore surprised to discover that the type of ground under a vehicle, even at VHF, does significantly still affect the radiation pattern for a 2 meter antenna at low angles. This is where we want our signals to be the strongest. Notice Figure 3, an elevation response plot.

What can you do about this? Nothing in most cases. Though if some day you are a long way away from a repeater and just barely making it in, try moving your car from dry ground to a moist green grassy area, or with such an area near the vehicle in the path to the repeater. This may just make the difference between a satisfactory contact and the dreaded "no copy old man" report.

HF Mobile Antennas

After looking at antenna placement on VHF, I repeated this process for HF. Not surprisingly my additional modeling showed that location effects are proportionately less significant at lower frequency and small but measurable on the lowest HF bands. Therefore one of my new rules of thumb for a 75 or 40 meter whip is that location on a vehicle isn't a major issue. For 20 meters and up, however, there is more benefit to picking the best location.

My other rule of thumb for HF is, mount the antenna as high as possible. A bumper is still a poor choice, mostly because of nearby metal. Half way up the rear ladder on a smooth-sided fiberglass RV is generally the best, provided that the ladder is well grounded to the RV's metal frame with wide straps. Also, as much of the antenna as possible should be above the vehicle body. It is normally not a good idea to put an HF antenna on top of a fiberglass RV. The ground plane will be compromised too much. On a metal-skinned RV it's a great place, if you don't drive down many tree lined avenues, or eat at drive-through restaurants.

For 2 meters, however, top mounting on an RV is an excellent choice, as long as you provide an adequate ground plane. Remember, the same rules of thumb that apply to cars also apply to fiberglass RVs. A large metal surface or a wire grid of at least half a wavelength in extent is just as necessary here as it is on a car. A metal roof-top luggage rack is only a fair alternate. It has notable lobes.

Photo by the author.

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John Portune, W6NBC, received a BSc in physics from Oregon State University in 1960 and a BA in liberal arts and communications from Ambassador College in Pasadena, California in 1963. He earned an FCC Commercial General Radiotelephone license and an FCC Radiotelegraph license. John retired as a broadcast television engineer and technical instructor at KNBC in Burbank and then from Sony Electronics in San Jose, California. John received his Advanced class amateur license in 1965. He spent five years in England as G5AJH and upgraded to Amateur Extra class in 1987. John is active on many bands and modes, predominantly from his HF equipped RV mobile station. He has written various articles in ham radio and popular electronics magazines and remains active as a VE team leader, ham license teacher and website designer. You can reach John at 1095 W McCoy Ln #99, Santa Maria, CA 93455, or at **jportune@aol.com**.