By Robert Gulley AK3Q

Emergency operations and training are excellent opportunities for amateurs to put their radio and antenna knowledge to use. We study propagation and antenna radiation patterns in an effort to know both how our signals are going to be received and where they are going. Nowhere is this more important than dealing with emergency communications.

NVIS, or *Near Vertical Incident Skywave* antennas are designed to fill the gap between the local coverage we can expect with line-of-sight VHF/UHF communications, and the more distant HF communications accomplished with traditional antennas. That gap, or skip range, is the very coverage we need in an emergency in order to communicate with state officials and emergency management teams. At least one NVIS antenna should be in every amateur's inventory. In this edition and the next I look at NVIS antenna theory, how to build a standard design as well as several variations on popular designs, and how to deploy them when needed.

NVIS: Not just for the "Other Guy"

I would like to start off by saying I believe an NVIS antenna, or several, should be a part of every ham's shack because any one of us at any time could be in a position to be maybe the only voice able to call out in an emergency. While this may sound a bit dramatic, in fact it is true. Our neighbors (and sadly too often we ourselves) have become so dependent on wired communications we just assume they will be available when needed.

For all intents and purposes, even our cell phones and our "wireless" Internet are really "wired" in practical terms, because the infrastructure which supports them can go down in an emergency. When amateur radio folks talk about infrastructure we are referring to people, not things.

The seemingly antiquated National Traffic System (NTS), ignored by so many modern hams, is an infrastructure designed to ensure messages get passed around the country and even around the world without reliance on the Internet or on phones. Real independence means we have backup power, plus local, long-distance, and medium-range communications covered both in terms of radios and antennas. The NTS uses tradition as well as cutting-edge digital and MESH modes to pass traffic, making sure whatever tool works best is used to get the job done.

Fortunately the amateur radio community, and emergency services in general, are waking up to the importance of having state-wide coverage as a part of their emergency planning, and NVIS antennas are becoming more commonplace. Statewide tests are beginning to be conducted around the

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country to encourage the use of NVIS antennas, making it something of a contest atmosphere.

The military has known about the importance of NVIS antennas for a long time. Close-in communications have been handled by VHF/UHF line-of-sight communications, of course, but the military long ago realized the need for the ability to cross over mountains and hills into adjacent valleys, as well as use communications to coordinate troops close-in without the signal travelling thousands of miles.

A commonly used NVIS antenna from the military is the AS-2559 described here from the army manual which accompanies the antenna, with much of the data coming from actual field use in Vietnam:

> The AS-2259/GR Manpack HF Antenna (Figure 1-1) is essentially a dipole antenna fed with a low-loss, foam-dielectric, coaxial mast that also serves as a support structure. The dipole system uses a set of crossed sloping dipoles positioned at right angles to each other. Physically the antenna consists of eight light-weight coaxial mast sections and four radiating elements that also serve as guys. The

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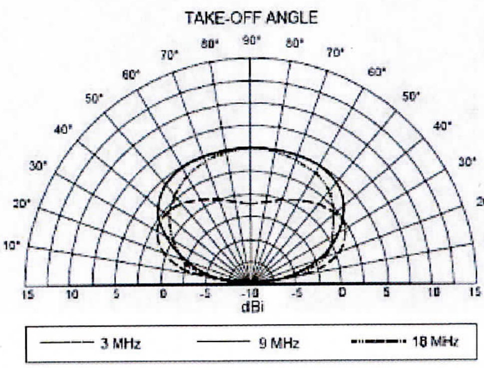
> antenna is transported in a canvas pack similar to a tool roll. The total packed weight of the antenna is 14.7 pounds. Erection is accomplished by two men in 5 minutes without the use of any tools.
>
> The AS-2259/GR antenna is designed to provide high-angle radiation (near vertical incidence) to permit short-range skywave propagation over communication circuits varying from 0 to 300 miles. The AS-2259/GR may be used with tactical HF radios that tune a 15-foot whip antenna, such as the AN/PRC-47. The frequency range of the antenna is 2.0 to 30.0 MHz and maximum RF power capacity is 1000 watts PEP, or average.

In the past, most short-range HF communications used vertical whip antennas. With these antennas, communications are achieved on very short ranges by ground-wave (surface-wave propagation), and longer paths are achieved by sky-wave propagation. This becomes problematic due to the inherent limitations of radio-wave propagation using whip antennas, because there is skip zone between the point where the ground-wave signal becomes unusable and where the sky-wave signal starts to become usable.

Depending upon terrain, ground conductivity, operating frequency, noise levels, etc., ground-wave signals are usable up to about 70 miles over average soil (assuming a 1K transmitter). Minimum distances for sky-wave paths, using whips, are typically around 200 miles (using the E-layer) during the day and 400 miles (using the F-layer) at night.

While the skip zone severely limits the usefulness of whip antennas for short-range communications, conditions become even worse in environments such as hilly or congested, urban terrain. This occurs because of the restricted range of ground-wave signals in these environments.



AS-2259 Vertical Radiation Pattern

The solution to the short-range communication problem is the use of sky-wave instead of ground-wave propagation on the short paths. This requires radiation from the antenna at very high elevation angles (near vertical incidence).

Vertical radiation characteristics like this are produced using horizontal antennas mounted above ground up to a height of about one-quarter wavelength. Such radiation characteristics are

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omnidirectional in azimuth and provide a one-hop range of about 300 miles. The antenna gain varies mainly with the height of the antenna above ground. For easy and speed of setup, typically the most important factor is determining the minimum effective antenna height required.

In terms of effectiveness we have to be concerned with the signal to noise ratio more than the signal quality itself. With the effects of atmosphere, possibly unfriendly weather conditions and the like, getting a signal out over the nose is of utmost importance.

Distances

Based on military testing of vertical antennas, solid ground-wave communications are expected at 25 miles at any time of the day assuming good ground conditions, and the range may be as much as 100 miles for a couple of hours at midday. This distance rapidly drops off, however, under poor ground conditions or in particularly difficult surroundings. The groundwave distance may drop to a mile or less.

Conversely the first Skywave propagation typically starts at 70+ miles, or more, and which may extend out several hundred miles. This leaves a large gap, often at ranges where contacts need to be made within a state or local region. In a large measure the extent of the skip zone is dependent upon soil conditions. For average environments, the skip zone lies between 70 and 200/300 miles; however, in extreme environments, it may include the range from 1 to 200/300 miles. Thus the need for an antenna which can make use of Skywave propagation but with minimal displacement. We are basically looking for "straight up-straight down" radiation pattern.

An illustration I ran across sometime back (and I apologize for not remembering the source) describes NVIS radiation pattern much like taking a garden hose in the back yard and pointing it straight up. While the water goes up in a straight pattern, it disperses a bit on the way back down, covering more ground around the hose than a single stream. This is what happens to RF signals through the influence of the atmosphere as it reflects (and refracts) back down to earth.

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To achieve the gap coverage we need requires near vertical incidence with the above scattering effect to make such coverage effective. By keeping the dipole height above ground to less than a quarter-wavelength, the majority of the signal travels in a vertical radiation pattern. However if too close to the ground the pattern starts to resemble a Beverage antenna.

No doubt a quarter-wavelength above ground can be hard to achieve, particularly when using an 80-meter NVIS antenna, but effective ranges can be had at roughly 0.035λ, or roughly 10 ft. for 80 meters, and ~6 ft. for 40 meters. At frequencies much above 40 meters or below 80 meters will likely surpass the daily maximum and minimum usable frequencies except under specific seasonal propagation conditions, so NVIS antennas are usually designed with 40 or 80 meters in mind.

A typical design of the well-known and often duplicated AS-2259 military NVIS antenna consists of the mast, wires, insulators, and ground stakes. The mast also serves as the transmission line, feeding the dipole elements at a height of 15 feet. The coaxial mast consists of eight identical sections, and is constructed of aluminum. The inner conductor of the coaxial mast is held concentrically within the outer conductor with a poly-urethane foam. Bayonet-type joints allow the mast sections to be joined together quickly and positively.

AS-2259/GR NVIS antenna from the Radio Operator's Handbook

The dipole radiating elements consist of four wires positioned at right angles to one another. They slope down to the earth and are made of flexible wire with short lengths of nylon rope attached to the ends through insulators. Two of the elements are connected to the inner conductor of the coaxial mast and the other two are connected to the outer conductor.

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When developing an alternate design to the AS-2259 antenna, David Cuthbert (WX7G) did some excellent test work using reflector wires to boost gain using low dipole heights (antenneX Online Issue No. 75 — July 2003). He determined the best gain was produced using 5 reflector wires placed 4' apart running parallel along the ground underneath the NVIS dipole, with a dipole height of six feet. Similar results were found using three reflector wires, which has the advantage of being a simpler design. David also found for matching purposes a folded dipole design significantly raised the impedance while maintaining a relatively simple deployment.

Wrap-up

We will look at more design modifications to the AS-2259 and alternatives for NVIS antennas next time around. As I mentioned at the start I believe the NVIS antenna is essential for all hams to have, or at least to understand and to be able to deploy rapidly should the need arise.

Our local club is participating for a second year in a row of having an NVIS antenna building day along with setting up stations to work other NVIS users. The goal is similar to field day in terms of emergency services and being able to work off the grid, but more specifically in this exercise to be able to contact local and state agencies and emergency services providers under difficult conditions.

There has been a significant amount of interest in NVIS antennas here in my area because of these efforts, as folks have found out both how practical, and how easy these antennas are to build. I recommend hams keep one in the car, wrapped up on spools, with the necessary hardware just as a safety precaution for themselves.

There are long stretched of highways with no repeaters, and DX is not going to do us much good if our responder is several thousand miles away! Having the ability to communicate locally far beyond line-of-sight can be priceless.

Give NVIS antennas a try, or get a group project together at your local club and make a day of it. Not only will everyone have fun, but everyone will take home something of real value—the ability to make meaning contacts in emergency situations. That is one of the main reasons we are hams in the first place, right?!**-30-**