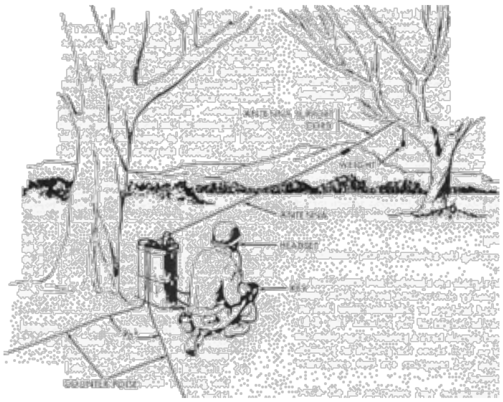

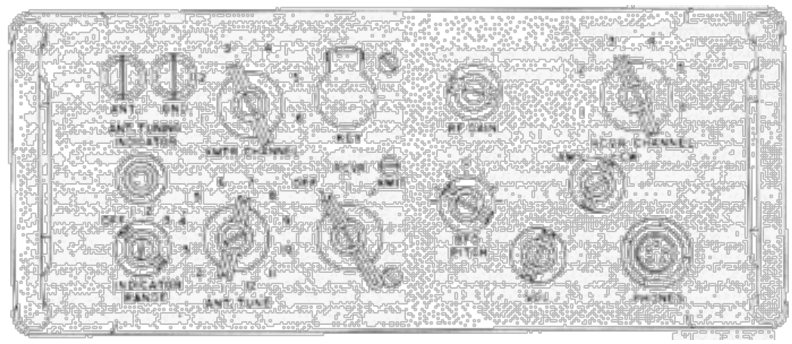

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Field Deployment

NVIS - What it is and how to use it

By Patricia Gibbons - WA6UBE

WHAT IS NVIS?

NVIS , short for Near Vertical Incidence Skywave, utilizes high-angle skywave paths between stations instead of ground-wave or surface-wave in order to communicate via HF radio. NVIS was originally evaluated by U.S. Army Forces in Thailand during the Vietnam conflict in the mid-1960's It was found that Mobile stations, using whip antennas bent parallel to the ground, could communicate more reliably with their base-stations. Signal strengths would be weaker using high-angle skywave but communications would be more reliable, less subject to fading, and consistent between stations. This was because the intervening terrain was less of an absorber of signals. Terrain obstructions between stations,

such as hills, mountainous areas, jungle growth, built-up areas with tall buildings, no longer become path obstructions with stations when NVIS techniques are employed.

It is important to note that as early as the first part of World War II, NVIS antennas were used by German Forces. This was due to the fact that early in the war, HF radio was of major importance to widely-dispersed forces under a centralized command and control structure. Even with the advent of Tactical FM radio later in the war, HF radio was of significant importance with forward recon units.

For distances out to 400 miles between stations, one F-layer hop, at vertical angles of 45 degrees or higher are used. It is not necessary to have high power transmitters. Typical 100 watt power levels are fine. It is necessary that all stations on an NVIS radio network use antennas that are parallel to the ground and the frequencies used are chosen via a radio propagation prediction program in order to have best results.

There is also on online resource that will provide near real time info on critical frequency

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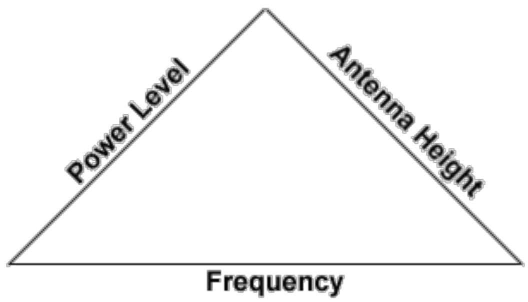
Frequently asked questions about NVIS:

- Isn't NVIS, when using a horizontal Dipole antennas, what amateur radio operators always
  have used? What is so different about it?
- ANSWER: NVIS can be viewed more as a "Systems Concept" and not just what antenna to use. The concept of NVIS is to have reliable communications anywhere within an 800 mile diameter circle, in which your station would be located at the center of this circle.
- What is the advantage of having the antennas close to the ground? I always thought that a radio antenna had to be as high in the air as possible?
- ANSWER: Stations communicating via high-angle sky-wave may also be close enough to each other to receive a ground-wave or surface-wave signal. Stations receiving both a sky-wave and ground-wave will copy heavily-distorted received

signals. This will include multi-path distortion because of the extreme difference in the lengths of the twp paths. Keeping antennas close to the ground will reduce the generation of a ground-wave signal. The next advantage of close-to-the-ground deployment is the ease of deployment, and, for covert-ops/tactical missions, the reduced possibility of enemy detection (Low Probability of Detection), also known as "LPD".

- Does NVIS work with low-power transmitters??
- ANSWER: Yes. In fact, reliable communications between stations are based on three major factors. These can be viewed in triangle form as follows:



After much research and testing of antennas over the past 5 years, it appears that the most important leg of the triangle is choice of correct frequency. Specific results will be discussed later on this page.

- What are the typical frequency ranges used for NVIS?
- ANSWER: Usually between 2.0 and 10 Mhz. Exact frequency is dependant on the degree of solar sunspot activity. The best choice of frequency is determined either via the use of a propagation prediction program, or with the employment of "Automatic Link Establishment" (ALE) techniques.

ACTUAL TEST RESULTS:

Summer of 1990:

A field test of NVIS was planned between myself and Carl Sato, AA6CF. Carl was located in San Francisco, California. The plan was for my station to run RTTY on the amateur 40 meter band and for Carl to log the field strength of my transmitter at Carl's location. I would try different types of antenna arrangements. The plan was to have a "blind test" in that AA6CF would not know which antenna I would be on at any particular time. My station was parked in a local park in Morgan Hill, California, which is approximately 70 miles from Carl's station in San Francisco. Morgan Hill, California was chosen for this test in order to absolutely limit the ability of ground-wave signals to reach between our two stations.

My station was a mobile arrangement consisting of a restored military communications truck and used one of the following three antenna arrangements for the test:

- 100 Ft horizontal long-wire at six feet above the ground and end-fed with an antenna tuner.
- 15 foot military whip antenna tuned with an SGC model SG230 "smart-tuner" with the antenna in a vertical position. The base of the vertical antenna was 7 feet off the ground.
- The same 15 ft military whip antenna but placed in a horizontal position behind the vehicle which allowed the horizontal whip antenna to be 7 feet above, and parallel to the ground.

Here is the horizontal wire antenna, deployed via the use of some AB777, telescoping masts, made by Collins Radio Corp (Now Rockwell).

They extend to a length of 6-feet and collapse to a length of about 2-1/2 feet for storage:

The amateur 40 meter band was used. The mobile station was set up to transmit 50 watts of "mark-idle" signal. AA6CF would then tell me the signal strength of the signal received as I rapidly changed between one of the three antenna configurations as listed above.

TEST RESULTS:
The received signal strength from AA6CF on each of the three antennas were:

- Horizontal wire antenna = S9
- Horizontal Whip antenna = S9
- Vertical Whip antenna = S8

Another field-test done in the Fall of 1990:

During the Boy Scout "Jamboree on the Air" (JOTA) event. My communications truck was set up at the San Jose Red Cross facility in their large parking lot.

- Antenna Used: 1/2 Wavelength Dipole antenna, center-fed via 6 feet of ladder line and an MFJ-989C antenna tuner. Antenna was spaced 24 inches off the ground on orange traffic cones that were spaced six feet apart. The antenna was free from nearby obstructions as it was located in the center of a large empty parking lot.
- Transmitter used: Yaesu FT70/G Paramilitary "Manpack" transceiver
- Power used: 10 watts on CW
- Frequency used: CW portion of 40 meter amateur band. 7025 - 7150 Khz.
- Location of stations worked:
  - All stations were within a radius of 200 miles of San Jose, in the area of San Francisco, Emeryville, Sebastopol, Oroville, Woodland, Sacramento, and Dublin, California.

TEST RESULTS:

All stations reported my signal to be from "S8" to " 10 over S9" with exception of one station located in Pleasanton California. The station in Pleasanton was using a Trap Vertical antenna and reported that my signal was "S3". All other stations worked had reported that they were using horizontal or "Inverted Vee" Dipole antennas.

Another Field Test - Spring of 1993:

The purpose was to evaluate and quantify the performance of antennas deployed close to the ground.

A dipole antenna in this test was located extremely close to the ground, and quantified measurements were made of it's performance in relation to a dipole antenna at more "normal" heights above ground.

- **Antenna #1:** A half-wave dipole at 10-1/2 inches off the ground, supported on plastic tent-stakes.
- **Antenna #2:** A half-wave dipole at 6 feet off the ground.

Both antenna were balanced to ground and matched with antenna tuners for minimum reflected power.

Ground conditions in the area were chosen in order to provide a "worst-case" as far as attenuation of the signal due to soil proximity. The ground was "soppy" wet due to recent rainfall. These conditions would degrade the measured performance of these two antennas significantly as the soil conductivity would be extremely good, even at ground-level.

- **Transmitter used:** Yaesu FT70/G paramilitary "Manpack" transceiver
- **Power used:** 10 watts on Single Sideband
- **Frequency used:** Voice portion of 40 meter amateur band. 7225 - 7300 KHz
- **Location of stations worked:** The plan was to find one station within NVIS range but far
  enough distance not to copy any ground-wave. The station found was located in Menlo Park, California, a distance of roughly 20 miles.

Displayed below is a detail regarding the use of 3/4-inch ladder-line.
A system was also tried at this park, using two half-wave dipoles, fed in-phase as a Broadside Array, and the ladder-line was used to couple the two dipoles together.
The line was also reversed between the two dipoles so that they were fed in-phase.
This allows the signal to be further directed straight up in the air.

The observation was made, by most of us in attendance, that the work involved in rigging-out such a system is not worth the additional 3-4 dB gain that may be gained:

Yes, that's me in the photo above, with an HT in my back pocket and bent-over while hooking up the plastic ladder-line...not a flattering picture of me, but..hey...
I was busy.... Our Chief Radio Officer, Earl Stevens - KC6ZDJ, is holding his hand next to

the antenna wire in order to give a sense of how close to the ground this antenna system actually was...

TEST RESULTS:
The station in Menlo Park, California reported my 10Watt PEP signal as:

- " 10 dB over S9" using the dipole antenna that was 6 feet off the ground.
- " S8 " using the dipole antenna that was 10-1/2 inches off the ground.

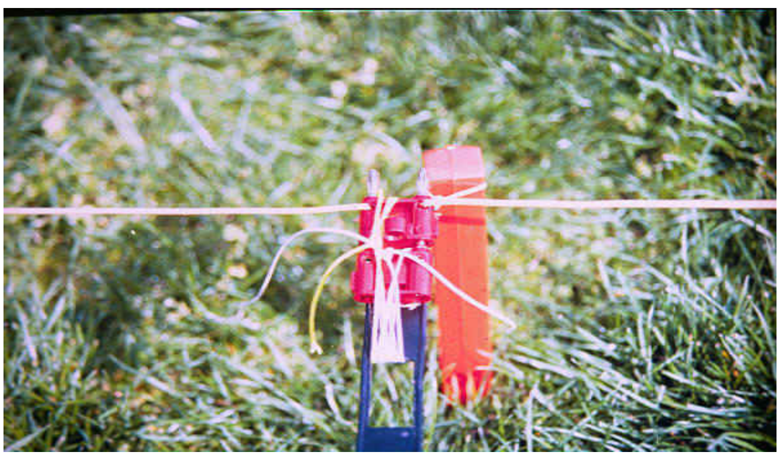
Post-Test equipment check:

The Yaesu FT70/G was checked with a Motorola Model 2410 Communications Service monitor to verify the actual difference in meter indications for an "S" meter reading of "S8" and "10 dB over S9" The actual difference in in signal strength, and it was found to be 15 dB.

The Yaesu FT70/G:

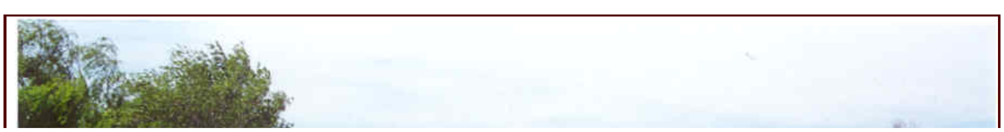
Here is the other side of the Two-Element, Broadside Array which is being fed with 450-Ohm plastic ladder-line:

Standard, Dual-banana plugs make excellent connectors for plastic ladder-line as shown in this photo:



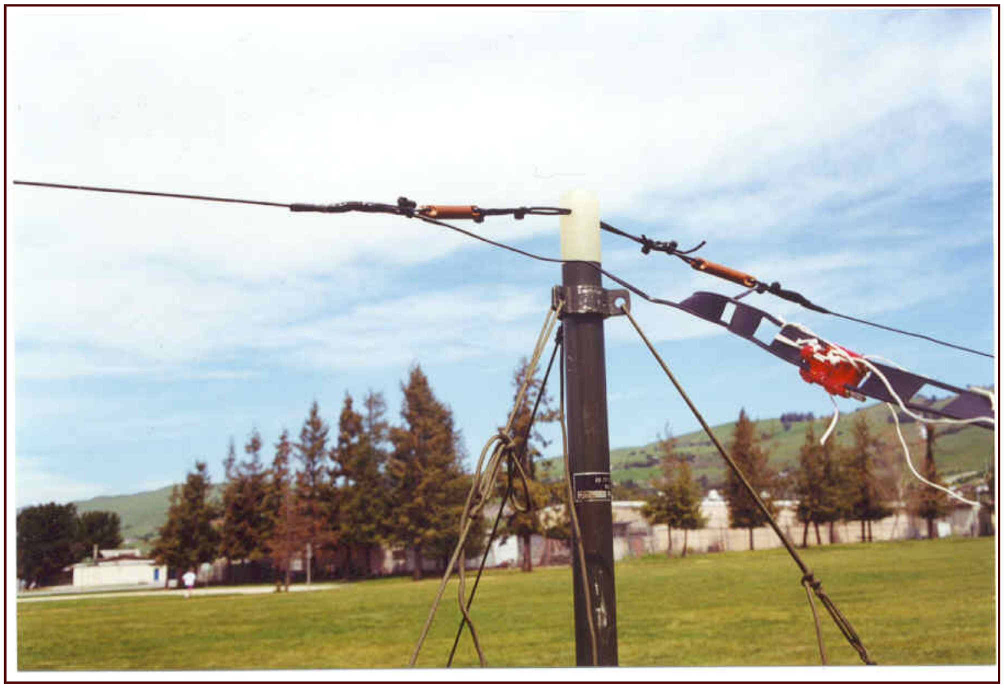
Berryessa Park (San Jose, California)
April 1st, 2000:

Next are some photo's of a recent deployment of an AN/PRC70 field radio and a dipole antenna system which is supported by some AB777 telescopic masts. The masts are built by Collins Radio and extend to a maximum height of 6-feet off the ground:




This dipole antenna system is 110 feet long, similar in length to a "G5RV" dipole, and is fed with 3/4-inch plastic ladder-line. This photo shows a total of 3 of the AB777 masts which are fully-extended.


Here is the same antenna system with the support masts collapsed to a height of only 2-1/2 feet off the ground. The signal-strength reports indicated about a 1 S-unit decrease in signal level (-6 dB) from the signal levels found with the supports fully extended to 6-feet.



The center support mast has an insulator which is machined out of "Delrin" plastic material. The insulator also has a slot in which the dipole antenna is supported.

You will notice that a bridle assembly is formed through the use of a pair of porcelain insulators, and the ladder-line feed is connected to the outer ends where the actual active segment of the dipole elements are placed.

Here I am operating the AN/PRC70 during one of our "armyradios" radio nets. Members of the armyradios mailing list, who are also on the U.S. West Coast, used to meet on the air at

10:00 AM Pacific Time, every Saturday morning, on 7296 KHz, Upper-Sideband.

Note that our current weekly net on the West Coast is:

8:00 PM Pacific Time -- Primary Frequency: 3996 KHz USB
Secondary: 7296 KHz USB
Alternate: 7283 KHz USB

The use of Upper-Sideband on this frequency allows other users of military radios to join us even if some of the military models of equipment only have Upper-Sideband capability. Note particularly that the "PRC70" is only designed for up to 20-Watts PEP output power in the "high-power" position. Not exactly a "QRP" radio, but for NVIS operations, a more standard 100-watt class of equipment is preferred in order to overcome the additional losses inherent in "close-to-the-ground" operations.

"Rules of Thumb" that were generated, based on the above operations on the 40 meter band:

- Assume a half-wave dipole at 1/4 wavelength above ground as a reference for comparison
- A half-wave dipole at 6 to 7 feet off the ground will have an attenuation of approximately -4 dB
- A half-wave dipole 10-1/2 inches off lossy ground will have a worst-case attenuation of approximately -20 dB
- Assuming correct choice of frequency and a 10.7 cm solar flux value in the 200 range, a half-wave dipole at 1/4 wavelength above the ground would provide a 20 dB over S9 signal reading at the distant station when the transmitter has a power output of 100 Watts.
- If the transmitting station uses an antenna at 6-feet above ground-level, the resultant signal strength would be: 16 dB over S9
- If the transmitting station uses an antenna at 10-1/2 inches above the ground, the resultant signal strength would be: S9

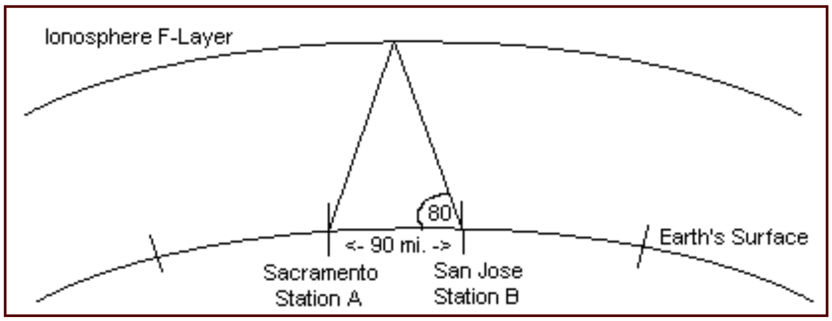
Based on actual documented tests between the station in Menlo Park and my station at the "San Jose Rose Garden" Municipal Park, This data tends to show that antenna height above ground is not be the predominant factor in establishing communications.

For a 10 Watt radio to receive an "S8" signal report with a half-wave dipole at 10-1/2 inches off the ground on plastic tent stakes, it is apparent that the most important factor is proper choice of operating frequency. The Rose Garden tests were able to be done during a time when our Solar Sunspot activity produced a 10.7 cm solar flux value appropriate for the operating frequency used for this test. It was, at the time of the test, in the 180's to 190's. As of today's writing of this article (January 23rd, 2000) report solar flux indexes are in the same region of the mid to mid 190's.

Why high transmission angles are important:

Illustrated here is an approximate representation of the height of the ionosphere's "F-Layer" in relation to the direct distance between San Jose, and Sacramento, California. This sketch indicates why a traditional mobile whip antenna, with vertical polarization, places the major-lobe of a mobile station's energy level in an incorrect direction.

The 90-statute mile distance between these two points require a vertical take-off angle of 80-degrees in order to place the signal in an optimum direction:



FURTHER COMMENTS ON NVIS:

The U.S. Army did quite a bit of study toward the end of the Vietnam conflict on how to use HF radio more effectively and reliably. This effort was published in issues of "Army Communicator" magazine by Lt. Colonel David Fiedler starting in the early 1980's. Lt. Col Fiedler found that other countries, including German Ground Mechanized units of WWII, and the Soviet Union of today had implemented NVIS Since the summer of 1990, I have presented the NVIS concept at two west coast ARRL conventions and many local radio club meetings, as a way of publicizing this concept within the amateur radio community. Also, Ed Farmer, AA6ZM wrote a very extensive and well researched article on NVIS in the January 1995 issue of QST Magazine.

As a result of this work, Stanly Harter of the State of California Office of Emergency Services has taken a serious look at the value of HF communications for disaster communications. This is especially valuable for units like our California Department of Forestry and Fire Protection (CDF), where operations in remote areas not served by the usual VHF and UHF mountain-top repeater sites could impact their ability to communicate effectively. Stanly Harter has also made recommendations for changes in HF antenna designs on their facilities used by State OES in order to effectively utilize the NVIS Concept.

In 1989, Just prior to the Loma Prietta earthquake here in the bay area, I had finished an equipment recommendation for the Director of our GSA-Communications Division with the City of San Jose. Included in the design of the radio equipment to by used by our San Jose Office of Emergency Services was an HF station which emphasized the use of NVIS high-angle skywave so that our center would have both County-wide and also solid, Northern and Central California coverage via HF communications. The Antenna consists of a 55 foot end-fed wire antenna mounted between two radio towers on the roof of our dispatch facility. At the top of one of these towers is an SGC "Smart-Tuner" which can then tune this horizontal wire on any frequency from 1.6 to 30 Mhz. The HF Radio used is a model RF3200 made by Harris/RF Communications Group. This HF station meets Part 90 rules for commercial type acceptance, and also covers any frequency from 1.6 to 30 Mhz. In an emergency, this station is capable of communications with State of California's Office of Emergency Services over their "Operation Secure" HF radio system.

DEPLOYABLE FIELD ANTENNAS:

Much experimentation has been done with horizontal antennas that are close to the ground. One of my favorites is the use of the larger-sized orange-colored traffic cones that are available to our City Department and are about 3-feet tall.

Another is a system close to the ground using plastic tent stakes. This system, and the results are outlined in the larger body of work that is listed earlier in this article.
The tent-stake method is sort of like the antenna arrangement from a company called "Eyring Research".

A common Military/Covert-Ops antenna for NVIS use is the AS2259/GR. This antenna does turn up on occasion from sources such as the TRW swap meet in Southern California,
and also via Fair Radio Sales

There is an article on the web written by Dr. Carl O. Jelinek in which he details the construction plans for building an NVIS antenna that appears to be patterned after the AS2259/GR. Please see Dr. Jelinek's write up at his website: Dr. Jelinek's Antenna

A well-written discussion of the "Two-wire, Terminated, Folded Dipole" , or "T2FD" is available on the 'Net, and is written by L.B. Cebic, W4RNL.

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