# NVIS - What It Is and How To Use It



By Patricia Gibbons - WA6UBE

NVIS , short for Near Vertical Incident 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. 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.

***Frequently asked questions about NVIS:***

1: Isn't NVIS, when using a horizontal Dipole antennas, what amateur radio operators always have used? What is so different about it?

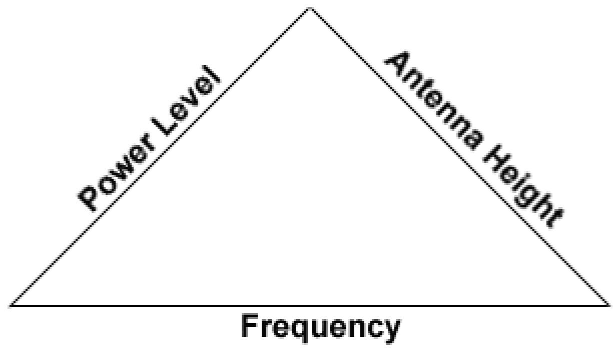
ANSWER: NVIS can be viewed more as a "Systems Concept" and not just what antenna to use. The concept of NVIS is to have reliable communications anywhere within an 800 mile diameter circle, in which your station would be located at the center of this circle.

2: 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 have 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.

3: 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, I have determined that the most important leg of the triangle is choice of correct frequency. Specific results will be discussed later on this page.

4: 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 through the use of a propagation prediction program.

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**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. 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:

1. 100 Ft horizontal long-wire at six feet above the ground and end-fed with an antenna tuner.
2. 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.
3. 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.

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:

1. Horizontal wire antenna = S9
2. Horizontal Whip antenna = S9
3. Vertical Whip antenna = S8

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**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 within a radius of 200 miles 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 Plesanton California. The station in Pleasanton was using a Trap Vertical antenna. All other stations reported using horizontal or "Inverted Vee" Dipole antennas.

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**Spring of 1993:**

Purpose of test: To compare two dipole antennas. One at 10-1/2 inches off the ground, and the other at 6 feet off the ground. Ground conditions were chosen to provide a "worst-case" as far as attenuation of the signal due to soil proximity. Soil conditions were extremely wet due to recent rainfall at a local park.

Antenna Used: Two types of antennas:

1. Dipole antenna at 10-1/2 inches off the ground supported by plastic tent stakes.
2. Dipole antenna at 6 feet off the ground and supported by short military telescoping masts.

Both antennas were balanced systems using ladder line from an MFJ989C antenna tuner.

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: Wanted to find one station within NVIS range but far enough distance not to copy any ground-wave. Station worked was located in Menlo Park, California. This was a distance of 20 miles.

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

1. "10 dB over S9" using the dipole antenna that was 6 feet off the ground.
2. "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 level was shown to be "15 dB".

"Rules of Thumb" based on the above operations on the 40 meter band:

A. Assume a half-wave dipole at 1/4 wavelength above ground as a reference for comparison
B. A half-wave dipole at 6 to 7 feet off the ground will have an attenuation of approximately -4 dB
C. A half-wave dipole 10-1/2 inches off lossy ground will have a worst-case attenuation of approximately -20 dB
D. Assuming correct choice of frequency and a 10.7 cm solar flux value in the 200 range,

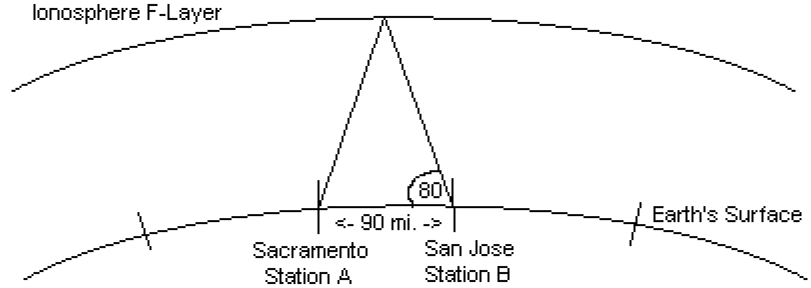
a half-wave dipole at 1/4 wavelength above the ground would provide a 20 dB over S9 signal reading at the distant station when the transmitter has a power output of 100 Watts.

E. If the transmitting station uses antenna "B" above, the resultant signal strength would be: 16 dB over S9
F. If the transmitting station uses antenna "C" above, 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 the antenna height above ground would not be the prevalent 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. As of today's writing of this article ( June 29th, 1995 ) report solar flux indexes are in the low to mid "70's".

Assume the crude drawing as follows:

Ionosphere "F-layer"



\ distance = 90 miles / Vertical radiation angle to reach from station "A" to "B" = 80 Degrees

**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 State Division of Forestry 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.

Dr.Earl Stevens, Our Chief Radio Officer has his hand pointed to the ground to show relative scale.

Completed dipole antenna feed with ladder line installed 10 inches off the ground on plastic tent stakes.

10infeed shows the manner of connecting the antenna system to 3/4 inch ladder-line by the use of dual-banana plugs.

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