

Mobile NVIS: the New Jersey Army

Because of the size, shape, and vertical direction of radiation, communications equipment can be hidden in depressions and under cover, thus making it harder to find . . . Mobile NVIS will make possible the selection of much more survivable sites than those used today.

by Lt. Col. David M. Fiedler

In previous articles in the ARMY COMMUNICATOR on the subject of short path (0-400km), high frequency (HF), skip zone free, radio communications, I challenged Army training and doctrine while attempting to inform tactical communicators of a more efficient way to use their HF radio equipment. In the Winter/Spring 1987 issue, I argued that the Soviet Union has a mobile near-vertical-incidence skywave (NVIS) capability that we lack, but one which we need if we are to support fast moving, deep penetration operations over wide areas.

Since then, fixed operations using wire dipoles have been incorporated into FM 24-18, Appendix N, though the reader should still be careful when using this FM, since some incorrect data about short path propagation and "skip zones" still remain in other sections of the manual. Appendix N is the correct picture for short skywave paths.

In the area of mobile operations, the situation becomes more complicated. While it was easy to adopt standard issue wire dipoles (like the AN/GRA-50) for fixed-station NVIS operation, the Signal Corps' lack of interest in short skywave path communications

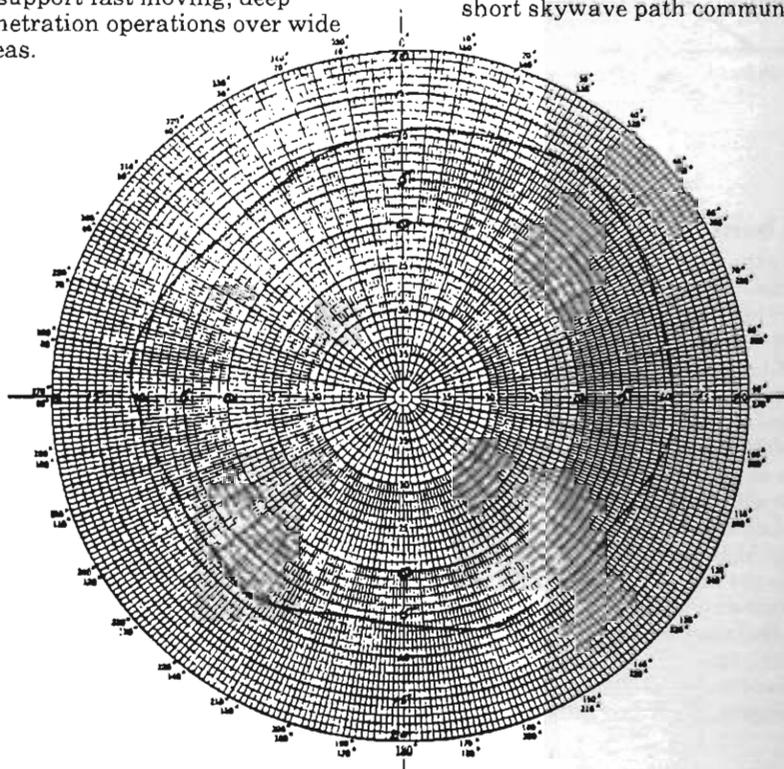


Figure 1. This NVIS antenna pattern is omni-directional, which means that the energy radiated from the antenna is of equal strength in all directions from the antenna. Such a pattern is achieved by radiating the signal in a near vertical direction at a frequency low enough for it to be reflected by the ionosphere. The effect is similar to that achieved by directing a water hose straight up at a flat surface: the water, hitting the surface above, rains down in a circular pattern without dry spots, covering the area below. All radio stations within the pattern will receive the same signal at approximately the same strength without gaps in coverage or "skip zones."

National Guard approach

produced no comparable mobile zenith radiating antenna or even the requirement for one. This being the case, my search for a starting point to match the Soviet capability had to begin outside the Signal community.

Fortunately, the U.S. Army Avionics Research and Development Activity (AVRADA) was faced with a similar wide-area continuous-coverage communications problem when attempting to communicate with aircraft engaged in "nap of the earth"

(NOE) flight. After consulting with Mr. John Brune and Mr. Frank Cancellor of AVRADA, I obtained Tech Report ECOM 4366 (Reference 1), which showed excellent omnidirectional antenna patterns with aircraft-mounted transline antennas. I felt that similar results could be obtained when the antenna was mounted atop tracked or wheeled vehicles as the Soviets were doing.

There is currently no TRADOC (Signal Corps) generated requirement

for this capability. However, the New Jersey State Area Command (NJSTARC) does have a requirement for continuous communication over an operational area very similar to that occupied by a typical U.S. corps. With the STARC mission in mind, I was able to convince the commander and staff of the New Jersey National Guard (NJNG) of the value of this capability and receive their support. Unfortunately, the adjutant general of New Jersey has no funds or



Figure 2. Series AV-600 NVIS antenna installed on Army UH-1

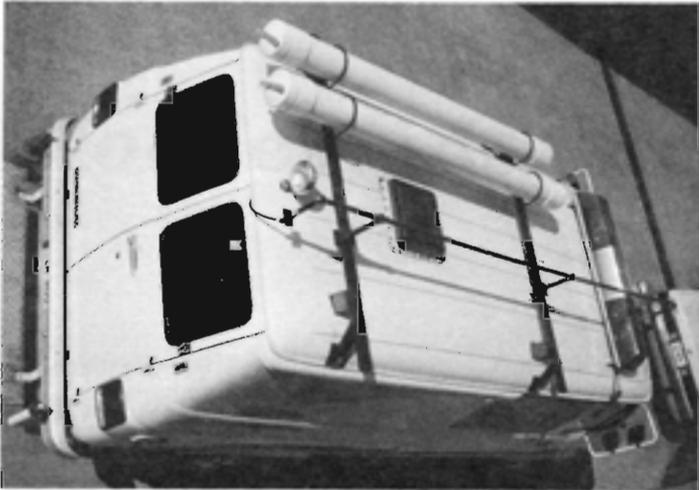


Figure 3. Mobile NVIS antenna installed on NJNG communications facility



Figure 4. End grounded to searchlight mount

manpower for R&D projects, so the work had to be accomplished by NJNG personnel on their own time and without funds.

This being the situation, I contacted Mr. Seymour Greenspan, former chief of the Airborne Systems Technical Area of AVRADA, who was working with the company supplying AVRADA with their aircraft antennas. Mr. Greenspan, Mr. Florenio Regala, and Mr. Frank Hoar of TRIVEC-AVANT then arranged for the NJNG to get a series AV-600 shorted loop NVIS antenna in exchange for a copy of any operational test results obtained.

The antenna was mounted on the NJSTARC mobile communications facility shown in Figure 3. It was fastened to the cargo rails on the van roof for support and grounded on one end to the searchlight mount as shown in Figure 4. The antenna was fed from the other end by a Kenwood Model 4305 transceiver modified for military operations and matched by a Kenwood Model AT-230 antenna matcher using a single-wire feed line as illustrated in Figures 5 and 6.

Matching the antenna was the most difficult technical problem, since this type of arrangement causes the antenna impedance characteristics to be highly inductive. In order to make the antenna match and thus radiate the maximum amount of signal toward the zenith in a vertical pattern similar to Figure 7, the matching unit

had to be sufficiently capacitive to cancel this inductance. In the beginning of the effort, we thought that the AT-230 matching unit did not have sufficient capacitance and that more would have to be added either at the feed end or the ground end of the antenna. Fortunately, we found that when tuning the AT-230 with the band switch in the 10MHz band, the unit had sufficient capacity to match the antenna at the operational frequencies of NVIS (2-8 MHz). This method is probably not as efficient as using a matcher designed specifically for the TRIVEC antenna, but it was simple and sufficient to do the job with the equipment on hand.

After completing the installation as shown, we conducted operational tests. Since we lacked the equipment necessary to measure either the actual antenna pattern or the amount of gain toward the zenith, much of our testing had to be of a less scientific, but more practical nature.

First, we established contact with fixed stations from the mobile facility at various ranges and azimuths. Each fixed station was equipped with the radio equipment described above, as well as with a horizontal dipole antenna .1-.25 wavelengths high, using an operating frequency of 4520 kHz. The locations of the stations and their range from the mobile

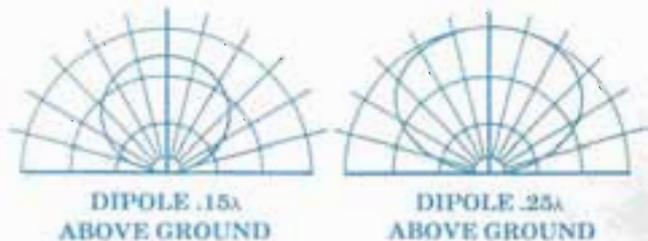


Figure 7. In order to achieve the omni-directional antenna pattern shown in Figure 1, the transmitter must radiate in a vertical direction as shown. This is achieved by locating a horizontal antenna .1-.25 wavelength above the ground so energy will be reflected at a high angle. This energy is in turn reflected by the ionosphere toward the earth, creating the circular area of coverage shown in Figure 1.



Figure 5. HF transceiver and antenna matching unit

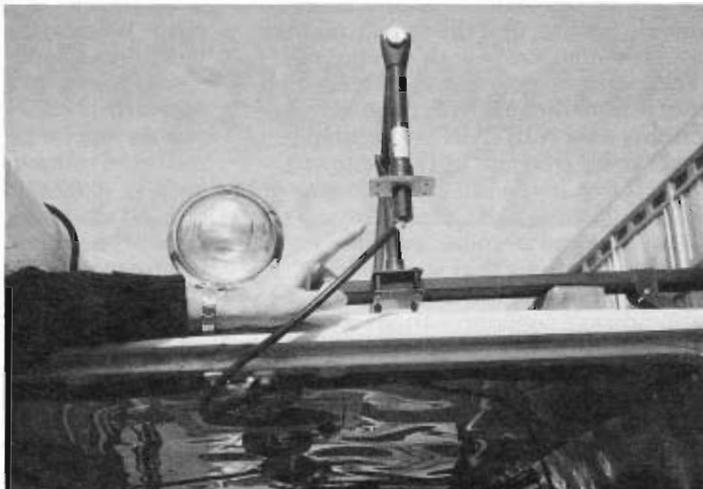


Figure 6. Antenna single wire feed point

facility are shown below and in Figure 8 (net station map). The performance was compared to a standard vertical whip antenna used on the same mobile facility, whose groundwave range, when communicating to the same fixed stations, never exceeded 25-30 miles. Results are shown below.

Station	Range	Conditions
Cape May NJ	79mi	beyond groundwave range (flat)
Dover NJ	48mi	beyond groundwave in (mountains)
East Orange NJ	47mi	beyond groundwave (urban rolling)
Jersey City NJ	51mi	beyond groundwave (urban rolling)
Lawrenceville NJ	.2mi	groundwave (flat)
Long Branch NJ	41mi	beyond groundwave (flat)
Morristown NJ	43mi	beyond groundwave (hills)
Newark NJ	47mi	beyond groundwave (hills)
Phillipsburg NJ	40mi	beyond groundwave (hills)
Plainfield NJ	32mi	beyond groundwave (hills)
Red Bank NJ	36mi	beyond groundwave (flat)
Riverdale NJ	58mi	beyond groundwave (hills)
Sea Girt NJ	38mi	beyond groundwave (flat)
Somerset NJ	34mi	beyond groundwave (rolling)
Teaneck NJ	60mi	beyond groundwave (hills)
Vineland NJ	53mi	beyond groundwave (flat)
Westfield NJ	33mi	beyond groundwave (hills)
West Orange NJ	49mi	beyond groundwave (hills)
Woodbridge NJ	36mi	beyond groundwave (rolling)
Woodbury NJ	34mi	beyond groundwave (flat)
Bordentown NJ	10mi	groundwave (flat)
Fort Dix NJ	15mi	groundwave (flat)
Fort Drum NY	270mi	beyond groundwave
West Orange NJ	44mi	beyond groundwave (hills)

Communications were established with all of the above stations on 4520 kHz during the days of the tests. All

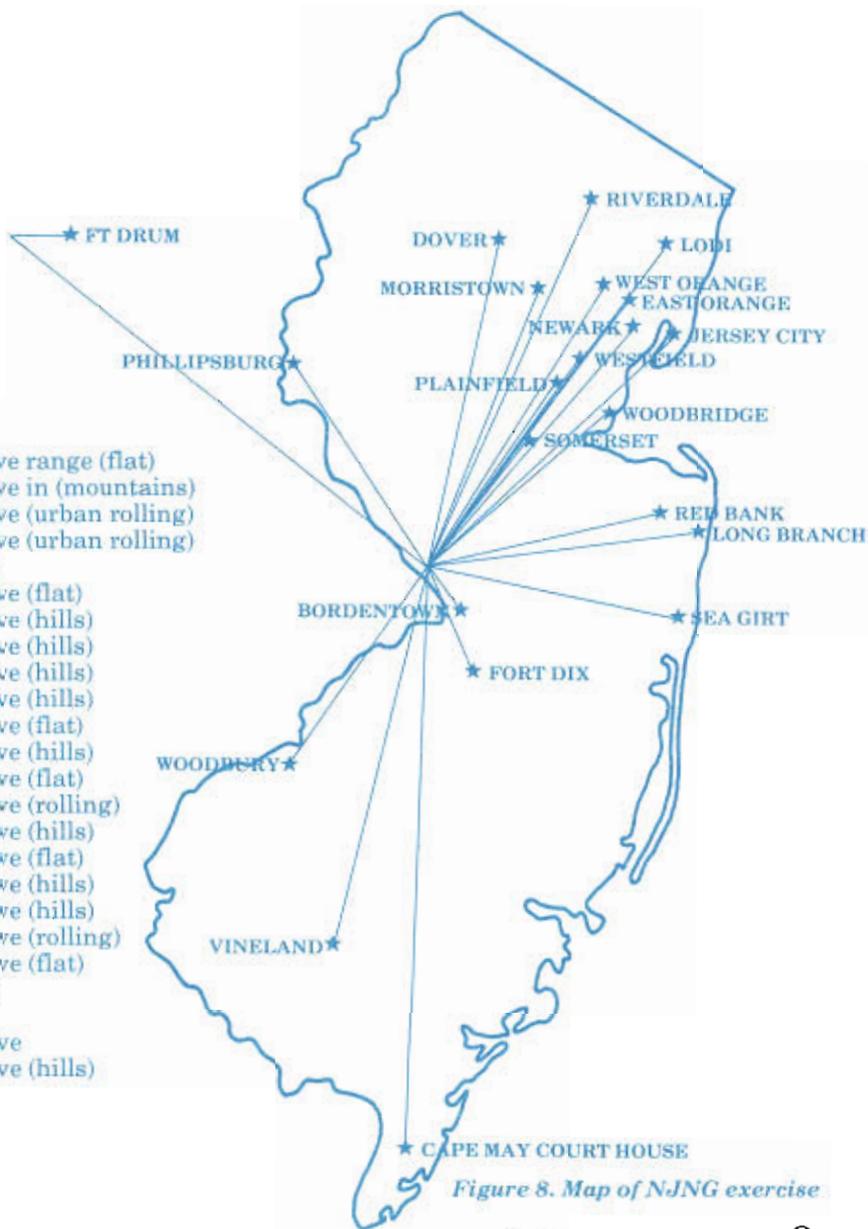


Figure 8. Map of NJNG exercise

stations could communicate with the mobile facility, and the mobile facility could communicate with all stations.

Second, we drove the mobile facility and communicated with fixed stations (in this case NJSTARC at Trenton and the NJNG base at Bordentown). We did this in the hill-covered areas of Mercer County, N.J., at ranges between 0 and 20 miles, purposely picking locations that were hidden behind terrain features so that groundwave communications were not possible. These tests were conducted both standing and on the move. Military considerations, such as cover and concealment, were also considered when picking locations. Good command post, but normally poor communications locations (when using current non-NVIS techniques) were purposely selected. Periodically during the tests, communications checks were also conducted with Fort Drum, N.Y., (range 260 mi) and West Orange (range 42 mi). At no time was the mobile facility, whether fixed or on the move, unable to contact either Fort Drum or West Orange.

Our third test was conducted to determine if, in fact, the antenna was directing the bulk of its radiated power in a vertical direction as shown in Figure 7. This was done to confirm that the mobile facility and its excellent communications results were indeed a product of NVIS design. We used an ME-31 field strength meter to detect the radiated field strength of the TRIVEC antenna from the ground level to a height of 30 feet above and next to the van. The meter showed no deflection at ground level but deflected steadily upward as it was elevated to approximately 2/3 scale at 30 feet elevation. While this is not an instrumented antenna range type of test, it does confirm that NVIS as a ground mobile concept is valid.

When constructing this system, we observed all the rules of frequency selection for NVIS systems explained in my previous papers and confirmed by the Soviet journals. Daytime operational frequency was below 8 MHz, and antenna height was as close to .1 wavelength as the height of the van would permit. In addition, antenna feed lines were kept as short as possible, and particular care was taken when grounding the end of the antenna to the van to assure a good ground connection.

The results of this work are very clear. We can, if we use NVIS techniques, communicate with all units in an area larger than that typically occupied by a U.S. corps. We can do this for both voice and data modes of communications, without gaps in coverage and while engaged in high mobility, Deep Battle/Deep Attack operations. In addition to improving communications, using mobile NVIS also results in the following significant military advantages:

- **Electronic warfare:** Since all radiated energy returns to earth from above at approximately the same signal strength, direction finding on the signal becomes very difficult, and the probability of intercept and detection is greatly reduced.

- **OPSEC:** Because of the size, shape, and vertical direction of radiation, communications equipment can be hidden in depressions and under cover, thus making it harder to find. In fact, the criteria for selection of HF radio communications sites will have to be revised, because mobile NVIS will make possible the selection of much more survivable sites than those used today.

- **Physical detection:** Studies by the Armor Center have shown that often the first item detected on a vehicle with the engine off is the vertical radio antenna. An NVIS antenna is flat and much harder to detect.

- **Safety:** Horizontal mobile antennas do not have a spear-like construction, which in the past has caused injury and even death to U.S. troops.

If there is any doubt in anyone's mind that mobile NVIS works, let me take this opportunity to invite them to New Jersey to see for themselves. Let me also take this opportunity to again urge the Signal Corps not only to teach this technique properly as part of a carefully designed program of instruction, but also to create the necessary requirements so that we can build on this preliminary work in the area of mobile operations and eventually catch up to the Soviet mobile capability. We know it works; we can see it in operation. Why should the NJNG and the Soviet Army be the only ones who can make it pay off in combat?

I wish to publicly thank the following for their help in this effort: Maj. Gen. Francis R. Gerard, Brig. Gen. Kenneth L. Reith, and Col. William Singleton, the adjutant general, deputy adjutant general, and chief of staff, respectively, of the New Jersey National Guard, for their command support of this effort; Brig. Gen. William Harmon, program manager, Joint Tactical Fusion Program, who provided encouragement when no one else wanted to listen; Mr. Seymour Greenspan, Mr. Florenio Regala and Mr. Frank Hoar of the TRIVEC-AVANT Corp., who provided the antenna hardware for a good cause and at a good price (gratis); and CWO Robert Herka and CSM Thomas Hannon of the NJNG, who provided the labor to put it all together in their spare time and also put up with my many phone calls to ask them if they were done yet.

References

1. U.S. Army Electronics Command, Research and Development Technical Report ECOM-4366, Avionics Laboratory, November 1975, by John F. Brune and Joseph E. Reilly.
2. **The Rules of the Antenna Game: What Every Ham Must Know About Antennas**, W5WJR Antenna Products, P.O. Box 334, Melbourne, Fla. 32902-0334 by Ted Hart.
3. TRIVEC-AVANT Corp. drawing D 60188 (AV 605-0), rev A TRIVEC-AVANT, 17831 Jamestown Lane, Huntington Beach, Calif. 92647.
4. U.S. Army Field Manual FM 24-18, **Field Radio Techniques**, December 1984, Appendix N.
5. "Beyond line-of-sight propagation modes and antennas," by David M. Fiedler and George Hagn, ARMY COMMUNICATOR, Fort Gordon, Ga., Fall 1983.
6. "Skip the skip zone: we created it we can eliminate it," by David M. Fiedler, ARMY COMMUNICATOR, Fort Gordon, Ga., Spring 1986.

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Lt. Col. Fiedler is presently employed as the chief of the Fort Monmouth Field Office of the Joint Tactical Fusion Program, and as the assistant project manager for Intelligence Digital Message Terminals. He is also the director of systems integration for the JTFP. Concurrently, he is the chief of the C-E Division of the New Jersey State Area Command, NJARNG. Prior to coming up to the JTFP, Lt. Col. Fiedler served as an engineer with the Army Avionics, EW, and CSTA Laboratories, the Communications Systems Agency, the PM-MSE, and the PM-SINGARS.