Near-Vertical Incidence Skywave propagation is gaining popularity with ham radio emergency communicators for regional HF contacts. K1EHZ describes tests between two types of antennas to see which is most effective on NVIS. (Hint: The answer is "yes.")

Comparing NVIS Dipoles for ARES Operations

BY JAY TAFT,* K1EHZ

Our Amateur Radio Emergency Service (ARES) group recently had a great opportunity to sharpen messaging skills while training alongside fire, police, CERT, and other emergency services. The Manchester, New Hampshire Fire Department requested Hillsborough County ARES support while testing the city's Radiological Emergency Response Plan. The training scenario required setting up a reception center for evacuees from multiple towns due to a nuclear power plant incident on the coast. ARES radio operators linked the reception center, EOC, health department and two major hospitals. We practiced during three evening drills, followed by a FEMA-graded exercise.

Along with this training, we decided to compare the performance of inverted-V dipoles to loaded-whip dipoles ("Hamsticks") for regional communication through Near-Vertical Incidence Skywave (NVIS) propagation[1, 2, 3]. We planned to collect data that would inform decisions about how each antenna could best meet future requirements. Open space for antennas at the site encouraged our curiosity as well.

Optimal NVIS Antenna

NVIS propagation occurs when RF radiated vertically reflects/refracts off the ionosphere nearly straight back down within a few hundred-mile radius. Modeling and data suggest an optimal NVIS antenna is a 0.5-wavelength (λ) dipole at 0.15λ above conductive ground. However, antennas as low as 0.05λ (10 to 15 feet above conductive ground) showed improved receive noise and produced solid signals at the dis-

Photo A. Homebrew inverted-V after a rain squall at the reception center.

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*5 Parker Lane
Bedford, NH 03110
email: <k1ehz@arrl.net>

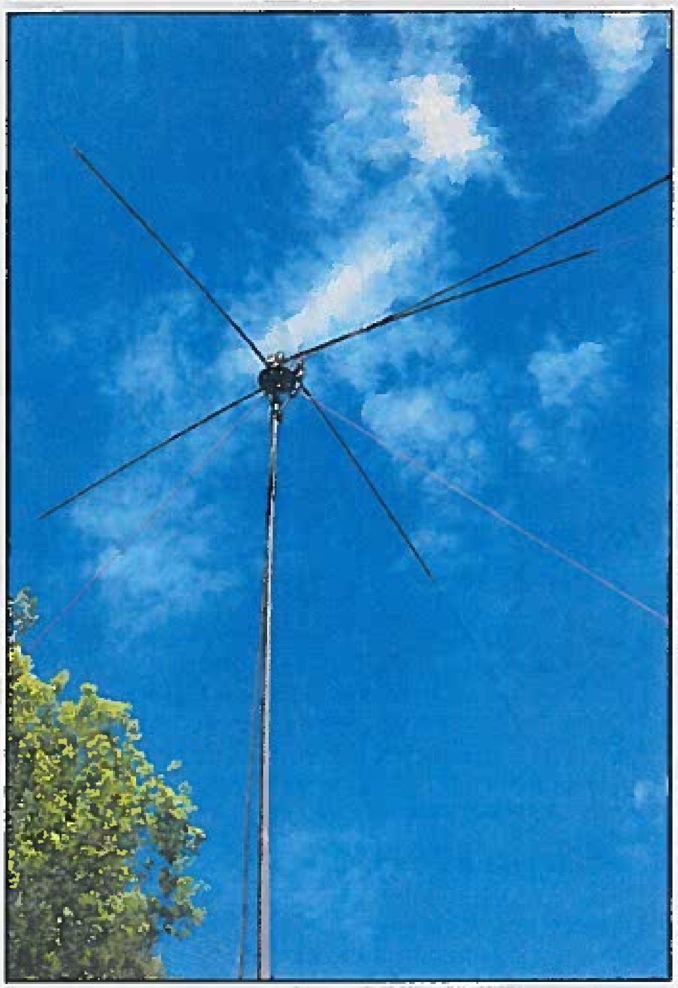


Photo B. Loaded-whip dipoles.

tant station[3]. Ground conductivity can be improved by adding wire below the antenna.

We did not have optimal conditions. The antennas we tested were compromises compared to an optimal dipole. New Hampshire soil conductivity is usually poor, so the actual ground plane lies at an unknown depth below the surface. We did not directly ground the antennas or place wire beneath them.

Inverted-V Dipoles

At the reception center, we used a homebrew version of the military AS-2259/GR inverted-V. The homebrew is a hybrid of two designs[4,5] with separate wires for 80 meters and 40 meters off a common dipole feed point (*Photo A*). Space at the reception center complex easily accommodated its footprint of about 3,000 square feet. For additional post-drill testing at home, I used a 40/80/160-meter coil-loaded inverted-V dipole[6] with a peak at 25 feet.

Loaded-Whip Dipoles

ARES and RACES also use linear loaded-whip dipoles[3,7]. We tested MFJ mini-dipoles for 40 and 80 meters (*Photo B*) at 15 feet. They were mounted at right angles on a telescoping fiberglass pole, connected with a jumper and fed with a single coax.

I adjusted the loaded-whips for minimum SWR at mid-band. This resulted in high SWR at digital and voice frequencies designated for NH ARES at opposite ends of each band. At the reception center, we chose test frequencies near the SWR minimum for each band so we wouldn't need a tuner.

For subsequent testing at home, I wanted to use NH ARES-designated digital frequencies at the low ends of the bands. Therefore, I used an auto-tuner with a battery and 1:1 choke balun in a gasketed ammo box (*Photo C*). I placed the tuner at the base of the mast to minimize impedance mismatch in the RG-8X coax back to the radio. I ran RG-8U coax from

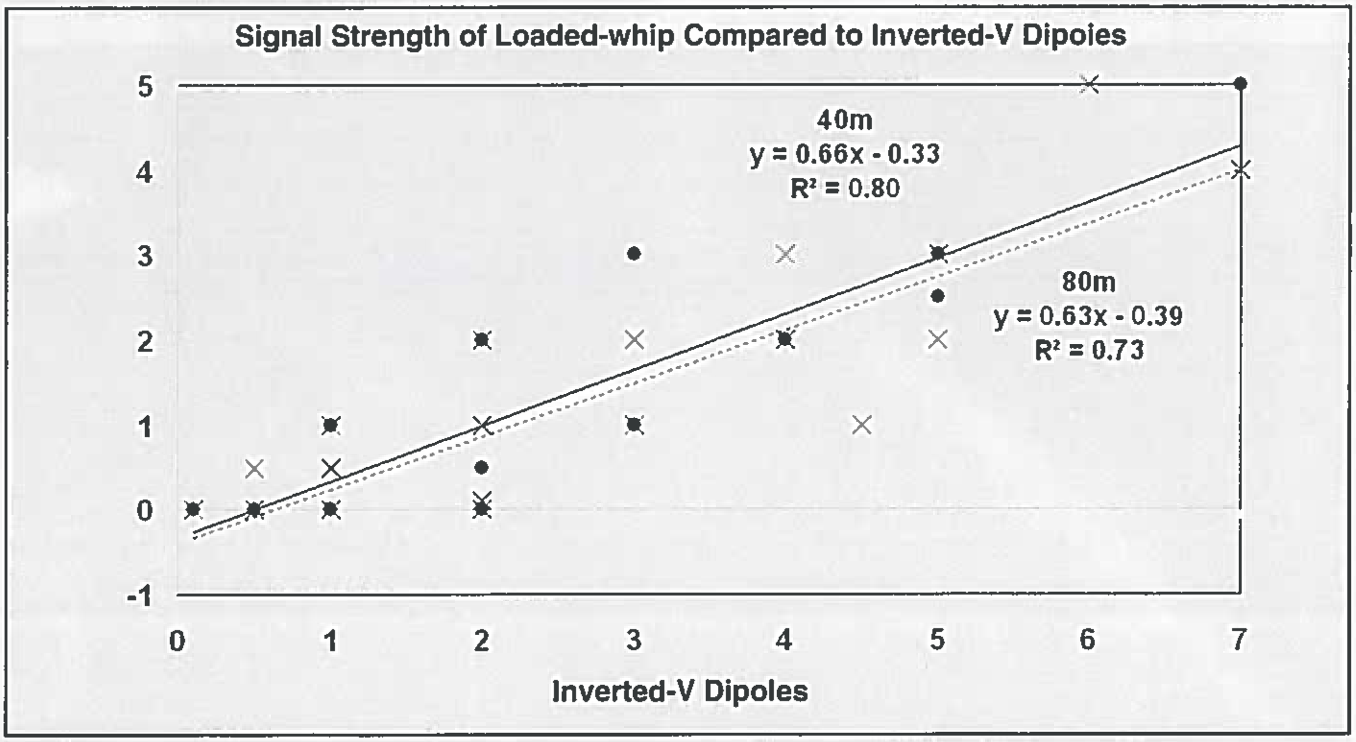


Figure 1. Results of 17 observations on 40 meters and 28 observations on 80 meters, showing data variability and similarity in linear regressions.

Stations	Ground-wave /Sky-wave	Distance, miles	Azimuth
NF1O	GW	<1	298
W1EAA	GW	7	278
KC1BOS	GW	8	43
NF1L	GW	12	176
K1PJS	GW	17	341
N1RCQ	SW	44	7
N1IMW	SW	84	219
N1GB	SW	110	2
K3FEF–SDR	SW	205	238
K2SDR–SDR	SW	233	213
KD2OM–SDR	SW	293	272
VE1BAS–SDR	SW	319	50

Table 1. Participating stations for ground-wave (GW) and skywave (SW) measurements.

Antenna	% Time Above Noise	
	2 S-units (12 dB)	1 S-unit (6 dB)
Inverted-V	70%	85%
Loaded-Whip	40%	60%

Table 2. Summary of 47 paired observations on 80 and 40 meters.

the tuner up to the dipoles to handle the effects of impedance mismatch while operating outside of the 50-kHz window where the SWR was 2:1 or less.

On-Air Tests

Twelve receiving stations participated in ground-wave and skywave testing (*Table 1*). I sent a 100-watt CW carrier for several seconds while receiving stations recorded the signal strength. We made paired observations by measuring received signal strengths on one antenna and then quickly switching to the other with a coax switch. In this way, we were able to capture nearly-identical propagation conditions for both the inverted-V and loaded-whip antennas on each band. The data pairs taken in quick succession were used to compare the differences in performance of the two antenna types after subtracting background noise from each measurement.

During the drills, most receiving stations were within ground-wave distances, so we collected limited NVIS data at the reception center. To get more NVIS data, I ran additional tests from home, seven miles west of the reception center. I accessed four SDR receivers 205 to 319 miles away over the internet (example in *Photo D*). I sent a 100-watt CW carrier and read the received signal strength at the remote SDRs. I measured signal strengths during morning, afternoon, and evening on each band for several days to cover a range of propagation possibilities.

Results

We made 63 paired inverted-V and loaded-whip dipole skywave observations on 40 and 80 meters. Usable signals were heard in 45 observations. *Figure 1* compares the data regressions for 40 and 80 meters, which are very similar. *Table 2* summarizes the results.

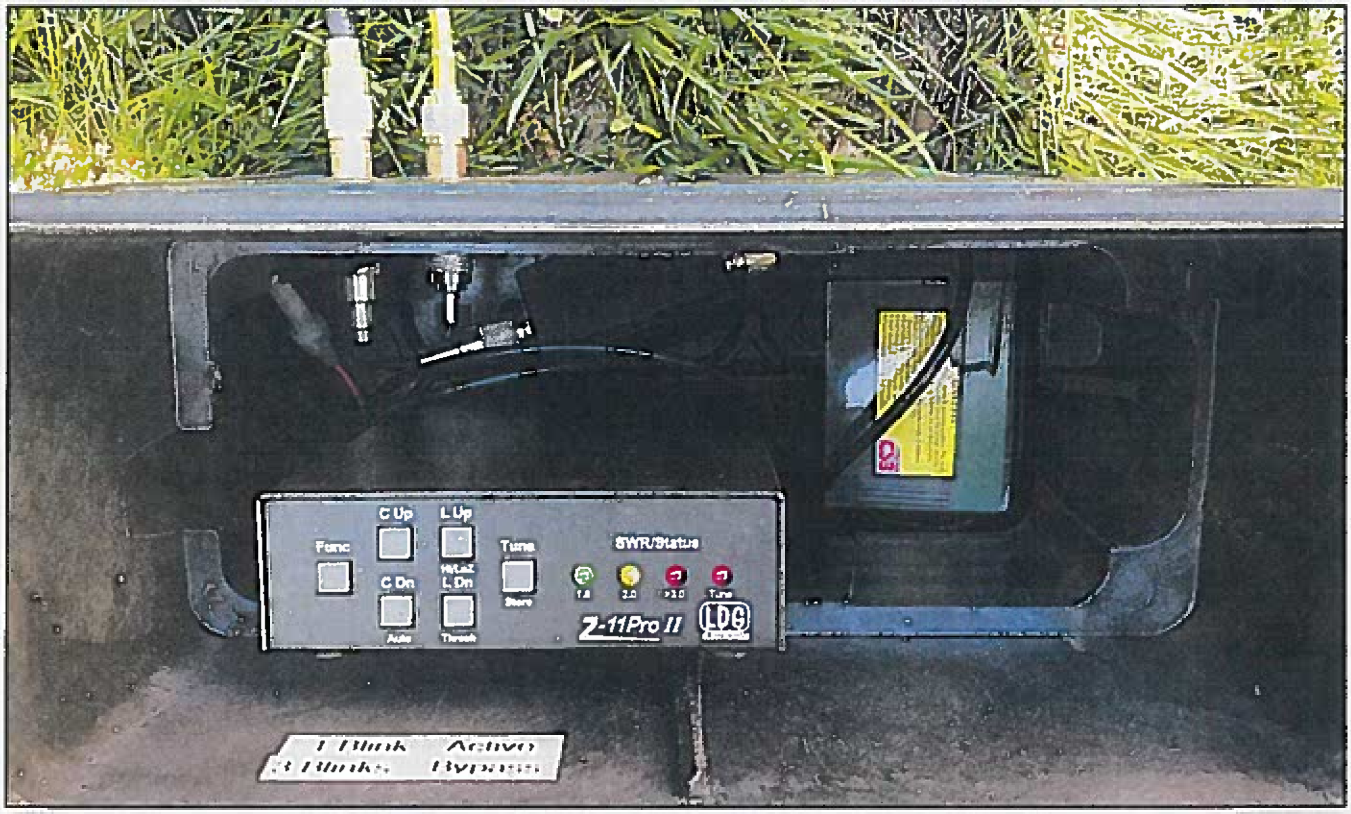
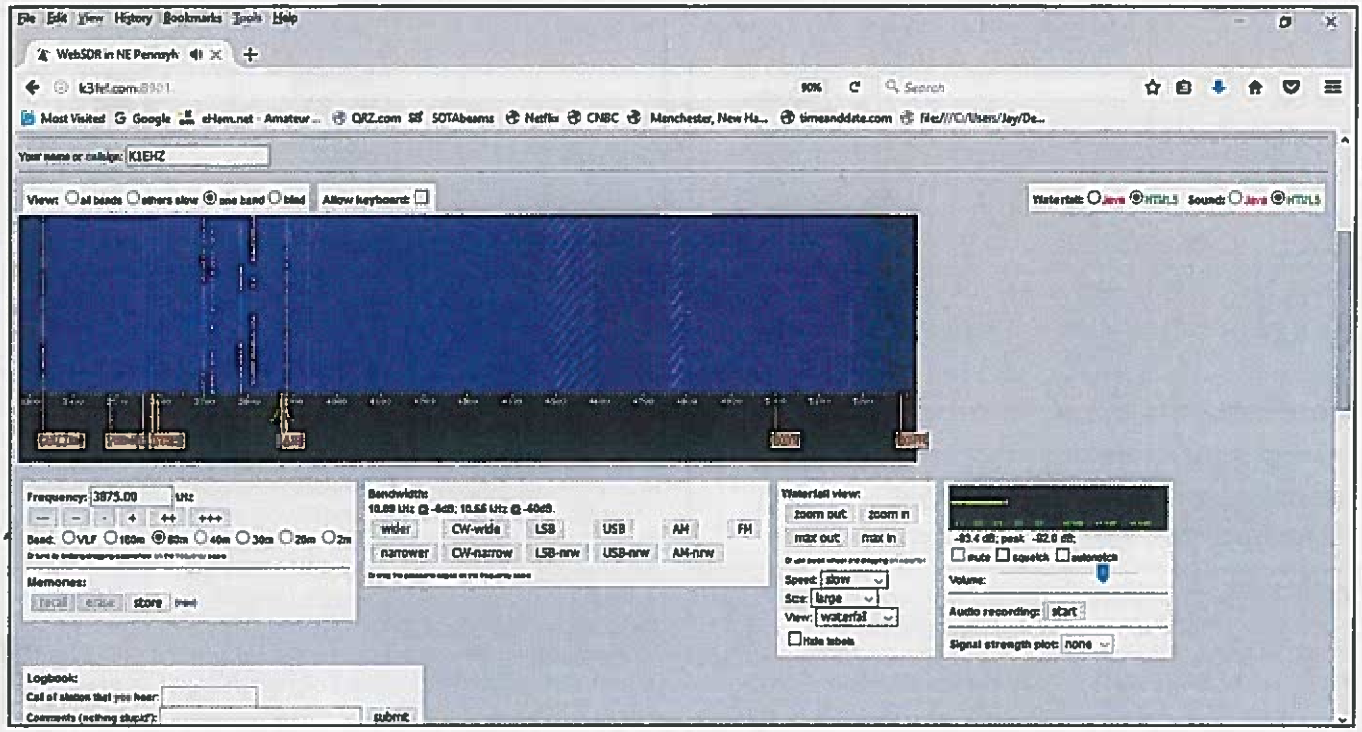


Photo C. Auto-tuner with battery and 1:1 choke in a gasketed ammo box.



Your name or callsign: K1EHZ

View: ○ all bands ○ others slow ● one band ○ blind

Frequency: 3873.00 kHz

Band: ○ VLF ○ 160m ● 80m ○ 40m ○ 30m ○ 20m ○ 2m

Bandwidth: 10.89 kHz @ -6dB; 10.56 kHz @ -60dB.

Speed: slow

Size: large

View: waterfall

-83.4 dB; peak -82.0 dB;

Audio recording: start

Signal strength plot: none

Photo D. K3FEF's SDR screen.

Based on the sky-wave observations:

- Inverted-Vs had an average signal strength advantage of 1.4 S-units or 8.4 dB over the loaded-whips.
- Inverted-V signal strengths were 2 S-units (12 dB) above the noise 70% of the time and at least 1 S-unit (6 dB) above the noise 85% of the time.
- Loaded-whip dipole signal strengths were 2 S-units (12 dB) above the noise 40% of the time and at least 1 S-unit (6 dB) above the noise 60% of the time.
- Across all measurements, the signal strengths ranged from the loaded-whips being equal to the inverted-Vs (0 dB difference when heard) to the loaded whips being down by about 3.5 S-units or 21 dB.

We also made nine paired observations from the reception center that I classified as ground-wave due to short distances between stations. Ground-wave results were not analyzed further because our main interest was skywave propagation.

Conclusions

We were not surprised that the longer inverted-Vs usually provided higher received signal strengths than the much shorter loaded whips. However, loaded whips do have positives for ARES operations:

- Smaller footprint than inverted-Vs.
- Mount on a relatively light telescoping fiberglass mast.
- Single coax feed through an auto-tuner at the base.
- One-person setup.

Based on these results, and depending on atmospheric conditions, loaded-whips could be acceptable for voice messaging part of the time. For a greater percent of the time we could expect loaded-whips to be useful for digital modes with Narrow Band Emergency Messaging Software (NBEMS)[8].

Digital modes have certain advantages over voice for emergency communications. For example:

- Can be very effective at low, and even negative, signal strengths relative to noise.
- Clearly convey medical information such as requests for medications or equipment with complicated names.
- Help conserve energy when power is limited.
- Often have formally-designated frequencies so dedicated loaded whips can be adjusted for best performance without a tuner.

Acknowledgements

ARES relies on teamwork and this effort involved many radio amateurs contributing effort and ideas. In addition to those listed in *Table 1*, these Hillsborough County ARES members participated: K1ATL, K1SMD, KA1IJN, KB1VOD, KB1VOV, KC1ASO, KC1ESG, K9AEN, and N1MEO. In addition, Assistant Emergency Coordinator Ed Leduc, KA1IJN; Emergency Coordinator Fletch Seagroves, N1MEO; NH Section Emergency Coordinator Wayne Santos, N1CKM; and NH Section Manager Pete Stohrer, K1PJS, also encouraged the antenna project.

Notes

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