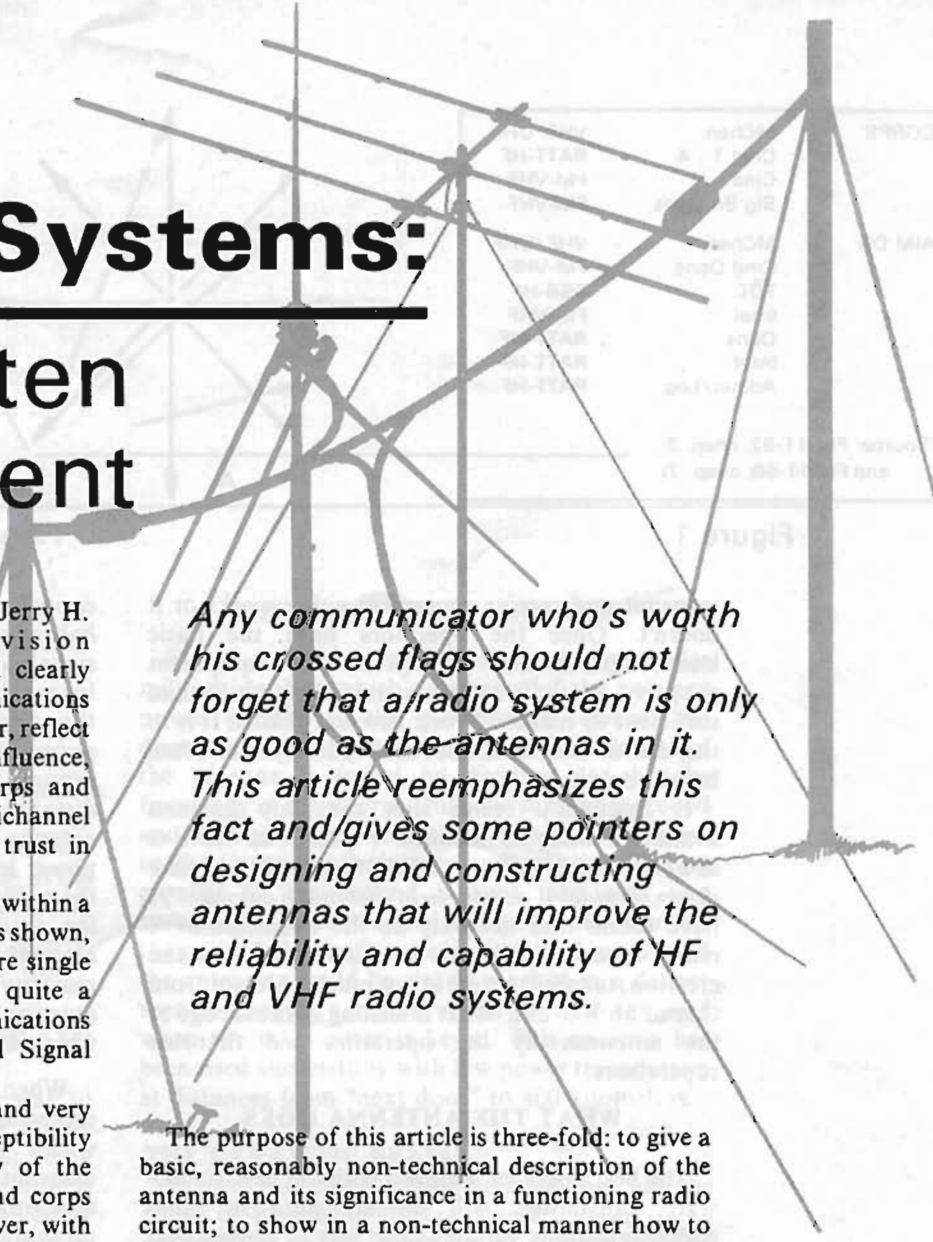
Antenna Systems:

The Forgotten Third Element

by SFC Gary H. Lusterman



Any communicator who's worth his crossed flags should not forget that a radio system is only as good as the antennas in it. This article reemphasizes this fact and gives some pointers on designing and constructing antennas that will improve the reliability and capability of HF and VHF radio systems.

In the Summer 1978 issue of TAC, LTC Jerry H. Hogan ("Signal Tips for Division Communicators") gave a marvelous and clearly written statement of his concept of communications at the division level. His comments, however, reflect a common error in thought, command influence, and interpretation of doctrine at the corps and division level: nearly total interest in multichannel communications and lack of interest or trust in other radio communications.

Figure 1 shows the communications nets within a typical corps and division. Of the 14 systems shown, only two are multichannel; the other 12 are single channel radio systems. This constitutes quite a percentage of the command's communications systems to be de-emphasized by typical Signal personnel!

Doctrine discourages the use of high and very high frequency radios because of their susceptibility to interception and jamming, but many of the operational requirements of a division and corps must depend on these very systems. However, with the advent of multichannel, the orientation of too many Signal personnel has been to downgrade HF and VHF to the detriment of the HF/VHF operators and the reliability of the systems.

A sometimes valid comment by many Signal personnel is that HF is not reliable enough. What is "enough"? Radio doctrine states that HF is reliable for a certain percentage of each day, depending on distance and frequency (presuming that the greatest distances involved are approximately 160 kilometers and that the sky-wave propagation is involved only at the extreme distance). As long as commanders are aware of the limitations, radio systems can be used very effectively in the combat environment at division and corps level. From the author's observations during the last 16 years, the ineffectiveness of HF and VHF circuits lies in two areas: the inability of the commander or non-radio Signal officer to understand what constitutes a *basic* radio system and, therefore, be able to recognize a possible deficiency; and the lack of operator and first-line supervisor knowledge of a physical one-third of their radio system - **the antenna.**

The purpose of this article is three-fold: to give a basic, reasonably non-technical description of the antenna and its significance in a functioning radio circuit; to show in a non-technical manner how to design a few antenna systems which may improve considerably the reliability and capability of HF and VHF radio systems; and to show how these antennas can be easily constructed in the field with few materials and no additions to a unit's table of organization and equipment.

ARE ANTENNAS REALLY THAT IMPORTANT?

How many commanders or unit Signal officers/platoon leaders or even operators can answer that question honestly? Very few in all likelihood. To a certain extent, there is a valid reason for it: the level of information available is so technical that it is almost impossible to understand by the average person. So let's start off fresh and put the system into non-technical language.

One can break any radio system into three simple parts: 1) operator/crypto system, 2) transmit/receive equipment, and 3) the antenna system.

In a unit with good leaders and trainers, the operators' use of proper procedure and the associated crypto systems create few problems. The

CORPS	MChan	VHF/UHF
	Cmd 1 - 4	RATT-HF
	Cmd	FM-VHF
	Sig Bn Opns	FM-VHF
AIM Div	MChan	VHF/UHF
	Cmd Opns	FM-VHF
	TOC	SSB-HF
	Intel	FM-VHF
	Opns	RATT-HF
	Intel	RATT-HF
	Admin/Log	RATT-HF

(Source: FM 11-92, chap. 3; and FM 11-50, chap. 7)

Figure 1.

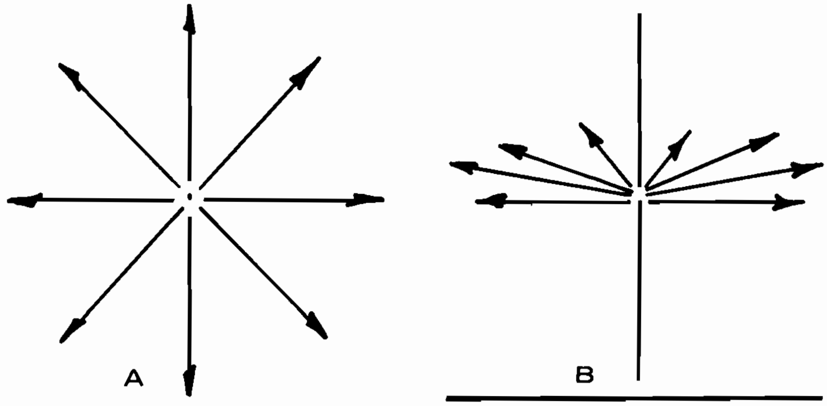


Figure 2.

transmit and receive equipment either works or it doesn't. Once the operators have the basic knowledge of how to operate the equipment properly, periodic refresher training is more than sufficient to maintain their necessary skills. It is in the use of antennas that the radio system often breaks down.

It frequently seems that the only antenna available today is a whip. *("Yeah, we have a doublet, but it takes too long to put up and take down. Besides it doesn't help that much anyway.")* I have found that not only do the operators have many types of antennas available, but that the erection/takedown time is not much different from that of an RC-292. What is lacking is knowledge of the antennas by the operators and first-line supervisors.

WHAT THE ANTENNA DOES

The best operator, coupled with the best 10,000-watt transmitter, will do no good in radio communications without some way to radiate that power. This is the function of the antenna. Depending on the type of antenna used, the operator can lose most of that power or can cause the same effect as multiplying the transmitter power in one or two directions.

To see how different antennas work, use the military doublet as a reference (which is close enough to the engineering reference, a free-space half-wave dipole). If we stand a doublet on end, the signal power goes out as is shown in Figure 2. (The longer the arrow, the greater the power radiated in that direction.) As the diagram shows, most of the power leaves the antenna almost parallel to the ground, which is desired for transmissions of short distances. This is also about the way the whip antenna works. Figure 3a shows how the signal power leaves a doublet antenna that is parallel to the ground. Most of the power leaves broadside to the antenna, but, as shown in 3b, the greatest amount goes nearly straight up. To radiate the majority of power parallel to the ground as in 3c, the antenna must be raised to a substantial height, which is impractical on most HF frequencies

When using an antenna to receive, the best reception is from the same direction or angle as that which would give the best power output for transmitting. There is one other consideration for a receiving antenna, however. The receiver depends on minute electrical signals picked up from the air to operate. The more physical area there is to pick up these small signals, the more total signal the receiver has. This information suggests why HF RATT communications often fail and offers a possible solution for the problem. The transmitter has sufficient power leaving the whip, but that same 5 or 10-meter whip does not pick up enough of the

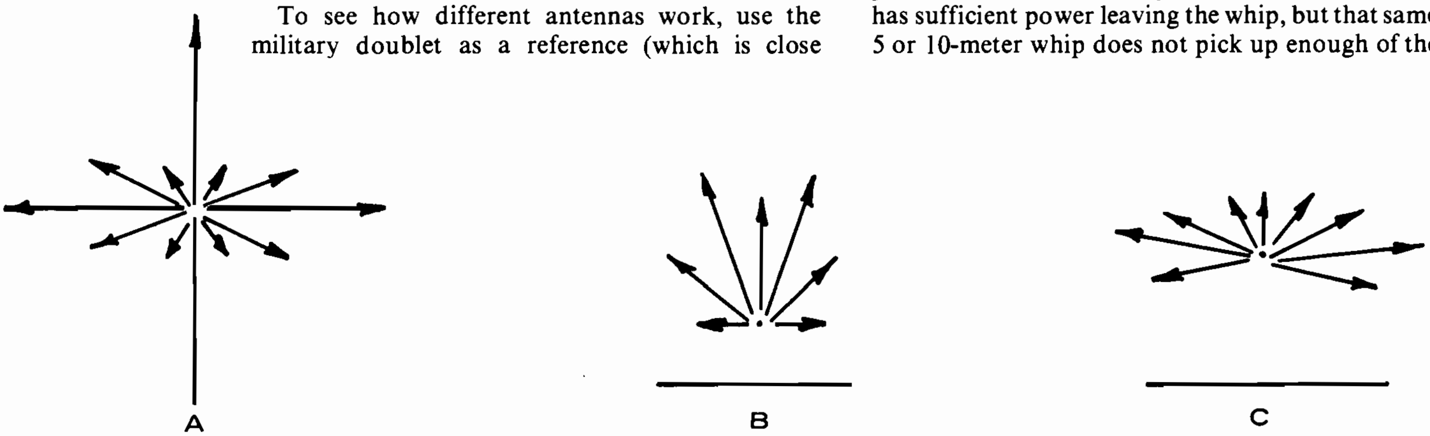


Figure 3.

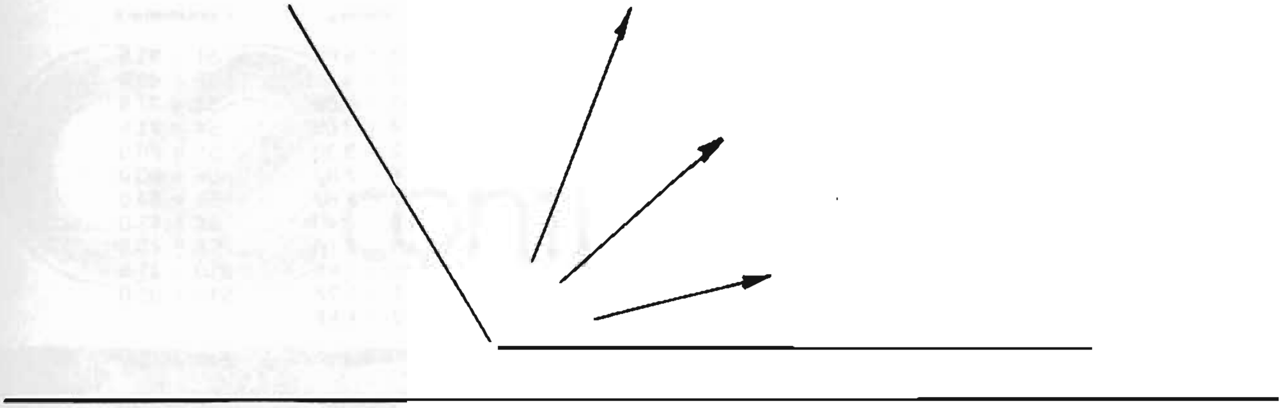


Figure 4.

signal to be heard over the atmospheric noise. By merely using a separate antenna for the receiver (a dipole or long wire), communications can often be easily made.

Now another problem crops up. The AN/GRC-142 and AN/GRC-122 radios do not have provisions for using a separate receive antenna for simplex (single frequency) operation. This leaves the operator with a perplexing problem. The whip works for transmitting but not for receiving; at the lower HF frequencies, the dipole must be put at an unreasonable height to make the main power radiate parallel to the ground. Fortunately, there is a relatively simple solution.

ROB PETER TO PAY PAUL AND TO COMMUNICATE

Refer to Figure 3a. If there were some way to reduce the power radiating off the ends of the doublet, that power could be added to that going broadside to the antenna. If the receiving station is located broadside to the antenna in 3a, the effect would be the same as if the transmitting station increased its power output. Since an antenna receives as much as it transmits, this principle for a receiving antenna would have the same effect: an apparent increase in transmitter power. With the antennas described here, the effective power of a transmitter can be raised to 42 times in a given direction.

THE SLANT WIRE ANTENNA

Figure 4 shows a method of erecting a regular military doublet which puts more of the radiated power parallel to the ground and towards the direction in which the leg points. The total length of the antenna is found by dividing 468 by the frequency in megahertz. Only one support is needed and the angle is not critical. However, angles close to 90 degrees give the best ground radiation. The leg parallel to the ground is kept taut with two suspension lines and raised about 30 centimeters off the ground. As a safety precaution, the area around the antenna should be clearly marked as a danger area to prevent someone stumbling into the wire when the transmitter is keyed. This antenna has been used successfully with low power transmitters at distances from "next door" to 400 kilometers.

THE PARASITIC BEAM

Figure 5 shows a simple antenna that has the effect of increasing the transmitter power six to seven times in the direction of the arrow. The antenna shown is constructed for 10 MHz. As an example of the size of a VHF antenna, the elements would be 2.5, 2.8, and 3.1 meters with 57.5-centimeter spacing between the wires. A similar antenna was used in Vietnam to extend the range of an RT-524 to over 160 kilometers using secure voice equipment.

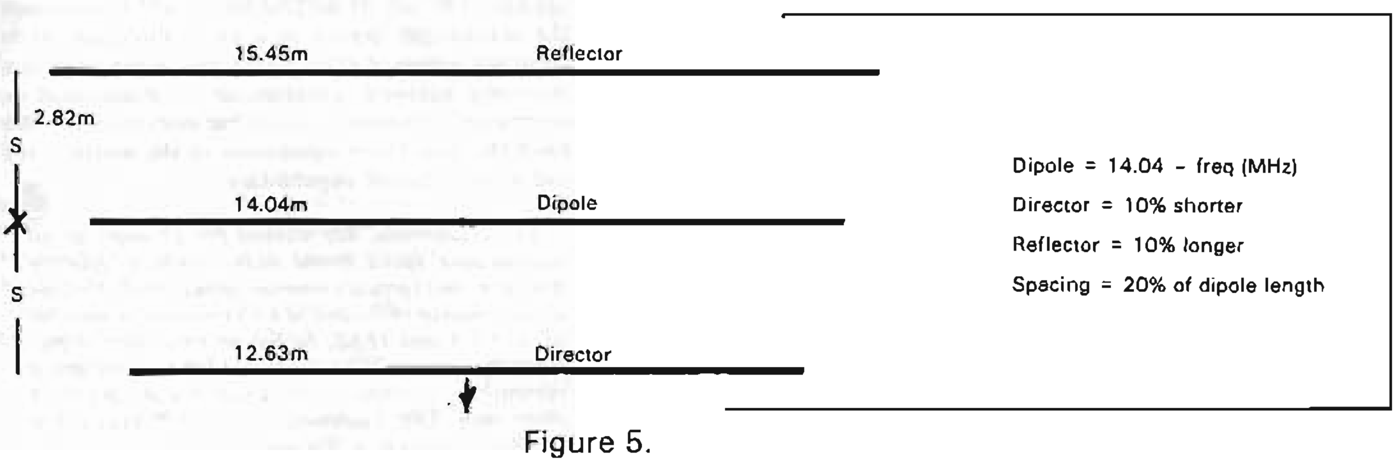


Figure 5.

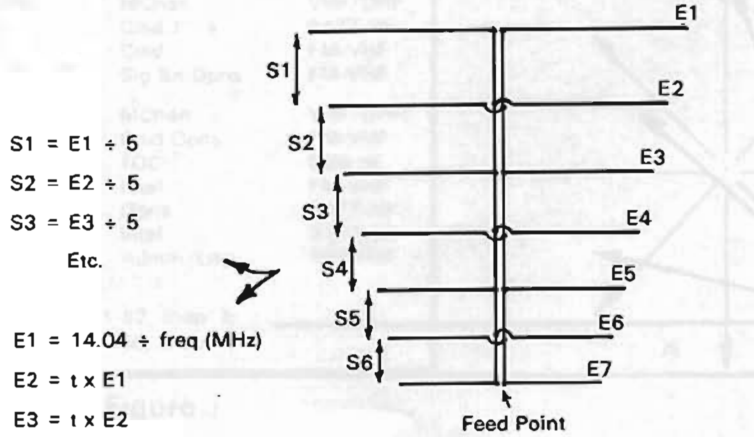


Figure 6.

Any type of suspension cord or heavy twine can be used to erect the beam. The antenna is constructed on the ground with cord tied to the insulators at the ends of the wires to keep the spacing interval. Four lines are then tied to the ends of the reflector and director to suspend the antenna. Since communications sites are often situated in or near wooded areas for overhead concealment, the trees themselves can be used to hang the antenna, eliminating the need for erecting masts. The center element could be the doublet supplied with the radio equipment and the other two made from W-1 acquired seperately. The front (shorter) end should be pointed within five degrees of the other station.

THE FREQUENCY INDEPENDENT ANTENNA

While the parasitic beam is a fine antenna and a simple one to build, it is constructed for only one frequency and often, especially with VHF, the operator is required to change frequencies several times per day. There is another class of beam antenna that is a bit more complicated to construct but, once made, is usable over a wide range of

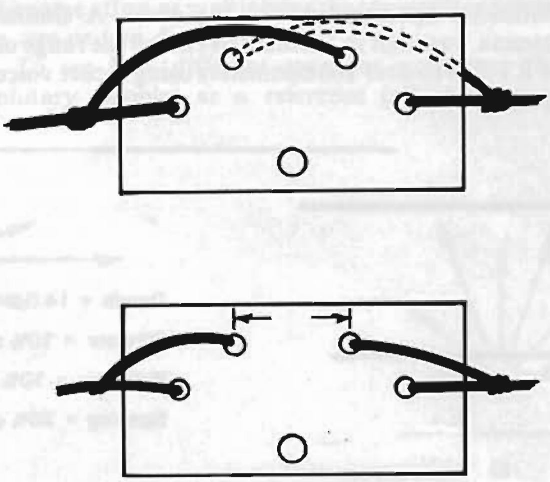


Figure 7.

Meters	Centimeters
E1 = 5.01	S1 = 97.5
E2 = 4.5	S2 = 90.0
E3 = 4.05	S3 = 77.5
E4 = 3.66	S4 = 72.5
E5 = 3.30	S5 = 65.0
E6 = 2.97	S6 = 60.0
E7 = 2.67	S7 = 50.0
E8 = 2.40	S8 = 45.0
E9 = 2.16	S9 = 40.0
E10 = 1.95	S10 = 37.5
E11 = 1.74	S11 = 35.0
E12 = 1.56	
Total length = 6.9 meters	Approx. gain = 32

Meters	Centimeters
E1 = 5.01	S1 = 97.5
E2 = 4.02	S2 = 77.5
E3 = 3.21	S3 = 63.0
E4 = 2.58	S4 = 51.0
E5 = 2.04	S5 = 40.0
E6 = 1.65	
Total length = 3.36 meters	Approx. gain = 8

Figure 8.

frequencies. Figure 6 shows the diagram of one and the data for computing the various lengths and distances. Figure 7 shows the center insulators for HF antennas. The insulator size would be about half that shown for a VHF antenna.

Figure 8 gives the figures for two antennas which will cover the entire range of an RT-524 or PRC-77. Notice the differences in the physical lengths and the gains. The first has greater gain but may be too large in some situations. The second is smaller but has a much reduced gain. The antennas can be erected with four masts or trees, or can be suspended by the center insulators with a cord and two supports with the ends pulled down and out to give the appearance of a pup-tent.

The value of "t" used in Figure 6 can be any number between 0.8 and 0.95. The lower the number used, the shorter the antenna and the lower the radiated power gain.

IN SUMMARY

Without the use of good antennas, the best equipment and the best trained operators are useless. The use of directional antennas increases the transmitter power in a given direction while reducing power in other directions. When used as a receiving antenna, interference — intentional or otherwise — is reduced in all but one direction. We have the best radio equipment in the world. Let's use it to its fullest capabilities.

SFC Lusterman has worked for 17 years as an intermediate speed morse radio operator, teletype operator, and tactical communications chief. He is an active amateur radio and MARS operator. A member of AFCEA and IEEE, he has an associate's degree from the University of the State of New York and is currently completing studies towards a BS degree in electronics. SFC Lusterman is presently assigned to the Berlin Brigade in Europe.

NO ASI

In February 1975, I attended one of the first FKV courses at Fort Monmouth, NJ. My class was told by the course NCOIC that we would be getting an additional skill identifier (ASI).

So far, I have not received an ASI for the course. Is there an ASI for FKV course or not? I am a primary 26L30 and a 31M30 secondary. I would like to work a digital system and maybe an ASI for the FKV course will help on upcoming assignments.

SSG WILLIAM JOHNSON
50th Signal Bn Support Co.
Fort Bragg, NC

According to our sources, the FKV course was taught to soldiers heading to Germany who would be working with the Frankfurt Konigstuhl Viaingenen (FKV) communications system. The course is now being taught at Fort Gordon as the Digital European Backbone (DEB) course. No ASI is--or ever has been--awarded for completion of the training.

Regardless of the ASI, though, make sure you have received credit for this training on Form 2 in your official personnel file. Good luck.

ANTENNA BANANA

"My article, "Antenna Systems: The Forgotten Third Element" in the Fall 1979 issue of TAC, was submitted using feet in the antenna designs and certain errors crept in when TAC decided to publish in metric measurement.

The formula given in the SLANT WIRE ANTENNA paragraph produces the length of the antenna in feet. The formula for computing the dipole length in figure 5 and E1 length in figure 6 should be: length (meters) = 142.5 ÷ Freq (MHz). Using this formula, the lengths of the antennas in figure 8 will be different from those shown by 2 to 8 cm. The lengths shown in figure 5 are 20 to 23 cm (8 to 9 inches) too short. If you wish to use feet as the measurement, the formula is 468 ÷freq (MHz).

In figure 7 the center insulators are shown upside down and the missing length should be 2.5 cm (1 inch). In figure 3A, an arrow was erroneously placed on one end of the antenna.

My comments in the early paragraphs would have been clearer if I had specified that while multichannel has many circuits per system, if that one SYSTEM goes out, the remaining systems must carry the load and that makes single circuit HF/VHF systems extremely critical.

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Oops we goofed! Since we can't find a diplomatic way to worm our way out of this one, we'll let your comments alone serve as the atonement for our mistake.

AK-47

I would like to comment on your feature story concerning "ROTC--Killing the Myths" (Summer 1979). The story by CPT Bush is concise and, above all, accurate. The pictures, with one exception, represent the new ROTC image.

The one exception, your cover photo, leaves me a little baffled. Since when does ROTC use AK-47 assault rifles? The photo, and it is a good one, depicts the rigors of traversing a rope bridge, but one of the cadets is carrying an AK-47. After spending three years as the Public Affairs supervisor at First ROTC Region Headquarters, and also knowing first hand the difficulties of publicizing ROTC, I find it incredible that you would use this photo in your magazine at all, and especially not as the cover.

SFC JAMES R. WOODY
Public Information Division
SHAPE, Belgium

Your letter prompted us to call Third ROTC Region Public Affairs, the office which provided us with the Summer 1978 Advanced Camp photos. The answer to our query is an interesting one to share with you and other TAC readers.

The cadet is not holding an AK-47 but a plastic model of an AK-47. Why? The story goes like this...Advanced Camp students train with real weapons, but during the rope bridge exercise plastic models of the M-16 are used. The rationale for this is that it would be rather costly to replace real weapons should some cadets plunge into the water while crossing the rope bridge.

Now, the story continues...more than 2,600 cadets attended Fort Riley's Advanced Camp in 1978. There were not enough plastic M-16s to go around; hence, some of the cadets used the AK-47 model, which is used for aggressor training.

We still think the photo made an outstanding cover. Had we realized it was an AK-47, we would have included that information in the cover narrative. Thanks for your letter, though, and for your keen observation.