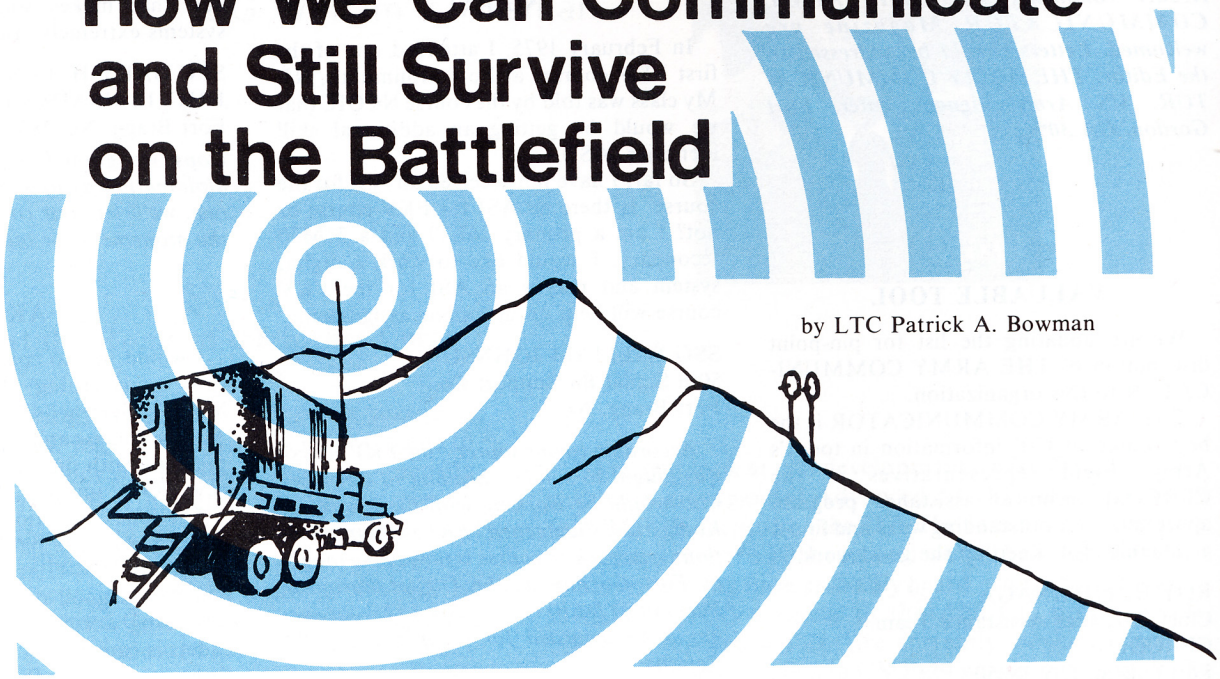
How We Can Communicate and Still Survive on the Battlefield



by LTC Patrick A. Bowman

This fresh and novel approach proposes a system of templates and color-coded maps to reduce the EW vulnerability of friendly communication and target acquisition systems.

The Soviets have devoted considerable quantities of manpower and equipment to developing their capability to conduct radio electronic combat (REC), or electronic warfare as we know it. Certainly the successes in this area that were documented as a result of the '73 Mid-East War would tend to verify that their REC system (used by the Arabs) can be successful. In fact, much of the literature today would have us believe that the Soviets are 10 feet tall in this area. They may be, but Murphy's Law (if something can go wrong, it will) works against them, too.

Their REC equipment, doctrine and tactics have limitations, and by prudent use of our own resources we can deal with this substantial threat. Thus, the purpose of this article is to examine theoretically how Soviet REC works and to postulate how we can counter/minimize this threat without developing lots of exotic new equipment.

Soviet REC

The Soviet REC system is designed primarily as an offensive weapon against our command and control communications system and our target acquisition means. The key elements of this system are direction finding (DF) and jamming assets. Each of these aspects will be examined in detail below.

The DF capability is tied in very closely with Soviet artillery assets, so that once a communications center has been located, massive amounts of artillery fire can be placed on the area target. DF techniques involve three known locations receiving an electronic signal and determining the bearing of the maximum signal strength. The intersection of these three bearings defines a target area.

In order for this bearing to be accurate, line-of-sight between transmitter and DF receiver is essential. Bearings from a radio signal which have been reflected or refracted (i.e., bent) provide false information as to locations of the transmitter. This can be very significant since some error has already been associated with determining the bearing. Thus, some plus or minus degree spread is given to the bearing. For example, if the equipment showed a maximum signal strength at 60 degrees, then the actual signal may be located in a fan of plus or minus X degrees from 60 degrees. The most accurate equipment has a small plus or minus degree spread.

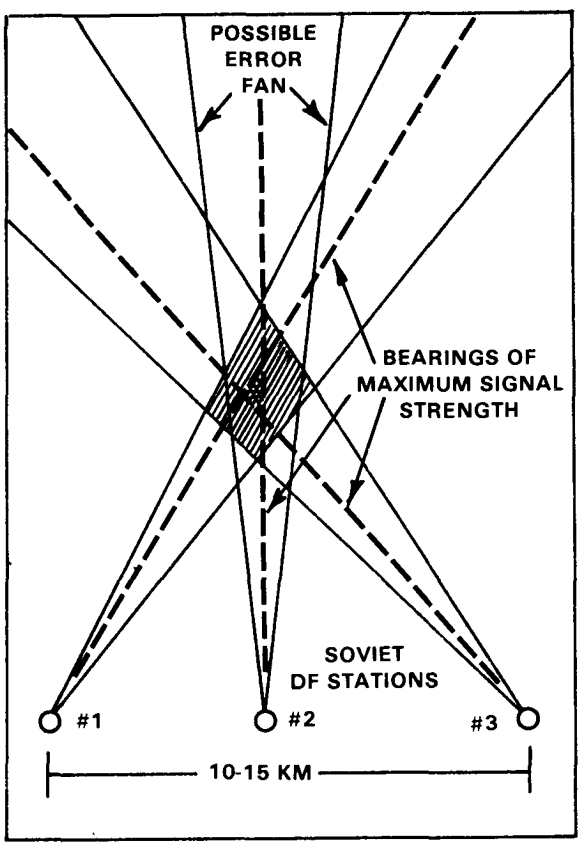
The intersection of these three fans defines the target area. Figure 1 portrays this situation with the small double cross-hatched area being the intersection without considering error, while the single cross hatched area considers error.

If only two stations can see the transmitter, then the intersection area of the two fans becomes larger and would probably make artillery saturation of the area infeasible. Additionally, if one of the DF stations is receiving a ground wave (i.e.,reflected off the ground or other terrain features) which may provide a false bearing, the area of intersect can be very large and again preclude artillery attack.

Even under ideal conditions, this target area may be fairly large. The farther away the target is from the receivers, the greater the area of intersection. However, using map analysis in coordination with the defined area, the technique can be very effective. For example, if the intersection area includes a great deal of open terrain and a patch of woods large enough for the suspected command post, the artillery can be directed at the patch of woods.

The other main Soviet REC capability which has the potential to degrade our communications seriously is jamming. This consists of transmitting some form of noise on a frequency in use by the other side. A radio receiver tuned to a certain frequency will receive or be captured by the strongest signal on that frequency. Therefore, if there are two signals coming in but one is much stronger than the other, the stronger signal is heard and the other one is not. If the stronger signal is noise, then the jamming is effective.

The factors which must be considered in jamming involve the transmitted power of both the friendly transmitter and the jammer, and the distance between the receiver and both transmitters. To jam a receiver which has its friendly transmitter closer than the jammer, the jammer must use greater transmitter power to be successful. These relationships are precise and can be mathematically determined for all cases. The relationship is called the jamming-to-signal ratio (JSR).



The Soviets can use both spot or barrage jamming. Spot jamming puts all the transmitter's power on jamming one frequency while barrage jamming transmits power on several frequencies simultaneously but the power of the signal for each frequency is less than that of spot jamming.

The Soviets have a great jamming capability. They will pick the time and place to make a massive jamming effort. For example, they can be expected to use jamming extensively — both spot (for selected critical communications nets and target acquisition means which have been identified) and barrage during their attack. Since jamming will also impact on their use of the electromagnetic spectrum, they will be prepared to attack without the use of radios.

US EW: No Help in Protecting Our Commo

Current US electronic warfare equipment, doctrine and tactics are designed primarily to gather intelligence and to attack electronically the Soviets' use of the spectrum. Development of new equipment in both the communication and EW arena will improve our capabilities. We should be able to field more accurate DF systems in the near time frame. New communications equipment is being designed with enemy EW capabilities in mind. New systems, currently in their prototype production phase, should minimize our vulnerability to Soviet direction finding and jamming. Until these new systems are fielded, however, we need to find a better way to communicate on the battlefield and survive.

US Communications Systems

Currently, US communications systems are planned with essentially one thought in mind: can we communicate with all necessary stations/commanders/communications centers? Little or no consideration is given to the technical vulnerabilities of that system to the Soviet REC capabilities. We either disregard his capability or tend to overestimate it. Signal Corps personnel plan the commo system while the Military Intelligence staff worries about Soviet REC.

The US EW staff officer (5M) is supposed to be the bridge between these two stovepipe functions. This 5M course, taught at Fort Huachuca, AZ, provides very good general information on this entire subject area. This general information merely emphasizes the need for more detailed information to assist communicators in planning and operating our communications systems.

FIGURE 1: DIRECTION FINDING TECHNIQUE

Minimizing the Threat

There are several ways to reduce the Soviet DF threat. For direction finding, the Soviets must be able to see electronically the radiated signal from three separate locations. Of course, there are many ways to reduce the possibility of this occurring: not transmitting, transmitting less or transmitting in a more efficient manner. Current literature discusses more reliance on wire and messengers, use of directional antennas, use of low power, reduction of transmission time and screening of our transmitters.

The effectiveness of enemy jamming can also be reduced. The methods used to reduce DF effectiveness, as well as changing frequency, changing transmitter mode, working through the jamming, reporting and other procedures, will help reduce enemy jamming effectiveness as well.

Unfortunately, these methods are applied sparingly, if at all, for two main reasons. First, most commanders want more and more capability for immediate communications with a greater number of users; the above techniques are generally viewed as reducing our communications capability. Second, many combat commanders do not have a technical background and therefore shy away from the details involved with either the communication system or the EW aspects. Electronic signature is "nebulous" and is therefore not considered. As a result, very few exercises have realistic EW play because its not understood and it certainly fouls up the information flow and disrupts the accomplishment of other training objectives. Hence, communicators can't train on those techniques which could assist in reducing our vulnerability to both DF and jamming.

If we could quantify electronic signature in simple terms and identify ways to reduce it and at the same time indicate or demonstrate that necessary communications can be accomplished, then the magnitude of the resistance to considering EW aspects may be reduced. We must be able to quantify our vulnerability, develop techniques to reduce that vulnerability and then practice and train on these techniques. Currently, the technical tools to achieve this capability are not readily available to communications planners, the EW staff officer or the MI/G2 types.

Possible Solution

It would be feasible to use computers with digitalized terrain to analyze line-of-sight in relation to US emitters and Soviet receivers (DF). This would be an extremely valuable tool, but not an extremely practical one since computers and digitalized terrain are hard to find.

This complex system may be accurate but it is not going to be available to most Signal planners for some time. We therefore need a simple expedient system which may not be totally accurate but which would enable us to approximate our vulnerability. Better planning could then be done and vulnerability could be reduced.

What we need are some simple templates which depict the electromagnetic radiation field of our common emitters. This radiation field must consider frequency, antenna, power out, terrain, weather and atmospheric conditions. The far extent of the pattern should consider attenuation of the signal and the receive threshold of the likely Soviet threat receiver.

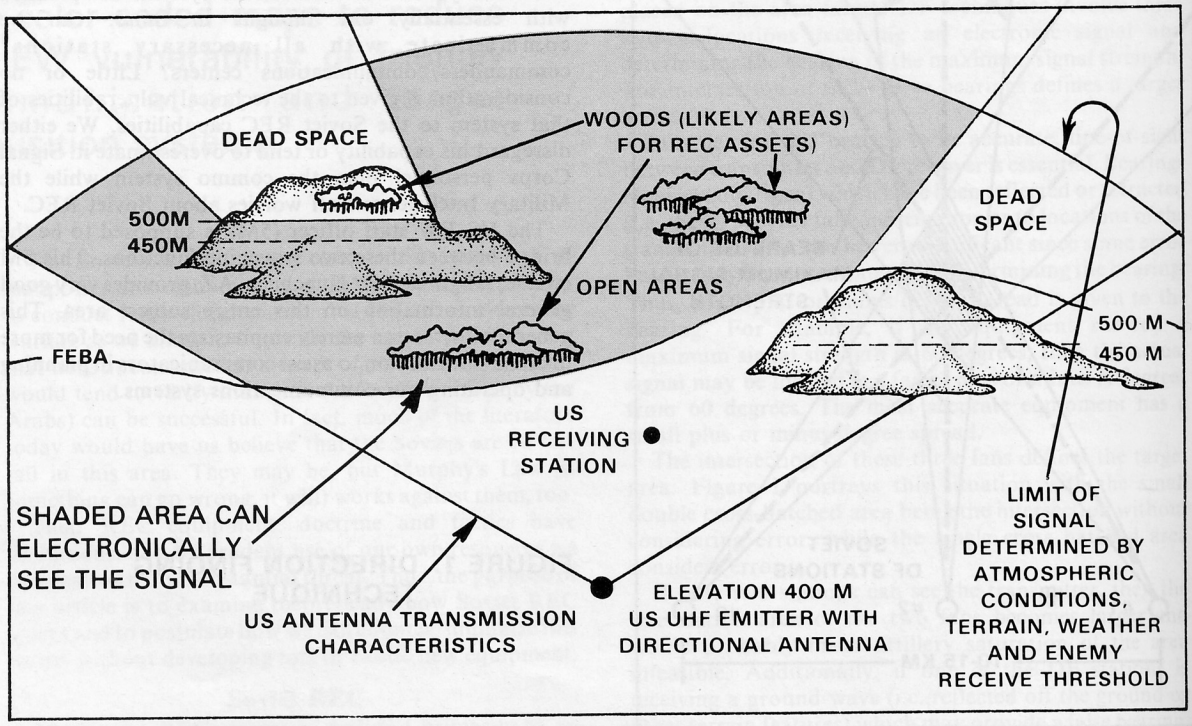


FIGURE 2: US TRANSMISSION VULNERABILITY

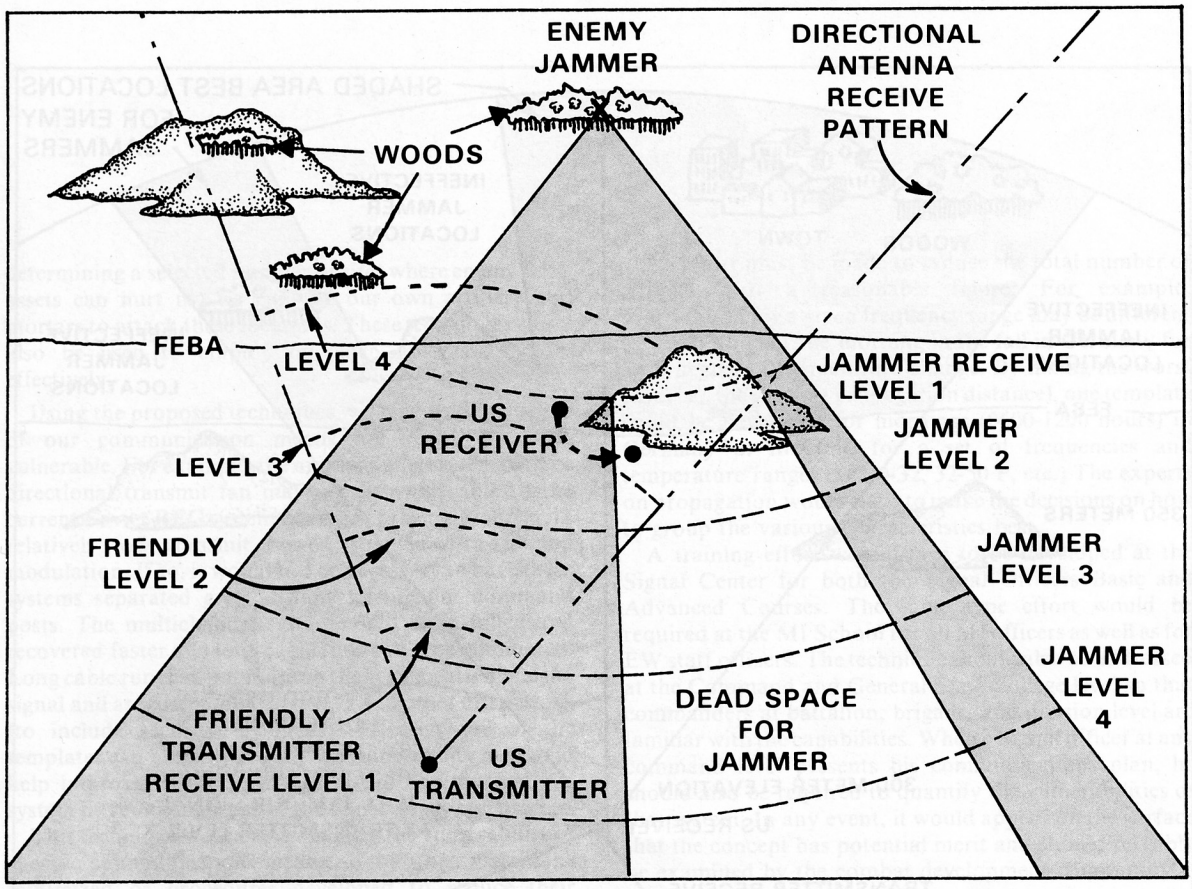


FIGURE 3: US RECEIVER VULNERABILITY TO JAMMING

Using generalizations of terrain, weather and atmospheric conditions, and "worst casing," the number of templates can be reduced to a reasonable quantity. With these templates, designed for use with tactical maps (1/50,000 or 1/100,000), terrain analysis using color coded maps can then be conducted. By using different colors for different elevations in increments of 50 or 100-meter intervals, we could determine gross line-of-sight between any two points or areas. If an antenna is at 400 meters, then line-of-sight is assumed to exist to all elevations within the template at 450 meters or less unless the signal encounters an elevation of 450 meters higher elevation prior to reaching that point.

A simple example, shown in Figure 2, would enable us to determine the area of vulnerability for our signal. Further terrain analysis could identify specific areas where enemy REC equipment would probably be placed to intercept our signal. Our vulnerability is then measured by the number and size of these areas, i.e., the greater the size and number, the more vulnerable we are. If there are only a few areas/locations, they can be targeted for preplanned artillery fires.

On the other side of the coin, the exact opposite circumstance can be developed to determine the effectiveness of enemy jammers against our emitters. Templates for their jammers with the maximum radius determined by weather, frequency, terrain, antenna, power out, and the receiver threshold of our radio, can be used as well. Several radius levels may be determined with receive signal levels identified. Using our transmitter template, also with various receive levels identified, various jam-to-signal ratios can be compared.

For any particular setup, the friendly receive level must be greater than the jam receive level by some specified amount to defeat the jamming. Again, using very rough estimates and worst casing, it could be determined if the jammer would be effective in capturing the receiver. In the simple case, shown in Figure 3, the jam-to-signal ratio (jammer receive level 1 to transmitter level 4 for worst case) would probably indicate that the jammer effectively blocks our transmission. Moving the receiver behind the hill would shield his jammer and would allow us to communicate.

A further expansion of the technique would be to define on the other side of the FEBA an area where enemy jammers would be most effective against a particularly important radio net or receiver. Knowing the receive level for the farthest friendly station in the net, we could determine a minimum jammer receive level which will jam our net.

Different templates for enemy spot or barrage jamming could be developed so that either case can be examined. There is a distance from the jammer associated with the minimum successful jammer receive level. Using that distance (spot jamming or worst case) as a radius from our receiver, we can draw an arc on the other side of the FEBA which defines a jammer employment area which, from a power standpoint, would jam our receiver. Again, with color coded maps and terrain analysis, some of that area can be eliminated. Figure 4 illustrates this simple situation. Highly probable locations for enemy jammers could be preplanned for artillery fire. If jamming is experienced, those fires could be called.

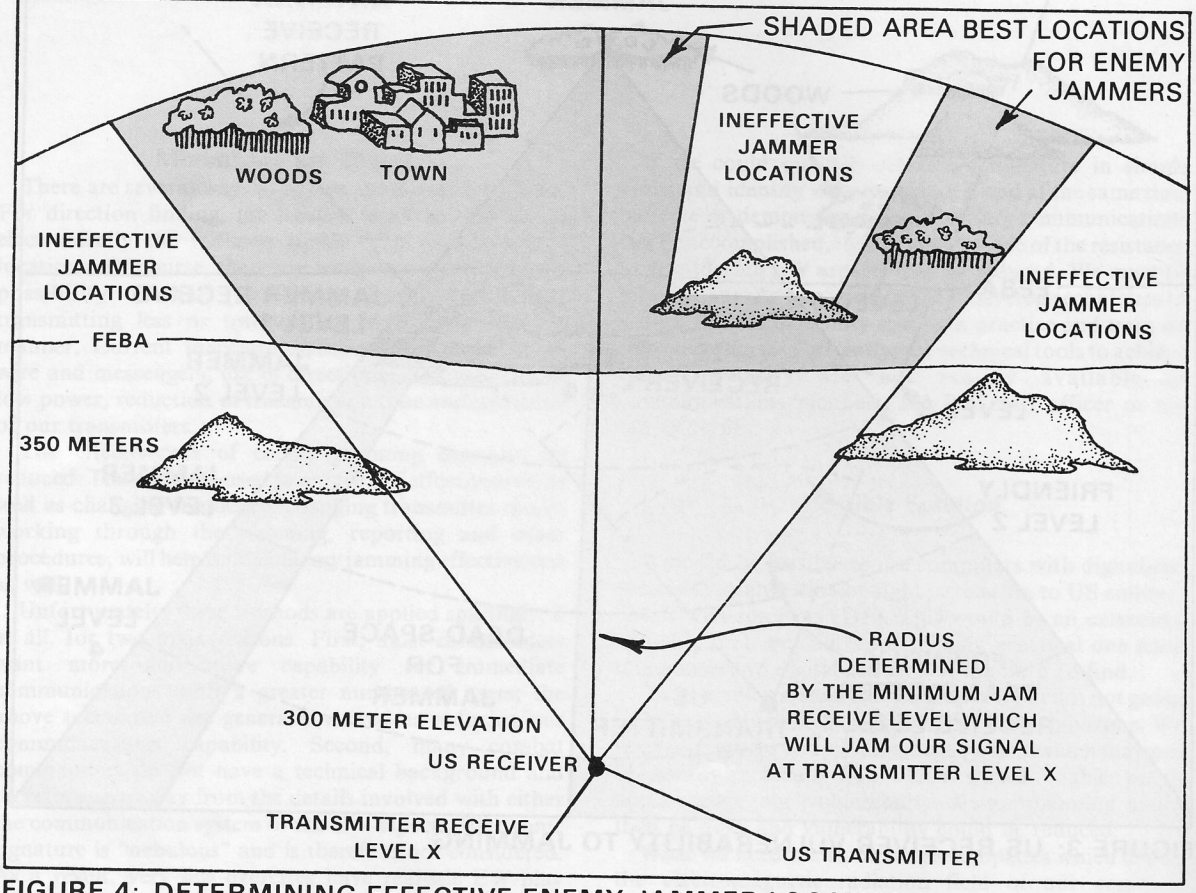


FIGURE 4: DETERMINING EFFECTIVE ENEMY JAMMER LOCATIONS

Devil's Advocate

Certainly this technique is not a precise one. There are errors and generalizations associated with its use. It is also recognized that a jamming signal may be reflected (ground wave) and still be effective. Even with these faults, this technique provides an opportunity to reduce Soviet jamming effectiveness without great expense. It is certainly more effort than we are now employing. Oversimplification, lack of detailed accuracy, radio proliferation, and problems associated with terrain analysis are noted as possible pitfalls. The technique does not address Soviet airborne REC assets (although it could). Training would be required which would involve both Signal and MI to employ the technique. Obviously, there can be many arguments against this idea.

Alternative

The alternative is to continue to do nothing. Or, worse yet, we can institute changes to our communications doctrine and systems which make it more difficult to communicate but do not buy us any real advantage in dealing with Soviet REC.

For example, "Add Survivability to the Command and Control Equation" (TAC, Summer and Fall 1979) recommends remoting all radios from the command post. Remoting will not reduce the communications signature. In fact, since we normally remote to higher ground, the Soviets may find more of our communication nets because they are able to see them better electronically. Thus, while remoting doesn't reduce our vulnerability, it does add an additional constraint on the communications system. We separate the subscriber from the radio, add an operator who may not respond as well as the subscriber desires, and more equipment (AN/GRA39 Remote Unit) is required. Additionally, we add a wire link which takes time to install and retrieve and which often gets disrupted.

Remoting may protect the commander and his staff from the DF artillery combination, but, if the Soviets can find the communications system and destroy it, the capability of the commander and his staff to influence the battle is eliminated or at least severely reduced. The protection offered may not be that good either since the Soviets know that remoting is done. If they find the communications center, know the constraints associated with remoting (i.e., distance to subscribers) and do a good terrain analysis around the communications center, the chances are the Soviets can blow the commander and his staff away anyway.

However, remoting in conjunction with the proposed technique could help reduce the electronic signature. We may want to remote to a lower elevation or a screened location if we can still communicate with the desired stations. This would help serve to defeat both the direction finding and jamming threat.

Advantages

Using these templates, communicators and MI/G-2 personnel can objectively begin to quantify (in terms of area and specific locations) the vulnerability of our command and control system to Soviet REC. Decisions concerning command post locations can now consider not only if we can communicate with all our stations but if we can survive. We can plan to minimize our use of those communication means which are the most vulnerable. By

determining a selected number of sites where enemy REC assets can hurt us, we can use our own artillery and mortars to attack these locations. These techniques could also be used to employ our own EW assets more effectively.

Using the proposed techniques, we may find that some of our communication means are really not that vulnerable. For example, the multichannel system with its directional transmit fan may not be vulnerable to the current Soviet REC system because of the multichannel's relatively low transmit power, frequency range and modulation. If so, it would not be necessary to have these systems separated great distances from our command posts. The multichannel system could be installed and recovered faster and long cable runs could be eliminated. Long cable runs can put noise on the system, attenuate the signal and are susceptable to breaks and other disruptions (to include security problems). Effective use of the templates can not only reduce our vulnerability but could help improve the performance of our communications system by removing some of the unnecessary constraints.

This technique would also quantify the vulnerability of specific communications means, so that their use can be minimized or procedures developed to reduce their vulnerability when in use. For example, the high frequency radio teletype would appear to be a very vulnerable system because of its high transmit power, antenna and the number and locations of Soviet threat receivers. We should probably greatly reduce our reliance on this means of communication as well as develop such techniques as transmitting on the move. Other procedures — e.g., requiring the equipment to be moved after transmitting X minutes in a location — may be sufficient to insure survivability. All RATT assets should be separated as far as possible from any command echelon. If the enemy can detect multiple RATT signals from a single location, he will be able to identify the command echelons because the number of RATTs assigned to a particular command can be equated with its echelon.

In using this technique, we must realize that the generators associated with the communications system may provide an infrared signature which also makes the command post vulnerable. What really is needed is a detailed command post vulnerability study by command echelon that examines all Soviet target acquisition capabilities against our systems employing our normal doctrine and tactics. It would seem that this should probably already exist somewhere but the information is not readily available to tactical units.

Feasibility/Cost of Proposed Solution

The development of simple templates as described above is both feasible and probably not too costly. The Signal Center, with technical information on our tactical equipment, the Army Communications Command, with propagation information, and the Intelligence and Threat Analysis Center, with technical estimates on the Soviet REC equipment, would have to combine their efforts to produce the templates. There may already be some computer programs in existence which could assist in the development.

An effort must be made to reduce the total number of templates to a reasonable figure. For example, propagation for a given frequency range may be different for each hour of the morning in the fall in Germany for each degree of temperature change. By taking the worst case (i.e., the greatest propagation distance), one template could be developed for mornings (0600-1200 hours) in Germany in the fall, for a set of frequencies and temperature ranges (i.e., 0-32, 32-50 F, etc.) The experts on propagation would have to make the decisions on how to group the various characteristics best.

A training effort would have to be developed at the Signal Center for both the Signal Officers Basic and Advanced Courses. The same type effort would be required at the MI School for all MI officers as well as for EW staff officers. The technique should also be addressed at the Command and General Staff College level so that commanders at battalion, brigade, and division level are familiar with the capabilities. When a Signal officer at any command level presents his communications plan, he should also be required to quantify the vulnerabilities of that system. In any event, it would appear on the surface that the concept has potential merit and should possibly be examined by the combat development community.

Summary

There can be no question that Soviet REC capabilities can severely hamper our ability to utilize the electromagnetic spectrum. We must develop some way to protect our electronic emitters better. If Signal planners had the templates and color-coded maps as described in this article, they could quantify the vulnerability of the communication system.

These templates would not in themselves solve the EW problem. However, they would enable us to get a ball-park figure on the magnitude of our electronic signature and, with properly trained communicators and well informed commanders, could help in a number of ways. Signal center locations can be evaluated in terms of both the ability to communicate as well as how much of our electronic signature is seen on the other side of the FEBA. The effects of high vs low power, directional antennas and antenna location (screening), can be objectively compared. This simple technique would enable the communicator, the intelligence and electronic warfare specialists, and commanders to look at something they all understand — a tactical map — to determine if we can communicate and survive at the same time.

LTC Patrick A. Bowman is the commander of the 121st Signal Battalion, 1st Infantry Division, at Fort Riley, KS. Previous assignments for the Signal officer include command of the 1st Support Battalion (PROV) of the 1st Infantry Division (Forward) in Germany, and staff positions on the Department of Army staff and at the Operational Test and Evaluation Agency, where he was involved in developing new communications systems and in fielding of Army tactical data systems. LTC Bowman was commissioned through ROTC at the University of Texas in El Paso, where he earned BS degrees in electrical engineering and physics. He holds an MS degree from the Naval Postgraduate School and is a graduate of both the Armed Forces Staff College and the Command and General Staff College.