Fiber Optic cable

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Tactical command and control communications systems, so necessary to the successful conduct of modern warfare, are vulnerable in many ways to the threat of hostile electronic warfare (EW). This vulnerability extends not only to the communications system itself, but also to the command and control headquarters which the system supports. The electromagnetic radiation emitted by most battlefield communications systems subject them to being located, jammed or, even worse, destroyed by a sophisticated enemy, if he decides that jamming or destruction is potentially more valuable to him than any intelligence information he may gather by simply listening.

Although effective measures are available to reduce the possiblity of this occurring for many battlefield systems, the division multichannel radio system, because of its unique electronic characteristics and manner of employment, will be vulnerable to enemy EW exploitation. New technology in the form of fiber optic cable systems may offer a solution, but only if a workable doctrine of employment may be developed for such a system.

To appreciate fully the problem posed by the multichannel radio system and possible solutions, we must fully understand the EW threat, the characteristics which make the multichannel radio system unique and vulnerable, as well as the characteristics of fiber optic cable as a replacement system. The feasibility of employing fiber optic cable tactically in the division must be fully considered.

The EW Threat

EW has been a threat to military command and control communications systems since the introduction of devices emitting electromagnetic radiation to the battlefield. The extent and capability of a hostile EW threat, seen most recently in the 1973 Middle East War, has led to the extensive inclusion of new EW doctrine in the Army's most basic manuals.

Most battlefield communications systems in tactical use today are potentially vulnerable to electronic combat techniques: electronic support measures (ESM) and electronic countermeasures (ECM). ESMs are actions taken to search for, intercept, locate and identify sources of electromagnetic radiation; and ECMs are actions taken to prevent or reduce an enemy's effective use of electromagnetic radiation.

Our forces use these techniques to exploit the enemy. Of course, these measures may certainly be used by an enemy in turn against us. To counter this threat, defensive EW is used to protect our own systems from ESM and ECM threats. Defensive EW is also known as electronic counter-countermeasures (ECCM).

The potential use of electronic combat against our forces by an enemy has led to the development of extensive defensive EW doctrine designed to help protect our forces and systems from exploitation by possible adversaries. However, one battlefield communication system for which proposed protection may not be wholly adequate is the division multichannel communications system.

The Division Multichannel Communications System

FM 11-50 specifies the doctrinal employment of the division multichannel system. The system is a combination of secure multichannel radio links, multichannel cable links, and terminals which are installed, operated, and maintained by the division Signal battalion. This system (Figure 1) is installed and operated at brigade headquarters; brigade support areas; the division tactical command post; a pre-positioned communications-electronic (C-E) site; the division main, division artillery, or corps artillery brigade (if attached) command posts; division support area; the air defense artillery and engineer battalions; and the division air field.

Radios form the majority of the links in the system. These radios are characterized by wide bandwidth, complex modulation schemes, and highly directional antenna radiation patterns, which distinguish them from other radios used in the division. The utilization of the multichannel system to carry common and sole user telephone circuits, as well as teletype channels between telecommunications centers and message centers of the division, means that the radios must be transmitting continuously to be effective, since many users share the same circuits.

This is completely unlike the other tactical radios in the division, which are formed into various nets and transmit only when there is a specific need. These technical characteristics and the doctrinal employment of the multichannel system give it a unique electromagnetic

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Reducing EW Vulnerability

identification which may make both the multichannel system and the command and control headquarters (which the system supports) vulnerable to enemy exploitation.

Multichannel Radio System Signature - A Problem

Equipment, facilities and personnel, in addition to being vulnerable to visual identification, emit various radiations which may allow them to be detected, located, or identified by an enemy. These total characteristics are called "signature." The signature of a military target may be visual, or it may consist of various emissions, such as heat, radio or radar emissions, or ignition noise. Concealment of the signature through emission control, proper use of communications-electronics operating instructions, and manipulative electronic deception are techniques used to conceal electromagnetic radiation emitters. Camouflage of various types may also be used to conceal other signatures.

A problem exists whenever any signature uniquely identifies an area as one containing a command and control headquarters — enemy attention will be focused there if the signature is detected. Due to the technical characteristics described previously and doctrinal employment at only the high level command and control headquarters of the division, the multichannel radio system both presents a unique signature and is located in the vicinity of major command and control headquarters.

This problem has, of course, been recognized. As CPT Jay R. Savage noted in "How to Hide a TAC" (The ARMY COMMUNICATOR Magazine, Fall 1978):

> *Multichannel is less susceptible to electronic warfare than any other means of radio communications. Opposing forces also recognize this and will mount a major effort to deny us this vital link. Our PCM equipment is directional by design - that is, once it has been located, it gives a good line to the command post location ... to minimize direction finder ... effectiveness, the multichannel terminals need to be moved as often as possible.*

The solution of changing transmitter sites frequently is but one of many communications protective measures which may be used to reduce vulnerability of both communications systems and supported headquarters.

Let us now examine doctrinal communications protective measures and other means of insuring reliable communications and protecting command and control facilities, and their applicability to the division multichannel radio system.

Existing Protection Doctrine

Existing communications protection doctrine for the division states that communications planners should both protect essential nets and circuits and provide alternate means of communications for essential nets and circuits if the enemy destroys or jams the primary means.

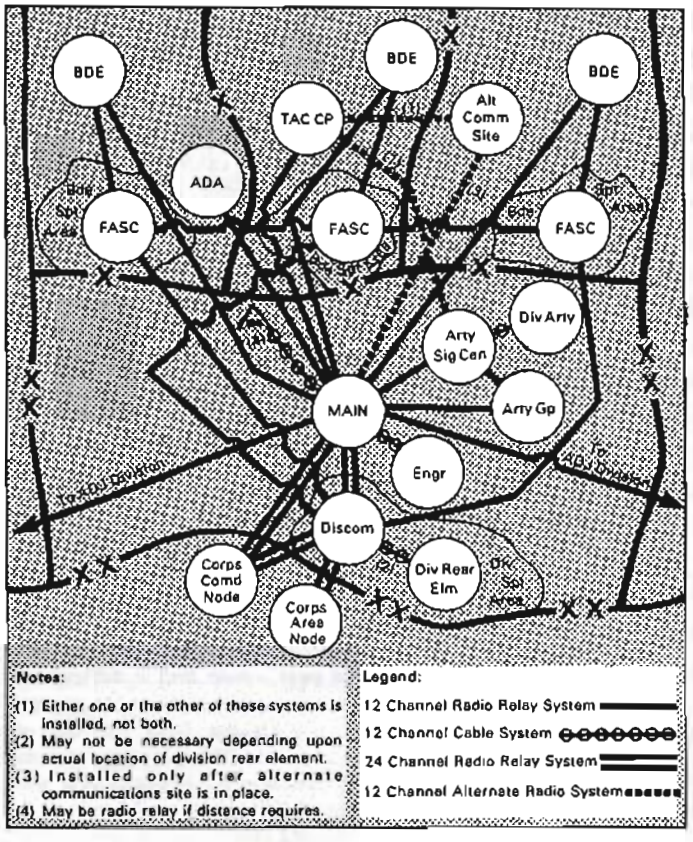

Figure 1. Division Multichannel System Diagram

An apparent assumption is that, if the communications system is protected, the command and control element for which the communications are being provided is also being protected. In examining the communications protective measures that apply to the division multichannel system, we find the following:

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Locate transmitters and antennas away from headquarters.

This measure is designed primarily to protect the command and control element by not giving away its exact location. It is effective for single channel radios which may easily be remoted. However, the unique signature of the multichannel radio, if anywhere near a major headquarters, is a dead give away of a location which would have more enemy attention focused on it. To be effective, multichannel radios would have to be remoted great distances from the headquarters, necessitating the extensive use of the division's pulse code modulation cable system. Existing cable systems may be insufficient to remote all multichannel radios.

Employ decoy antennas.

This measure protects the communications system rather than the headquarters. If the enemy is using the multichannel signature to locate command and control headquarters, he will be searching in the vicinity of the signature for indications of the headquarters, and not necessarily for antennas.

Change transmitter site frequently.

This measure does not completely protect the command and control headquarters unless it also moves frequently. Frequently moving remoted transmitters will protect them, but the presence of unique multichannel signatures at various times in the same general vicinity can once again indicate an area which will attract more enemy attention.

If the headquarters also moves, this measure will be effective. However, large headquarters, such as the division main command post, could find it difficult to move often enough for self-preservation once the general location has been detected by the large number of multichannel radio systems. In addition, frequent moves make a large command and control headquarters less effective than if stationary because effort and resources are being expended in moving rather than in controlling the battle.

Disperse transmitters around headquarters elements.

Once again, this measure protects communications by insuring that all systems will not be lost in one attack, but does little to protect the supported headquarters. The presence of a large number of communications devices, and especially the unique multichannel signature, permits the enemy to identify an area to examine more closely.

Use directional antennas.

This is an excellent protective measure for single channel radios, as well as already being designed into multichannel systems. The advantage of making the signal harder to locate, though, is offset by the fact that to be effective, the multichannel system must transmit continuously. This means that the signal can be located relatively easily; and, once located, the multichannel radio signal forms a direct line to the vicinity of a major command and control installation.

Use terrain features to mask the signal.

This measure is effective in protecting the multichannel system from ground-based interception and direction-finding. However, an enemy airborne detection capability would negate it since the vertical spread of the directional antenna pattern is considerable. Because of the importance of the headquarters, which is identified by its signature, the enemy can be expected to use airborne detection systems targeted against the multichannel radio system.

Don't transmit.

This, of course, is the most effective method of preventing the enemy from exploiting the multichannel system. However, by not transmitting, the multichannel system is rendered incapable of fulfilling its function of providing the critical sole user telephone and teletype circuits, and the common user telephone circuits so necessary for the efficient operation of the division. This means that critical communications would have to take place over the FM or RATT nets, thus making them more vulnerable to enemy exploitation, or by using alternate means of communications, which may cause unacceptable delays in critical situations.

Manipulative deception.

This technique is employed to simulate a unit where none exists. It may be accomplished by committing multichannel radios to areas where there are actually no units, in an attempt to deceive an enemy as to the true location of headquarters of command post elements. The problem with this technique is that the division has limited multichannel radio assets, and committing adequate numbers to a deception effort would significantly degrade overall multichannel communications support to the division.

What then of the traditional "alternate means" of communications? Messengers may certainly be used as a primary means of communication when response time is not critical or when made necessary by a loss of other communications. Visual and sound techniques have been recommended as short range methods of communications, useful in limiting the need for radio traffic. Wire and cable, once installed, is as responsive as radio to communications needs, and limits the enemy's ability to locate critical positions. Can these means of communication help in reducing the vulnerabilities inherent in the multichannel radio system?

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Messengers.

Messengers are a reasonable substitute for any means of communication, providing response time is not critical. However, the type of traffic carried on the multichannel system is often of a critical nature. It would not be suited to replacement by messenger service unless there were no other alternative method of communications available.

Visual and sound techniques.

Visual and sound techniques are a good alternate means of communication at brigade or battalion level. However, because of the great distances involved, visual and sound techniques are unsuitable as a replacement for the division multichannel system.

Wire and cable systems.

These are the best alternatives to the multichannel radio system problems discussed earlier, for the simple reason that a wire and cable system does not radiate electromagnetic energy which could be detected by an enemy at long range. Cable systems provide fast reliable communications once installed; however, there are many disadvantages to the use of cable systems. These include restrictions caused by the distance between users of the system, i.e., the time required for installation, maintenance and recovery of the system, and the users' need for mobility.

In addition, wire and cable are susceptible to damage by artillery or by our own tracked vehicles. These disadvantages, coupled with the recent emphasis on mobility, have led many communicators to de-emphasize cable installations in the division. Some have even gone so far as to recommend that cable systems be completely eliminated, because the division will be moving too fast to take the time to install them.

At this point we can see that in an EW intensive environment, the division multichannel radio system could increase the vulnerability of our command and control headquarters to EW exploitation. We further see that, although communication protection measures can decrease the vulnerability somewhat, the unique signature and doctrinal employment of the multichannel system make complete protection unlikely. The concept of movement as a protective measure may be ineffective for the larger command and control headquarters which may not be able to move often enough for protection and still carry out their functions. The only alternate means of communication which is capable of solving the EW vulnerability problem, while at the same time can be responsive to critical information needs, is a multichannel cable system. However, the time needed to install, maintain and recover such systems makes them impractical if the division must move rapidly.

Is the solution then to slow down the overall pace of division operations in an EW intensive environment, to allow time for cable systems to be effective in providing reliable, low signature communications? The momentum of modern mechanized battle will probably not permit this. However, the use of cable will continue to be a practical necessity on the EW intensive battlefield. New technology, in the form of fiber optic cable, may help solve this dilemma.

Fiber Optic Cable Systems - A Solution?

It has been recognized that "the maintenance of continuous communications on the battlefield is no simple task, especially with the signal equipment now authorized in the division. It has been made even more difficult with the implementation of 'win the first battle' tactical doctrine" ("Command and Control Communications," SIGNAL Magazine, September 1977) which initially requires an active defense.

While existing cable systems are generally unsuited for use in most fluid situations, this will not necessarily be the case in the near future. The development of light-weight, inexpensive, wideband, air-layable, fiber optic cable equipment could help solve the electronic signature problem, while at the same time allow reasonable speed of installation of effective communications on the battlefield.

Fiber optic communications consists of using dielectric fibers to guide optical (light) energy that has been modulated with information between various points in a communications system. The new equipment retains some disadvantages of metallic cable systems when compared to a multichannel radio system in that it is still difficult and time consuming to install and recover. However, it has the following advantages when compared to multichannel metallic cable systems.

- *Does not radiate electromagnetic energy or pick up electromagnetic interference.*
- *Has design benefits in labor, installation, and in shipping and handling.*
- *Has larger information transfer capability.*
- *Has low cost.*
- *Possesses computer interfacing advantages.*
- *Has no electrical ground or short circuit problems.*
- *Reduces total system power consumption.*
- *Has improved reliability and maintainability.*

Because of these advantages, the military is currently developing fiber optic technology for many communications applications. Tactical applications have, in general, been divided into three transmission ranges:

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Rather than being abandoned as too slow and difficult to use, divisional cable systems should be increased as a practical solution to the difficult problem of EW vulnerability.

- *Short Distance (less than 100 meters): used for intra-shelter connections, data buses, antenna connections, etc.*
- *Moderate Distance (100 meters to one kilometer): used for command post local distribution, computer interconnections, etc.*
- *Long Distance (one kilometer to more than 60 kilometers): long haul cables, air-layable cables, "down the hill" (remote) connections to microwave systems, rapid payout cable systems, etc.*

Formal requirements for systems in all three of the above applications have been approved by the Army, with fielding planned for 1984.

The short and moderate distance applications have immediate application in the division, replacing appropriate cable in local areas and specific equipment. The long distance application could replace the presently authorized multichannel cable capability in the division.

The one characteristic of cable systems which make them so attractive from the point of view of an electronic counter-countermeasure, that of electromagnetic indetectability, has now been enhanced by technology to the point where cable systems no longer need to be as bulky, expensive and time-consuming to install and maintain as in the past. This means that in addition to replacing existing cable systems, multichannel fiber optic cable should be considered as a replacement for selected multichannel radio links in the division system, due to the advantages offered in an EW environment.

Conclusion

Divisions may find themselves deprived of control of the electromagnetic environment in any future conflict. The enemy will attempt to destroy or disrupt communications, with the electromagnetic signatures of command post communications elements providing pointers to lucrative targets. To reduce this threat, present doctrine stresses frequent displacement of command post and headquarters elements, and other communications protective measures. To support this concept, communicators are trained in rapid movement and fast establishment of critical communications. However, the multichannel radio signature uniquely identifies critical command and control elements of the division, thus making them more vulnerable to enemy exploitation.

In the EW intensive battlefield of today, the use of cable systems could play an important role in providing effective communications, thus increasing the division's capabilities to accomplish its mission. This "combat multiplier" — effective communications in an EW environment — could significantly increase the relative combat power of the division at a critical time, while at the same time reducing the need for constant command post movement.

Unfortunately, the present doctrinal emphasis on movement has caused some communicators to recommend the complete abandonment of multichannel cable presently used in the division, because of its adverse effect on mobility.

Rather than being abandoned as too slow and difficult to use, divisional cable systems should be increased as a practical solution to the difficult problem of EW vulnerability. The commanders of divisional elements should accept the limitations of cable systems in certain circumstances as a necessary outcome to insure reliable communications and to reduce vulnerability of critical divisional command post elements.

Both the communicator's and the tactician's reluctance to utilize cable systems may be reduced in the near future by the introduction of fiber optic cable systems. In an EW environment, fiber optics, because of their many advantages over existing conventional cable systems, should be considered as possible replacements for much of the multichannel radio system of the division.

A fiber optic cable system could add that extra bit of communications "combat multiplier" needed to "win the first battle," provided the new technology is properly integrated into the combat environment rather than relegated to the tactical scrapheap because of pre-conceived notions about the utility of any presently employed cable system. Given that operating with cable may be a necessity in the EW environment, tactical commanders, if they want assured communications, must continuously learn to operate under the limitations of cable now, rather than being surprised by the re-introduction of cable in the form of fiber optics in the future.

Can they afford not to?

BIBLIOGRAPHY

Cerney, Richard A., and Hudson, M. C., "Fiberoptics." THE ARMY COMMUNICATOR, Spring 1978.

Christian, J. Robert, and Divorkin, L. V., "Fiber Optic Communications for the Army." SIGNAL, October 1977.

Hogan, LTC J. H., "Signal Tips for Division Communicators." THE ARMY COMMUNICATOR, Summer 1978.

Hogan, LTC J. H., and Smith, MAJ L. R., "Command and Control Communications Within the Division." SIGNAL, September 1977.

Rosenburg, MAJ Ralph C., "Relative Combat Power." MILITARY REVIEW, March 1978.

Savage, CPT Jay R., "How to Hide a TAC." THE ARMY COMMUNICATOR, Fall 1978.

US, Department of the Army, Field Manuals: 11-50 and 100-5; Training Circular 101-5.

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