COMMUNICATIONS AND IMAGING TECHNOLOGY: REVOLUTIONIZING COMMAND AND CONTROL OF THE FUTURE BATTLEFIELD

A thesis presented to the Faculty of the U.S. Army
Command and General Staff College in partial
fulfillment of the requirements for the
degree

MASTER OF MILITARY ART AND SCIENCE

by

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B.S., University of South Dakota, Vermillion, South Dakota, 1975

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This thesis examines the effects and relationships that communications and imaging technology have of AirLand Battle and Airland Battle Future doctrine. The thesis uses secondary analysis as the research methodology for its comparisons between current AirLand Battle and AirLand Battle Future doctrine. The study relied upon the expertise of the Future Battle Laboratory personnel in investigating future communications and imaging technologies.

Among the conclusions which could be drawn from this investigation are: (1) Communications and imaging technology is revolutionizing command and control of the current and future battlefield. (2) ATCCS does not provide the bandwidth required to support real-time imaging to all players on the battlefield. (3) Support for AirLand Battle Future command and control requirements necessitates continued advancement in communications technologies.

This thesis includes definitions of the Army Tactical Command and Control System as well as technical definitions of communications and imaging systems.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

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MAJ Harley D. Rinerson, USA, 128 pages.

This thesis examines the effects and relationships that communications and imaging technology have on Airland Battle and Airland Battle Future doctrine. The thesis uses secondary analysis as the research methodology for its comparisons between current Airland Battle and Airland Battle Future doctrine. The study relied upon the expertise of the Future Battle Laboratory personnel in investigating future communications and imaging technologies.

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I would like to thank several people for their assistance and tolerance in the completion of this project. First, and foremost is my wife, Patricia, for her patience and understanding. She endured many a cold dark night as she walked the dogs which normally would have been a boy job. MAJ James Hankins for being the grammar teacher I never had. His astute criticism made this thesis readable. His knowledge of computers was invaluable. Mr. Bryan Gorman who tolerated a torrent of questions as to the inner workings of communications networks and for providing a reality check on my proposals. LTC Lowndes F. Stephens for setting the academic parameters and keeping this project focused on a literate goal.

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CHAPTER I

INTRODUCTION

The United States Army has a thirst for information. In part, this may be attributed to the continued centralization of the decision making process. Centralization at higher levels of the military is created due to the increasing capabilities of communications. The command and control relationships of our military are continually changing as we respond to these new technological advances. Understanding the principles of command and control currently used by the United States Army will help provide insight into the potential impact on Airland Battle Future.

This thesis focuses on how communications and imaging technologies relate to these command and control principles. This study limits research to the relationships of communications and imaging technologies in support of command and control.

In the integration of communications with computers, we now have the capability to expedite decision making that affects a larger operational area than at any other time in history. The introduction of imaging technologies into the battlefield over communications and computer systems may allow real time viewing of personnel, terrain, and targets. The combination of seeing the battlefield and simultaneously controlling and interacting with systems and personnel through real time communications and automation systems may achieve the synchronization of forces that every commander endeavors to obtain. Synchronization on the battlefield is essential for any large armed service and is more especially pertinent for a land army. The United States Army includes synchronization as one of four basic tenets in its Airland Battle Doctrine. It is the inherent transitory nature of synchronization on the battlefield that must be understood and controlled. Synchronization must be mastered in order to fully utilize our smaller but more highly technical forces.

The effective employment of these forces is the end result of the application of a variety of technologies defined as force multipliers. These force multipliers are represented in many ways by such things as precision guided munitions, advanced composites for armored vehicles, and large hovercraft for ship-to-shore logistic operations. The force multipliers that affect the synchronization of forces through command and control are communications and the commanders capability to project his image of the battlefield to his forces.

Background

The society in which we live is enchanted with high technology. We see its effect on the populace everywhere we look. It was embraced by our entertainment industry a decade ago in the space adventure "Star Wars". A president, caught up in its vision, subsequently named one of the largest defense initiatives in our history after it. The reliance on high technology spreads from our leaders to the nation. The citizens of our country appear to think that most of our problems can be solved through high technology.

> Most citizens agree on the value of advanced technology for sustaining a vital and flexible defense posture-featuring enhanced effectiveness and reduced costs. Advanced technology is seen as a "magic solution" for avoiding hard choice[1]

We have lofty expectations of high technology. The forces aligned in the Persian Gulf during the Iraq war reflect this expectation. The force ratio as of January 15 1991 was 1.3 to 1 in favor of the Iraqi Army.[2] The rule of thumb that makes the odds even, as to who the victor of the battle might be, is a 3 to 1 ratio in favor of the attacker. Why would the United States Army go up against these odds? One of the answers is our belief that technology can be used as a force multiplier.

The United States has determined that a small standing army is adequate because it plans to go from a end strength of 760,000 to 526,000 by 1995. Technology is seen as an effective way to balance the odds, while reducing the costs of maintaining a large national force. Modern equipment systems are more lethal and capable than

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[1]Asa A. Clark IV, "Defense Technology: Conclusions and Implications," in DEFENSE TECHNOLOGY, ed. Asa A. Clark IV and John F. Lilley, (New York, NY: Praeger Publishers, 1989), 276.

[2]Kansas City Star, 15 January 1990.

in the past; however, the cost in procurement and sustainment of these "high tech" systems is exorbitant. Do we really need a large army? Maybe not, the size of modern armies is shrinking while the geographical area which they cover increases. This relationship for different armies of the past and the area of battlefield covered is shown in Table I.

A major contributing factor for the physical expansion and the mental compressing of the area operations and the area of interest is near real-time communications. It is the use of communications systems as a force multiplier on the non-linear battlefield that enables the effective employment of Airland Battle and Airland Battle Future doctrine.

The ability to command and control forces in near real time over great distances, shown in Table I, allows for smaller force densities. With Airland Battle Future coming of age and a continuation of decreased defense budgets, the trend to increase the distance between forces will continue. These forces are also required to be autonomous, yet work in concert with one another. In order to do so, direct and reliable communications are necessary. One method of providing the technology to support the future doctrine is through the procurement of nondevelopmental off-the-shelf items.

Table I
U.S. Ground Combat
Force-to-Terrain Ratios
Source: William E. DePuy, DEFENSE TECHNOLOGY, 1989.

Operational Cases Square Kilometer Division Sector	Battalion Sector Wth (meters)	Div Sector	Men by Area	Men by Div Front
Employments of Linear Doctrine:				
WWI	600	3X10=30	2500	1000
WWII	1500	9X20=180	400	80
NATO	6000	40X50=2000	50	8
NATO extended	6000	40X100=4000	50	4
Employments of Non-linear Doctrine:				
Vietnam 1966		5000		.3
Middle East Scenario		100,000 to 250,000		<.2

In today' s technological race to employ weapons systems that out-see, out-range, and out-kill competitive weapons systems, there is an ever decreasing time delay from the research and development phase to deployment. Cooperative commercial research and development programs are producing state-of-the-art military systems. This has resulted in the purchase of Nondevelopmental Item (NDI) weaponry, particularly communications equipment, becoming common place. The commanding general of TRADOC, disseminated the following command policy:

> If the commercially available equipment can do the job, has a lower life cycle cost and can be supported by the U.S. Army, it is the preferred alternative.[3]

By incorporating NDI state of the art technology into our military systems, we by-pass the lengthy procurement process. The field evaluation and testing that normally took several years to perform is routinely accomplished within months. This results in highly technical equipment reaching the field in an expeditious manner. The time from operational conception to functional reality is greatly reduced. Even so, what we gain in the speed of fielding is

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[3]Carl H. McNair, Jr., "A User's View: NDI Acquistions," in <u>TACTICAL C3 FOR THE GROUND FORCES</u>, ed. James M. Rockwell, (Washington, D.C.: AFCEA International Press, 1985), 53.

compromised by a loss in the amount of requirements satisfied. This is shown in the trade off of fast fielding versus gain of operational capability over time, Figure 1.

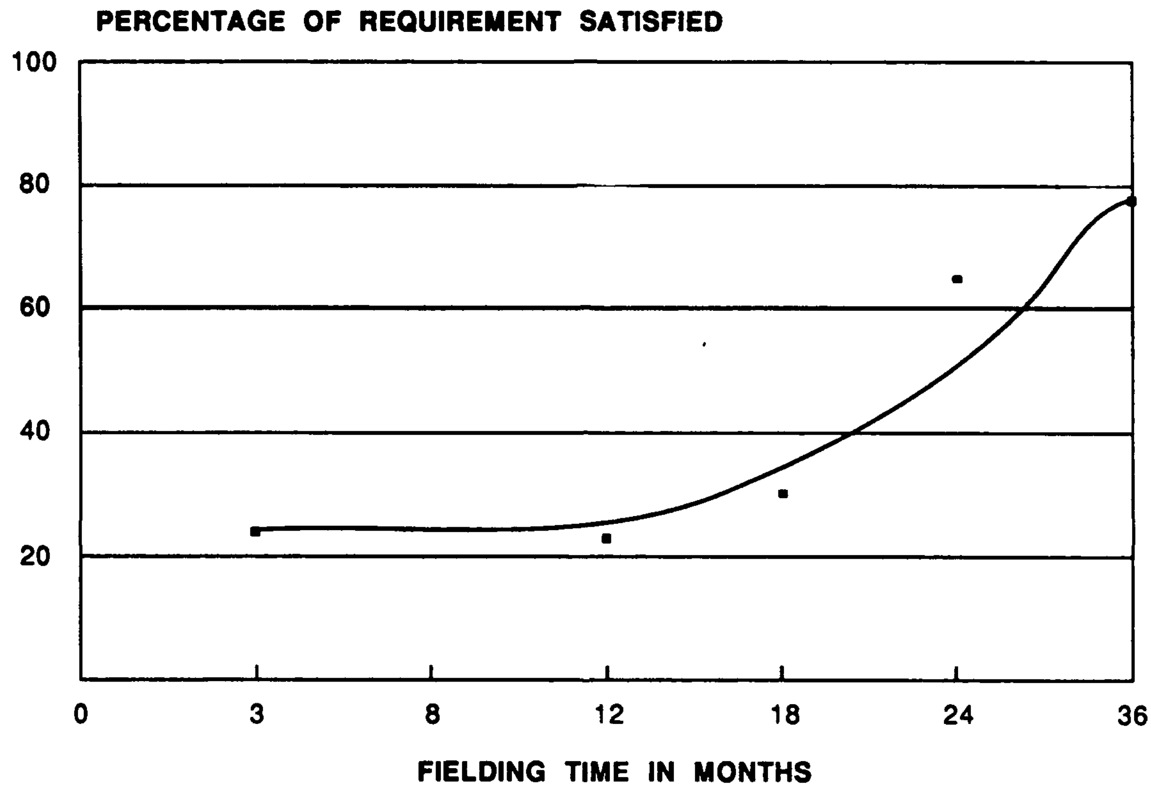

Figure 1
Fielding Time vs. Capability Trade-off
Source: Data from Carl H. NcNair, TACTICAL C3 FOR THE GROUND FORCES, 1985.

While NDI may satisfy specific requirements in an expeditious manner one must take a longer term approach in the establishment of network architectures. Future systems should support the open network architecture philosophy. This network architecture philosophy assumes that different makes of terminal equipment have the ability to access a common network transmission media. If this were done the mixing and matching of NDI equipment would satisfy the specific needs of the user without major network communications problems.

Daily we see new devices or more efficient procedures that expand our awareness and are our capability to access large amounts of data. Where will we store, and how will we manage this influx of data and information on new technology? We turn, once again, to a force multiplier, the computer. The computer has all but engulfed our society and has greatly increased our access to information. The communications community, both military and civilian, has benefitted from the advent of the computer. With standardization in both the communications and computer industry, it is becoming less clear where communications end and computers begin.

The continuing development of large communications and computer networks may never see the completion of a final configuration. Communications transmission means usually consist of separate paths that link many nodes and gateways supporting computers of all types and sizes. These paths provide redundancy for the networks to insure operations due to scheduled and unexpected outages. These national networks allow access to information stored in a variety of databases.

A few of these networks, such as the Worldwide Military Command and Control System Intercomputer Network (WIN), Defense Data Network (DDN), and the future Joint Tactical Information Distribution System (JTIDS), provide communications access, not available a decade ago, to large stores of information. The extension of these networks to the battlefield is becoming a reality.

The United States Army uses the Army Tactical Command and Control System (ATCCS) as its operational command and control system. The ATCCS supports the Battlefield Automation Systems at corps level and below. These systems provide a robust network that has inherent fault tolerance. United States forces are also receiving a secure tactical communication network called Mobile Subscriber

Equipment (MSE). While MSE supports Airland Battle doctrine, it also has the capability to exchange information with other nontactical networks via packet switching communications gateways. The United States Army built the foundation of future communications systems in the structuring of ATCCS. Mobile Subscriber Equipment (MSE), Combat Net Radio (CNR), and Army Data Distribution System (ADDS) systems will inevitably be the fundamental communications and computer architecture to carry the U.S. Army into the 21st century.

The integration of communications and computers into the military can also be found in many other nations. The Soviets, realize the importance of an "automated battlefield":

> A base is being created for the automation of many processes of armed combat. Prerequisites for this exist in remote controlled reconnaissance systems, in automated systems of troop control, and in the combined functions of reconnaissance, directing fire, and striking... All this creates conditions for visualizing the so-called automated or electronic battlefield of the future.[4]

The new electronic battlefield of the future will incorporate improved and innovative imaging technologies. They will change the

[4] Koziej, P. "Anticipated Directions for Change of Ground Forces," Przeglad Wojsk Ladowych, No. 9, (September 1986), p. 7.

way we visualize the battlefield by providing new ways to view target and terrain information. With the increased modernization of our communications systems, such as the use of fiber optics, the amount of data that can be passed over transmission media will increase dramatically. This increase will have an impact on command and control. Video teleconferencing will become more feasible and may be provided down to a smaller organizational level. The method of displaying information will increasingly make use of high technology through the use of large screen displays, wideband video switching, and helmet computer displays.

Will communications and imaging technologies dramatically change the command and control of the future battlefield? This question is yet to be answered; however, it is one that needs to be asked. The way we integrate our communications and computer networks to support our future battlefield command and control systems makes this topic relevant to military art and science.

Purpose of the thesis

Through secondary analysis, research the United States Army's current Airland Battle command and control doctrine. Evaluate how it compares with the command and control doctrine of Airland Battle

Future. Given this comparison, evaluate the likely impacts of communications and imagining technologies on Airland Battle Future doctrine.

Assumptions

One assumption is that command and control is an unmeasurable entity. It cannot be defined in terms of communications or information systems and equipment alone, but must be viewed as a complex process of ideas, responsibilities, procedures, people, and systems. The synergistic interdependency of each of them in this process makes it difficult to evaluate them separately. On a whole they are evaluated in a positive or negative light by the overall success of the mission or war.

For example, imagine that your communications systems are inoperative and the commander has personally taken over command and control of the battle. If he is successful, then adequate command and control has been achieved. The inverse could also be true, that is, if communications to subordinate units were superb but the commander did not project his orders and they lost the battle, then command and control was inadequate. Command and control is a nebulous term with many different meanings.

Methodology

The methodology for this thesis is secondary analysis through library research, one purpose of which is to develop a knowledge base by investigating command and control doctrine fundamentals and its connection to current and future command and control doctrine. With this knowledge the author analyzes the thesis topic relationships. The organization of this analysis is the definition of communications and imaging technologies, and future command and control architectures. In researching command and control a major strength for this methodology emerged. This strength was the location of the study at the Combined Arms Research Library located in the Command and General Staff College at Fort Leavenworth. This facility provided access to a wealth of information and knowledge about command and control. Fort Leavenworth also has the proponent for command and control doctrine of Airland Battle Future in the Combined Arms Combat Development Activity.

The Army's Future Battle Laboratory is also located at Fort Leavenworth. The Future Battle Laboratory (FBL) is a United States Army organization that integrates state-of-the-art technologies into prototypes for proof-of-concept demonstrations. As a subordinate to the Command and Control Directorate the Future Battle Laboratory is heavily involved in the application of communications and computers to command and control problems. It evaluates equipment, procedures, and software by fielding NDI commercially procured items to military units.

To keep abreast of current technology, information was collected from the Future Battle Laboratory. The imaging research resulted from attendance at several video teleconferences on tactical video teleconferencing. Information was received from the Future Battle Laboratory in the form of memoranda, reports, and studies concerning the thesis topics. Future Battle Laboratory continues to provide the most updated information.

Once command and control patterns were established and defined, the relations between communications and imaging was pursued. The relationships between communications and imaging were more technical in nature than were command and control relationships and therefore more easily compared in measurable terms.

A common thread connects communications and imaging. This commonality is the amount of data that imagery produces as compared to the amount of data that communications can transmit. A technical description is required for comparison and is included in the following chapters.

Limitations

The areas of research on which I intend to focus encompass three broad categories. Command and control doctrine, communications technology, and imaging technology. Command and control doctrine has received a vast amount of coverage and scrutiny. It is continuously in a state of change and revision. Command and control analysis limitations will be the comparison of basic models to identify fundamental similarities in each model. Communications and imagery are large and highly technical fields. The authors background is managerial and not technical so only basic technical descriptions are used in the thesis.

Delimitations

This thesis describes systems, equipment, and doctrine in terms of capabilities, interoperability, and relationships. It also covers command and control doctrine as it relates to commander's information needs on the battlefield. The analysis of communications techno. .ies examines current and future communications network architectures. Transmission capabilities of communications media are important in relation to the bandwidth requirements of real-time imaging.

The imaging technologies concentrate on visualization of the battlefield, command and control, and information display. The information is primarily target acquisition and terrain visualization. How this information is transmitted and used with command and control will focus on communications and video images.

Significance of the Study

This study researches command and control doctrine to identify the basic information requirements of the commander. It establishes relationships between these requirements and the field of imaging. This allows the assessment of imaging technology applications with command and control information requirements. The thesis then examines current and future communications networks to identify what imaging requirements can be supported.

CHAPTER II

REVIEW OF LITERATURE

Command and Control, the Present and the Future

In order to understand how command and control is thought of in the United States military system it is necessary to review some of its basic concepts. Command and control is defined in processes, environments, and images. This chapter reviews command and control through the United States Army's Airland Battle doctrine. It also defines the current communications doctrine and support of Airland Battle. Lastly, the formative concepts of Airland Battle Future doctrine are addressed.

As in any large organization the United States Army must set priorities in the expenditure of its resources. One forum that sets these priorities is the general officer steering committee. This symposium meets on a recurring basis and identifies issues and topics that require solutions or consideration by the United States Army as a whole.

The general officer steering committee held its first plenary meeting on 8 February 1990. The them for that meeting was "Focus on the Commander," in recognition of the reality that leadership and C2 transform potential combat capability into actual combat power. The steering committee identified three priority areas on which the C2 community must focus in order to assist field commanders:

-See the battlefield.
-Communicate intent.
-Synchronize the battle.[5]

Models of Command and Control

Several models of command and control exist that focus on the priorities of the general officer steering committee. In Command, Control, and The Common Defense by C. Kenneth Allared, we see several of these models acknowledging the same basic precepts.

John Boyd's model, figure 2, keeps the command and control

[5]Wishart, Leonard P. III "Leader Development and Command and Control." Military Review, vol LXX, 7 (July 1990): 16.

process at a fundamental level. He describes a four-step process of observation, orientation, decision, and action or O-O-D-A link.

This is the typical maneuver warfare school of thought that focuses on turning inside your enemies decision cycle. This is the ability to command and control your forces faster than your enemy. This enables the commander to make decisions or respond to events before your opponent does. More significantly, it provides a philosophy of targeting your opponents command structure rather than his physical forces.[6]

This command structure, as shown in the Iraqian war, is targeted by either firepower or electronic warfare. The target consist of communications nodes and systems, field headquarters, and command posts. The initial concentration of the coalition airpower was aimed at "decapitating" [7]the command and control of the enemy by not allowing the leadership to communicate with their forces in the field.

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[6]Allard Kenneth D. , Command, Control, and the Common Defense, (New Haven: Yale University Press, 1990), 150.

[7]"General Kelly, Pentagon News Brief", CNN. February 1991.

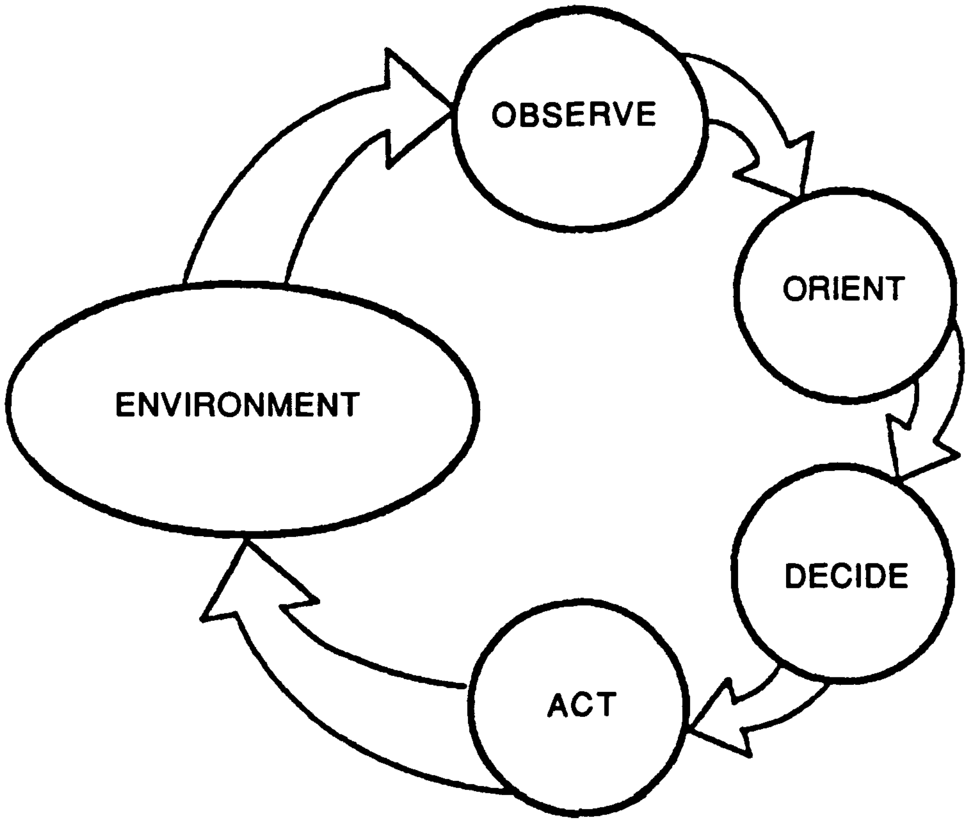

Figure 2
Command and Control Model
Source: John Boyd, Command, Control, and The Common Defense. 1990.

Joel S. Lawson's model, figure 3, uses a four-step model consisting of sensing, comparing, deciding, and acting. Though this model is slightly more complicated than John Boyd's, the fundamental processes are virtually identical. Lawson says....the purpose of the command control process is to either maintain or change the equilibrium state of the environment, as determined by a higher authority.[8]

In both the Boyd and Lawson command and control models, a key step in the process is the sensing or observation step. In fact, it is the first step that initiates the subsequent actions. This observation or imaging of the battlefield is of great interest to military commanders.

One of the primary themes heard from commanders is the need to build an image of the battlefield, or, as they commonly refer to it, seeing the battlefield. The image of the battlefield is gained by the commander through the information he receives from all available sources.[9]

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[8]Ibid. 152.

[9]Ibid. 173.

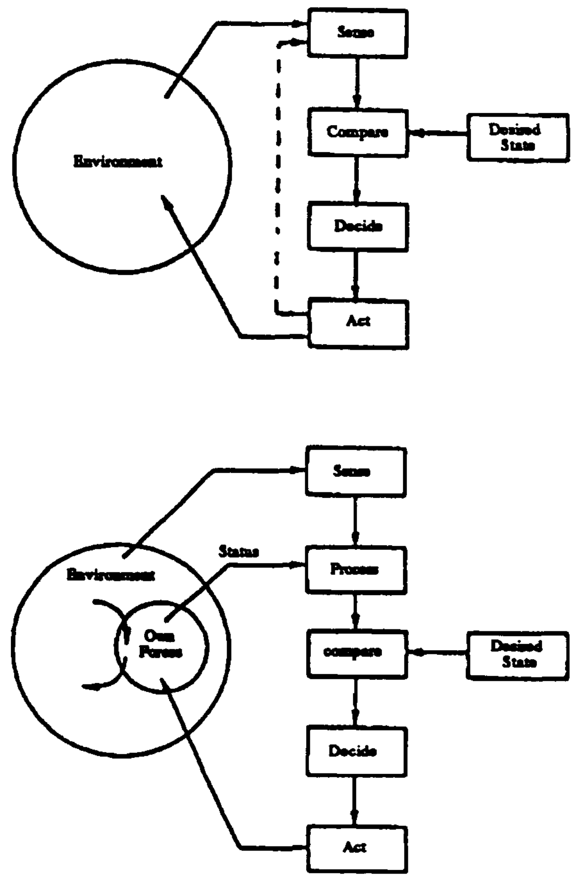

Figure 3
Command and Control Model
Source: Joel W. Lawson, Command, Control, and the Common Defense.

The information content the commander requires thus arises from his image of the situation... The commander seeks to build an image of the situation that can be translated into action by the forces under his command. The image begins with the commander's current view of the situation plus his mission from higher headquarters. The commander's own training and experience, plus his understanding of the appropriate doctrine, together shape his intent.[10]

[10]Kahan, P. James, D. Robert Worley, and Cathleen Staxz, Understanding Commanders' Information Needs, (Santa Monica, CA: The RAND Corportation, June 1989), 15.

Graphically displayed (figure 4) this synergism of information shapes the viewpoint of the commander in such a way that his subsequent decisions are made with this central image of the situation. If his initial image is skewed, his ensuing decision and action will also be skewed. This cycle will continue until he has additional information. So far we have examined command and control theory. Where does this theory fit in Airland Battle doctrine?

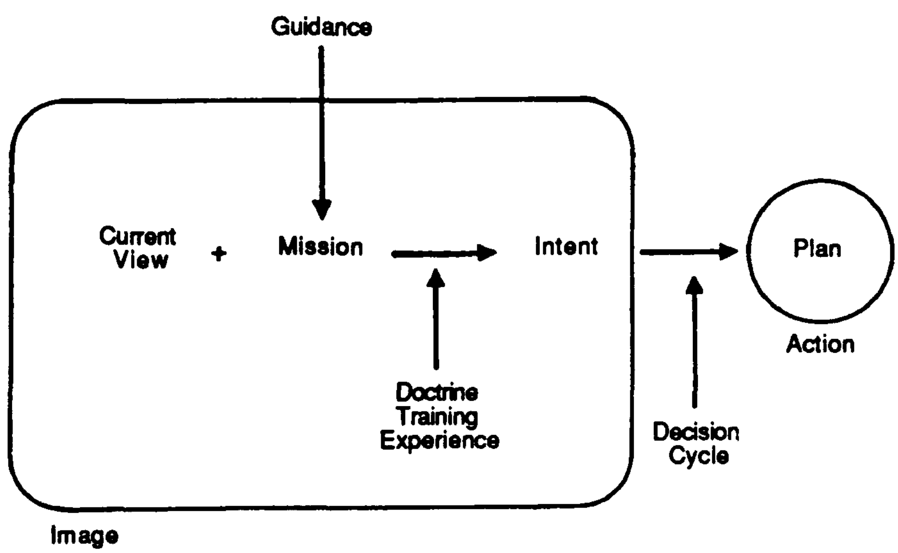

Figure 4
Image to Action
Source: RAND Study "Understanding Commanders' Information Needs".

Airland Battle Doctrine

The principal document for the applications of Airland Battle doctrine is Field Manual 100-5, "Operations". The doctrine espoused in this manual emphasizes four basic tenets: initiative, agility, depth, and synchronization.[11]

Initiative is defined as bringing the battle to the enemy though action. It is the key tenet to the Airland Battle doctrine. The doctrine of the United States Army is offensive in nature. In order to fight and win one must aggressively attack the enemy. In order to seize the initiative, the forces must be capable of faster action than the enemy. This is accomplished through the second tenet, "agility". Its' implementation goes back to the command and control models of observing, orienting, decision, and action. By "getting inside the enemies decision cycle" the friendly command and control process has more agility than its enemy. An important part of Airland Battle doctrine is the ability to use depth to advantage. The use of depth, figure 5, allows extending operations in space, time, and resources. It gives the commander the room to maneuver effectively. The last

[11]U.S. Army, FM 100-5, Operations, (Washington: Department of the Army, 1986) 15.

tenet, synchronization, is the arrangement of battlefield activities in time, space and purpose to produce the maximum relative combat power at the decisive point.[12]

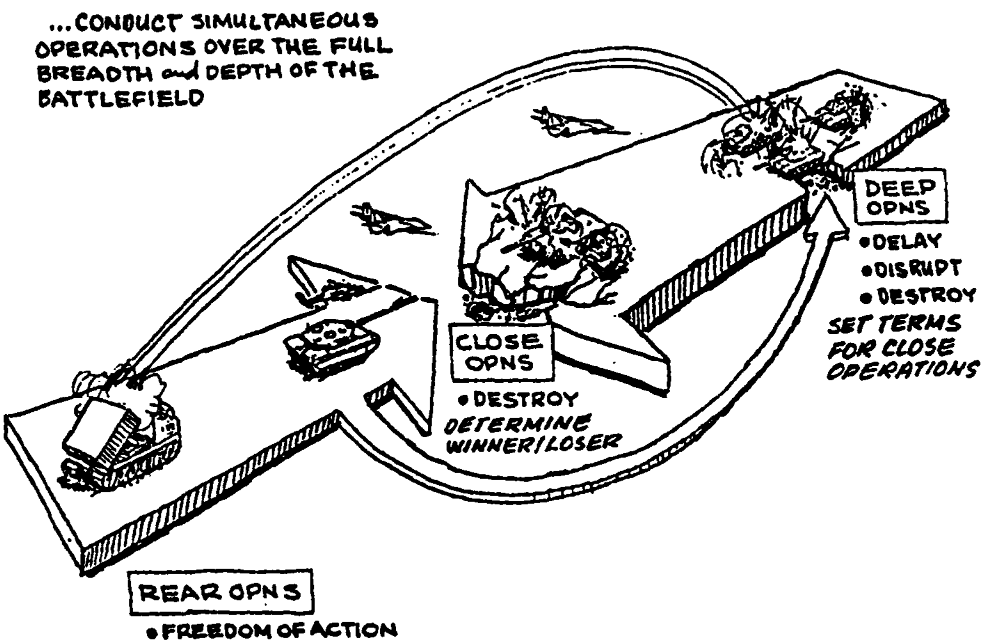

Figure 5
Airland Battle Deep Operations
Source: United States Army

With Airland Battle tenets in mind, command and control of the battlefield must sustain the ability of the commander to maneuver while retaining the capability to execute his wishes at a different location. The command and control system must make use of

[12]Ibid. 17.

available time by standardizing procedures for units and staffs while maintaining flexibility of action to capitalize on any opportunities. This requirement for flexibility and freedom of movement stresses the communications systems that support command and control.[13]

> The ultimate measure of command and control effectiveness is whether the force functions more effectively and more quickly than the enemy.[14]

Signal Doctrine for Airland Battle

With Airland Battle doctrine increasing a commander's informational requirements anywhere on the battlefield, communications doctrine needs to meet Airland Battle's requirements. Addressed by the Signal Corps in Field Manual 24-1, Signal Support in the Airland Battle, Final Draft, June 1990. Four operational signal support principles, figure 6, apply to signal

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[13]Ibid. 21.

[14]Ibid. 22.

support of Airland Battle doctrine.[15]

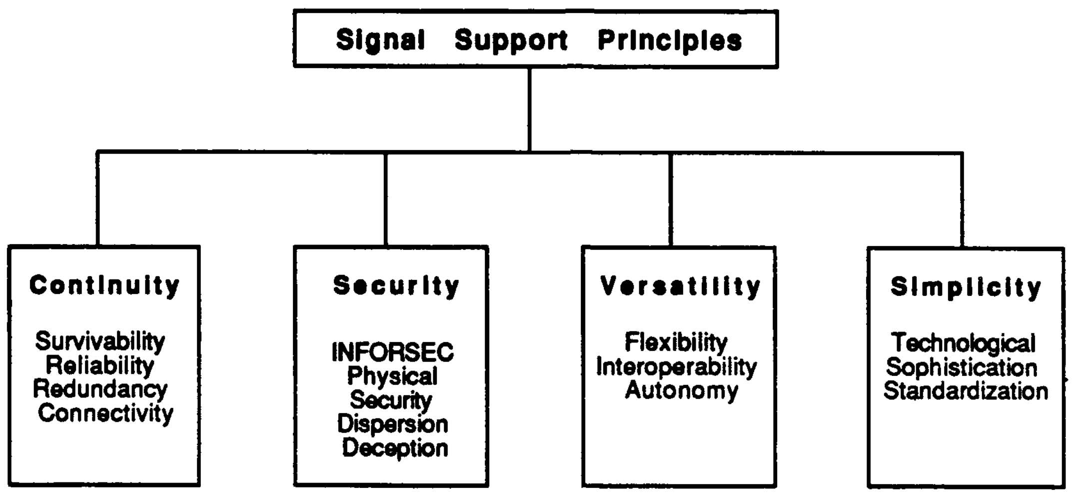

Figure 6
Operatiohnal Signal Support Principles
Source: U.S. Army, FM 24-1, Final Draft, June 1990.

These principles are the theoretical base on which a communication architecture is built. The correct application of

[15]U.S. Army, FM 24-1, Signal Support in the Airland Battle, (Fort Gordon, GA: United States Army Signal Center, June 1990). 2-1.

these signal support principles set the doctrinal framework necessary for the continuous uninterrupted flow of information. The implementation of connectivity establishes the rules (figure 7) for providing various communications links. This doctrine provides the rules that allow communications linkages to be installed in a expeditious and efficient manner. Security accomplishes the two functions of protecting signal support and supporting deception operations. In practice, versatility through the use of speed is one of the more difficult principles. It must be able to adapt to all possible battlefield conditions. These adaptations require prior staff and unit planning, the physical mobility of communications assets, and the electronic flexibility of the networks. Simplicity is factored into the user's environment in order to reduce the technological sophistication of the systems. Standardizing equipment and procedures in these complicated systems is required to support the Airland Battle environment. Development is required as the complexity of our communications systems grows to support Airland Battle Future.[16]

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[16]Ibid. 2-1.

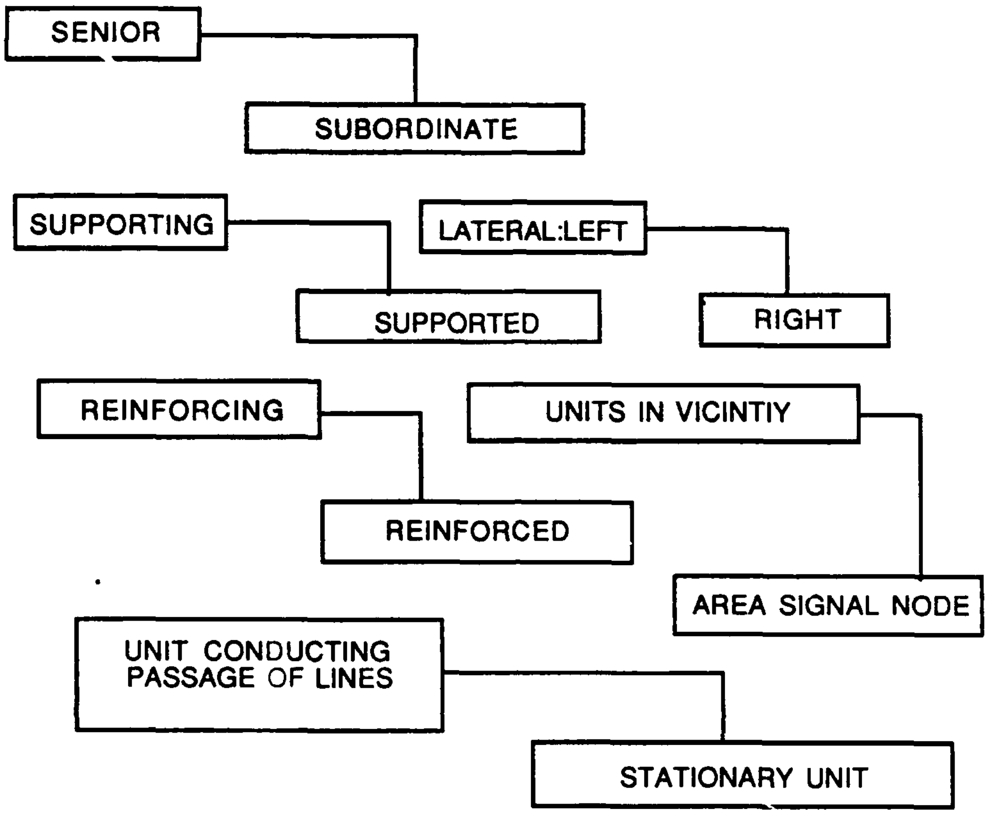

Figure 7
Connectivity Hierarchy
Source: United States Army, FM 24-1, Final Draft, June 1990.

Airland Battle Future Doctrine

Airland Battle Future (ALB-F) links future Army force capabilities with projected national interests and strategy. The capability will be developed as part of U.S. military strategy based on an evaluation of the threat to our national interests. This is divergent from currently published Airland Battle doctrine that focuses on the operational and tactical level, not the strategic. A global viewpoint that recognizes the differences in regional significance will shape the way our future forces are organized, equipped, and manned.

> Meeting the challenges posed by Airland Battle Future requires the implementation of sound strategic imperatives. These imperatives prescribe key operating requirements for successful execution of the concept. Strategic force imperatives are deployability tailorable forces, global intelligence, command and control, long-range fires, manpower enhancements and refinement of noncombat roles.[17]

The strategic force imperative that is implemented first is

[17]U.S. Army, Airland Battle Future Umbrella Concept, unpublished (Fort Leavenworth, KS: CAC CD, 1990), 27.

the acquisition of intelligence. The information and data collected determines how the other strategic imperatives are executed. Intelligence is a perishable commodity and depends heavily on communications to accomplish its intended purpose. The need to disseminate intelligence products to more users in widely dispersed locations quickly, will increase as we convert to Airland Battle Future doctrine.

The strategic imperatives hinge on the ability of our leadership to command and control all aspects of the employment of our forces. This command and control must have communications systems that are survivable. "Future C2 systems need to be more mobile and redundant to ensure continuous operations."[18] With the strategic imperatives in mind, leadership is able to support the operational concept through positive command and control.

In Airland Battle Future the operational concept of the United States Army's role is one of noncombat and combat operations. The noncombat role will take on a larger perspective as well as continue to focus on national disaster relief and nation building support to the separate theaters. The combat role will focus on nonlinear

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[18]Ibid. 29.

operations. The types of forces that will carry out these operations are defined as Forward Deployed, Contingency, Reinforcing, Nation Development, and Unique Mission.[19]

Forward deployed forces support our strategic regional interests. Contingency forces "....provide the shock effect necessary to gain the initiative, control the crisis, stop the conflict, influence decisions, and allow time for negotiations or for further U.S. military build-up."[20] Reinforcing forces deploy to assist the forward deployed forces. Though similarities exist among contingency forces, in deployment capability they are dissimilar. Reinforcing forces connect to established command and control and logistical support facilities while contingency forces plan to go into a undeveloped theater.

Nation development forces have the mission to develop national good will. They provide humanitarian assistance, disaster relief, and security assistance. Unique mission forces "....complement regional combat and noncombat operations with discriminative and limited-focus missions....for application across

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[19]Ibid. 15.

[20]Ibid. 16.

the entire operational continuum."[21]

ALB-F's operational concept "....for conducting nonlinear operations must take full advantage of emerging technology and the expected lower density of forces on the future battlefield. Use of technology in the form of sensors rather than forces is needed to locate, identify and track the enemy. We plan to attack enemy formations with massed, long range, lethal fires and follow up with fast, agile combined arms teams."[22] ALB-F will focus on nonlinear operations that attack enemy forces as compared to terrain retention.

The Airland Battle Future battlefield is loosely divided into three areas: the Detection Area, Battle Areas, and Tactical Support Areas (figure 8).

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[21] Ibid. 19.

[22] U.S. Army, Airland Battle Future-The Concept, unpublished (Fort Leavenwoth, KS: CAC CD), 6.

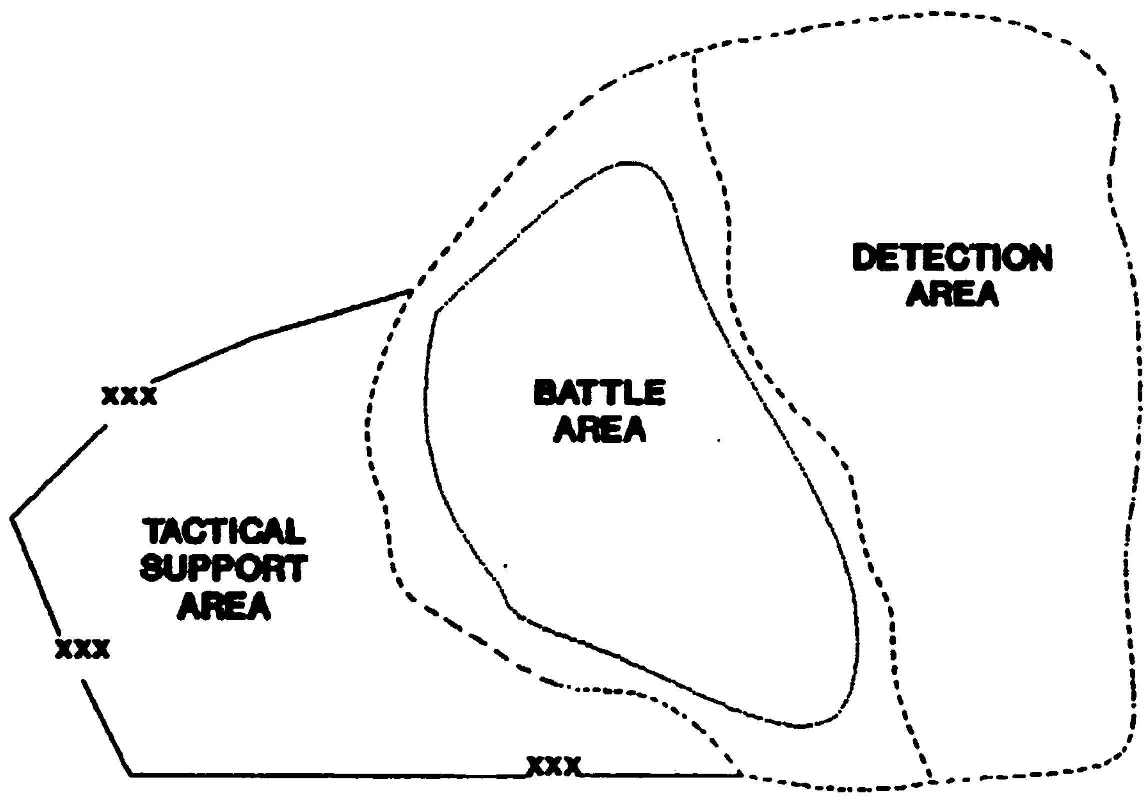

Figure 8
Corps Area of Operation
Source: United States Army, Airland Battle Future-The Concept, unpublished.

Within these areas, combat operations are conducted in four phases. (Figure 9):

Phase I: Sensor/Acquisition. Establish the detection area to develop the enemy situation, refine the expected battle area, and conduct target acquisition.

Phase II: Fires. Continue target and situation development and conduct long range air and ground fires to destroy enemy forces throughout the detection and battle area.

Phase III: Maneuver. Continue target and situation development. Continue the long range fires to destroy the enemy as well as synchronize with maneuver elements. These maneuver ıorces are then committed to complete destruction of enemy units.

Phase IV: Reconstitute. Maneuver force returns to support area, in the defense, or the Tactical Support Area moves forward, in the offense. Combat power is reconstituted to prepare for new missions. A new detection area is established.[23]

While the doctrinal impact of ALB-F is studied "....the four tenets of today's Airland Battle doctrine will remain the keys to guiding the way we conduct combat operations...."[24] However ALB-F will key on enemy detection through sensors that "see the battlefield" and their subsequent destruction through long range fires.[25] The control of the battlefield systems will be through a

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[23]Ibid. 7.

[24]U.S. Army, Airland Battle Future Umbrella Concept, umpublished (Fort Leavenwoth, KS: CAC CD, 1990), 35.

[25]Ibid. 5.

integrated battlefield communications system.[26] That will allow the commander and his staff to view an image of the battlefield in real time.[27] Reaching this level of command and control has a good probability of technical success as the U.S. defense research and development expenditures in electronics account for about 40 percent of the total research and development effort.[28] The question remains as to the political feasibility of continuing this amount of research and development expenditures during defense budget shrinkage.

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[26]M. A. Rice and A. J. Sammes, Communications and Information Systems for Battlefield Command and Control, (Shrivenham, UK: Brassey's 1989), 254.

[27]COL Lawrence G. Karch and James R. McGrath, Ph.D., "Remotely Piloted Vehicles for Company and Battlaion Size Units," Marine Corps Gazette, (January 1989): 22-24.

[28]Dr. A. Singer, "Technology and War, " Defense Science, (June 1989): 70.

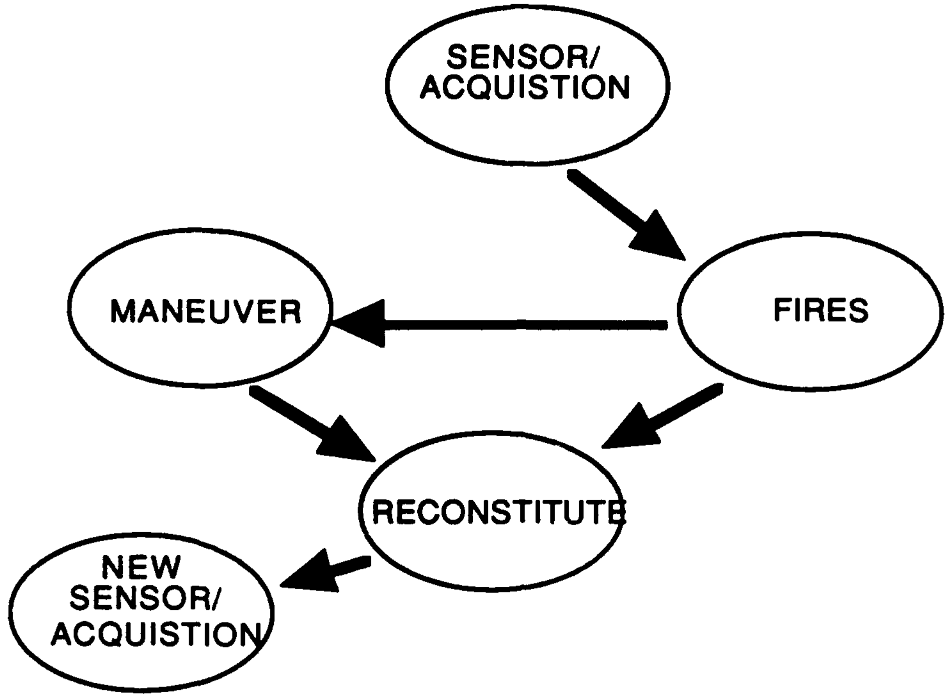

Figure 9
Combat Operations Overlapping Continuous Phases
Source: United States Army, Airland Battle Future

CHAPTER III

COMMUNICATIONS AND FUTURE TECHNOLOGY

The United States Army Planning for the Future with ATCCS

The United States Army command and control systems, that built in support of Airland Battle Future, are in their formative stages. What commanders and their staff informational needs are continues to be under development. The gathering of requirements data that delineates who needs what information and when is dependant on doctrinal, organizational, and equipment change. With the advent of Airland Battle Future and the advancing technological breakthroughs in communications hardware and software, these information requirements will most certainly continue to change. A flexible, expandable architecture is needed to ensure the commander's information requirements can be met. The commander's information requirements are supported by the expandable architecture of the Army Tactical Command and Control System (ATCCS). This system is composed of all facilities, equipment, communications, procedures, and personnel essential to commanders at corps level and below for planning, directing, and controlling operations of assigned forces. Each ATCCS automated component system must function as an integral part of the total system, which will process and display essential information to the commanders and staff within the five battlefield functional areas of Maneuver, Air Defense, Combat Service Support, Fire Support, and Intelligence/Electronic Warfare.[29]

It is ATCCS that will support Airland Battle Future. In its inception, ATCCS is planned for deployment in the 1992 to 1996 time frame. The principal communications and automation components of the system will be fielded by this time. In order to sequence the acquisition of equipment, software, and systems, a series of phased procurement is planned. With each additional phase, increased capabilities are to be added to meet user

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[29]Friedman, D. et al Sytem Description for the Army Tactical Command and Control Sytem. MITRE 1988. xix.

requirements. The attainment of the objective system, Table II, by phases is planned into the twenty-first century.

The structure of ATCCS comes from three major requirements documents, the Army Command and Control Master Plan (AC2MP), the Army Battlefield Interface Concept (ABIC), and the Command, Control, and Subordinate Systems Functional Description (CCS2 FD). The AC2MP furnishes the overall direction, guidance, and information for the management and the development of the Army Command and Control System (ACCS). The ABIC identifies the interoperability requirements among all battlefield automated systems at corps and below. The CCS2 FD is developed and agreed upon by the Combined Arms Command, Combat Development Activity (CAC CD) and the United States Army Communications-Electronics Command (CECOM) which structures the command and control systems within the five functional areas.[30] Additional requirements are incorporated into ATCCS upon completion of continued mission area analyses. ATCCS is a living architecture whose structure is transforming to meet changing needs.

ATCCS development started with a requirement to support the Army of Excellence force structure. The Army of Excellence structure was the

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[30]Ibid. 1-5.

way the army would have been organized through 1992; this structure has since fallen victim to budgetary cuts. ATCCS philosophy and architecture continues to be valid and supports Airland Battle. Even though its original purpose is curtailed, ATCCS continues to target a future objective. While ATCCS interconnects with other communications and computer systems it primarily covers the following tactical systems:

1. Maneuver Control System.
2. Forward Area Air Defense Command, Control & Intel System.
3. Advanced Field Artillery Tactical Data System.
4. Combat Service Support Control System.
5. All-Source Analysis System.
6. Single Channel Ground/Air Radio System.
7. Mobile Subscriber Equipment.
8. Enhanced Position Location Reporting System
9. Joint Tactical Information Distribution System.

ATCCS fielding will be in phases. This will allow for the integration of future doctrine and technological advancement. The phases concentrate on hardware fielding early in the life cycle (table II) followed by software upgrades as the systems mature. The ATCCS transitional concept allows for a baseline of fielded equipment on which product improvements and enhancement can take place. The lessons learned early in the fielding will be invaluable in the later software upgrade phases.

Table II ATCCS Fielding Phases
Source: System Description for ATCCS, xxvii.

AREA OF ATCCS AUTOMATION	BLOCK A 1988-91	BLOCK B 1992-96	OBJECTIVE 1997-
FUNCTIONAL AREA CONTROL SYSTEMS			
Maneuver	MCS with Ver. 11 software	MCS with Ver. 12 software	MCS with enhancements
Air Defense		FAADC2I Build 2	FAADC2I w/enhancements
Combat Service Support		CSSCS	CSSCS w/enhancements
Fire Support	TACFIRE	AFATDS	AFATDS w/enhancements
Intelligence/ Electronic Warfare		ASAS unique	ASAS on common hardware
Force Level Control System	FLCS on TCP manual interface	Common hardware resident software	Common hardware resident software

The current method of command and control relies heavily upon manual methods of communications. Staffs spend a majority of their time tending to the updating of information. A considerable amount of time is in the accounting of unit locations and status. With this high volume of information, accuracy and timeliness is in question. Some common problems are:

1. The commander is unlikely to filter out effectively and efficiently the information most critical to his decisionmaking.

2 As it is reported successively from facility to facility and from person to person, information repeatedly handled by humans is prone to error during transcription and transmission. Often, relevant information never makes its way through the system but simply disappears.

3. In relation to the dynamics of the battle, the slow pace of manual reporting and posting procedures means that by the time information arrives at an appropriate decisionmaker, the facts represented in the information will have changed, reducing the value of the information. Given that the window of opportunity for gaining a tactical advantage is expected to be fleeting and narrow, this pace of information flow will not adequately support the timeliness demands of the commander.

4. Due to the latency factor of information being reported manually, decisionmakers in two or more facilities who are trying to keep track of the same situation will rarely perceive it in a like or near-like manner.[31]

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[31] Ibid. 2-2 to 2-3.

The essential information that the commander must have, are the location and status of all units both friendly and enemy. Appendix A provides a listing of graphic and text information requirements for a commander's situation report.

CCS2 Architecture in support of Information Requirements

The structure built to support the previously identified command information requirements is the Command, Control, and Subordinate Systems architecture (CCS2). CCS2 establishes the conceptual foundation for using communications and automation systems to achieve the objective ATCCS systems. The use of this architecture will provide to the commander and his staff the timely information required for the decisionmaking process. Once the commander's decisions are made his orders are disseminated across the same communications media. The CCS2 architecture:

1. Replaces slow, manual methods of current command and control procedures with faster ones, especially in the areas of information dissemination, preparation of decision aids, (such as battle map overlays and spreadsheets), and quantitative problem solving (such as weapon-target assignment). The Army believes that, in aggregate, this added speed will enable faster responses to rapidly changing situations, potentially outpacing the enemy's actions.

2. Supports the efficient handling of high volumes of information, ensuring that information a decisionmaker deems critical reaches his attention at the right place and time.

3. Enables the fast and reliable flow of accurate information both within and among facilities (especially among force level command posts), such that commanders and staff at different locations may base their decisions on the same information baseline.

4. Enhances the survivability of the command and control structure and the continuity of command and control operations, through the redundant distribution of essential information and functions. This redundancy would permit critical command and control, decisionmaking to take place at more than one location, thereby reducing the impacts when a node is temporarily or permanently lost or when a decisionmaker is forced to relocate to another command post.[32]

CCS2 architecture breaks command and control down into three systems, the functional systems, subordinate systems, and Force Level Control System (FLCS). This concept is best understood by viewing (figure 10). Also shown and of particular note is the anticipated communications means used to transport data within the system.

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[32]Ibid. 2-4.

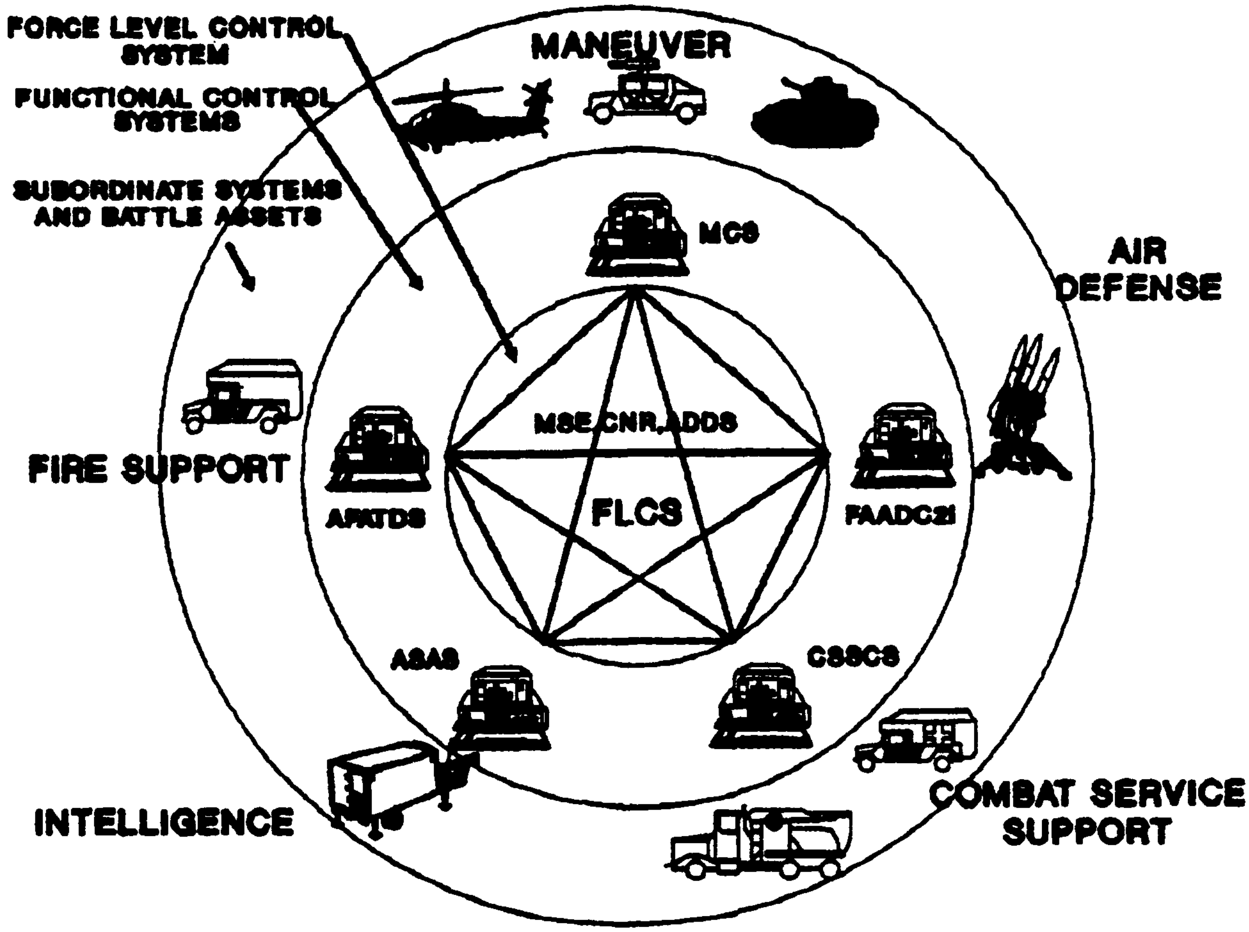

Figure 10
CCS2 Architecture
Source: System Description for the ATCCS, 2-6.

The five battlefield functional areas each have specified automated functional control systems. In Maneuver it is MCS, Air Defense has FAADC2I, Combat Service Support has CSSCS, Fire Support has AFATDS, and Intelligence/Electronic Warfare is supported by ASAS. Appendix B shows the connectivity from maneuver units through corps for each functional control system. MCS and CNR are funded programs with major procurement and fielding schedules in place and on time. This is in contrast to ADDS which is undergoing review and may be placed under funding constraints as the United States Army reduces it forces.

Subordinate systems are characteristic of their specific battlefield functional area. For example, TACJAM, TRAILBLAZER, and TEAMPACK are subordinate systems. In the case of intelligence and electronic warfare system. These systems are jammers and direction finding systems at maneuver battalion level. They send their data to division headquarters for analysis, (Appendix B). All the battlefield functional areas have such unique subordinate systems.

The Force Level Control System is a software system that will interconnect the functional control systems at decision making levels. It will structure the great influx of information and raw data into meaningful intelligence. Once the commander has utilized these decision aids he will disseminate his orders and guidance through the functional control system. Since FLCS nodes are networked throughout the entire theater of operation (Table III) commanders at all levels down to battalion are able to command and control their forces from many different locales.

This connectivity allows for the different levels of staff to access and coordinate their activities with other staffs. This lateral coordination allows for a higher level of efficiency and accuracy not found on previous battlefields. Initially FLCS will consist of the following functions:

1. The exchange of force level control information among the functional control systems at any echelon.

2. The storage and maintenance of command critical and commander's situation report information in the force level control data base.

3. The processing, formatting, and presentation of the commander's situation report information using common displays.[33]

The FLCS will utilize the same computing hardware that MCS, CSSCS, FAADC2I, ASAS, and AFATDS use.

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[33]Ibid. 4-27.

Table III
FLCS Node Locations
Source: System Description for the ATCCS, 4-29.

Tactical Echelon	FLCS Location	Functional Control System Host
Corps, Division	Main, Tac, Rear CP	MCS
Brigade	Main, Rear CP	MCS
Separate Bde/ACR	Main, Tac, Rear CP	MCS
Battalion	Main CP	MCS
Corps, Division	Main CP Fire	AFATDS
Brigade	Support Element	AFATDS
Separate Bde/ACR	" "	AFATDS
Battalion	" "	AFATDS
Corps	CTOC Spt Element	ASAS
Division	DTOC Spt Element	ASAS
Corps	ADA Bde ABMOC	TDB
Division	FAAD Battalion ABMOC	FAADC2I
Brigade	FAAD Battery HQ Sec	FAADC2I
Separate Bde/ACR	FAAD Battery HQ Sec	FAADC2I
Corps	Support Command HQ Section	CSSCS
Division	Support Command HQ Section	CSSCS
Brigade	Forward Support Battalion Ops Sec (Hvy) Forward Area Support Team (Light)	CSSCS
ACR	Forward Support Battalion Ops Sec	CSSCS

Communications Means for ATCCS

The foundation of all I have discussed previously is dependent on the reliability, flexibility, and survivability of the communications system interconnecting all the ATCCS functional control systems. These communications systems are broadly defined as wide area and local area systems. Wide area systems provide the long haul connections within a large network. It connects major communications nodes over a large geographical area; it can be global in size. Local area systems provide connectivity off of wide area nodes to a smaller geographical area. It can provide for a relatively large number of users but will normally be small relative to the size of the headquarters or command post it supports.

Wide and local area communications are based on three United States Army communications systems: the area common user system, combat net radio, and the data distribution system. These systems provide the communications connectivity that tie the five battlefield functional areas and their functional control systems together (Table IV).

The Combat Net Radio (CNR) system is comprised predominately of Single Channel Ground/Airborne Radio System (SINCGARS). SINCGARS is a primary communications means for tactical units from brigade and below.

Though used mostly for secure voice traffic, by using broadcast communications for those in its net, it can also be used for data transmission. SINCGARS uses VHF-FM frequency hopping technology to reduce the probability of intercept or detection. Improved High Frequency Radio (IHFR) is a NDI radio that will replace existing High Frequency (HF) radios in the inventory. It has a planning range of 2000 kilometers.

The Army Data Distribution System (ADDS) is a system that supports near real time data communications. It provides for position location and identification of friendly units. Two systems, the Enhanced Position Location Reporting System (EPLRS) and Joint Tactical Information Distribution System (JTIDS), comprise ADDS. EPLRS is a computer based system designed to transmit small amounts of data to other nodes via line-of-sight signals. It has spread spectrum, frequency hopping, and automatic rerouting that provides for a high degree of security. It operates at 420-450 MHZ and with a hopping rate of 512 HOPS/S. The data rate for EPLRS is 1.2 to 3.6 KB/S which is sufficient for its planned uses. It will reduce the use of tactical voice radio nets, have a high reliability, and provide almost real time positioning to all net users.

Table IV
Communications Supporting ATCCS
Source: System Description for ATCCS, 4-39.

System Type	System	MCS	FAADC2I	CSSCS	AFATDS	ASAS
Area Common	ATACS	o				
User System	MSE-DNVT	o	o		o	o
Combat	AN/VRC-12	o	o	o	o	o
Network	AN/PRC-77	o	o			o
Radio	AN/PRC-68				o	
	SINCGARS	o	o	o	o	o
	IHFR	o		o	o	o
	AN/GRC-193				o	
	AN/GRC-106					o
	SCOTT	o				o
Army Data	EPLRS	o	o	o	o	o
Distribution	*JTIDS*		*o*			
Other	Field Wire	o	o	o	o	o
	USCGNET	o		o		o
	TRI-TAC	o		o		o
	Host nation telephone	o		o		o
	AUTODIN					o
	DDN					o
	AUTOVON	o		o		
Communications	TSEC/KG-31	o	o	o	o	o
Securtiy	TSEC/KG-57	o	o	o	o	o
	TSEC/KG-68 (MSE DSVT)	o	o	o	o	o
	TSEC/KG-84	o		o	o	o

JTIDS is also non-nodal, line-of-sight UHF radio system which provides users with precise positioning, identification, and location data. JTIDS uses the same anti-jam communications features of EPLRS, and uses over 51 channels between 969-1215 MHZ at hopping rate of 77,000 HOPS/S. JTIDS also has a higher data rate (28.8 to 238 KB/S) than EPLRS. JTIDS is used with fast moving aircraft of the United States Air Force. It is integrated with the United States Army air defense elements for use in

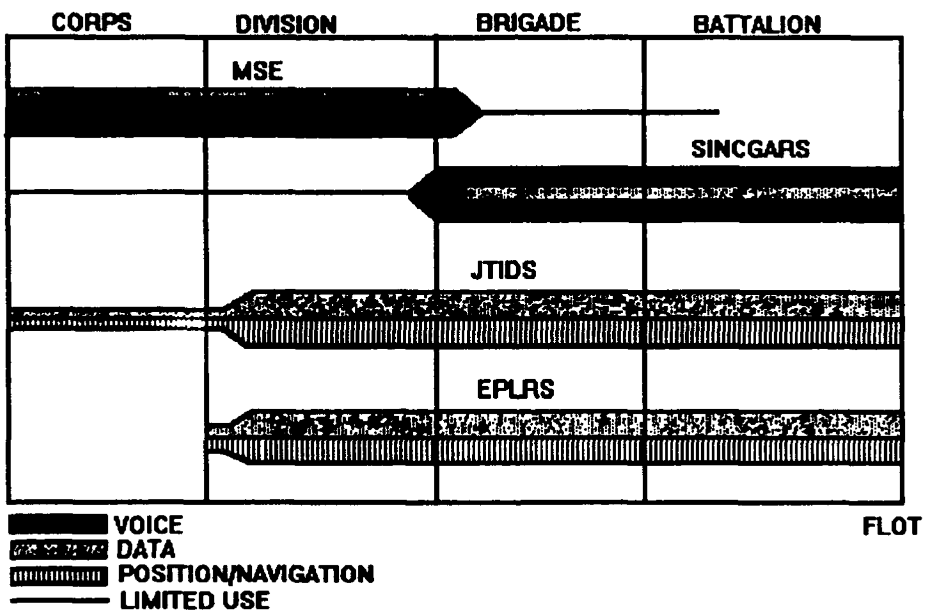

Figure 11 Types of Traffic
Source: Adapted form a Descrtiption of the ATCCS, D-10.

Identification Friend or Foe (IFF) operations. The types of traffic, such as voice or data, and the communications transmission means by unit size is best illustrated in (Figure 11).

The area communications system for the United States Army is Mobile Subscriber Equipment (MSE). Simply, MSE is a common user secure communications system that can be used by fixed or mobile subscribers. Node Center (NC) switches provide hubs to extension switches throughout the area of operations. There are forty-two NCs in a normal corps area of operation, as illustrated in (Figure 12).

These NCs interconnect automatic switch boards called Small Extension Nodes (SEN) and Large Extension Nodes (LEN) to provide a digital telephone network. This telephone network operates similar to commercial networks in that each subscriber has assigned telephone number. The major difference from previous systems is that this telephone number remains the same even as the users location changes.

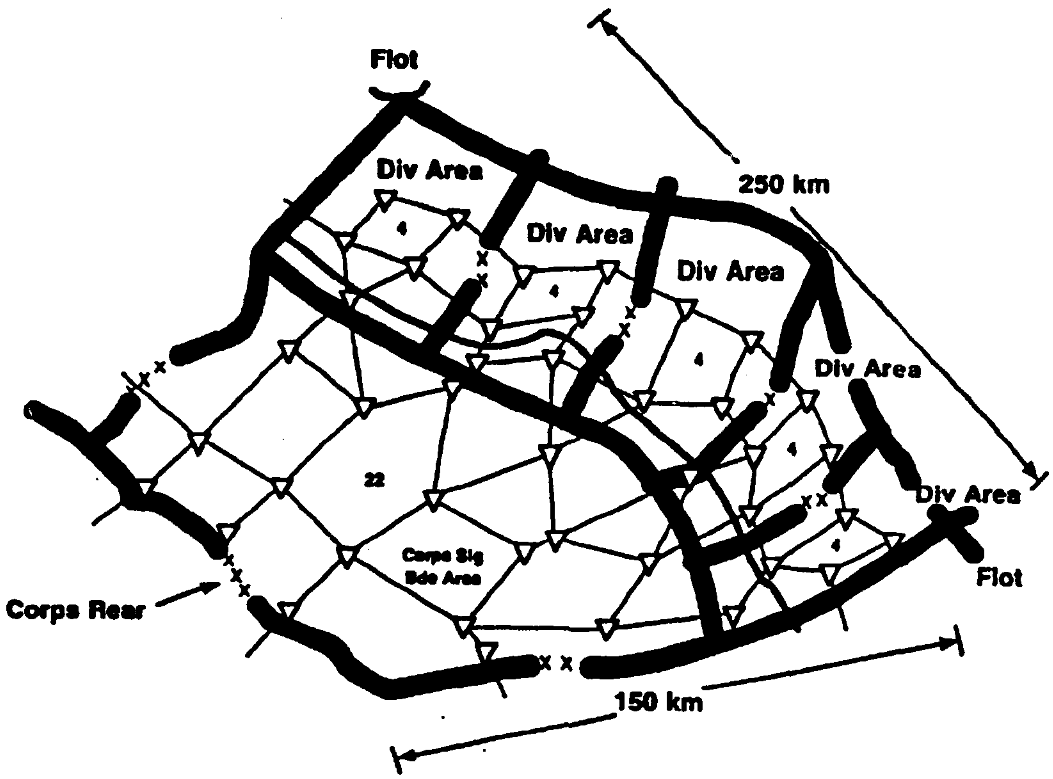

Figure 12
Corps MSE Deployment
Source: Corps and Division Commanders MSE Handbook

Radio Access Units (RAU) provide entrance into the telephone system for the Mobile Subscriber Radiotelephone Terminal (MSRT). This system provides access for secure voice and data, at 16 KB/S, throughout the battlefield. It is similar to commercial cellular car telephones. The MSRT is vehicle mounted and enables the subscriber to communicate, on the move, anywhere on the battlefield. In some cases a graphic representation can relay concepts and information better than a narrative description. To support this graphic transmission of requirements the MSRT has the capability of supporting the receipt and transmission of facsimile. The ability to command and control is greatly enhanced by MSE.

Communications Technology

> Much of tomorrow comes from yesterday, and the transfer of ideas from the past into the probable actions of the future is often the way to prepare for tomorrow.[34]

Communications as with any twentieth century technology is a combination of many fledgling technological gains. These gains by themselves may not look very advanced but in combination with each other they produce a "high tech" product that can revolutionize the way we view our world. The layering of technology advancement, as described above, is the rule not the exception. The slow plodding of technological advancement can be counted on to solve future problems.

The future types of communications in support of Airland Battle Future will take the form of voice, data, video, and high speed facsimile.[35] The transmission of these types will be over the ATCCS communications systems, CNR, MSE, and ADDS. Their speed and reliability, or data rate, is

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[34]Boyes, Jon L. "The Future Influence of C3 Technologies." SIGNAL, (June 1988): 113-117.

[35]Ibid. 115.

directly related to the bandwidth of the transmission media. The greater the bandwidth of a channel, the greater the data rate, which is measured in kilobits per second. Conversely, the greater the data rate, the greater the bandwidth required to support it. The categories of transmission media found in the United States Army include wire pairs, optical fiber, terrestrial microwave, satellite systems, Line-of-sight (LOS) multichannel, combat net radio and high frequency radio. I will examine data rate on the different categories of transmission media as the primary criteria in measuring future communications advancement.

Wire pairs, commonly known as twisted pair, have dominated communications for the first half of the century. Its use is still significant for local requirements. The principal characteristic of wire is the smaller the diameter of the wire, the greater its resistance to the propagation of a signal. This means that increased resistance results in a decreased bit transfer rate across the communications path. A smaller wire produces less total surface for the signal path, resulting in increased signal loss. A larger wire has a greater cross-sectional area and thus allows for increased signal strength. The transmission distances attainable on wires depend upon the gauge, line condition, operating environment, and speed of transmission.[36] In Table IV the performance of wire pairs shows a direct relationship on throughput vs. distance and size of wire. However, even the larger size wire pair has explicit limitations on its information carrying capabilities.

Table V Labortatory Performance of Wire Pairs
Source: Data Networks Concepts. Theory. and Practice, 1989.

	#19		#22		#24		#26	
Kbit	mi	km	mi	km	mi	km	mi	km
1.2	32	51	22.5	36	17.5	28.5	14	22.5
2.4	28	45	19.5	31.5	15.5	25	12	19.5
4.8	24	38	16	26	12.5	20	10	16
9.6	14	22.5	9	15	7	11.5	5.5	9
19.2	12.5	20	7.5	12	5.6	9	4.3	7
48.0	11	18	6.2	10	4.4	7.1	3.2	5.2
56.0	10.5	17	6	9.5	4.2	6.7	3	4.8
64.0	10	16	5.8	9.3	4.0	6.5	2.9	4.6

[36] Uyless Black, Data Networks Concepts. Theroy. and Practice. New Jersey: Prentice Hall, 1989.

One of the most exciting technologies in the last few years is the expanded use of optical fibers. Optical fiber is the preferred method of communications for newly established commercial long-distance carriers. There are several reasons for this. Optical transmission has a very large information capacity compared to wire pair (figure 13). Fiber also has several favorable attributes: it is not effected by interference from outside electrical forces; optical fibers have less loss of signal strength than wire pair which allows for greater distance between repeaters. It also is very small and light... for example, 900 copper wire pairs pulled through 1000 feet in a building would weigh approximately 4800 pounds. Two optical fibers pulled the same distance with its protective covers weigh only 80 pounds.[37] Of specific interest to the military is optic fibers inherent security. Not only do you not have spurious electromagnetic radiation transmissions, as you do in wire pair, but it is very difficult to tap into a optic fiber without the owner knowing about it.

[37] Ibid. 129.

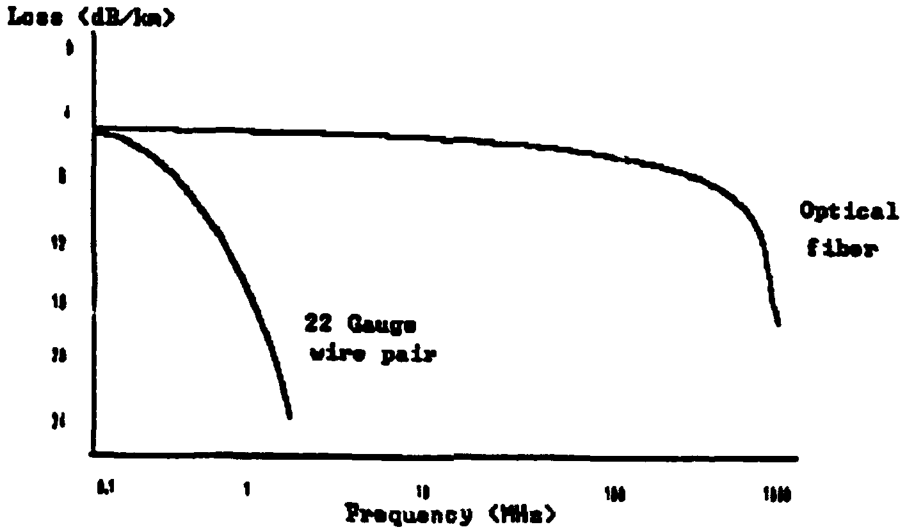

Figure 13
Comparison of Optical Fiber and Wire Pairs.
Source: Data Networks Concepts. Theory. and Practice, 1989.

The military applications using fiber optics are flourishing. In summary, the advantages of using optical fiber over conventional wire or coaxial cables include lighter weight, portability, ruggedness, low-signal to loss ratio, transmission, larger bandwidth, reduced need for shielding, high safety levels, and lower cost. Drawbacks to the military use of optical fiber include the potential for degradation of fiber in a nuclear environment, maintenance and repair, and static fatigue or stress corrosion of the fibers. The advantages to using optical fibers far outweigh the drawbacks.[38] The greatest advantage is fibers large bandwidth capacity. The highest data rates achieved to date are 8 gigabit/sec, and the longest distance for coherent transmission is 290km. It is theoretically possible to transmit hundreds of terrabits/sec on a noise-free carrier across a dispersionless fiber. This is equivalent to 1.6 million TV channels on a single fiber.[39] Obviously, the research and development community must devote a great deal of effort before we can reach this level of sophistication. Currently a fiber system can transmit data up to a rate of 12 Mbit/s over 1.5km. Researchers at the Rome Air Development Center at Hanscom Air Force Base are working to increase the system's capability so that 100 Mbit/s can be transmitted over 35 km.[40]

Microwave is a line-of-sight radio transmission. It is generally

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[38]Joseph F. Benzoni, and David T. Orletsky, "Military Applicaitons of Fiber Optics Technolgy," A RAND Note, (May 1989): 13.

[39]Ibid. 14.

[40]Ibid. 19.

used at echelons above corps, but was common in older corps area signal battalions prior to MSE fielding. Microwave trunks are used extensively for long haul connectivity in the United States and Europe. In any modern battlefield, use of host nation communications support is always a planning consideration. This factor makes microwave important.

Microwave transmission covers a wide range of the frequency spectrum. Typically, frequencies range form 2 to 40 GHz, although most systems operate within the range of 2 to 18 GHz. The data rate is greater at the higher frequencies. A data rate of 12 Mbit/s can be obtained on a 2 GHz band microwave system, yet a data rate of 274 Mbit/s is possible on a 18 GHz band system.[41] Television transmission also utilizes microwave transmission, because microwave provides the capacity required for video transmission.[42]

Communications with satellites through Ground Mobile Forces (GMF) stations allows communications anywhere on the globe and provides quick and reliable connectivity for command and control. Satellites provide a large communications capacity. They operate from 3 to 14 GHz and

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[41]Uyless Black, Data Networks Concepts, Theory, and Practice, (New Jersey: Prentcie Hall, 1989), 136.

[42]Ibid. 136.

transmit with data rates up to 1.544 Mbits/s. New technology will expand the frequency range available for satellite communications. The 20 to 30 GHz range will be the next area of employment with small antennas; smaller wavelengths result in smaller antennas, and greater data rates.

The area coverage or backbone of the United States Army communications system at corps and below is its MSE multichannel system. This system uses a radio grid to inter-connect node centers at a average distance of 25 kilometers between nodes. The multichannel system supports the digital subscriber voice terminal (DSVT) and the digital nonsecure voice terminal (DNVT) a data rate of up to 16 Kbit/s. The DSVT and DNVT are radio telephones that each have a single data port for connection of an interface cable. These radio telephones access the multichannel system through a Radio Access Unit (RAU). This dynamic network theoretically allows for the connectivity of all computers on the battlefield.

The multichannel system for MSE was designed to originally support voice and message traffic. Since MSE will be a voice-oriented, circuit-switching system, large amounts of data may cause unacceptable degradation of the system. Multiple addressing for data subscribers is only limited though the use of a TYC-39 message switch.[43] However GTE Government Systems, the builder of MSE, is preparing to field a MSE Packet Switch Network (MPN) that will address the data subscribers problems.

MPN provides off-the-shelf equipment that allows packet switching between NCS, LEN, and SEN. It will also connect to DDN via gateways (T/20) and packet switches (C/3-XA). The T/20 gateway is the same that is used in the MILNET/ARPANET gateways. MPN packet switch is X.25 based in addition to having a CCITT X.75 resident capability for interface with NATO and other commercially based systems. The MCS NC system will provide the bulk of the capability for the data transfer with both 16 and 64 Kbit/s data rates. Local connectivity within the SEN, LEN, and NC is supported by IEEE 802.3 Ethernet Local Area Network (LAN). A Ethernet LAN runs at a 10 Mbit/s data rate.

As previously discussed, the typical corps has 42 node centers at its disposal. While the LEN also has 16 and 64 Kbit/s gateways the SEN only has 6 Kbit/s capacity. This is of importance when sending video freeze frame and other image based information over the network. Most of the

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[43]D. Fredman et al. System Description for the Army Tactical Command and Control System, MITRE Corporation (McLean, VA: Washingtion C3I Division, 1988), d-17.

battalion-sized units will connect to the MSE system through a SEN. Of particular note is the current practice of co-locating two SENs at division main for use in a hot jump operation. A hot jump requires one SEN to be operational at all times which allows for continuous communications between the old and new headquarters locations. The headquarters would be limited to only a 16 kbit/s packet link into the MSE network. A potential problem could be alleviated by locating the headquarters SEN adjacent to a NC which has IEEE 802.3 LAN connectivity into the network.

So far I have addressed the organization levels of brigade/battalion and above. What has not been discussed is the interface of the CNR at brigade/battalion and below. The CNR for the United States Army is the Single Channel Ground-Air Radio System (SINCGARS). SINCGARS has a digtal data capability of up to 16 Kbit/s. It also has a built in data rate adapter to allow transmission of data at 75, 150, 300, 600, 1,200, 2,400, and 4,800 Bit/S. With the data transmission capability SINCGARS will be the major communications resource for ATCCS computers at brigade and lower echelons. It will share its channels on a noninterference basis among other data and voice traffic.

The ability to network computers through our communications systems is increasing. We are able to communicate from the foxhole, through the network, to anywhere in world. This connectivity is changing the command and control procedures at every organizational level. While we have informational access to large databases the amount of information tends to bog us down unless we manage it. Information management will exact strict controls upon the requesters of this information. Higher headquarters will implement rigorous programs to purify the information available to lower echelons.

On the other hand the higher headquarters will require very detailed information for their analysis. The ability of the CNR and MSE to transmit 16 Kbit/s information currently restricts the transmission of real time images. As the quest for information continues, this data rate barrier will become intolerable and advanced technology will be applied to see the battlefield.

CHAPTER IV

IMAGING TECHNOLOGY

The Need of Imaging for Airland Battle Future

The Airland Battle Future concept envisions a three dimensional, widely dispersed, and highly lethal environment. It will require coordinated but independent action by small units across the depth and breath of the area of operation. It will be imperative to have good intelligence and exceptional command and control of your forces. Unless you do, highly deadly precision weapons may destroy forces as they mass. The separate maneuver commanders must be able to visualize the battlefield.

Visualization of the battlefield occurs by several methods. The most important is the experience of the commander. He may need only to look at a map to understand the tactical significance of his situation. Other commanders may need accurate and detailed reports to solidify their image. Most commanders make their decisions based on limited information. Would their decisions and orders change if they had all the accurate and timely information they wanted? Understandably, the answer would be a resounding, yes.

The visualization that is needed, from a land warfare point of view, is where am I and where is the enemy. Commanders need accurate and timely terrain and target identification information. Most tactical commanders prefer to be where the action is to see first hand what the battlefield looks like. But by doing so the commander is not available to be somewhere else. Tomorrow's battlefield will allow the commander to see and influence several actions concurrently with more efficiency.

This reconnaissance, surveillance, and target information is, as the Joint Projects Office (JPO) of the Naval Air Systems

Command states....returned by downlink either directly or through airborne relays to mission planning and control stations and external receiving systems. Data received by mission planning and control stations can be distributed to remote video terminals located in tactical operations centers.[44] The United States Army can use this type of image technology to visualize the battlefield. In fact, it intends to.

Remotely-piloted vehicles (RPVs) also called unmanned aerial vehicles (UAVs) have been in existence for years. They flew missions during the 1962 Cuban missile crisis and during the Vietnam War. Their real utility and potential is only now being realized through advanced technology.

> UAVs will play a significant role in Airland Battle Future because the proposed doctrine emphasizes deep reconnaissance, target acquisition,lethal UAVs and smart munitions. In addition, the characteristics of the nonlinear battlefield, fewer forces, rapidity of action, fluidity and flexibility, will put a premium on UAV capability.[45]

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[44]Prina, Edgar. "UAVs: The Forward Line of Technology." Sea Power, (October 1989): 39.

[45]Libbey, A. Miles, and Patrick A. Putignamo, "See Deep Shoot Deep UAVs on the Future Battlefield." Military Review, (February 1991): 39.

Airland Battle Future will depend on sensor technology to identify enemy forces in the detection zone of the area of operations. In large measure, UAVs will be used to verify targets for prioritization of long range destructive fires. Since national and other remote sensing assets are expensive and therefore limited in numbers, they are managed closely. The restricted use limits imaging assets available to lower maneuver units. When imaging support is accessible it is usually less than real time. Inexpensive UAVs will provide the real time imaging at the operational and tactical levels. For example, long range endurance UAVs would have been very useful in the early days of the air campaign of the Iraqi War when there was a need for continuous target acquisition in search of Scud mobile missile launchers. Additionally the battle damage assessment process would have been aided by long range UAVs that were kept on station long after the Air Force left the killing zone. The utility of using UAVs for a variety of battlefield imaging missions is unrefutable. While pure ground commanders will see them with merit.... some pilots see the UAV as a threat to their "community," much as the battleship admiral's regarded aircraft carriers up to the time of the Japanese attack on Pearl

Harbor.[46]

Imaging Technology

There are two current ways of getting images from the source to the receiver in near real-time. They are freeze frame and compressed video. The primary factor in the transmission of images is data rate. The lower the data rate the smaller the communications bandwidth required. Less bandwidth means less capability which translates to reduced cost. Additional bandwidth is not available in the United States Army communications systems except for special short term situations servicing limited users. The MPN for MSE was planned for but not funded until 1991. Its bandwidth will limit most types of video transmission. The bottom line is that additional bandwidth, for the majority of users on the ATCCS systems, is not avaliable.

Freeze frame technology selects a video image and transmits that frame to a distance receiver. The receiving station then has a near real time video picture that can be analyzed or stored for later

[46]Prina, Edar. "UAVs: The Forward Line of Technology.: Sea Power, (October 1989): 38.

retrieval. A color and black-and-white freeze frame system, on an OH-58D helicopter, has been used in Germany REFORGER exercises. Its high-resolution images received high praise....not only could we identify the type of tank, but the image was clear enough that we could see the tank number and identify whose it was." [47]

One such freeze frame system is the Harris RF-3750-05 tactical video imagery terminal and RF-3490 data processor. In a OH-58D, the observer would freeze the image on his video screen and store or transmit the images over a VHF-FM radio. The transmitted images are received by the RF-3750-01 base station video imagery terminal and displayed on a color monitor. The terminal has the capability to manipulate the image by zooming or enhancing it for clarity. The transmission of color images from the helicopter took an average of 35 seconds at 4.8 Kb/s. Retransmission between base stations ranged from 76-120 seconds at 2.4 Kb/s.[48] The low data rates required for freeze frame imaging can be supported by our current and planned ATCCS architecture as explained in the previous

[47]Mordorff, F. Keth, "Harris-Equipped OH-58D Transmits Near Real-Time Reconnaisance Images." (December 1988): 111.

[48]Ibid.

chapter. Though freeze frame will satisfy some military missions the need for real-time imagery still exists.

Near real-time video is more completely supported through techniques called data compression. Compressed video is used extensively in video teleconferanceing by commercial and military organizations. A CODEC (COder/DECoder) is used to compress and decompress the video at each site. CODEC equipment generally transmits at data rates from 56 Kb/s to 384 kb/s. The higher the data rate the more life like the full motion projection. Motion performance continues to be the most important factor in assessing CODEC quality. The inverse to larger data rates for better quality, is to achieve higher compression ratios in the CODEC. These higher compression ratios will reduce the communications bandwidth requirement. The problem that results is the lack of acceptable resolution in the projection. Progress toward reaching higher compression ratios continues using the algorithms of discrete cosine transform (DCT). A new video chip that....compresses digital video signals at ratios of 200:1, will mean that video conferencing stations, currently costing $30,000 to $50,000 may drop to about $5,000 and be available by the end of 1991.[49]

Another algorithm, professed to be fifty times less complex than the more conventional DCT, offers a 500:1 compression ratio at 30 frames-per-second frame rate. This process....compresses a frame of video data by working on one scan line at a time. As each line is scanned, it's sampled, and the analog signal is....digitized and compressed "on the fly" to produce full motion video.[50] The user can manipulate the frame rate to a higher level to achieve better compressed full motion video or reduce the frame rate for a high resolution still. The realization of higher rates of compression is likely to occur as the technology of multimedia matures.

In order to transmit real-time video at the NTSC, 525 line, 30 Hz standard, a data rate of 88 Mb/s is required.[51] The LANs most currently used, comply with IEEE standards of 802.3 and 802.5 which use a data rate up to 10 Mb/s. A new broadband standard the Fiber

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[49][Edited], "Affordable Videoconferencing on the Way?" Data Communications. (Novermber 21, 1990): 10.

[50][Edited] "Multimedia Chip Compresses Video and Audio In Synch." Computer Design, (1 February 1991): 102.

[51]Hartmayer, W. et al, to Bryan Gorman [Technical Report] U.S. Army CECOM Center for C3 Systems Local Area Communicaions Division, (1990): 3.

Distributed Data Interface (FDDI) is emerging that will connect major communications hubs at 100 Mb/s.[52]

The problem with the pre-FDDI standard is that it isn't yet available on desktop computers and it promises to be expensive when compared to Ethernet. As with all new emerging technologies, not everyone interested in the final objective product are in agreement. Especially in the communications and computer arena interoperablity standards and internationally agreements take years to solidify.

Jet Propulsion Laboratory (JPL) has tested the combining of real-time voice, video and data traffic onto the same network. Its goal was to....demonstrate the feasibility of serving a variety of Command, Control, and Communications (C3) needs with the tactical Army using a FDDI based LAN for high-speed integrated voice/video/data communications. JPL concluded that...with the emergence of FDDI compatible components, it is only a matter of time before high-speed networks will be in common use. The data communications industry projects a continuous rise in the amount of

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[52]Mcquillan, John, "Broadband Networks," Data Communicaions, (June 1990): 76.

image data transmissions (Figure 14).

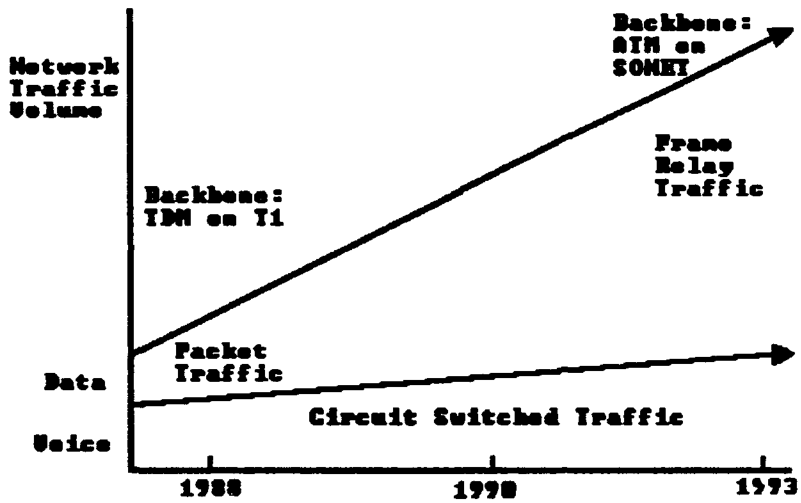

Figure 14
Data Traffic Growth
Source: Data Communications, June 1990.

Command and Control through Video Teleconferencing

The day of interactive video teleconferencing will soon be common place on the battlefield. A popular television program comes to mind, StarTrek the Next Generation, when I think of how the military will use this emerging technology. On a large screen high definition display multiple windows will be presented. A commander of a division may be talking to his brigade commanders while adjacent to their image is the readiness reports of their brigades. A battalion commander may be talking about a future bridgehead while UAV real-time images of it are displayed to a information fusion center hundreds or thousands of miles away. This is the future.

One military organization whose job it is to look into the future and demonstrate potential technologies is the Future Battle Laboratory (FBL). They are prototyping a information fusion center that addresses the concepts professed above. Under the name of their sponsor, FBL's USAREUR project is intended to help the commander see the battlefield, convey his intent, and synchronize the battlefield.[53] The FBL has integrating equipment within transportable shelters that will act as a command and control fusion center. It contains such services as, overlay production and distribution, large screen display, terrain analysis and visualization, and communications as shown in (Figure 15).

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[53]Gorman, Bryan. [Unpublished Briefing] Video Teleconference Center, Fort Leavenworth, 1990.

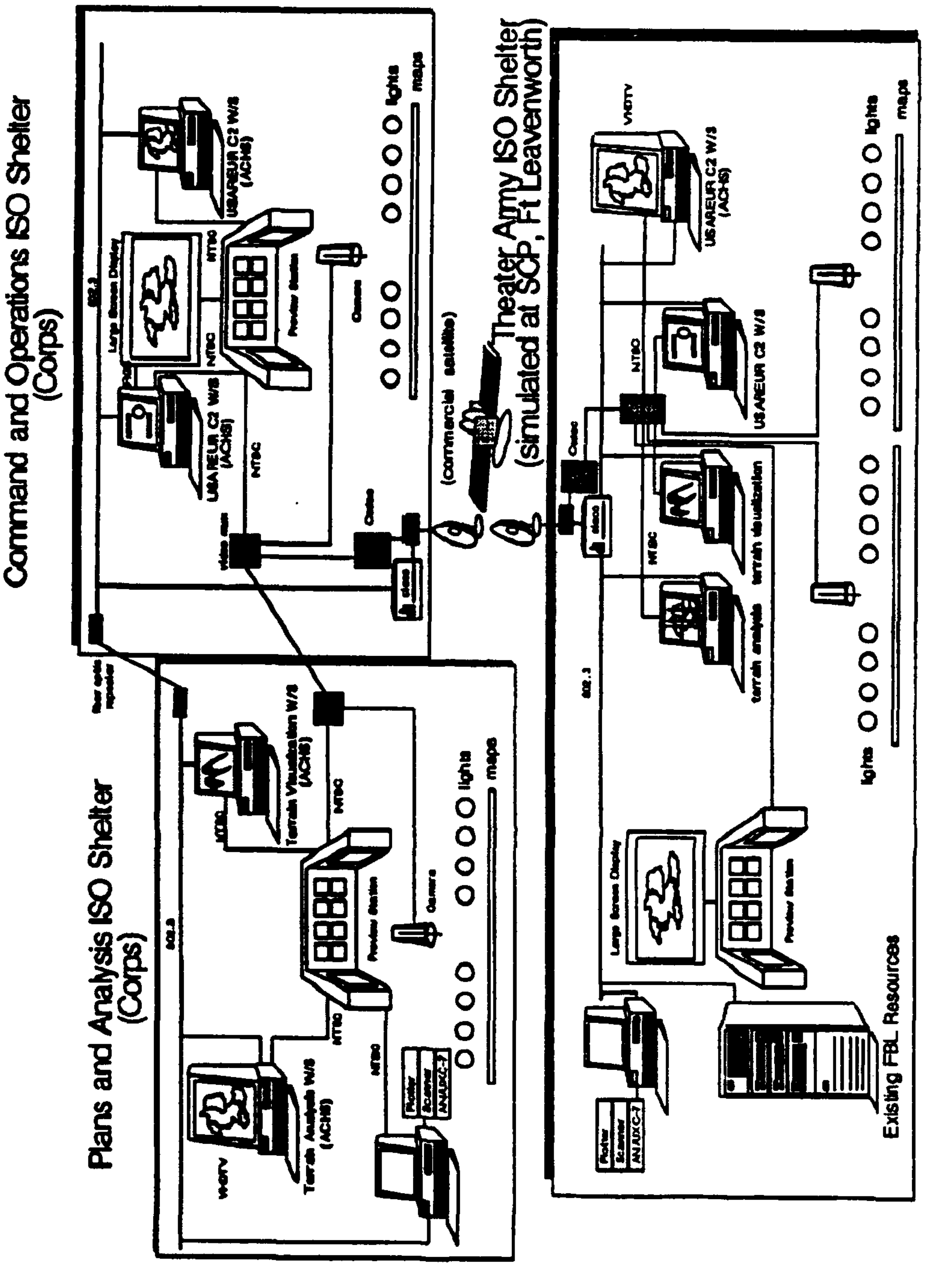

Figure 15
FBL Fusion Center Source: CAC CA-FBL Ft. Leavenworth

This project networks with both tactical and commercial communications systems. It provides for the fusion and display of information from many different sources such as three dimensional terrain visualization and intelligence imagery. It switches the images from computer workstations to large screen displays. These workstations with their databases may be connected by satellite or other means to other systems thousands of miles away.

Display of Information

FBL is working on several projects that deal with the increased efficiency in the display of information. Two of these projects are directly related to imagery. The first is the large screen display. The utility of displaying images or full motion video on a large screen is usually linked with terrain, maps, and conferences. The current problem with large screen display is resolution and size. The objective large screen display would be a flat screen that you could hang on the wall and be sharp enough to read the display of topographic maps. Imagine being able to broadcast intelligence quality maps to maneuver size elements real-time. A step in that direction is high definition television (HDTV) or its equivalent.

HDTV produces pictures as crisp and clear as 35 millimeter slides in approximately the same format or aspect relationship (16:9).[54] Another promising technology is electroluminescent panel displays which operates at a much lower power setting than more common displays. It produces.... 884,736 individually addressable pixels on a display, the equivalent of a 19-inch diagonal cathode ray tube work station monitor.[55] The amount of interest in high definition displays by the research and development community will provide many alternatives before a military standard is selected.

On the opposite end of the scale are small screen displays or tactical helmet mounted displays. Small 2" by 2" screens with a resolution of 400 x 200 pixels are commercially available. A resolution of 1024 x 1024 pixels on a 1/2" by 1/2" surface is

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[54]Lindsey, Lonnie. "High Definiton Television: A Primer." SIGNAL, (August 1989): 73.

[55]Robinson, Clarence A. "Army's display Technology Emerging to Eclipse HDTV." SIGNAL (August 1990): 26.

feasible in the next decade.[56] A helmet mounted display (HMD) has several advantages over traditional displays. The most obvious is the freedom of movement of the user while retaining access to information. While the applications are many, consideration for the communications requirements may curtail its growth to every soldier.

The military will continue to fund imaging technology research and development. Imaging applications will continue to be found in the commercial sector which supports a growing consumer market. The quest for "high tech" solutions to economic and military problems will continue.

[56]Schoening, James. "Tactical Helmet-Mounted Displays and Pocke Computer Systems for the Future Battlefield A Systems Concept Paper." Advanced Systems Concepts Office U.S. Army CECOM. (2 March 1989): 12.

CHAPTER V

Conclusions and Recommendations

Communications and imaging technology is revolutionizing command and control of the future battlefield. This continued technological change can be viewed as occurring at two rates. Communications has accelerated rapidly in the last two decades and its technological changes are readily accepted. Industry and the military see an inherent value in these advances and quickly implement them. Imaging, in the context of this thesis, on the other hand is not as common place and will meet a resistance until its advantage is realized. Imaging technology requires a higher user confidence level before it is a full partner with communications.

Communications technology is tremendously effecting how the United States Army commands and controls its forces. The planned future command and control architectures and communications systems are designed to support the Airland Battle. The command and control of forces, by the ATCCS architecture will fulfill the tenets of Airland Battle.

The communications support of Airland Battle Future is not as clear. With ATCCS there is a great reliance on line-of-sight systems provided by MSE. Airland Battle Future may result in the deployment of forces that are more widely dispersed and therefore not within sight of one another. If this is the case, the stretching of communications line-of-sight backbone systems designed for Airland Battle will be problematic when supporting Airland Battle Future. Airland Battle Future will have a higher reliance on space based satellites or endurance UAVs used for communications.

Command and control under the planned open systems architectures is more efficient for lateral and vertical communications. As a result, the increased communications capability will cause a problem for some commanders due to the human factor. The by-passing of your headquarters to a higher level headquarters in order to get what your immediate commander wants is a time honored tradition. This method is tempered by commanders when they allow only certain personnel, usually primary staff officers, to release messages or talk for the overall command. It was enforced by the communications personnel as they will only send messages that are properly formatted and signed. With access to a global network, available anywhere on the battlefield, new and more stringent procedures will be enacted by commanders to control their communications.

Imaging is revolutionizing the battlefield. This was poignantly demonstrated in the Iraq war by the high tech images televised to the globe. Imaging was crucial in the battle damage assessment of Iraqian targets. Visible light video imaging was used for target identification and fire correction by United States Naval battleships off the coast of Kuwait. They launched and recovered UAVs that relayed video images back to fire direction control centers for the fire correction of their sixteen inch main guns. I believe that if United States did not have had air-superiority the use of UAVs would have been more extensive.

ATCCS and specifically MSE, does not provide the broadband communications required for current real-time imaging or video technology down to brigade and lower tactical units. While special demonstrations show its utility, the larger architecture simply was not build to support imaging. A leap in the level of imaging transfer and communications transmission is required to obtain its widespread use over the ATCCS system.

The end state that we need to strive for in imaging and communications is the ability to transmit, receive, and manipulate, full motion video across Mobile Subscriber Equipment. The accomplishment of this technical feat will allow for many of the applications discussed in this thesis to be implemented. The only acceptable and suitable way of reaching this end state is through the development of faster imaging processors. These faster processors must bring full motion video transmission requirements down below 16 Kb/s. Once the 16 Kb/s barrier is broken imaging will be supportable across a wide spectrum of MSE users. The capability to process high volumes of information and images are absolutely critical in the support of Airland Battle Future.

Significance of Study

Though there are many advocates of the different subjects covered in this thesis (communications, imaging, and command and control) their advocacy lacks a central component. That is, the affiliation of the parts on the whole. In researching these topics, only one source considered the use of communications and imaging on command and control, this was the Future Battle Laboratory. They are focused by necessity on the technical aspects of communications and imaging as compared to its doctrinal effect.

The United States Army has transitioned its procurement process to a concept based system. For example, in the past, procurement was technology driven. When a new device was invented, the United States Army would devise a way to use it and later develop its doctrine. With technology increasing, at a rapid rate, the United States Army could not keep pace. It was necessary to set a goal toward which everyone would head. A concept based procurement system develops doctrine first and then considers a technology to achieve a specific goal. Technology will in some cases cause conceptual changes but the conceptual method of integrating technology is the most cost efficient in the long term. This study attempts to link communications and imaging and its future significance under the new doctrine of Airland Battle Future.

Suggestions for Further Research

The application of state of the art technology to vast an complex military systems is a slow and deliberate process. With the innumerable checks and balances strewn into politics, the acquisition of expensive systems takes time and research. Small projects are able to bypass the systems myriad of obstacles to deliver near state-of-art systems through rapid prototyping. (The following projects merit further research):

1. Though previews studies have focused on communications, imaging, or UAVs there are few that focus on their combination use in doctrinal command and control. Airland Battle Future will require the doctrinal employment of sensors in the detection area. The use of these sensors and the study of doctrinal employment of a imaging command and control fusion center at operational and tactical levels, is needed.

2. A low cost, day/night video, endurance stealth UAV is technically possible. A technical solution to allow for its

information to be processed at a imaging command and control fusion center, such as the one at the Future Battle Laboratory, can demonstrate imaging technology and its applications to commanders.

3. In order to reach the level of imaging required to be useful tactically, a increase in the processing speed that allows for the transmission of full motion video over MSE must be achieved. Research and development organizations, such as DARPA, have the capability to make such technological gains possible.

Summary

The objective Airland Battle Future doctrine, when reached in fifteen years, must have the capability to communicate with dispersed forces. The tactical computers at these locations have access to hugh databases. They communicate by wireless LANs and WANs anywhere in the world. They do so by putting an interactive video in a window on their display while other information runs in the background in another window. If they need to visualize the battlefield they do so by stored digetized three dimensional maps or a real-time images from a UAV. They receive their orders from the commander who looks them straight in the eye, even though he is one hundred miles away at the other end of the camera. This is the way the commander will "see the battlefield".

APPENDIX A

Information Content of the Commander's Situation Report[57]

[57]U.S. Army, Force Level Control System Requirnments working papers, unpublished (fort Leavenworth, KS: CAC CD, 1990).

Control measures

- Unit boundaries
  - Enemy unit boundary
  - Friendly unit boundary
- Phase lines
- Forward line of own troops
- Axes of advance
- Damage avoidance criteria

Friendly unit status

- Identification
- Location
- Overall operational status
- Command Posts
  - Identification
  - Location
  - Operational status
- Personnel status

Enemy unit status

- Enemy organization information

Enemy location

Enemy operational status

Overlays

Fire support

Field artillery units status

Location

Operational status

Personnel status

Fire support plan

Targets with specified area

Priority targets

Final protective fires

Air defense

Air defense units status

Location

Operational status

Personnel status

Air defense weapons system coverage

Air defense weapons system and ammunition status

Aviation

Aviation units status

- Location
- Operational status
- Personnel status

Friendly/enemy helicopter attack route

Friendly/enemy fast mover attack route

Re-arm/re-fuel points activity and status

- Engineer

Engineer units status

- Location
- Operational status
- Personnel status

Obstacle/barrier plan

Critical obstacles/barriers

Point targets/area targets

Targets emplaced

Targets executed

Targets prepared

Targets turned over

Targets breached

NBC

- NBC units status
  - Location
  - Operational status
  - Personnel status
- Contaminated areas
  - Damage avoidance location
  - Damage category
  - Hazard area
  - Nuclear contamination lines
- Vulnerability assessment
- Decontamination sites status, location
- Possible decontamination site status, location
- Fallout predictions
  - Minimum safe distance data
  - Surface burst data
  - Contaminated area data

Army airspace command and control

- High density airspace control zone
  - Location

Altitude limits

Coordinating altitude

Restricted operations area

Minimum risk routes

Standard use Army aircraft flight route

Combat Service Support

Main supply route condition and status

Ammunition supply points locations and status

Ammunition transfer points location and status

Maintenance collection points locations and status

Clothing exchange/bath points locations and status

Graves registration points locations and status

Water points locations and status

Medical facilities locations and status

Class III supply point locations and status

Signal

Signal units status

Location

Operational status

Personnel status

Intelligence

Intelligence units status

Location

Operational status

Personnel status

Intelligence Summary: covers enemy air, maritime, and ground situations; weather and terrain; enemy vulnerabilities, capabilities, and probable courses of action.

Intelligence Appraisal Worksheet: a matrix used to document friendly and enemy predicted activities by avenue of approach. For each numbered avenue of approach, the worksheet will present:

Overall status of avenue of approach

Enemy status

Enemy organization information

Enemy operational status and location

Enemy activity

Friendly status

Friendly units identification

Friendly units operational status and location

Friendly unit activity

Estimated force ratio

Intelligence Appraisal Map: the same map as the situation map with the same content, but gives the projected situation.

Friendly Resources Detail: a matrix depicting , by parent and subordinate units, the specific items within a category of class of supply that are being tracked by the commander.

Class I (rations) status

Class III (petroleum, oil, lubricants)

Status (authorized versus on-hand)

Supply rate

Class V (ammunition)

Status

Available/controlled supply rate

Class IX (repair parts and components) status

Communications terminal status

Command and control information system status

Weapons/weapon system status

FAAD system status

Water status

Weapon systems status (authorized versus on-hand)

Engineer system status

Chemical equipment status (authorized versus on-hand)

Maintenance system status

Support system status

Radar systems status (authorized versus on-hand)

Aviation systems status (authorized versus on-hand)

Intelligence collection systems status

Friendly Resources Summary: a graphic that tracks up to six command specified resources and five other resource categories in a unit. Records resource status quantitatively and with color coding.

Status of top six command specified pacing item resources (on-hand versus operational)

Personnel status

Status of top six command specified support systems

Status of top six command specified ammunition types

Status of top six command specified oil/lubricants

Status of top six command specified ration types

Command, control, and communications systems status

Status of top five command specified other resource categories

Other information

Commander's subjective evaluation of unit combat effectiveness

Unit radiation status

Operational exposure guidance

Mission oriented protective posture

Unit mission

Unit task organization

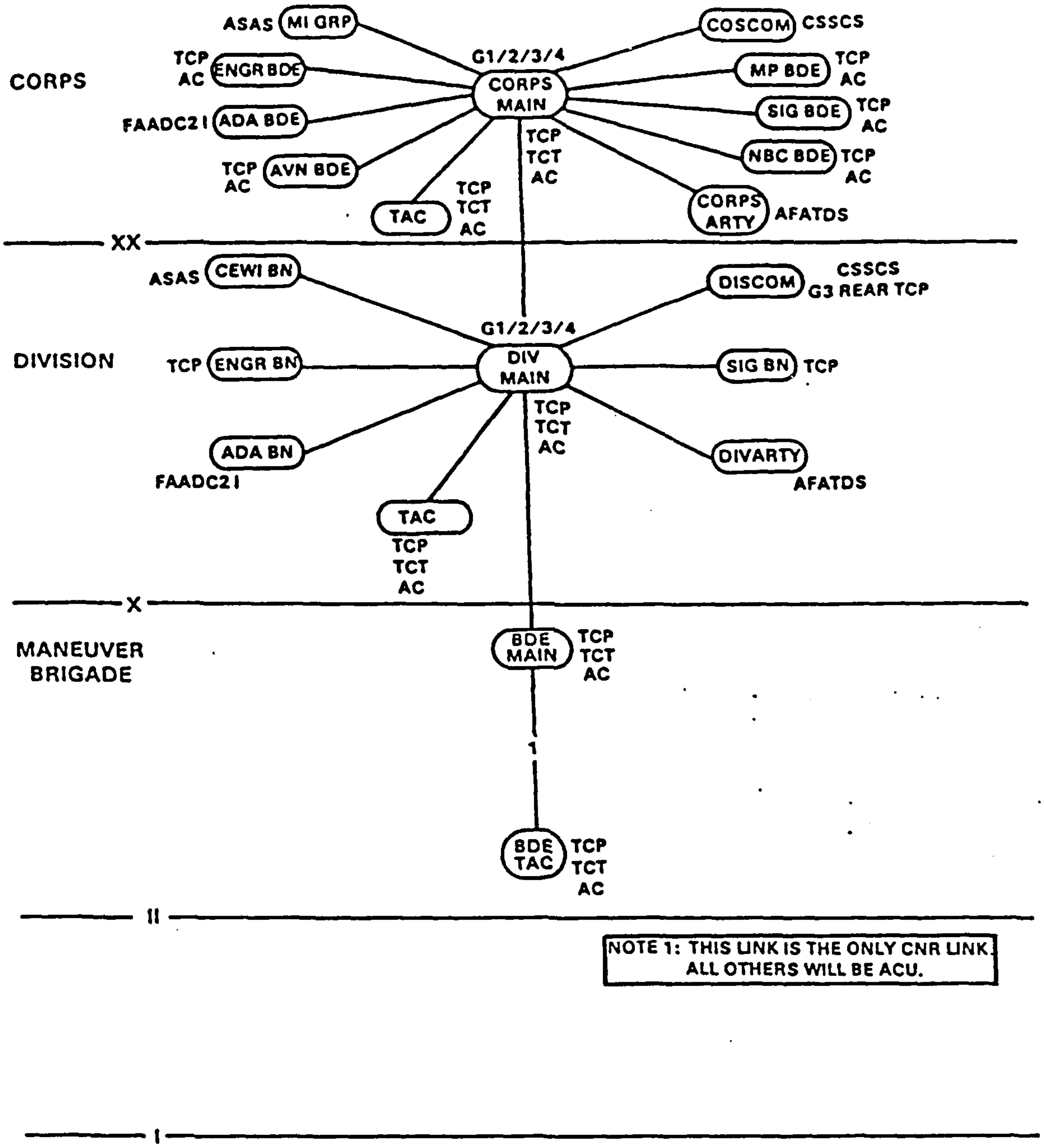
Main, tactical, and rear command post locations

Main command post helipad locations

APPENDIX B

AUTOMATED BATTLEFIELD SYSTEMS[58]

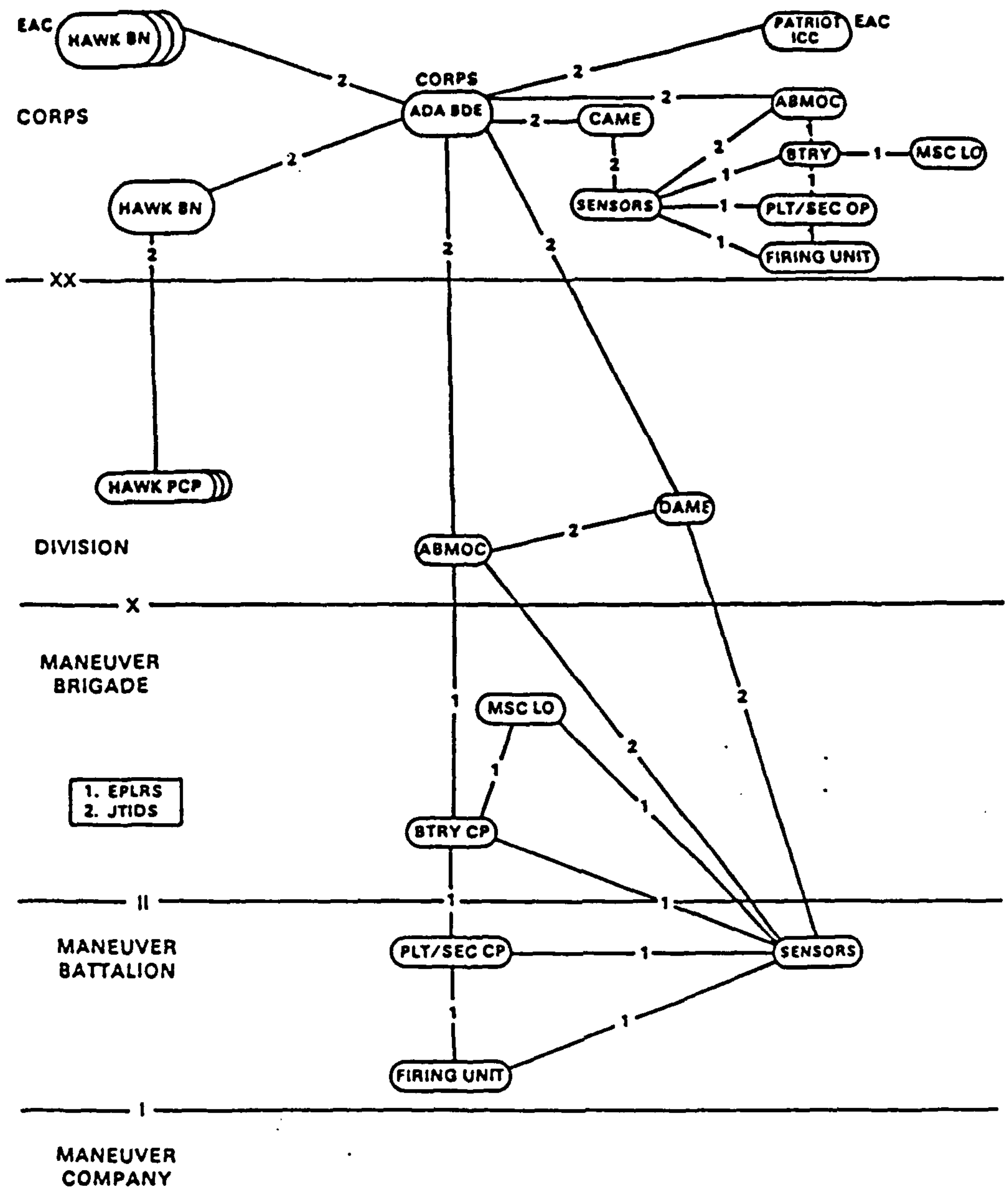
[58]U.S. Army, Doctrine and Tactics Training Pamphlet Corps and Divison Commanders' Handbook: Mobile Subscriber Equipment, (Fort Leavenworth, KS: undated).



LEGEND:

AC	-	Analyst Console
ACU	-	Area Common User
AFATDS	-	Advanced Field Artillery Tactical Data System
ASAS	-	All Source Analysis System
CSSCS	-	Combat Service Support Control System
FAADC2I	-	Forward Area Air Defense Command, Control, and Intelligence
TCP	-	Tactical Computer Processor
TCT	-	Tactical Computer Terminal

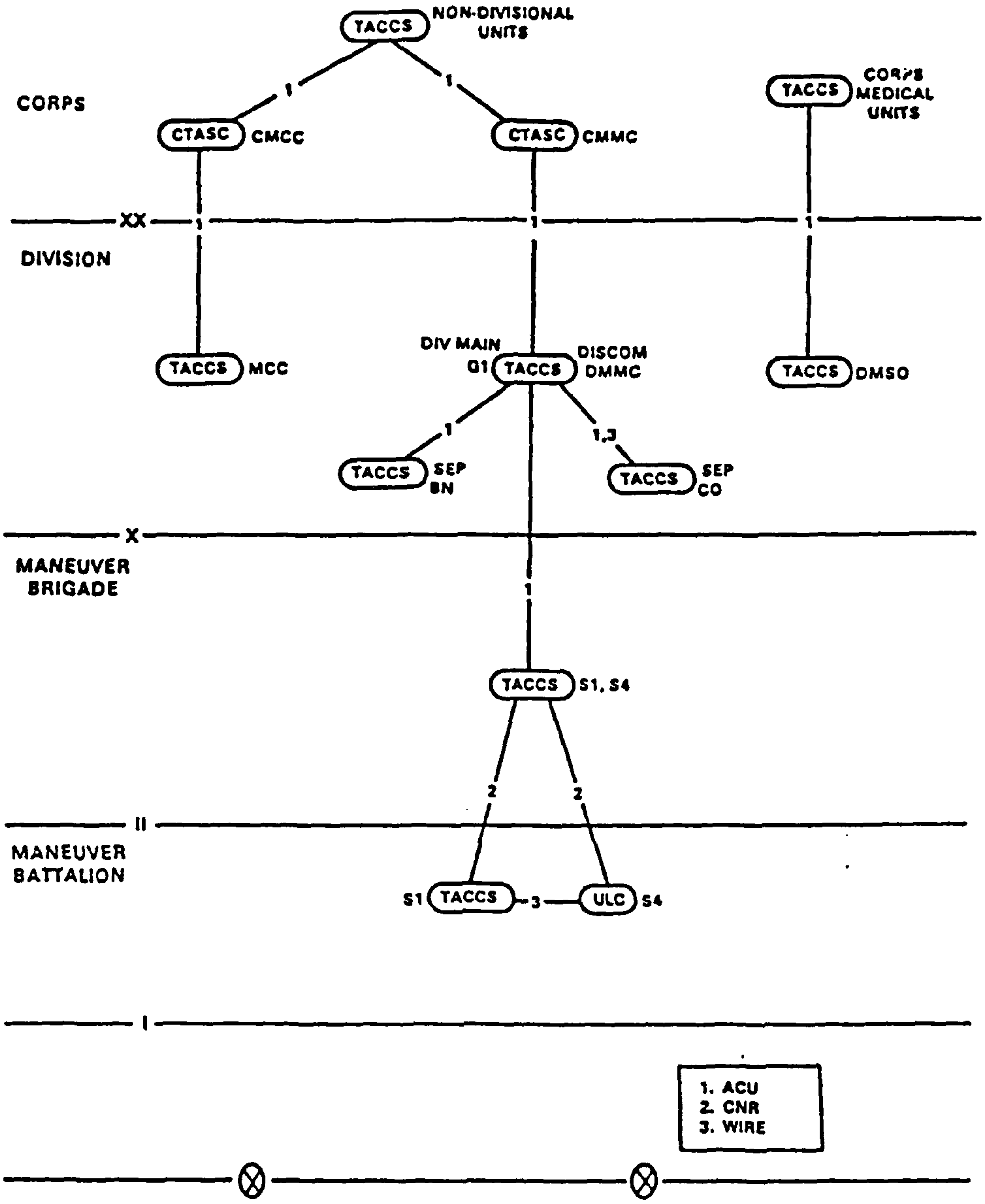
Objective maneuver control systems.



LEGEND:

CAME	-	Corps Airspace Management Element
DAME	-	Division Airspace Management Element
ICC	-	Information Control Central
MSC LO	-	Major Subordinate Command Liaison
PCP	-	Platoon Command Post

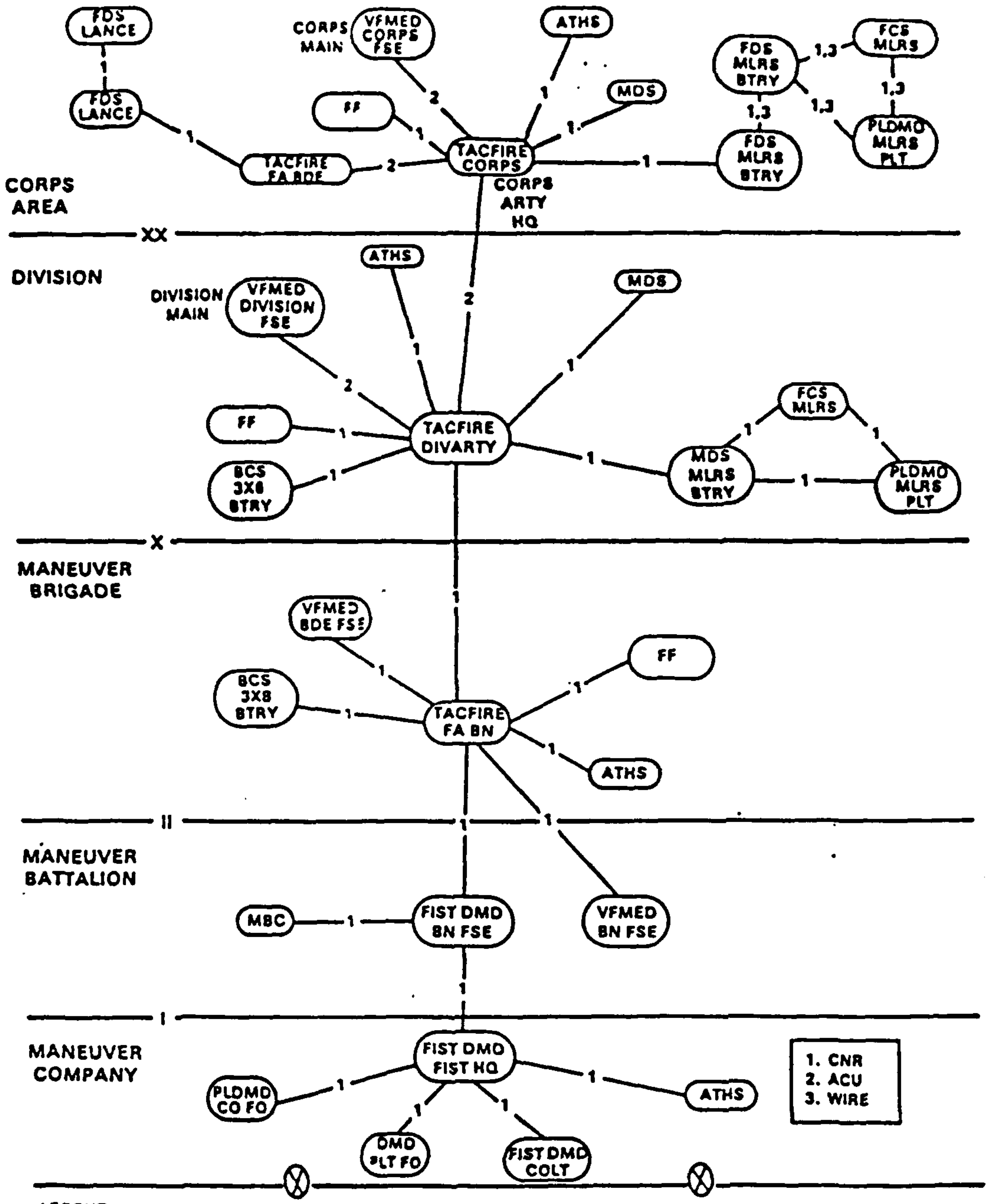
Objective ADA systems.



LEGEND:

CTASC	-	Corps-Theater ADP Service Center
DMSO	-	Division Medical Service Officer
MCC	-	Movement Control Center
MMC	-	Materiel Management Center
TACCS	-	Tactical Army CSS Computer System
ULC	-	Unit Level Computer

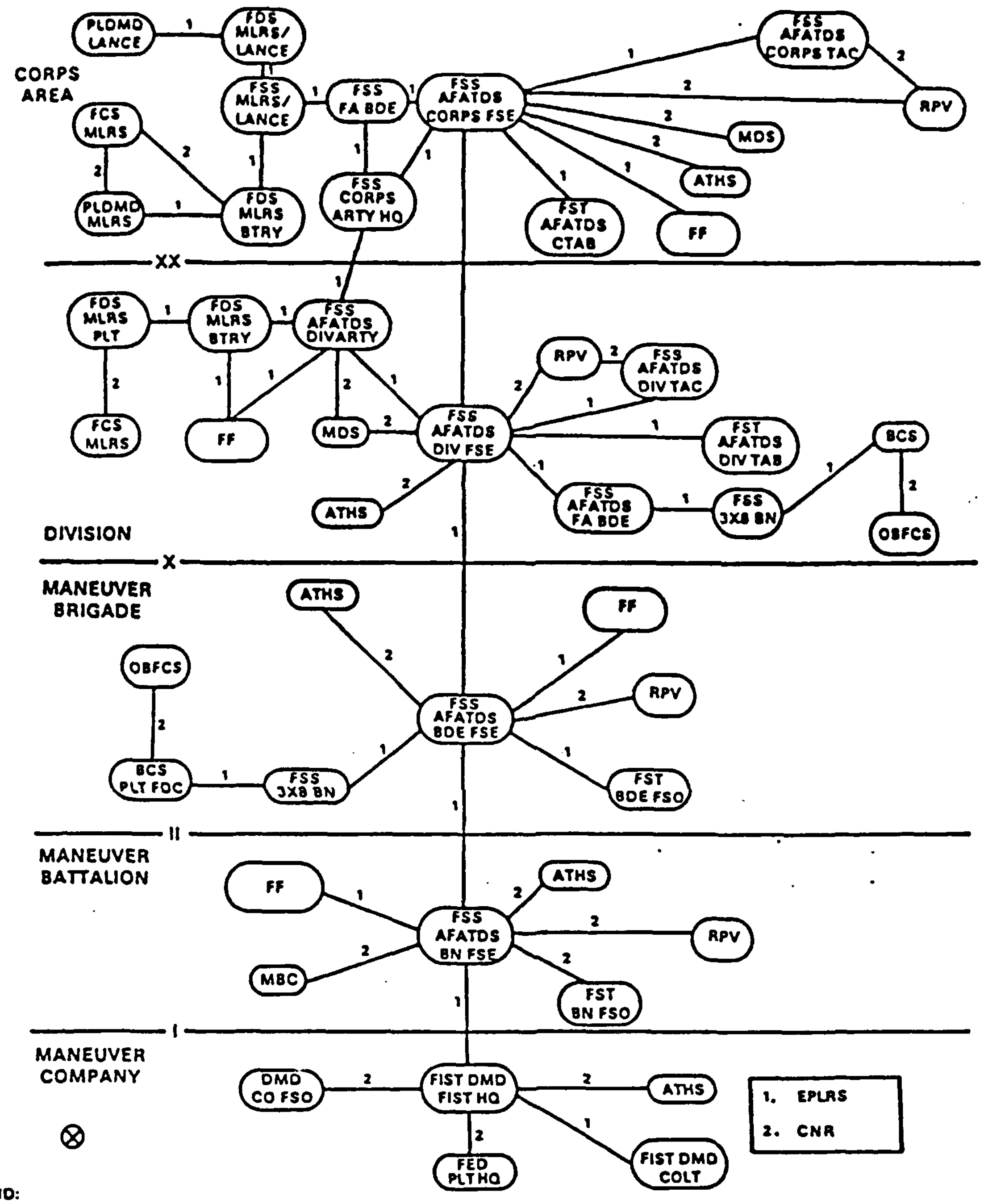
Objective combat device support systems.



LEGEND:

ATHS	-	Airborne Target Handoff System
DMD	-	Digital Message Device
FCS	-	Fire Control System
FDS	-	Fire Direction System
FF	-	Fire Finder
FIST DMD	-	Fire Support Team Digital Message Device
MBC	-	Mortar Ballistic Computer
MDS	-	Meteorological Data System
MLRS	-	Multiple Launch Rocket System
PLDMD	-	Platoon Leader's Digital Message Device
VFMED	-	Variable Format Message Entry Device

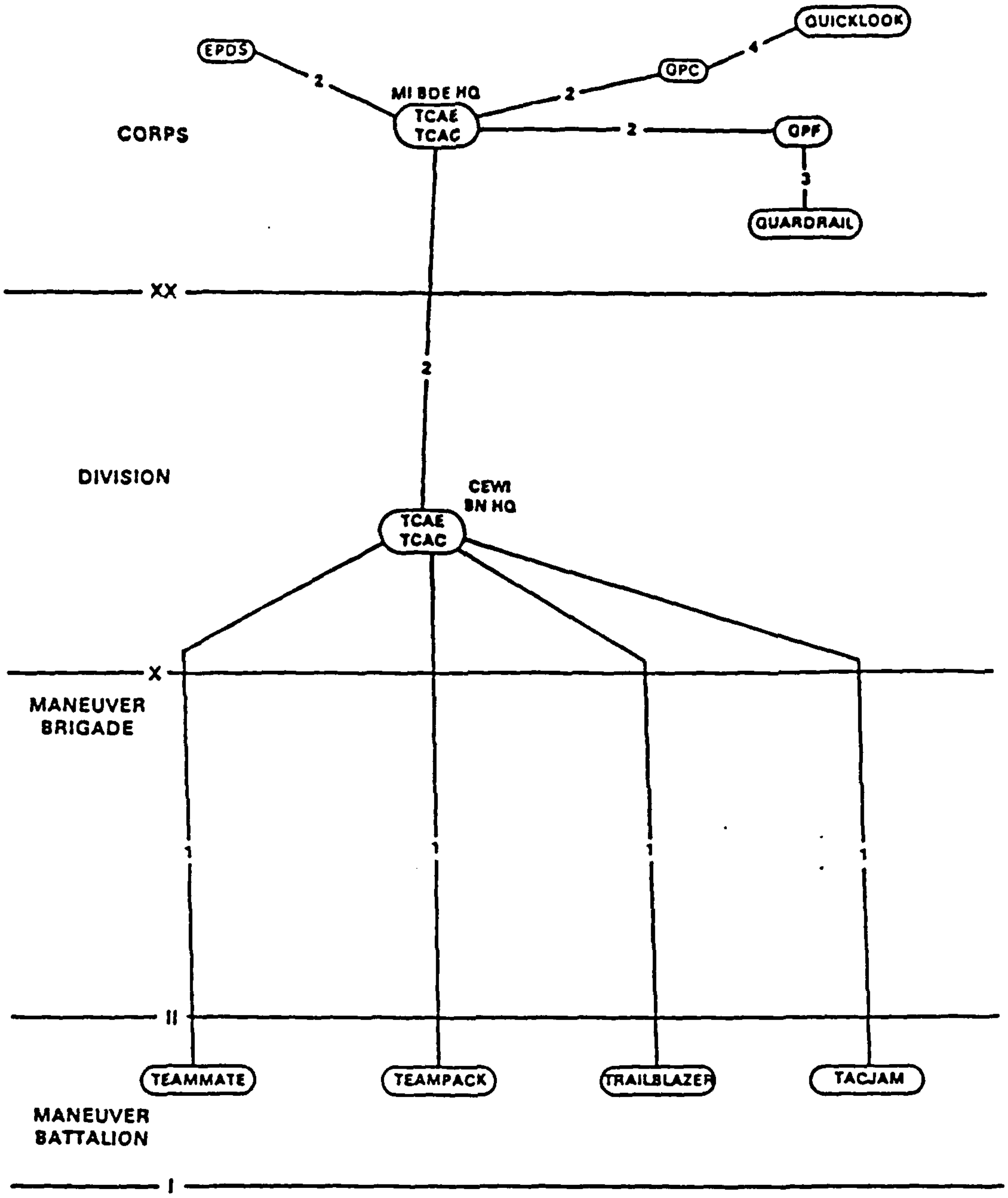
Current FS systems.



LEGEND:

AFATDS	-	Advanced Field Artillery Tactical Data System
ATHS	-	Airborne Target Handoff System
BDE FSO	-	Brigade Fire Support Officer
FCS	-	Fire Control System
FDS	-	Fire Direction System
FF	-	Fire Finder
FIST DMD	-	Fire Support Team Digital Message Device
FSS	-	Fire Support System
FST	-	Fire Support Terminal
MBC	-	Mortar Ballistic Computer
MDS	-	Meteorological Data System
MLRS	-	Multiple Launch Rocket System
OBFCS	-	On Board Fire Control System
PLDMD	-	Platoon Leader's Digital Message Device
RPV	-	Remotely Piloted Vehicle
TAB	-	Target Acquisition Battery

Objective FS systems.

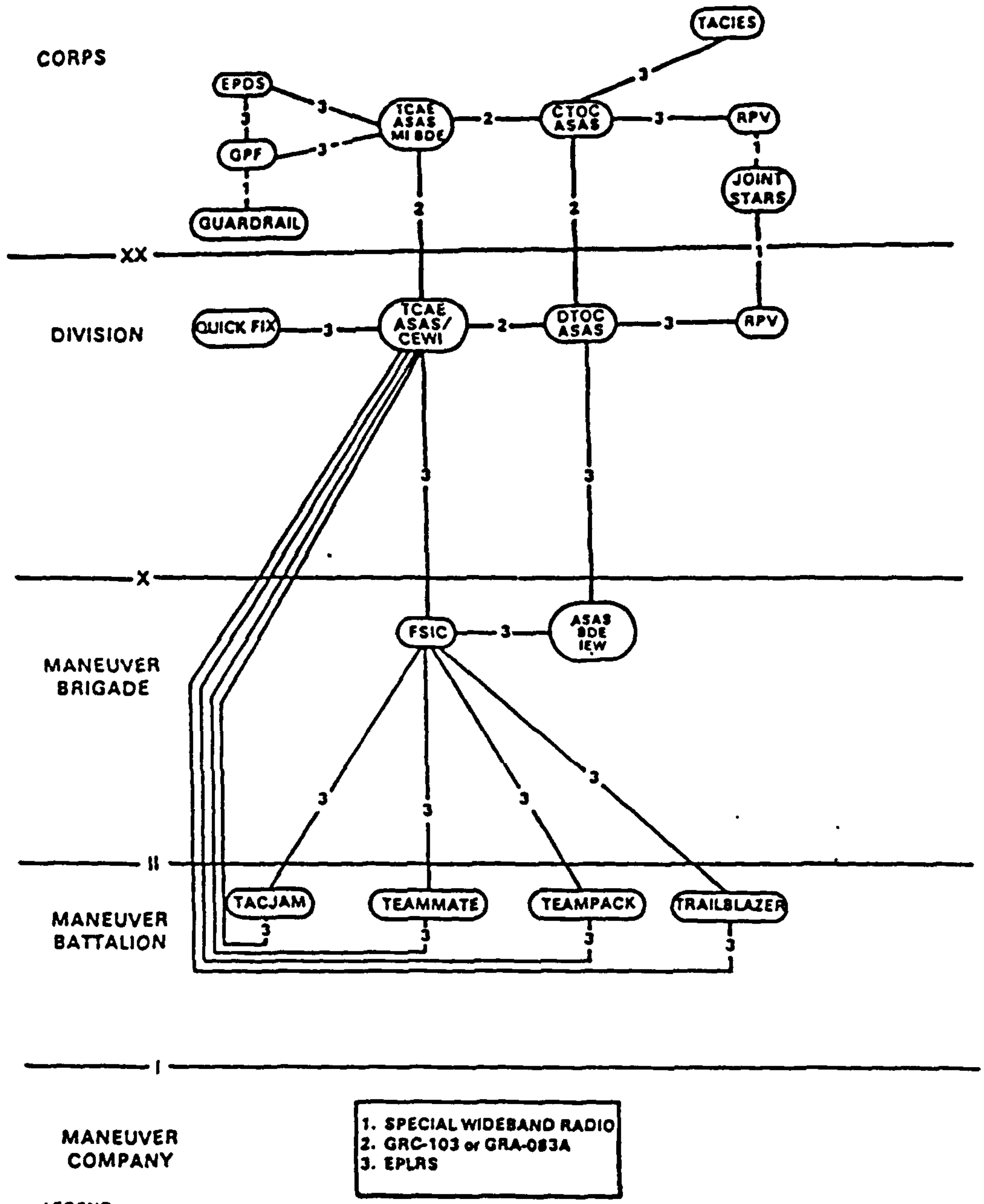


1. CNR
2. ACU
3. SPECIAL WIDEBAND RADIO
4. ARC-164

LEGEND:

EPDS	-	Electronic Processing and Dissemination System
GPC	-	Ground Processing Center
GPF	-	Ground Processing Facility
TCAC	-	Technical Control and Analysis Center
TCAE	-	Technical Control and Analysis Element

Current IEW systems.



LEGEND:

ASAS	-	All Source Analysis System
EPDS	-	Electronic Processing and Dissemination System
FSIC	-	Forward Sensor Interface and Control
GPF	-	Ground Processing Facility
RPV	-	Remotely Piloted Vehicle
RWS	-	Remote Workstation
TACIES	-	Tactical Imagery Exploitation System
TCAE	-	Technical Control and Analysis Element

Objective IEW systems.

DEFFINITION OF TERMS

AFATDS (Advanced Field Artillery Tactical Data System) will be the Fire Support Functional control system used from corps through platoon. The AFATDS will furnish automated support to Fire Support commanders, their staffs, and other personnel through the fire support and the field artillery chain of command. The AFATDS will support decision making related to fire support execution, fire support planning, movement control, field artillery mission support,and field artillery fire direction.

ASAS (All-Source Analysis System) will be the Intelligence/Electronic Warfare functional control system employed at corps and division. The ASAS will furnish automated support to the Intelligence/Electronic Warfare commander, his staff, and the force commander's intelligence staff officer. The ASAS will support these users in developing collection missions, preforming intelligence collection management and analysis, controlling communications jammers, processing intelligence, disseminating intelligence, and analyzing and forecasting weather.

ATCCS (Army Tactical Command and Control System). This system is composed of all facilities, equipment, communications, procedures, and personnel essential to commanders at corps and below for planning, directing, and controlling operations of assigned forces. Each ATCCS automated component system must function as an integral part of the total system, which will process and display essential information to the commanders, and staff within the five battlefield functional areas of Maneuver, Air Defense, Combat Service Support, Fire Support, and Intelligence/Electronic Warfare. These component systems will facilitate the flow of information among commanders and staff of different functional areas and support interfaces to facilities external to the Army's tactical forces.

BAS (Battlefield Automation Systems) these systems are used on the battlefield at corps, division, and brigade levels to collect, process, and distribute the information required by commanders and staffs. These system include but are not limited to ASAS, AFATDS, and MCS.

BATTLE AREA A tactical subdivision of an area of operation where the commander intends to employ all combat means under his command or control to annihilate the opposing force.

CSSCS (Combat Service Support Control System) will be the Combat Service Support functional control system at corps, division, and brigade. The CSSCS will furnish automated support to the Combat Service Support commander and his staff, and to the force commander's personnel staff officer and logistics staff officer. The CSSCS will exchange, summarize, process, and display summary resource management information drawn from the Combat Service Support automated subordinate systems, which are among the

Standard Army Management Information Systems.

COMMAND CRITICAL INFORMATION is the information supporting the force concept of operation. While the information critical to each command will generally be of the same types, the facts represented by the information will be unique to that command.

DATA COMPRESSION reduces the number of bits needed to encode information, often resulting in a corresponding reduction in the bandwidth needed to transmit that information. One method replaces a string of repeated characters by a character count. Another method uses fewer bits to represent the characters that occur more frequently.

DEFENSE DATA NETWORK is a worldwide packet-switching network operated by the U.S. Department of Defense which will provide a capability for tactical echelons to interconnect with echelons above corps. Currently, the DDN supports three interface classes (X.25 basic, X.25 standard, and Advance Research Projects Agency Network (ARPANET) 1822DH) for host connection. Systems connected to the DDN can communicate to other subnetworks (MILNET, ARPANET, local area networks) from the one to which they are commonly attached, if they use the DOD Transmission Control Protocol/Internet Protocol (TCP/IP). The DDN supports the DOD standard electronic mail, file transfer, and virtual connection protocol and will transition to the evolving ISO standards.

DETECTION AREA A defined area which includes the area of operation but varies in size and shape based on regional, operational, and echelon considerations, in which the commander develops intelligence about all future enemy activities which might affect the friendly force throughout the duration of the current or future operations.

FAADC2I (Forward Area Air Defense Command, Control, and Intelligence System) will be the Air Defense functional control system at division and brigade. The FAADC2I system will furnish automated support to the Air Defense Commander and his staff. It will support Air Defense alerting of FAADC2I subsystems, cuing of the forward area air defense weapons, Air Defense track acquisition and dissemination, identification of aircraft, distribution of weapon control orders, and air battle management messages.

FLCS Force Level Control System will support the exchange and use of force level control information among the battlefield functional area commanders and staff at an echelon. The Force Level Control System will be a software suite consisting of the applications that support the following functions:

1. The exchange of force level control information among the functional control systems at an echelon.

2. The storage and maintenance of command critical and commander's situation report information in the force level control data base.

3. The processing, formatting, and presentation of the commander's situation report information using common displays.

The Army will implement the Force Level Control System at corps, division, brigade, armored cavalry regiment, separate brigade, and battalion. The Force Level Control System will appear as software host on the same computing devices that will host the MCS, FAADC2I, CSSCS, AFATDS, and ASAS.

FORCE LEVEL INFORMATION EXCHANGE is the information developed within one battlefield functional area and is used either to generate and support the force commander's concept of operation or to serve as input to decisionmaking of another functional area.

IMAGING an optically formed duplicate, counterpart, or other representative reproduction of an object; especially, an optical reproduction of an object formed by a lens or mirror.

LARGE EXTENSION NODE (LEN) provides wired communications for personnel stationed at a large, fixed command post. A LEN allows wired subscribers to communicate freely via a Large Extension Node Switch (LES) with automatic flood search routing. Subscribers have access to NCs and the rest of MCS via LOS radios, which are cabled to the LEN.

LINE-OF-SIGHT RADIO (LOS) as related to MSE they are radio links that connect all NCs together tn a grid network that provides automatic switched services to all wire and mobile subscribers. They must have direct line of sight of one another to communicate.

Generally this is up to twenty-three miles without obstructions between there LOS path.

MANEUVER a principle of war, which is the movement of forces in relation to the enemy to secure or retain positional advantage. It is the dynamic element of combat, the means of concentrating forces at the critical point to achieve the surprise, psychological shock, physical momentum, and moral dominance which enable smaller forces to defeat larger ones.

MCS (Maneuver Control System) is the Maneuver functional control system. The MCS will furnish automated support from corps through battalion/squadron to the force commander and his staff, and to commanders of maneuver mission areas and their staffs. The MCS will collect, correlate, filter, process, extract, store, format, and display current enemy, friendly, and common situation information. These displays will take the form of battlefield maps and decision graphics.

MSE (Mobile Subscriber Equipment) is the area common-user voice communications system in the corps. It is the backbone of the corps communications system and provides voice and limited data communications from the corps rear boundary forward to the division maneuver battalions' main CP. MSE provides the user with a switched communications system.

NODE CENTER (NC) are the heart of MSE they provide the key switching and traffic control points. Linked by LOS radios, NCs are tandem switches and access points that handle all switching and flood search routing services to ensure optimum communications throughout the entire deployed area. If one NC is disabled, the network will automatically route all communications through another.

NONLINEAR BATTLEFIELD A battlefield upon which the commander, either by choice of the lack of maneuver forces to cover all the terrain, has placed his forces in dispersed, noncontiguous areas from which he can operate to destroy enemy forces with his area of operations. Emphasis is on destruction of the enemy force rather than terrain retention.

NONLINEAR OPERATIONS Operations in which forces are dispersed and not locked into a line of contact with the enemy so that they are able to move and mass combat power quickly; fight a violent short battles to destroy the enemy; and then disperse to fight again. Applies at all levels of organization.

SMALL EXTENSION NODE (SEN) supports small command posts with wired telephone service via a Small Extension Node Switch that provides local switching and routing. SENs access the network, MSE, by connecting to NCs with LOS radios.

SIMPLICITY this principle of war requires the strategic, operational, and tactical dimension, guidance, plans, and orders, should be as simple and direct as the attainment of the objective will allow. Political and military objectives and operations must therefore be presented in clear, concise, understandable terms.

SYNCHRONIZATION is the arrangement of battlefield activates in time, space, and purpose to produce maximum relative combat power at the decisive point. Synchronization is both a process and a result. Commanders synchronize activities; they thereby produce synchronized operations.

TACTICAL SUPPORT AREA A tactical subdivision of an area of operation where the commander intends to protect the force, preserve his freedom of action and continuity of operations, and assure uninterrupted support of the battle area and regeneration of combat power.

TRADOC (U.S. Army Training and Doctrine Command) the Fort Monroe based Command that is responsible for U.S. Army training and the implementation of doctrine. This command also is the U.S. Army's combat developer.

UNITY OF COMMAND this principle of war ensures that all efforts are focused on a common goal. Coordination may be achieved by cooperation; it is, however, best achieved by vesting a single commander with the requisite authority to direct and to coordinate all forces employed in pursuit of a common goal.

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