IMPROVING TACTICAL MANEUVER WITH DIGITAL SITUATIONAL AWARENESS

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MASTER OF MILITARY ART AND SCIENCE

by

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This study investigates the use of digital situational awareness to improve tactical maneuver functions of armored and mechanized company teams. The concept presented concludes that all maneuver functions realize a potential for improved execution by enhancing the operators ability to perceive, comprehend and predict future states of his environment by employing advanced command and control systems to create digital situational awareness. The Army is expending significant effort toward making qualitative improvements to the lethality, tempo and survivability of warfighting organizations as it develops the force for the 21st century. Central to this effort is an initiative to digitize the battlefield by applying advanced information technologies to the battle command systems of the combined arms team. This study explains how and why tactical maneuver is improved by digital situational awareness. This study examines current tactics, techniques and procedures (TTP), findings from Army Advanced Warfighting Experiments (AWE) and Situational Awareness Theory from Human Factors psychology to determine the nature of performance improvement. For the Army to realize the enhancements it is seeking, it must fully understand the effects that digital systems have upon small units executing tactical maneuver.

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ABSTRACT

IMPROVING TACTICAL MANEUVER WITH DIGITAL SITUATIONAL AWARENESS, by MAJ Arthur S. DeGroat, USA, 77 pages.

This study investigates the use of digital situational awareness to improve tactical maneuver functions of armored and mechanized company teams. The concept presented concludes that all maneuver functions realize a potential for improved execution by enhancing the operators ability to perceive, comprehend and predict future states of his environment by employing advanced command and control systems to create digital situational awareness.

The Army is expending significant effort toward making qualitative improvements to the lethality, tempo and survivability of warfighting organizations as it develops the force for the 21st century. Central to this effort is an initiative to digitize the battlefield by applying advanced information technologies to the battle command systems of the combined arms team.

This study explains how and why tactical maneuver is improved by digital situational awareness. This study examines current tactics, techniques and procedures (TTP), findings from Army Advanced Warfighting Experiments (AWE) and Situational Awareness Theory from Human Factors psychology to determine the nature of performance improvement. For the Army to realize the enhancements it is seeking, it must fully understand the effects that digital systems have upon small units executing tactical maneuver.

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First, I wish to acknowledge my mentor, MG (R) Lon E. Maggart, former Chief of Armor and Cavalry, for instilling in me the passion, wisdom and commitment to work towards preparing for the future of mounted combat. His efforts to accelerate the transformation of our Force to Army XXI serve as a guiding light for those whom will follow along the path he has helped set.

Secondly, I wish to thank SFC John T. Broom, Ph.D. for his efforts as a member of my research committee. He has singularly provided me the greatest support in this effort and by his example, serves to remind me of the awesome power of a soldier's intellect.

Next, I wish to acknowledge the men and women of the combined arms team whom deserve nothing but the best warfighting capability our Nation can provide. It is from their sacrifices that I draw energy for making the Army of the future better than it is today.

I remain solely responsible for any errors or faults in this thesis.

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CHAPTER 1

> The United States will be the first nation to pass through the Information Revolution, emerging with different strengths that can give us an edge across the entire spectrum of contingencies against which the nation may need to commit its military.[1]
>
> Admiral William A. Owens, USN

Introduction

The United States Army is going to extensive efforts to improve the way tactical units will fight in the twenty-first century. Since 1989, the U.S. Army has been pursuing an effort to "reconceptualize and redesign the force at all echelons, from foxhole to the military industrial base, to meet the needs of a volatile and ever changing world."[2] This process of transforming the U.S. Army is known as Force XXI. The Force XXI process seeks to conceptualize, develop, experiment and field new warfighting technologies, organizational designs, and doctrine to insure that the U.S. Army remains the world's dominant land force in the future. Central to this effort is the concept of *digitization of the battlefield.*

Digitization of the Battlefield

"Digitizing the battlefield" is the central initiative of this tremendous undertaking. The Army is currently inserting advanced information technologies (digital) into combined arms units in order to enhance their lethality, tempo, and survivability for future operations. Recent experimentation and operational tests indicate that digital command and control systems provide tactical commanders with unprecedented amounts of information needed for planning and executing tactical maneuver. To date, combat information, when distributed over digital data networks and when graphically presented in multimedia formats, has (1) enhanced the commander's awareness of the tactical situational, (2) created a shared or common view of the battlefield with other members of his unit, and (3) assisted commanders in the task of visualizing future states and actions. The Army refers to the product of this new capability as *digital situational awareness*.

The capability to provide digital situational awareness to American soldiers is fully endorsed by the Army's senior leaders due to its potential for enhancing battlefield performance. General William Hartzog, the Training and Doctrine Command Commander, stated that "Digitization and situational awareness are the heart of future warfighting."[3] In response to a Command and General Staff College student's question regarding Army modernization funding, General Dennis J. Reimer, Army Chief of Staff stated that, "The potential of digitization is so great that we (the Army) must stay the course."[4] While the Army's commitment to this concept is firmly established, not all is known about its potential effect upon tactical maneuver operations.

Digital Situation Awareness

Digital situation awareness is as monumental a change in commanding and controlling maneuver operations as was the development of the wireless radio. While the Army considers this capability as an evolutionary step in battlefield technological development, the potential effects of this new capability may be revolutionary if applied effectively. Digital situation awareness, in the current military application, is the capability to automatically share friendly and enemy position locations, terrain data, targeting information, and logistics status over digital communications networks or *tactical internets.* Data burst transmission of graphical overlays, dynamic situation displays, and automatic combat reporting may provide tactical leaders and soldiers with more essential information needed to perform many critical maneuver functions faster than ever possible with current analog (voice-only radio) systems. The challenge the Army currently faces is determining how to best apply this new informational capability to derive a maneuver advantage over potential future adversaries.

Emphasis on Maneuver

The Army has been seeking to insure maneuver dominance for the past two decades. The Army's capstone warfighting doctrine of Field Manual 100-5, Army Operations (1993), continues the evaluation from attrition-oriented warfare to establish a primary emphasis on the role of maneuver to achieve decision. This emphasis on the concept of maneuver supports the current U.S. Joint doctrine for land-based warfare. Joint Publication 3.0, Joint Operations (1995), states "that the focus of land-based warfare is to render opponents incapable of resisting by shattering the morale and physical cohesion (their ability to fight as an effective coordinated whole) rather than to destroy them physically by attrition."[5] It is upon this conceptual basis that the Army's Force XXI efforts are focused on developing improved maneuver capabilities for its tactical units.

"The line of thought that digitizing the battlefield is only automating the command and control function for improving the speed and accuracy of information is only partially correct."[6] What the Army is seeking to gain by digitizing its force is the *net gain* of command and control (C2) enhancements of every lower-echelon warfighting unit, realized as greater combat power for formations as a whole. Simply stated, the Army seeks to derive greater combat power from its units by enhancing C2 functions that will enable a *net gain* in performance of "critical elements of combat power--maneuver, firepower, protection and leadership."[7] These desired improvements are measured in terms of increases to lethality, survivability, and the ability to increase and regulate the tempo of battle.

The Army defines maneuver as both a system and a function. Maneuver derives its conceptual basis from FM 100-5 as a battlefield operating system. Battlefield operating systems are defined in FM 100-5 as the major *functions* performed by the force on the battlefield to successfully execute battles and engagements in order to accomplish military objectives directed by the operational commander.

The Army further specifies maneuver as a function in TRADOC Pamphlet 11-9, Blueprint of the Battlefield (1994). This definition is provided later in this chapter. This pamphlet serves as a common reference source for the development of all Army warfighting functions and is used by field commanders, combat developers, analysts, planners, doctrine developers, and trainers. This research uses the TRADOC Pamphlet 11-9 methodology for analyzing combat functions due to its status as the Army-wide standard framework for developing doctrine, materiel, and training.

Force XXI Experimentation

In an effort to accelerate the development of enhanced concepts and battlefield systems, the U.S. Army is undertaking a large-scale experimentation program. This program is a major axis of effort within the Force XXI process and is centered around the conduct of advanced warfighting experiments (AWE). Based upon results from several battalion-sized AWEs, the Army is currently preparing to conduct two major AWEs in 1997 and 1998 at the brigade and division levels. The primary purpose of these AWEs is to examine the potential of digital situation awareness. The Army designated the 4th Infantry Division (Mechanized) at Fort Hood, Texas, as the Experimental Force or (EXFOR) for these experiments.

The EXFOR's success during these AWEs will be measured by how well they can utilize their digital information advantage to out think, decide and act over the Opposing Force (OPFOR). It is imperative that the EXFOR optimize their advanced information systems to produce digital situation awareness and improve critical tactical functions such as maneuver. The U.S. Army's Test and Experimention Command (TEXCOM) is the lead agency responsible for "determining whether (tactical) capabilities are increased or the time line (to execute battle tasks) is reduced by the technology being tested."[8] A critical step towards optimizing these new capabilities will be the continued development and refinement of tactics, techniques, and procedures for tactical maneuver. The intent of this study is to support this developmental process.

In summary, improving tactical maneuver is a fundamental objective of the U.S. Army's digitization effort. However, developmental work to date *has not* identified precisely how to apply this new capability to maximize its potential within the function of tactical maneuver. This thesis intends to support General Hartzog's directive to " Optimize the utility of the digitization capabilities that we are putting into the force today."[9]

Definition of the Problem

The purpose of this thesis is to identify relationships between digital situational awareness and tactical maneuver functions in order to support the Army's effort to develop doctrine, tactics, techniques and procedures (DTTP) for digital warfighting. The primary research question that this thesis serves to answer is: What specific tactical maneuver functions and tasks can be improved by providing leaders and soldiers with digital situational awareness? More specifically, this research seeks to identify potential applications of digital situational awareness capabilities to improve the functions of tactical maneuver for the mounted (mechanized and armored) combined arms company teams.

In order to answer the primary research question, the following five secondary questions require research and analysis:

1. What are maneuver functions for tactical units?

2. What is situational awareness in the theoretical and military contexts?

3. What measures of performance (MOP) constitute improvement to current maneuver functions?

4. What specific situational awareness capabilities are produced by digital command and control systems at the brigade level and below?

5. What are the current tactics, techniques, and procedures for digital situational awareness and do they improve tactical maneuver functions?

Background

In order to establish a context for this research, it is essential to first review the genesis of this research problem, then briefly examine the digitization effort of the Force XXI Battle Command-Brigade and Below (FBCB2) Program, and the Army's process for developing TTP for digitally equipped units. The purpose of this review is to provide an account of the development of this research problem, as well as background information regarding the FBCB2 program and TTP development as they relate to the research problem.

The problem of developing optimal tactical applications for new battlefield technologies is not new to the U.S. Army. However, the scope of the digitization initiative is orders of magnitude greater in complexity than the Army's past experiences in integrating new capabilities. This increase in complexity manifests itself into every element of force development--doctrine, training, leadership, organizational design, materiel, and soldier systems (DTLOMS). For the purpose of this study, the primary concern is development of doctrine and TTP. This increase in complexity is caused by at least five factors.

A Complex Problem

The first cause of increased complexity in developing new tactical methods is the new and unique nature of digital systems. Digital systems represent new ways and means of performing battlefield functions. This is contrasted to the U.S. Army's past experience integrating product-improved or enhanced versions of existing systems, such as the process of changing from an M1 tank to an M1A1 tank.

Second, the development of prototype systems for experimental purposes parallel to the development of objective systems produces profound program challenges given current resource constraints within the Army modernization effort. The Army's digitization effort is one of the first modernization efforts performed within the new requirements determination process instituted in 1995-1996. Under this new process, the Chief of Staff, U.S. Army has "placed the TRADOC Commander as the approval authority for all Army warfighting requirements."[10] By doing so, TRADOC is the primary agent for managing the complexity of balancing the digitization programs that meet contemporary operational needs of the field commanders for go to war systems, with the development of future systems based upon concepts and experimentation. Supporting the simultaneous development of two separate, but converging digital systems with tactics, techniques and procedures remains a daunting task for the foreseeable future.

Third, effort to develop optimal applications of digital capabilities given the current method of horizontal technology integration (HTI) of commercial-based technologies into military systems is problematic to many force development processes. This is problematic due to the inherent, rapid pace of change associated with this strategy. "While HTI has the potential to provide force improvements in order of magnitude beyond old ways of doing business, it changes the environment and processes by which the Army modernizes."[11] One of these critical processes affected is the development of optimal doctrine and TTP.

The fourth factor causing increased complexity of developing military applications of digital capabilities is the dynamic manner in which the U.S Army defines the conceptual and physical environments of a future battle. The significant intellectual work performed within the military over the past four years has resulted in the establishment of several visions of what a future battle may entail. All documents, such as the Chairman of Joint Chiefs of Staff's Joint Vision 2010; TRADOC Pamphlet 525-5; Force XXI Operations; TRADOC Black Book Land Combat in the 21st Century; and operational concept wargame reports from the Office of the Secretary of Defense's (OSD) Revolution in Military Affairs (RMA) program, provide descriptions of the operational environment within which units will fight with digital systems in the future. While these visions provide focus to the overarching digitization initiative, conceptual disparities and lack of consensus among Army leaders as to their impact upon the development of tactics exacerbates the problem of designing optimal TTP for digital warfighting.

Last, the current low to mid-level of maturity of both the computational and communicational technologies required for military applications inhibit development of new, *optimal* tactical methods. As General Hartzog stated, "We have made great progress in identifying those technologies required for the future but we are not over the technological hump yet."[12] The Army's recent AWE Focused Dispatch validates this challenge by determining that "shortfalls in inter-connectivity among currently fielded digital systems imposes more of a burden on the user than they return in terms of useful capability and improved force effectiveness."[13] Despite increasing maturity and usability of digital systems, the development of optimal TTP will remain a difficult task until the U.S. Army propels itself over this hump.

Developing TTP for Force XXI is a critical task. To meet this task the U.S. Army has undertaken profound steps to deal effectively with new strategic complexities that influence the path of Army modernization. "In the last several years, the rapidly increasing pace of change in both world conditions and technological advancement has prompted the Army to not only change itself but change the way it changes."[14] The U.S. TRADOC, chartered by the Chief of Staff, U.S. Army, as the "architect" for the future Army, established "a set of dynamic, audacious organizations to identify the physical and mental elements of change required by the Army to stay in front of the bow-wave of change in this world in which our Army works."[15] These organizations were established in May of 1992 as the Battle Lab Program.

The Battle Lab Program is primarily responsible for identifying concepts and requirements for new doctrine, training, leader development, organizations, materiel, and soldier systems. As such, the Battle Labs perform the central role in "documenting the TTP of how to operate on the digitized battlefield."[16] To date, the Battle Lab Program has developed two sets of digital TTP--differentiated as operational (go to war) and experimental. The operational set of TTP was developed to support the fielding of M1A2 digitally equipped tanks to the 1st Cavalry Division at Fort Hood, Texas. The experimental set of TTPs was developed for the EXFOR.

What is Force XXI Battle Command Brigade and Below?

One of the Army's programs responsible for developing this digital capability is the FBCB2 program. It is imperative to understand the basic elements of the FBCB2 program as it relates to this research. FBCB2 is a program developed "to provide the Army with near-term digital command and control capabilities to Force XXI units at brigade and subordinate echelons."[17] The FBCB2 system is comprised of: (1) appliqué (bolt-on) and embedded system hardware, (2) FBCB2 software, (3) position navigation and reporting capability, (4) interface to land and/or satellite-based communications system, and (5) A combat identification capability.

The principal significance of this program is its effect upon the development of Army command and control systems. The FBCB2 program, initiated by the development of the M1A2 tank as the Army's first front-line digital system, "reoriented the development of the digital battlefield architecture from the bottom-up instead of from the top-down."[18] Consequently, the FBCB2 is the first Army command and control system being developed to optimize the informational needs of the lower-echelon warfighter, while designed to be fully interoperable with existing and emerging higher-echelon C2 systems. Therefore, the tactical performance enhancements, or value-added from digitization, will most likely be realized within lower-echelon warfighting functions. This will require determination of optimal warfighting TTP.

In order to appreciate the program objectives of FBCB2, it is instructive to consider the existing brigade and below command and control system shortfalls that FBCB2 is attempting to overcome. The Army's approved User Functional Description (UFD) (TRADOC,1996) for FBCB2 describes existing C2 system shortfalls as:

1. Inadequate means to disseminate battlefield information higher, lower and laterally.
2. Primary reliance on voice communications.
3. Antiquated or obsolete information technologies at the tactical level of war.
4. No capability to receive or transmit imagery/graphics.
5. Manual-only means of sharing position information and combat identification.
6. No means of accessing military and non-military distributed databases.
7. Limited functionality to support C2 of logistical functions.

This same source enumerates the capabilities that the objective FBCB2 system will provide. This list is found at Table 1. Where the FBCB2 program develops what the future Army will fight with, TTP will determine how the Army will fight. Therefore, understanding the digital-TTP developmental process is essential to this research.

How Does the Army Develop Digital Tactics, Techniques, and Procedures?

As previously stated, the U.S. Army TRADOC has developed both experimental and operational TTP for the employment of digital systems to command and control tactical operations. This TTP has been developed in an iterative manner over the past three years. After every major test, experiment, or fielding of a new system or version of software, subject-matter experts and users have rolled feedback back into the TTP literature to reflect new discoveries of how command and control functions are improved. While this "rolling baseline" approach has been generally effective to date, the resulting TTP is focused primarily on the *enabling function* of command and control - not on tactical maneuver itself. While this work is essential to the development of digital warfighting, it is insufficient to fully determine the effect of this new capability upon the primary function of tactical maneuver.

Another challenge to developing effective methods for employing digital situational awareness tools is overcoming existing performance problems of executing conventional (nondigital) TTP. The current versions, or baseline, digital TTP is based upon conventional TTP and thus contains some inherent execution shortcomings. Numerous empirical studies exist that describe unit performance shortcomings regarding execution of tactical operations in both training exercises and in actual combat. An extensive analysis was performed after Operation Desert Storm to identify the shortcoming of current techniques, particularly as they were employed under conditions deemed applicable to modern, twenty-first century battle. Additionally, lessons learned through the Army's Combat Training Centers (CTC) highlight systemic challenges units have in executing tactical operations today.

Consequently, the Army's effort to identify and realize the potential of digitization will require continual work to optimize new capabilities towards enduring battlefield functions, such as maneuver. This will require overcoming existing execution shortfalls while developing optimal methods of employing digital situational awareness towards enhancing the Army's tactical maneuver capability. The Army, through TRADOC, must provide digitally equipped units with *definitive* tactics, techniques, and procedures that enable them to exploit the unique capabilities they possess to maneuver their units on the modern battlefield to achieve decisive victory.

Assumptions

Analytical research on this topic requires the following assumptions:

1. "Transition to Force XXI will remain one of the Army's top peacetime priorities."[19] This research assumes that the Army will continue its commitment towards aggressively supporting the development of battle command capabilities--both operationally and technically.

2. Digital communications and information systems will continue to improve technically in their ability to enhance the breadth, speed, and quality of information flow among appropriate members of large, complex organizations, such as tactical units.

3. Operational requirements developed by the Army are fixed and valid for the purposes of developing and acquiring digital systems for the Army. This research will assume that operational requirements documents (ORDs), mission needs statements (MNSs), and user functional description (UFD) fully document the objective functionality of digital situational awareness capabilities that the Army will field to tactical maneuver units.

Limits to the Topic

This thesis will no address research, development, or acquistion of materiel systems. The following limitations were imposed upon this study to enable intellectual focus and foster precise outcomes. These limitations are:

1. Type of Military Organization. The population for this study is limited to combined arms, armored, and mechanized ground-maneuver units. This research will refer to this force

type as the *mounted force*. While aviation and dismounted forces are integral elements of the combined-arms team, they are beyond the scope of this research.

2. Size of Military Force. This research will limit its scope to company-sized units.

3. Type of Digital Systems. This study is limited to the command and control and maneuver systems inherent to the FBCB2 program. Primarily, FBCB2 is organized with the M1A2 tank's Intervehicular information System (IVIS), the Maneuver Control System (Phoenix variant), and the FBCB2- Appliqué system. These digital systems are currently fielded to both experimental and operational units.

4. Time. This research is limited to the near-term developmental period of Force XXI as defined in the Force XXI Campaign Plan (TRADOC, 1995) as 1995 to 2003.

Operational Definitions

Several operational terms require definition for the purpose of this study. Due to the experimental nature of many of these new concepts and programs, doctrinal definitions do not yet exist. Where doctrinal definitions exist, they have been used. Where they do not exist, official U.S. Army sources were used to provide acceptable definitions. The following operational definitions apply to terms that are integral to this study.

Tactical Maneuver. Tactical maneuver is defined in TRADOC Pam 11-9 Blue Print of the Battlefield (1994), as "the employment of forces on the battlefield through movement and direct fire in combination with fire support, or fire potential, to achieve a position of advantage in respect to enemy ground forces in order to accomplish the mission." TRADOC Pamphlet 11-9 decomposes the tactical maneuver system into four critical functions - move, engage enemy with direct fire, control battle space, and integrate direct fire with maneuver. These functions are the basis of this research. A detailed listing of these functions, along with subordinate tasks is found at Table 2 of this thesis.

Digitization of the Battlefield. Digitization of the battlefield is one of the central initiatives of the Army's Modernization Plan. Digitization of the battlefield, or digitization, is defined in the United States Army Posture Statement for Fiscal Year 1997 as,

> The application of information technologies to acquire, exchange, and employ timely battlefield information throughout the entire battle space. It enables friendly forces to share a relevant, common picture of the battlefield while communicating and targeting in real or near-real time. It will reduce the fog of war and decrease decision making time by optimizing the flow of command and control information.[20]

Digital Communications. Cardine (1994) accurately defines digital communications as:

> The encoding of any information into a discrete or discontinuous signal by partitioning the signal and assigning it a numerical binary code (one or zero) value. These codes are less sensitive to noise, interference from other frequencies, signal distortion and fading, and have greater transmission efficiency than continuous variable (analog) signals. Because these signals are in a numerical code they can be processed by computers using mathematical algorithms to manipulate the information for many purposes. Conversion of the digital signal into an analog signal is done by use of a modulator-demodulator (modem) device. This digital technology and the analog-to-digital and digital-to-analog conversions are the physical basis that permit the transmission and processing of vast amounts of data by computers and is the enabling technology of the Information Revolution.

Battle Command. Battle command is the U.S. Army's new command philosophy. This philosophy provides the conceptual framework for the integration of intellectual, organizational, procedural and technical aspects of commanding soldiers and units in battle. U.S .Army Field Manual 100-5, Operations (June 93), defines Battle command as,

> The art of battle decision-making, leading and motivating soldiers and their organizations into action to accomplish missions. It includes visualizing the current and future states, formulating concepts of operation to get from one to another, and doing so at least cost. Assigning missions, prioritizing and allocating resources, selecting the critical time and place to act, and knowing how and when to make adjustments during the fight are also included.[21]

Situational Awareness. The Army enterprise strategy is the unified vision statement for the modernization of Army command, control, communications, computers, and intelligence (C4I). This document defines situational awareness within the current military context. It is defined as,

> The graphic and instantaneous knowledge of your own location and the relative locations of friendly and enemy forces in your area. For lower echelons down to combat crews, situation awareness is essential for survival and combat effectiveness.[22]

TRADOC Pamphlet 525-5, Force XXI Operations (1 August 1994), expands this definition to include, "creating a common, relevant picture of the battlefield scaled to specific levels of interest and special needs."[23]

Army Battle Command System. The Army Battle Command System (BCS) is defined in the US Army Field Manual 24-7, Army Battle Command System Management Techniques (1995), as the overarching system that consists of doctrine, tactics, techniques, and procedures (TTP) and tools used to command and control forces on the tactical battlefield. The ABCS provides the means (equipment and procedures) to: (1) collect and organize large amounts of information, (2) combine information from multiple sources, (3) process information to analyze trends, (4) develop courses of actions based on situational factors, (5) exchange information efficiently among and within command posts (CP) and (6) present information as graphical displays and textual summaries.

The ABCS is the keystone of the digitization of the battlefield effort that provides the commander an integrated digital information network that supports warfighting systems and ensures command and control decision-cycle superiority.

Tactical Decision-Making Process. This research references the two primary tactical decision-making processes used most often at the brigade and below level, the Combat Decision-Making Process (CDMP) and Troop Leading Procedures (TLP). According to US Army Command and General Staff College (CGSC) Student Text (ST) 101-5, Command and Staff Decision Process, "the CDMP is an abbreviated form of the deliberate decision-making process (DDMP) used by commanders and staffs in combat situations to plan quickly."[24]

Troop Leading Procedures. The TLPs are an eight step process used to be combat leaders (without staff support) to plan, prepare, and execute tactical operations. TLPs are generally employed by small units, companies, and platoons, and they complement the CDMP of higher echelon units, such as battalions and brigades.

Tactical Internet. A tactical internet is an integrated battlefield communications network modeled after the commercial Internet. This network will provide reliable, seamless, and secure communications connectivity required to support systems of the FBCB2 program. Information flow within this network is based upon the exchange of common tactical message sets that have been developed for use by most tactical data systems used by Army and other services and agencies. The tactical internet is a critical enabling capability for developing a shared picture of the battlefield among elements of digital units.

Significance of the Study

> Desert Storm showed the potential with only the first generation of systems and concepts. Today the U.S. is moving to the second generation and developing the operational concepts, doctrine and tactics that go with it.
>
> Honorable William T. Perry, Foreign Affairs

The purpose of this research is to *advance* the Army's effort towards realizing the tactical warfighting potential of digital situational awareness. This study intends to add to the body of research of this new area of strategic importance to the U.S. Army. Prior to one of the Army's advanced warfighting experiments, LTC Joseph E. Orr, Commander of Task Force 2-33 Armor, one of the Army's first digitally equipped units, challenged his troops "to be a part of something greater--a digital team."[25] This study is an attempt to support the Army's effort in making digitization something greater.

The complex method of conceptualizing new digital TTP requires focused analytic research to supplement the military judgment of the TTP developers involved in this process. To date, little analytical research has been conducted to support this essential undertaking.

This study's resulting recommendations provide a conceptual perspective to support the development of the next generation of digital, maneuver-oriented TTP. This study, when included with other analytical research, experimental findings, and expert military judgment, will assist the Army in realizing its goals and objectives for Force XXI.

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[1]William A. Owens, Dominant Battlespace Knowledge (Washington, DC: National Defense University Press, 1995), 3.

[2]U.S. Army, Force XXI, America's Army of the 21st Century (Ft. Monroe, VA: Office of the Chief of Staff, Army, (January 1995), 1.

[3]William W. Hartzog, discussion with author, notes, Ft. Monroe, VA, 28 November 1995.

[4]Dennis J. Reimer, authors address notes, Ft. Leavenworth, KS, 25 October 1996.

[5]U.S. Department of Defense, Joint Publication 3-0, Joint Operations (Washington, DC: Joint Chiefs of Staff, February 1995), IV 8-9.

[6]Ibid.

[7]U.S. Army, FM 100-5, Army Operations (Washington, DC: Department of the Army, 1993), 2-19.

[8]Dennis Steele, "Countdown to the Next Century," Army (November 1996): 20.

[9]William W. Hartzog, discussion with author, notes, Ft. Monroe, VA, 28 November 1995.

[10]U.S. Army, Requirements Determination, (Ft. Monroe, VA: U.S. Army Training and Doctrine Command, March 1996), preface.

[11]U.S. Army, 1996 Modernization Plan (Washington, DC: Department of the Army, 1996), 15.

[12]U.S. Army, Land Combat in the 21st Century (Ft. Monroe, VA: U.S. Army TRADOC, 1996), preface.

[13]U.S. Army, AWE Focused Dispatch: Final Report (Ft. Knox, KY: Mounted Battlespace Battle Lab, June 1996), 1-5.

[14]U.S. Army, Battle Labs: Defining the Future, (Ft. Monroe, VA: U.S. Army TRADOC, May 1995), preface.

[15]Ibid.

[16]Ibid., 16.

[17]U.S. Army, U.S. Army Digitization Master Plan (Washington, DC: Army Digitization Office, March 1996), 6-1.

[18]Christopher V. Cardine, Digitization of the Battlefield (Carlisle Barracks, PA: U.S. Army War College, 1995), 21.

[19]U.S. Army, Joint Venture Campaign Plan (Ft. Monroe, VA: U.S. Army TRADOC, April 1995), 3.

[20]U.S. Army, U.S. Army Posture Statement FY 97 (Washington, DC: Department of the Army, 1996), 68.

[21]FM 100-5 (1993), 2-27.

[22]U.S. Army, U.S. Army Enterprise Strategy (Washington, DC: Office of the Secretary of the Army, July 1993), 18.

[23]U.S. Army, TRADOC Pamphlet 525-5, Force XXI Operations (Ft. Monroe, VA: U.S. Army TRADOC, 1994), 2-1.

[24]U.S. Army, CGSC Student Text 101-5, Command and Staff Decision Process (Ft. Leavenworth, KS: U.S. Army Command and General Staff College, 1996), 3-5.

[25]U.S. Army, AWE Focused Dispatch: Final Report (Ft. Knox, KY: Mounted Battlespace Battle Lab, June 1996), App A.

CHAPTER 2

LITERATURE REVIEW

> Innovation is fostered by information gathered from new connections; from insights gained by journeys into other disciplines or places; from active, collegial networks and fluid, open boundaries. Innovation arises from ongoing circles of exchange, where information is not just accumulated or stored, but created.
>
> Margaret J. Wheatley
> Leadership and the New Science (1994)

Purpose

This chapter reviews relevant literature regarding key facets of the research question. The purpose of this review is to examine published literature that; (1) identifies authoritative works in the field , (2) provides essential information on specific subject areas, and (3) answers several, secondary research questions. This review provides definitive information of the following three areas of this research:

1. Current maneuver TTP for digital company teams.
2. Results of Advanced Warfighting Experiments.
3. Situational Awareness Theory.

Method

This chapter begins with an overall description of the project's informational needs that are satisfied by this literature review. This is followed by an examination of the Army's digital TTP manuals that describe current applications of digital situational awareness. Next, this review provides relevant insights from several of the Army's Advanced Warfighting Experiments (AWE) that establish a preliminary baseline of performance indicators of current digital TTP. Finally, this chapter concludes with an overview of Situational Awareness Theory in order to establish a foundation for analyzing the Army's current utilization of this concept.

Information Needs and Availability

The following questions must be answered in order to determine the current state of digital TTP:

1. What are current digital TTP applications for the mounted company team?

2. What insights have been gained by recent Advanced Warfighting Experiments that indicate the effect that digital situational awareness has on maneuver functions?

3. What principles of Situation Awareness Theory effect the Army's integration of digital technology into TTP?

This information is available through three sources. First, current digital TTP is available through HQ, TRADOC's Joint Venture Office at Fort Monroe, Virginia. Secondly, the Battle Command Battle Laboratory and the Center For Army Lessons Learned, both at Fort Leavenworth, Kansas maintain experimental data and reports from the Army's Advanced Warfighting Experiments. The third source of information is the Army Research Institute Field Office at Fort Knox, Kentucky where current literature on Situational Awareness Theory and Human Factors Research is maintained. These three sources provided the information contained in this study.

Current Digital Tactics, Techniques and Procedures (TTP)

There are two primary sources for TTP for U.S. Army digital units at the company team level. They are:

1. ST 71-1-1, TTP for the Digitized Company Team (1995).

2. FKSM 71-1-1 (Appliqué), TTP for the Appliqué-Equipped Company Team (1996).

Each of these manuals is written for a different user. The Special Text (ST) is written for company teams with M1A2 tanks and Bradley Infantry Fighting Vehicles (IFV) digitally-equipped with the Inter-Vehicular Information System (IVIS). The Fort Knox Supplemental Material (FKSM) is written for Appliqué-equipped company teams of the EXFOR. While the IVIS and Appliqué units have different capabilities at the present time, the objective digital system as described in the FBCB2 program will comprise the capabilities of both of these systems. Therefore, the this study examines both of these sources.

ST 71-1-1, TTP for the Digitized Company Team contains 27 new tactics, techniques or procedures that employ digital situational awareness capabilities for maneuver functions (See Table 3 of Appendix). These new TTPs span the planning, preparation and execution over the spectrum of tactical missions that a company team performs, including attack, defend and other operations such as passage of lines and withdrawal. The distribution of these 27 new TTPs over the four maneuver functions of TP 11-9, Blueprint of the Battlefield is:

1. Movement -- 8 new TTPs.

2. Engage the Enemy -- 6 new TTPs.

3. Control Battle Space -- 6 new TTPs.

4. Integrate Direct-Fire with Maneuver -- 7 new TTPs.

The nearly equal distribution of these new TTPs across the 4 maneuver functions indicates that digital situational awareness has a significant impact upon company team maneuver.

A review of this manual identifies several general applications of digital capabilities that require mention. First, all of the new TTPs are characterized as significant improvements to conventional practices. These improvements are described as the capability to:

1. Perform various steps of tactical tasks *simultaneously.*

2. Perform critical tasks *earlier* within the sequence of larger processes.

3. Perform functions with more accurate and *timely information.*

4. *Collaboratively* perform tasks with higher, lower and adjacent units.

5. Perform critical leader tasks *while physically remote* from the unit.

6. Maintain a more *accurate orientation* of the situation.

7. Disseminate critical information precisely using *graphical representations.*

Secondly, the M1A2 tank's far-target designation capability impacts upon TTP equally as much as the digital information system does. Far-target designation entails the use of the vehicle navigation system, laser range finder and microprocessor to automatically determine target locations and generate icons on the information display. These icons can be labeled and near-instantly passed to other units to orient them toward enemy targets, hazard areas and terrain features.

Presently, 13 of the 27 new TTPs in this manual integrate the use of the far-target designation capability of the M1A2 tank with the digital information system (IVIS) to improve critical maneuver functions. The specific functions effected are engaging enemy targets, controlling battle space and integrating direct fire with maneuver. The only maneuver TTP that does not combine the use of far-target designation and IVIS is the movement function. This finding is significant to this research because it suggests that at the company team level, the far target designation capability, while not a feature of the FBCB2 program, is an essential *enabling* capability to achieving improvements in tactical maneuver through digital situational awareness. Moreover, the lack of far-target designation systems in the EXFOR may prove to be a significant limit over the effectiveness of the digital capability they possess.

Lastly, this source identifies new TTPs that were previously not feasible to perform. The ability to digitally disseminate graphic overlays and reports creates conditions where the performance of security operations (counter-reconnaissance) can occur *simultaneous* to company battle position preparation and engagement area planning at a remote location. Furthermore, the ability to send obstacle information in graphical form simultaneous to their emplacement creates new methods of integrating and synchronizing maneuver. This manual posits that in addition to enhancing maneuver "the cumulative effect of these advanced battlefield capabilities is a more tactically agile and lethal company team."[1] This is significant because agility and lethality are essential characteristics of tactical maneuver.

FKSM 71-1-1, (Appliqué), TTP for the Appliqué-Equipped Company Team is the only other source of TTP for digitally-equipped company teams. This manual was produced in 1996 by the Mounted Battle Space Battle Lab, Fort Knox, Kentucky for the EXFOR. This manual was based upon the TTPs previously developed for the IVIS-equipped units of the 1st Cavalry Division. As such, these TTPs are very similar to those described in the Special Text (See Table 3).

Despite their similarities, the Appliqué-equipped company team TTP does vary slightly from their IVIS-equipped counterpart. Specifically, this source cites six differences. These differences result from having different capabilities in each of the digital forces. The appliqué digital units are equipped with an electronic combat identification system (Battlefield Combat Identification System [BCIS]) that enables them to perform precision combat identification procedures that the IVIS-equipped units currently cannot perform. This capability impacts upon the TTPs associated with the maneuver functions of engaging enemy targets and integrating direct fire with maneuver.

While the combat identification system gives the Appliqué company team an increased fratricide prevention capability over the IVIS company team, their lack of a far-target designation system on their combat platforms reduces their ability to rapidly and precisely derive target locations. A review of the Appliqué TTPs clearly indicate the limitations that manual target determination procedures place upon the unit as they conduct maneuver and employ direct fires.

Another variation of significance is that this source describes a technique where, "the ability to know where the friendly forces are without having to maintain visual contact enables the company team to maneuver along several axes, thus moving up to an objective and massing combat power more rapidly on the enemy."[2] This TTP represents a much bolder approach to the conduct of company level maneuver than the other source. However, this tactic is not fully described in this manual.

In summary, the ST and FKSM both represent the current state of TTP development for the digitized company team. This review has determined the level to which digital situational awareness systems have been integrated into the four functions of tactical maneuver. Additionally, variations between the capabilities of the uniquely equipped digital units were identified to highlight the impacts that ancillary systems, such as far target designation and BCIS, have upon the use of digital information systems. This review of TTP is not sufficient alone to determine the current state of digital operations. Therefore, this study examined relevant Advanced Warfighting Experiments to complete this review.

Results of Advanced Warfighting Experiments (AWE)

There are two primary sources for information regarding experimental insights from digital maneuver operations at the battalion-level and below. These sources are:

Final Report of AWE Desert Hammer, (1994)

Final Report of AWE Focused Dispatch, (1996) This review of experimentation provides insights into the effects that new TTPs and systems have upon tactical maneuver.

Advanced Warfighting Experiment Operation Desert Hammer VI (AWE ODH-VI) was conducted at the National Training Center, Fort Irwin, California during 2 - 24 April 1994. This was the U.S. Army's first large-scale, field experiment aimed to "examine the battlefield impacts of a battalion/task force possessing digital communications across all Battlefield Operating Systems (BOS)."[3] This important experiment was predicated upon a central hypothesis that " a battalion/task force using Force XXI Battle Command (systems) would outperform a unit without such communications."[4] In addition, numerous, subordinate hypotheses were developed in the areas of battlefield lethality, survivability and tempo, the battlefield operating systems (BOS), and the force development systems of doctrine, training, leadership, organizations, materiel and soldier support (DTLOMS).

Overall, the central hypothesis was neither validated nor refuted. The AWE Final Report states technical immaturity of these digital systems (many still in prototype stage), insufficient quantities of digital equipment for all vehicles and an inability to establish baseline data for comparison were cited as contributing factors to the inability to answer the hypothesis. Additionally, this report establishes that (1) current digital systems provide limited improvements in lethality, survivability and tempo, and (2) despite the inability to answer the central hypothesis, this experiment was extremely successful in gaining *warfighter insights* into the potential value-added by digitization.

This report specifies 7 improvements observed of the AWE Task Force that relate to company team maneuver functions. These improvements cite digital TTPs employing situational awareness capabilities as causing:

1. Increased flexibility and ability to react to unexpected actions.

2. Increased ability to integrate direct fires with obstacles.
3. Increased ability to maneuver CSS assets securely.
4. Reduction in the number of critical navigation errors.
5. Increased number of fighting vehicles that participate in decisive engagements.
6. Decrease in the time expended to complete actions upon contact.
7. Increased ability to hand-off targets to other elements to engage.

While many TTPs were validated as feasible during this experiment, many were not due to technical shortfalls of the systems provided. Most of these centered around the lack of interoperability (interconnectivity) between the maneuver, intelligence, fire support and air defense systems. In the cases where important TTPs were not fully evaluated, some threads of feasibility were subjectively derived by the Subject-Matter Experts (SME) that observed the experiment. It was upon this basis that thereport recommended "continuing development of doctrine and training literature through iterative AWEs," and "continuing materiel development of these systems."[5]

Where AWE Desert Hammer VI focused on the broad areas of improving lethality, survivability and tempo, AWE Focused Dispatch focused specifically on training support and TTP for digital warfighting at the small-unit level. Major General (Retired) Lon E. Maggart, then chief of Armor and Cavalry, stated, "whereas NTC 94-07 (AWE Desert Hammer VI) proved that digitized systems are powerful, the new AWE (AWE Focused Dispatch) was charged with figuring out how to begin maximizing that power."[6]

AWE Focused Dispatch was conducted 14-31 August 1995 as a series of experiments employing constructive, virtual and live simulations at both Fort Knox and the Army National Guard Western Kentucky Training Area in Greenville. The final report states the overarching goal of the experiment "was to refine the digital tactics, techniques and procedures (TTP) for hand-off to the Experimental Force (EXFOR) participating in the follow-on Task Force AWE. It was accomplished by focusing on the processes of how to best employ digital technology."[7]

The AWE Focused Dispatch Final Report is the most comprehensive work describing the performance of digital TTP to date. Fourteen company team, maneuver TTPs were examined in these experiments. Of these fourteen TTPs, thirteen were validated as feasible and effective. One TTP was refuted due to the inability of current systems to send a digital contact report in adequate time to initiate an engagement. Whereas these TTP were validated for continued use by digital units, their status as *improvements* over conventional TTPs were not determined by this AWE.

Comparable to AWE Desert Hammer VI, significant technical shortfalls existed that limited the interconnectivity required between digital systems to optimize their effectiveness. This report declares that "the stovepipe legacy systems used in this AWE demonstrated that systems without seamless interconnectivity and integration impose more of a burden on the user than they return in terms of useful capability and improved force effectiveness."[8] This finding is most valid when applied to the battalion/task force level. AWE conclusions of company team operations were generally much more favorable, primarily because they were not directly effected by these stovepipe systems.

The Focused Dispatch Final Report makes several conclusions about digital TTP for company team maneuver that are important to this study. They are:

1. Current hardware designs inhibit usage during vehicle movement.

2. Digital systems allow more efficient use of the leaders time.

3. Digital situational awareness reduced uncertainty for the company commander, resulting in efficient movement and rapid response time.

4. Current combat net radios are insufficient to *move* required digital information. Far-target designation systems are essential to optimize digital TTP.

5. Current Variable Message Formats (VMF) are too lengthy to use during contact.

6. Computer icons are simpler to use than conventional graphical control measures.

To summarize, the final reports of these two AWEs provide information that establish the current effectiveness of digital TTPs. These sources also identify critical technical shortcomings that limit the potential of digital systems for improving tactical maneuver. Perhaps the greatest value of these reports is the effort placed in articulating the "art of the possible" gained by extrapolating potential capabilities and TTPs based upon subjective conclusions of the current state. Exploring these potentialities is the aim of this research.

Situational Awareness Theory

This section of this literature review examines the current state of Situation Awareness (SA) research from the scientific field of Human Factors Psychology. The objective of this review is to determine what principles or insights may relate to the Army's efforts to create digital situational awareness To meet this objective the following questions must be answered:

1. What is the origin of SA theory?

2. What is the definition of SA from psychological and military perspectives?

3. What research findings and theoretical principles may relate to the Army applications?

The Origins of Situation Awareness (SA)

SA as a cognitive and behavioral study originated in the U.S. military. Flach (1995) states "the term situation awareness originated with fighter pilots of the U.S. Air Force as they attempted to articulate the difficulties of managing the complex information processing demands of air combat. The term has more recently been embraced by the human factors community to define a domain of research whose goal is to study cognition as it occurs in complex, dynamic work environments."[9]

The term situation awareness spread rapidly throughout the Air Force and into commercial aviation literature. In April of 1994, then Air Force Chief of Staff, General Merrill A. McPeak tasked Armstrong Laboratory to define SA, and to determine whether it can be measured and learned.[10] The Laboratory organized a team of researchers as the situation Awareness Integration Team (SAINT) to conduct the inquiry and answer General McPeak's questions. SAINT's technical report was submitted and briefed to General McPeak and the Air Force Science board in June of 1994. This report included a literature review of human factors research in this field of psychology and proposed an operational definition of SA for Air Force use. More importantly the team determined positively that SA could be measured and learned.

The origin of U.S. Army applications of situation awareness theory is traced to two Army Research Institute (ARI) projects initiated in 1989 as "Research in Future Battlefield Conditions and the Combat Vehicle Command and Control (CVCC) Program."[11] These research efforts were aimed to support the Army movement toward vehicle-based automated command and control (C2) systems, and to identify new challenges small unit commanders will face in managing battlefield information.

The Army Research Institute's Field Unit at Fort Knox, Kentucky conducted basic and applied research to "enhance soldier preparedness through identification of future battlefield conditions and to develop training methods to meet those conditions."[12] Additionally, the CVCC program aimed to identify "the information management performance of platoon leaders equipped with a future command and control system."[13]

To summarize, SA theory resides primarily in the field of Human Factors research as a branch of psychology. The migration of this research into the military was first officially recognized in aviation applications by the U.S. Air Force and then to ground combat applications by the U.S. Army as part of the digitization initiative. The significance of this origin is that Human Factors research is a field of science relevant to current military developmental efforts towards enhancing battlefield awareness and information management through technology and training.

Situation Awareness Defined

Billings (1995) in an effort to describe SA as a field of research states that "we must remember that in many cases we are no longer able to appreciate the true situation without the aid of machines. And if this is true, however, then those machines must tell us more of what we need to know, and must do it more effectively and less ambiguously than they have done to date."[14] For reasons previously stated in this study, these assertions are the basis of the U.S.Army's digitization effort.

Situation Awareness is defined by Endsley (1995) as "the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future."[15] This definition is cited in nearly all major works in the field. Endsley further declares SA as both a process and a product by adding that "situation *awareness* is a state of knowledge, while situation *assessment* is the process used to achieve that state."[16]

Endsley makes several other statements regarding the definition of SA. First, he maintains that "SA does not encompass all of a person's knowledge. It refers to only that portion pertaining to the state of a dynamic environment."[17] In other words it is *situational*. Secondly, Endsley states that SA is "explicitly recognized as a construct *separate* from decision-making and performance; and that SA, decision-making and performance are different stages with different factors influencing them and with wholly different approaches for dealing with each of them."[18] Lastly, Endsley states that SA exists as a construct at both the individual and collective or crew levels.

The U.S. Air Force's SAINT report defined SA as:

> a pilot's continuous perception of self and aircraft in relation to the dynamic environment of flight, threats, and mission, and the ability to forecast, then execute tasks based on that perception.[19]

Furthermore, this report states that most researchers "have written extensively on the cognitive underpinnings of the SA construct as a *mental model*."[20] The SAINT report recommends that the U.S. Air Force emphasize the cognitive nature of this construct; and to view the role of information technology as a enabling effort that supports the construct.

Simply stated, all of the variations of SA definitions point to "knowing what is going on." Several critical distinctions are established by these definitions that directly relate to Army applications of this construct toward developing digital situational awareness. These are further examined in Chapter 4.

Research Findings Applicable to US Army Efforts

This review of SA research resulted in identifying nine compelling insights that may relate to the Army's effort of creating digital situational awareness capabilities as a means of improving performance of tactical tasks and functions. While these insights are introduced and described below, analysis of their implications are addressed later in this study.

Insight #1. The Three Levels of SA. Endsley (1988) describes the three levels of SA comprising this construct as "perception of the environment (level 1 SA), comprehension of the current situation (level 2 SA) and projection of future status (level 3 SA)."[21] These levels of SA are commonly used by researchers and information system designers to develop applications that enhance this cognitive process.

Insight #2. The elements of SA. Pew (1995) defines SA as "comprising five elements of awareness."[22] They are:

1. Spatial awareness: keep current with the physical aspects of the environment.
2. Mission/goal awareness: keep current with current phase and goals of the mission.
3. System awareness: tracking the operational status of information systems.
4. Resource awareness: keeping track of physical and human resources involved.
5. Crew awareness: knowledge of current activities of other crew members.

Pew believes that most automation systems are developed primarily for enhancing spatial awareness, however automation can objectively enhance all other elements as well.

Insight #3. The States of SA. Pew (1994) makes an important distinction in defining the three states of SA as *ideal, attainable and actual.* Billings (1995) defines ideal SA as "a perfect match between the real situation and the observer's mental model of that situation."[23] "The attainable case, which is never ideal, represents the best level of awareness in a perfect observer who assimilated all of the information available about the situation."[24] He continues to define actual SA as "what we as fallible mortals actually have at any given moment."[25]

Pew (1994) takes his model one step further by analyzing two possible relationships. These relationships are valid as the Army examines its digital applications. Pew proposes that if operators are found consistently to have *actual* SA that is inadequate compared to that which is *attainable*, we have either an information transfer problem, or we have a training problem because we haven't taught operators how to gain and use information. He further posits a design problem when *attainable* SA falls short of the *ideal* because the information available to an operator is not in a useful format. The last situation is caused when information was never made available to the operator because the system designer never thought the operator needed the information. This condition is described in the AWE reports as a major shortfall of current digital battle command systems.

Insight #4. Better Distribution of Attention. A research study by Curry and Ephrath (1977) finds "that monitors (operators) of an automated system actually performed better than manual controllers (in a flight task)."[26] This finding confirms many other studies in the SA field that determine that operators using automated information systems to support their SA are able to better distribute their attention across other systems and information sources to aid in task performance.

Insight #5. Effects of SA on Cognitive Workload. Studies have determined that automated SA systems can either increase or decrease cognitive workload depending on their design. Billings (1991) found that automation can improve SA by reducing excessive workload. He states that automated SA can reduce cognitive workload "by relieving the operator of inner loop control, by providing integrated information and allowing the operator to operate at a higher level."[27] Billings (1991) also found cases where automation has made "the information acquisition and assessment tasks more difficult because of the plethora of information now available, some of it not well represented."[28] This research suggests that design is critical to the effectiveness of automated SA systems--which can either enhance or degrade the operator.

Insight #6. SA and Knowledge and Technical Ability. Research indicates that high degrees of level 1 SA (perceptual) *does not* improve performance if the operator does not possess the knowledge and technical ability to comprehend or apply the information he possesses. In other words, an increase to one's perceptual SA does not, per se, result in increases in comprehension or projection abilities. Therefore, Endsley (1995) suggests that "good SA can therefore be viewed as a factor that will increase the probability of good performance but cannot necessarily guarantee it."[29]

Insight #7. Information-Based Task Performance. Endsley (1995) determined that the value added by the SA concept is that automated means can be designed to better provide information to operators to aid in task performance. He states that the SA concept "provides a means of moving from a focus on providing operators with *data* to providing operators with *information.* When focusing on data, all of the integration, comprehension and projection is still up to the operator. When focusing on information, the design focus is on presenting what the operator really needs to know in the format that it is needed in, thus allowing the operator to achieve more SA at a given level of workload."[30] This finding is critical to the Army's continued development of battle command systems that empower, not encumber the soldiers that operate them.

Insight #8. SA and the Effects of Stress. Automation supported SA systems have been found to effectively offset the negative effects that stress places upon human performance. The most widespread finding of the effects of stress on operator SA is that people tend to narrow their field of attention. Sheridan (1981) has termed this effect "cognitive tunnel vision"[31] Research has found that this often results in operators coming to premature closure, and arriving at decisions without considering peripheral information. Additionally, when under stress operators have been found likely to focus mostly upon negative information, disregarding the positive aspects that coincide with the situation. Many SA researchers believe this an area where automated information systems may enhance SA in dynamic environments of stress.

Insight #9. SA and Out-of-the-Loop Performance Problems. Endsley and Kiris (1995) conducted a study to examine out-of-the-loop performance problems in situations where operators derive information from automated systems. This research determined that operators only trained on automated systems *are more likely* to be handicapped when their systems fail than operators of automated systems that have learned task performance first by manual means.

Secondly, this research found that full-automation of SA tends to change the nature of operator activity from *active* information processor to *passive.* This passivity was found to negatively effect SA by reducing operator vigilance in monitoring the system, as well as inducing complacency. Endsley and Kiris conclude that "this shift from active to passive processing was most likely responsible for decreased SA under automated conditions.[32] This important study further concludes that partial-automation of SA is a better design approach than full-automation because it requires the operators to actively process information.

Concluding Observations

This literature review concludes with these observations:

1. Digital situational awareness (DSA) near-equally effects all four functions of tactical maneuver (moving, engaging, controlling battle space and integrating direct-fire with maneuver).

2. While both IVIS-based and Appliqué-based TTPs are similar, some differences exist resulting from differing *enabling capabilities* such as BCIS and far-target designation.

3. Far-target designation systems are critical enablers of digital TTP at the company team level and below.

4. Maneuver TTPs are enhanced by application of DSA because of an:

Increased capability to orient oneself and to orient others.

Increased amount of precise information to base decisions and actions upon.

Increased ability to provide *context* for critical data through the use of graphical images of friendly, targets and terrain.

Increased interaction between leaders and subordinates during *execution* of tasks, even when physically remote from each other.

5. AWE insights conclude that despite technological problems, current TTP applications are valid.

6. AWE findings report that digital situational awareness generally results in a more flexible, tactical unit that is capable of adapting to rapidly changing situations without loss of effectiveness.

7. AWE reports posit that determining optimal TTP applications of DSA are not possible until the Army resolves technical problems such as stovepiping of systems, lack of inter-connectivity, and bandwidth limitations.

8. Current DSA applications make *process efficiencies* that reduce the time required for task performance, and ultimately results in a greater ability to *respond effectively* in dynamic environments.

9. The U.S.Army application of situational awareness is consistent with the Human Factors definition of SA. However, there is little evidence that the Army is integrating the other structures of SA theory, such as the three states of SA, five elements of SA and individual and crew SA, into its effort to create digital situational awareness.

10. SA research findings extensively address the negative effects of automated systems used to develop and maintain SA. AWE reports suggest that the Army may be rediscovering lessons already learned in this field.

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[1] U.S. Army Armor Center, Special Text 71-1-1 Tactics, Techniques and Procedure of the Digitized Company Team (Fort Knox, KY: US Army Armor Center, 1995), 3-1.

[2] U.S. Army Armor School Fort Knox Supplemental Material 71-1-1 Tactics, Techniques and Procedure of the Appliqué-Equipped Company Team (Fort Knox, KY: Mounted Battlespace Battle Lab, 1996), 3-7.

[3] U.S. Army Armor Center Final Report Advanced Warfighting Experiment Operation Desert Hammer VI (Fort Knox, KY: Mounted Warfighting Battlespace Lab, 1994), exec sum-1.

[4] Ibid., exec sum-3.

[5] Ibid., abstract.

[6] U.S. Army Armor Center Final Report Advanced Warfighting Experiment Focused Dispatch (Fort Knox, KY: Mounted Warfighting Battlespace Lab, 1996), introduction.

[7] Ibid., iv.

[8] Ibid., 1-5.

[9] John M. Flach, "Maintaining Situation Awareness when Stalking Cognition in the Wild," Proceedings of the International Conference on Experimental Analysis and Measurement of Situation Awareness , ed. Daniel J. Garland and Mica Endlsey, (Daytona Beach, FL: Embry-Riddle Aeronautical University Press, 1995), 25.

[10] Grant R. McMillan, "Report of the Armstrong Laboratory Situation Awareness Integration Team," Situation Awareness: Papers and Annotated Bibliography AL/CF-TR-1994-0085, ed. M. Vidulich, C. Dominguez, E. Vogel and G. McMillan, (Wright-Patterson Air Force Base, Ohio: Armstrong Laboratory, 1994), 37.

[11] Carl W. Lickteig and Cathy D. Emery, Information Management Performance of Future Platoon Leaders: An Initial Investigation , Technical Report 1000, (Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, June 1994), v.

[12] Ibid.

[13] Ibid., I.

[14] Charles E. Billings, "Situation Awareness Measurement and Analysis: A Commentary," Proceedings of the International Conference on Experimental Analysis and Measurement of Situation Awareness , ed. Daniel J. Garland and Mica Endsley, (Daytona Beach, FL: Embry-Riddle Aeronautical University Press, 1995), 1.

[15] Mica A. Endsley, "Theoretical Underpinnings of Situation Awareness Theory: A Critical Review," Proceedings of the International Conference on Experimental Analysis and Measurement of Situation Awareness , ed. Daniel J. Garland and Mica Endsley, (Daytona Beach, FL: Embry-Riddle Aeronautical University Press, 1995), 18.

[16] Mica A. Endsley, "Toward a Theory of Situation Awareness in Dynamic Systems" Human Factors 37 (January 1995), 33.

[17] Ibid. 36.

[18] Ibid.

[19] McMillan, 38.

[20] Cynthia Dominguez, "Can SA be Defined?," Situation Awareness: Papers and Annotated Bibliography AL/CF-TR-1994-0085, ed. M. Vidulich, C. Dominguez, E. Vogel and G. McMillan Wright-Patterson Air Force Base, Ohio: Armstrong Laboratory, 1994), 9.

[21] Endsley, "Toward a Theory," 36.

[22] Richard W. Pew, "The State of Situation Awareness Measurement: Circa 1995," Proceedings of the International Conference on Experimental Analysis and Measurement of Situation Awareness , ed. Daniel J. Garland and Mica Endsley, (Daytona Beach, FL: Embry-Riddle Aeronautical University Press, 1995), 8-9.

[23] Billings, 1.

[24] Ibid.

[25] Ibid.

[26] Mica A. Endsley and Esin O. Kiris, "The Out-of-the-Loop Performance Problem and Level of Control in Automation" Human Factors 37 (January 1995), 384.

[27] Ibid.

[28] Billings, 4.

[29] Endsley, "Toward a Theory," 40.

[30] Ibid., 51.

[31] Ibid., 52.

[32] Endsley and Kiris, 394.

CHAPTER 3

METHODOLOGY

> We must have freedom of mind, no prejudices, no prepossession, no fixed ideas, no opinion accepted without discussion and merely because it has always been heard or practiced. There should be only one test-reason.
>
> Marshal of France Ferdinand Foch, quoted in Liddell Hart, Foch: The Man of Orleans (1931)

Purpose

This chapter describes the analytical approach used to "arrive at a dependable solution"[1] to the research question. The organization of this thesis paper parallels the research method used. Each chapter of this study presents information gained through specific research steps and serves as a building block for following procedures. Therefore, this work follows a logical, sequential process of gathering facts and evidence, performing analysis and culminates in formulating conclusions and making recommendations.

Research Design

This study is most accurately characterized as a *descriptive comparison* form of research. An eight-step analytical process was designed and used in this effort. The eight steps of this research design are:

Step 1: Definition of the Problem. Preliminary inquiry resulted in the development of a central issue characterizing a problem in the development of digital warfighting TTP. This central issue was further examined and structured as a primary research question based upon verification of the problems existence. The preliminary research performed to establish the existence of the problem identified compelling indicators as to the importance of this research to the field of contemporary military science. Chapter one recorded the results of this preliminary process.

Step 2: Determination of Variables to the Problem. The next step of the research design aimed to determine the critical elements, or variables, of the problem. A more detailed review of relevant literature assisted in isolating and refining the variables that make up the research problem. These variables are FBCB2 capabilities and maneuver functions and tasks. This step resulted in identification of precise informational needs for this study. These informational needs became the focus of the literature review. Additionally, this step also resulted in a several revisions of the primary research question. This step was also addressed in Chapter one.

Step 3: Identification of Current State of the Variables. A focused literature review was performed and resulted in meeting the studies information needs and providing answers to secondary research questions. This step was critical in the determination of the current state (or *what is*) of the variables needed later in the research process for deriving conclusions and recommendations for *potential* (or *what could be*) applications of digital SA. Both Chapters one and two provide the results of this step.

Step 4: Establishment of a Relational Model of FBCB2 Capabilities to Maneuver functions. After determination of the current states of each of the variables, it was essential to relate them to one another. In this study, the FBCB2 capabilities were related to the tactical maneuver functions. The outcome desired is the identification of which FBCB2 capabilities are involved in the performance of each of the maneuver functions and tasks. Both subjective and objective data were used as evidence proving the existence of these relationships. This data was gained by the literature review of TTP and AWE findings. Results of this step are found in Chapter four.

Step 5: Application of Screening Criteria to Determine Improvement Potential. Determination of critical relationships between the major variables is insufficient to answer the primary research question. Therefore, Step 5 takes this process a step further in order to search for evidence of an *improved* relationship between the variables. This step required the development and definition of screening criteria that measure actual or potential improvements to the performance of maneuver functions when aided by digital SA. The results of this step are found in Chapter four.

It is important to note that Steps 1 through 5 generally follow an inductive reasoning methodology where "observed facts are used to generate a theory."[2] This theory is primarily a set of assumptions (gained by observation) that describe a valid relationships between the two research variables. The remaining steps of this research follow a deductive reasoning process that asks "what are the consequences of the theory."[3]

Step 6: Analysis to Determine What Maneuver Functions C*an Be* Improved. This step analyzes the evidence gained from Steps 4 and 5. The outcomes of this step determine whether the relationships caused by the integration of FBCB2 to maneuver functions have a performance improvement effect. More importantly, this step answers the primary research question. The outcome of this step is expressed as determination of the presence, nature and description of a causal effect. These findings are addressed in Chapters four and five.

Step 7: Comparison of Current State to Potential State. The next step of this research design compares the current state of digital TTP to the potential state of the *improved* FBCB2-enabled maneuver functions and tasks. Conclusions are then made relative to the potential state.

This step results in establishing both scope and significance for the answer to the primary research question. Conclusions made of this comparison are expressed in Chapter five.

Step 8. Formulate Recommendations for Potential TTP Applications and Further Research. The last step of this research design is the formulation of recommendations based upon the answer to the primary research question. Additionally, recommendations are made for further research in this field. Recommendations are found at Chapter five.

This research would be incomplete without a mechanism for drawing conclusions as to the validity of the research design itself. To complete this research, conclusions are made in Chapter five that address the following concerns:

1. Did the research design adequately address the research question?
2. Did the research design accurately define the variables?
3. Can the results of the study be generalized to larger tactical echelons?

Measurement Procedure

This section provides an overview of the measurement theory used to answer the research question of this study. Specifically, a measurement theory describes "a set of assumptions about the way the world of theory is related to the world of observation."[4] For this study, a measurement theory was designed to *logically* relate FBCB2 digital situational awareness capabilities to the functions and tasks of tactical maneuver to produce a set of FBCB2-*enabled* maneuver functions. Then, the FBCB2-*enabled* maneuver functions were examined against screening criteria that indicate the presence and nature of improvement. In a practical sense, the measurement system of this study is used to determine causal relationships between observations and the theoretical underpinnings of the digital situational awareness concept as applied to the ground maneuver.

The specific measurement procedure devised and employed is composed of Step 4 (develop relational model) and Step 5 (apply evaluation criteria) of the overarching research design addressed earlier in this chapter. First, a relational model was developed to link specific FBCB2 capabilities to each maneuver function and task. The basis for these linkages are: evidence of applications in current TTP, observations from AWEs, and subjective judgments from military experts.

The product Step 4 is a model showing FBCB2-*enabled* maneuver functions and tasks. Thus, this model only shows the logical "relatedness" of the two variables and does not make any judgments as to the nature or value of these relationships.

The objective of Step 5 of the measurement procedure is the identification of the nature of the relationships from the relational model. Specifically, this step applies screening criteria to identify current or potential improvements for each maneuver function and task. The product of this step is a matrix that identifies *improved* FBCB2-*enabled* maneuver functions and tasks.

This research procedure recognizes that these causal relationships are not mutually exhaustive, meaning that other variables are involved that may influence performance in addition to FBCB2 situational awareness. However, this limitation does not inhibit the search for a valid answer to the primary research question. Moreover, this measurement procedure looks only to examine maneuver functions where evidence of improvement potential exist. Therefore, the identification of negative effects of applying digital situational awareness to maneuver are not within the scope of this research. Thus, the outcomes of this measurement procedure allow the determination of logical, casual relationships (if they exist) that indicate potential performance increases for maneuver TTP at the company team level.

Screening Criteria

Identifying improvements in the performance of maneuver functions is the goal of this research. Therefore, selecting valid screening criteria that indicate improvement are essential. This study uses three screening criteria:

Criterion one is the speed of function or task performance. This criterion determines whether there is evidence that a maneuver function or task could be performed faster. This criterion assumes that an increase in task performance, without loss of effectiveness, would constitute an improvement to current capabilities.

Criterion two is the level of interaction between leaders and subordinates. This criterion determines whether evidence exists to indicate an increase in leader and subordinate interaction before, during and after the performance of a maneuver function. This criterion assumes that increased interaction is achieved without degradation of timeliness of action, leader autonomy, or task overloading of the soldiers involved.

Criterion three is the level of orientation. This criterion determines whether evidence exists to indicate an increased capability to achieve and maintain physical alignment of unit combat vehicles and weapon systems in relation to critical aspects of terrain, enemy targets, and other friendly forces. This criterion assumes that achieving increased levels of orientation will cause improvement to performance of maneuver related tasks.

For the purpose of this study, an improvement is defined as the presence of one or more screening criteria for a specific FBCB2-enabled maneuver function and task.

Summary

The research design described in this chapter provides the means to answer the primary research question. The measurement procedure used includes accepted (albeit inexact) features for comparison, determining causal relationships and deriving valid conclusions for the current state of digital TTP applications. More importantly, this research design enables the formulation of recommendations as to potential applications of digital situational awareness capabilities to improve tactical performance.

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[1]U.S. Army, ST 20-10 Master of Military Art and Science Research and Thesis (Fort Leavenworth, KS: U.S. Army Command and General Staff College, June 1996), 9.

[2]Claire Sellitz, L.S. Wrightman, and S.W. Cook, Research Methods in Social Relations (New York: Holt, Rinehart and Winston, Inc., 1976) 6.

[3]Ibid., 7.

[4]Ibid., 38.

CHAPTER 4

ANALYSIS

> Armed forces execute dominating maneuver when they successfully exploit technology, organization, training, and leadership to attain qualitatively superior fighting power as well as dramatic positional advantages in time and space which the enemy's countermeasures cannot defeat.[1]
>
> Colonel Douglas A. Macgregor, Breaking the Phalanx

Purpose

This chapter highlights the analysis of data gathered to answer the primary research question. The results of this analysis are represented in two models. The first model identifies tactical maneuver functions that are enabled by digital situational awareness capabilities of the FBCB2 system. The product of this analytical model is FBCB2-enabled maneuver functions. The second model takes the FBCB2-enabled maneuver functions and measures them against screening criteria that indicate their potential for improving performance. This chapter concludes with a presentation of findings gained through synthesis of these two models.

Analysis of FBCB2 Capabilities Related to Maneuver Functions

Determining which maneuver functions can be improved by applying digital situational awareness required the construction of a model that logically relates digital capabilities to specific maneuver functions. The FBCB2 Capabilities Related to Maneuver Functions model at Table 4 portrays these connections. This model determines a maneuver function or task to be designated as being enabled by FBCB2 if any of the FBCB2 system's twenty capabilities are found to aid in the performance of the function.

Analysis of Table 4 information finds all maneuver functions and tasks affected by FBCB2 capabilities. Furthermore, the degree to which digital situational awareness affects each maneuver function is not equal. While all functions were found to be affected by FBCB2, they were so to varying degrees. Analysis of the variations between FBCB2 affects suggest that maneuver functions involving the employment of direct fire have a greater relationship with FBCB2 capabilities than other maneuver functions that do not involve direct fire. A more detailed analysis of this model finds patterns that describe these relationships in deeper dimensions.

Additional analysis was performed to more fully understand the significance of the relationships of FBCB2 to tactical maneuver functions as represented in Table 4. The first area of inquiry was to determine the number of different FBCB2 capabilities involved in the performance of each maneuver function. This was accomplished in order to gain insights into which maneuver functions were most affected, in a quantitative sense, by digital situational awareness. This measurement procedure records the number of FBCB2 *capabilities* involved in the performance of each maneuver function. For this analysis, the maximum number of possible FBCB2 capabilities found in any one maneuver function is twenty. Therefore, a score of twenty capabilities would mean that every FBCB2 capability is utilized in the performance of a particular maneuver function. After scoring the maneuver functions in this manner, they were rank ordered. By rank ordering the maneuver functions from the most FBCB2 capabilities to the least, insights were gained about the variations in FBCB2 affects. The FBCB2-enabled maneuver functions in rank order are:

1: Integrate Direct-Fire with Maneuver Function (20 FBCB2 capabilities)

2: Control Terrain Function (average 10 FBCB2 capabilities)

2a: Control by Fire Task (10 FBCB2 capabilities)

2b: Control by Occupation Task (10 FBCB2 capabilities)

3: Engage the Enemy Function (average 7.7 FBCB2 capabilities)

3a: Process Targets Task (8 FBCB2 capabilities)

3b: Select Weapon Systems Task (8 FBCB2 capabilities)

3c: Select Targets Task (7 FBCB2 capabilities)

4: Move Function(average 5.3 FBCB2 capabilities)

4a: Position/Reposition Forces Task (6 FBCB2 capabilities)

4b: Negotiate Terrain Task (5 FBCB2 capabilities)

4c: Navigate Terrain Task (5 FBCB2 capabilities)

There are several significant outcomes achieved by this step. First, a list of 10 FBCB2-enabled maneuevr functions was developed for further analysis. Secondly, patterns began to form regarding the applicability of each FBCB2 capability towards maneuver functions. This data suggests that every FBCB2 capability is employed in the maneuver function of Integrating Direct Fire with Maneuver. Ten of the twenty, or half , of the FBCB2 capabilities were involved in the performance of the Controlling Battle Space function. Engagement of the Enemy and Move functions were found to be positively affected by FBCB2 , but with lesser numbers of FBCB2 capabilities applied. This information clearly establishes that digital situational awareness capabilities have a strong influence upon the four maneuver functions.

Another measurement procedure used to better understand the relationship between maneuver functions and FBCB2 capabilities involved focusing upon the specific FBCB2 capabilities over the full range of maneuver functions. Where the previous measurement determined the number of FBCB2 capabilities in each maneuver function, this procedure aimed to determine the number of times each one of the twenty FBCB2 capabilities was involved in all ten maneuver functions and tasks. This procedure took a deeper look into the relationship between digital situational awareness capabilities and maneuver by measuring the number of times that FBCB2 capabilities are involved in the performance of all ten maneuver functions and tasks. Therefore, the best score a FBCB2 capability could receive would be ten applications. This would mean that an FBCB2 capability was involved in every maneuver function and task. The rank ordering of FBCB2 capabilities from the most to the least maneuver applications are:

1: Friendly Situational Awareness Reports (10 maneuver applications)

2: Overlays (9 maneuver applications)

Coordinate Combat Operations (9 maneuver applications)

3: Report Enemy Information (6 maneuver applications)

Report Identification Friend/Foe (6 maneuver applications)

4: Report Combat Information (4 maneuver applications)

Obstacle Report (4 maneuver applications)

Logistics/Personnel Report (4 maneuver applications)

5: Medevac Report (3 maneuver applications)

Battle Damage Assessment Report (3 maneuver applications)

Request for CAS (3 maneuver applications)

Call for Fire (3 maneuver applications)

Intel Planning (3 maneuver applications)

Analysis of this data indicates that FBCB2 capabilities that aid in general purpose tasks, such as providing situational awareness and enemy information, have the greatest impact upon the performance of all tactical maneuver functions. Perhaps this significant impact is realized because digital situational awareness mitigates the great difficulty in exchanging situational awareness data within voice-only radio transmissions.

Determination of which FBCB2 capabilities *least support* maneuver functions and tasks was the final measurement procedure used to analyze the relationship between FBCB2 capabilities and maneuver functions. This measurement was performed the same as the procedure used to identify the *most* applications of FBCB2 capabilities to maneuver functions. Inverting the rank order procedure from least to most maneuver applications was the only difference in this measurement. A threshold of two or less maneuver applications was established in order to eliminate duplication of data from the previous analysis. The rankings are:

1: NBC Reports (1 maneuver application)

Alerts (1 maneuver application)

R&S (1 maneuver application)

OPORD (1 maneuver application)

Plan Combat Ops (1 maneuver application)

2: EPW Request (2 maneuver applications)

Analysis of this data indicates that planning-oriented and single purpose tasks, such as NBC and EPW reporting, have the least impact upon tactical maneuver functions and tasks. This may be caused by either the lack of need to digitize these tasks or shortcomings to the design of the FBCB2 capabilities that support them. Determination of which factor is causing this finding is beyond the scope of this research. Regardless, this finding is helpful in understanding the nature of the relationship between digital situational awareness and tactical maneuver functions.

Analysis of FBCB2-Enabled Maneuver Functions Related to Screening Criteria

The next major step of this analytical process was to examine the FBCB2-enabled maneuver functions for evidence or performance improvement. This step involved applying three screening criteria designed to indicate actual or potential improvements to the performance of the FBCB2-enabled maneuver functions and tasks. The resulting data of this process is presented in Table 5. A simple three step process was used to complete this step of the research. This process was to:

1. Identify which FBCB2 capabilities are involved in the performance of each FBCB2-enabled maneuver function from Table 4.
2. Determine the presence of the screening criteria for each application.
3. Establish a rationale for each positive screening criterion

The data in Table 5 indicates the presence of one or more of the performance improvement criteria to each of the FBCB2-enabled maneuver functions and tasks. Therefore, this data suggests that digital situational awareness can improve the performance of *all* maneuver functions and tasks. Moreover, five of the ten, or 50% of the maneuver functions and tasks showed presence of two or more of the screening criteria indicating a rather significant potential for improvement. In one case, that of the position/reposition forces task of the move function, evidence of all three improvement criteria were found. Preliminary analysis also finds that while all maneuver functions are improved by digital situational awareness, they are not improved for the same reasons or to the same degree.

Secondary analysis of this data was performed in order to reveal greater meaning of how digital situational awareness actually improves task performance. The first concern was to examine the distribution of performance criteria to the maneuver tasks. The rank ordering of the improvement criteria from most prevalent to least was found to be:

1. Increased Orientation (present in 7 of 10 maneuver tasks)
2. Increased Interaction (present in 6 of 10 maneuver tasks)
3. Increased Speed of Task (present in 3 of 10 maneuver tasks)

The most prevalent improvement criteria is increased level of orientation. Evidence of this criteria were found in seven of the ten, or in 70%, of the FBCB2-enabled maneuver functions and tasks. Moreover, the confidence level of this finding is very high because it is based primarily upon AWE observation data. The significance of this finding is that tactical functions that require maintaining physical orientation, or alignment, of combat vehicles, weapon systems and units can benefit most from digital situational awareness.

Evidence of increased speed of maneuver task performance was found the least. Three of the ten maneuver tasks, or 30%, contained evidence of digital situational awareness capabilities as enabling the tasks to be performed faster than without digital systems. Interestingly, evidence of increased speed in task performance were found in many maneuver functions at the sub-task level. However, increased speed in sub-task performance via digital systems was not found to result in the major task or function being performed any faster. Simply stated, there is evidence of being able to do some of the lower-order tasks faster. The significance of this is that digital situational awareness systems do have a positive impact at the sub-task level even if the primary tasks they support are not performed at a greater rate. Most of the sub-tasks identified as being accelerated were planning-oriented procedures.

The final step of this analytical process was performed in order to examine which improvement criterion impacted the most toward each maneuver function. The objective was to examine the data from Table 5 to determine which criterion, increased speed, level of interaction or orientation, were the predominant cause of improvement to each of the maneuver functions. This analysis proved useful in determining the nature of these enhancements.

By examining the data in Table 5, it appears that both the Move and Control Terrain functions are improved predominantly by increasing the level of orientation of subordinate units through the use of digital situational awareness displays. The FBCB2 capabilities that assist in route planning, dissemination of hazard area information, such as obstacles and enemy position, and navigation aids were found to cause this increased level of orientation which are essential to performing the Move and Control Terrain functions of maneuver.

The Engage the Enemy function indicates that increases in speed of task performance were the most beneficial applications of digital situational awareness. More specifically, increasing the speed at which several critical task can be performed by the use of digital situational awareness systems results in an overall improvement to the performance of this maneuver function. The FBCB2 capabilities that allow first-line leaders to continuously and passively monitor the locations of their subordinates in relation to known or suspected enemy positions appear to reduce the time they require to select targets, select and assign subordinate weapons system for engagement, and to put fire control mechanisms into place within the window of time normally allotted in such circumstance. This affect results in creating advantage for digitally equipped units to act faster in time-competitive situations common to direct fire engagements.

Lastly, the Integrate Direct-Fire and Maneuver function was found to improve primarily through digital systems that increase the level of interaction between leaders and their subordinates. FBCB2 capabilities that support combat identification were found to have a major impact in this area. Additionally, the capability of integrating movement with engagement activities *while* leaders are physically remote historically has been found to be a major obstacle in the performance of this function. The FBCB2 capabilities that enable sharing of situational information in graphical format between commanders and leaders were found to offer new mechanisms for achieving integration during the execution of these activities.

Findings

The analysis of data gathered in this research effort resulted in identifying eight findings. These findings provide the answer to the primary research question, as well as serving as a basis for making conclusions and recommendations. In addition to answering the primary research question, these findings offer insight into the nature of the relationships between digital situational awareness capabilities and tactical maneuver functions and tasks. The findings are:

1. All tactical maneuver functions and tasks are affected by FBCB2 capabilities. The degrees to which the functions are affected by FBCB2 vary. The Integrate Direct Fire with Maneuver function was found most affected by FBCB2 while the Move function was found the least affected.

2. Tactical maneuver functions and tasks involving the employment of direct fire derive a greater benefit from FBCB2 capabilities than those functions that do not require fire.

3. FBCB2 capabilities that aid in the performance of general purpose tasks, such as sharing situational awareness information, have the greatest impact upon tactical maneuver functions and tasks.

4. Planning-oriented and single purpose FBCB2 capabilities have the least impact upon tactical maneuver functions and tasks.

5. Digital situational awareness can improve all tactical maneuver functions and tasks. Improvements to maneuver functions were generally found being caused by multiple reasons such as increases to the speed of task performance, increases in leader-subordinate interaction and increases in levels of orientation of those executing maneuver activities.

6. Tactical maneuver functions and tasks benefit the most from increased levels of orientation produced by digital situational awareness capabilities.

7. Increases in the speed of task performance as a result of FBCB2 were found primarily at the sub-task level. This indicates that digital situational awareness has a positive affect at lower levels even if the major tasks and functions which they support are not accelerated.

8. Move and Controlling Battle Space functions generally improve in terms of increases in orientation; Engagement functions are improved by the speed of their execution; and Integration of Direct Fire and Maneuver function improves by increased levels of interaction.

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[1]Douglas A. Macgregor, Breaking the Phalanx (Westport, Connecticut: Praeger Publishers, 1997), 37.

CHAPTER 5

CONCLUSIONS

Purpose

This chapter provides concluding statements that describe the nature of the study's findings. These conclusions attempt to explain why digital battle command systems effect tactical maneuver as described in previous chapters of this study. This chapter then makes several recommendations concerning future digital TTP development and applications of situational awareness. This chapter concludes with an evaluation of the research design used in order to establish a degree of confidence in its findings and conclusions.

Conclusions

This study makes five conclusions based upon the findings listed at the end of chapter four. These conclusions are made to explain why digital situational awareness effects the tactical maneuver functions as found in this study. The conclusions are:

1. Digital situational awareness can improve all maneuver functions by increasing the speed of task performance, increasing leader-subordinate interaction during task execution and increasing the levels of orientation of operators conducting maneuver activities. These improvements are based upon three reasons.

First, FBCB2 was found to enable units to perform maneuver tasks more rapidly by performing many of them simultaneously and earlier in the sequence of the larger processes or functions that they support. The shift from sequential task performance to simultaneous was observed during AWE Desert Hammer, where simultaneous target hand-off procedures enabled by digital situational awareness was found to decrease the time required for maneuver units to complete actions on contact.[1] Observers of AWE Focused Dispatch concluded that increased levels of situational awareness gained from digital systems resulted in units performing certain tasks earlier in the sequence of larger processes or functions, thus increasing the speed of its execution and achieving more expeditious movement and decreasing the response times required to act to unexpected battlefield situations.[2]

Secondly, digital situational awareness has been found to improve tactical maneuver because it increases the level of interaction between leaders and subordinates. This increased interaction is gained by technical means that enable increased collaboration during task performance and increased levels of participation by operators who are physically remote but connected via digital communications. These resultant effects expand the influence that both leaders and subordinates have in executing maneuver tasks by reducing many of the constraints imposed by physical separation and the limitations of conventional command and control systems. Moreover, AWE Desert Hammer observers concluded that this increased level of interaction resulted in increasing the number of fighting vehicles that participate in decisive engagements.[3]

Thirdly, maneuver functions performed with digital systems have been found to improve levels of orientation by increasing the accuracy, timeliness and usability of information provided to the operator. Most noteworthy is the finding that tactical information when presented in graphical format, such as icons, has been found to accelerate operator perception, comprehension and projection of future states by simplifying the use of graphical control measures.[4] This enhancement accounts for AWE observations attributing digital situational awareness as the primary factor in reducing the number of critical navigation errors, increasing the ability to integrate direct fire with obstacles and to increases in the secure maneuver of combat service support units.[5]

2. The degree to which digital situational awareness improves tactical maneuver functions vary based upon differences in (a) the level of situational awareness required for effective execution of each function, (b) the type of elements of situational awareness required to perform the function, and (c) the availability of key enabling capabilities such as far-target designation and combat identification devices. The reasons why these three areas differ is important in understanding the phenomena of digital situational awareness as applied to tactical maneuver.

This research concludes that each maneuver function has different informational requirements that operators need in order to perform them. More specifically, the levels of operator situational awareness required to perform them appears to be the reason that some maneuver tasks are more effected by digital systems than others. This study finds that those maneuver tasks which require the lowest level of situational awareness derive the greatest benefit from FBCB2. By using Endsley's "construct of the levels of SA, the ability to perceive ones' environment (level 1 SA)"[6] appears to be best provided by the current FBCB2 system. Conversely, the current state of the FBCB2 system is limited in its capacity to support operators performing maneuver tasks or functions requiring significant degrees of level 2 and 3 SA.

The type of awareness required by the operator also appears to effect the degree to which digital systems improve maneuver. By comparing the informational requirements of operators performing each of the tactical maneuver functions to Pew's "five elements of awareness"[7] it appears that the type of awareness required for task performance, such as spatial, goal, system, resource or crew, greatly effects the degree to which digital systems are used. This study concludes that the current state of FBCB2 provides information primarily supporting the elements of spatial and resource awareness. Thus a maneuver task requiring a high degree of crew awareness such as load, aim and fire a weapon system would not be significantly improved by the current digital battle command system.

Another reason for this variance in levels of improvement due to digital situational awareness is the availability of key enabling technologies such as far-target designation and combat identification systems. The tactical maneuver function of Engaging the Enemy is predicated upon tasks that select targets and weapon systems to engage them with. In this case, the principle task is to obtain unknown information - not it's dissemination. Digital units with M1A2 tanks equipped with far-target designation capabilities use advanced technical means to derive unknown information and automatically integrate it into their digital battle command system for rapid dissemination. The degree to which enabling capabilities such as far-target designation are available and integrated into the battle command system greatly effects the degree to which digital situational awareness improves tactical maneuver.

3. Increased level of orientation is found to be the greatest benefit gained by employing digital battle command systems to tactical maneuver functions. As was found in recent developments in aviation, contemporary ground combat has evolved to a level of complexity that demands the aid of advanced information systems in order to perform effectively. The difficult cognitive task of maintaining orientation while performing company team maneuver requiring synchronized actions with up to 24 friendly individual combat platforms, against an infinite array of threat systems, within a dynamic physical battlefield environment has been exacerbated by recent increases in operational tempo. Inadequacies with current command and control procedures and communications systems in sustaining operator orientation to acceptable levels appear to be mitigated to a significant degree by technical solutions that create digital situational awareness. AWE observations to date have found that digital battle command systems advance

operator situational awareness to a higher state of orientation than conventional command and control systems. These factors appear to account for the nature of improvements observed of digital systems.

4. Tactical maneuver functions that involve employment of direct fire receive the greatest benefit from digital situational awareness because digital systems reduce cognitive workload by "providing integrated information that allow operators to perform at a higher level"[8] while performing direct fire tasks. The capability to depict and convey engagement information within an integrated graphical display appears to "allow the operator to achieve more situational awareness at a given level of workload."[9] This would account for AWE observations that describe units being capable of integrating more combat systems into decisive engagements as well as completing the engagements much faster than non-digital units.

5. Tactical maneuver functions receive a greater benefit from FBCB2 capabilities that provide information for multiple uses rather than single uses because it precludes some of the operator's out-of-the-loop performance problems associated with fully-automating tasks. The findings of Endsley and Kiris' "out-of-the-loop"[10] research conducted in 1995 appear to account for this conclusion. Maneuver tasks performed with information solely provided by digital means where not found to derive significant levels of improvement during recent AWEs. Examples of this are chemical and air attack early warning and reporting tasks. The near-full automation of these tasks within FBCB2 was found to cause operator complacency and passivity during performance. Conversely, maneuver tasks performed with partial-automation of operator situational awareness information were found to have significantly fewer out-of-the-loop problems.

Recommendations

This section makes recommendations as to how the Army can maximize the application of digital situational awareness towards improving tactical maneuver in the future. The purpose of these recommendations is to provide a broad, conceptual basis for the continued development of digital warfighting tactics, techniques and procedures. As such, they are intended to set an azimuth for future research, experimentation and implementation.

1. This study finds that current applications of digital battle command effectively support improvement of tactical maneuver functions and tasks and recommends the continued development of FBCB2. To do so would require a continued commitment to develop digital architectures using the new, bottom-up approach established by FBCB2. This design focuses on the informational needs of the small-unit warfighter and builds upward to his command structure. This study finds this new paradigm essential to optimizing the use of digital technology on the battlefield.

2. The availability of key enabling systems that capture or derive critical target information such as far-target designation of the M1A2 and combat identification devices are crucial in gaining a digital situational advantage. These enabling systems should be developed for all combat platforms, especially infantry fighting vehicles. This study's findings strongly recommend that procurement decisions in the future take into account the major role these systems have upon achieving qualitative performance improvements when utilizing these systems embedded within a combat platform.

3. This study recommends that the Army initiate a major effort to reengineer the tactical decision making process given the significant changes in performance conditions that digitization creates. The central focus of such an effort should be to find procedures to better distribute the use of available time to develop more flexible plans given the greater propensity for digital units

to synchronize activities during execution. Several Army organizations, such as the National Training Center and the Command and General Staff College, are currently exploring modifications to the current planning process that capture the new conditions that digital systems create when monitoring, planning and directing tactical engagements and battles. Army senior leaders should continue to support such effort.

4. Recommend that the Army continue to support research of naturalistic decision making theories for potential application to digital battle command at the small-unit level. This area of research explains how decision making occurs as a natural though process of people involved in dynamic situations such as combat. Models like Klein's (1986) Recognition Primed Decision Model[11] appear to have great relevance towards the performance of digitally-enabled tactical maneuver and battle command functions. This study recommends experimentation and incorporation of naturalistic decision making strategies into digital battle command processes that support tactical maneuver.

5. This study finds the research completed in the situational awareness field as extremely relevant to the development of battlefield awareness. The states, levels and elements of situational awareness are useful constructs for military developers and practitioners to use to develop future warfighting capabilities. The Army should integrate more of these constructs into its leader development models and warfighting TTP. For example, understanding the five elements of situational awareness (Pew, 1995) would help company commanders to develop better information requirements, such as CCIR, as well as improving reporting techniques employed to disseminate critical combat information. Developing TTP that accounts for the three states of situational awareness (Pew, 1994) would assist in identifying reconnaissance objectives that are linked to key decisions and actions that may increase the probability of success of tactical engagements. These and other applications should be explored for the future.

6. Recommend that the Army re-examine the information system design descriptions of current and proposed digital systems based upon the findings in the Human Factors field. Contemporary research indicates that information system design has as much to do with creating cognitive overload as does the volume and frequency of information involved or procedures employed by the operator. Clearly, the Army must address all the variables effecting this important challenge if it intends to achieve a significant warfighting advantage by leveraging enhanced informational capabilities. The Information-Based Task Performance model described in Chapter Two appears to be a lucrative place to begin such an effort.

7. This study recommends that the development of our operators must parallel or exceed the rapid developments of the materiel systems in which they will fight with. Current technologies do not replace the human operator's function in deriving level 2 SA (comprehend the environment) and 3 SA (predict future states of the environment from the current), and making tactical decisions. Leader development through education and training is increasingly an essential enabling capability to digital warfighting. Situational awareness theory suggests that our warfighters will require a rich and broad array of mental models gained by repetitive, simulated and actual engagement experiences if they are to be capable of comprehending the information that is now available to them. This study recommends focusing the warfighting aspects of Army leader development towards developing the mental models required to comprehend tactical situations and predict future states from them.

8. This study recommends that the Army continue to develop digital technologies employing the strategy of partial-automation in order to preclude or mitigate the potential for operator out-of-the-loop performance problems. Additionally, training strategies must contend with the dual nature of training both manual and automated modes of many critical tasks in order to maintain the capacity for operators to perform during periods of system failure. To do so

would require the Army to develop a full complement of training literature, including Soldier's Manuals that incorporate both digital and manual procedures.

9. Future research of this topic should be focused upon comparing these findings with the data gained from the recent Army Task Force XXI Advanced Warfighting Experiment completed in March, 1997. Validating or refuting the conclusions made in this study based upon new evidence would advance this most important field of contemporary military science. Towards this end more research is recommended.

Evaluation of Research Design

The research design results in an acceptable degree of confidence for conclusions about the manner in which digital situational awareness improves tactical maneuver functions within the parameters set forth in this study. Given the relative immaturity of this field of military science, this research design was intended to induce an unproved solution to the primary research question based upon observed facts gained during experimentation and theoretical conclusions of the literature review. Towards this end this research is successful. However, a shortcoming exists that requires articulation for those undertaking further research of this topic.

The validity of applying the conclusions made regarding the capabilities of the FBCB2 system in the future is somewhat limited due to the changing nature of the prototype system examined. Effort to extend the validity of these findings was made by controlling this variable by examining both objective and supplied FBCB2 capabilities. Any major changes to the capabilities being developed for the objective FBCB2 system will require further research to determine optimal applications. Despite this shortcoming, the conclusions made in this study remain within acceptable level of validity.

While this study examined the effects of digital situational awareness on maneuver functions at the company team level, it's findings are not limited to this echelon alone. The conclusions and recommendations made are reasonably valid for extrapolating to battalion and brigade echelons as well. During the conduct of this research significant evidence was found to validate the causal relationship between digital situational awareness and maneuver functions at echelons above company. Moreover, many of the conclusions and recommendations regarding the use of situational awareness apply to other battlefield functions other than maneuver. The battle command and fire support functions are found to share reasonably similar relationships with digital systems as does maneuver. In these instances, this study may serve a broader purpose of advancing the development of digital warfighting at all tactical echelons. If so, then this research was successful.

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[1]U.S. Army Armor Center Final Report Advanced Warfighting Experiment Operation Desert Hammer VI (Fort Knox, KY: Mounted Warfighting Battlespace Lab, 1994), D-9.

[2]U.S. Army Armor Center Final Report Advanced Warfighting Experiment Focused Dispatch (Fort Knox, KY: Mounted Warfighting Battlespace Lab, 1996), 3-9.

[3]Final Report Advanced Warfighting Experiment Operation Desert Hammer VI, D-32.

[4]Final Report Advanced Warfighting Experiment Focused Dispatch, A-78.

[5]Ibid., 3-9.

[6]Mica A. Endsley, "Toward a Theory of Situation Awareness in Dynamic Systems" Human Factors 37 (January 1995), 36.

[7]Ibid., 35.

[8]Mica A. Endsley and Esin O. Kiris, "The Out-of-the-Loop Performance Problem and Level of Control in Automation" Human Factors 37 (January 1995), 384.

[9]Endsley, "Toward a Theory," 51.

[10]Endsley and Kiris, 394.

[11]Gary A. Klein, R. Calderwood and A. Clinton-Cirocco, "Rapid Decision Making on the Fire Ground" Proceedings of the Human Factors Society 30th Annual Meeting (1986), 576.

Table 1. Capabilities of Force XXI Battle Command-Brigade & Below (FBCB2)

1.0	Friendly Situational Awareness Reporting
2.0	Identify Friend or Foe (IFF)
3.0	Conduct Intelligence Planning
4.0	Report Enemy Information
5.0	Collect/Disseminate Combat Information & Intelligence
6.0	Plan Combat Operations
7.0	Prepare and Issue Orders
8.0	Coordinate Combat Operations
9.0	Request Fire Support
11.0	Collect / Report RECON & SURVEILLANCE Information
12.0	Prepare and Issue Alerts
13.0	Report NBC Information
14.0	Report Battle Damage Assessment
15.0	Request MEDEVAC
16.0	Report Obstacles
17.0	Prepare and Consolidate Overlays
18.0	Plan & Report Logistical/Personnel Information
19.0	Report EPW, Non-Combatants & Detainees
20.0	Network Management

Source: U.S. Army, Force XXI Battle Command - Brigade and Below (FBCB2) User Functional Description (Fort Knox, KY: U.S. Army Armor Center, 1995), 1.

Table 2. Maneuver Functions and Tasks

T.A 1.1 MOVE:

TA.1.1.1 Position/Reposition Forces

- -TA. 1.1.1.1 Prepare for Movement
  - -Load
  - -Inspect

- -TA 1.1.1.2 Move While Mounted
  - -Initiate Movement
  - -Formations & Movement Techniques
  - -Respond to Vehicle Emergencies
  - -Transfer Between Modes of Conveyance

- -TA 1.1.1.4 Close into Tactical Positions
  - -Disembark From Conveyance
  - -Deploy Into Position

TA.1.1.2 Negotiate Terrain

- -Travel Over Unimproved Terrain
- -Ford/Swim
- -Cross Gaps in Stride
- -Self-Breach Obstacles
- -Self-Recovery

TA.1.1.3 Navigate

- -Determine Distance, Direction, Location and Elevation
- -Select Routes
- -Provide Data for Navigation Aids
- -Maintain Orientation
- -Determine Rates of Movement

T.A 1.2 ENGAGE ENEMY:

TA.1.2.1 Employ Direct-Fire

- -TA. 1.2.1.1 Process Direct-Fire Targets

- -TA.1.2.1.1.1 Select Direct-Fire Targets
  - -Designate Target Areas/Fields of Fire
  - -Prepare Sector Sketch
  - -Choose Targets for Engagement

Table 2. Maneuver Functions and Tasks (Continued)

TA.1.2.1 Employ Direct-Fire (continued)

-TA.1.2.1.1.2 Select Direct Fire Systems
- -Determine System Capabilities
- -Determine System Availability
- -Choose Weapon Systems

-TA.1.2.1.2 Engage Direct-Fire Targets
- -Emplace Direct-Fire Weapons
- -Update Fire Control Systems
- -Prepare Ammunition
- -Load, Aim and Fire Weapons

T.A 1.3 CONTROL BATTLE SPACE/TERRAIN:

-TA.1.3.1 Control Terrain Through Fire/Fire Potential

-TA.1.3.2 Occupy Terrain
- -Occupy Fighting Positions
- -Occupy Support Positions

T.A 1.4 INTEGRATE DIRECT FIRE WITH MANEUVER:

-Combine all tactical direct-fires with the maneuver into a cohesive action.

Source: U.S. Army, TRADOC Pamphlet 11-9 Blueprint of the Battlefield (Fort Monroe, VA: U.S. Army Training and Doctrine Command, September 1993, D-1.

Table 3. Current Digitized Company Team TTPs
(As Related to Maneuver Functions)

Maneuver Function: Move

Move Dispersed During Limited Visibility (A,I)
Select Maneuver Routes with Digital Information System (A,I)
Navigate Using Digital Information System (Waypoints) (A,I)
Maintain Formation Orientation by Monitoring Automatic Position Reports (A,I)
Move To/Through Breached Lanes with Digital Route Information (A,I)
Inspect Subordinate Maneuver Graphics While Remote (A,I)
Use Movement En Masse Formation (A,I)
Monitor Movement Progress with Digital Reports (A,I)
Move on Dispersed/Separate Routes (A)

Maneuver Function: Engage Enemy

Digital Call-For-Fire Technique (A,I)
Orient/Control Fires with Digital TRPs (A,I)
Prepare/Disseminate Digital Sector Sketches (A,I)
Shift Fires Between Overwatch and Maneuver Forces with Digital Icons (I)
Select/Monitor Target Engagements with Digital TRPs (I)
Integrate Platoon and Company Fire Plans Digitally (A,I)
Perform Precision Combat Identification (A)

Maneuver Function: Control Terrain

Digitally Exchange Graphics with Adjacent Units (A,I)
Orient/Monitor Reorganization-Consolidation with Digital Information (A,I)
Perform Overwatch of Key Terrain while Maintaining Awareness (I)
Monitor Friendly Forces Operating in Terrain Beyond Physical View (A,I)
Initiate Be Prepared Missions with Digital Graphics (A,I)
Coordinate / Execute Passage of Lines with Digital Situational Awareness (A,I)

Maneuver Function: Integrate Direct Fire with Maneuver

Develop/Fight With Digital Fire Plans (A,I)
Control Direct Fires and Maneuver with Digital Information (A,I)
Digitally Disseminate Results of Leaders Recon (A,I)
Perform Digital Obstacle Reporting (A,I)
Integrate Fires and Maneuver by Dynamic Digital Overlay Management (A,I)
Direct Fire and Maneuver with Digital Icons (I)
Integrate Adjacent/Supporting Unit Maneuver/Fires by Digital Overlay Exchange (A,I)

Note: The designation (A) denotes an Appliqué TTP; (I) denotes an IVIS-based TTP.
Source: U.S. Army Armor Center, Special Text 71-1-1, Tactics, Techniques and Procedures for the Digitized Company Team (Fort Knox, KY: U.S. Army Armor Center, 1995), 3-1.

Table 4. Relationship of FBCB2 Capabilities and Maneuver Functions

FBCB2 Capabilities	Maneuver Functions and Tasks (at Company Team Level)									
	Move			Engage				Control Terrain		Integrate DF w/ Maneuver
	pos	negotiate	navigate	process tgts	select tgts	select syst	engage tgts	control fire	occupy terrain	
1.0 SA Report	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2.0 IFF	N	N	N	Y	Y	Y	N	Y	Y	Y
3.0 Intel plan	N	N	Y	Y	N	N	N	N	N	Y
4.0 Enemy info	N	N	N	Y	Y	Y	N	Y	Y	Y
5.0 Combat info	N	N	N	Y	Y	Y	N	N	N	Y
6.0 Plan cbt ops	N	N	N	N	N	N	N	N	N	Y
7.0 OPORDs	N	N	N	N	N	N	N	N	N	Y
8.0 Coord cbt ops	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
9.0 CFF	N	N	N	N	N	N	Y	Y	N	Y
10.0 CAS	N	N	N	N	N	N	Y	Y	N	Y
11.0 R & S	N	N	N	N	N	N	N	N	N	Y
12.0 Alerts	N	N	N	N	N	N	N	N	N	Y
13.0 NBC	N	N	N	N	N	N	N	N	N	Y
14.0 BDA	N	N	N	N	N	N	Y	Y	N	Y
15.0 Medevac	Y	N	N	N	N	N	N	N	Y	Y
16.0 Obstacle rpt	Y	Y	N	N	N	N	N	N	Y	Y
17.0 Overlays	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
18.0 Log/Pers	N	N	N	N	N	Y	N	Y	Y	Y
19.0 EPW	N	N	N	N	N	N	N	N	Y	Y
20.0 Net mgnt*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes: * FBCB2 capability "network management" is required for all functions/tasks

Table 5. Relationship of FBCB2-Enabled Maneuver Functions to Improvement Criteria

FBCB2-Enabled Maneuver Functions and Tasks	Improvement Criteria (Screening Criteria)		
	Increase in speed of task performance	Increase in leader & subordinate interaction	Increase in level of orientation
Integration of DF w/ maneuver	NO	YES (D, S)	YES (A, D)
Control terrain with fire	NO	NO	YES (D, S)
Occupy terrain	NO	YES (D, S)	YES (D, S)
Engage: Process targets	NO	YES (A, D)	NO
Engage: Select weapon systems	YES (A, D)	NO	NO
Engage: Select targets	YES (D, S)	YES (D, S)	NO
Engage: Engage targets	NO	NO	YES (A, D)
Move: Position/reposition	YES (A, D)	YES (A, D)	YES (A, D)
Move: Negotiate terrain	NO	YES (A, D)	YES (D, S)
Move: Navigate	NO	NO	YES (A, D)

Key: Basis for findings are A: from AWE observation; D: from current digital TTP;
S: subjective judgment by subject-matter expert

BIBLIOGRAPHY

Books

Macgregor, Douglas A. Breaking the Phalanx. Westport, CT: Praeger Publishers, 1997.

Owens, William A. Dominant Battlespace Knowledge. Washington, DC: National Defense University Press, 1995.

Sellitz, Claire, L.S. Wrightman, and S.W. Cook. Research Methods in Social Relations. New York, NY: Holt, Rinehart and Winston, 1976.

Senge, Peter M. The Fifth Discipline. New York, NY: Doubleday, 1990.

Turabian, Kate L. A Manual for Writers of Term Papers, Theses, and Dissertations. 6th ed. Chicago, IL: The University of Chicago Press, 1982.

Wheatley, Margaret J. Leadership and the New Science. San Francisco, CA: Berrett and Koehler Publishers, 1992.

Government Documents

Department of Defense. Joint Publication 3-0, Joint Operations. Washington, DC: The Joint Chiefs of Staff, 1995.

U.S. Army. Army Digitization Master Plan. Washington, DC: Army Digitization Office 1995.

_______. Army Enterprise Strategy. Washington, DC: Office of the Secretary of the Army, 1993.

_______. Army Modernization Plan-1996. Washington, DC: Office of the Secretary of the Army, 1993.

_______. Army Posture Statement FY 97. Washington, DC: Headquarters, Department of the Army, 1996.

_______. "Battle Command" (Draft 2.1). Fort Leavenworth, KS: Battle Command Battle Laboratory, 1994.

_______. Battle Command Techniques and Procedures; A Commander's Guide (Final Draft). Fort Leavenworth, KS: Battle Command Battle Laboratory, 1996.

_______. Battle Labs: Defining the Future. Fort Monroe, VA: Headquarters, Training and Doctrine Command, 1995.

_______. Field Manual 24-7, Army Battle Command Systems Management Techniques. Washington, DC: Headquarters, Department of the Army, 1995.

U.S. Army. Field Manual 100-5, Operations. Washington, DC: Headquarters, Department of the Army, 1993.

_______. Field Manual 101-5, Command and Control for Commanders and Staff (Final Draft), Fort Leavenworth, KS: US Army Command and General Staff College, 1995.

_______. Field Manual 101-5, The Staff and Combat Orders. Washington, DC: Headquarters, Department of the Army, 1940.

_______. Final Report: Advanced Warfighting Experiment Desert Hammer VI. Fort Knox, KY: Mounted Battlespace Battle Lab, 1994.

_______. Final Report: Advanced Warfighting Experiment Focused Dispatch. Fort Knox, KY: Mounted Battlespace Battle Lab, 1996.

_______. Force XXI, America's Army of the 21st Century. Fort Monroe, VA: Headquarters, Training and Doctrine Command, 1995.

_______. Fort Knox Supplemental Material 71-2-1, The Digitized Battalion Task Force. Fort Knox, KY: Headquarters, US Army Armor Center, 1995.

_______. Information Management Processes in High Performing Units. Fort Monroe, VA: Battle Laboratory Integration, Technology, and Concepts Directorate, 1995.

_______. Joint Venture Campaign Plan. Fort Monroe, VA: Headquarters, Training and Doctrine Command, 1995.

_______. Land Combat in the 21st Century. Fort Monroe, VA: Headquarters, Training and Doctrine Command, 1996.

_______. Requirements Determination. Fort Monroe, VA: Headquarters, Training and Doctrine Command, 1996.

_______. Student Text 20-10, Masters of Military Arts and Science Research and Thesis. Fort Leavenworth, KS: US Army Command and General Staff College, June 1996.

_______. Special Text 71-3, Tactics, Techniques and Procedures for the Digitized Brigade. Fort Knox, KY: US Army Armor Center, 1995.

_______. Student Text 101-5, Command and Staff Decision Process. Fort Leavenworth, KS: US Army Command and General Staff College, 1996.

______. TRADOC Pamphlet 525-XXX, "Concept for Battlefield Visualization" (Final Draft). Fort Monroe, VA: Headquarters, Training and Doctrine Command, 1995.

U.S. Army. TRADOC Pamphlet 525-5, The Evolution of Full Dimension Operations Concept. Fort Monroe, VA: Headquarters, Training and Doctrine Command, 1994.

______. TRADOC Pamphlet 525-69, Concept for Information Operations. Fort Monroe, VA: Headquarters, Training and Doctrine Command, 1995.

______. TRADOC Pamphlet 525-71, Force XXI Division Operations Concept. Fort Monroe, VA: Headquarters, Training and Doctrine Command, 1996.

______. User Functional Description: Force XXI Battle Command Brigade and Below. Fort Knox, KY: Headquarters, Armor Center, 1994.

Articles and Periodicals

Endsley, Mica A., and Esin O. Kiris. "The Out-of-the-Loop Performance Problem and Level of Control in Automation." Human Factors, 37, January 1995, 384.

Longhouser, John E. MG "Converting Computing Power into Combat Power." Army Research, Development and Acquisition Report, March-April 1996, 4.

Steele, Dennis. "Countdown to the Next Century," Army, November 1996, 20.

Reports

Billings, Charles E. "Situational Awareness Measurement and Analysis: A Commentary." Paper presented as part of the "Proceedings of the International Conference on Experimental Analysis and Measurement of Situational Awareness." Daytona Beach, FL: Embry-Riddle Aeronautical University, November 1995.

Cardine, Christopher V. "Digitization of the Battlefield." Army War College monograph. Carlisle Barracks, PA: U.S. Army War College, 1995.

Dominguez, Cynthia. "Can SA be Defined?" Situational Awareness: Papers and Annotated Bibliography, Report AL/CF-TR-1994-0085. Wright-Patterson Air Force Base, OH: Armstrong Laboratory, 1994.

Endsley, Mica R. "Theoretical Underpinnings of Situational Awareness Theory: A Critical Review." Paper presented as part of the "Proceedings of the International Conference on Experimental Analysis and Measurement of Situational Awareness." Daytona Beach, FL: Embry-Riddle Aeronautical University, November 1995.

Endsley, Mica R. "Toward a Theory of Situation Awareness in Dynamic Systems." Texas Tech University, Lubbock, TX, 1995.

Fallesen, Jon J. Technical Report 984 "Overview of Army Tactical Planning Performance Research." U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Leavenworth, KS, 1993.

Federico, Pat-Anthony. "Expert and Novice Recognition of Similar Situations." Navy Personnel Research and Development Center, San Diego CA, 1995.

Fischer, Susan C., and James Geiwetz. Technical Report 1031 "Training Strategies for Tactical Pattern Recognition." U.S. Army Research Institute for the Behavioral and Social Sciences, Santa Barbara, CA, 1996.

Flach, John M. Maintaining Situational Awareness when Stalking Cognition in the Wild. Paper presented as part of the "Proceedings of the International Conference on Experimental Analysis and Measurement of Situational Awareness." Daytona Beach, FL: Embry-Riddle Aeronautical University, November 1995.

Halpin, Stanley M. and Keene, Delane S. "Desert Storm Challenges: An Overview of Desert Storm Survey Responses." U.S. Army Research Institute for the Behavioral and Social Sciences, Research Report 1633, 1993.

Lickteig, Carl W., and Cathy D. Emery. Technical Report 1000 "Information Management Performance of Future Platoon Leaders: An Initial Investigation." U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Knox, KY, 1994.

Lussier, James W., and Terrill F. Saxon. "Critical Factors in the Art of Battle Command." US Army Research Institute for the Behavioral and Social Sciences, Fort Leavenworth, KS 1994.

Mayfield, Thomas D. "Parallel Planning: How Digital Information Systems Can Improve the Combat Decision-Making Process." School of Advanced Military Studies monograph. Fort Leavenworth, KS: Command and General Staff College, 1995.

McGinnis, Michael "Battlefield Information for Commanders." Naval War College monograph. Newport, RI: US Naval War College, 1995.

McMillan, Grant R. "Report of the Armstrong Laboratory Situational Awareness Integration Team." Situational Awareness: Papers and Annotated Bibliography. Report AL/CF-TR-1994-0085, Wright-Patterson Air Force Base, OH: Armstrong Laboratory, 1994.

Nichiporuk, Brian. Report DRR-659-A "Information Technologies and The Future of Land Warfare." RAND Arroyo Center, Santa Monica, CA 1994.

Pew, Richard W. "The State of Situational Awareness Measurement: Circa 1995." Paper presented as part of the "Proceedings of the International Conference on Experimental Analysis and Measurement of Situational Awareness." Daytona Beach, FL: Embry-Riddle Aeronautical University, November 1995.

Unpublished Materials

Hartzog, William W. GEN, Commander, U.S. Army Training and Doctrine Command. Meeting notes by author, 28 November 1995, Headquarters, Fort Monroe, VA.

Reimer, Dennis J. GEN, Chief of Staff, U.S. Army. Address notes by author, 25 October 1996, Fort Leavenworth, KS.

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