Technical Report 1117

Defining Digital Proficiency Measurement Targets for U.S. Army Units

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14. ABSTRACT *(Maximum 200 words)*: The U.S. Army is exploring the advantages of networked computer systems to enhance battlefield situation awareness and command and control, a program known as digitization. The long-term goal of the present effort is to develop measures of the skills needed to exploit the advantages of digitization. The initial challenge was to identify candidate digital skills, since there was no listing of digital skills available to use as a starting point. This report focuses on the approach used to identify candidate digital skills. First, data from the Center for Army Lessons Learned (CALL) were analyzed to identify long-term, high-profile problems likely to be addressed by the effective use of digital systems. Next, digital procedures that units might employ to address these problems, and the cognitive capabilities soldiers would need to implement these solutions, were described. Through this process, twenty-two candidate skills were identified which could be used to identify measures of skill performance. The findings of this report will be used to help define performance standards and develop after action review aids.

15. SUBJECT TERMS Digitization, Skills, Measures of Performance, Digital Training, Digital Skills, After Action Review, Situation Awareness, Battlefield Visualization, Command and Control

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FOREWORD

Digital communications networks are being procured and fielded by the U.S. Army. Digitization of the force has tremendous potential impact on U.S. Army operations. Used appropriately, digitization shows the potential to give everyone from commander to frontline soldier a near perfect view of the battlefield, and also to increase operating tempo so that tasks that once took hours now take minutes. However, as with any new technology, considerable development is required before it can be used to its best advantage.

This report is the first in a series aimed at identifying the best methods for measuring soldiers' proficiency with digital technology.

The work described in this report is a portion of research task 234, Defining and Measuring Digital Skill Proficiency, sponsored by Simulation, Training, and Instrumentation Command's (STRICOM) Project Manager for Training Devices. The results of this research were briefed at the Quarterly In Process Review for the U.S. Army Battle Command System Integration (ABCSI) Project, on 11 July 2001, at the Applied Research Laboratories of the University of Texas. The briefing was attended by STRICOM's ABCSI project director, the government and contractor ABCSI project team, and U.S. Army Training and Doctrine Command representatives of the maneuver combat training centers. The ABCSI Project is concerned with providing trainers at the U.S. Army's maneuver combat training centers with information from the digital data stream needed to support the training of digitized units. The ABCSI project team has developed the capability to load essentially all of the digital communications into a relational database, and they are attempting to identify the digital after action review aids that need to be produced from these data. The team requested the report as input for its After Action Review (AAR) aid identification task.

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DEFINING DIGITAL PROFICIENCY MEASUREMENT TARGETS FOR U.S. ARMY UNITS

EXECUTIVE SUMMARY

Research Requirement:

The U.S. Army's use of networked computer systems to enhance mission accomplishment, known as *digitization*, has the potential to effect massive changes in how operations are conducted and training exercises are evaluated. Digital systems, and the procedures for using these systems, are still evolving.

The starting point for this effort was the identification of high-profile problems in the performance of analog units likely to be addressed by the effective use of digital systems.

There is a need to define digital proficiency measurement targets that focus on the ability of units to exploit the capabilities offered by digital systems, rather than focusing on operator interactions with software products that are likely to change many times in the coming years. The measurement targets should be applicable across specific systems, versions of a system, and the span of a soldier's career. The targets should be linked to combat effectiveness.

Procedure:

We analyzed data from the Center for Army Lessons Learned (CALL) to identify the most frequently occurring *needs emphasis* trends, that is, trends that need training emphasis to improve unit performance. The CALL database is based upon observations made by trainers at the U.S. Army's maneuver combat training centers, and these observations focus on aspects of unit performance believed to be critical in determining mission outcomes. We then examined the data further to identify the specific problems contributing to each trend.

We considered whether the capabilities of digital systems to help leaders visualize the battlefield and/or implement a faster operating tempo (OPTEMPO) would help address each problem and described the mechanisms whereby digitization might address each problem. Due to the large number of performance problems we examined, we looked for recurring themes in terms of performance problems that would help us summarize our

observations. Finally, we described skills that U.S. Army personnel would need to support each mechanism.

Findings:

We identified 24 needs emphasis trends that met our criteria for being considered high-frequency. We recorded over 200 problems in unit performance that contribute to one or more of these trends. Over 92% of these problems might be addressed by effective use of digital systems. All but a few of these problems fell into one or more of eight general categories listed below.

- Lack of awareness of some aspect of the tactical situation
- Lack of synchronization in terms of time, space or activities
- Lack of awareness of some aspect of the plan or lack of input to the plan by a battlefield operating system (BOS) or subunit
- Missing details from unit plans
- Lack of understanding of the tactical situation
- Late production of key elements of the plan
- Inadequate mission preparation
- Vulnerability and/or reduced lethality

We identified over forty mechanisms whereby improved battlefield visualization and increased OPTEMPO can help address high profile problems in unit performance. Most of these mechanisms apply to a wide variety of problems.

We also identified 22 candidate digital skills. Four of these skills are concerned with making sure the communications network is functioning properly, and three are basic operator skills involved in sharing information. We also identified six basic user skills and nine exploitation skills that directly addressed high profile problems in unit performance. User skills are skills carried over from the non-digital (analog) environment that are not inherently facilitated or improved by digitization. On the other hand, digitization enables exploitation skills. That is, it is much easier to employ these skills effectively in a digital setting. Exploitation skills are also carried over from the analog environment, but they are facilitated substantially by digitization.

Utilization of Findings:

This work identified three targets for measuring the ability of units to employ digital systems.

- High-profile problems in combat effectiveness likely to be addressed by the effective application of digital systems
- Mechanisms whereby digitization has the potential to increase battlefield visualization and OPTEMPO
- Candidate digital skills important in implementing these mechanisms

These findings establish a foundation for efforts to define performance standards and develop after action review aids for digitized units.

DEFINING DIGITAL PROFICIENCY MEASUREMENT TARGETS FOR U.S. ARMY UNITS

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DEFINING DIGITAL PROFICIENCY MEASUREMENT TARGETS FOR U.S. ARMY UNITS

Introduction

The U.S. Army is investigating how best to employ digital technology to support the combat soldier, through a process referred to as *digitization* (Department of Defense [DoD], 2000). Selected units, called *digital* units, are being equipped with networked computer systems designed to quickly distribute combat-related information and help leaders and soldiers visualize the battlefield.

Fielding digital hardware is merely one step in the digitization process. Digitization also includes finding out how to best employ digital systems and deciding what changes need to be made in doctrine, organization, training, leadership, materiel, and soldiers (DOTLMS) to support the use of digital systems. Units are still in the process of developing the tactics, techniques and procedures (TTPs) and standard operating procedures (SOPs) that guide employment of digital systems.

To determine the best ways to employ digital systems, the effectiveness of digital units must be measured. Our mission is to facilitate measurement of how well units employ digital systems and digital skill proficiency levels. The immediate challenges to this mission are that digital skills have not yet been defined and digital systems, along with the procedures for using these systems, are still evolving. On the other hand, it is difficult to envision how digital skills can be defined and digital systems and procedures refined without measures of how well digital systems are being employed. In the absence of measures of proficiency in employing digital systems, what guides the refinement of digital TTPs?

For our efforts to have enduring value, it is necessary to focus on measuring the U.S. Army's ability to exploit the potentials of digitization rather than focusing on the skills required to operate existing versions of digital systems. Our approach to identifying targets of opportunity for measuring employment of digital systems was to focus on weaknesses of analog (non-digital) units that are likely to be addressed by the effective use of digital systems. This report describes the approach and outcomes of an effort to identify and address requirements for measures of digital system employment that would retain their value as the digitization process continues.

Digital Systems

The U.S. Army has a number of automated data processing systems which support military operations. Largely, U.S. Army contractors designed each system to perform functions for a particular staff section, known as a Battlefield Operating System (BOS). A BOS is a set of related critical tactical activities grouped together for closer coordination (Department of the Army, 1997). Table 1 shows how BOSs are related to specific digital systems. In addition to the systems shown in Table 1, there is a platform level system called Force XXI Battle Command, Brigade and Below (FBCB2) that supports the dissemination of information to those that execute mission plans.

Table 1
Digital systems supporting Battlefield Operating Systems (BOS)

BOS	**Digital System**
Intelligence	All-Source Analysis System (ASAS)
Maneuver	Maneuver Control System (MCS)
Fire Support (Artillery)	Advanced Field Artillery Tactical Data System (AFATDS)
Air Defense	Air and Missile Defense Warning System (AMDWS)
Mobility/Counter-mobility/ Survivability	None
Combat Service Support	Combat Service Support Control System (CSSCS)
Command and Control	No specific system (may use FBCB2)

Although each of these digital systems was developed independently, they are capable of sharing data over a network (TRW, 2000). Because interoperability exists among these systems, they are subsets of an overall digital system, that is, a system of systems. To make sure that these systems work together and to correct problems identified in user testing, each individual system has progressed through a number of versions, and this process will continue for several years.

Digitization is expected to provide U.S. Army units with a number of benefits. As part of our developmental work, we analyzed the affects of digitization and developed a model of how we believe digitization enhances unit performance. Our model suggests digitization enhances unit performance through two central mechanisms; improved battlefield visualization, and

increased operating tempo (OPTEMPO). For a discussion of the model and the enabling mechanisms, see Appendix D.

Impact on Trainers

Trainers are tasked with observing unit performance and using those observations to help guide After Action Reviews (AAR). AARs are interactive discussions in which a unit decides what happened, why it happened, and how to sustain or improve future performance.

Digitization often complicates the role of trainers for collective training and increases their workload substantially (Army Training Modernization Directorate, 2000; Brown, Anderson, Begley, and Meliza, 1999; Gerlock and Meliza, 1999; Meliza, 1999). For trainers monitoring command and staff operations in a tactical operations center (TOC) environment, new observation requirements emerge with digitization. In addition to existing observation requirements, trainers in the TOC environment find it necessary to monitor operator interactions with digital systems, interactions between system operators and users of the system (e.g., interactions between ASAS operators and the S2), and interactions among operators of different digital systems.

Trainers at company level and below are pulled out of many portions of a unit's tactical information loop. Instead of merely monitoring multiple voice nets to track communications within and across units, trainers have to take on the additional duty of interacting with multiple computers to track the digital communications within versus across units. These trainers also have to contend with the fact that they do not know which digital communications are being examined by their unit counterparts.

One means of reducing the workload for trainers of digitized units is to focus measurement efforts on assessing whether units and individuals are exploiting the capabilities of digitization and reaping the intended benefits. This approach is also consistent with our goal of developing measures of digital proficiency that will not lose value as digital hardware and software evolve.

Measurement Targets

While it may be possible to measure the expected benefits of digitization (lethality, survivability, responsiveness, deployability, agility, and sustainability [U.S. Army

Directorate of Integration, 2000]) the results may be hard to interpret. That is, these benefits focus on outcomes and outcomes are influenced by variables in addition to unit proficiency employing digital systems. Further, the diagnostic value of these measurements may be limited. What is it that my unit has to do to become more agile? Which of the steps needed to ensure unit agility is my unit not already taking?

Impact of digitization on high profile problems in unit performance. One way to begin measuring the impact of digital systems on unit performance is to focus on problems in analog unit performance, particularly those high-profile trends for which digitization might provide a high payoff. Trends analysis data provided by the Center for Army Lessons Learned (CALL) is an important source of information regarding unit performance problems. CALL has analyzed data provided by trainers at the U.S. Army's maneuver combat training centers to identify *needs emphasis* trends in the performance of units training at these centers. These trends typically are areas where training emphasis is needed to improve unit performance, hence the term needs emphasis trend. While these trends, per se, are described in broad terms, CALL's reports include descriptions of the specific problems that contribute to the trends. These problem descriptions tend to be diagnostic.

For example, a needs emphasis trend might be "Reconnaissance and Surveillance (R&S) Plan development" (CALL, 2000). A specific problem in this category might be "intelligence gaps not being identified." If this trend tends to occur repeatedly, it might be considered a high profile problem. Therefore, addressing this trend would provide a high payoff in terms of reducing the total number of unit performance problems.

Mechanisms enabling digitization to address problems in unit performance. Naturally we want to be able to measure the extent to which unit employment of digital systems results in improved battlefield visualization and increased OPTEMPO. In addition, we want to know whether units are employing digital systems in a way that ensures they will gain these benefits as compared to non-digital units. For example, we want to know if digitized units do a better job of sharing information during the development of a mission plan than do analog units. We also want to make sure that we can relate measures of how units are employing digital systems with measures of high profile performance problems.

Digital skill proficiency. We want to identify digital skills and measure digital skill proficiency. Ideally, we want to be able to focus on digital skills with greater training value. We consider digital skills to have a high training value to the extent they apply across digital systems, software versions of a specific system, and the span of leader's career. We also consider digital skills to have a high training value to the extent they can be linked, fairly directly, to high profile problems in unit performance and mechanisms for improving battlefield visualization and increasing OPTEMPO.

Defining High Profile Problems in Unit Performance Likely to be Addressed by Digitization

Identifying High Profile Problems in Unit Performance

We examined the compendia of trends from the National Training Center (NTC) for the 3rd quarter of 1996 to the 2nd quarter of 1998 and the Joint Readiness Training Center (JRTC) for the 4th quarter 1996 to the 3rd quarter of 1997. These reports were the most recent available.

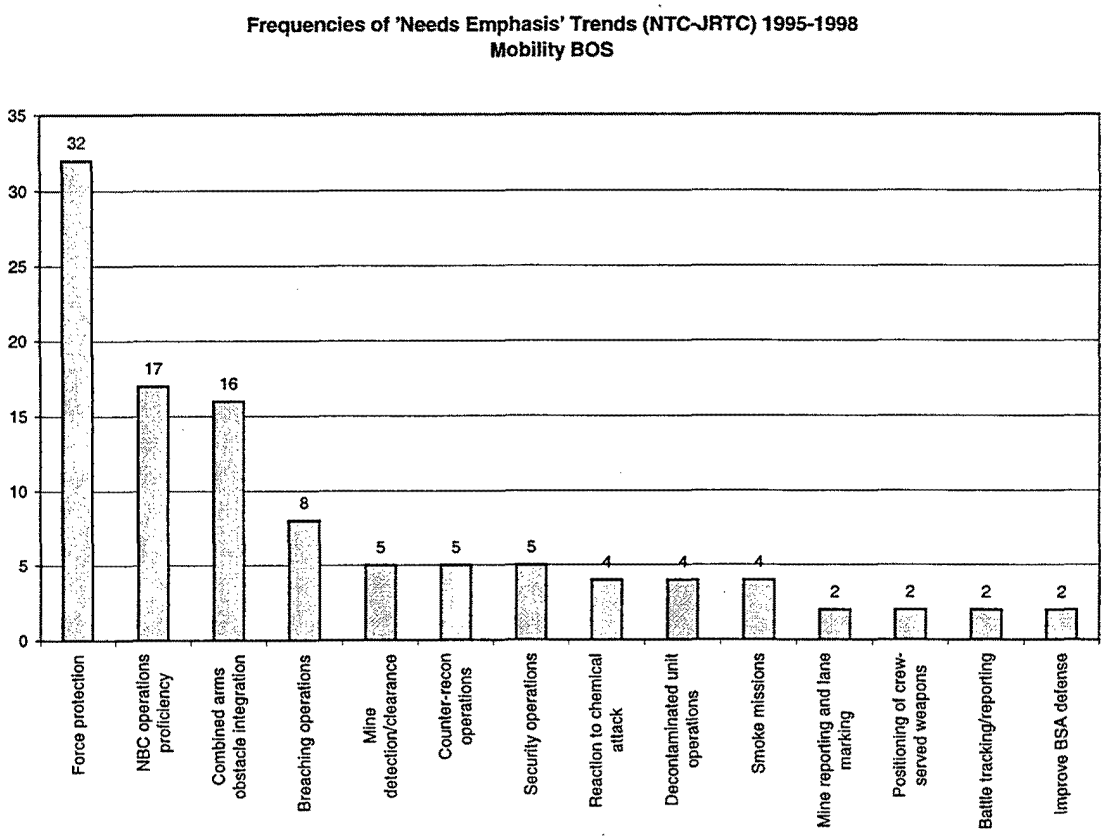


Figure 1. Graph of needs emphasis trends for mobility BOS.

We examined CALL's trend analysis data to identify the most frequently cited performance trends. The negative trends for each BOS were graphed (see Figure 1 for an example). Predictably, the graphs suggest that although most negative trends occurred at a relatively low rate, several trends tended to recur during every Combat Training Center (CTC) rotation. A visual examination of the graphs indicated a definite inflection point for most BOSs. This inflection point is where the slope of the line goes from fairly steep to relatively shallow, and

was considered a dividing line between high- and low-frequency trends. Those trends occurring more frequently were chosen for further analysis. The high-frequency trends are grouped by BOS in Table 2.

Table 2
Negative Trends Selected for Analysis by Battlefield Operating System (BOS)

BOS	Trend [a]
1.0 Intelligence	1.1 Reconnaissance and Surveillance Plan Development 1.2 Intelligence Preparation of the Battlefield Process and Application 1.3 S2 Analysis and Reporting
2.0 Maneuver	2.1 Direct fire planning and execution 2.2 Movement formation and techniques 2.3 Actions on contact 2.4 Use of dismounted infantry
3.0 Fire Support	3.1 Integration of fire support with maneuver 3.2 Fighting and observation positions/observation planning 3.3 Fire support planning 3.4 Triggers versus target location
4.0 Air Defense	4.1 Early warning dissemination/reaction
5.0 Mobility, Counter-Mobility, and Survivability	5.1 Force Protection 5.2 Nuclear, Biological, and Chemical Proficiency 5.3 Combined Arms Obstacle Integration
6.0 Combat Service Support (CSS)	6.1 Supply Management 6.2 Logistics Estimates/CSS Planning and Integration 6.3 Material Readiness 6.4 Combat Health Services/Medical Support
7.0 Command and Control	7.1 Battle Tracking and Predictive Analysis 7.2 Military Decision Making Process (MDMP) 7.3 Troop Leading and Discipline 7.4 Course-of-Action (COA) Development and Wargaming 7.5 Task Force Rehearsals

[a] Trends are numbered by BOS and frequency, with 1.1 being the most frequent trend in BOS 1, etc.

For most BOSs this meant the top three trends, although for the command and control BOS the top five trends were selected,

and for maneuver BOS the top four trends. The Air Defense BOS had only one high-frequency trend.

Next we recorded the problems contributing to each trend. Needs emphasis trends include descriptions of specific problems that occurred within each trend. For example, under the needs improvement trend "fighting and observation positions/ observation planning" a contributing problem is "smoke plans are rarely made and coordination of the targeting process between fire support and maneuver does not occur" (CALL, 2000).

Table 3
General Causes of High-Profile Problems in Unit Performance

General Problem	Frequency
Lack of awareness of some aspect of the tactical (friendly or threat) situation	46
Lack of synchronization (within or across BOSs) in terms of time, space, or activities	48
Lack of awareness of some aspect of the plan or lack input to the plan by a BOS or sub-unit	22
Details missing from plan (often the scope of the plan is less than the scope of the mission, plan fails to address a portion of the battlespace or plans for certain subunits are consistently missing)	31
Lack of understanding of the tactical situation (often a failure to predict how the tactical situation will evolve)	25
Key elements of the plan produced late	13
Inadequate mission preparation (especially lack of rehearsals (due to inadequate time) or rehearsals with the objectives not clearly defined)	13
Unit is highly vulnerable or lacks lethality	36

We identified over 200 problems in unit performance. These problems are listed in Appendix B. To help us summarize these measurement targets of opportunity we looked for recurring themes. We found that all but one or two of the problems fell into one or more of the eight categories shown in Table 3.

Identifying Problems Likely to be Impacted by Digitization

Of the over 200 unit performance problems we recorded, roughly 92% were considered to be of a type that can be addressed, at least in part, through the effective use of digital systems. Appendix B shows, for each problem, whether we expected improved battlefield visualization, increased OPTEMPO,

or both to help address the problem. We dropped those problems which we judged not to be sensitive to digitization from further analysis.

Table 4
High-Profile Problems in Unit Performance and Digitization Potential

General Problem	Digitization Potential
Lack of awareness of some aspect of the tactical (friendly or threat) situation	Battle Visualization (increased situation awareness [SA])
Lack of synchronization (within or across BOSs) in terms of time, space, or activities	Battlefield Visualization (increased SA, wargaming tools) and Increased OPTEMPO (sharing of evolving plan)
Lack of awareness of some aspect of the plan or lack input to the plan by a BOS or sub-unit	Increased OPTEMPO (Sharing of evolving plan)
Details missing from plan	Increased OPTEMPO (sharing of evolving plan)
Lack of understanding of the tactical situation	Battlefield Visualization (increased SA, wargaming tools)
Key elements of the plan produced late	Battlefield Visualization (increased SA) and Increased OPTEMPO (sharing of evolving plan)
Inadequate mission preparation	Battlefield Visualization (increased SA) and Increased OPTEMPO(sharing of evolving plan)
Unit is highly vulnerable or lacks lethality	Battlefield Visualization (increased SA, wargaming tools)

Table 4 summarizes this part of the effort at a high level by addressing the eight categories of unit performance problems. In general, the benefits of digitization likely to address one problem in a category should also address other problems in the same category. As can be seen by reviewing Appendix B, Table 4 does not try to define specific mechanisms. However, a discussion of the specific mechanisms where digitization is likely to address problems can be found in Appendix E.

Identifying Candidate Digital Skills

Soldiers must develop digital skills to exploit the advantages of digital systems. Our research seeks to identify those skills and develop means to measure them. Unfortunately, recent research into computer skills has been relatively limited. Little research has focused on identifying digital skills or on developing reliable, diagnostic measures of computer skills.

Previous Research

Potosky and Bobko (1998) discuss recent efforts to measure computer experience and ability. Studies which sought to measure computer experience used measures of frequency of use or length of time of computer ownership. Other studies used available tests of computer programming ability to assess computer usage ability (Potosky and Bobko, 1998).

The Georgia Institute of Technology has conducted a series of studies concerning internet usage. The tenth and latest study measured skill levels of internet users (Kehoe, Pitkow, Sutton, Aggarwal and Rogers, 1999). The measure discriminated between skill levels by asking respondents to list how many of twelve internet related tasks they had performed.

In a study of U.S. Army soldiers, Dyer and Martin (1999) investigated the computer background of infantrymen. They used a survey to examine the experience soldiers had with computers and their subjective perceptions of their own computer skills. In addition, they used an objective assessment of computer operator skills which measured soldier's ability to recognize computer icons. They found officers in the Infantry Officer Basic Course (IOBC) had the most computer expertise, whereas, in the other groups tested, about half of the soldiers had limited computer operator skills.

The National Research Council (NRC)(1999) investigated the concept of information technology fluency. Their definition of *skills* included only the ability to use specific hardware and software resources. They theorized that fluency with information technology also included the ability to handle unexpected problems and adapt to changing hardware and software.

As this review shows, the body of research concerning digital skills is presently relatively modest. Therefore, with minimal foundation for our investigation, we found it necessary

to conduct some preliminary work to define our terms and establish boundaries for the problem.

Our Working Definition of a Digital Skill

We defined a digital skill as an acquired, generalizable ability, normally gained through training and practice, to exploit the advantages offered by digital systems to accomplish the unit's mission more effectively. Using this definition, any ability a soldier or commander exhibited which used digital resources to accomplish a task which couldn't be done as well without such digital resources would be a digital skill.

The term *acquired* was included to differentiate learned skills from innate abilities. The phrase *normally acquired through training and practice* is included to eliminate those actions which are so readily acquired they do not warrant attention, such as pushing a button or using a computer mouse. The intent of this research is to focus on skills which require some effort to acquire, since these would most likely be the limiting factors in training. *Generalizable* was included to indicate we were seeking skills which were not hardware or software specific, but generalizable across software versions. To the extent possible we would also like to focus on skills that apply across systems and would continue to be useful across the span of a leader's career.

Our User-Oriented Focus

Our review of previous research into computer skills found that often the skills studied involved operating the computer hardware rather than using the product (cf. Kehoe, et al., 1999). Since we are more interested in how well units are able to apply the products of digital systems, we felt it necessary to distinguish between these two levels of skills. From our perspective, being able to use information produced or obtained through the operation of digital systems is generally a more important training objective.

We made use of two sources of information in identifying candidate digital skills. First, we reviewed available documentation regarding how digital systems were to be operated. Second, we were able to draw information from a related effort to describe the evolution of digitization and digital skills within the U.S. Army's first digitized division, the 4th Infantry Division (ID) (TRW, 2001). In both cases, we were

looking for digital activities that appeared to cut across specific digital systems or software versions.

Candidate Digital Skills

Table 5 lists the 22 candidate digital skills we identified. Appendix C provides a description of each skill and describes the source of the concept for the skill.

Table 5
Candidate Digital Skills

Network Skills
Prepare for, and recover from, system crashes or other periods of non-availability
Establish and check communications links and network connections
Protect network from operator error and malfunctions
Perform periodic checks of digital systems
Basic Operator Skills
Prepare and update plans, reports, and other messages
Exchange data with external databases
Create, modify, and employ overlays, templates, and graphics
Basic User Skills
Assess completeness of information on the tactical situation
Assess currency of information on the tactical situation
Assess completeness and clarity of planning products
Coordinate with others to acquire information
Identify situations where a physical terrain reconnaissance is required
Monitor changes in planning products
Exploitation Skills
Maintain awareness of own unit relative to threats
Compare expected and actual status of friendly units
Maintain awareness of trigger events and events addressed by execution matrices
Use SA data to move to a vehicle or control measure location
Use SA data and terrain analysis tools to select routes and positions
Use SA data to control unit movement and deconflict routes
Use SA data and terrain analysis tools to predict contact variables and support BOS integration
Monitor timing of planning activities
Define rehearsal objectives

Most of the skills identified as *basic user skills* or *exploitation skills* were derived from our analysis of high-

profile performance problems and the mechanisms whereby digital systems can be employed to address these problems. That is, the skills are needed to implement the mechanisms. Three of the network skills were identified during a number of interviews with leaders of digitized units in the scope of a related project (TRW, 2001). Prior to these interviews we had failed to appreciate the extent and depth of cognitive tasks required to assure the digital network is fully operational. The importance and complexity of this aspect of digitization was also made apparent in our reviews of Warrior-T products (Warrior-T, 2000).

In reviewing our descriptions of digital skills the reader will find that we have not mentioned specific digital systems and duty positions. In accordance with our goals described at the beginning of this chapter, we have attempted to define skills that apply across systems and versions, and endure over time.

Digital Skill Categories

Network skills. We realized a central component of digitization was the network, and we theorized that important digital skills would involve keeping the network operating. Based upon a review of several interviews conducted within the 4th ID, we decided that multiple networking skills were warranted, because keeping the network operational had proven to be a substantial challenge. Initially we viewed the network skills as being procedural skills with perhaps a small decision-making component; however, personnel interviewed within the 4th ID stressed the importance of leaders and soldiers understanding the data flow within and among digital systems when attempting to define and address network problems.

In many training situations, other digital skills cannot be practiced unless the network is operational, and substantial effort is required to keep it operational. It is important that digitized units have confidence in the robustness of the network. End-product oriented measures of networking skills can serve the additional purpose of illustrating the robustness of digitization (e.g., you were able to react to a system crash without regressing to a pure analog mode).

Basic operator skills. These skills are those required to operate digital hardware/software systems and create products. These skills include such activities as deciding when to update reports and products and deciding whether any of the intended

message recipients need to be alerted regarding the message or product using voice communications.

The basic operator skills are largely procedural skills. Recent work has shown that procedural skills involved in preparing and sending graphics and messages using digital systems tend to be highly perishable (Sanders, 1999). The operator skills defined in the current work also include decision-making skill components, such as deciding who needs to be contacted, how they should be contacted, and when graphics or messages are updated.

Basic user skills. User skills are those which relate to applying the products of digital systems. These skills go beyond the ability to simply create digital products and address the abilities to employ digital products to enhance mission performance. Activities identified as basic user skills address tactical decision-making actions performed in both analog and digital environments. The difference is that these skills are employed using digital systems in the digital environment. For example, both developers and recipients of plans should make sure that plans are complete in terms of details. In the digital environment, senders and receivers examine planning products that are in an electronic format.

All of the basic user skills listed in Table 5 address high-profile problems in unit performance. These skills are decision-making skills rather than procedural skills.

Exploitation skills. Exploitation skills are those abilities which give digital units a significant tactical advantage over non-digital units. Like user skills, these skills address high-profile problems in unit performance. Unlike the case with basic user skills, the exploitation skills are enabled by digitization. That is, digital systems should make it easier to employ these skills to standard.

These skills demonstrate the advantages of digitization. Measures of how well unit members employ these skills can do double duty by being used to illustrate the power of digitization to units.

Summary and Future Research

The work described in this paper has defined three digital proficiency measurement targets.

- Assess impacts of digitization on high-profile problems in unit performance (and on each of the eight categories of performance problems)

- Assess impacts of digitization on the ability of units to visualize the battlefield and increase their OPTEMPO, and whether mechanisms enabling these advantages to enhance unit performance are in evidence

- Assess the degree to which the twenty-two candidate operator and user digital skills we identified are in evidence

Our ongoing efforts are directed at drafting and refining measures of performance supporting each of these targets and identifying the types of data needed to apply each measure.

A sister effort is monitoring TTP and SOP development within the 4th ID in an effort to identify trends. For example, do units attempt to standardize operations to make it easier to assess the currency of information? As the U.S. Army gains more experience using digital systems, TTPs and SOPs will be developed for using these systems. At that point, new measurements will need to be developed to assess compliance with TTPs and SOPs.

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Appendix A

Acronyms List

AAR	After Action Review
ABCS	Army Battle Command System
ADA	Air Defense Artillery
AFATDS	Automated Field Artillery Tactical Data System
AGCCS	Army Global Command and Control System
AMDWS	Air and Missile Defense Warning System
AO	Area of Operations
ARI	Army Research Institute
ASAS	All-Source Analysis System
ATCCS	Army Tactical Command and Control System
ATP	Ammunition Transfer Point
AWE	Advanced Warfighting Experiment
BCT	Brigade Combat Team
Bde	Brigade
BMO	Brigade Medical Officer
BOS	Battlefield Operating System
BSA	Brigade Support Area
BV	Battlefield Visualization
C^2	Command and Control
CALL	Center for Army Lessons Learned
CAS	Close Air Support
CASEVAC	Casualty Evacuation
CHS	Combat Health Services
COA	Course-of-Action
CP	Command Post
CSS	Combat Service Support
CSSCS	Combat Service Support Control System
CTC	Combat Training Center
CTCP	Combat Trains Command Post
CVCC	Commander's Vehicle Command and Control System

DI	Dismounted Infantry
DoD	Department of Defense
DOG	Digital Operators Guide
DOTLMS	Doctrine, Organization, Training, Leadership, Materiel, and Soldiers
DOW	Died of Wounds
ECOA	Enemy Course of Action
EFST	Essential Fire Support Tasks
EVENTEMP	Event Template
FA	Field Artillery
FASP	Forward Ammunition Supply Point
FBCB2	Force XXI Battle Command, Brigade and Below
FTCP	Field Trains Command Post
FIST	Fire Support Team
FRAGO	Fragmentary operations order
FSB	Forward Support Battalion
FSE	Fire Support Element
FSO	Fire Support Officer
GPS	Global Positioning System
ID	Infantry Division
INTSUM	Intelligence Summary
IOBC	Infantry Officer Basic Course
IPB	Intelligence Preparation of the Battlefield
IVIS	Inter-Vehicle Information System
JRTC	Joint Readiness Training Center
LD	Line of Departure
LOGSTAT	Logistics Status Reports
LTP	Logistics Transfer Point
MCS	Maneuver Control System
METT-TC	Mission, Enemy, Terrain, Troops, Time and Civilians
MDMP	Military Decision-Making Process
MSB	Main Support Battalion
NBC	Nuclear, Biological, and Chemical warfare

NMC	Non-Mission Capable
NRC	National Research Council
NTC	National Training Center
OC	Observer/Controller
OPORD	Operations Order
OPTEMPO	Operating tempo
PERINTREP	Periodic Intelligence Report
R&S	Reconnaissance and Surveillance
RSO&I	Reception, Staging, Onward movement, and Integration
RSTA	Reconnaissance, surveillance, and target acquisition
S1	Personnel Officer/Staff
S2	Intelligence Officer/Staff
S3	Operations Officer/Staff
S4	Logistics Officer/Staff
SA	Situation Awareness
SBF	Support by Fire
SITEMP	Situation Template
SOP	Standard Operating Procedure
SPO	Support, Plans, and Operations Officer
STAMIS	Standard Army Management Information System
TAAF	Training Analysis and Feedback
TAF	Training Analysis Facility
TF	Task Force
TOC	Tactical Operations Center
TRADOC	US Army Training and Doctrine Command
TTP	Tactics, Techniques, and Procedures
UAV	Unmanned Aerial Vehicle
UMCP	Unit Medical Command Post

Appendix B. Digitization Impacts Data

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
1.1a Reconnaissance & Surveillance (R&S) Plan Development	Intelligence gaps not being identified	Lack of Situational Understanding	Battlefield Visualization	Improved Situation Awareness (SA) regarding the enemy, friendly and environmental situation make it easier for the unit to identify intelligence gaps; improved SA makes it possible for the unit to develop plans which are more precise, making it easier to identify gaps in the intelligence data needed to validate the plan
1.1b	Emerging reconnaissance requirements not being addressed	Lack of Situational Understanding	Increased operating tempo (OPTEMPO)	Easier to revise and disseminate plans
1.1c	Scout platoons being over tasked/unable to maintain OPTEMPO	Limited SA	Battlefield Visualization	Reduced data collection requirements due to increased SA
1.1d	Scout platoons taking casualties through poor route planning and counter-recon threat	Vulnerability	Battlefield Visualization	Terrain analysis tools combined with increased SA
1.1e	R&S effort being delegated to S2 (Intelligence) with inadequate support	Poor Synchronization	Battlefield Visualization	Reduced data collection requirements due to increased SA
1.1f	R&S products lacking critical pieces of information	Plan Lacking Details	Increased OPTEMPO	Increased ability to support and respond to review of R&S products
1.1g	R&S plan does not include relevant information from other BOS's	Limited Plan Awareness/Input	Increased OPTEMPO	Evolving plan available to all BOSs and echelons
1.1h	R&S plan is not complete in time to position scouts and other reconnaissance assets	Late Planning Products	Increased OPTEMPO	Planning process is initiated at a higher level of SA; concurrent review and electronic transmission reduce preparation time
1.1i	The R&S plan often is not coordinated horizontally and vertically	Limited Plan Awareness/Input	Increased OPTEMPO	Evolving plan available to all BOSs and echelons
1.1j	R&S plans do not include sufficient detail	Plan Lacking Details	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness of orders

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Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
1.1k	R&S plans not prepared in a timely manner	Late Planning Products	Increased OPTEMPO and Battlefield Visualization	Planning process is initiated at a higher level of SA; concurrent review and electronic transmission reduce preparation time
1.1l	Intelligence requirements are not updated as situation changes	Lack of Situational Understanding	Increased OPTEMPO	The unit's motivation for updating intelligence requirements should increase, because digital systems make it easier to implement changes in the R&S plan in response to changing needs
1.1m	Execution of R&S plan is often poorly managed	Limited SA	Battlefield Visualization	Increased SA makes it easier to monitor activities of R/S plan executors
1.1n	R&S efforts are frequently not rehearsed	Inadequate Preparation	Increased OPTEMPO and Battlefield Visualization	Planning process is initiated at a higher level of SA; concurrent review and electronic transmission reduce preparation time; digital tools support rehearsals of some aspects of the plan
1.2 a Intelligence Preparation of the Battlespace (IPB) Process And Application	IPB Products are incomplete/lack important information	Plan Lacking Details	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness of orders
1.2b	IPB products are not ready in time to be useful	Late Planning Products	Increased OPTEMPO and Battlefield Visualization	Planning process is initiated at a higher level of SA; concurrent review and electronic transmission reduce preparation time;
1.3 a S2 Analysis And Reporting	Critical information is not distributed to the appropriate BOSs or echelons	Limited SA	Battlefield Visualization	Increased SA combined with ability to distribute these data more easily
1.3b	Analysis is often inadequate and does not continue into the execution phase	Lack of Situational Understanding	Battlefield Visualization	Increased SA should lead to more precise questions regarding enemy intent, making it easier to answer questions

Appendix B. Digitization Impacts Data

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
1.3c	Reports are not timely or are out of date	Late Planning Products	Increased OPTEMPO	Digitization should decrease the workload required to perform many tasks (e.g., transposing to spatial formats) helping to ensure reports are timely
1.3d	Staffs fail to use reports (Intelligence Summary [INTSUM]; Periodic Intelligence Report [PERINREP]) to update templates and graphics	Lack of Situational Understanding	Battlefield Visualization and Increased OPTEMPO	The capability to distribute templates and graphics during missions should help to motivate the staff to update templates and graphics; improved SA should result in a situation where more precise questions are being asked and thus the answers are likely to be interpreted more easily
1.3e	Staffs fail to use reports or their templates and graphics to update predictive analyses	Lack of Situational Understanding	Battlefield Visualization	Increased SA should lead to more precise questions regarding enemy intent, making it easier to answer questions
2.1a Direct Fire Planning and Maneuver	Companies are not achieving effective, overwhelming fires on enemy formations during offense or defense	Reduced Lethality	Battlefield Visualization	Improved SA should improve the quality of information regarding enemy location, status, and intent; in addition to improving targeting, this information can be used to make sure that priority of fires fits the actual enemy situation; improved SA should also increase the probability that the unit will have a detailed plan for employing fires against the enemy
2.1b	No company team plan exists for employing direct fires	Plan Lacking Details	Battlefield Visualization	Improved SA means that units have better information about the enemy situation prior to contact, as input for fire planning
2.1c	Leaders fail to adequately address actions on the objective in their orders and rehearsals for offensive missions	Plan Lacking Details	Battlefield Visualization	Improved SA means that units have better information about the enemy situation prior to contact, as input for fire planning; evolving plan available to all BOSs and echelons; executors have time and means to provide feedback regarding completeness of orders
2.1d	Graphic control measures are insufficient to allow company/team to mass fires or cover zone in depth for offensive and defensive missions	Limited Plan Awareness/Input	Battlefield visualization and Increased OPTEMPO	Improved SA may remove the need for certain control measures; graphics can be disseminated during mission execution

Appendix B. Digitization Impacts Data

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
2.1e	Too many units are not preparing range cards and sector sketches to standard, if at all	Limited Plan Awareness/Input	Battlefield Visualization	The value of range cards to the preparer increases, because SA data can be combined with range card data; terrain analysis tools may be used to reduce the amount of information units are expected to include in range cards
2.2a Movement Formation and Techniques	Combat support units do not arrive at their destination safely and on time	Vulnerability	Increased OPTEMPO and Battlefield Visualization	Increased SA makes it easier to control unit movement and keep it on schedule; improved SA and terrain analysis tools make it easier to select routes offering cover/concealment and to deconflict routes
2.2b	No thought is given to using control measures for ensuring timely, controlled moves	Limited SA	Battlefield Visualization	Increased SA makes it easier to control unit movement and keep it on schedule
2.2c	Land deconfliction, boundaries, cover/concealment, limited visibility, and reconnaissance of routes are not considered in route planning	Lack of Situational Understanding	Battlefield Visualization	Increased SA makes it easier to control unit movement and keep it on schedule; improved SA and terrain analysis tools make it easier to select routes offering cover/concealment and to deconflict routes
2.2d	Units make contact with the enemy when moving in formations providing little protection against the enemy	Vulnerability	Battlefield Visualization	Increased SA makes it easier to decide when units will make contact and allow a unit to take protective measures
2.3 a Actions on Contact	Company teams rarely execute effective actions on contact	Vulnerability, Reduced Lethality	Battlefield Visualization	Increased SA makes it easier to decide when units will make contact so that a unit can be prepared to take appropriate actions to control the situation
2.3b	Units fight on the enemy's terms rather than their own	Vulnerability, Reduced Lethality	Battlefield Visualization	Increased SA makes it easier to decide when units will make contact so that a unit can be prepared to take appropriate actions to control the situation
2.3c	Units do not visualize how enemy will use combat multipliers to shape the battlefield	Lack of Situational Understanding	Battlefield Visualization	Wargaming tools, such as computer generated forces, can be used to envision the battlefield; units have the flexibility to find and implement new ways of describing the battlespace by envisioning new types of graphics

Appendix B. Digitization Impacts Data

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
2.3d	Units do not rehearse actions on contact	Inadequate Preparation	Battlefield Visualization and Increased OPTEMPO	Taking advantage of improved SA to speed up the planning process allows more time for mission rehearsal; improved SA regarding the enemy makes it easier to plan for actions on contact and identify the specific issues that need to be addressed in a rehearsal
2.3e	Planning does not address simultaneous forms of combat	Plan Lacking Details	Battlefield Visualization and Increased OPTEMPO	Taking advantage of improved SA to speed up the planning process allows more time for considering multiple enemy Courses-of-Action (COAs)
2.3f	Commanders not able to "see themselves" at various points in the battle and anticipate when and where the enemy will use combat multipliers	Lack of Situational Understanding	Battlefield Visualization	Improved SA regarding the enemy, and the availability of wargaming tools, make it possible for commanders to visualize what contact might look like
2.4 a Use of Dismounted Infantry (DI)	Mechanized infantry/armor task forces do not effectively use dismounted infantry	Vulnerability, Reduced Lethality	Battlefield Visualization	Increased SA provides information needed to decide how to best employ Dismounted Infantry (DI)
2.4b	Lack of employment of DI during offensive operations is a continuing long-term trend	Vulnerability, Reduced Lethality	Battlefield Visualization	Increased SA provides information needed to decide how to best employ DI
2.4c	DI do not have the proper equipment because they are unsure of their mission	Limited Plan Awareness/Input	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness of orders
2.4d	DI are not used in conjunction with their vehicles	Vulnerability, Reduced Lethality	Battlefield Visualization and Increased OPTEMPO	The more precise planning made possible by improved SA should increase the probability that roles for DI will be included early in plans, providing infantry with time to consider how to use their vehicles to support dismounted operations
2.4e	Soldiers dismount with little or no orientation or guidance regarding the tactical situation	Limited SA	Battlefield Visualization	Improved SA regarding the enemy and friendly situations

Appendix B. Digitization Impacts Data

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
2.4f	Plans do not include a clear task and purpose for dismounts	Plan Lacking Details	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness of orders made possible by platform-level systems
2.4g	DI actions seldom planned at battalion or company level	Plan Lacking Details	Increased OPTEMPO	The more precise planning made possible by improved SA should increase the probability that roles for DI will be included early in plans; sharing of the evolving plan makes it possible for infantry units to raise questions regarding DI roles early enough in the planning process to gain a response
3.1a Integration of Fire Support with Maneuver	Fires are not sufficiently integrated into the scheme of maneuver	Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	The more precise maneuver plan made possible by improved SA should make it easier for fire support to decide how to support maneuver; sharing of the evolving plan makes it possible for fire support and maneuver elements to raise questions regarding synchronization; increased SA makes it possible to employ event-based triggers
3.1b	Many task force fire support plans lack flexibility because the Fire Support Officer (FSO) has not planned in depth or developed a plan for use of all fire support assets	Plan Lacking Details	Increased OPTEMPO	Early sharing of evolving plan provides opportunities to review fire support plan for completeness
3.1c	Fire plans usually do not describe the conditions for success on the objective during the attack	Plan Lacking Details	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness of orders
3.1d	Artillery fires are often lifted and shifted before the task is complete	Vulnerability, Reduced Lethality, Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Evolving plans can be shared and reviewed to make sure they define the criteria for deciding when a fire support task is complete; improved SA can also be used to decide if the criteria for completion of certain tasks have been met (e.g., Unmanned Aerial Vehicles [UAVs] may show it the enemy is withdrawing from a position)

Appendix B. Digitization Impacts Data

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
3.1e	Fire support plans often lack the specificity to support the scheme of maneuver and do not clearly designate when units have priority of fires	Plan Lacking Details, Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Executors have time and means to provide feedback regarding completeness of orders; improved SA supports BOS integration by making it easier to use events as triggers
3.1f	Specifically, smoke or suppressive fires are overlooked to assist maneuver	Plan Lacking Details, Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Executors have time and means to provide feedback regarding completeness of orders; improved SA should reduce the number of contingencies operations to be planned/supported, making it easier to devote resources to actual threat situations as they are encountered
3.1g	Staffs and plans do not fully integrate destructive fires such as Close Air Support (CAS), indirect fires, and air Volcano to limit enemy reaction to the fire and maneuver plan	Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Improved SA makes it possible for units to develop fire and maneuver plans that are more precise; it is easier to see when CAS, indirect fires and air Volcano can be most useful
3.1h	Plans do not include triggers to shift priority of fires	Plan Lacking Details	Increased OPTEMPO	Improved SA should reduce the number of contingencies operations to be planned/supported, making it easier to devote resources to actual threat situations as they are encountered
3.1i	During wargaming, FSOs do not understand the scheme of maneuver and what fires are necessary to support the maneuver plan	Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Digital wargaming tools make it easier to envision battlefield geometry variables and identify useful event triggers

Appendix B. Digitization Impacts Data

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
3.1j	FSOs complete plans without a thorough knowledge of the critical fire support tasks	Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Evolving plan available to all BOSs and echelons Executors have time and means to provide feedback regarding completeness of orders; increased SA should reduce the number of contingency actions to be planned, allowing a more precise statement of the maneuver plan to be supported by fire; digital wargaming tools make it easier to examine the impacts of battlefield geometry and other variables on fire support task requirements
3.1k	Fires are normally planned after and not concurrently with the other BOS during the planning process	Poor Synchronization	Increased OPTEMPO	Evolving plan available to all BOSs and echelons
3.1l	Higher headquarters often push combat multiplier resources to the executing unit with little or no planning guidance and no consideration of the supported unit's maneuver plan	Poor Synchronization	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness of orders
3.2 a Fighting and Observation Positions/Observation Planning	Establishment of support-by-fire (SBF) positions is not synchronized with the task force scheme of maneuver	Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Improved SA makes it easier to employ event-based triggers to support the synchronization of SBF positions and maneuver; more precise maneuver plans, enabled by improved SA, makes it easier to see when and where supporting fire would be most useful to the maneuver effort
3.2b	Lack of effective SBF positions will normally result in the breach and assault forces not accomplishing the mission	Vulnerability, Reduced Lethality, Poor Synchronization	Battlefield Visualization	Improved SA regarding the enemy and friendly situations should make it easier to select effective support by fire positions
3.2c	Observation plans lack sufficient detail to provide the company fire support team (FIST) with a focus for planning, preparation, and execution	Plan Lacks Details	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness of orders; increased SA should reduce the number of contingency actions to be planned, allowing a more precise statement of the maneuver plan to be supported by fire

Appendix B. Digitization Impacts Data

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
3.2d	Task forces do not develop and execute observation plans supporting essential fire support tasks (EFST), scheme of fires/maneuver	Plan Lacks Details, Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Sharing of evolving plans should help to ensure BOS integration; improved SA makes it easier to employ event-based triggers to synchronize BOSs
3.2e	Observer plans lack the detail and synchronization required to ensure observers are in position and prepared to execute the scheme of fires	Plan Lacks Details, Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Executors have time and means to provide feedback regarding completeness of orders; digital wargaming tools can be used to identify and try out trigger points
3.2f	Company teams are not given adequate clarification of the SBF purpose and associated tasks (assume a destroy mission when fix or suppress mission may meet need)	Plan Lacks Details	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness of orders
3.2g	Task force staffs do not complete detailed terrain analysis of the planned SBF	Inadequate Preparation	Battlefield Visualization	Improved SA and wargaming tools can help perform terrain analysis of SBF positions
3.2h	Effective triggers, assault positions, and observation points are not planned and if planned are usually ignored during execution	Poor Synchronization	Battlefield Visualization	SA displays make it easier to use event-based triggers rather than the less effective time-based triggers Wargaming tools can be used to select and tryout triggers
3.2i	Smoke plans are rarely made and coordination of the targeting process between fire support and maneuver does not occur	Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Increased SA and terrain analysis tools make it easier to see when and where smoke missions would be useful; SA displays make it easier to use event-based triggers rather than the less effective time-based triggers for synchronizing smoke and maneuver
3.2j	Observers frequently commit errors in observed fire procedures resulting in inaccurate target locations	Limited SA	Increased OPTEMPO	Digitized units can lase targets to provide location data in ten digit coordinates

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
3.2k	The FSO does not synchronize the observer plan with the scheme of maneuver during the wargaming process	Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Improved SA makes it easier to employ event-based triggers to synchronize fire support and maneuver; reducing the time required to perform certain planning tasks can free up time for rehearsals
3.2l	Rehearsals are inadequate and company team observer plans are not refined	Inadequate Preparation	Increased OPTEMPO and Battlefield Visualization	Increased OPTEMPO provides more time for rehearsals; improved SA can result in more precise plans, making it easier to identify rehearsal objectives; wargaming tools provide a means of rehearsing many aspects of the observer plan
3.2m	FISTs are not in position at right time & place to acquire the enemy before the task force becomes decisively engaged in the enemy's battle space	Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Increased OPTEMPO during the planning process provides time for mission preparation activities; improved SA and wargaming tools can make it easier to predict when and where fire support is needed to support maneuver
3.3a Fire Support Planning	Task forces do not develop the fire support plan to standard	Plan Lacks Details	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness of orders; increased OPTEMPO provides more for rehearsals to refine the fire support plan
3.3b	The brigade fire support element (FSE) does not develop a complete scheme of fires during the planning phase	Plan Lack Details	Increased OPTEMPO and Battlefield Visualization	Executors have time and means to provide feedback regarding completeness of orders; increased OPTEMPO provides more for rehearsals to refine the fire support plan
3.3c	FSOs do not adequately allocate available resources or identify required volume or duration of fires necessary to mass fires and shape battlefield	Plan Lacks Details	Battlefield Visualization	Sharing the evolving plan provides the opportunity for plan executors to provide feedback about their completeness; increased SA should make it easier to estimate the magnitude of fire support requirements
3.3d	The brigade FSE does not provide timely and essential information to the battalion task force FSOs to permit concurrent planning	Late Planning Products	Increased OPTEMPO	Evolving plan available to all BOSs and echelons; executors have time and means to provide feedback regarding completeness of orders

Appendix B. Digitization Impacts Data

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
3.3e	Poor information dissemination does not prepare the task force FSOs and FSEs to participate in the planning process	Limited Plan Awareness/Input	Increased OPTEMPO	Evolving plan available to all BOSs and echelons; executors have time and means to provide feedback regarding completeness of orders
3.3f	The commander's guidance for fires does not cover the entire operation	Plan Lack Details	Increased OPTEMPO	Evolving plan available to all BOSs and echelons; executors have time and means to provide feedback regarding completeness of orders
3.3g	The brigade FSE personnel do not have all the tools needed for wargaming and do not have a complete understanding of the expected product	Lack of Situational Understanding, Plan Lacks Details	Battlefield Visualization	Digitization provides wargaming tools
3.3h	The scheme of fires is typically completed after the wargame is finished	Planning Products Late	Increased OPTEMPO	Concurrent review and electronic transmission reduce preparation time
3.3i	Rehearsals do not meet the needs of the brigade in ensuring the fire support plan is integrated with maneuver and synchronized	Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Improved SA can result in more precise plans, making it easier to identify rehearsal objectives; digital wargaming tools provide a means of rehearsing many aspects of the fire support plan
3.3j	The desired effects (i.e., suppress, destroy, obscure) that fire support was to achieve are not described in detail	Plan Lacks Details	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness of orders
3.3k	CAS is not effectively integrated into the brigade fire support plan	Poor Synchronization, Reduced Lethality	Increased OPTEMPO and Battlefield Visualization	Increased SA and wargaming tools should make it easier to decide when CAS would be most effective
3.3l	Artillery movement plans are not well coordinated with fire support events	Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Improved SA makes it easier to employ event-based triggers to support the synchronization of fire support tasks and movement of artillery

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
3.3m	Battalion FSOs are unable to conduct concurrent planning because of missing information	Plan Lacks Details	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness of orders; evolving plan available to all BOSs and echelons concurrent review and electronic transmission reduce preparation time
3.3n	Brigade (Bde) FSEs do not plan fires to support the close fight, anticipate/ provide for transition from deep to close, and assign specific tasks to battalion FSEs	Plan Lacks Details	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness of orders
3.4a Triggers versus target location	When defending, task forces emplace ineffective triggers because enemy is not engaged by indirect fire when crossing the target area	Reduced Lethality	Battlefield Visualization	Improved SA make it easier to use event-based triggers
3.4b	When defending, observers order firing as enemy crosses trigger, but distances do not correspond to enemy's movement rate plus flight time	Reduced Lethality	Battlefield Visualization	Wargaming tools can be used to test triggers
3.4c	Time and distance factors are incorrect for the placement of triggers	Reduced Lethality	Battlefield Visualization	Wargaming tools can be used to test triggers
3.4d	During the wargame, the FSO does not request the S3 (operations) to clearly state the intent for each target	Plan Lacks Details	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness of orders
3.4e	Task force FSOs do not adequately define the task and purpose for each task force target	Plan Lacks Details	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness of orders
4.1a Battle tracking and predictive analysis	Commanders and staff lack SA	Limited SA	Battle Visualization	Improved SA regarding enemy and friendly situation
4.1b	Battle tracking graphics/boards are incomplete	Limited SA	Battlefield Visualization	Digitization performs many battle tracking functions for units (especially locations of friendly units), freeing up time for tracking additional aspects of the battlefield

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Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
4.1c	Predictive analysis is not accomplished	Lack of Situational Understanding	Battlefield Visualization	Increased SA makes it possible to ask questions that are more specific, facilitating predictive analysis
4.1d	Critical information often does not reach the commander/ appropriate BOS	Limited SA	Increased OPTEMPO	The common tactical picture should help to ensure that information is available to those with a need to know
4.1e	Command Posts (CPs)/Tactical Operations Centers (TOCs) do not adequately track all enemy and friendly forces	Limited SA	Battlefield Visualization	Tracking of friendly forces is highly automated in the digital environment, leaving more time to devote to tracking enemy forces
4.1f	Information from CP/TOC not routinely integrated and disseminated; information not shared among staff elements	Limited SA	Increased OPTEMPO	Common tactical picture makes information available to all BOSs and echelons
4.2 a Military Decision making Process (MDMP)	Commanders/staffs often fail to conduct a full and complete MDMP	Inadequate Preparation	Battlefield Visualization and Increased OPTEMPO	Improved SA and wargaming tools make the job of using the MDMP easier; the sharing of information helps to make sure that input is received from all BOSs
4.2b	MDMP often fails to consider some critical elements	Limited Plan Awareness/Input	Increased OPTEMPO	Executors and other BOSs have time and means to provide feedback regarding completeness of plans
4.2c	Some staff products are not available in time to be included into the MDMP	Late Planning Products	Increased OPTEMPO	Sharing of evolving plans should help to ensure that one BOS does not fall behind other BOSs in terms of preparing planning products
4.2d	Staff planning of the BOS elements is not synchronized with the MDMP	Poor Synchronization	Increased OPTEMPO	Sharing of evolving plans should help to ensure that one BOS does not fall behind other BOSs in terms of preparing planning products
4.2e	Not all BOS elements are integrated into the MDMP	Limited Plan Awareness/Input	Increased OPTEMPO	Sharing of the evolving plans should ensure that all BOSs are involved in the planning process; sharing of evolving plans should help to ensure that one BOS does not fall behind other BOSs in terms of preparing planning products

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
4.3a Troop leading and discipline	Pre-combat checks and inspections are not accomplished	Inadequate Preparation	Increased OPTEMPO	The ability to plan a mission more quickly should result in more time to prepare for the mission
4.3b	Basic tasks are not accomplished in a timely manner	Inadequate Preparation	Increased OPTEMPO	The ability to plan a mission more quickly should result in more time to prepare for the mission
4.4a COA development and wargaming	Wargaming is not conducted with the appropriate level of detail; it is either too detailed and never finished, or superficial	Inadequate Preparation	Increased OPTEMPO and Battlefield Visualization	Improved SA should lead to more precise plans for a mission, making it easier to identify specific issues that need to be addressed during rehearsals
4.4b	Wargaming rarely results in a synchronized plan	Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Improved SA should lead to more precise plans for a mission, making it easier to identify specific issues that need to be addressed during rehearsals
4.4c	COAs are not fully developed prior to wargaming	Late Planning Products	Increased OPTEMPO	Improved SA, the ability to share information among BOSs during mission planning, and the ability to electronically distribute materials should reduce the amount of time required for many planning tasks so that more take is available to consider COAs
4.4d	COAs frequently do not include input from all BOS's and do not include the commander's decisive point	Limited Plan Awareness/Input	Increased OPTEMPO	Early sharing of planning products provides the opportunity for feedback regarding completeness and clarity of the products
4.4e	Wargaming is often conducted without appropriate products (situation template [SITEMP], event template [EVENTEMP], etc) available	Late Planning Products	Increased OPTEMPO	Increased OPTEMPO helps ensure planning products will be available sooner
4.4f	Staffs are not able to define, in doctrinal terms, what they want subordinate units to do	Limited Plan Awareness/Input	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness and clarity of orders

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Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
4.5a Task force rehearsals	Rehearsals are frequently not conducted; when they are conducted they lack a standard format and a clear task and purpose	Inadequate Preparation	Increased OPTEMPO	Increased OPTEMPO increases time available for rehearsals; improved SA makes it possible to develop plans which are more precise, making it easier to identify specific rehearsal objectives
4.5b	Units become disorganized on the objective because not all players are aware of the plan	Limited Plan Awareness/Input	Increased OPTEMPO	Evolving plan available to all BOSs and echelons
4.5c	Support plans (such as fire support, medical support, Combat Service Support [CSS], etc) are not synchronized with the scheme of maneuver	Poor synchronization	Increased OPTEMPO and Battlefield Visualization	Evolving plan available to all BOSs and echelons; improved SA makes it easier to employ event-based triggers for synchronization; improved SA makes it possible to develop a more precise maneuver plan, making it easier to develop plans that support maneuver
4.5d	Rehearsals are frequently simply verbal back-briefs; they do not use terrain models to visualize friendly and enemy maneuver	Inadequate Preparation	Battlefield Visualization	Digital systems provide wargaming tools to support rehearsals
4.5e	Not all BOSs are integrated into rehearsals	Inadequate Preparation, Poor Synchronization	Increased OPTEMPO	Evolving plan available to all BOSs and echelons; executors have time and means to provide feedback regarding completeness and clarity of orders, and clarity/completeness issues often define potential rehearsal objectives
4.5f	Units often do not allow time for rehearsals through poor time management	Late Planning Products	Increased OPTEMPO	Increased OPTEMPO provides more time for rehearsals
4.5g	Units do not concentrate on the critical aspects of the plan during rehearsals	Inadequate preparation	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness and clarity of orders, and clarity/completeness issues often define potential rehearsal objectives
5.1a Force Protection	Units are highly vulnerable to enemy attack due to inadequate self-defense	Vulnerability, Inadequate Preparation	Increased OPTEMPO and Improved SA	Improved SA should result in a situation where units do a better job of anticipating specific threat situations and preparing for these situations

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
5.1b	Unnecessary casualties occur due to Nuclear/ Biological/ Chemical (NBC) contamination	Vulnerability	Battlefield Visualization	Improved SA regarding the location of contaminated areas and the location of friendly vehicles
5.1c	Fratricide risks are high during R&S operations	Vulnerability, Limited SA	Battlefield Visualization	Improved SA regarding the location of friendly units and minefields/obstacles
5.1d	Inadequate efforts to construct hardened battle/alternate positions, use camouflage/ concealment, and develop coordinated defense plans	Inadequate Preparation	Increased OPTEMPO	Increased OPTEMPO provides more time for mission preparation activities, such as preparing defensive positions
5.1e	Units that identify contaminated areas are having problems keeping follow-on forces out of the contamination	Vulnerability, Limited SA	Battlefield Visualization	Improved SA regarding the location of contaminated areas
5.1f	R&S operations are inadequately supervised, leading to increased risk of fratricide	Vulnerability, Limited SA	Battlefield Visualization	Improved SA regarding the location and activities of R&S assets
5.1g	Units have unnecessary chemical casualties	Vulnerability, Limited SA	Battlefield Visualization	Improved SA regarding the location of contaminated areas
5.2a NBC Operations Proficiency	Units fail to receive warnings of enemy employment of chemical weapons	Vulnerability, Limited SA	Battlefield Visualization	Improved SA regarding the location of friendly elements makes it easier to identify the units threatened by a chemical attack
5.3a Combined arms obstacle integration	Obstacles are rapidly bypassed or reduced by enemy engineers	Late Planning Products	Battlefield Visualization	Early sharing of planning products should help to ensure that obstacles are covered by direct and indirect fires; improved SA should make it easier to use event-based triggers to control fires; improved SA and wargaming tools should make it easier to predict when enemy forces will reach obstacles
5.3b	Damage/casualties are incurred due to friendly obstacles	Vulnerability, Limited SA	Battlefield Visualization	Improved SA regarding the location of friendly obstacles relative to the location of friendly units
5.3c	Damage/casualties are incurred due to enemy obstacles	Vulnerability, Limited SA	Battlefield Visualization	Improved SA regarding the location of enemy obstacles relative to locations of friendly units

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Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
5.3d	Engineers often site obstacles without coordinating with covering force and consequently are not coordinated with direct and indirect fires	Poor Synchronization	Increased OPTEMPO	Evolving plan available to all BOSs and echelons' increased OPTEMPO makes it more likely that rehearsals addressing covering of obstacles/minefields by fire will be conducted and problems identified regarding lack of coverage
5.3e	The obstacle plan is developed without coordination from other concerned BOS's or consideration of commander's intent	Limited Plan Awareness/Input	Increased OPTEMPO	Evolving plan available to all BOSs and echelons
5.3f	Obstacles are not planned or emplaced to attack enemy maneuver	Reduced Lethality	Battlefield Visualization	Improved SA make it easier to place obstacles along enemy routes of advance
5.3g	The obstacle plan is often narrow in scope, considering only the primary enemy COA	Plan Lacks Details	Increased OPTEMPO	Increased OPTEMPO makes it possible for a unit to consider multiple enemy COAs
5.3h	Obstacles are emplaced prior to engagement area reconnaissance	Limited SA	Increased OPTEMPO	Evolving plan available to all BOSs and echelons
6.1a Early warning dissemination and reaction	Units often maintain a readiness level of the air defense warning system that is too high for the situation	Limited SA	Battlefield Visualization	Improved SA regarding location of friendly units that can be compared with information about potential air attacks
6.1b	Obstacle position and construction is not properly recorded or coordinated; friendly minefields and lanes through enemy minefields are not marked	Vulnerability, Limited SA	Increased OPTEMPO and Battlefield Visualization	Digitization provides a means of showing where minefields/obstacles are located over a map display, a less error prone approach than sending coordinates
6.1c	Supported maneuver elements fail to sufficiently disseminate the warnings	Limited SA	Battlefield Visualization	Improved SA should help units to devote more attention to warnings
6.1d	States of readiness are based on air defense warning of overall area of operations (AO) rather than what is in sector, and protection is not adequate to the threat	Limited SA	Battlefield Visualization	Improved SA regarding the location of friendly platforms and the identify of units threatened by air attack

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Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
6.1e	There is confusion at the company team level concerning the nature of the actual threat, and the overall reaction to directed early warning is poor	Limited SA	Battlefield Visualization	Improved SA regarding the location of friendly platforms and the identification of units threatened by air attack
7.1a Supply Management	Field trains unable to replenish personnel and combat systems and forecast Class III (fuel) and V (ammunition) requirements	Vulnerability	Battlefield Visualization	Improved SA regarding supply status and enemy situation makes it easier to predict the impact of mission execution on supply levels
7.1b	Delays in establishing Brigade Support Area (BSA) Ammunition Transfer Point (ATP) causing units to receive ammunition late	Inadequate Preparation	Increased OPTEMPO	Increased OPTEMPO can reduce planning time so that more time can be spent on mission preparation activities
7.1c	The field trains CP generally does not receive accurate logistical status from the company teams and separate platoons in the task force	Limited SA	Battlefield Visualization	Digital status reports should improve the accuracy of status reports by ensuring they are timely
7.1d	Forecasting of Class III by Brigade Combat Team (BCT) through use of Logistics Status (LOGSTAT) Reports is poor and contributes to lack of synchronization	Lack of Situational Understanding	Increased OPTEMPO	Digital status reports should improve the timeliness (and thus the accuracy) of status reports
7.1e	Units have difficulty tracking task force key classes of supply within the Combat Trains Command Post (CTCP) or Field Trains Command Post (FTCP)	Limited SA	Improved SA	The requirement for CSS elements to share information regarding the location and supply status of CSS locations using graphical displays should force/motivate these elements to do a better job of tracking supply levels
7.1f	Data logistic status reports are bypassing key people in the task force CSS team	Limited Plan Awareness/Input	Increased OPTEMPO	Digital LOGSTAT reports are sent to parties with a need to know
7.1g	Lack of synchronization in Class III resupply operations between the main support battalion, forward support battalion, and maneuver task forces	Poor Synchronization	Battlefield Visualization	Improved SA makes it possible to use event-based triggers as opposed to time-based

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Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
7.1h	Resupply windows within BCT tend to be rigid time periods versus event driven, and do not consistently support maneuver	Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Evolving plan available to all BOSs and echelons to support synchronization efforts; improved SA makes it possible to use event-based triggers as opposed to time-based
7.1i	Forward Support Battalion (FSB) support operations officers do not coordinate for refuel windows with supported units	Poor Synchronization	Increased OPTEMPO	Improved SA and more precise taskings increase the ability to make valid estimates of CSS requirements
7.1j	Task Force (TF) S4s (Logistics) experience difficulty with supply of either III or V, and sometimes both, yet TF S4s are not informing Bde about their problems	Limited SA	Increased OPTEMPO	The trend towards increased sharing of information enabled by digitization should help ensure problems are brought to the attention of higher echelons
7.1k	Staffs do not adequately identify anticipated ammunition requirements or resupply triggers based upon critical fire support tasks	Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Improved SA makes it easier to use event-based triggers; improved SA makes it possible to develop more precise plans, making it easier to envision when resources will be expended
7.1l	Ammo convoys moving forward from the Forward Ammunition Supply Point (FASP) are often not clear concerning the location of the Brigade Support Area's (BSA's) Ammunition Transfer Point	Limited SA	Battlefield Visualization	Improved SA in that platform-level displays show location of CSS locations; elements can use displays to navigate to a specific control measure
7.2 a Logistics Estimates/CSS Planning and Integration (20%)	Units enter COA development with a distorted view of potential combat power	Limited SA	Battlefield Visualization	Improved SA regarding friendly and enemy combat power

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
7.2b	Casualties die of wounds (DOW) when they are not evacuated in a timely manner	Vulnerability, Limited SA	Battlefield Visualization	SA displays can be used to navigate to platforms with wounded soldiers and to casualty collection points; improved SA and wargaming tools can be used to estimate where the greatest densities of friendly casualties are likely to occur so that CSS assets can be located accordingly
7.2c	Most engineer battalions end up being the sole executors of planning, preparation and execution phases of Class IV (construction materials) and V logistical operations	Poor synchronization, Plan Lacks Details	Increased OPTEMPO	The readily availability of the evolving plan to all BOSs makes it possible to check and see whether other units are given roles in Class IV/V logistical operations
7.2d	Without an integrated brigade plan, field artillery (FA) units find themselves with no priority to draw classes of supply or receive maintenance support	Poor synchronization, Plan lacks details	Increased OPTEMPO	Improved SA and the ability to share information electronically reduce the time required to perform certain planning tasks so that more time can be devoted to integrating/synchronizing plans within and among BOSs
7.2e	Scout platoons are not supplied, evacuated, etc	Vulnerability, Limited SA	Increased OPTEMPO and Battlefield Visualization	Sharing of the evolving plan makes it possible for scouts to make sure they are supported by the CSS plan; including scouts within the chain of command for LOGSTAT reports helps to ensure their needs are reported; improved SA data makes it easier to find scouts
7.2f	Company/Teams often confused about recovery plan or lack any knowledge of the plan	Limited Plan Awareness/Input	Increased OPTEMPO	Executors have time and means to provide feedback regarding completeness and clarity of orders
7.2g	Units often do not begin collecting vehicles until change of mission	Vulnerability, Reduced Lethality, Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Sharing of the evolving plan makes it possible for units to make sure they are supported by plans for vehicle recovery; improved SA data makes it easier to locate vehicles during mission execution

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Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
7.2h	CSS annex does not contain adequate detail and is not synchronized with FSB/main support battalion (MSB) resupply actions	Plan Lacks Details, Poor synchronization	Increased OPTEMPO	Executors or other BOSs have time and means to provide feedback regarding completeness of plans
7.2i	Company teams are not resupplied	Vulnerability, Limited SA, Poor Synchronization	Increased OPTEMPO, Battlefield Visualization	Improved SA; more time available to check plans to make sure that company team resupply is addressed
7.2j	Task Force CSS elements frequently make no effort to conduct a formal or informal logistics, casualty or personnel estimate	Lack of Situational Understanding	Battlefield Visualization	Improved SA and more precise taskings increase the ability to make valid estimates of CSS requirements
7.2k	Units plan with no consideration of the current maintenance posture or projected combat power in the next 6, 12 or 24 hours	Limited SA, Lack of situation Awareness	Improved SA and Battlefield Visualization	Digitization should provide more accurate and timely information regarding maintenance status; improved SA makes it possible to predict accurately the affects of upcoming activities on maintenance
7.2l	Maintenance planning at the task force level is poor; Brigade Medical Officer (BMO) frequently left out of task force planning, Operations Order (OPORD) prep, and rehearsals	Limited Plan Awareness/Input	Increased OPTEMPO	Evolving plan is available to all BOSs and echelons for review
7.2m	BMO, Unit Medical Command Post (UMCP) personnel, and forward recovery teams are not aware of the enemy situation or the task force mission	Limited SA, Limited Plan Awareness/Input	Increased OPTEMPO and Battlefield Visualization	Evolving plan is shared with all BOSs and subordinate units; improved SA regarding friendly and enemy situation
7.2n	Casualty Evacuation (CASEVAC) planners do not balance anticipated casualties against available evacuation resources and estimate casualty densities/zones	Lack of Situational Understanding	Battlefield Visualization	Improved SA and more precise taskings increase the ability to make valid estimates of CSS requirements; improved SA and wargaming tools can be used to predict areas where highest density of casualties will occur

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
7.2o	Shortcomings in CASEVAC are not identified	Lack of Situational Understanding	Increased OPTEMPO and Battlefield Visualization	Improved SA and wargaming tools make it easier to estimate when and where friendly casualties will occur; evolving plan is available to all BOSs; executors or other BOSs have time and means to provide feedback regarding completeness of plans
7.2p	CSS is rarely integrated into the brigade planning process; some units do not consider bringing personnel to the logistics transfer point (LTP)	Limited Plan Awareness/Input	Increased OPTEMPO	Evolving plan is available to all BOSs; executors or other BOSs have time and means to provide feedback regarding completeness of plans
7.2q	Combined arms responsibilities for packaging/moving IV/V barrier materials and operating IV/V supply points are rarely covered in brigade orders	Poor synchronization, Plan Lacks Details	Increased OPTEMPO	Evolving plan is available to all BOSs; executors or other BOSs have time and means to provide feedback regarding completeness of plan (e.g., are combined arms responsibilities for packaging/moving barrier material covered in brigade orders?)
7.2r	FA Bns not adequately integrated into brigade's plan to build combat power during reception, staging, onward movement and integration (RSO&I)	Poor Synchronization	Increased OPTEMPO	Evolving plan is available to all BOSs; executors or other BOSs have time and means to provide feedback regarding completeness of plan
7.2s	Too often the CSS for the scout platoon is an afterthought by the TF battlestaff	Lack of Situational Understanding	Increased OPTEMPO	Evolving plan is available to all BOSs; executors or other BOSs have time and means to provide feedback regarding completeness of plans
7.2t	Scout platoon leaders often forced to coordinate with internal and external elements for support, without TF command emphasis	Lack of Situational Understanding, Plan Lacks Detail	Increased OPTEMPO	Evolving plan is available to all BOSs; executors or other BOSs have time and means to provide feedback regarding completeness of plans
7.2u	Recovery plan for not-mission-capable vehicles lack essential detail (do not plan collection points or do not support the TF mission)	Plan Lacks Detail, Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Evolving plan is available to all BOSs; executors or other BOSs have time and means to provide feedback regarding completeness of plans; improved SA makes it possible to define more precise maneuver operations, making it easier for other BOSs to decide how to support these operations

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Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
7.2v	An S1 (Personnel) casualty estimate is not consistently made during the planning process	Lack of Situational Understanding	Battlefield Visualization and Increased OPTEMPO	Improved SA and wargaming tools make it easier to estimate when and where friendly casualties will occur; evolving plan is available to all BOSs; executors or other BOSs have time and means to provide feedback regarding completeness of plans
7.2w	Bde Main CP CSS planner often prepares CSS plans based upon guidance from the TOC without input from FSB Support, Plans, and Operations Officer (SPO) or even the Bde S4	Limited Plan Awareness/Input	Increased OPTEMPO	Evolving plan is available to all BOSs; executors or other BOSs have time and means to provide feedback regarding completeness of plans
7.2x	Need to work on integrating CSS plan and maneuver; S4 and CTCP must anticipate unit needs during battle to push supplies to companies	Poor Synchronization, Lack of Situational Understanding	Battlefield Visualization	Improved SA make it easier to employ event-based synchronization of BOSs; improved SA also makes it easier to develop a precise maneuver plan, which, in turn, makes it easier for other BOSs to envision what they need to do to support maneuver
7.2y	S1 and S4 not integrated into planning process and CSS does not support maneuver	Limited plan Awareness/Input, Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Evolving plan is available to all BOSs' executors or other BOSs have time and means to provide feedback regarding completeness of plans; improved SA makes it possible to define more precise maneuver operations, making it easier for other BOSs to envision what they need to do to support maneuver
7.2z	Companies do not receive supplies or receive them late	Vulnerability, Limited SA, Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Evolving plan is available to all BOSs; executors or other BOSs have time and means to provide feedback regarding completeness of plans; improved SA makes it easier for units to locate CSS locations and for CSS assets to locate units; improved SA and wargaming tools make it easier for CSS elements to estimate the needs of units

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
7.2aa	FA Bns do not determine and track ammo requirements properly and do not consider requirements based upon critical fire support tasks	Limited SA, Lack of Situational Understanding	Increased OPTEMPO	Improved SA leads to a situation where units can more accurately predict the tasks to be performed and the outcomes of task performance; logistical reporting supported by digitization should make it easier to track supply levels
7.2bb	Artillery staff does not direct resupply triggers	Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Improved SA makes it easier to use event-based triggers; improved SA makes it possible to develop more precise plans, making it easier to envision when resources will be expended; evolving plan is available to all BOSs; executors or other BOSs have time and means to provide feedback regarding completeness of plans
7.2cc	Staffs do not have systems in place to track ammo consumption at section/platoon/battery/bn level, making it hard to project ammo requirements	Limited SA	Battlefield Visualization	Improved SA regarding the status of personnel, equipment and supplies enabled by platform-level transmittal of logistical and personnel reports in an electronic format
7.3a Materiel Readiness (17%)	Reduced preventive maintenance, parts ordering, and operations readiness rates	Vulnerability	Battlefield Visualization	Improved SA regarding the status of equipment and supplies enabled by platform-level transmittal of logistical reports in an electronic format
7.3b	Units fail to maintain an accurate picture of what equipment is inoperable, what parts are required, and requisition rates	Limited SA	Battlefield Visualization	Improved SA regarding the status of equipment and supplies enabled by platform-level transmittal of logistical reports in an electronic format, combined with effective linking of tactical logistical systems
7.3c	Task forces have difficulty controlling flow of vehicles in and out of UMCPs; often have fully mission capable vehicles in UMCP for long periods	Limited SA	Battlefield Visualization	Improved SA should make it easier for units to track NMC platforms
7.3d	Once released, have difficulty linking up vehicles with their units prior to Line of Departure (LD)	Limited SA	Battlefield Visualization	Improved SA should make it easier to link up platforms with their units in a timely manner

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Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
7.3f	CSS units have difficulty transitioning Standard Army Management Information System (STAMIS) from garrison to field because of lack of manual tracking when STAMIS off line	Limited SA	Battlefield Visualization	Digital methods of tracking supplies are available when STAMIS is off line
7.3g	Transportation manifests do not get to forward support battalion support operations prior to each shipments arrival in the Brigade Support Area (BSA)	Limited SA	Increased OPTEMPO	Electronic distribution of manifests is now possible
7.4a Combat Health Services/Medical Support (16%)	High DOW rate due to lack of timely treatment	Vulnerability, Reduced Lethality, Poor Synchronization	Battlefield Visualization	Improved SA and use of wargaming tools should make it easier for units to predict where casualties will occur and focus evacuation and medial assets accordingly
7.4b	Medical assets are not effectively positioned or utilized from company/team through task force levels	Poor Synchronization	Battlefield Visualization	Improved SA and use of wargaming tools should make it easier for units to predict where casualties will occur and focus evacuation and medial assets accordingly
7.4c	Task force medical platoons, company medics, and unit lifesavers run out of medical supplies and are unable to care for casualties	Lack of Situational Understanding, Poor Synchronization	Increased OPTEMPO and Battlefield Visualization	Improved SA and use of wargaming tools should make it easier for units to predict requirements for medical supplies; digitization should also make it easier to keep track of levels of medical supplies
7.4d	The medical company has additional Class VIII (medical supplies) but does not push it forward	Limited SA, Lack of Situational Understanding	Battlefield Visualization	Improved SA and use of wargaming tools should make it easier for units to predict requirements for medical supplies; digitization should also make it easier to keep track of levels of medical supplies
7.4e	Insufficient evacuation platforms are at the right place and right time to support the casualties incurred	Lack of Situational Understanding, Poor Synchronization	Battlefield Visualization	Improved SA and use of wargaming tools should make it easier for units to predict where casualties will occur and focus evacuation and medial assets accordingly

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
7.4f	No coordinated flow of vehicles through area or patients through facilities	Limited SA	Battlefield Visualization	Digitization should make it easier to keep track of wounded personnel and casualty evacuation assets on the battlefield
7.4g	Combat health support not integrated early enough in planning process	Limited Plan Awareness/Input	Increased OPTEMPO	Sharing of the evolving plan provides BOSs and echelons with the opportunity to provide feedback regarding completeness, clarity and compatibility of plans
7.4h	Units typically do not have a method to integrate the medical plan into the CSS plan and the maneuver plan	Poor Synchronization	Battlefield Visualization	Improved SA makes it easier to use event-based triggers when synchronizing BOSs
7.4i	The medical platoon does not know the plan until the CSS rehearsal	Limited Plan Awareness/Input	Increased OPTEMPO	Digitization allows sharing of the evolving plan with subordinate elements
7.4j	Medical company commanders do not have systems in place to track the Bdes medical assets	Limited SA	Battlefield Visualization	Digitization supports the development and implementation of plans for tracking and visualizing location of medical assets
7.4k	The Combat Health Support (CHS) plan for placement of medical assets on the battlefield does not support the maneuver commander's plan	Poor Synchronization	Battlefield Visualization	Improved SA and use of wargaming tools should make it easier for units to predict where casualties will occur and focus evacuation and medial assets accordingly
7.4l	CHS plan for placement of medical assets on the battlefield fails to take into consideration time/distance factors in casualty evacuation and treatment	Lack of Situational Understanding	Battlefield Visualization	Improved SA and use of wargaming tools should make it easier to consider time distance factors influencing casualty evacuation
7.4m	Task force medical platoons, company medics, and unit lifesavers run out of medical supplies and are unable to care for casualties	Poor Synchronization, Limited SA, Lack of Situational Understanding	Battlefield Visualization	Improved SA and use of wargaming tools should make it easier for units to predict requirements for medical supplies; digitization should also make it easier to keep track of levels of medical supplies
7.4n	The medical company has ambulances available but does not react since they are unaware that evacuation platforms are Non-Mission Capable (NMC)	Limited SA	Battlefield Visualization	Improved SA should make it easier for units to track NMC platforms

Appendix B. Digitization Impacts Data

Needs Improvement Trend	Problem Description	Problem Type	Digitization Impacts	Mechanism
7.4o	The medical planning and the S1 are not considering the casualty estimate when developing the CHS plan	Lack of Situational Understanding	Increased OPTEMPO and Battlefield Visualization	Sharing of the evolving plan should make it easier to identify BOS integration problems in time to take corrective actions
7.4p	The medical planner is not integrated into the Bde's military decision making process	Limited Plan Awareness/Input	Increased OPTEMPO	Sharing of the evolving plan can bring all subunits into the tactical information loop

Appendix C. Description and Genesis of Digital Skills

Digital Skill	Description/Definition	Genesis
1. Prepare for, and recover from, system crashes or other periods of system non-availability.	This skill covers the actions taken to make sure that the loss of a specific system does not reduce the ability of a unit to accomplish its tactical mission. A major goal of this skill application is to have backup capabilities that take advantage of digital systems by getting these systems back on line and ready to support a specific mission as soon as possible and/or promptly shifting functions to other digital systems (e.g., using All Source Analysis System (ASAS) to support maneuver if the Maneuver Control System (MCS) crashes). What one can do to recover from a system depends in large part on what one has done to prepare for the possibility of a crash. This skill is also concerned with preparing for known periods of system non-availability, such as that occurring when a tactical operations center is moved, and it may include deciding an optimal time to move the Tactical Operations Center (TOC).	The need to focus on this capability was made evident by a mix of sources. Many leaders within the 1st Brigade (Bde) talked about the importance of being able to shift to another digital system when one crashed, and they provided examples of how they shifted to alternate systems. We also found that leaders at lower levels were inclined to regress to analog capabilities. The digital operator's guide (DOG) contains selected guidance about how to prepare for crashes at platform level.
2. Establish and check communication links/network connections.	This skill addresses what must be done to set up the lower and higher tactical internet and make sure the systems are functionally interoperable. From the perspective of the Force XXI Battle Command, Brigade and Below (FBCB2) operators this includes making sure that individual platforms can be seen by others on Situation Awareness (SA) displays.	The need to focus on this activity as a major skill was driven home during interviews within the 1st Bde. Units had discovered, for example, that the order in which systems were brought up in the TOC could influence the viability of the network and planned to develop Standard Operating Procedures (SOPs) to address this concern. Unit leaders also point out that it was important for operators to understand how the various systems interfaced so that they could diagnose problems and envision work arounds. Further, leaders pointed out the importance of performing checks that measure interoperability among systems as well as measuring performance of a specific system per se. For example, FBCB2 operators sometimes mistakenly assumed that if there system checked out as green/green (operational) that their icon was being displayed on other systems.

Digital Skill	Description/Definition	Genesis
3. Protect network from operator error and malfunctions.	This skill involves avoiding actions that tend to lead to system malfunctions and taking actions that have been found to reduce the probability of malfunctions. The malfunctions include crashes, but are not limited to crashes. For example, it would also include distributing of information in a format that slows down the operation of a system, creating unnecessary tasks for system operators/users, or creating problems in data interpretation.	This was a skill identified and justified by a leader within the 1st Brigade (Bde).
4. Perform periodic checks of digital systems.	It is assumed that operators will need to check the functioning of their system, including the ability to interface with other systems, on a period basis during an exercise. Operators will need to know what to check and how to check it.	The need for conducting periodic checks was deduced rather than being recorded in existing guidance or reported by digital leaders. It is assumed that events can occur during an exercise that will influence the viability of the network (e.g., jamming, terrain masking).
5. Prepare and update reports and other messages.	This skill begins with basic operator requirements for preparing and sending messages, including target location data provided via lasing. It also involves being able to identify situations that require updating plans and reports and knowing how to label the update so that other members of the unit will know what it is an update of. It includes alerting parties that need to know when a product has been updated. This skill includes selecting the appropriate message format and assigning the appropriate message priority. It also includes establishing priorities for communicating information and using voice radio or other means to alert recipients of digital messages. Further, it includes selecting options to have an acknowledgement when a message is received, opened or responded to by recipients. It includes any additional action a sender might take to make sure receivers understand the message. Finally, this skill includes the capability to use subject descriptions that will convey important information about the content of the message.	Being able to prepare, send and address reports is a basic operator requirement. The Army Research Institute (ARI) demonstrated during testing of the Inter-Vehicle Information System (IVIS) that the accuracy and effectiveness of reports tended to increase with digital systems. For example, message recipients were less likely to query the sender to clarify the contents of reports, and reports on the location of enemy elements and targets were more accurate. Many leaders within the 1st Bde also pointed out the high degree of accuracy of enemy or target locations made possible by using digital systems to provide location data through lasing. An important measurement goal concerning this skill is to measure the quality and impacts of digital reporting, rather than merely measuring whether proper procedures were employed. Measures of this skill should provide information about the accuracy and effectiveness of reporting so that users can "see" the benefits they gain with digitization. Accuracy buys time for the unit and increases OPTEMO.

Digital Skill	Description/Definition	Genesis
6. Exchange data with external databases/ systems.	The major instances of this skill identified to date concern transfer of supply data between Standard Army Management Information System (STAMIS) and Combat Service Support Control System (CSSCS). Other possible examples may include threat data and terrain databases. This skill also includes knowing how to exchange data with external systems such as reconnaissance, surveillance, and target acquisition (RSTA) systems .	The major instances of this skill identified to date concern transfer of supply data between STAMIS and CSSCS. This activity is called out in the CSSCS user's manual and in the DOG. Intuitively, other examples may include threat data and terrain databases. At present, we know little about the potential problems performing these activities, and thus it is too early to decide whether these activities warrant focus as a digital skill. This skill also includes exchanging information with reconnaissance, surveillance, and target acquisition (RSTA) systems. In the commander-centric warfare of the future, for example, a commander may control RSTA systems using the same systems used to perform other command and control functions. The information provided by these external systems reduces the amount of time units must spend acquiring this information by other means. That is, it can buy a lot of time for a unit and increase OPTEMPO.
7. Create, modify and employ overlays, templates and graphics.	This skill encompasses the ability to distribute and use graphical information during mission execution as well as creating these products during the mission planning and preparation process. Innovative ways of using the ability to send graphics in controlling unit actions are still being discovered. This skill includes more than the basic capabilities of downloading overlays from a central source to a specific system and then selecting the overlay or combination of overlays to be displayed on that system. The skill also includes knowing how to use the growing variety of information that can be included in overlays.	Creating, modifying and sending and using graphics are basic operator tasks addressed by user's manuals. Measures of this skill must also consider whether the content/complexity of the products match the information needs of recipients, and they should consider whether the sender keeps file sizes small. These measures are in response to problems in creating and sending overlays identified in past digital rotations to the National Training Center (NTC) that units have attempted to address through SOP development. In addition, measures should be sensitive to creative use of graphics to help units visualize the battlefield or control the execution of tasks. The capability to electronically transmit graphics over the battlefield is one that buys a lot of time for a unit and increases OPTEMPO.

Digital Skill	Description/Definition	Genesis
8. Assess completeness of information on the tactical situation.	Review SA data to decide if it provides all of the information needed on the Mission, Enemy, Terrain, Troops, Time and Civilians (METT-TC) situation. This skill would include, for example, deciding whether it was necessary to display vehicle or platoon icons rather than aggregating at platoon or company level.	The idea for including this as a digital skill came from analyzing Combat Training Center (CTC) performance trends and Warrior-T battlestaff tasks. A long term problem in the performance of units at the CTCs is that the various BOSs fail to contribute fully to the job of identifying information needs to be addressed by the intelligence preparation of the battlefield (IPB) process. The Warrior-T battlestaff tasks attempt to define what the contributions of the various BOSs are likely to be. Another reason for focusing on this activity as a digital skill is that human beings sometimes have a tendency to focus on the content of computer screens and forget that there is other information they need to know that is not included on the screen (Mosier, Skitka, Heers, and Burdick, 1998).
9. Assess currency of information on the tactical situation.	Decide if the SA data provides an up to date description of the METT-TC situation including status of: enemy elements; friendly vehicles and crews; friendly dismounted infantry; and other types of information where data currency can be a problem due to infrequent updates.	The topic of being able to decide the age of information is mentioned in the Digital Operators Guide (DOG) in terms of enemy situation awareness data. Other cases where data age may be important were deduced when reading the DOG. For example, information based upon LOGSTAT reports may be out of date if substantial unit movement and firing has occurred since the last LOGSTAT report, and overlays describing supplies available at CSS locations may be out of date if there have been interpolated resupply activities.

Appendix C. Description and Genesis of Digital Skills

Digital Skill	Description/Definition	Genesis
10 Assess completeness, accuracy and clarity of planning products.	Decide whether orders and plans describe clearly the tasks to be performed, address the five W's (who, what, when, where, and why), and address the elements of information that are often missing from plans (e.g., what roles should vehicles play in dismounted operations?). Although this is a tactical skill applicable in the analog situation, it takes on new importance in the digital environment where orders can be issued without face to face contact, briefbacks might have to be conducted over digital systems, and the order recipient might have to gain clarification using digital systems. An important component of this skill might be deciding when face to face interactions are critical when issuing orders.	Problems in the completeness and clarity of planning products have been demonstrated repeatedly for analog units at the CTCs. These problems can be addressed in the digital environment to some extent on either the sending end (I have checked to make sure the CSS plan addresses gaps in information commonly found in CSS plans) or the receiving end (this plan does not tell me where the casualty evacuation points are located). Interviews with leaders in the 1st Bde of the 4th Infantry Division (ID) indicated that digitization bought additional time for units to examine the contents of plans. The digital environment makes it possible for leaders at all levels to call up and review the evolving plan for a mission.
11. Coordinate with others to acquire information.	Given an identified gap in the information needed regarding the METT-TC situation, what does one do to address the shortfall? (Who do you notify and how is the notification made?)	Given that gaps in the information to be provided by specific BOSs are a common problem for units at CTCs, one has to think about how these gaps would be addressed in the digitized environment. For example, if scouts realize that their CSS graphics do not show casualty collection points anywhere near the area in which they will operate, what do they do about this situation (e.g., do they send a message to the S2 [Intelligence] or the S4 [Logistics]). At this point, the literature still has little to say about how information gaps are addressed in the digital world versus the analog world. Digitization may change patterns of communication.

Digital Skill	Description/Definition	Genesis
12. Identify situations where a physical terrain reconnaissance is required.	Terrain analysis tools do not take vegetation into consideration, and some of these tools do not consider the height of viewpoints or the height of objects above ground level. There are likely to be cases where a more extensive physical terrain analysis is needed.	Interviews of a digitized unit conducted by TRW after a 2000 NTC digital rotation raised the issue of whether someone viewing an electronic map can effectively pick locations that provide appropriate fields of observation, cover and concealment. The interviewees suggested that someone on the ground should select positions and conduct a reconnaissance of routes. Based upon the fact that many line-of-sight calculations do not consider vegetation, the height of the viewer, and the height of the target, there may indeed be cases where forces on the ground require greater latitude in selecting positions and routes.
13. Monitor changes in planning products.	Digitization enhances the ability of units to employ detailed data in mission planning, and it includes the capability to update that data very quickly. Digitization also makes it easier for echelons and BOSs to examine planning products and provide feedback to the developers of those products, and it makes it easier for product developers to make changes in products and redistribute them. This increased planning capability even carries over into the execution phase so that major changes can be made and implemented as the tactical situation unfolds. The ability to track and use changes in planning products is likely to be a critical skill.	During interviews of the 1st Bde a number of participants mentioned using SA data to navigate to a point. Previous ARI research has shown that some individuals have a problem translating what they see on screen to what they see when they look out their hatch. Using SA data to move to a point on the ground is likely to be an acquired skill in some instances. During interviews within the 1st Bde we discovered that the variety of situations in which this skill might be employed were not immediately obvious to all system users.

Digital Skill	Description/Definition	Genesis
14. Maintain awareness of location of own unit relative to threats.	This skill involves using SA data to correlate the position of a unit with a wide variety of threat situations that include: enemy positions, enemy fire sacks, enemy or friendly obstacles/minefields, contaminated areas, likely avenues of enemy advance, boundaries, artillery fire for effect missions, and choke points.	Intuitively, a map showing where you are, where other friendly elements are, and where threats are located should keep units from entering threatening areas. Using SA data to protect the force is an important selling point for digitization, and a critical skill that needs to be acquired early. It is also a critical skill measurement goal for the same reason. It is a mistake to assume that this skill will be mastered quickly. During the Force XXI Advanced Warfare Experiment (AWE) there where long periods during which selected company commanders did not look at their screens, and there were cases where vehicles were damaged when they entered threat zones, including friendly minefields. We are likely to see procedures evolve for applying this skill. That is, how can we best describe the potential threat situations in a way that will help leaders "visualize how enemy will use combat multipliers to shape the battlefield" by, for example, envisioning the possibility of multiple forms of contact at the same time. Threat situations should include environmental variables.
15 Compare expected and actual status of friendly units.	This is an exceptionally complex skill that involves envisioning the steps a subordinate unit must take to perform its missions, identifying indicators that a unit is/is not taking the appropriate steps, using SA data to apply the indicators, and providing feedback to subordinate units in time for them to take corrective action. For example, a company commander may decide that a platoon is moving too slowly to reach its support by fire position on time.	During interviews of the 1st Bde a number of cases were reported where leaders observed problems in the performance of subunits when observing friendly icons on screen and alerted the subunit to the problem (e.g., the unit was halted at the wrong location). There are many times of recurring performance problems at the CTCs that could be diagnosed in real time by watching friendly icons (e.g., units approaching friendly minefields).

Digital Skill	Description/Definition	Genesis
16 Maintain awareness of trigger events and events addressed by execution matrixes.	This skill involves knowing what events should elicit responses from friendly or enemy units and being able to track the occurrence of these events. This skill is considered to be a major contributor to BOS synchronization and to the synchronization of activities across echelons. For example, it would include deciding what event would trigger the beginning of a fire support mission as well as what event would trigger the end of the mission. Logically, the triggers should be synchronized with the needs of the unit being supported. This skill is also assumed to be critical to mission rehearsals in that testing of triggers (will the unit know when the triggering event occurs and does the triggered event meet the need of the supported unit) is expected to be consistent objective of rehearsals.	Many of the performance problems observed at the CTCs can be addressed by identifying tactical events likely to have an effect on enemy and friendly actions, identifying the possible actions, and deciding what to look for to draw a conclusion about what course-of-action was being taken. In the digital world, trigger events and execution matrixes will be applied using SA data to a large extent and current literature has little to say about how this will be accomplished. This is an extremely important skill that is likely to be critical to synchronizing activities among BOSs and across echelons, and poor synchronization is a commonly occurring problem at CTCs. Measures of these skills can also be used to demonstrate improved synchronization.
17. Use SA data to move to a vehicle or control measure location.	This skill includes the capability to correlate an out the turret view with what is observed using an SA screen.	This skill is critical in terms of demonstrating the power of digitization. Units are impressed with the fact that they can use SA data to navigate to a point under even those conditions were visibility is extremely poor. A problem in using this capability is that many individuals have trouble translating what they see on screen to an out the hatch view of the situation.
18. Use SA data and terrain analysis tools to select routes and positions.	This skill involves using SA data (enemy positions and other threat situations) and terrain analysis tools (line-of-sight, range fans, trafficability) to select routes that offer cover and concealment, avoid enemy fire sacks, and avoid obstacles/minefields. This skill is also used in selecting positions that effectively match the task assigned to an element (e.g., provide supporting fire, cover a minefield/obstacle, recover vehicles, provide medical treatment) and help protect the element (e.g., avoid placing CSS locations along likely avenues of enemy approach).	This skill addresses a major benefit of using digital systems. During interviews within the 1st Bde we found that some leaders at platoon and company level did not know how to use this capability.

Digital Skill	Description/Definition	Genesis
19. Use SA data to control unit movement and deconflict routes.	This skill involves using SA data to monitor the formation being used by unit, the speed of movement, and the dispersion of vehicles or units. It can be used to find out if a unit is moving and where it should be moving (location and direction of movement) at a specific point in time. The skill is also used to identify cases where the paths of two moving units are likely to cross, a unit is moving when it should not be moving, or a unit is in a halt position when it should be moving.	This skill addresses a major benefit of digital systems. During interviews within the 1st Bde, some participants described instances where they used this capability or would use this capability.
20. Use SA data and terrain analysis tools to predict contact variables and support BOS integration.	This skill is also used to decide where, when and how enemy contact is likely to occur and where the greatest density of friendly casualties is likely to occur as input for supporting fire requirements, smoke requirements, breaching requirements, Air Defense Artillery (ADA) requirements, and positioning of CSS assets.	This skill addresses an extremely important capability enabled by digital systems.
21 Monitor timing of planning activities.	This skill includes making sure that the timing of planning products supports BOS integration. For example, are casualty evacuation points identified in time to be reflected in the R&S plan? This skill also involves making sure that planning products are available in time to support rehearsals.	The need for this skill was deduced based upon the widespread problem of late delivery of planning products combined with questions about how one would track and synchronize the availability of various planning products.
22. Define rehearsal objectives.	Digitization of the battlespace includes the capability to employ computer generated forces as a battlefield visualization and mission rehearsal tool. Units have the ability to, for example, simulate the mission environment using differing values for unknowns (e.g., simulate an attack with and without enemy infantry in front of the enemy main body). This skill is concerned with deciding the specific issues to be examined during mission rehearsals. It is also concerned with digitization-specific communication methods that may need to be tried out during a rehearsal.	One of the expected benefits of digitization is that the increased ease of communications will speed up the planning process and provide the opportunity for developing a more detailed plan earlier in time. As a result, one would expect a unit to be better prepared to perform mission rehearsals, addressing one of the frequently encountered problems in unit performance at CTCs. In addition, the digital environment tools can be applied in conducting rehearsals. A well trained digitized unit should do a better job of identifying and addressing rehearsal objectives in comparison with a less well trained one, or an analog unit.

Appendix D

Expected Benefits of Using Digital Systems

Theoretically, digitization offers a number of advantages to combat units, including increased lethality and survivability (U.S. Army Directorate of Integration, 2000). Other advantages include increased responsiveness, deployability, agility, and sustainability (DoD, 2000). The U.S. Army expects digitized units to be more lethal because they can identify targets and direct weapons onto those targets more quickly than "analog" (non-digital) units. They are more survivable because improved communications allows them to react to the enemy attacks more quickly to protect combat assets from destruction.

General Mechanisms Enabling Benefits

The use of digital systems is expected to increase the combat effectiveness of units through two general mechanisms. First, it will help leaders and soldiers visualize the battlefield and gain a greater understanding of the tactical situation. Second, digital systems can increase the operating tempo (OPTEMPO) of a unit through the improved ability to share information.

Improved battlefield visualization. Battlefield visualization is a concept proposed by the U.S. Army (Training and Doctrine Command [TRADOC], 1994) which has elements in common with situation awareness (SA). TRADOC defines battlefield visualization as:

> "The process whereby the commander **develops a clear understanding of the current state** with relation to the enemy and environment, **envisions a desired end state** which represents mission accomplishment, and then subsequently **visualizes the sequence of activity** that moves the commander's force from its current state to the end state." (bold added) (TRADOC, 1994).

Therefore, battlefield visualization includes three steps: (a) developing a mental model of the current state (tactical situation), (b) envisioning a desired end state, and (c) visualizing the sequence of activity to move from the current state to a desired end state.

In the case of SA, the senses bring information about the environment into the working memory where it is formulated into

a mental model of the outside world. This occurs in three levels (Endsley, 1995); (a) a perception of the elements of the current situation, (b) comprehension of the situation, and (c) projection of future status.

Although both models have three steps or levels, an examination of the models suggests SA may be a subset of battlefield visualization and that it is an important battlefield visualization tool. Table D-1 lists the steps in battlefield visualization integrating the three levels of SA. Higher levels of SA suggest that individuals should be able to predict actions in the future based on their knowledge of the current situation. The battlefield visualization process takes this further by visualizing the desired outcome and deciding what actions a unit must take to modify events so that the predicted outcome becomes the desired outcome. Battlefield visualization goes beyond SA by encompassing the backwards planning process.

Table D-1
Steps in Battlefield Visualization

1. Develop an understanding (mental model) of current state
1.1. Acquire information from environment (Perception of the elements of the current situation; SA level 1)
1.2. Understand how the information affects the current situation (Comprehension of the situation; SA level 2)
1.3. Build a mental model of current state
2. Envisions a desired end state
3. Visualizes the sequence of activity to move from the present to the end state
3.1. Extrapolate the current situation to the future (Projection of future status; SA level 3)
3.2. Compare desired end state with extrapolated future
3.3. Identify elements which must change for extrapolated future state to become desired end state
3.4. Determine how to affect those identified elements so that extrapolated future state becomes desired end state

The improved capability of digitized units to visualize the battlefield is gained through increased SA combined with the use of wargaming tools included within the digital systems. Table D-2 shows how digitization can impact the three steps of battlefield visualization. We have described these impacts in Appendix B. The SA level 1 data available in the digital environment includes the location of friendly and enemy elements

and the location of threatening situations and supporting situations.

Table D-2
Impacts of Digitization on Battlefield Visualization

BATTLEFIELD VISUALIZATION	DIGITIZATION IMPACTS
Step 1: Develop mental model of end state. -Acquire information from the environment (SA level 1) -Understand how information affects current state (SA level 2) -Build a mental model of the current state	-SA level 1 is closer to ground truth -SA Displays give meaning to SA level 1 information -Analytical tools give additional meaning to SA level 1 information - SA Displays and analytical tools provide a physical picture of the current state
Step 2: Envision desired end state	-Analytical tools help envision end state
Step 3: Visualize the sequence of activity to move from current to desired end state -Extrapolate current situation to the future (SA level 3) -Compare desired end with extrapolated future -Identify elements which must change for extrapolated future to become desired end state	- Analytical tools help extrapolate to the future -Provides new command and control tools for affecting elements

SA level 1 includes bits of information about the situation. Effective use of digital systems should increase the precision of information regarding the enemy situation. Instead of knowing that threat situations may be encountered as a unit moves to an objective, a leader is more likely to know the locations, size and nature of threat situations. SA level 1 is more likely to be very close to ground truth. One reason that the SA level 1 is more likely to approach ground truth is that digital systems provide Global Positioning System (GPS)-enabled data on the location of friendly vehicles. Another reason SA level 1 is closer to ground truth for digital units is that information on the enemy situation can be collected through enhanced reconnaissance, surveillance, and target acquisition (RSTA) assets, such as unmanned aerial vehicles.

Capabilities included in the digital system of systems also make it easier for personnel to understand how the SA data

affects the current state (i.e., reach SA Level 2). Digital systems can provide information on the location of friendly forces, enemy forces, enemy obstacles, friendly obstacles, contaminated areas, combat service support areas, and control measures in a manner that allows the receiver to immediately view this information over a map display. The job of building a mental model of the current state is reduced in complexity by the fact that the user is provided with a picture of the current state.

The capability of the user to understand the implications of SA data is further enhanced by the availability of wargaming tools for digitized units, such as terrain analysis tools. For example, given the location of enemy forces and a possible route of advance for the friendly force, leaders can find out where their unit is likely to be engaged by the enemy (i.e., establish intervisibility).

The increased SA level 1 and level 2 made possible by digitization, possibly combined with the use of wargaming tools, can also help personnel perform the second step in battlefield visualization, envision the desired end state. Consider a case where a unit has the mission of moving to an objective area and denying the enemy access to the objective. Units can use information about enemy forces and wargaming tools to decide whether it is better to cover enemy avenues of approach to the objective from positions on the objective or from surrounding terrain. The result of this decision can influence how the unit leader decides to execute the mission.

The enhanced SA facilitated by digitization can also be used in performing the third step of battlefield visualization. These tools can also be used to extrapolate the current situation into the future (SA level 3). Finally, the increased SA levels 1, 2 and 3 can be combined with the use of wargaming tools to visualize the sequence of activity to move from current to desired end state. For example, leaders can decide when and where smoke and/or suppressive artillery fire might have to be employed to protect the force. The fact that increased SA level 1 data will also be available during mission execution can be exploited during the planning process to envision event-based triggers for synchronizing BOSs. For example, the fire support element will provide a smoke mission when the maneuver unit reaches a specific point on the ground.

Research has demonstrated the beneficial effects of increased SA. The ready availability of processed information

at all echelons seems to significantly increase SA among commanders and soldiers. In an experiment by McGuinness, Foy and Forsey (2000), military commanders were asked to command simulated forces using a digital interface similar to those used by U.S. Army digital units. The commanders were provided with information of enemy forces (red, or enemy SA), as well as status and position information of friendly forces (blue, or friendly SA).

They found commanders who used digital systems were able to provide much more detailed information on enemy forces than those who relied on conventional tools. These commanders also reported they felt they had a better appreciation of the status and location of friendly forces. They reported this enhanced awareness of the status and position of friendly forces to be the most useful benefit of digital systems.

The capability to visualize the battlefield is increased further when wargaming tools are used to take advantage of increased SA. It is probably fair to say that the wargaming tools available in current digital systems represent only a small portion of the tools that will be available in the future. It is probably also fair to say that the variety of ways available to describe aspects of the tactical situation in today's digital systems may be only a subset of the ways available in future systems.

Increased OPTEMPO. Digitization allows combat units to increase their OPTEMPO, or the speed at which they can conduct combat operations. Units are able to collect information, make decisions, and implement those decisions more quickly than the enemy. This process of collecting, deciding, and implementing is known as a decision loop. Digitization allows units to get "inside the enemy's decision loop." That is, make decisions faster than the enemy (DoD, 2000).

Substantial evidence that digitization can increase OPTEMPO has been available for ten years. An early experiment with a pre-FBCB2 system called the Intervehicular Information System (IVIS) showed armor platoons equipped with IVIS completed missions faster and reported battlefield events with more accuracy. They also successfully executed more change-of-mission, obstacle bypass, battle position, and call-for-fire tasks (Du Bois & Smith, 1991). Similar experiments with company-level armor units using a system called the Combat Vehicle Command and Control System (CVCC) showed comparable advantages (Atwood, et al., 1991).

Increased awareness and understanding of the tactical situation provide digitized units with a time advantage in terms of mission planning and preparation activities. Digital systems help leaders gain information in a manner that fits human sensory modalities better and adds to the time advantage throughout a mission.

From the point of view of sensory modalities, most tasks performed by commanders and staff officers are primarily visual/spatial. Many tasks, such as route planning, terrain analysis, plotting artillery fans, etc., involve identifying spatial relationships between units and tend to use maps as planning tools. The most frequently used tools are templates and overlays, in which relevant data is overlaid onto a map of the objective geographical area. These tools are often supplemented by tactical reports which require the sender to identify the location of the event being reported.

Analog units must translate locations into coordinates of some kind before they communicate the locations to other units. Often the sending unit encodes information about the location of an event (spatial) into coordinates (numerical/semantic). The receiver must then recode the numerical information back into spatial data; typically by plotting the data on a map. The encoding and decoding of the information normally requires greater cognitive effort, slows down the transfer of information, and increases the probability of errors (Sanders & McCormick, 1993).

Using digital systems and displays allows staff elements to manipulate spatial data on a visual display and send it without translating the data into coordinates. The audience receives the information in visual form without having to convert it from numerical data. Therefore, units receive the information more quickly, and it is in a form they can readily use without complex data conversion.

Initial observations suggest using digital tools may reduce planning time by as much as 84% (U.S. Army Directorate of Integration, 2000). This time advantage is further enhanced by the capability of these systems to expedite many command and control activities. The additional time gained can be used to spend more time performing activities that often receive scant attention due to time pressures, or it can be used to start mission execution earlier.

Digital systems make it possible for evolving mission planning products to be shared in an electronic format among command and staff, as well as subordinate units, to make sure mission activities are synchronized. Information can be transmitted to a wide audience more quickly than was possible using paper maps and acetate overlays. The electronic format also makes it possible to revise and redistribute planning products quickly, even when spread out over a large battlefield. This means that the plans supporting mission execution can be updated and distributed in response to new information even after a unit has already initiated the mission.

Appendix E

Defining Specific Mechanisms Whereby Digitization is Likely to Address Problems

We identified over forty mechanisms which offered solutions to many different problems in unit performance. For example, the ability to use event-based rather than time-based triggers to initiate task execution has the potential to address a wide variety of problems where there is a lack of synchronization of activities among BOSs or among echelons within a BOS.

As a case in point, digitization would be expected to address the problem "smoke plans are rarely made and coordination of the targeting process between fire support and maneuver does not occur" (CALL, 2000) via multiple mechanisms. Increased awareness of the location of enemy forces, combined with the use of terrain analysis tools, makes it possible to predict where and when moving friendly forces are likely to be seen by the enemy. This allows the fire support element to plan to support the maneuver unit with smoke at a time when the maneuver unit is likely to benefit most.

Since digital systems allow the unit to see where friendly forces are located, the unit can use the more precise trigger of unit location rather than the less precise trigger of time to initiate the smoke mission. In this way, if the pace of movement of the maneuver unit is faster or slower than expected, the unit can avoid a situation where smoke is provided too late or too soon to be of use to the unit. The fire support element has a general timeframe to support mission preparation activities, and a specific event trigger to initiate execution.

Appendix B briefly describes the specific mechanisms whereby digitization would influence unit performance for each problem.

Some of the more prevalent mechanisms are described below.

Increased SA should:

- lead to more precise maneuver plans for a mission,
  - making it easier to identify specific issues that need to be addressed during rehearsals
  - making it easier for other BOSs to envision what they need to do to support maneuver

- increase the ability to make valid estimates of CSS requirements

- lead to more precise questions regarding enemy intent,
  - making it easier to answer questions
  - reducing data collection requirements

- make it easier to control unit movement and keep it on schedule (increased SA sometimes removes the need for schedules)

- make it easier to estimate the magnitude of fire support requirements

- allow planning to begin at a more advanced level,
  - speeding up the planning process and allowing more time for mission preparation activities

- make it easier to employ event-based triggers to synchronize BOSs

- make it easier to employ valid time-based triggers to synchronize BOSs

- make it easier to deconflict routes during movement

- help units to devote more attention to specific warnings

- help soldiers navigate to specific control measure, unit, or vehicle locations

- perform many battle tracking functions for units (especially locations of friendly units), freeing up time for tracking additional aspects of the battlefield

- reduce the number of contingency operations to be planned/supported, making it easier to devote resources to actual threat situations as they are encountered

- make it easier to select routes offering cover/concealment

- provide information needed to plan actions on contact and direct fire plans

- help units predict areas where highest density of casualties will occur

- make it easier to monitor selected aspects of the performance of subordinate units

- reduce the time a unit devotes to trying to track the location of friendly units, providing time for other activities

Electronic sharing of evolving plan should:

- make sure anyone with a need to know has access to planning data (as opposed to certain BOSs or subunits being cut out of the tactical information loop unintentionally)

- reduce the time required to perform many mission planning tasks so that units can have time to:
  - consider alternative courses of enemy action
  - consider alternative courses of friendly action
  - plan and conduct mission rehearsals
  - perform mission preparation tasks
  - initiate the mission early when advantageous to do so

- provide executors with time and means to provide feedback regarding completeness and clarity of orders

The capability to share graphics electronically should:

- make it easier for leaders to convey information about what they want subordinates to do

- make it easier for leaders to control direct fires

- reduce the possibility of errors transposing map coordinate data to map overlays

- enable the capability for units to distribute modifications in plans quickly

- motivate and enable units to update information on the actual or perceived status of the battlefield that is conveyed most effectively or efficiently in the form of graphics (such as situation templates, range cards, locations of threatening situations, locations of breach points)

The capability to combine improved SA with the use of wargaming tools:

- provides a means of rehearsing many aspects of a mission
- provides a means for predicting when many key mission events are likely to occur as input for synchronization of activities within and across BOSs