Simulation-Based Training and Assessment of Digital Command Staff: Training and Assessment for Network-Centric Command and Control

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Abstract

Increasing digitization of the modern battlefield brings with it new demands on military command staffs for rapid, flexible decision making, execution of complex digital skills such as visualization and information management, and coordinated, communication-intensive teamwork. The Army's Battle-Command Reengineering III exercise (BCR III) simulated the demands of the future digital command environment by placing a command staff in the context of a soldier-in-the-loop simulation, with a suite of digital tools including email, shared whiteboard, and SA-enhancing common-operating views, to test concepts in future battle command. In this context, we developed an innovative approach to *decision- skills training* using short, focused vignettes that provided staff members with opportunities to utilize the same digital equipment to accomplish goals in each of several stages of the natural battle-preparation and execution cycle. To assess the degree to which the training approach was successful and to develop a picture of individual and team outcome/process, we developed a set of targeted performance measures. These measures fell into several categories ranging from measures of individual performance to measures of team-level perceptions of teammates' roles and workload. We employed a mix of observation, participant survey and objective measurement to provide measures of both *team outcome* and *team processes.*

1 Introduction and Significance to Command and Control

Increasing digitization of the modern battlefield brings with it new demands on military command staffs for rapid, flexible decision making, execution of complex digital skills such as visualization and information management, and coordinated, communication-intensive teamwork. The same technologies that are driving battlefield digitization are also driving a revolution in command training and performance assessment: It is now possible, using high-fidelity distributed simulations, to expose command teams to realistic, rigorous simulated command exercises that provide practice on a range of cognitive skills and demand considerable coordination of action. Indeed —and consistent with John Shalikashvili's Joint Vision 2010 —new high-fidelity simulation technologies are making it increasingly possible for today's command staffs to "train the way [they] fight." These new capabilities have brought with them a number of new challenges in training and performance assessment, however, and innovations in training and assessment must now catch up with the pace of technological innovation to insure the benefits of simulation-based training.

The introduction of digital technologies and the increasing volume of information these technologies have made possible have led to a shifting emphasis in the training needed by today's commanders. Increasingly, *digital skills* such as information management, rapid visualization, and information fusion are becoming required on the battlefield. Teamwork skills have also become more important in the era of network-centric warfare (NCW) where teams of specialists are tethered together by satellites, and coordination is accomplished through virtual collaboration and email. In addition to the need to modernize our approaches to training, traditional measures of performance and effectiveness (MOPs and MOEs) must also be adapted to meet the challenges of measuring performance in these new skill domains and assessing digital-skill learning and retention. Measures must capture both outcome (were the right decision made?) and process (were the decisions made right?) to effectively assess command performance in digital environments.

The Army's Battle Command Reengineering III exercise (BCR III), took place at the Mounted Maneuver Battlespace Lab's (MMBL's) Mounted Warfare Testbed (MWTB) in Fort Knox, KY, in April '99. This exercise offered opportunities to examine new approaches to training and assessment in the context of a large-scale digital exercise. The exercise applied soldier-in-the-loop simulation and semi-automated force technologies to test concepts in future battle command. It placed a new command-team architecture in a digital command environment, providing staff control over digital resources to support planning, battle rehearsal, coordination, communication, and situation awareness. Command staff participated in nine days of exercises designed to assess the impacts of digital technologies on command efficiency and the command decision-making process. To prepare participating command staff for this rigorous exercise, we developed *decision-centered training* based on focused training vignettes that emphasized three key skill areas —*digital decision skills, information management,* and *team performance*—and a range of *measures designed to assess individual and team performance, process and outcome* in each of these areas. The paragraphs below describe the approach used and some outcomes of the exercise.

2 Training Key Command-Team Skills

The competing goals of training individuals to proficiently *utilize digital equipment* — to use the computers, file systems, email, chat and white board capabilities — and training them to efficiently *command an ongoing battle using this equipment* — engage in a *"digital"* decision making process — make the job of training digital staff complex. Knowing how to use digital resources in isolation (push the right buttons) is not enough to insure command efficiency and is likely to lead commanders to fall back on what they know rather than fully exploit the strengths of new technologies. To strike a balance between the "push-button" training needed to achieve proficiency on the equipment and the more decision-oriented command-level training needed to mesh digital skills into the command decision-making process, we separated these aspects in our training.

The BCR III training program utilized a decision-centered approach, using short, focused vignettes that placed the command staff in isolated stages of the natural battle-preparation and execution cycle. By isolating *battle planning, course of action (COA) development, rehearsal*, and *execution*, we trained the staff how to utilize the same digital equipment to accomplish goals of each stage. This is important because the same tools — email, whiteboard, plan view display (PVD) overlays, video teleconference, and stealth display — were utilized in different ways in each stage.

In addition to isolating natural stages in the battle preparation and execution cycle, we also built "themes" into our vignettes to insure stress on key digital-command competencies. We focused on three main skill areas: *decision making skills, information management strategies,* and *team performance strategies*. While there were demands on each of these skills sets in our vignettes, we intentionally stressed one over the others in individual vignettes in order to focus staff attention on how the digital equipment could be used to improve each.

Decision-centered training — Vignettes were intentionally designed to offer challenging deliberate practice opportunities and ample feedback and reflection opportunities to insure that learning would take place. Before each vignette, we conducted group discussions of expectations and roles and functions designed to help the team develop common mental models and strategies. During the vignettes, action was stopped to "calibrate" situation awareness — get everyone on the same page — and reflect on performance up to that point, correcting anything that was not working. At the end of the exercise, the team critiqued their own performance and repaired processes for the next vignette (methods based on Klinger & Klein, 1999)

Training teamwork and coordination skills — Research has show that effective teams are able to flexibly adapt their decision making and coordination strategies, and their overall organizational structure to the demands of performance. Our own work in the Tactical Decision Making Under Stress (TADMUS) program has suggested that the foundation of skills required to adapt in these ways can be trained (Serfaty, Entin, & Johnston, 1998). In the current context, we applied insights from Team Adaptation and Coordination Training (TACT) (Entin, Serfaty, and Deckert, 1994) by using training vignettes as opportunities for explicit practice of proven performance-enhancing teamwork strategies. These strategies included: *periodic intent updating, explicit reflection on team member roles and functions, monitoring the workloads of others, and anticipating the information loads and needs of others*.

Training for digital information management – Of the three areas covered, this one is perhaps the most important to the digital staff. The BCR III exercise placed the command staff in a unique four node command architecture in which the commander was supported by a mirror-image deputy command staff and two additional nodes concurrently supporting current and planning future operations. These nodes were located in separate command vehicles and supported the commander by communicating and sending information via email, radio, teleconference, whiteboard, and map overlays. The sheer volume of data and number of data sources required that the staff be trained to efficiently share and manage information to avoid information overload. Our training method, based on experimental findings and a related model of information management (Entin, Serfaty, Klein & Wolf, 1998), trained the staff to *pre-define information requirements, improve their level of organizational awareness* (to better predict the information needs of others) and *make better decision about when and how to pull (request) and push (disseminate) information*.

3 Measuring Team Outcomes, Process and Performance

To assess team performance, and provide some data on the degree to which our training approach was successful, we developed a set of targeted individual and team outcome and process measures. These measures fell into several broad categories that ranged from measures of individual performance to measures of team-level perceptions of one another's roles and workload. We employed a mix of observation, participant survey and objective measurement. Importantly, this package of measures went beyond typical *outcome* measures by looking directly at the *processes and performance* of the team. Categories of measures included:

Outcome performance measures – to assess dimensions of team performance. Several of our measures were modeled after event-based performance-assessment methods such as the TARGETS approach (Fowlkes, Lane, Salas, Franz, and Oser , 1994) and the Advanced Team Performance Index (ATPI) developed by the Navy and used by Serfaty, Entin, and Johnston (1998). These methods were based on direct observation by specialized observers/trainers of pre-determined critical team events or groups of events.

Individual-level Process measures – to capture the mechanisms or processes by which the team achieves performance. These process measures included levels of information seeking, resource utilization, failure to perform tasks, and individual decision-making or problem-solving strategies in the team context (Serfaty & Kleinman, 1989).

Team-level process measures – describe how team strategies were accomplished. These observer-based teamwork measures included behaviorally-anchored items designed to assess key dimensions of teamwork (Serfaty, Entin, & Johnston, 1998).

Patterns of team communication – to strike a balance between analyzing raw communication data (e.g., overall number of messages/unit time) and an exhaustive semantic analysis of the team utterances, we used a focused communication capture form. From the data collected using this observation-based form, more elaborate measures of team coordination (e.g., anticipation ratios, information compression ratios, push-pull ratios) can be computed (Serfaty, Entin and Deckert, 1993).

Workload and Cognitive measures – indicate the demands along various dimensions including time, mental effort, and psychological stress. We utilized variants of the NASA Task Load Index

(TLX) (Hart and Staveland, 1988) to assess individual and team workload and the dynamic redistribution of workload in teams. Research has shown that the ability to shift workload among team members in response to changing task demands can lead to more effective team performance (e.g., Serfaty, Entin, & Johnston, 1998). To assess the teams abilities to adapt, and their perceptions of load distribution, we utilized several derived measures of team workload, based on individual team members' ratings of their own workload and the workload of the others.

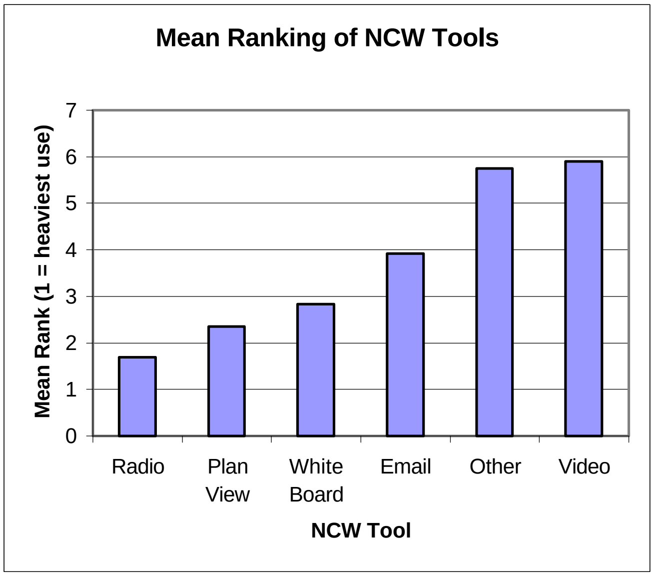
The table below summarizes the measures we utilized during the BCR III exercise.

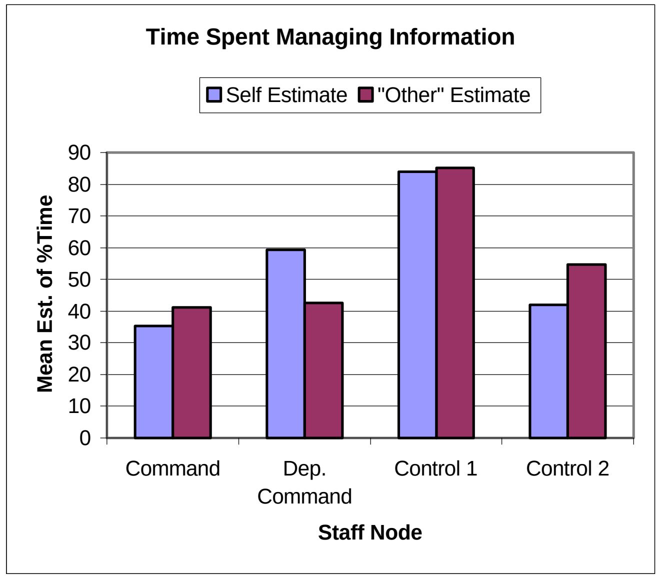
	Performance Measures	
	Process (How)	*Outcome* (How much)
Individual	• Individual Workload Index • Info-Management Questionnaire • Organizational Awareness Form	• Embedded (simulation generated) outcome measures
Team (Intra-Node) and *Team-of-Teams* (Inter-Node)	• Mutual Workload Rating • Communication Load Questionnaire • Teamwork Skills Rating (process assessment) • Operations Planning Questionnaire	• Embedded (simulation generated) outcome measures • Teamwork Skills Rating (outcome)

4 Outcomes and value

The BCR exercise provided nine full days of data collection during which the command staff conducted several, multi-day missions. Observers were placed at each of the four nodes, and were able to listen to the radio traffic generated within and between nodes, as well as look over the shoulders of staff members in their assigned nodes to see plan-view contents and monitor white board sessions. These observers collected communication data consisting of counts of communication events in a limited set of theoretically-relevant categories (requests and transfers of information, requests and commitments to perform actions or use key resources). Observers also provided overall ratings of team performance on several dimensions including back-up behavior, communication, and coordination. At the end of each mission day, the full command staff (14 members) completed a set of surveys assessing workload, information management, team process, and mission outcome.

Of particular interest to the assessment team and the Battle Lab were the effects of information technologies on C2 performance and success. As can be seen in Figure 1, information technologies such as email, video and whiteboard surpassed more traditional communication tools such as radio. This may have been due to the novelty of the technologies in this setting, but, when workload was highest and the team was attending to operational goals, these technologies were still used, suggesting that they were successful communication tools. An interesting and related finding, shown in Figure 2, which is consistent with what one would expect in a network-centric C2 team, is that the control node of the organization felt that they were spending a significant amount of time managing information. Patterns of information flow suggest that the command node was, in fact, acting as a hub of information management in the organization –and interesting role that may suggest an emerging requirement for future C2





organizations. The two bars of this image represent self assessment and the assessment of the rest of the team as a check.. Same-height bars in this case indicate the team agreed with the command node's assessment of their own load and recognized their information-management role in the team. This is an important finding, because evidence suggests that the ability of individuals to appreciate the demands placed on their teammates correlates well with overall team performance (Serfaty, Entin, 1995; Serfaty, Entin, & Volpe, 1993; Serfaty, & Kleinman, 1985). *These findings underscore the growing importance of digital skills training for the network-centric future.*

The introduction of digital technologies and emerging importance of digital skills, collaborative work, and network-supported team coordination are providing a new set of challenges for training and performance measurement. Our experience with the BCR III has provided a number of lessons learned that will be invaluable for future digital skills training development. Further, our experience in the application of a range of field methods for capturing and assessing real-time performance in the context of complex mission simulation provides a solid foundation for future performance assessment efforts. Our data will be used to assess the degree to which the staff utilizes digital technologies to support improved individual and team performance, the level of awareness individuals maintain of the workload and information requirements of others, and the degree to which our initial training program provides an adequate foundation to orient non-digital staffs to the possibilities of the digital, network-centric command environment of the future.

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