# Automated Measures of Staff Performance for Battle Command Reengineering III[1]

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## Abstract

This paper documents the design, development, and demonstration of prototype automated performance measures for staffs using advanced command, control, communications, computer, and intelligence ($C^4I$) systems. These prototype measures were implemented in a simulation-based experiment to examine the impact of digital systems on future Battle Command training and performance assessment at the battalion and brigade level. A short review of previous research and relevant literature on automated measures is presented, followed by the design and development of the prototype measures, and a discussion of sample results and lessons learned. More detailed information can be found in Throne et al. (1999). The complete results produced from the automated measures are presented in the five-volume set of materials entitled *Training and Measurement Support Package, Battle Command Reengineering III, Mounted Maneuver Battlespace Lab* (Training and Measurement Support Package, 1999). Selected results from this effort are also included in the Mounted Maneuver Battlespace Lab's (1999a) Experiment Final Report.

[1] All statements expressed in this paper are those of the authors and do not necessarily reflect the official opinions or policies of the U.S. Department of the Army.

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## Introduction

The Army's growing reliance on computer-mediated work (Caldera & Reimer, 1999) underscores the potential of digital technologies to automatically collect and analyze real-world performance data. As command, control, communications, computer, and intelligence ($C^4I$) systems become more integral to the performance of individual and collective tasks, the human-computer interactions associated with these systems become more critical and collectible. Digital information systems potentially can provide a powerful method for improving staff training and performance assessment (Dwyer et al., 1997).

Researchers involved in measuring team performance (e.g., Cannon-Bowers and Salas, 1997) note that both processes and outcomes must be addressed. Process measures address the activities, responses, and behaviors that people use to accomplish tasks. They include planning, decision-making, information processing, and synchronization. Many process measures also have corresponding products, such as decision support and synchronization matrices. Efforts to improve staff processes, however, must also be linked to unit outcomes, such as execution activities and combat effects since the staff functions within a unit and its mission is to support command and control ($C^2$) of the unit. Outcome measures are usually not diagnostic by themselves since they do not show the underlying causes of performance, or how to improve it. Thus, it is necessary to collect staff process and product measures as well as outcome measures and find a way to relate them to each other.

Three traditional methods of performance measurement used in previous performance assessment research are: observation, survey, and interview (e.g., Campbell et al., 1999). These methods have traditionally provided the measurement basis for conventional, that is pre-digital, staff performance assessment (Crumley, 1989). Together, these methods can yield a multifaceted look at staff processes during training. A fourth method, examined here, is the use of automated measures of staff performance.

Digital technologies are uniquely suited to automatically collect user performance data. In fact, most computers can and do routinely log or track all user inputs and system responses. Common examples of user interactions that computers routinely log include: "Back" keys, lists of recently opened files, and "Undo" commands. To achieve the training feedback and assessment potential of digital technologies, however, computer workstations must be more fully instrumented (Lickteig and Throne, 1999). For clarification, we provide a working definition of this instrumentation requirement for computer-mediated soldier performance. Instrumentation equates to a log of all soldier-computer interactions correlated with the battlefield situation in which they occur. Individual logs maintained on each operator's $C^4I$ device, however, are inadequate for examining collective performance by a group or staff of individuals working as a team. Fortunately, the collaborative nature of digital media readily supports a network of $C^4I$ devices and an integrated log of soldier-computer interactions across all members of a networked team. In fact, this digital collaboration extends this network and log to other types of digital technologies including sensor and weapon systems as well as simulation-based exercises in which staff performance occurs.

While a balanced set of measurement methods is often required, some key advantages of automated measures are briefly considered. First, as suggested, the more workers rely on computers to do their work, the more their computer interactions will become meaningful aspects of work processes and outcomes. Second, automated measures are not only objective, they are direct measures *of* performance. In contrast, many traditional measurement methods are measures *about* performance. Third, a greater reliance on automated measures may increase the scope and precision of performance assessment and feedback. Fourth, automated measurement and analysis may be needed for more complex work settings, such as $C^2$ staff performance. Finally, unobtrusive and automatic data collection may reduce measurement error as well as observer workload and resource requirements.

The potential of automated measures was demonstrated during the Combat Vehicle Command and Control (CVCC) program conducted by ARI at Fort Knox (e.g., Leibrecht et al., 1994). The objective of the CVCC effort was to determine the effect of vertically integrating digital $C^2$ systems in an armor battalion. To assist in this evaluation, 64 automated measures were developed. These measures were based on the tactical battlefield operating systems for maneuver, fire support, $C^2$, and intelligence. Results from the CVCC program of research used automated measures to assess training, soldier-machine interfaces, and operational effectiveness.

The Army's growing reliance on $C^4I$ systems, however, underscores the need for additional research and development on automated measures based on the ability of digital technology to support training assessment and feedback. In particular, automated measures are needed that address staff performance and the expanding role of $C^2$ systems for information-age forces. A key challenge is how to obtain automated measures of staff processes and products. A subsequent challenge is how to relate these automated measures to unit outcomes in order to provide more effective feedback on staff performance.

## Project Background

In response to the concerns and issues resulting from the Army's digitization efforts, ARI's research unit at Fort Knox is engaged in the design and development of training and performance evaluation techniques to support Force XXI digital capabilities (ARI, 1997). ARI's research in this area seeks to capitalizes on recent advances in the cognitive and behavioral sciences, and is focused on providing an empirical foundation for improved staff training and evaluation strategies for the digital battlefield of the future. As part of this ARI effort, the present research project entitled, Prototype Methods for the Design and Evaluation of Training and Assessment of Digital Staffs and Crewmen ($DC^4I$) was performed by the contractor consortium of the Human Resources Research Organization (HumRRO), Litton-PRC, Klein Associates, and Aptima.

The objective of the $DC^4I$ effort was to design prototype training and evaluation methods for staff operations in the future digital tactical operations center at brigade and below. The research addressed methods for training leaders and staffs of future digital environments. It led to the development of: the content of such training, the methods for providing the training, and the means for assessing performance outcomes as a result of training. The focus of this paper is on the last issue, the assessment of digital staff processes and product development through automated measures.

An opportunity to implement the automated measures of staff performance developed under DC$^4$I was provided by the Battle Command Reengineering (BCR) III Concept Experimentation Program being conducted at Fort Knox by the Mounted Maneuver Battlespace Lab (MMBL) in the Mounted Warfare Test Bed (MWTB). The DC$^4$I team, in reviewing the BCR III issues, determined that it could assist in answering 10 issues based on the team's military staff expertise. Six issues were thought to be potentially answerable through automated measures. As a check on the automated results, traditional measurement methods (survey, observation, and/or interview) were also used for the six selected measures (Throne et al., 1999). A complete set of the BCR III evaluation issues and methods are provided in the MMBL's Experiment Plan (MMBL, 1998). Table 1 provides the subset of BCR III issues focusing on staff performance that were selected for measures development.

Table 1

BCR Issues Addressed by DC$^4$I Measures

| **Issues** |
|---|
| 1. Can the reengineered Battle Command (RBC) decrease the time for planning and increase the time to prepare and rehearse?[1,4] |
| 2. Can the RBC provide the information and support system to assist the Commander's decision-making process?[1,2,3,4] |
| 3. Can the RBC allow efficient synchronization of combat, combat support, and combat service support assets?[1,3,4] |
| 4. Does the RBC provide efficient battle tracking and facilitate precise execution?[1,3,4] |
| 5. Does the RBC contribute to more rapid and efficient destruction of enemy forces?[1,4] |
| 6. Can the RBC increase the span of control of the Commander?[1,3,4] |
| 7. What effective tactics, techniques, and procedures (TTPs) are emerging from the RBC process?[4] |
| 8. What are the information management demands on multi-functional officers and what are the impacts of these demands on individual and team performance, process, and training requirements?[2,3,4] |
| 9. What are the impacts of RBC on team performance and process and how do new tools, capabilities, and roles change the task force organizational architecture?[2,4] |
| 10. What are the impacts of RBC on perceived and actual workload, the attribution of workload to individual, team, and task demands, and individual awareness of the distribution of workload across the team?[2] |

Note. 1 = addressed by automated measures; 2 = addressed by surveys; 3 = addressed by observations; 4 = addressed by interviews.

Specifications for the evaluation plan began with analysis of the issues and determination of the methods that could best be used to address each issue. The data collection plan was multifaceted, involving a combination of automated measures, surveys, observations, and interviews. The specific measures (e.g., survey and interview questions, observation points, and automated measures) were then designed and developed to provide broad yet efficient coverage of the issues[2]. These research issues became the framework around which the automated measures were developed.

## Method

Difficulties associated with assessing $C^2$ team performance are well documented and include: evaluation of teams vs. individuals; behaviors that are difficult to observe and evaluate; complexity of environment; and no standard criteria by which to evaluate performance (Cooper et al., 1984; Crumley, 1989). These are valid concerns and formidable obstacles for which automated measures are no panacea. However, the automated measures developed during this project attempt to help overcome such difficulties and extend the methods available for assessing and improving staff performance. This section describes how automated measures of staff performance were designed and developed.

### *Analysis*

Measure development began with an analysis of conventional staff performance (Crumley, 1989). The analysis quickly expanded, however, to a consideration of how digital systems and future staff organizations might impact staff performance. In particular, analysis focused on how the surrogate command, control, communications, and computer ($SC^4$) system used by staff personnel during BCRs impacted staff requirements to acquire and communicate information.

Staff members in BCR III were equipped with individual $SC^4$ systems that were digitally networked to share information despite being geographically separated in four separate $C^2$ vehicles, as depicted in Figure 1. Each soldier on the staff operated an $SC^4$ workstation that was equipped with: an electronic map that displayed automatic updates of friendly and opposing forces' (OPFOR) location and status; e-mail messaging; collaborative mission planning tools, including electronic whiteboard conferencing; voice communications; and a computer-generated virtual display of the battlefield, to include terrain information and both friendly and OPFOR vehicles and personnel.

The analysis was also driven by the fact that the BCR's $SC^4$ systems were designed and developed as instrumented systems. Each $SC^4$ workstation was instrumented to acquire data on a wide range of soldier-$SC^4$ system interactions. These interactions included the frequency and duration of $SC^4$ "tool" use, such as map scaling and terrain analysis, as well as information flow based on $SC^4$ communication systems such as e-mail and Whiteboards. The analysis focused on matching BCR research issues with available instrumentation data. Examples of the automated measures based on $SC^4$ interactions to track the staff's use of digital tools and communication systems include measures 2d and 2e in Table 2.

[2] Sample measures from the observations, surveys, and interviews can be viewed in Throne et al. (1999) or the complete package can be viewed in the Training and Measurement Support Package (1999).

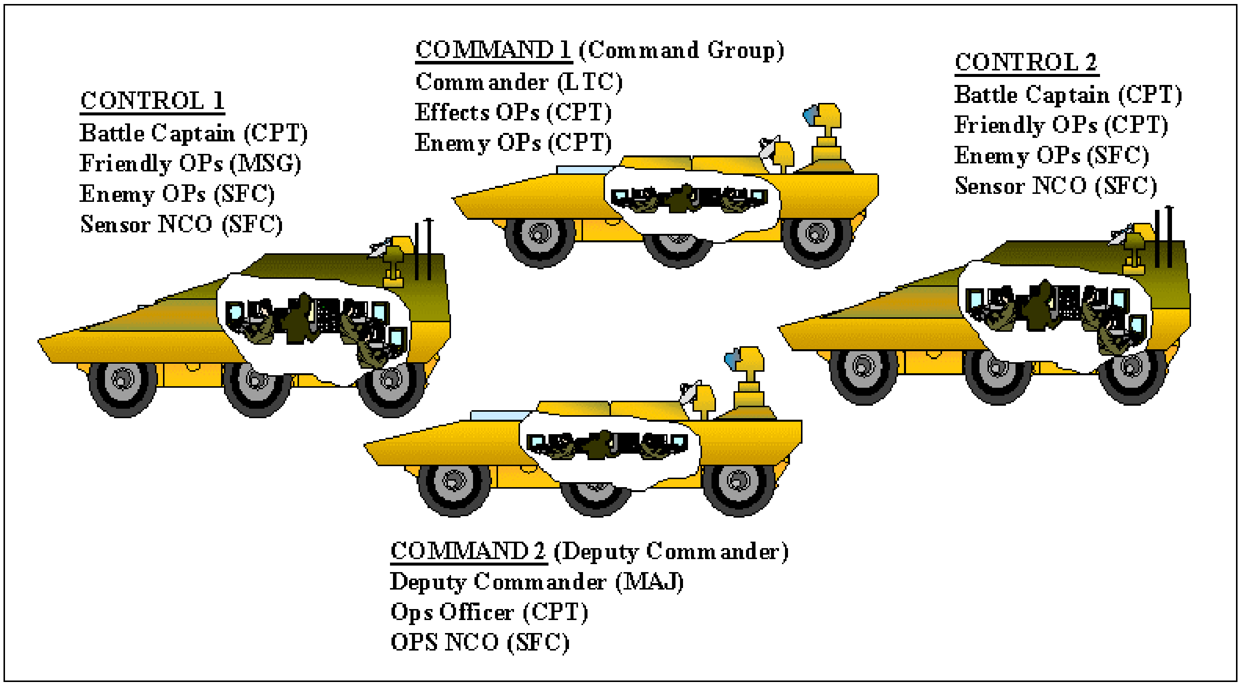


Figure 1. Reengineered Battalion Command Group Structure.

Measure analysis also examined how the mission exercises performed by the staff during BCR III were conducted in the Mounted Warfare Test Bed (MWTB) using distributed interactive simulation. This virtual simulation environment relies on a distributed networked that links and records all manned and semi-automated force entities including sensors and weapon system activation. The analysis focused, therefore, on matching BCR research issues with available simulation data. Examples of the automated measures based on simulation data to track the use of sensors and weapon systems include measures 2a-2c in Table 2.

Overall, most of the automated measures developed and listed in Table 2 exploit the availability of both $SC^4$ interactions and simulation data. For example, many of these staff performance measures assess staff interactions with $SC^4$ systems in conjunction with simulation-based systems, such as sensors and weapon systems. During the BCR's six trials, data on $SC^4$ interactions and simulation events were automatically logged by the MWTB's Data Collection Analysis (DCA) system. The temporally synchronized nature of the DCA's composite database supported the requirement to correlate staff process and product development to exercise events including mission outcomes. The measures were designed with these capabilities in mind.

Table 2

Reengineered Battle Command (RBC) Questions and Automated Measures of Performance

| Question | Measure of Performance | Description |
|---|---|---|
| 1. Can the RBC decrease the time for planning and increase the time to prepare and rehearse? | Battalion staff communication patterns | Total time spent using each of the communication tools (e.g., e-mail, Whiteboard) for each node position for each planning and execution session |
| 2. Can the RBC provide the information and support system to assist the Commander's decision-making process? | a. UAV mission effectiveness | Number of opposing force vehicles first detected by UAVs divided by total number of OPFOR vehicles detected |
| | b. Percent of enemy vehicles inside the battalion's area of responsibility[3] that were detected | Number of unique OPFOR vehicles detected by sensors, scouts, or weapons systems controlled by the battalion divided by the number of OPFOR vehicles |
| | c. Percent of enemy vehicles inside the battalion's area of responsibility that were never detected | Number of unique OPFOR vehicles not detected by sensors, scouts, or weapons systems controlled by the battalion divided by the number of OPFOR vehicles |
| | d. Use of SC[4] communication tools during mission | Total time spent using each communication tool and the number of communication tool initiations per mission for each node position |
| | e. Use of SC[4] tools allowing analysis of past, present, and projected battlefield positions | Total time spent using each tool and the number of tool initiations for each node |
| 3. Can the RBC allow efficient synchronization of combat, combat support, and combat service support assets? | a. Percent of OPFOR kills inside effects box | Number of OPFOR kills in effects box divided by total number of OPFOR kills |
| | b. Ratio of indirect to direct fire OPFOR kills | Number of indirect fire kills to number of direct fire kills |

*(table continues)*

[3] The unit's area of responsibility was delineated by its rear, flank, and forward boundaries assigned by its higher headquarters.

Table 2 (Continued)

| Question | Measure of Performance | Description |
|---|---|---|
| 4. Does the RBC provide efficient battle tracking and facilitate precise execution? | a. Percent of OPFOR vehicles engaged from flank or rear | Total number of flank or rear engagements on OPFOR vehicles divided by total number of OPFOR vehicles |
| | b. Percent of friendly force vehicles engaged from flank or rear | Total number of flank or rear engagements on friendly force vehicles divided by total number of friendly force vehicles |
| | c. Average range of OPFOR fire engagements | Average range of friendly weapon systems, by type, against OPFOR vehicles that were killed during a mission |
| 5. Does the RBC contribute to more rapid and efficient destruction of enemy forces? | a. OPFOR vehicle kills by friendly weapons types | Number of OPFOR vehicle kills by friendly weapon types during the mission |
| | b. Time to destroy OPFOR | Time from first OPFOR engagement until OPFOR vehicle losses exceed 70% |
| 6. Can the RBC increase the span of control of the Commander? | Number of subordinate unit leaders Battalion Commander personally contacted during mission execution | Commander's frequency of and amount of time for use of communications tools across each of the different personnel with which he interacted during mission execution |

***Design***

The automated measures were designed to address the six MMBL questions listed in Table 2. Although the target variables in these research questions (e.g., efficient synchronization, span of control) were not completely measurable by objective data, automated measures were developed to supplement the data obtained from more traditional evaluation methods to address these issues.

While designing the automated measures, it became apparent that many of them were dependent upon observer assessment of when certain events in each mission began or ended. Therefore, an exercise flag log was developed to establish the data collection windows for each exercise (see Figure 3). For the mission events listed in Figure 3, only a few could be independently identified by the DCA data including start of mission, first direct fire engagement, and the end of mission. Start and stop points as well as battlefield locations and areas for the rest of the Table 2 events were identified by observers using the flag log.

**Exercise Flag Log**

Today's Date ________________ Exercise ID ____________________

*Battalion area of interest/responsibility*

*Coordinates of upper left hand corner* (________________________________)
*Coordinates of lower left hand corner*(________________________________)
*Coordinates of upper right hand corner*(________________________________)
*Coordinates of lower right hand corner*(________________________________)

*Battalion area of operation*

*Coordinates of upper left hand corner* (________________________________)
*Coordinates of lower left hand corner*(________________________________)
*Coordinates of upper right hand corner*(________________________________)
*Coordinates of lower right hand corner*(________________________________)

*Start of Mission* (Time [HH:MM:SS ] _____:_____:_____)

*Receipt of Brigade order* (Time of Receipt [HH:MM:SS ] _____:_____:_____)

*Start/end of planning*

(Start time of mission planning [HH:MM:SS ] _____:_____:_____)
(Stop time of mission planning [HH:MM:SS ] _____:_____:_____)

*Start of mission rehearsal* (Time [HH:MM:SS ] _____:_____:_____)

*Start/end of execution phase*

(Start time of mission execution [HH:MM:SS ] _____:_____:_____)
(Stop time of mission execution [HH:MM:SS ] _____:_____:_____)

*Cross line of departure* (Time [HH:MM:SS ] _____:_____:_____)

*First direct fire engagement* ( Time [HH:MM:SS ] _____:_____:_____)

*Report of completion*

(Time mission completion reported [HH:MM:SS ] _____:_____:_____)

*Start of staff consolidation*

(Start time of staff consolidation [HH:MM:SS ] _____:_____:_____)

*End of mission* (Time [HH:MM:SS ] _____:_____:_____)

Figure 3. Exercise Flag Log.

## *Development*

An initial set of 14 automated measures was developed for the BCR III. The automated measures focused on issues regarding the effectiveness and efficiency of the Reengineered Battle Command (RBC). The questions, the specific measures of performance designed to address them, and their operational definitions can be seen in Table 2. Although these measures do not tell a complete story about staff performance on their own, they are an attempt at using automated measures to assess staff processes and products and their relation to unit outcomes. Also, they become more informative when used in conjunction with more traditional processoriented measurement methods, such as observations and self-reports. Although beyond the scope of this paper, examples of how data from automated and traditional measurement methods were used to address BCR issues are available in Throne et al. (1999).

The BCR III data analysis, due to various resource limitations, occurred after the BCR III trials were completed and the training unit departed. Once the recorded experiment exercise files, which had a complete record of all simulation activities and individual soldier-$SC^4$ system interactions, were examined, additional data collection formats had to be designed in order to pull the data from the system to support the measures of performance described in Table 2. Preliminary radio system data analyses indicated, for example, numerous radio transmissions of 1 second or less in length. The data were then filtered again to exclude transmissions of this length since they were determined to contain no information other than a soldier started to transmit a message but stopped before any information could be conveyed.

As expected, the initial DCA outputs on automated measures included numerous other data points, so considerable data examination, editing, and subsequent analyses were required. For example, when trying to determine the number of OPFOR combat vehicles the experimental unit fought against during a specific mission, off-line filtering of the DCA data was required to isolate the specific vehicles involved from additional vehicles. Most of these additional vehicles were placed into the exercise to set the conditions for the following experimental trials.

Notably, comparability of results was not an analytic consideration. Performance data collection during the BCR III was not designed to evaluate the performance of the unit since there were no doctrinal or baseline standards on which to base performance measures and BCR III conditions did not permit pre- and post-training performance measurements of the unit. However, comparability is an important issue and underscores the potential for change in staff performance due to the introduction of advanced $C^4I$ systems. For example, $C^4I$ tools such as Whiteboards for staff conferencing and automated terrain intervisibility checks are not available to non digital staffs. While analog parallels exist, such as staff huddles and map exercises, more traditional measurement methods would be taxed to provide the precision and scope about staff utilization that is readily available with digital tools and automated measures. More fundamental changes in staff performance attributed to advanced $C^4I$ systems, including changes to the Military Decision Making Process, are examined in the MMBL's report on BCR III (MMBL, 1999a).

### *Results*

To illustrate the potential of automated measures, selected results pertaining to the $SC^4$ system's capability to support the Commander's decision-making process are provided[4]. One way this was measured was by looking at the performance of the unmanned aerial vehicles (UAVs), which were controlled by the battalion staff, and micro-UAVs, which were controlled by the battalion scout platoon (Table 2, Measure 2a). These two systems, properly employed, could provide the Commander with accurate, timely information about the location and activity of the OPFOR. Over the course of the nine mission trials during the BCR III, the UAVs and the micro-

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[4] A complete description of the results of the automated measures developed for BCR III can be found in the Training and Measurement Support Package (1999).

UAVs were the first to detect 51% of all OPFOR vehicles in the battalion's area of interest[5]. In a further breakdown, the two systems detected 32% of tanks, 53% of infantry fighting vehicles (IFV), and 56% of artillery vehicles. When all types of sensors (i.e., ground, airborne, and satellite) were included (Table 2, Measure 2b), 70% of OPFOR vehicles were detected.

Notably, the majority of these vehicles were first detected in the area of interest, beyond the area of operations, which gave the Commander more time to assess OPFOR strength, capabilities, and intentions before they closed to within range of the unit's combat systems. For the 30% of OPFOR vehicles not detected, the majority were second echelon tanks or artillery systems (Table 2, Measure 2c). None of these undetected systems had an impact on the outcome of any mission. Grouping the data results from these three measures together, the Commander knew the location of 70% of the OPFOR vehicles in sufficient time to make an informed decision.

Overall, results from all of the automated measures developed under this project helped the MMBL conclude that the RBC provided the information and support system needed to assist the Commander's decision-making process. More complete results for the sample of automated measures described as well the other automated measures listed in Table 2 are available in the Mounted Maneuver Battlespace Lab's (1999a) Experiment Final Report.

## Conclusions

Considerable research remains to be done on developing both performance standards and evaluation methods for future battle staffs operating advanced $C^4I$ systems. While surveys, observations, and interviews were used to gather data during BCR III, the project team focused on developing automated measures to supplement the more traditional measurement methods that could take advantage of the analytical power and processing speed of advanced $C^4I$ systems to provide real or near real-time feedback to the training participants. Several lessons learned during this effort concerning automated measures, and particularly automated measures of staff performance, may be of value to other researchers.

A key lesson is that there needs to be extensive collaboration among the researchers, subject matter experts, and programmers developing automated measures. For example, operational definitions may need to be revised to specify the format in which the automated measures data is to be reported. This could allow the programmer extracting data to set up the output so it can be readily converted into a format suitable for staff performance feedback sessions. The DCA used during this project provides the programmer with a multitude of methods to manipulate and format data. Working with both the operational definition of an automated measure and the specific format in which it is to be reported, the programmer will be better able to meet the requirements for training and performance assessment.

A second related lesson is that measures under development normally require iterative runs to refine them. The initial runs may provide insights into reformatting the output or limiting the parameters to exclude extraneous information. Preliminary analysis of the data could also point to another area to be investigated that was not considered during the analysis and design of the measures.

[5] The battalion's area of interest extended 15 kilometers beyond the unit's area of responsibility.

For future research, standards or even baseline "case" examples of staff performance would be useful. If staff processes and products are to be the focus, then a detailed analysis of the processes or at least a description of the processes would help guide measures development. This analysis should include who is involved, what tools are used, and what products are generated. Even if unit outcome measures will not be the primary tool to provide staff performance feedback, they are generally easier to develop than staff process measures. Consequently, they should always be considered to supplement or back up staff process measures.

Additional research on and development of automated measures of staff performance was continued for the BCR IV Experiment at Fort Knox during April, 2000. During this follow-on project, $DC^4I$-2, the research team attempted to refine and expand the automated measures that were developed for BCR III. To support the BCR IV effort, a draft taxonomy for proposed automated measures was introduced; conceptual formats for reporting the automated measures were developed; and a team consisting of programmers, subject matter experts, and psychologists was formed to guide and prioritize the development effort. The results of this research will be reported as they become available.

In summary, while the work reported here was promising and useful to the BCRs, automated measurement of staff performance continues to have unrealized potential. Additional research is required to determine how soldier-computer interactions can be used to measure staff processes and products rather than just unit outcomes and how these are related. As $C^4I$ systems become more integral to staff performance, automated measures should help achieve more balanced methods for measuring staff performance, and more effective and immediate feedback for improving staff performance.

## References


Army Research Institute. (1997). The U.S. Army Research Institute's Science and Technology (S&T) program for FY 98. Alexandria, VA: U. S. Army Research Institute for the Behavioral and Social Sciences.

Caldera, L., & Reimer, D. J. (1999, February). A statement on the posture of the United States Army fiscal year 2000 [On-line]. Available: http://www.army.mil/aps/00/aps00.htm.

Campbell, C. H., Deter, D. E., Ford, L. A., Graves, C. R., Campbell, R. C., Pratt, D. M., Jenkins, S. N., & Quinkert, K. A. (1999). Combined arms operations at brigade level, realistically achieved through simulation III (COBRAS III): Report on development and lessons learned (ARI Research Report 1736). Alexandria, VA: U. S. Army Research Institute for the Social and Behavioral Sciences.

Cannon-Bowers, J. A., & Salas, E. (1997). A framework for developing team performance measures in training. In M. T. Brannick, E. Salas, & C. Prince (Eds.), Team performance assessment and measurement (pp. 45-62). Mahwah, NJ: Lawrence Erlbaum Associates.

Cooper, M., Shiflett, S., Korotkin, A. L., & Fleishman, E. A. (1984). Command and control teams: Techniques for assessing team performance (AFHRL-TP-84-3). Brooks Air Force Base, TX: Air Force Human Resources Laboratory. (ADA141442)

Crumley, L. M. (1989). Review of research and methodologies relevant to army command and control performance measurement (ARI Technical Report 825). Alexandria, VA: U.S. Army Research Institute for the Social and Behavioral Sciences.

Dwyer, D. J., Fowlkes, J. E., Oser, R. L., Salas, E., & Lane, N. E. (1997). Team performance measurement in distributed environments: The TARGETs methodology. In M. T. Brannick, E. Salas, & C. Prince (Eds.), Team performance assessment and measurement (pp. 137-153). Mahwah, NJ: Lawrence Erlbaum Associates.

Leibrecht, B. C., Meade, G. A., Schmidt, J. H., Doherty, W. J., & Lickteig, C. W. (1994). Evaluation of the combat vehicle command control systems: Operational effectiveness of an armor battalion (ARI Technical Report 998). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Lickteig, C. W. (1996). Research methods for advanced warfighting experiments (ARI Technical Report). Alexandria, VA: U.S. Army Research Institute for the Social and Behavioral Sciences.

Lickteig, C. W., & Emery, C. D. (1994). Information management performance of future platoon leaders: An initial investigation (Technical Report 1000). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Lickteig, C. W., & Throne, M. H. (1999). Applying digital technologies to training: A focus on pictorial communication (ARI Technical Report 1097). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Mounted Maneuver Battlespace Lab. (1998). Battle lab experiment plan (BLEP) for battle command reengineering III (BCR III). (Available from Mounted Maneuver Battlespace Lab, Attn: ATZK-MW, Fort Knox, KY 40121)

Mounted Maneuver Battlespace Lab. (1999a). Battle lab experiment final report (BLEFR) for battle command reengineering, phase III. (Available from Mounted Maneuver Battlespace Lab, Attn: ATZK-MW, Fort Knox, KY 40121)

Mounted Maneuver Battlespace Lab. (1999b). Battle command reengineering III user's manual for the battle command reengineering III battle lab warfighting experiment. (Available from Mounted Maneuver Battlespace Lab, Attn: ATZK-MW, Fort Knox, KY 40121)

Throne, M. H., Deatz, R. C., Holden, W. T. Jr., Campbell, C. H., Sterling, B. S., & Lickteig, C. W. (1999). Prototype staff training and evaluation methods for future forces (ARI Research Report 1745). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Training and Measurement Support Package, Battle Command Reengineering III, Mounted Maneuver Battlespace Lab, Volumes 1-5. (1999). (Available from Mounted Maneuver Battlespace Lab, Attn: ATZK-MW, Fort Knox, KY 40121)

U.S. Army Research Institute (1997). The U.S. Army Research Institute's Science and Technology (S&T) program for FY 98. Alexandria, VA: U. S. Army Research Institute for the Behavioral and Social Sciences.