2006 CCRTS

THE STATE OF THE ART AND THE STATE OF THE PRACTICE

Title of Paper: Issues and Solutions for Command Post Simulations

Topics: C2 modeling and simulation, C2 experimentation, C2 analysis, lessons learned

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Report Documentation Page					*Form Approved* *OMB No. 0704-0188*
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE **JUN 2006**		2. REPORT TYPE			3. DATES COVERED **00-00-2006 to 00-00-2006**
4. TITLE AND SUBTITLE **Issues and Solutions for Command Post Simulations**					5a. CONTRACT NUMBER
					5b. GRANT NUMBER
					5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)					5d. PROJECT NUMBER
					5e. TASK NUMBER
					5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Institute for Defense Analyses,4850 Mark Center Drive,Alexandria,VA,2231**					8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)					10. SPONSOR/MONITOR'S ACRONYM(S)
					11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**					
13. SUPPLEMENTARY NOTES **2006 Command and Control Research and Technology Symposium**					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES **12**	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**			

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

ISSUES AND SOLUTIONS FOR COMMAND POST SIMULATION

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ABSTRACT

Highly efficient command post teams are essential to efficient execution of network centric warfare operations. Unfortunately, the modeling of joint command post teams is still very much in its infancy and this lack of foundational research hinders our ability to assess the performance of command post teams[1] and to assess the ability of a new technology or procedures to improve command post operations. Therefore, determining how to model command posts is an important need. While the challenges to efficient network centric warfare command post operations can be addressed by experimentation and exploration, command post simulation in turn poses its own set of challenges. In the main, these challenges arise from the differences between real-world command post settings and the environments that are available within even the best simulation environments and from the differences between modeling team performance and modeling individual performance. These challenges have not been addressed in sufficient detail to date.

In our experience, if a command post simulation is to be useful, a critical characteristic that must to be preserved is the ability to translate experimental results into real-world actions, which requires proper experimental design. Specifically, the lessons learned and insights gained in the simulation environment must be able to be exploited and implemented in the real-world in order to improve the capability of the teams modeled in the command post simulation. The challenges faced in accomplishing this translation are developing a simulation environment that has sufficient fidelity in the proper components so that useful real-world conclusions can be drawn and in identifying the scale at which conclusions should be made so that they can translate into real-world actionable recommendations.

In this paper, we discuss our experience in command post team simulation and the insights we have gained into command post team simulation. Section One of the paper discusses the motivation for our work and the benefits we hope to derive from this research. Section Two presents relevant background research and its relationship to our current effort. Section Three discusses the insights gained into command post simulation as a result of the research project and the results we have obtained. Section Four contains a summary and suggestions for future work.

1. Introduction

Highly efficient command post teams are essential to efficient execution of network centric warfare operations. Unfortunately, the modeling of teams, let alone command post

[1] A team consists of two or more individuals working cooperatively to achieve a common goal.

teams, is still very much in its infancy and this lack of foundational research hinders our ability to assess the performance of command post teams[2] and to assess the ability of a new technologies or procedures to improve command post operations. Therefore, determining how to model command posts is an important need and the current inability hinders efficient network centric operations. While addressing the challenges to efficient network centric warfare command post operations can be accomplished by experimentation and exploration, command post simulation poses its own set of challenges. As with network centric command posts, network centric command post simulation technological challenges have not been addressed sufficiently to date. In the main, command post simulation technological challenges arise from the differences between real-world command post settings and the fidelity of the command post environments that are available within even the best simulation environments and from the differences between modeling team performance and modeling individual performance. The simulation shortfalls arise from differences in technology and equipment, differences in number and expertise of personnel, and differences in control and communication abilities and technology. The team modeling shortfalls are important because command posts are comprised of both teams and individuals, resulting in team-to-team, team-to-individual, and individual-to-individual interactions occurring simultaneously while the command post is in operation. The team modeling ability shortfalls arise from our lack of knowledge about team modeling, about the complex interactions between individuals in the team, about the reinforcing and countervailing skills within the team and how they affect team performance, and about the varying competencies among team members in the command post. While the challenges of command post simulation, especially for network centric warfare, are formidable, our experience has demonstrated that they are not insuperable if the experiments and explorations are properly designed and if the conclusions drawn are appropriate in light of the fidelity of the command post simulation environment. This paper reports on our experience in command post team simulation and the insights we have developed based on our experience.

If a command post simulation is to be useful for improving command post operations in the real world, a critical quality that must be present in the simulation environment is the ability to transform experimental results into real-world actions[3], which requires proper experimental design. Simply, the lessons learned and insights gained in the simulation environment must be able to be exploited and implemented in the real world in order to improve the capability of the command post teams that were modeled in the command post simulation. The challenges faced in accomplishing this transformation include developing a simulation environment that has sufficient fidelity in the proper components so that useful real-world conclusions can be drawn and in identifying the scale at which conclusions should be made so that they can translate into real-world actionable recommendations. An experiment for command post simulation must address three critical and ubiquitous simulation shortfalls in order to allow its results to be employed in the real-world. The simulation environment shortfalls typically encountered are inability to replicate: 1) the actual command, control, and communications (C3) environment that exists in the real-world, 2) the actual size and composition of the command posts that are simulated, and 3) a scenario that is of sufficient length and intricacy to assess the command post team response to: real-world stress, human task overload, individual expertise, and complexity. These constraints limit our ability to draw conclusions about individual performance

[2] A team consists of two or more individuals working cooperatively to achieve a common goal.

[3] The guidance in the *NATO Code of Best Practices for C2 Assessment* is foundational for our research.

enhancements, but do not prohibit assessment of factors that can improve command post team performance [1-59].

In addition to the shortfalls, research performed to date indicates that there are several reasons for the difficulty encountered in transferring the results from command post team simulations to their real-world counterparts [1-59]. One of the most serious impediments to employing the results of the experiment in the real-world are the disparity in the number of participants in the experiment versus the real-world. Other impediments are the difference in equipment, individuals, team competencies, individual motivations, and differences in mental models between simulation world team members and real-world command post members. Because of these differences, there is no experiment that can be devised that uses the available manpower and equipment and that has the fidelity and scope of the real-world activity. As a result, valid conclusions concerning methods for improving individual performance in the real-world generally are not possible to achieve while at the same time determining means to improve command post team performance. Nevertheless, in spite of the constraints, the question remains; How can we achieve more timely and accurate actions and decisions and improved command post performance? To address this question, two subsidiary and fundamental questions are evident. The first question concerns which command and control structure and process results in the best anticipatory response to precursor events. The second question concerns which command and control structure and process best deals with managing/controlling the response to precursor events and to events themselves. Therefore, the command post simulation experiment design must focus on improvements in team behavior and performance since the conclusions reached about a team within the bounds of the experiment environment can translate to changes to be made to actual command post processes, procedures, and functionality in the real-world.

So, even though we cannot replicate the entire milieu faced by a command post team in the real-world, the literature is clear that if we preserve the necessary components of the real-world environment then we can draw useful conclusions using the experimental simulation world that are actionable in the real-world. Because of this fact, the one fidelity that is crucial to the experimental simulation world in order to project experimental results back into the real-world is the fidelity of the mental model of the battlespace held by each person in the command post. However, the mental model must be scaled in space and time to correspond to that which is possible in the real world given the differences in equipment and personnel. An additional issue that is important is the ability to control team workload and thereby determine if changes to the environment result in improved team decisions and actions.

Within the realm of command post experiments, there are four aspects of each experiment that must be considered: 1) Sensors, 2) Intelligence reports, 3) Network/communications devices, and 4) Personnel who perceive environment, make decisions, and take actions. All four aspects are nearly independent, that is, an improvement in sensors <u>may</u> but does not necessarily lead to improved decisions. Likewise, improved network and communications devices may or may not result in better decision-making. The greatest inter-dependence appears to be between intelligence and decision-making. This dependence, in turn, results in two cases, the <u>first case</u> is one in which we attempt to determine how to improve the <u>factors</u> (sensors, human perception, cognition, and event correlation) that affect decision-making for command and control (C2). The <u>second</u> <u>case</u> is one in which we are attempting to improve the <u>decision-process</u>, which is the ability of decision-makers to react to events and the ability of decision-makers to correlate events so as to detect pre-cursor events by correlating activities that signal an impending event. However, due to the simulation environment shortfalls mentioned above, we can only address these two cases at the team level of activity. The first case revolves around determining how well the command and control structure and process are able to correlate activities in the environment that are signals of events. The second case revolves around determining how well the command and control structure and process is able to move information between its constituent components that need the information at any point in time. As a result, command post team simulation experiments should do the following: 1) concentrate on these two cases, 2) assess the flow, quality, and quantity of information, 3) attempt to be equivalent to real-world command post team expertise, numbers, and taskload in its key aspects, and 4) attempt to match the equipment available in the command post being simulated. Our research focused on means for insuring that these challenges are considered and accounted for in the experiment design.

The paper discusses our experience and resulting insights into in command post team simulation. The remainder of the paper is organized as follows. The next section contains a discussion of relevant background research and its relationship to our current effort. Section Three contains a discussion of our research project and the results of our efforts. Section Four contains a summary and suggestions for future work.

2. Background

There are two major factors that determine if and how well command post simulation experimental results can be translated into the real-world. The first factor is the difference between individual and team decision-making. The second factor is the difference between the simulation environment and the real-world.

2.1 Individual versus Team Decision-Making

There are many differences that can be noted in the manner in which individuals and teams perform decision-making, as summarized in Table 1[1-59]. For example, individual decision-making may have a much more narrower focus and may not consider all relevant data when compared to team decision-making. Additionally, team decision-making is usually driven by a desire to build a degree of consensus; whereas, individual decision-makers do not have that obstacle. In addition, apparently it is more difficult for a team than an individual to assemble a consistent mental model of the battlespace but teams are more likely to have a broader appreciation for the complexities of the battlespace than an individual's inherent limitations allow them to attain. Experimentation has determined that individuals are limited to being able to accommodate (attend to) seven (plus or minus two) items in mind at any instant [60]. No equivalent formulation that describes a team's attention has been developed; but it would seem to be greater due, no doubt, to the ability of the people in the team to overlap and reinforce items to which their individual concerns are addressed (or attended). On the other hand, individuals can readily attend to one item and exclude all other matters from attention; individuals have a well-documented ability to focus their attention on one item to the exclusion of all others. Conversely, it is apparently very difficult for an entire team to focus its attention on one item (and in many circumstances it is counterproductive to do so), providing both the promise that important activities are not overlooked but also threatening to dilute the effectiveness of the actions and decisions of the team. The difference in ability to attend to one matter versus several corresponds to the difference in the number of active decision processes in an individual and a team at any time. Generally, an individual can pursue one active decision process, whereas a team can have several. Interestingly, the literature suggests that both individuals and teams are subject to the problem of process interruption; that is, when a process is underway (whether it is a decision or information flow) and it is interrupted, it is a challenge for the team or individual to recover from the interruption. Though it appears that teams may be able to recover more often than individuals, teams are also subject to more catastrophic failures when interrupted during the execution of a task than are individuals due to the need for communication and a shared understanding of the state of task accomplishment[4].

There are other differences in the characteristics of individuals and teams. In general, an individual has one skill level and has one fatigue level at a given time and they change relatively slowly. As a result, it is possible to characterize a person's response to events and potentially determine how to improve individual performance when fatigued, under stress, or when performance does not meet expectations. On the other hand, a team has multiple skill levels in effect concurrently as well as multiple fatigue factors and it is not clear how to combine them or ameliorate their effects in order to improve team performance. Finally, an individual remains relatively "constant" in their performance over the duration of a simulation experiment, a team does not appear to remain "constant" since the team can vary (in composition and therefore "skill" and "performance," as well as in group dynamic and teamwork) over the duration of a simulation experiment.

Characteristic	**Individual**	**Team**
Scope of detail	Limited, difficult to consider/attend to many details simultaneously	Broad, many details can be considered simultaneously
Breadth of attention	Limited, 7 +/- 2	Unknown, but seems to scale with size of team
Focus of attention	Can be highly focused	Counter-productive to focus on one item
Rapidity of decision-making	Personality dependant	Team competence and composition dependant
Number of active decision processes	One or few	Multiple, no generally accepted model
Fatigue	One level	No certain model
Decision-making model	OODA	None
Decision-process interruption	Problem	Problem

Table 1: Individual versus Team Characteristics for Information Management and Decision-Making

These differences between individuals and teams in both the real-world and the simulation environment serve to limit the types of conclusions that we can draw from our command post team experiments. These differences are not insuperable hurdles that prevent the exploitation of the results of the experiment within the real-world command post environments that are being modeled because they can be overcome by careful experimental design.

2.2 Simulation and Real-World Differences

To insure that command post experiments have utility in the real-world, the experiment's objectives, available equipment, number of available players, and player expertise must be

[4] One of the more memorable examples of this problem is the August 16, 1987 crash of a Northwest Airlines MD-80 on takeoff from Detroit International Airport. An untimely interruption of the crew during execution of the takeoff checklist resulted in each crew member thinking that someone else had insured that the wingflaps were down, when in fact they had never been extended.

assessed in order to determine how they would affect the experiment and the translation of its results into the real-world. Properly addressing these issues insures that the experiment has applicability in the real-world; ie., that the experiment results can be translated from the experimental setup into real-world operation. These differences are not trivial and if not properly managed, would degrade the utility and applicability of the experiment. Current research indicates that the most serious impediments to employing the results of a team simulation experiment in the real-world are the disparity in the number of participants in the experiment versus the real-world and the disparity between available equipment in the experiment versus the real-world. Because of the differences in available manpower and equipment, it is not possible to conduct a command post team experiment that matches both the scope and the complexity of the corresponding real-world activity. Because we are interested in improving command post team performance, the scope of activity must be maintained and individuals must perform additional tasks within the team than they would be called upon to perform in real-world operations. As a result, valid conclusions concerning methods for improving individual performance in the real-world can not be drawn within a command post experiment; however, we can draw valid conclusions concerning methods for improving team[5] performance (where a team is a command post entity). Our goal, then, for developing a command post team experiment and for insuring that experiment results can translate into the real world is to insure that the experiment is designed so that essential characteristics of the team aspect in the real-world are present in the experiment. Achieving this quality of simulation is a challenge because of the differences between the simulation environment and the real-world.

In sum, as a result of the constraints and goals identified for a command post simulation experiment, the experiment must focus on improvements in team behavior and performance in support of decision-making. This focus is necessary because the conclusions reached about a team within the bounds of the experiment environment will translate to changes that can be made to actual command post processes, procedures, and functionality in the real-world. Because of the differences between the simulation environment and the real-world, improvements in individual performance in the simulation environment should <u>not</u> be assumed to result in improved individual or team performance in the real-world.

3. Discussion

To assess the performance of a command post team, two types of information are essential. The first type of information is an understanding of the factors that affect command post team performance and the second type of information is a set of metrics for assessing the performance.

3.1 Team Performance Considerations

Because the command post team level is the domain of interest for the experimental results, the guiding imperative was to insure that the simulation command post team and the real-world command post team were as similar as possible in all of the key areas that affect team performance. Within the design of command post experiments, as we have noted above, there are four factors that affect command post team performance: 1) sensors, 2) intelligence reports,

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[5] We use the term ***team*** instead of ***group*** because of the differences in connotation that these words have in the research community and everyday usage. A team is generally considered to be composed of a number of individuals, working toward a common purpose, each with assigned tasks, under some form of leadership/command/authority. A group, on the other hand, is unstructured, has a vaguely defined purpose, shifting responsibilities, and no clear authority.

3) network/communications devices, and 4) personnel who make decisions, and take actions. All four factors are nearly independent. For example, an improvement in sensors may but does not necessarily correlate with improved decisions and actions by personnel. Likewise, improved network and communications devices may but do not necessarily correlate with improved personnel decision-making. However, there is an inter-dependence between intelligence reporting and personnel decision-making in command post team performance.

3.1.1 Team Performance Areas to be Evaluated

The research literature and analysis indicates that there are two broad areas of command post team evaluation that must be examined experimentally. The *first* experimental area is the investigation of the four factors separately. The *second* experimental area is examination of the interconnection between intelligence and personnel decisions and actions. Fortunately, the two areas are independent enough so that they can be examined simultaneously; ie., one experiment can test hypotheses for both areas simultaneously without corrupting the experiment results for either area.

When attempting to gain insight into the first area, experiments must be performed to determine how to improve each of the four factors that affect command post team performance. When attempting to gain insight into the second area, experiments must be performed to determine how to improve the processes for gathering, handling, examining, and managing intelligence that affect command post team performance. In sum, command post team simulation experiments should do the following: 1) concentrate on these two cases, 2) assess the flow, quality, and quantity of information, 3) attempt to match real-world command post team expertise, numbers, and taskload, especially in the areas of command post performance that are central to the experiment, and 4) attempt to match the equipment available in the command post being simulated. For both cases, quality of intelligence reporting may be a factor and should be explicitly considered in the experimental design.

3.1.2 Assess Impact of Intelligence Upon Team Performance

The research literature and analysis indicated that within the area of command post team operations dealing with intelligence that there are two distinct cases of intelligence input to consider. The first intelligence case revolves around determining how well the command and control structure and process are able to correlate activities in the environment that are precursors to events. A mix of intelligence inputs are needed because the experiment is actually trying to determine how well a significant event can be separated from background information (aka noise). False/inaccurate intelligence would be a normal part of that background, so the ability to detect and reject false positives as well as insure that detection of true precursors is determined. The measures of command and control (C2)performance that must be applied in this case are those that assess the command and control (C2) structure's ability to determine the accuracy/validity of the information that it has and how well a given C2 structure and processes supports the information determinations that must be made. The second intelligence case revolves around determining how well the command and control structure and process is able to move information between the command post components that need the information at any point in time. In this experiment case, the goal is measuring the latency between the time when information becomes available until all portions of the command post structure that need the information have the information.

3.2 Team Performance Metrics

When considering experimental area one, the metrics to be used vary depending upon the intelligence case being considered. For intelligence case one in experimental area one, potential metrics include but are not limited to the following: 1) elapsed time, 2) number of participants in the process, 3) number of extraneous participants in the process, 4) number of precursor events that are addressed by the C2 structure, 5) number of alternative explanations for a precursor event that are considered, 6) criteria applied to determine the significance of a precursor event, 7) the number of times that the explanation assigned to a precursor event by a given C2 structure is accurate, 8) the "difficulty" faced when determining what a precursor event signifies, 9) the number of times a sensor is re-tasked correctly, 10) the number of times a sensor is re-tasked incorrectly (unnecessarily), 11) the "quality" of the decision/interpretation, and 12) the overall "quality" of decision process. For intelligence case two in experimental area one, potential metrics include the following: 1) the speed of the movement of information through the command post and C2 structure, 2) the number of people who should have the information but did not get it (directly), 3) the number of people who did not need the information but received it, 4) the information volume, 5) the "quality" of communication, 6) the number of times that information has to be retransmitted, and 7) the latency between when a re-tasking directive is sent and when the re-tasking is accomplished.

When considering experimental area two, the metrics to be used do not vary depending upon the intelligence case being considered. For this experiment area, potential metrics include but are not limited to the following: 1) the elapsed time to make a decision, 2) the "quality" of a decision, 3) the number of alternative responses considered, 4) the "quality" of processes employed, 5) the number of people involved in the decision process, 6) the number of extraneous participants in the process, 7) the criteria applied to determine a response, 8) the "difficulty" of determining the correct response, 9) the number of pieces of information considered when formulating a response, 10) the number of pieces of extraneous information considered when formulating a response, and 11) the overall assessment of the command post's "understanding" of the battlespace.

Clearly, assessing command post team performance is a challenge and requires careful planning for the experiment (The *NATO Code of Best Practices for C2 Assessment* is a useful aid), determination of the data to be collected, and development of a data analysis plan. In addition, to improve the validity of the command post simulation experiment it should be repeated as much as practicable in order to improve the statistical validity of the results.

4. Summary and Future Work

Highly efficient command post teams are essential to efficient execution of military operations. Unfortunately, the modeling of joint command post teams is still a new field and the lack of foundational research hinders our ability to assess the performance of command post teams and to assess the ability of a new technology or procedure to improve command post operations. Therefore, determining how to model command posts is an important research question. To enable the translation of the simulation environment's experimental results into the real-world, the simulation command post team the information flow must be essentially identical to the information flow in the real-world command post.

In this paper, we presented our experience in command post team simulation and the insights gained into command post team simulation. We briefly examined relevant background research and its relationship to command post simulation. We also discussed insights gained as a result of our research project and results. However, many research questions related to command post simulation and effective command post operation remain to be addressed. One of the challenges arises from the need to learn how to exploit the coming capabilities for improved communication. These improved communication capabilities can be used to improve command post operation and command and control structures as well as to improve understanding about the battlespace. Another challenge originates from the need to improve the structure and composition of the command post teams so that the various teams that comprise a command post increase their efficiency, both individually and in the aggregate. Other challenges arise from the need to learn how to increase command post operational efficiency and how to conduct command post operations in a network centric environment. These achievements must also be coupled with the drive to reduce the number of people who are used to operate a command post. These and other challenges to command post team operations can be addressed by using simulation experiments to evaluate alternative command post configurations.

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