Using communication patterns in the design of an adaptive organizational structure for command and control

John Graham
Cleotilde Gonzalez
Dynamic Decision Making Laboratory
Social and Decision Sciences Department
Carnegie Mellon University

Michael Doyle
Senior Military Analyst
Battle Command Battle Lab - Leavenworth

What type of analysis should be used to inform design when both the future organizational structure and the experimental simulation are tenuous? Neither the application of a qualitative process tracing method nor low-level quantitative organizational designs are warranted. We hypothesized the analyses of high-level communication patterns in a role-playing exercise of a future organization structure would yield results that could both inform organizational design and shape iterative experimental designs. This study summarizes the comparison between communication patterns in an envisioned organizational structure and the actual patterns of information exchange of experienced military participants role-playing staff members in a future organizational design. The comparison between the hypothesized and actual communication performance indicated a different distribution of communication interaction from the expected. These results help guide both the future organizational concept as well as next iteration experiments.

INTRODUCTION

The US Army is in the opening phase of a ten-year organizational design process for a knowledge-centric command and control element. In support of this initial effort, the Fort Leavenworth Battle Command Battle Laboratory (BCBL) has conducted the first high fidelity experiment to determine organizational constructs that will support command and control in the Objective Force. The experiment assumed a knowledge-centric staff cell structure supported by a higher level of automation to increase shared situation awareness. The automation specifically assists commanders and staff in detecting and resolving short-term conflicts in real-time. The advent of this capability implies that the force will not be as dependent on tactical and strategic constraints during battle planning to ensure the smooth execution of operations. This also means that the Command and Control relationships and communication requirements will be different from those in today's operational command and control structure.

This study summarizes findings that compared the envisioned communications performance against the actual communications performance of experienced military members role-playing staff members in the future Objective Force. The envisioned communications performance metric was developed via a complex knowledge object-grouping task by an expert panel of military officers and Army scientists. The experimental measures of communication performance were derived from the data log of three offensive battle simulations conducted by the role-players over three days (8+ hours of coding). The coding and comparison was not conducted "in the blind". However, as will be explained in this paper, that level of experimental method is not required at this stage of the experimental-organizational design iteration process.

The purpose of this comparison is to examine an alternative initial high-level quantitative approach to qualitative and low-level quantitative approaches. Qualitative approaches such as future incident forecasting (Smith et al, 1998) or process tracing methods (Woods, 1993) may be inappropriate because of a lack of specification of the organization concept. For the same reason, low-level quantitative measures such as those provided by organizational design systems (Entin & Entin, 2001) are also unsuitable. However, a gross level comparison of high-level quantitative measures such as communication allows for generation of specific research questions, measurement methodologies, and metrics to be designed into the next iteration of the design process. In addition to designing future iterations of the experiment, this high level quantitative analysis identifies Objective Force issues via an envisioned vs. actual performance delta. This delta can be explained through cognitive systems engineering issues (human, technology, training, etc) that can be addressed in the next iteration of organizational design. We propose that qualitative and a more specified quantitative set of metrics will be useful once future iterations of this organizational design and experimental design have reached a greater level of specification.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **OCT 2003**	2. REPORT TYPE	3. DATES COVERED **00-00-2003 to 00-00-2003**
4. TITLE AND SUBTITLE **Using Communication Patterns in the Design of an Adaptive Organizational Structure for Command and Control**		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) **Carnegie Mellon University,Dynamic Decision Making Laboratory,Pittsburgh,PA,15213**		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 **In Proceedings of the 47th Annual Meeting of the Human Factors and Ergonomics Society (pp. 410-413), 13-17 Oct 2003, Denver, CO. U.S. Government or Federal Rights License**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

METHOD

Envisioned Communication Performance

A representative set of Army intellectuals was assembled at Ft Leavenworth six months before the command and control experiment Twenty-six Army officers ranging in rank from Brigadier General to Captain[1] served as participants in knowledge object (KO) development and grouping. All participants had worked with the military for a minimum of 7 years and the average time working with the Army was approximately 16 years.

Participants were given one day of military decision-making training (review) to provide common ground for discussion in future sessions. On day two, in four ninety minutes sessions, the group specified a separate set of KOs for each of the typical operational missions of an Army command and control element: Offense, Support, Defense, Stability. They then individually submitted ratings of each of the knowledge objects to specific operational missions as in Figure 1. On day three all participants were assembled and required to create "Natural Knowledge Clusters" based on mission-type for each of the knowledge objects.

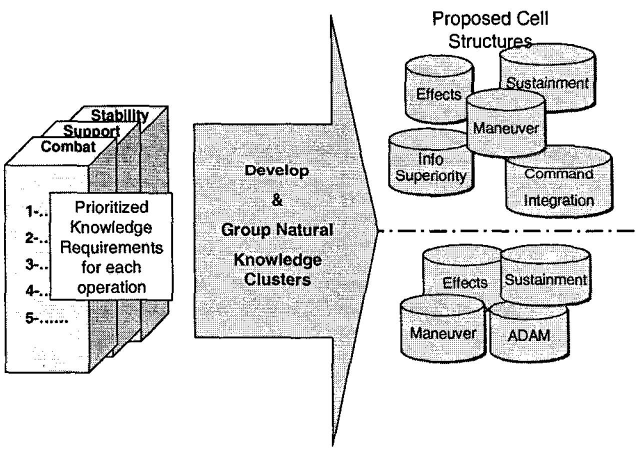

Figure 1. Knowledge Object development, prioritization and clustering resulted in cell structures designed for Combat (offensive, defensive), Support, and Stability operations.

Knowledge object ratings were distributed using a majority wins process. The "Natural Knowledge Clusters" resulted in a proposed cell structure for the experimental staff organization. The knowledge objects were then clustered a second time to maintain a consistent command and control organization across operational missions. The resulting experimental staff organization and the knowledge object distribution is represented in Figure 2.

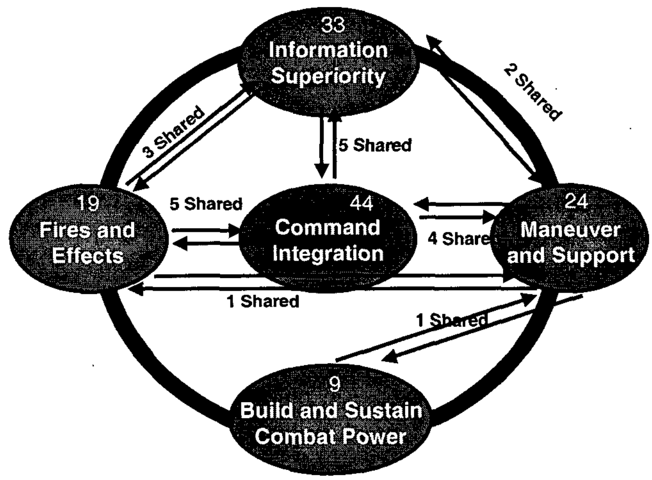

Figure 2. Cell structure resulting from initial Knowledge Object distribution workshop conducted at the Ft Leavenworth Battle Command Battle Laboratory. 111 of the knowledge objects are represented in this depiction.

Actual Communication Performance

In February 2003, the first experiment iteration using the knowledge object cell structure was conducted at the Fort Leavenworth BCBL. 26 Army officers served as role-players for the experimental command and control staff. They spent one week in team training. During this time, they were required to learn a) the concepts behind the experimental organization, b) a new method to make decisions in the experimental organization, c) their role in the structure of the experimental organization, and d) how to use the simulation software during the experiment.

The experiment itself was conducted as a command post exercise using OneSAF simulation software. The role-players gathered information and input actions on the battlefield via the simulation. Throughout the experiment, an average of fourteen data collectors entered observations, real-time, into a data log on Group Systems (Nunamaker et al, 1991). As a result every observable information transaction was captured. Each entered transaction was time-stamped with the participants, the discussion, and the outcome.

We coded the data log for speaker /receiver, prompted/ unprompted push/pull of information, purpose of interaction (military context relevant categories). Due to a limitation of audio, we were only able to check the data log entries against the commander's (Command Integration Cell, Figure 2) position. Therefore, we only coded entries in which the commander was either the speaker or the receiver. Further, we only coded the first three days of operations. All three of these simulations were progressively more complex offensive operations.

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[1] representing 13 military posts and 16 command organizations and nine Army and civilian scientists representing an equal number of theoretical approaches

RESULTS

The distribution of communications to and from the commander position from the data log codings yielded an unexpected result. Specifically, about 60% of the commander's interactions were outside his command and control organization. Almost all of those interactions were to his subordinate leaders in the operation (See Figure 3).

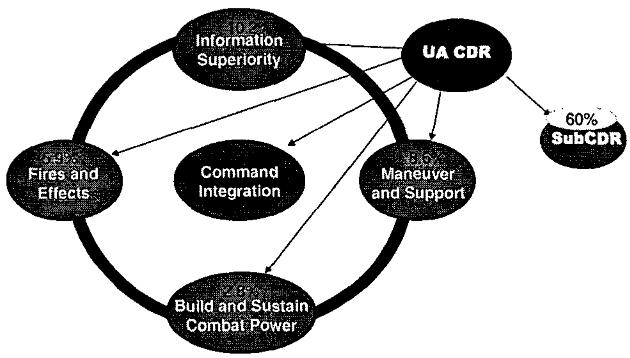

Figure 3. Envisioned (Desired) knowledge object distribution moderated communications compared to the actual leader (commander) communications during the first experiment

While this was an interesting finding, we also had to look into the percentages of knowledge object calculated from the distribution previously shown in Figure 2. The distribution of communications to and from the commander is shown in Figure 4. The resulting percentages support an envisioned prioritization of leader (commander) interaction with his staff: Command Integration Cell, Information Superiority Cell, Maneuver & Support Cell, Fires & Effects Cell, followed by the Build and Sustain Cell. Even after model adjustments to account for external leader communication, every actual leader-cell interaction from the data log codings differed from the envisioned leader-cell interaction from the knowledge object distribution. As opposed to the envisioned communications, the actual communications priority favored the Effects Cell. The comparisons were similar in their low valuation of communication with the Logistics (Build and Sustain) Cell.

DISCUSSION

There are two major quantitative deltas in the actual vs. envisioned interactions. First, the amount of leader communication external to the staff organization was about 60% of his total communication. Second the actual distribution of interaction within the staff did not match the envisioned distribution of interaction based on the knowledge object assignments. These two findings have major implications for both next iteration experimental design as well as the design of the future organization. The remainder of this section will propose adjustments that will reduce the delta to insignificance before final organizational design implementation and fielding.

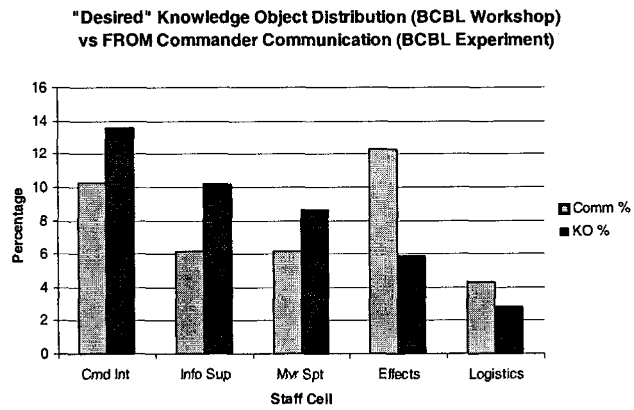

Table 1. Envisioned prioritization of the leader-cell communications are based on the knowledge object distribution.

The next iteration of experiments must establish measures to capture process data between the leader and the external communicators. The process measures will better explain potential organizational impacts of the external communications. In the case of the organizational structure, we will also have to reconsider the role of the subordinate commanders and their knowledge object responsibilities. This change should increase the validity of next iteration experiments.

The knowledge objects distribution contributes to a second problem. The simulation allows members full access to all data and does not provide a prioritization system. Shattuck et al (2000) hypothesized that access to all data was counter-productive to leader decision-making. To replicate a better technological support to decision-making in the future organization, the salience of knowledge objects should be increased based on context. The next knowledge object grouping task will need a greater level of specification and a "push" system is necessary before the next iteration experiment.

The presence of a large shared visual display presenting all available information may have contributed to the delta. In their study of shared mental models, Bolstad & Endsley (1999, 2000) found that providing a fully shared display was actually a detriment to performance. Teams that started with a fully shared visual display never reached performance levels of teams with a partial or no shared visual display. This research indicates it is possible that the presence of a large screen shared visual space was counter-productive to some organizational communication. The next iterations of the future organization experiment will examine the value of this technology to group processes.

Bolstad & Endsley (1999, 2000) found that training a shared mental model would improve performance. There is some evidence that the role-players often developed an inappropriate shared mental model based the decision-making heuristics from their years of legacy organization experience. One week of classroom instruction was not sufficient for them to develop future organization thinking and heuristics. One heuristics training approach, Instance Based Learning, is under development by Gonzalez et al (in press). The approach holds promise as a pre-simulation training methodology for role-players in future simulations and could provide ˉ ıppropriate heuristic base and shared mental model at th‹ ›eriment outset.

CONCLUSION

These experiments are extremely expensive. Therefore sample size will remain small. As such, it is difficult to give validity observations that occur in a small number of replications in the early stages of a design process. However, at this first iteration of a decade long process, we found that a high level quantitative approach was appropriate. Describing the delta obtained from a high level quantitative approach using informed observation and established human computer interaction theory provided significant findings that will shape both the organizational design and the experiment methodologies.

Acknowledgements

This work was Prepared through collaborative participation in the Advanced Decision Architectures Consortium sponsored by the U. S. Army Research Laboratory under the Collaborative Technology Alliance Program, Cooperative Agreement DAAD 19-01-2-0009. The U.S. Government is authorized to reproduce and distribute reprints for Government purposes notwithstanding any copyright notation thereon. We would like to thank Karol Ross of Klein Associates for data access and the Battle Command Battle Lab in their application of the Group Systems software. Also, thank you to Doug Gillan for urging on the publication of this work.

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