VT 220 or similar terminal, I wouldn't be able to do that, so I'd probably be more frustrated."

"Scrolling through messages/folders and having a graphical interface in general is a big win."

"I like doing so much with just the mouse, and seeing something on the screen and saying 'I want to select that', instead of having to type it in.

It's more well, the word that keeps popping up is that it is more intuitive."

Summary

Usability is manifest in the experience of people using systems in their work environments. Through contextual inquiry, we found consistency in the kinds of problems mail users raised, and variations in the types of solutions they imagined. This suggests the critical importance of understanding the users' work, their work environments, and their everyday experiences of system usability in the design of mail systems.

We believe that the themes of navigation, organization, integration, and customization indicate fundamental domains of work for mail users. The direct manipulation paradigm and graphical workstation technology offers possibilities for transforming the work that terminals do not. The challenge before us is to design a mail system the transforms the work of mail users.

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COMPUTER-MEDIATED GROUP PROCESSES IN DISTRIBUTED COMMAND AND CONTROL

J. M. LINVILLE
R. W. OBERMAYER
J. J. FALLESEN

INTRODUCTION

These studies investigate the effects of computer-mediated communications on distributed Command and Control (C2). The military C2 system presently is distributed functionally and geographically and will be distributed even more in the future. This distribution will enhance increased survivability and will increase the breadth of command and control. To support collaboration of distributed remote command staffs, computer- mediated communications may be needed to share information, provide supervision, coordinate objectives, perform analyses, and provide recommendations and decisions.

Functional Distribution

The mission of a division headquarters is to plan, direct, and support the fighting of it's brigades and other elements. This planning, direction, and support are performed at the three division command posts. Within the main, rear and tactical command posts there are representatives from each of the primary functional elements of the commander's staff: personnel, intelligence, operations, and logistics. Each of the command posts uses a cellular structure, grouping different functional representatives and liaison elements for the performance of the different tasks. The functional distribution and the cellular structure of a division main command post is shown in Figure 1.

Geographic Distribution

The C2 system is dispersed throughout the battlefield. In the example division sector, not including combat service support units or reserve units, there are 47 command posts from company to division level (see Figure 2). These are dispersed in an area that may be approximately 18-30 miles in width and 30-50 miles in depth.

PROCEDURE

To test the potential of computer-mediated communication two experiments were conducted. The first of these experiments (DYAD) required two people to collaborate to perform a task based on a military tactical movement order.

FUNCTIONAL DISTRIBUTION:

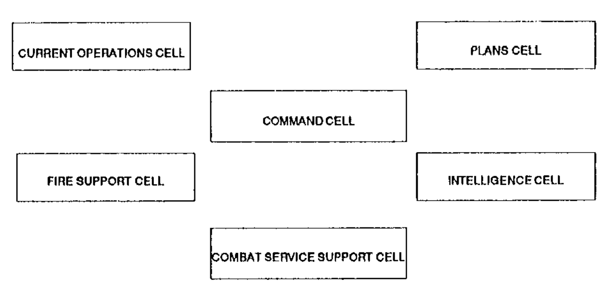

Figure 1. Division main command post.

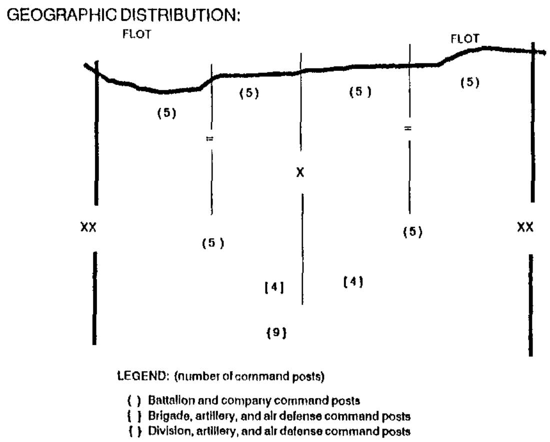

Figure 2. Command posts in division sector.

Additionally both people were required to accomplish other work to simulate a multi-task environment typical for command staffs. The second experiment (TRIAD) examined the ability of a supervisor to interact with two other team members, and to exercise control over task accomplishment based on the communication mode examined. Of particular interest was the ability of the supervisor to remain cognizant of the task being performed and to be able to affect the task activities. Other work was performed during this task and an additional requirement to accomplish priority work was added.

Communication Modes

Face-to-face. The team was collocated and used a single computer to complete the tasks.

Synchronous computer-mediation. Two separated team members communicated through personal computers, connected by cable between RS-232 ports. They had shared-display (what I see is what he sees) screens. INSYNCH software provided synchronized functions for file and screen transfer, simultaneous movement of a cursor on both screens, and annotation with typed text or free-hand drawing. Additionally, a push-to-talk intercom device was provided to team members. For the TRIAD experiment, the supervisor was remotely placed from the other separated team members. He viewed a duplicate screen (repeated from one of the participants) to monitor the task interaction between the team members and also was furnished an intercom with the team members. For the DYAD experiment only, a shared text message window (one can read while the other types a message) was provided for communications between the team members, rather than voice communications. This allowed two different synchronous conditions (with and without voice) to be examined for the DYAD experiment.

Asynchronous computer-mediation. Physically separated team members sent and retrieved messages in the form of computer text and graphic map files. Files were transmitted to a location where they were stored for access. This equated to a time-delayed mail capability with information retained indefinitely for multiple subsequent access. The delay consisted of creating the text or graphic file, calling the mailbox, and transmitting at a 1200 Baud rate. The recipient of the message had to call the mailbox, receive the file at a 1200 Baud rate, and then read or view the file on his workstation computer. No voice communication was provided. For the TRIAD experiment, the supervisor was located separate from either of the team members and had access to the mailbox computer terminal. This allowed him to participate on the electronic mail network. All interactions between team members and the team members and the supervisor were done through electronic mail.

Dyad Experiment

Work was performed face-to-face and with two people separated using various modes of computer-mediated communications. The following experimental modes were selected: (1) face-to-face (FTF), (2) synchronous with voice communications (SYNCH+V), (3) synchronous without voice communications, but with the exchange of typed computer text messages (SYNCH-V), and (4) voiceless asynchronous electronic-mail communications (ASYNCH). The laboratory layout for the SYNCH+V and ASYNCH modes is shown in Figures 3 and 4.

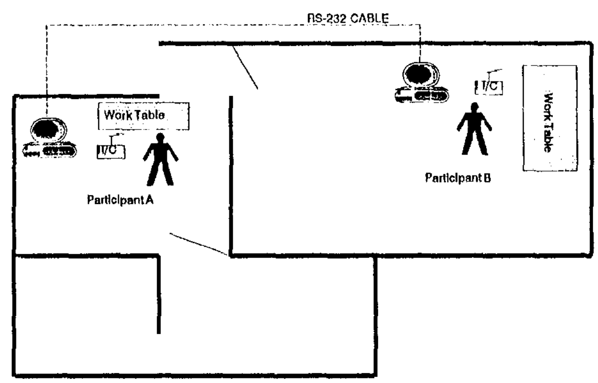

Figure 3. Laboratory layout for SYNCH+V (DYAD).

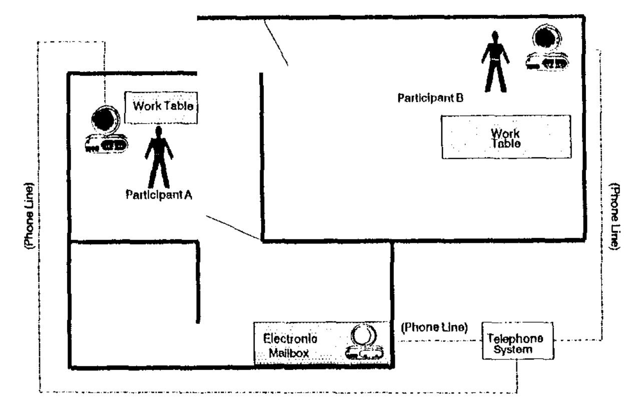

Figure 4. Laboratory layout for ASYNCH (DYAD).

Triad Experiment

Work was performed face-to-face and with the three people separated using various modes of computer-mediated communications. The following experimental modes were compared: (1) face-to-face (FTF), (2) synchronous with voice communications (SYNCH+V), with the supervisor receiving a duplicate screen, and (3) asynchronous electronic-mail communications (ASYNCH). The laboratory layout for the SYNCH+V and ASYNCH modes is shown in Figures 5 and 6.

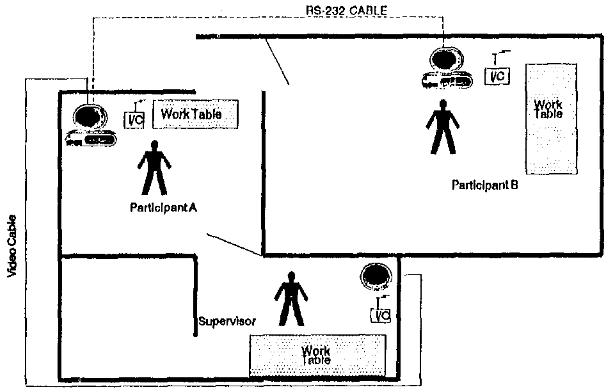

Figure 5. Laboratory layout for SYNCH+V (TRIAD).

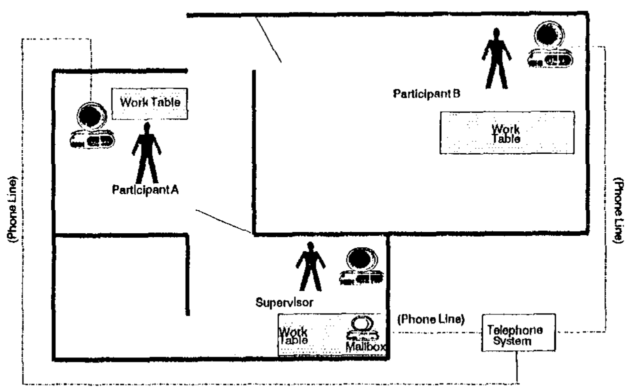

Figure 6. Laboratory layout for ASYNCH (TRIAD).

Experimental Task

The task related to the development of a tactical movement plan, normally performed by the operations planning cell of a division command post. Development of the plan requires coordination among major functional staff groups and collaboration within a single functional group. The sub-tasks included in the laboratory required: (1) route selection, and (2) for the DYAD experiment, computation and creation of movement time tables. The task required selecting the shortest route satisfying a number of task requirements, (e.g. avoiding engaging in battle while enroute, avoiding or removing obstacles to movement, and avoiding or upgrading inadequate bridging). The route selection task required extensive use of graphics, in the form of a map and task specific markings, and the final solution was produced as a graphic. The movement table task involved making time entries in pre-formatted computer tables, showing convoy and serial start and stop times, meal and rest stops, and overnight stops.

Experimental Goals

DYAD -- The goal of this experiment was to study the effects of communication modes on task performance. To accomplish this goal a priori comparisons of the FTF mode to the other three modes were performed. The contrasts were: (1) FTF versus SYNCH+V, (2) FTF versus SYNCH-V, and (3) FTF versus ASYNCH.

TRIAD -- The goals of this experiment were to study the effects of communication modes on task performance and on the interactions of the supervisor with the team. The contrasts were: (1) FTF versus SYNCH+V and (2) FTF versus ASYNCH.

Experimental Measures

Route Agreement Time. This is the time elapsed for the two participants (or the imbedded dyad in the TRIAD experiment) to reach an agreement on the selected route and mark and save to disk the first computer map sheet with bridges and obstacles driven through, upgraded or removed. Prior to presenting the solution to the supervisor for approval, the remainder of the computer map sheets must be marked and saved to disk.

Route ID Time. This is the total time necessary for the completion of the graphical task.

Supervisor Ending Time. This is the time used by the supervisor (TRIAD experiment) to verify the solution, provide approval, complete any administrative requirements, and end the task. This time is computed as the difference between the time that the solution is presented and Route ID Time.

Table Time. This is the time necessary for the completion of the data entry task for the movement tables (DYAD experiment).

Route Score. A set of penalties was developed based on the degree to which the task requirements have been satisfied for each route during the Route ID Task.

Other Work. This measure is the number of other work items completed per unit of time (1 hour). Other work consisted of fact-based and general knowledge questions and was a secondary performance measure.

Priority Work. Priority work was a condition of the task (TRIAD experiment) rather than a measure. Time spent in Priority Work was measurable for the FTF and SYNCH+V modes, and when removed from the other time measures did allow an approximate comparison between TRIAD and DYAD performance.

Transcripts from all of the modes were analyzed. A number of dependent variables were identified for analysis. All transcripts were coded by the experiment leader before the analysis. This coding allowed several language characteristics to be analyzed. Figures 7 and 8 show the relationship of the time measures.

FINDINGS

In both experiments the differences between face-to-face and synchronous with voice conditions were negligible. It appears that no significant speed is lost when transitioning from face-to-face to synchronous plus voice. There were notable differences from these two modes to synchronous

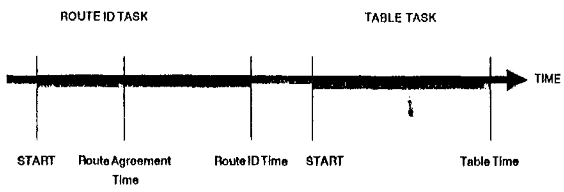

Figure 7. Relationship of time measures (DYAD).

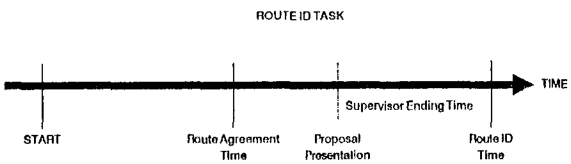

Figure 8. Relationship of time measures (TRIAD).

without voice and to the asynchronous modes. The existence or nonexistence of a voice communication channel appears to be the most responsible for performance differences rather than physical separation or computer-mediation. Additionally, the synchronous mode did create a different and apparently, desirable, supervisory environment than the face-to-face, even though performance was not affected. On the post-laboratory questionnaire subjects reported that the supervisor was the most effective in the SYNCH+V mode. Some of the findings for the DYAD experiment are plotted in Figures 9, 10, and 11. TRIAD experiment findings are in Figures 12, 13, 14, and 15. TRIAD results and DYAD results are not directly comparable because of slightly different experimental conditions. However, in Figure 16 and 17 the differences for Priority Work have been removed and a DYAD versus TRIAD comparison for the FTF and SYNCH+V modes are shown.

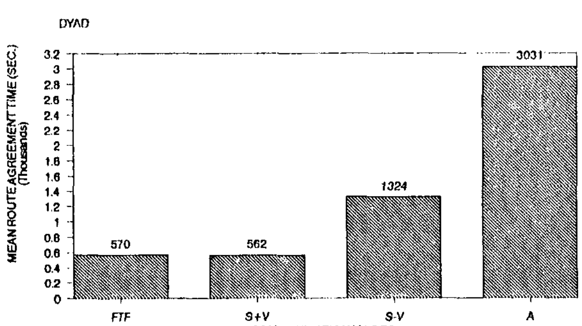

Figure 9. Mean route agreement time (DYAD).

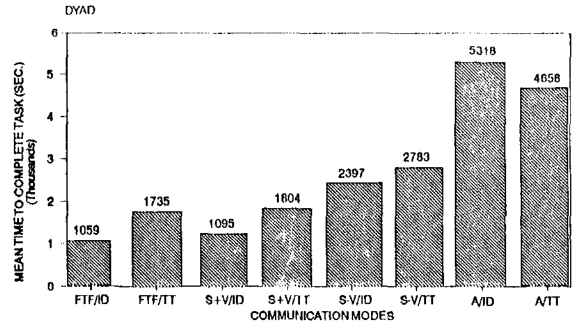

Figure 10. Mean time to complete task [route ID & table time] (DYAD).

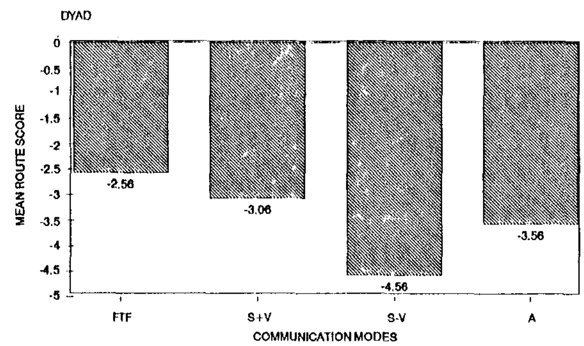

Figure 11. Mean route score (DYAD).

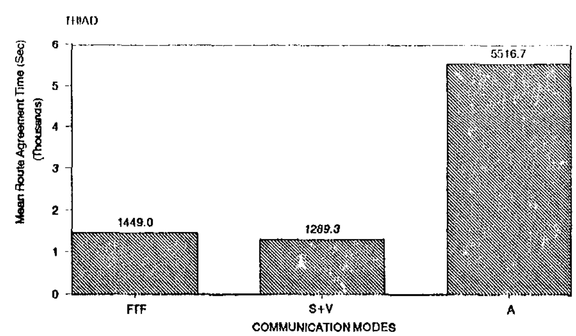

Figure 12. Mean route agreement time (TRIAD).

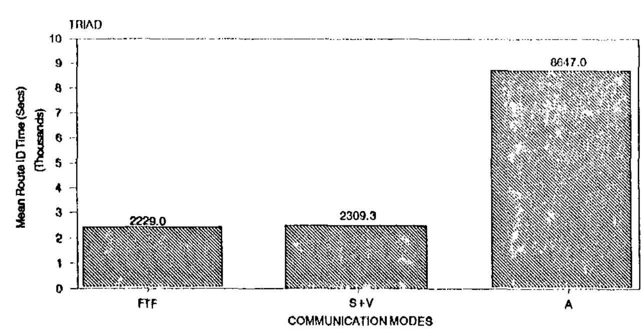

Figure 13. Mean route ID time (TRIAD).

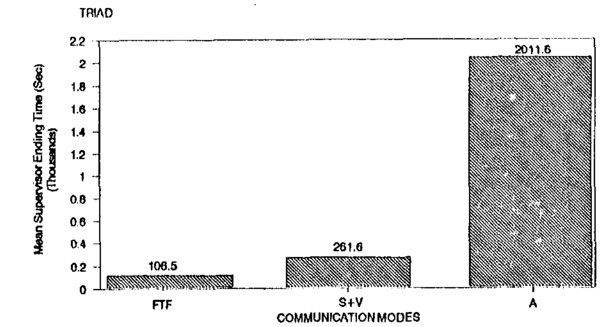

Figure 14. Mean supervisor ending time (TRIAD).

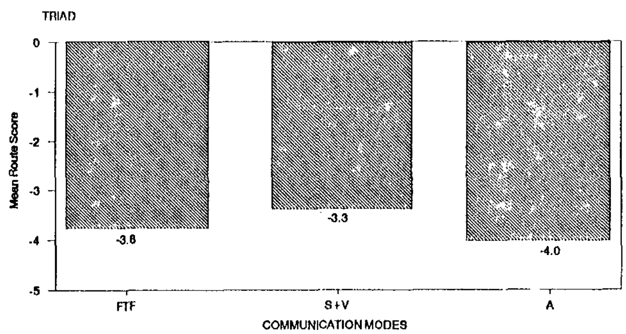

Figure 15. Mean route score (TRIAD).

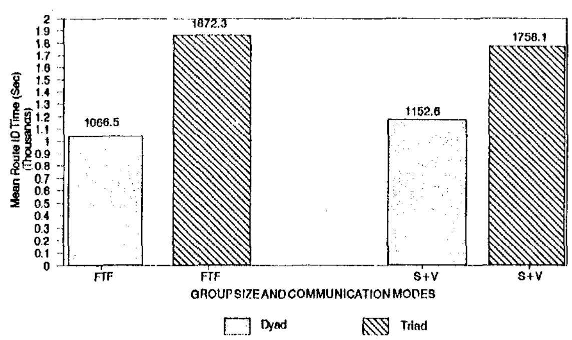

Figure 16. Comparison of mean route ID time for DYAD and TRIAD.

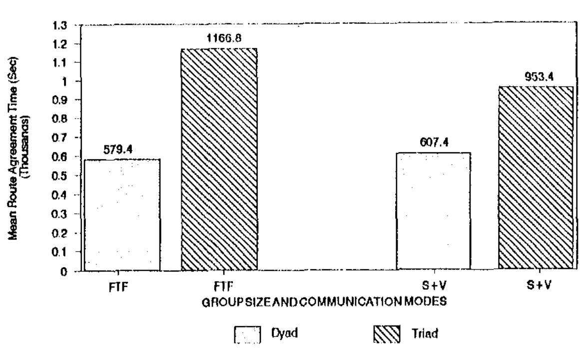

Figure 17. Comparison of mean route agreement time for DYAD and TRIAD.

UTILIZATION OF FINDINGS

Combat developers of C2 systems should consider computer-mediated communications as a viable alternative to face-to-face and voice only communications. The benefits of computer aiding, shared graphics, shared data bases, and two-way graphic communications have the potential of creating an environment that accommodates distribution of function and dispersion of assets. Just as important is the possibility of expanding the commander's sphere of influence by allowing supervision to take place from remote or distributed locations.

Two steps logically follow this research. The first addresses the need for further research in the asynchronous mode to discover if acceptable performance levels can be achieved by the application of technology that allows multi-tasking capabilities, windowing, faster communication speeds, multiple communication net access, and a means of allowing more timely access of key messages and information. The second examines whether reliance on voice communications can be reduced by making the computer-mediated mode faster and richer through the development of a symbolic graphical communication language.

GRAPHIC COMMUNICATIONS

The goals of the ongoing research are to develop and test a graphic communication language for the staff task used in the DYAD and TRIAD experiments and to develop a methodology for creation of a graphic language that is more universal and applicable to additional military staff tasks. An enabling objective of the program is to derive a suitable method for development of such a language.

The computer-mediation experiments were closely examined to determine if specific task states existed. It was determined that four task states and supervisory functions existed for the task regardless of the mode being examined. The task states are shown in Figure 18.

A semantic and syntactic analysis of the transcripts from the computer-mediation experiments was performed. Basic language building blocks will be defined, from which all relevant communication can be constructed. The semantic and syntactic map for the supervisory function is shown in Figure 19. Based on the task state and the semantic and syntactic analysis, a minimum set of candidate symbols were constructed.

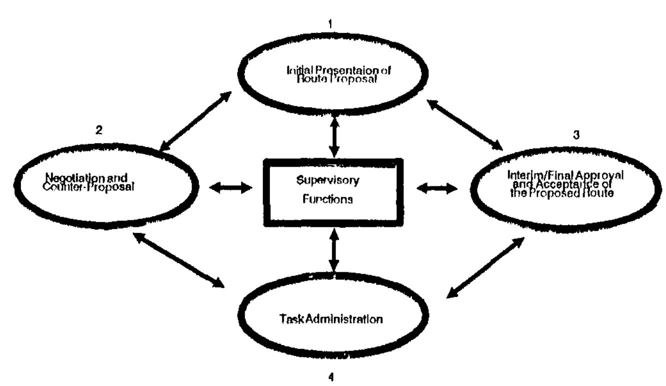

Figure 18. Example of task states and supervisory functions.

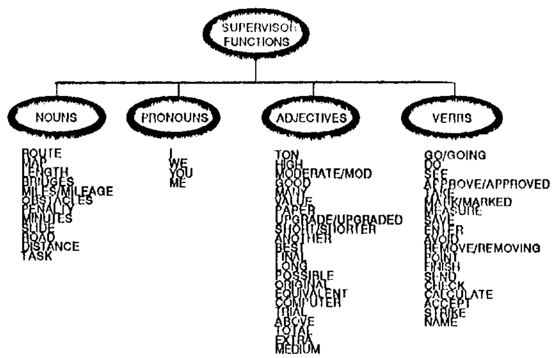

Figure 19. Semantic and syntactic map for supervisor functions.

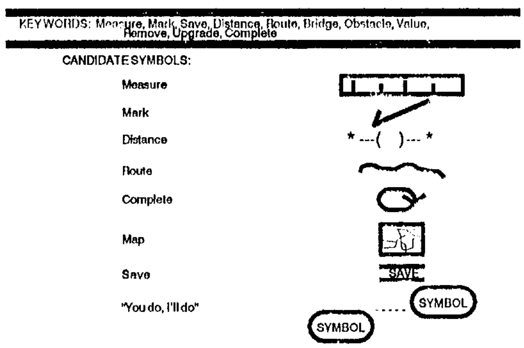

Figure 20. Candidate set of symbols for task state 4.

Catalogues of Army and international symbols were reviewed. Symbol candidates were generated for each object and action identified in the analyses. These symbols were then reviewed by military SMEs. The SMEs independently generated symbols based on task key words and state. A temporary sample set of symbols was then selected for use and experimentation. Figure 20 shows a candidate set of symbols. A computer presentation tool is being developed for experimentation. This tool will allow symbol selection, manipulation, testing of interaction protocol, will provide for task activities, and will serve as a performance measurement device.

RELATED READINGS

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Jon Fallesen is a research psychologist with the Fort Leavenworth Field Unit of the Army Research Institute. He received a B.S. in psychology and statistics from Kearney State College in 1978, and an M.S. and Ph.D. in human factors psychology from the University of South Dakota in 1980 and 1981, respectively. As leader of the staff operations team, his current research focuses on improving command and control decision making procedures through the investigation and application of computer support.

IDEA: FROM ADVISING TO COLLABORATION

JAMES R. MILLER
WILLIAM C. HILL
JEAN MCKENDREE
TIMOTHY P. MCCANDLESS
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MCC Human Interface Laboratory

IDEA is an application independent environment for the development of intelligent advisory systems for a wide range of interactive computer interfaces. Our work on IDEA addresses two particular aspects of these systems: