Command and Control Human Performance Modeling

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The future military command and control (C2) process will be altered because of impacts of new information technology and organizational changes. To predict how these changes will impact soldier performance, the Human Research and Engineering Directorate of the U.S. Army Research Laboratory developed models to analyze human performance under current and proposed future operational conditions. C2 soldier task performance and workload was modeled for a "typical" maneuver battalion task force configuration and in a future technology-based configuration.

To assess the impact of expected technology and organizational changes on a battalion-level command and control center, the project team developed a human performance model of the C2 tasks performed by soldiers using the baseline and future systems. The model was constructed to quantify task and workload for various configurations and to answer the following questions:

- Can the soldiers complete required tasks in a timely manner?
- Can tasks be reallocated to improve information-processing efficiency?
- Is the soldier workload and utilization at an acceptable level?
- Does working in a moving vehicle significantly impact human performance?

The models were built in three steps:
1) Task analysis and workload demand estimation for battalion C2 tasks
2) Develop message scenario data
3) Develop task network models of task and information flow.

To address the issues discussed above, it was necessary to develop a model that is flexible and will allow rapid development. We wanted to be able to evaluate a variety of soldier task allocations, equipment and scenarios, ranging from worst to best case, without a lengthy development and analysis effort. Discrete-event processing models are suitable for this type of analysis.

The MicroSaint™ discrete-event simulation tool was used to develop these models. MicroSaint™ enables tasks, task sequences, flow logic, task timing, and workload data to be built into executable models. The input to the models are message events from the scenario input file, which present an information event stream in a time sequence synchronized to mission activity phases. As these information events enter the model, tasks are triggered and performed in a pattern that reflects the *a priori* logic for task branching, interrupt priorities, time outs, and collaborative (interactive) tasks.

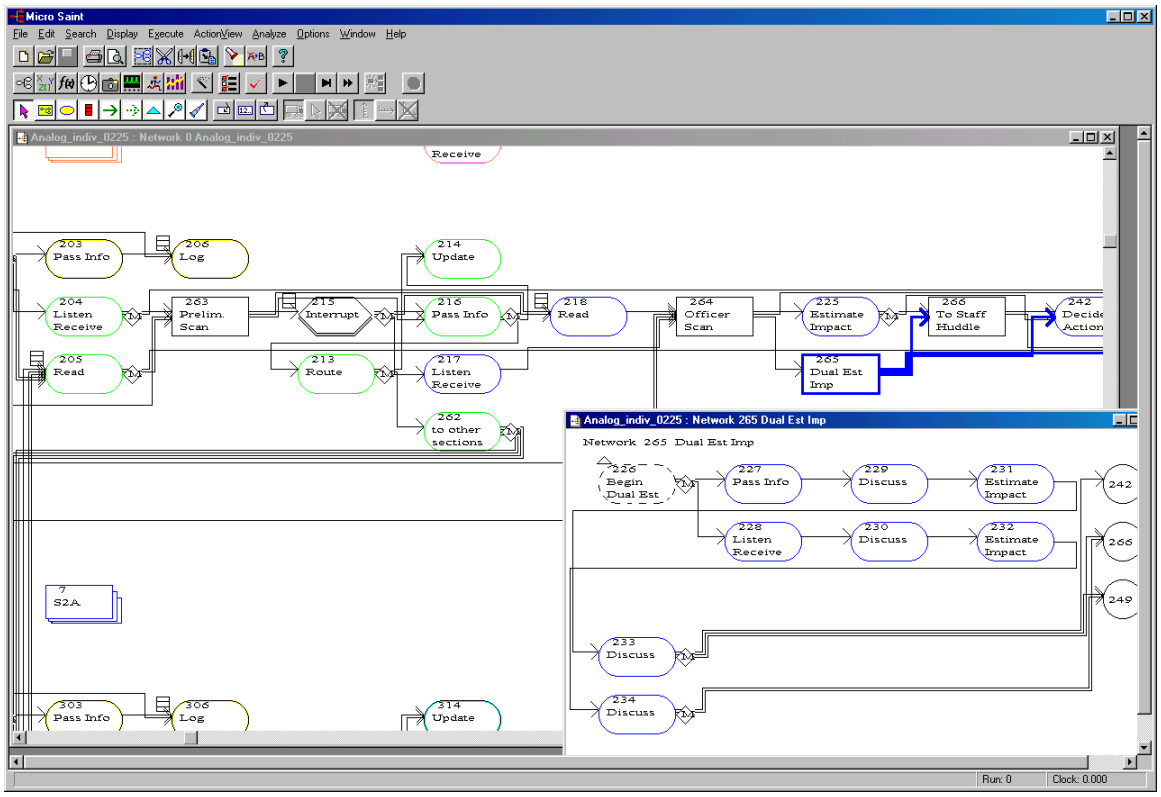

Figure 1. MicroSaint™ model layout.

To provide an analytical tool that would be useful to the customer, we implemented unique capabilities. These large models contain approximately 575 tasks and networks. An example of the intelligence staff section network is shown in Figure 1. The most challenging user requirement was the capability to add new scenario events and change the way in which the human operator responded, without having to alter the developed task network. Because of the size of these models, it was a challenge to provide this capability. Parameterizing the task and scenario data with variable values provided the ability to rapidly perform "what if" analysis. We accomplished this by creating a spreadsheet containing the parameters requiring manipulation. The user can enter the required information directly into a spreadsheet, outside the task network. Replacing values in the spreadsheet, the user changes the logic and flow of the model without reprogramming. The task data include parameters to determine which operator would complete the task, the workload associated with the task, the time required for the task, how the task time is degraded by environmental conditions, and how this task relates to the other tasks being performed. For the scenario, users can alter parameters such as the time the message arrives, where the message enters the model, the radio or digital net it is on, the number of words included, as well as indicators of how the message should move through the system. As the model runs, it reads the branching directions from variables set by the user. This parameterization resulted in a flexible platform through which a user, untrained in modeling and tool syntax, can study a variety of scenarios and configurations.

A six man-month effort was required to build two models that represent a baseline configuration and a future equipment configuration. Changes in task assignment, scenario events, and workload requirements can be made in less than an hour. Model runs for a 24-hour-long movement scenario take about 15 minutes. Current models are being assessed to determine differences in performance when C2 tasks are completed in a stationary versus moving vehicle.

Analysis

The results from the models were analyzed to assess the differences in the C2 operations on information flow and workload and to identify information-processing bottlenecks and overloads. The outcomes from each model run are analyzed independently and then in comparison. The overall goal of comparative analysis was to discern the impacts of the varying combinations of equipment, functional groupings, and environmental conditions on the C2 information flow and workload. Some of the analytical techniques are listed in Figure 2. Preliminary analysis shows that the impact of future equipment is greater than the impact of C2 "on-the-move."

Parametric statistical comparisons:
- **Information flow measures**
  - **-messages dropped, queued, and interrupted**
- **Soldier workload measures**
  - **-cumulative and average utilization**
  - **-workload at specified intervals**
  - **-percent workload**
  - **-task processing times**
- **Degradation profiles**
  - **-stressors (fatigue, noise, vibration, motion sickness)**

Trend analysis of frequency tables
- **Information flow measures**
  - **-reasons for task drops, interruptions, and queues**
- **Soldier workload measures**
  - **-workload profiles for each soldier**

Multivariate cluster analysis
- **Workload and utilization measures**

Figure 2. Analysis approach.

Conclusions

Information flow and task workload models were developed and exercised to provide an analysis and decision-making tool for comparing different personnel and equipment design trade-offs for operating in a C2 environment. The current design of these models allows for ease in "what if" analysis of a complicated system. The model gives quick answers to C2 human performance questions that would be difficult and expensive to answer in field trials.