DSE - A Decision Support Environment

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Abstract

The complexity and size of the integrated command and control system make it extremely difficult for acquisition decision-makers to obtain an omniscient view of the whole system. This view is necessary for examining alternative design options.

This limited perspective deters the development community's understanding of how a proposed "improvement" will integrate, augment and/or supplement fielded capabilities. Thus, designs are developed which may not satisfy user requirements. When expectations are not satisfied, the communities are *balkanized* into groups that do not collaborate to field effective C2 capabilities.

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PREFACE

This paper describes a new method for evaluating "improvements to command and control systems" within the conventional command and control design and development process. We invite interested organizations to collaborate with us in building this capability.

1. Problem

The complexity of the integrated command and control system being developed today makes it extremely difficult for the acquisition decision makers to make timely and complete examination of alternative design options during the development cycle.

The difficulty in obtaining an omniscient view of the functionality of the integrated command and control system makes it harder for the development community to understand the command and control "system" and how a proposed "improvement" will integrate, augment and/or supplement fielded capabilities. As a result, designs are developed which may not satisfy the stated user requirements. Because the expectations of the user community are not satisfied, the user, acquisition program, service provider and development communities are *balkanized* into groups that do not collaborate tightly to achieve the goal of fielding more effective C2 capabilities.

2. Relevance to C2

If we can quantify user goals and explore "what-if" alternatives early in the development process, we can improve the acquisition, service provider and development communities'

understanding of the user's needs, also the user community will have a new tool for honing their operational plans and support and the development of tactics while husbanding resources.

There are five main benefits of the proposed activity:

- The development community gains a detailed understanding of operational missions using the user and service provider community's wisdom. From this understanding, the development community gets an appreciation for the value of the proposed "improvement," vulnerability of systems, uncertainty predictors, availability analysis, pedigree analysis and tailorability assessment.
- The user community gets an evaluation of the implications of the proposed improvement in an operational context using metrics as campaign/mission goal attainment, HCI assessment, timeline analysis, situational awareness impact, cost of implementation, etc.
- The R&D Community gets a forum/testbed which could examine decision analysis/argument theory, collaboration/source opportunities etc.
- The acquisition community gets a better understanding of the implications of requirements compliance and development decisions upon cost, schedule and functionality.
- The service provider community gets an appreciation of the importance of the required services on accomplishing the operational mission.

3. Proposal: A "Vision Center" for Improving the Design Process

3.1 *Introductory Statements*

Because computing environments now make it possible to integrate learning about complex team interactions with learning about complex business interrelations, we can create an environment where the value of the "improvement" can be quantified early in the design process using a team of individuals from the user, developer, service provider and acquisition communities.

3.2 *The Proposition*

3.2.1 *Exercise*

"Model-based simulation" techniques and technologies offer a new way to get the "big picture" and explore alternatives early in the development cycle. In a dedicated, networked facility, trained moderators will facilitate the actions of a group (12 or so) of users, developers, service providers and program personnel in a staged operational exercise. Members of the group will play required decision making roles while executing the tasks associated with a selected mission.

The goal of the exercise is to conduct a null hypothesis test, namely, to quantify and compare the performance of the system modified with the "improvement" with the performance obtained with the unmodified system. The individual tasks to be executed by the group will be defined by task analysis prior to the start of the exercise. A trained "moderator" guides the decision-makers through the execution of the selected mission using an operational scenario and operational user interfaces to perform the tasks required to execute a defined mission. (The implication is that the moderators are fluent in the mission tasks and actions required during mission execution.)

During the exercise, cognitive scientists use observations and “recordings” to monitor the actions of each group member. Computer support “records” the actions and interactions of the group during the exercise. The decision-makers have access to a tool set which supports their assigned tasks. The tool set is comprised of commercially available and custom products. User-defined relevant metrics are employed to determine the degree of goal attainment observed during the exercise. Following completion of the exercise, the moderator oversees a “hot wash” analysis of the exercise results by the group. This analysis includes the variances from the expected decisions postulated by the initial task analysis. This analysis focuses on the decision-makers’ rationale for the actions made during the exercise. One outcome of the analysis is the development of a decision tree which addresses actions made during the completed exercise. The decision tree also illustrates alternative courses of action which could be developed to address problem areas identified during the exercise. The alternative courses of action could be the basis for follow-on mediated sessions.

Following completion of the "hot wash," the moderator distills the results of this analysis and places the results in a web library accessible by interested parties. A related set of tools could operate on the session results from a historical context. For example, these tools could examine the speed/correctness of the decisions made by a group of users that had some previous training/experience in a given scenario vs. groups of the same type who did not have that level of training /experience.

The decision support environment "records" the actions of the role players and the moderator, the events that preceded their actions and the results of these actions. The candidate items for recording are designated by the moderator prior to and during the conduct of the exercise and the selections are based on the goals of the mission session. The decision support environment supports interaction with group personnel located remote from the physical environment via the use of collaborative virtual tools. Cognitive science team will monitor the remote personnel during the mission exercise.

3.2.2 *Environment*

The physical environment contains multiple interactive wall displays of sequenced multimedia screens on which the problem and related material is presented to members of the group. The multi-screen presentation illustrates the problem being executed and provides space to illustrate the process being played out. A representative layout for an eight-screen facility is shown in Figure 1 below.

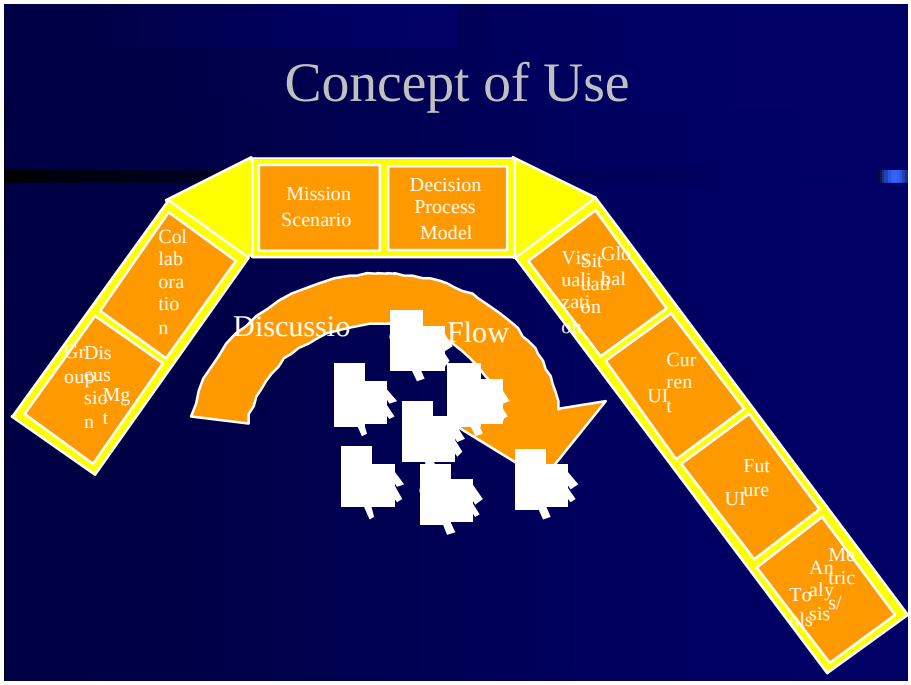

Figure 1. Concept of Use

The screens in Figure 1 are:

- Left 1 - Session Agenda – Group Notes / Questions
- Left 2 - Collaboration with Remote Personnel
- Left 3 – Mission Scenario (God's Eye)
- Left 4 – Decision Process Model
- Right 1 – Global Mission Simulation
- Right 2 – Current User Interface(s)
- Right 3 – Proposed User Interface(s)
- Right 4 – Metrics / Analysis / Goal Attainment

3.3 *Session Preparation*

In preparation for a session, the moderator defines the problem under study, states the purpose of the session, which is to quantify the value of a proposed "improvement" and contrast its value with the existing capability and configures the environment in which a mission-specific scenario will be executed. The moderator defines the C2 systems which will be involved, coordinates the session activities among the distributed participants and describes the tasks attendant to the

selected mission. Mission objectives are defined by the moderator and user-relevant metrics established for monitoring the achievement of mission objectives. The moderator describes the metrics to the group. The mission scenario and metrics are installed in the environment and the moderator defines the allocation of the wall displays to the required information.

Roles are assigned and the moderator previews the mission-specific process focusing on the allocated decision authority at each designated decision-maker's location. He counsels the group that the selected scenario will produce events which generate perceptions by the decision-makers and drive decisions from each individual within the C2 decision process associated with the selected mission.

3.4 *Session Conduct*

The moderator starts the exercise and the members of the group perform their assigned tasks while the moderator assumes the role of "watchdog" and exercise manager. In this role, the moderator and a cognitive science team collect and display metric results and take notes on events which arise during the exercise and the reactions of the decision-makers to events which arise during the session. The notes are stored for use during the subsequent "hot wash." During the session, the moderator has the option of injecting adversary reaction as a real time response to team actions during the mission exercise.

3.5 *Post Exercise Analysis*

Following the completion of the exercise, the moderator conducts a post-mission analysis session or "hot wash." The goal of this effort is to develop a group consensus regarding the utility of the proposed improvement, recommendations for modifications to the "improvement" based on the results of the exercise and proposals for new metrics which could provide better insight into the utility of the proposed capability. The group reviews the events and actions which occurred during the exercise while the moderator points out significant events which occurred between the group members and the simulation. The results of the exercise are examined in light of the metrics employed for that exercise. The moderator uses the notes taken during the exercise to stimulate probing of the group's thinking concerning the reasons which caused decisions to be made during the exercise. The cognitive science team conducts post mission "interviews" of each participant and uses these results in the "hot wash" discussions.

Following completion of the "hot wash" session, the moderator distills the "lessons learned" for the completed exercise and places the summary of the results on a web server, which is accessible by interested parties.

3.6 *Architecture*

Figure 2 illustrates the architecture of the proposed exercise environment.

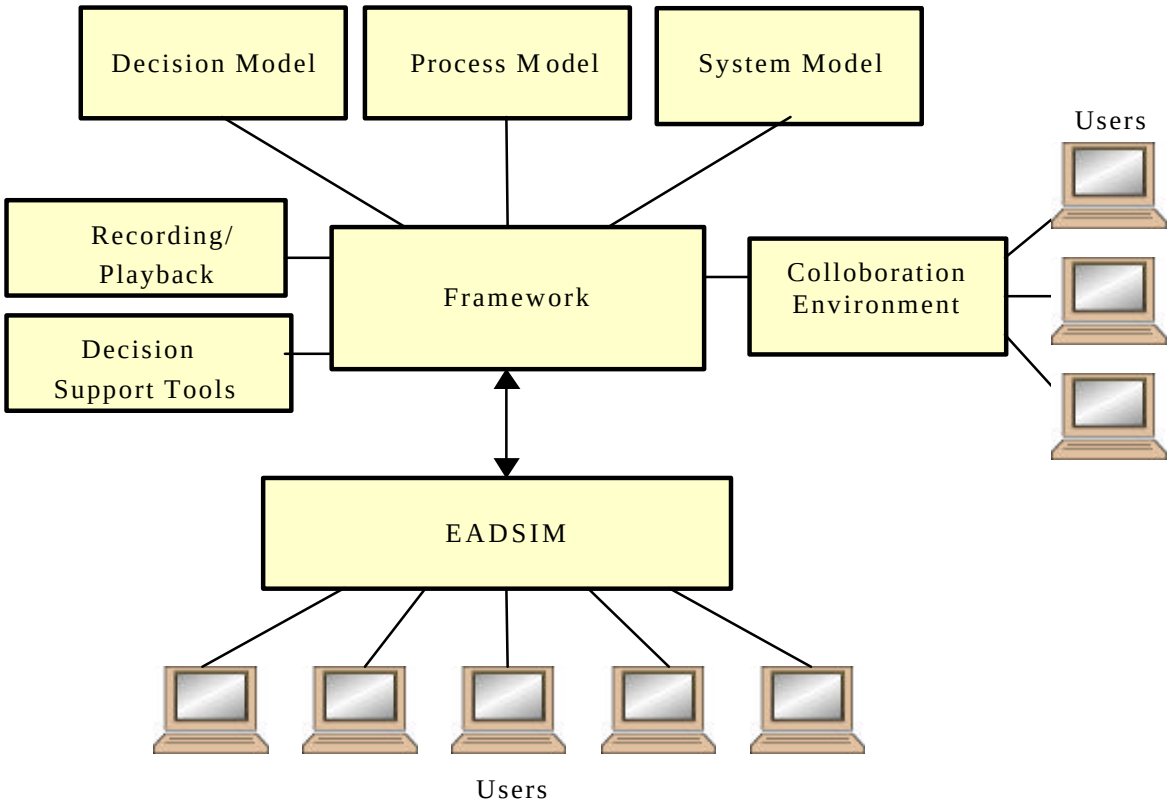

Figure 2. Architecture

The heart of the environment is a framework which controls the exercise environment. The framework supports rapid integration of models, “recording capabilities” simulations and optionally live inputs. Existing operational scenarios, such as EADSIM, will be employed to drive the mediated session through the selected mission based operational tasks. EADSIM interacts with the system model and the process model during the exercise. The system model defines the “communities” involved with execution of the selected mission while the process model defines the expected sequence of operations within the mission statement.

The system model for the complete set of missions is quite complicated and for the proposed mission exercise should be simplified as follows. For a given mission, illustrate only those system elements functioning within the selected mission and group those organizations delivering similar functions into a separate part of the system model presentation. Each segment is defined as a "community."

For example, the ISR “community” encompasses the intelligence and sensor assets located within the theatre. The command and control “community” includes the organizational entities responsible for allocating resources, achieving campaign and mission goals and monitoring progress. The decision authority to allocate assets in order to achieve the defined campaign/mission goals resides within this "community." The platform “community” incorporates all weapons systems and delivery systems available for the mission. The combat support “community” includes maintenance and supply functions available to the user. The mobility “community” includes the transport assets to and from the garrisons/depots and the

theatre. Additional communities could be defined as necessary to match the mission at hand. The location of the decision authority is defined within each organizational entity in the “community” together with the message traffic associated with the defined mission and related operational tasks. The scope of the “community” within the mission-based context will be joint and eventually coalition.

The decision model is based on the results of task analyses conducted by cognitive engineering staff. The decision model highlights the expected decisions and contains the location of the decision authority based on the selected mission and scenario. The operational scenario interacts with decision model to illustrate the timing of decisions based on the attainment of mission objectives.

The process model defines the timelines of the decision process and alerts the players and systems in accordance with the demands of the scenario, and the selected mission.

The cognitive engineering analysts will focus their attention on two aspects of the mediated session: first, monitor the execution of the expected decisions during the exercise and be alert for the unexpected decisions which may arise during the session. If the expected outcomes are not achieved, analysis will be conducted to determine why the alternative decisions were made as well as to develop an understanding of the impact of the alternative decision on the goals of the mission as contrasted to the expected outcomes.

One aspect related to the actions made by decision-makers is the set of interactions made between the proposer of an action plan and the approver of an action plan. This process has been modeled in a capability known as principled negotiation where a proposer agent and the proposition offer an action plan to be examined by an approval agent. This process may be the basis for the preparation of alternative courses of action developed by the decision support environment based on a set of goals and constraints defined by the action plan developers and approvers. Maturation of this capability could result in the creation of a new tool which augments the decision-maker’s ability to weigh alternative courses of action as the situation develops.

The "recording" environment monitors mission operations including human-to-computer interactions and human-to-human interactions. This repository would be available for review during the "hot wash."

Initially, we plan to use operational simulations employed throughout the service so as not to face the problem of certifying the scenario. As the decision support capability matures, we will add operationally certified scenarios and employ simulated problems with live exercise.

3.7 *Infrastructure*

The infrastructure contained within the proposed environment provides a variety of capabilities deemed suitable and necessary for the conduct of effective mediated sessions. A short description of each capability follows.

- **"Unobtrusive Monitoring:"** A means would be provided of “looking over the shoulder” of individuals who are executing a set of tasks related to the selected mission. This capability would be useful from the education aspect as well as monitoring the decision process in action.
- **Networked World:** As the proposed capability exploits simulations of problems, systems and process and these capabilities are distributed across multiple locations, a robust network infrastructure is a given.
- **Collaborative Environment:** As the team exercising the integrated system may be distributed across multiple locations and integrated via collaboration capabilities, a robust collaborative infrastructure is assumed.
- **C & C Organizational Elements Mission Focused Library:** The basis for understanding the existing and proposed operations of the operational entity in a mission scenario is by illustrating the process sequence of those organizations involved in a selected mission together with the decision authority defined within the mission dependant organizational structure. The grouping of organizations into “communities” results in clearer illustration of the organizations involved. The requirement for joint and coalition participation is driven by the fact that future operations will be based on allocation of resources from those communities. The definition of the decision authority and process sequence using these assets is an activity which will be accomplished as this capability develops.
- **Visualization Infrastructure:** A key to developing an understanding of the decision process by the exercise team lies on the use of an effective set of visualization capabilities within the facility. A multi-screen capability in the facility allows the layout of a storyboard, notes, alerts, metrics, system simulations and a “God’s eye” view of the mission being conducted. The presentation of visualizations of abstract information extracted from databases and tools employed in the exercise to the team will assist the team in the decision making process as well as provide insights during the “hot wash” analysis session.
- **Decision Support Tools:** A variety of decision support tools will be available for use by the participants during the exercise and the post exercise session. Three types of tools are Analytic, Operational and Presentation.

  Examples of analytic tools are “what-if” simulation, office automation products, course-of-action development and data mining.

  Examples of operational tools are resource planning and leveling, collaboration with other individuals, airspace deconfliction, threat indication & warning, temporal & spatial presentations and time critical targeting aids.

  Examples of presentation tools are group discussion enabler, context based tailoring, task management and planning, decision chain modeling, information system modeling & profile based tailoring and "information flares."

  Many of these tools will use agents to accomplish the specific function embedded in the tool. Tailorable agents will be provided for use by the exercise participants. Examples of agents are those capable of operating as “information flares” which will monitor exercise activity. These “flares” will alert the user when an alarm condition is met or exceeded. The user, prior to the

start of the exercise, would predefine the alarm condition. Examples of a “flare” could be a temporal and /or spatial activity within a defined area of a particular type(s) of target

- **Recording/Playback:** A record/playback capability will be available for use by the moderator and the exercise team**.** This capability will record all human-to-computer and human-to-human interactions associated with the conduct of the exercise. The control of this functionality will perform analogous to a VCR.
- **User Metrics:** Metrics will be defined by the user cadre and will be based on the goals of the defined campaign and mission**.**
- **User Interfaces:** Existing and proposed user interfaces to existing systems and proposed systems will be provided and positioned on dedicated screens within the facility. These screens will indicate situation in the area of coverage/interest. The state of the sensor/systems together with the status of the communication network will be available as a separate screen for use by the team. Initially, the systems will be simulated but capability to integrated live systems will be added as the system matures.
- **Security:** The facility will operate at the secret and top secret level.

4. Results

Initial efforts focused the development of an infrastructure/environment which would support multimission exercises. Demonstrations of this capability will be conducted in the 3QFY00 and the results of this activity will be described at the symposium.