ALPHATECH, INC.

TR-853

DEVELOPMENT OF A SEARCH AND RESCUE SIMULATION TO STUDY THE EFFECTS OF PROLONGED ISOLATION ON TEAM DECISION MAKING

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ABSTRACT

The goals of this project were to identify and investigate aspects of team and individual decision-making and risk-taking behaviors hypothesized to be most affected by prolonged isolation. A key premise driving our research approach is that effects of stressors that impact individual and team cognitive processes in an isolated, confined, and hazardous environment will be projected onto the performance of a simulation task. To elicit and investigate these team behaviors we developed a search and rescue task concept as a scenario domain that would be relevant for isolated crews. We modified the Distributed Dynamic Decision-making (DDD) simulator, a platform that has been extensively used for empirical research in team processes and taskwork performance, to portray the features of a search and rescue scenario and present the task components incorporated into that scenario. The resulting software is called DD-Search and Rescue (Version 1.0). To support the use of the DDD-Search and Rescue simulator in isolated experiment settings, we wrote a player's manual for teaching team members to operate the simulator and play the scenario. We then developed a research design and experiment plan that would allow quantitative measures of individual and team decision making skills using the DDD-Search and Rescue simulator as the experiment platform. A description of these activities and the associated materials that were produced under this contract are contained in this report.

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SECTION 1

RESEARCH PLAN

1.1 BACKGROUND

In the near future, space crews will be expected to carry out their mission for extended periods of time in a state of relative isolation. Heterogeneous crews will have to maintain high levels of teamwork, reliability, and effectiveness over periods of several months. While these crews are extensively trained to accomplish their individual tasks, there is little research to draw on that focuses on the training of their *teamwork* skills, such as coordination, communication, and mutual feedback, and almost no research on the effects of prolonged isolation on their teamwork skills. An important research goal, therefore, is to determine the effects of prolonged isolation and confinement on several aspects of team decision making and underlying teamwork skills. Such information would allow the development of team training strategies that would compensate for the long-term cumulative effects of isolation on team decision making and performance.

1.2 TECHNICAL APPROACH

Table 1 summarizes the technical tasks planned for this effort. As Table 1 shows, the original plan was to develop and test a new simulation using an ad hoc sample of teams, conduct a baseline study with a sample of Antarctic wintering-over crews, and make refinements as necessary based on the baseline results. Due to funding cutbacks and other constraining circumstances, however, only the tasks delineated for the first year were performed and even here constraints prevented some tasks from being fully completed.

TABLE 1. RESEARCH TASKS

YEAR 1 TASKS
Enhance and adapt DDD simulation task for Antarctic teamwork environments
Conduct a baseline experiment using enhanced DDD and an ad hoc sample of teams
Refine DDD simulation and scenarios based on baseline data
YEAR 2 TASKS
Develop assessment measures
Test DDD with network capability
Conduct second baseline experiment using DDD and an untrained wintering-over sample as a control group to contrast with teams receiving the training
YEAR 3 TASKS
Refine assessment procedures
Refine DDD simulation and scenario

To create an environment and experiment materials which could be used to investigate aspects of team and individual decision-making and risk-taking behavior thought to be most affected by prolonged isolation we:

1. enhanced and adapted the Distributed Dynamic Decisionmaking (DDD) simulator (Serfaty & Kleinman, 1985; Kleinman & Serfaty, 1989)
2. developed a simulation to identify the effects of prolonged isolation and confinement on specific teamwork skills
3. developed a research design that would allow quantitative measures of individual and team decision making skills at multiple time periods

As an analog to long-duration space we sought to secure a sample of over-wintering Antarctic crews to participate in our research program. Prior to the termination of the two out years of this contract, contact was made and proposals were sent to Dr. Wendy Haston (Manager, Research Unit, Gordon Institute of Technology) and Dr. Claude Bachelard (Director, Terres Australes et Antarctiques) to secure Antarctic wintering-over subjects. Tacit approval was received from both individuals, indicating their willingness to cooperate in the research.

1.3 DEVELOPMENT OF THE SIMULATOR AND SCENARIO

1.3.1 Selection of the DDD Simulator

A key premise driving our research approach is that effects of stressors (primarily prolonged isolation and forced confinement) that affect individual and team cognitive processes in an Antarctic environment will be projected onto the performance of a simulation task. This is what led us to choose a simulation environment for this work. We chose the DDD because it is a team-in-the loop simulation that incorporates many relevant team-oriented cognitive tasks, including hypothesis testing, risk assessment, resource allocation, problem solving, and cooperation (Serfaty & Kleinman, 1985; Kleinman & Serfaty, 1989). These cognitive tasks are embedded in the scenarios used on the simulator. If stressors present in the environment impair a crew's abilities to function effectively as a team because of degradation of cognitive processes, then we should see evidence of similar degradations when they perform the simulation tasks. If a team's risk assessment or resource allocation abilities have deteriorated, then we will assess such deterioration on tasks performed in the simulation. If prolonged isolation and confinement have cumulative effects over time, then the periodic simulation sessions will detect these effects.

1.3.2 The Search and Rescue Task Concept

The core of this effort was the development of the search and rescue task concept. This concept focused the development of new scenarios and the modifications made to the DDD simulator. The search and rescue task entails finding a crew that left an Antarctic base camp to perform a mission, has failed to check in for some protracted time, and is presumed lost (and perhaps has sustained damage and injury). The simulator and scenario development were organized to take participants through five phases. During the first phase the players perform a situation assessment, during which they explore questions such as: What do they know about the lost crew's mission? Where might they have gone? What was their last known location? This is followed by resource allocation: How to allocate resources in terms of a simulated crew (and its abilities) to vehicles to best cope with the situation as they know it. The third and longest phase is the search. Driving out from base camp, looking for clues as to which direction the lost crew went, sharing information, coordinating their action, and ultimately locating the lost crew. The fourth phase involves carrying out the rescue (repairing damages and treating injuries), and the fifth phase entails completing the lost crew's mission. An important aspect of the scenario concept is that the tasks in the last two phases must be planned for in the resource allocation phase and not compromised during the search phase.

1.4 DOCUMENT OVERVIEW

In the first section of this report we have discussed the motivation for this research and the technical approach. In Section 2 we briefly describe the DDD simulator, modifications made to it, and the newly devised Antarctic search and rescue scenario. In Section 3 we provide an overview of the search and rescue scenario and the user's manual that was developed to instruct participants how to play the search and rescue simulation. The scenario itself is provided in Appendix A and the players' manual comprises Appendix B of the report. In Section 4 we describe the research design developed to evaluate the simulation, scenario, and participating ad hoc teams decision making skills. Section 5 presents our conclusions and recommendations.

SECTION 2

THE SEARCH AND RESCUE DDD SIMULATOR AND SCENARIO

The DDD has been used extensively to study team decision making, resource allocation, and situation assessment in military command and control situations (Serfaty et al., 1985; Entin et al., 1993; Serfaty et al., 1993). It was the current military version (legacy version) that was enhanced and adapted to create the search and rescue version of the DDD simulator. We first present a brief description of the legacy version of the DDD to provide a general view of the simulator's conceptual structure. We then describe the modifications made to the legacy version to produce the search and rescue version.

2.1 THE LEGACY DDD SIMULATOR

The DDD simulator, developed by ALPHATECH, involves team processing and decision making about complex situations based on information and resources provided by various team members (Serfaty & Kleinman, 1985; Kleinman & Serfaty, 1989). In a typical DDD scenario, a team of decision makers must make coordinated decisions based on uncertain, ambiguous, and sometimes decentralized information. Each team member has only a portion of the needed information and/or resources to accomplish the team task The simulator may be easily configured for teams of up to seven members, networked together to form a variety of organizational structures.

In order to create the task environment, the DDD simulator generates dynamic scenarios of external ("world") events presented to the decision makers through a set of graphical and alphanumeric displays. Figure 1 shows a configuration for a team of four decision makers—one leader and three subordinates—with typical DDD team decision-making tasks in such a configuration.

A team task such as the one illustrated in Figure 1 re-creates many of the cognitive demands associated with team decision making and cooperative work in a variety of domains. The DDD task has often been used to study military decisions in a distributed tactical environment. It has also been reconfigured to represent manufacturing and production scheduling problems (Wang, Luh, Serfaty, & Kleinman, 1991) and decentralized medical diagnosis in teams (Pete, Pattipati, & Rossano, 1991).

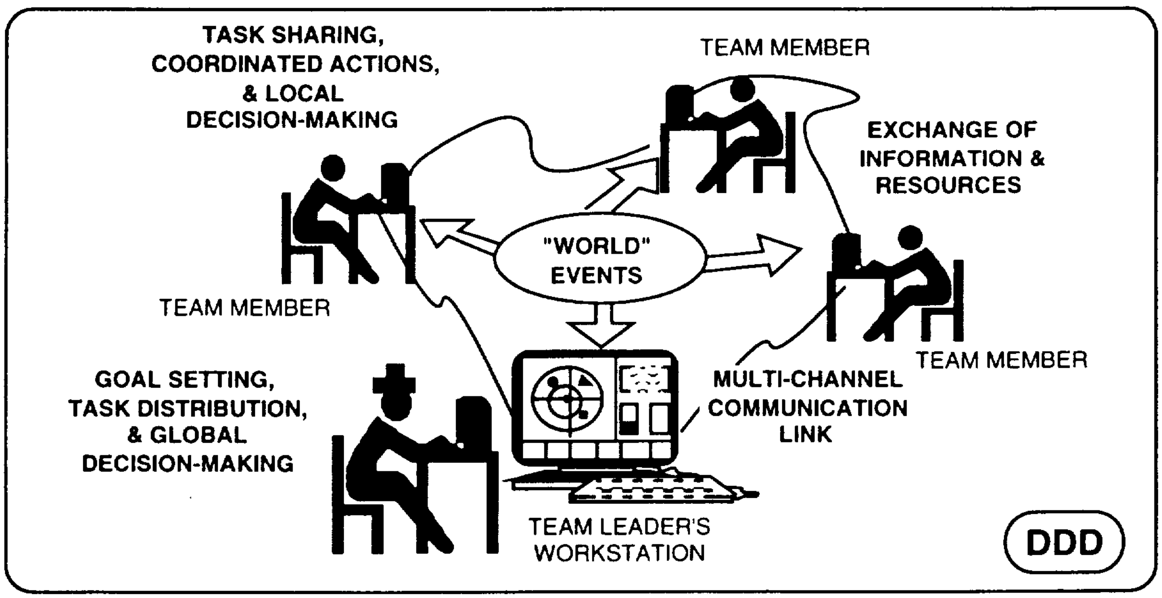

Figure 1. Typical DDD Configuration and Team Decision Making Tasks

The DDD simulation is designed with a flexible structure that can be manipulated to vary a number of different elements of task complexity (e.g., risk, uncertainty, time-pressure, information distribution, communication structure.) The DDD software provides real-time control and on-line data collection during experiments, an interactive display/interface media, and a computerized intra-team communication sub-system. All communication traffic, external events, and decision makers' actions are automatically computer-recorded for subsequent analysis. Written communication via electronic mail is recorded automatically; verbal communication is facilitated by a separate communication system, and can be tape recorded for systematic scoring.

The DDD simulator has served as a vehicle for evaluating team processes and taskwork performance. The DDD can record performance measures (for example, identification of ambiguous objects), and it can also record teamwork process measures such as requests for information or resources and transfers of resources between team members. During a trial, observers are used to record the flow of verbal communication between members of the team.

2.2 THE SEARCH AND RESCUE DDD SIMULATOR AND SCENARIO

There were two challenging aspects involved in the modification of the DDD simulator for research involving isolated teams. The first was to insure that the DDD scenario designed is in some way analogous to the actual tasks that are performed by Antarctic over-wintering teams. The second was to insure that these scenarios are appropriate for eliciting the kinds of teamwork skills that have been identified for study. For example, if one of the skills that is targeted is risk taking behavior, then we must insure that the DDD scenarios have been designed to allow for observations of this behavior.

In order to successfully develop the search and rescue scenario, recast the DDD simulator to represent a search and rescue scenario and address the two challenges mentioned above, extensive library research, Internet search, and interview efforts were undertaken. This work helped us to understand the structure and dynamics involved in working in isolated environments, and the constraints that would be imposed on experiments conducted in such environments.

Based on our findings the simulator was altered in several significant ways. A new background geographical map was developed that presented an analog to an Antarctic base camp and its environs. This was coupled with a second modification, a representation of terrain. To implement the effects of terrain on scenario play, "active zones" were developed and implemented. An active zone is a specific (usually small) area of the map where certain conditions can be programmed to occur if a player enters that region. Active zones provide analogs, for example, to the effects of weather, specific terrain conditions, accidents, and hazards. An active zone might be visible on the map as hills, a mountain, hazardous terrain, or an occurring storm. Or it might be invisible until encountered as a hazardous area, or used to simulate an accident. If an active zone is representing the effects of a hill, rough terrain, or a storm, for example, then when a player's vehicle enters the zone its speed would be reduced or its "sensor" impaired.

Another development was the introduction of sensors and probes that team members can use to learn about environment and to detect another added feature, "clues." The search and rescue scenario call for vehicles, controlled by the players, to be launched from the base camp to carry out the search and rescue task. Each vehicle is equipped with sensors and probes to help navigate the treacherous terrain and locate clues that might yield information on the whereabouts of the lost crew.

Although other modifications were called for the ones discussed above were the most extensive. Many of the search and rescue modifications are address with examples in the Player's Instruction Manual discussed in the next section.

SECTION 3

PLAYER'S INSTRUCTION MANUAL FOR THE DDD-SEARCH AND RESCUE SIMULATOR AND SCENARIO

3.1 SETTING THE SCENE: THE SCENARIO BRIEF

We developed a scenario brief to set the scene for the search and simulation. The scenario brief describes various aspects of the Antarctic environment, the surrounding terrain, and the base camp. The brief also describes the general mission for all crews at the base station, provides aspects of station protocol and procedure, and gives specific information concerning the lost crew. Appendix A contains a copy of the scenario brief.

3.2 USING THE SIMULATOR: THE PLAYER'S MANUAL

We also developed a player's manual to explain how to operate the DDD-Search and Rescue simulator, and how to play the search and rescue scenario. Appendix B contains a copy of the manual.

SECTION 4

EXPERIMENTAL DESIGN AND METHOD

4.1 OVERVIEW

The purpose of the first experiment is to conduct a baseline test of the search and rescue DDD simulator and the associated scenario. We will use this experiment to assess whether the task is engaging and suitably complex, and whether it captures the team processes and behaviors it is designed to elicit. The experiment will also be used to insure that the scenario vignettes are sufficiently different from one another as to maintain participants' interest and task complexity. Finally conduct of the experiment will allow us to identify any shortcomings that emerge in the implementation of the scenario on the DDD simulator, on the running of the simulator, and on the capture of the independent variables. Most important, the experiment will provide baseline data on team processes and decision making in non-isolated teams.

Each four-person team learns of the plight of the lost crew by reading the scenario brief. The brief also relates that the standard protocol to launch a search and rescue mission is to staff and equip three vehicles for the search operation, each vehicle crew to be led by one of the team leaders (the participants) while the base leader (another participant) remains at the base camp to coordinate activities. The base leader will also relate information derived from a special satellite tasked to the base, as crews in the vehicles can not receive transmissions from the satellite.

Within each four-person team each player will be the leader of a virtual team that has three additional virtual members. Each real team member and his/her virtual team members have an assigned platform (vehicle). It is through the different backgrounds and expertise (e.g., mechanic, medical, scout) imbued to these virtual team members that resources and capability are distributed across the real team members.

The participants are guided through five scenario phases: situation assessment; resource allocation and planning; search; rescue; and mission completion. During the conduct of the scenario, the phases can overlap somewhat. During the first phase (situation assessment) participants gather all the information they can on the lost crew's whereabouts. For the next phase, resource allocation and planning, (which parallels somewhat the first) participants engage in resource allocation and planning. Here they load the vehicles with three-person simulated crews. The abilities of the simulated crew members differ, so vehicles may be staffed with different capabilities. Based on what they can learn and infer about the lost crew location and condition, participants attempt to staff their vehicles with the appropriate skill mixes to locate the lost team, help them, and complete their mission.

Once the vehicles are staffed and an initial plan agreed upon, the vehicles leave base camp to begin the search phase. The environment is hostile and many hazards await the searchers. Using different sensors and probes the searchers attempt to avoid the hazards, detect clues, process clues to yield information as which direction the lost crew followed, and locate the lost crew. Once the lost crew is located, the participants must effect the rescue by rendering medical and mechanical aid to the lost crew. This means such capabilities must be available on the vehicle or vehicles that located the lost crew. The fifth phase entails completing the lost crew's mission. Again implying that such abilities are available on the search vehicles.

4.2 SUBJECTS

A sample of 16 individuals will be solicited from the NASA Ames staff, San Jose State University, or other university populations to serve as subjects. All subjects will be remunerated for their participation. The individuals will be randomly assigned to one of four four-person teams. Team composition will remain intact through the entire experiment.

4.3 INDEPENDENT VARIABLES

Although the primary purpose of this experiment it to obtain baseline data in team processes and decision making, we can, without sacrificing that objective, also test two independent variables that we hypothesize are affected by isolation. The design we have proposed calls for the manipulation of two independent variables: reliability and communication mode. Descriptions of the two independent variables are given below.

4.3.1 Reliability

Each message reported by satellite assets and each sensor asset report in the search and rescue scenario will be accompanied by a reliability estimate. Reliability estimates will range from 0% (very low reliability) to 100% (very high reliability. To operationalize the reliability independent variable, the reliability estimates accompanying the satellite and sensors information will be varied over two conditions: low and high reliability. Under conditions of *high reliability* the reliability estimates will have an approximate mean and standard deviation of 0.80 and 0.10, respectively. Thus, by and large all the information provided the team will be relatively reliable (i.e., free of uncertainty). Under conditions of *low reliability* the reliability estimates will have an approximate mean and standard deviation of 0.50 and 0.10, respectively. In this condition the information provided will be relatively unreliable (i.e., froth with uncertainty). The exact mean and standard deviation for each condition will be determined on the basis of several pilot runs that will be conducted to ascertain the optimal values for these measures.

We hypothesized that low reliability in the satellite and sensor information will foster highly conservative strategies on the part of the teams and that in the low reliability condition there will be more cooperation and coordination among the high-performing teams as they attempt to pool information to clarify conditions.

4.3.2 Communication Mode

During a simulation run, two modes of communication will be possible. Players will be able to speak to one another and exchange verbal (voice) messages via a communication system. Players will also be able to send and receive free-format and pre-formatted electronic messages using the DDD-Search and Rescue simulator. Two experimental conditions will be used. Under the *unconstrained communication* condition, team members will be able to communication by voice and electronic messages. Under the *constrained communication* condition team members will be limited to electronic communication only.

Communication is a primary channel for coordination. The richer the communication mode or the greater the band width, the easier and more efficient it will be for team members to coordinate and synchronize activities. Thus we predict that unconstrained communication condition will allow for easier and more efficient communication among team members, thereby facilitating performance. The constrained communications mode will make communication more difficult (i.e., labor intensive) and less efficient, thereby inhibiting performance somewhat.

4.4 DEPENDENT MEASURES

There will be three types of dependent measures: outcome measures (performance), process measures (team and individual), and attitudinal measures (feelings, opinions and attitudes). Three different modes of data collection will be used: automatic capture by the DDD simulator, recordings made by trained observers, and self-report.

4.4.1 DDD Based Measures

The DDD simulator will be programmed to record most actions players take. Many outcome (performance) measures can be derived from the recorded data including measures associated with task performance, resource usage, and time spent. We will operationalize and capture the following measures from the DDD:

- Number of tasks performed
- Time taken to complete a task
- Resources lost
- Resources used per task
- Number of "blind alleys" entered
- Number of hazard zones entered
- Time spent in hazard zones
- Consequences of being in hazard zone (if any)
- Number of hazard zones actively circumvented

- Number of repairs/restores
- Number of clues found
- Communication rates and patterns (any specifics, or is this just the mail log?)
- Number of tasks team members coordinated on
- Number of overlaps or repeats by team members
- Number of probes used per task and overall

4.4.2 Observationally Based Measures

Two observational instruments have been devised to assess team performance and teamwork: The Outcome-Performance Observational Measure and the Teamwork Observational Measure. Both of these instruments are adaptations of earlier instruments used to assess command and control performance (see Serfaty et al., 1993; Entin et al., 1993; Entin et al., 1994). The Outcome-Performance Observational Measure consists of eight subtasks or activities performed by a team. Each subtask or activity is accompanied by a seven point behaviorally anchored scale that an observer uses to evaluate the team's performance on that task. The last item is an overall assessment of the team's performance on a particular trial for the search and rescue problem. In a similar manner the Teamwork Observational Measure is constructed around six dimensions and consists of 10 behaviorally anchored items to assess the six dimensions of teamwork: team orientation, communication behavior, monitoring behavior, feedback behavior, back-up behavior, and coordination behavior). Trained observers using the Outcome-Performance Observational Measure and the Teamwork Observational Measure will evaluate the quality of overall performance outcome and overall teamwork at the end of each trial.

4.4.3 Self-Report Measures

Two self-report questionnaires will be administered, one prior to and one following an experiment trial. The Pre-Trial Questionnaire will consist of item clusters to assess mood, confidence, and climate. The Post-Trial Questionnaire will contain the Task Load Index (TLX) designed by NASA to assess workload and item clusters to assess situational awareness, mood, confidence, and climate. The pre- and post-trial questionnaires are drawn from an amalgamation of questionnaires and clusters of items that have been used in other research focused on team performance and processes.

Following the Resource Allocation portion of a trial, a questionnaire will be administered to capture the outcome of the allocation process, measure situation awareness, and record initial plans.

4.5 DESIGN

The two independent variables will be completely crossed to produce a 2 X 2 within-subjects design (with four experimental conditions). Each team will experience all four conditions in a different counter-balanced order.

4.6 SIMULATION AND SCENARIOS

The DDD simulation, described in Section 2, is hosted on four interconnected Sun workstations. Four search and rescue scenario vignettes have been developed for use in the experiment. The scenario vignettes are similar to one another in purpose and structure, but the location of lost team, position of clues, active hazard zones, navigation of certain terrain features are varied from vignette to vignette to give each a novel look. Given the number of teams that will be involved in the experiment, it will not be possible to counter-balance experimental conditions across scenario vignettes. Thus, although the ordering of the experiment conditions will be systematically varied, for this experiment an experimental condition will be confounded with a scenario vignette. Each team will therefore see the same scenario vignette-experimental condition pairing.

4.7 PROCEDURE

A team will receive a briefing on the initial conditions of the vignette, complete the pre-trial questionnaire, receive satellite data, and negotiate and allocate resources, and develop a team structure. The team will then complete the situation awareness measure and be allowed to complete the trial. At this time, the post-trial questionnaire will be completed, any observational measures taken, and a short after action review conducted (this will be tape record for later analysis).

A trial with its associated data taking is expected to last 60-70 minutes. Each team will complete two trials in the first session. Approximately five to seven days later each team will complete two more trials for session two. At the end of the experiment all subjects will be completely debriefed.

SECTION 5

CONCLUSIONS AND FUTURE WORK

5.1 SUMMARY AND CONCLUSIONS

The goal of this research project was to learn how prolonged isolation and confinement, such as might be experienced on long space flights or long space station missions, affects decision making and teamwork processes of isolated teams. We assumed that an appropriate analog to the confinement and isolation of space travel was that experienced by wintering-over teams in the Antarctic. A key assumption to our research approach holds that whatever effects were produced by the stressors of confinement and prolonged isolation on the decision making of an isolated team would (also) be projected onto a simulation game demanding decision making and other teamwork processes.

A search and rescue task in an Antarctic was developed and used to focus the reconfiguration of an existing simulation and the design of an accompanying scenario. We modified the legacy DDD simulation to produce the tool we required to portray the simulation and conduct the research. A players manual was developed to instruct participants how to use the simulator and play the search and rescue scenarios. We conducted several pre-experiment trials of the simulation, associated scenario, and manual, and corrected shortcoming that were identified. We developed an experiment procedure and measurements instruments that would be used to capture team processes and decision making. In short, all the tools necessary to commence a study of the effects of prolonged isolation and confinement on team decision making processes are in place.

5.2 RECOMMENDATIONS

There is still little empirical information on the effects of prolonged isolation and confinement on team processes and decision making. The need to understand how to effectively train teams to cope with the detrimental effects of isolation and confinement remain unchanged.

The current effort has produced tools to allow such research and study to go ahead. We recommend that a baseline experiment be conducted using the search and rescue DDD simulator and scenario with an hoc subject sample as described by the experiment design in Section 4. Such an effort will allow for further improvements and calibration of the simulation and associated materials as well as provide baseline data on nonisolated team decision making processes.

We further recommend that a sample of Antarctic wintering-over teams be located who are willing to participate in multiple trials of the search and rescue simulation while they are in isolation. The data that is obtained can be compared to the baseline data and analyzed for the effects of prolonged isolation and confinement on team processes and decision making. Such finding will allow the development of a training program to mitigate the effects of the stressors prolonged isolation and confinement.

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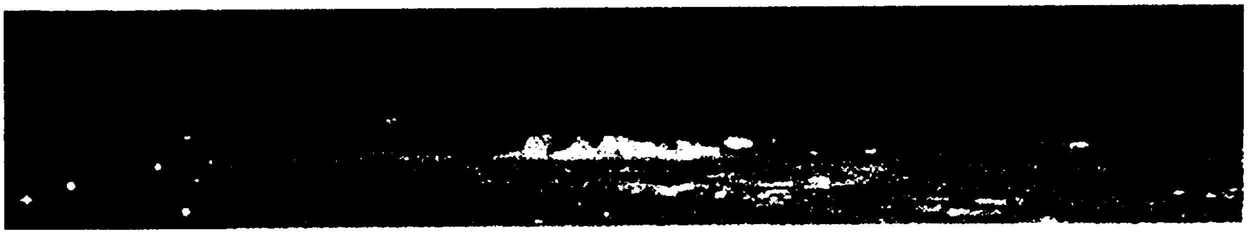
APPENDIX A

TR-853-A

Search and Rescue Scenario Brief



TIME: MAY, 1999

LOCATION: STATION GREEN, SOUTH POLE (Lat.: 80; Lon.: -120)

BACKGROUND:

Your crew is to winter-over at station Green. Different members of the 20 person crew will be conducting meteorological, geological, communication, astrophysical, and medical/biological observations and experiments during the eight-month wintering-over period. The remaining crew members present on station are mostly in support (e.g., technicians, mechanics, cook). Everyone has received training on how to run the station and survive in the Antarctic's hostile environment. In short, you have been told the Antarctic is an inherently dangerous place. Stay hydrated and be aware of altitude sickness effects. Dress warmly and carry dry clothes and a radio if traveling away from the station. Do not travel on days with less than 100 meters of visibility. Read the Fire Safety Guide. Be trained on equipment and vehicles and obtain permission prior to use. Be aware of smoking policies. Check station bulletin board for additional safety information.

It is the fall season. The previous crew has gone and now the wintering-over period has begun. Except for the other crew members, you will not see another human being for eight months. There are at most a few hours of daylight, mean temperature is about -25 deg. C, the wind blows almost constantly (10 - 40 km/hr), and although there is little precipitation there is a fair amount of blowing snow. On the best of days visibility is less than 1 km.

Station Green is located 50 km inland on an ice sheet at an altitude of 1,530 meters. Thirty km further inland, to the southeast of the station is the Young mountain range with peaks as high as 3,350 meters. The terrain around the station is low undulating hills. A short distance to the east of the station there are canyons and bluffs formed by huge cracks and displacements in the ice sheet. There are natural and man-made bridges across some of the canyons. In some places the wind has formed sharp scallops in the ice sheet. Such areas are difficult and hazardous to traverse. In other places the wind blows snow and ice chunks over smaller cracks in the ice covering them with a brittle cap. These areas are **very** hazardous to cross. Vehicles and individuals on foot can be trapped or lost when they break though the brittle crust. Due to the catabolic winds (resulting from cold air flowing down off the interior ice sheet) local storms can come up suddenly producing zero visibility, 80 km/hr winds (190 km/hr winds gust), and -75 deg. C temperatures.

The station is equipped with specially designed Snow Cats that can navigate the terrain in all but the most severe weather. The Snow Cats can carry four persons and supplies, have a top speed of 10 km/hr, and at their cruising speed of 8 km/hr can go 90 km before refueling. These special Snow Cats are equipped with communication gear, navigation gear, and a set of special sensors and probes. One type of sensor can read the terrain and give an evaluation as to how hazardous it will be to cross. One type of probe can determine if a pass is open. Sensors or probes, however, are not perfect. They possess some inherent inaccuracy and they are differentially affected by environmental conditions. With each sensor or probe report there is an accompanying estimate of uncertainty to help the decision maker use the information effectively.

Station Green receives reports from several satellites. These satellites give information on the weather and certain geological conditions, and can be tasked in narrow beam mode to search for man-made objects and even lost individuals. In narrow beam mode a small area is searched intensely, thus it takes many passes and some time to cover the area around the station. The satellite sensors are not perfect and also return an estimate of uncertainty.

Protocol requires that when a task or tasks have to be performed outside the station a work team or teams of four persons each are formed for protection and safety. **You** are one of the team leaders around whom a work team would be organized. There is only one team leader per team. Because the weather and environment are so hostile virtually all travel is done in the Snow Cats, thus each team leader is assigned a specific Snow Cat (identified by color).

Protocol also dictates a particular process to be followed for each task or mission. Every task or mission starts with a resource allocation phase where team leaders determine the individuals with the appropriate skills (e.g., medical, mechanical, scouting) and accompanying resources (supplies) to comprise a team or teams. In phase two team leaders perform situation assessment and planning. All the available information impacting a task or mission is analyzed to produce the best picture of the situation and what is occurring. Plans are then made in light of the current situation assessment. In the third phase one or more teams leave the station to perform the task or mission.

INCIDENT:

A team departed the station yesterday for the Young Mountains on a 2.5 day mission to install special geological equipment to monitor movement in the mountain range and the ice sheet around it. Teams outside of Station Green are required to report in every two hours. About two hours from base the team reported encountering a local severe storm that damaged the Snow Cat. The team's leader did not believe the damage was serious enough to abort the mission, given that the window of opportunity to perform this important mission was closing fast. The storm also closed some passes and changed the terrain requiring the team to alter its original course. After this transmission the next two reports were completely garbled. It is now four hours after the last garbled transmission, absolutely nothing has been received from the team, and all attempts to contact them have failed. Apparently, unknown to the team, their Snow Cat's communication equipment was damaged. On this particular Snow Cat the communication and navigation equipment are interrelated so it is a good guess the team is lost and/or has sustained further damage.

Protocol requires that a search and rescue mission be mounted. You are to work with the other three remaining team leaders to plan and carry out the search and rescue mission. If possible it would also be to the station's advantage to complete the original mission to install the special geological equipment. Whatever is to be done, it must be done quickly because satellite information now indicates that a large severe storm will hit this area in about 3 days. If the lost team is not found before the storm hits they will perish. Moreover, if everyone does not return to the station before the storm reaches full intensity there will be more loss of life.

The usual search and rescue plan is to have three teams out on the search and the remaining manpower at the station coordinating satellite search activities with the out-of-station searchers. Because Snow Cat's communication equipment can not receive the satellite transmissions, the only way teams away from the station can learn the satellite information is to have someone at the station relate it to them. Although time is of the essence, it is important that the resource allocation and situation assessment phases be carried out carefully as mistakes at this stage can have dire consequences later.

APPENDIX B

TR-853-B

Search and Rescue DDD Simulation:

Player's Manual

SECTION 1

CONTROLLING SIMULATION OPERATIONS

To start the DDD simulation, the experimenter must open the **controller** window. To start the **controller** window, type **controller &** at the command prompt in the xterm window. The cursor will change to a cross, and you will be able to place the window (shown in Figure 1) on the screen by clicking the left mouse button.

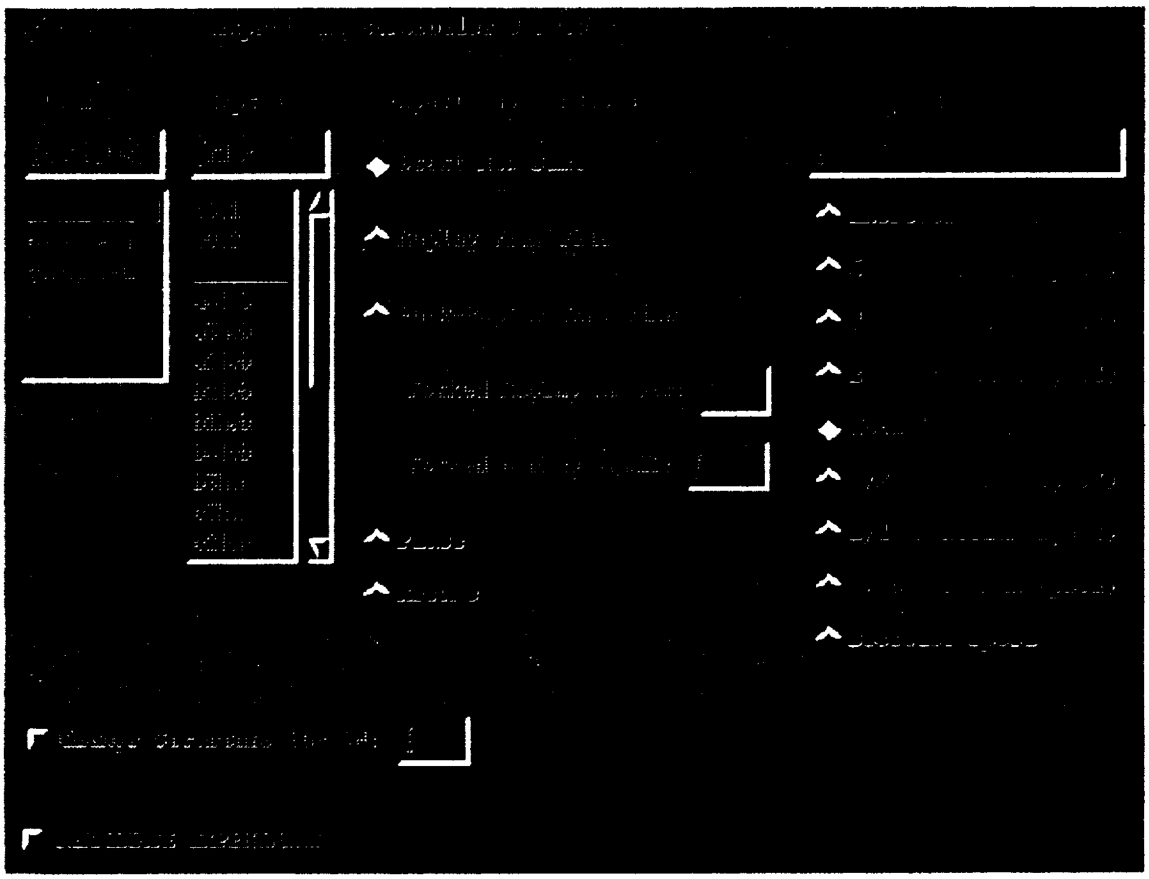


Figure 1. Controller Window

The controller window has buttons that control the simulation. The main tasks that concern the experimenter for this simulation are **Starting**, **Pausing** and **Resuming**, and **Ending**.

1.1 STARTING THE SIMULATION

1) To begin the simulation, select the **Team** that is participating in the simulation and the **Expt #** for the scenario that will be used. The column labeled **Team** lists all the teams that will be participating in the experiment. Click with the left mouse button to select the **Team**, and the name of that team will appear in the text field above the column. The column labeled **Expt #** lists the scenarios that the DDD can use. Click with the left mouse button to select the scenario, and its name will appear in the text field above the list.

2) Click on **Start New Game** button and a message will appear in the xterm window where you typed controller to start a number of **locals**. **Locals** are the main windows that each decision-maker has on his screen.

> *Note: Clicking on* ***Start New Game*** *before selecting the Team and* ***Expt #*** *will result in an error which must be corrected by restarting the controller.*

3) All players must then type **local N** in an xterm window on their individual workstations where **N** is the number corresponding to the decision-maker. The team leader should type **local 0**, other team members should type **local 1**, **local 2**, and **local 3** (one per number), and the experimenter should type **local 4**. **Local 4** is reserved for the observer or the experimenter, as it shows the locations of all the decision-makers, launched resources, clues and items.

4) All decision-makers must click with the left mouse button on the **Start** button in their windows. The simulation will not start until everyone has clicked on **Start**.

1.2 PAUSING AND RESUMING

If it is necessary to pause the simulation, the experimenter can click with the left mouse button on the **Pause** button in the controller window. This will pause, not terminate, the simulation if it is running. Clicking on the **Resume** button in the controller window will continue the simulation if it has been paused.

1.3 ENDING THE SIMULATION

Clicking **TERMINATE EXPERIMENT** button ends the experiment and closes all of the team members' local windows. It is important that the experimenter ends the experiment by clicking on this button rather than killing the processing from the xterm in order to ensure that the results of the experiment are recorded accurately in the log file.

1.4 CAUTIONS AND NOTES

The **Replay From File** and **Fork-Replay From File** are not currently available in this version of the DDD.

The DDD currently has controls for adjusting the **Speed** of the simulation. It is not recommended that the speed be changed in this heavily graphic version of the DDD since this usually overloads the computer to a point where all windows will freeze.

SECTION 2

LOCAL DECISION-MAKER WINDOW

The rest of this document details how to use the controls and resources in order to participate in the simulation. Each decision maker has a window (see Figure 2) which shows a map of the region, controls for the display, and text windows that keep team members updated as to what actions are being taken by some or all players throughout the simulation. On the middle of the right side of the window there are some control buttons that are used to control the display. The bottom left text window is the report window. In the report window, the time, subject, and sender or recipient for incoming and outgoing email messages are displayed. The bottom right text window displays information about actions that decision makers are taking throughout the simulation such as a launch attempt, launch completion, resource launches, resource returns, and clue processing.

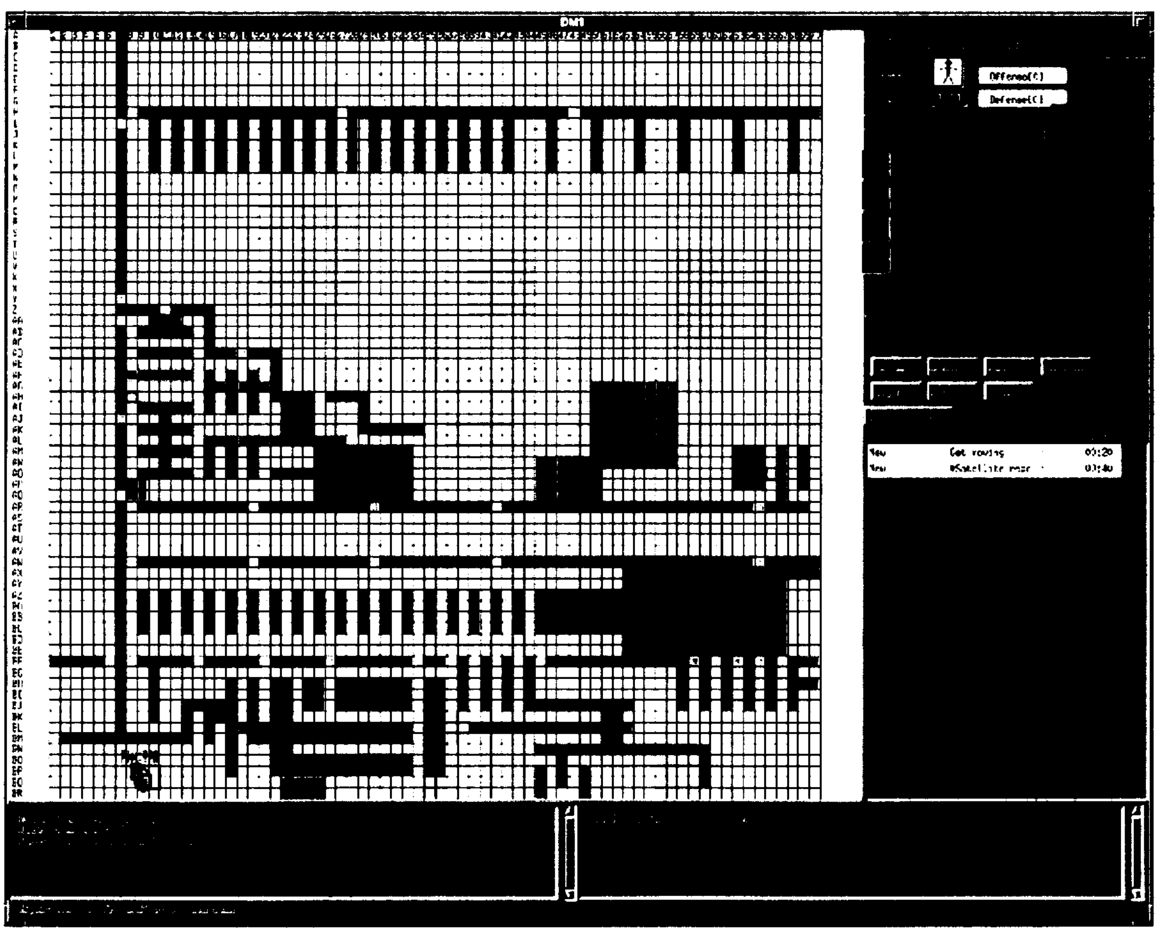


Figure 2. Reduced local Decision-maker window

2.1 UNDERSTANDING THE MAP WINDOW

The map shows the layout of the region of interest. The different terrain are represented in different colors. These can be found by clicking on the **Legend** button on the map window. A description of the different colors and associated terrain attributes follows:

Color	Description
brown	impassable (0-20, if open, 21-40)
yellow	storm, passable, but lose 50% speed and 50% visibility (41-60)
gold	passable, but moderately dangerous. Moderate to high likelihood of being damaged (61-80)
red	passable, but very dangerous. High to very high likelihood of being damaged
pink	Passes (manmade or natural bridges) which may or may not be open. If you click on pink terrain, a **Terrain Window** will pop up on your screen. One line in this window will indicate whether the pass is **Open** or **Closed**
small white squares with green border	There are two supply sheds (east and west). If you are near enough to detect them, you will see a supply icon (see **Legend**) and you can process (see how to process items below) to replenish any of your losses.
large white square with green border	Green station and starting position

2.2 ZOOM IN / ZOOM OUT

You will need to zoom-in and zoom-out in order to click on various icons presented throughout the simulation. To zoom-in on an area:

1) Click on the **Zoom In** button with the left mouse button. The mouse pointer will change to a cross.

2) Click with the left mouse button and drag a square over the area you want to zoom-in on.

3) Click on the **Zoom Out** button to return to the previous screen where you zoomed in from.

2.3 MOVING VEHICLES AND ITEMS

Throughout the simulation, you will need to move your vehicle and resources around the terrain in order to get closer to clues and to eventually find the missing party. These options are only available for resources that you own.

To move a vehicle:

1) Click and hold it with the right mouse button. You can choose to move your vehicle at three different speeds. However, the faster you move the vehicle, the lesser your radius of detection will be.

Speed name option	Speed (km/hr)	Detection radius
Fast	10	1.0
Medium	7	1.4
Slow	5	2.0

2) Select one of these speeds and release the mouse button.

3) Click on the destination point with the left mouse button and the item will begin moving. The vehicle or item will stop moving once it reaches its destination. If the path you set moves within zone boundaries, the item you are moving will stop automatically at the border, giving you an opportunity to decide whether or not you want to continue along that path. You will need to follow the above steps to continue moving.

2.4 ADDING WAY-POINTS

Once you start moving an item, it will move in a straight line from origin to destination. If you want to lay out a path for an item to move beyond its initial destination, you can do so by adding way-points.

After you have an item moving, you have the option of adding way-points to its path. Click on the item with the right mouse button, select **Add Way-Point**, and add the way-point by clicking with the left mouse button on the destination.

2.5 STOPPING VEHICLES AND ITEMS

If you wish to **Stop** your vehicle or item before it stops automatically, click and hold it with the right mouse button and select **Stop** from the menu. If you had previously laid out way-points that the vehicle has not yet reached, **Stop** will clear them.

> NOTE: The only time your speed and detection radius is affected by terrain is during a storm, when your speed and visibility will both decrease by 50%.

2.6 MOVING WINDOWS

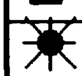
Sometimes, you may want to have more than one message open on your screen. If you like, you can move any window by clicking and dragging with the left mouse button on the top bar of the window. For example, when you are **Forwarding** a message, you may need to move the windows so they do not overlap one another.

SECTION 3

RESOURCE HANDLING

There are three types of resources in this simulation: personnel, probes, and scanners. Table 1 shows a listing of all types resources that can be used to process clues that will come into your detection range throughout the simulation:

TABLE 1. ICONS REPRESENTING RESOURCES

Icon	Description
	Technical Personnel(Te)
	Mechanical Personnel(Me)
	Medical Personnel(Md)
	Scout Personnel(Sc)
	Probes (Pr): 2 km detection range, and reusable.
	Scanners (Sn): 3 km detection range. A scanner resource of any reliability level can only be use once.

There are three levels of expertise for each type of personnel: 3- low expertise, 5- moderate expertise, and 7-high expertise. The are also three levels of reliability for probes and scanners: 3-low, 5-moderate, and 7-high. For example, a medical personnel with an expertise level of 5 will be label **Md5**. A scanner with a reliability level of 7 will be labeled **Sn7**.

3.1 RESOURCES DISTRIBUTION

Each decision-maker is assigned a vehicle of a different color at the beginning of the simulation. The vehicle is equipped with a default set of three probes and three scanners, one at each reliability level. All personnel are located initially on the blue vehicle, but these can be transferred at the beginning of the simulation. Figure 3a shows the initial resource list of the blue vehicle and Figure 3b shows the initial resource list of other vehicles.

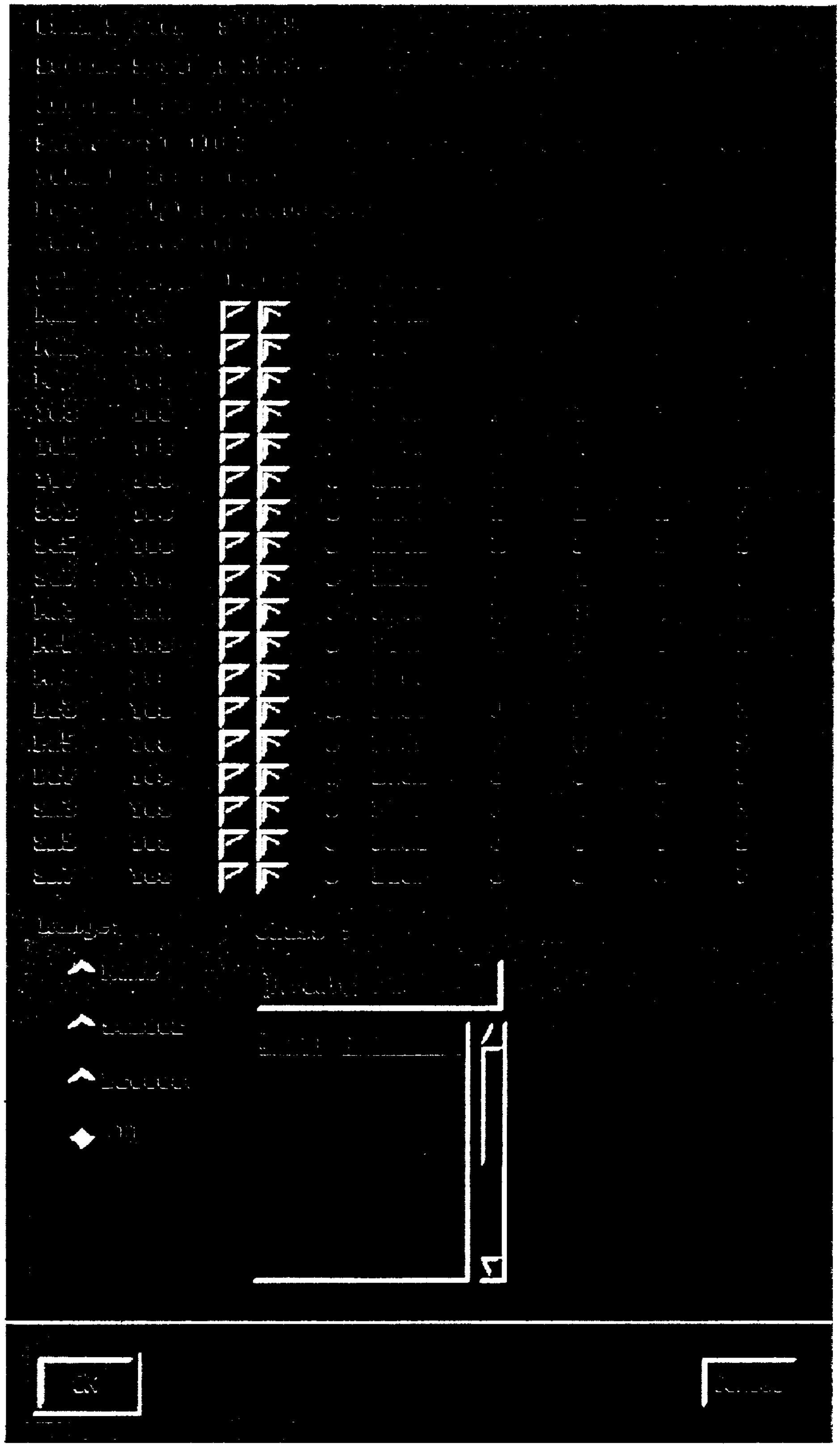


Figure 3a Initial Blue Platform Resource List

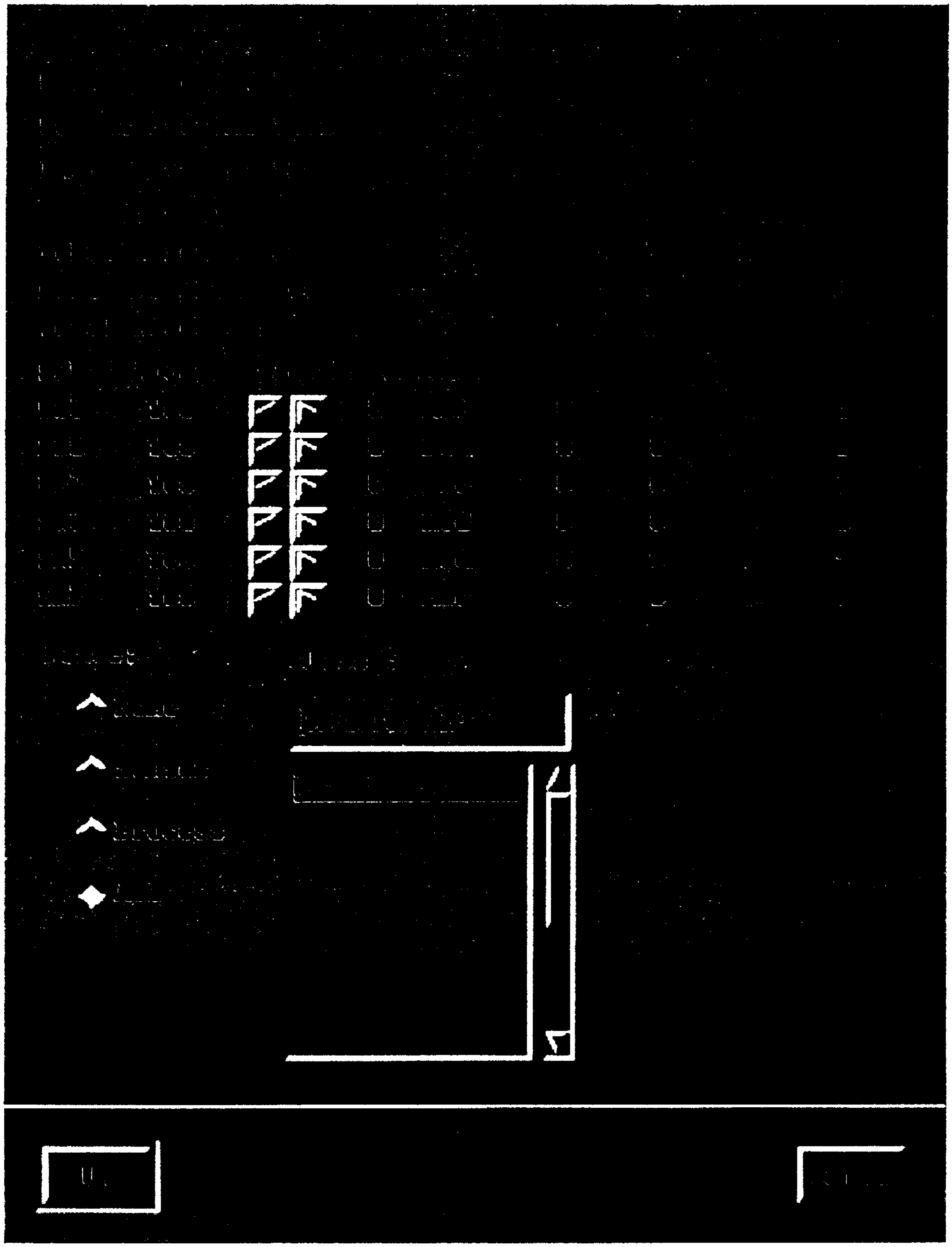


Figure 3b Initial Resource List of Other Platforms.

3.2 FINDING OUT WHAT RESOURCES YOU OWN

1) Click with the right mouse button on your vehicle and select **REQ Info** from the menu.

2) A vehicle information window like those shown in Figure 2a and 2b will pop up on your screen. The list of resources that you own is listed under the column **Sub**.

3.3 LAUNCHING RESOURCES

Before you use any resource, it has to be launched from the vehicle. To launch a resource:

1) Bring up your vehicle information window by clicking with the right mouse button on your vehicle and select **REQ Info** from the menu.

2) Click with the left mouse button on the right arrow in the **Launch** column corresponding to the resource you want to launch.

3) Click with the left mouse button on the **OK** button in the lower-left corner of the window. The icon of the launched resource will appear near your vehicle once the launch is complete.

> *Note: You can **Launch** as many resources as you like from your platform. There is no limit. However, you can only launch one resource per information window opening.*

3.4 RETURNING RESOURCES TO VEHICLE

When you are finished using a resource, it is usually a good idea to return it. If a resource has been away from a vehicle for a certain amount of time, it will be returned to the platform automatically, and you might not be able to use it when you need it. By returning the resource to your vehicle, you will have more control over the availability of the resource. To **Return** a resource to a vehicle:

1) Click and hold with the right mouse button on the resource you wish to return to your vehicle and select **Return** from the menu. A **Return** window (see Figure 4) will pop up on your screen.

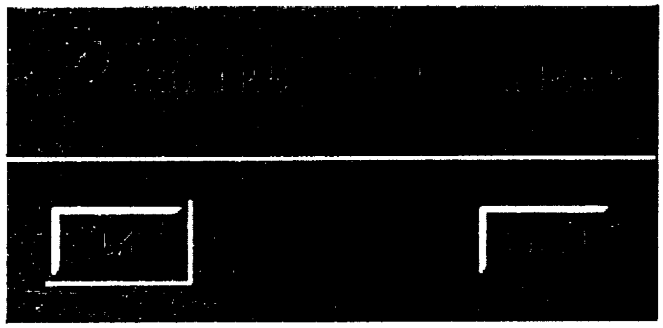


Figure 4. Return Window

2) Click with the left mouse button on the **OK** button and the vehicle will be returned to the vehicle.

3.5 TRANSFERRING RESOURCES

If another team member asks you for a resource, and you want to give it to him/her, you will have to transfer it.

1) Launch the resource from your vehicle (see **Launching Resources**).

2) Click with the right mouse button on the resource you want to transfer and select **XFR** from the menu. A **Transfer** window (see Figure 5) will pop up on your screen.

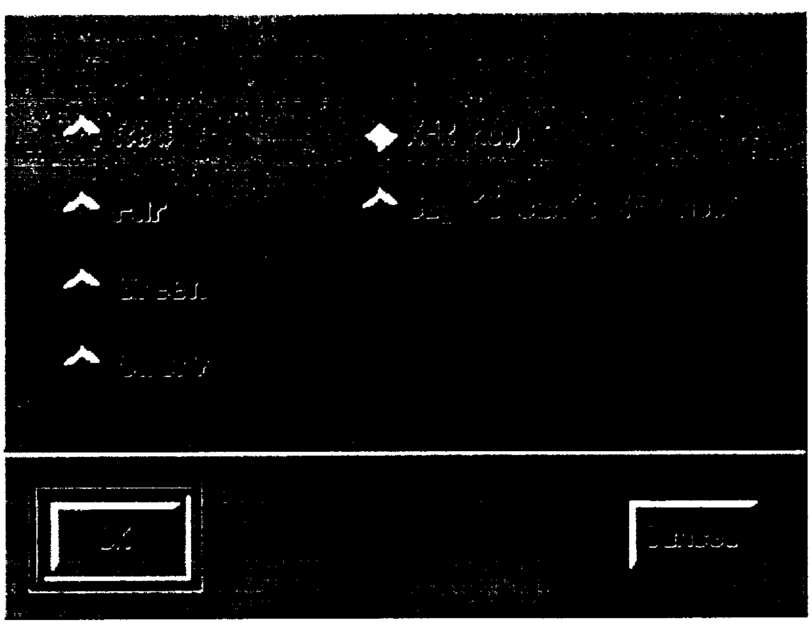


Figure 5. Transfer Window

3) Choose the team member to whom you want to transfer the resource by clicking on the button corresponding to the team member's color.

4) Click the **OK** button and the resource is transferred.

5) The recipient of the resource can now bring the resource to his/her vehicle by clicking with the right mouse button on the resource and selecting **Return** from the menu.

> *NOTE: You can transfer a maximum of two resources per team member at a time. If you wish to transfer a third resource to a team member, that team member must return at least one of the recently transferred resources to his/her platform.*

3.6 REQUESTING RESOURCES

There are two ways to request a resource. One way is to send an email message (see Section 5.6) to the resource owner and asking for it. The other is to send a resource request, which is a more formalized means of requesting a resource. The steps on how to formally initiate a resource request follow.

1) Click with the right mouse button on a resource that you want but do not own and select **Req XFR**. A **Request Transfer Window** (see Figure 6) will pop up on the screen. The button corresponding to the resource owner (in the **ASK** column) will be selected by default. The button corresponding to you (in the **TO** column) will be selected by default. These default settings are usually what will be used, but you are allowed to request that a resource be transferred to another team member.

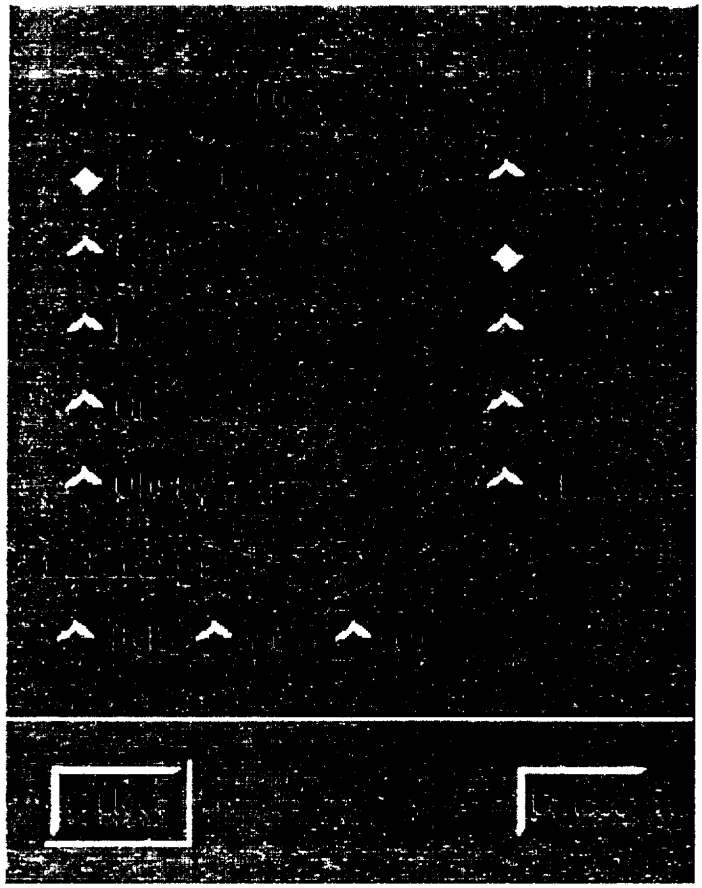


Figure 6. Request Transfer Window

2) Click with the left mouse button on a priority setting to let the current resource owner know the urgency of the need for the resource.

3) Click with the left mouse button on the **OK** button to send the resource request.

4) The team member on the receiving end of the transfer request will receive a message in the confirmation (lower left) text window saying that the decision maker requested that resource.

SECTION 4

CLUES AND ITEMS

As you traverse the terrain throughout the simulation, items and clues will come into your detection radius. The detection radius is indicated by the outermost of concentric rings around your vehicle. Each of these rings is a different color. The following is a description of the rings that surround your vehicle and launched resources:

Name	Color	Description
Detection	Black	Objects can be detected and icons will appear in the canvas area within the ring.
Process	Magenta	Clues and items can be processed once they are within this range

Note: There are two other rings in this simulation, dark blue and light blue. Do not worry about these for the purpose of the search and rescue scenario.

4.1 TYPES OF CLUES AND ITEMS IN THE TERRAIN

When you click and hold with the right mouse button on a clue or item, you will see a menu with several options come up. The only option used for this simulation is **Info On Clue/Item** (see Figure 7). This will display a likelihood number of the validity of the clue. A number greater than 50 means that the clue is probably true, while a number less than 50 is probably false. Refer to the **Legend** for the different clue and item icons. Read below for descriptions of each type of clue and item.

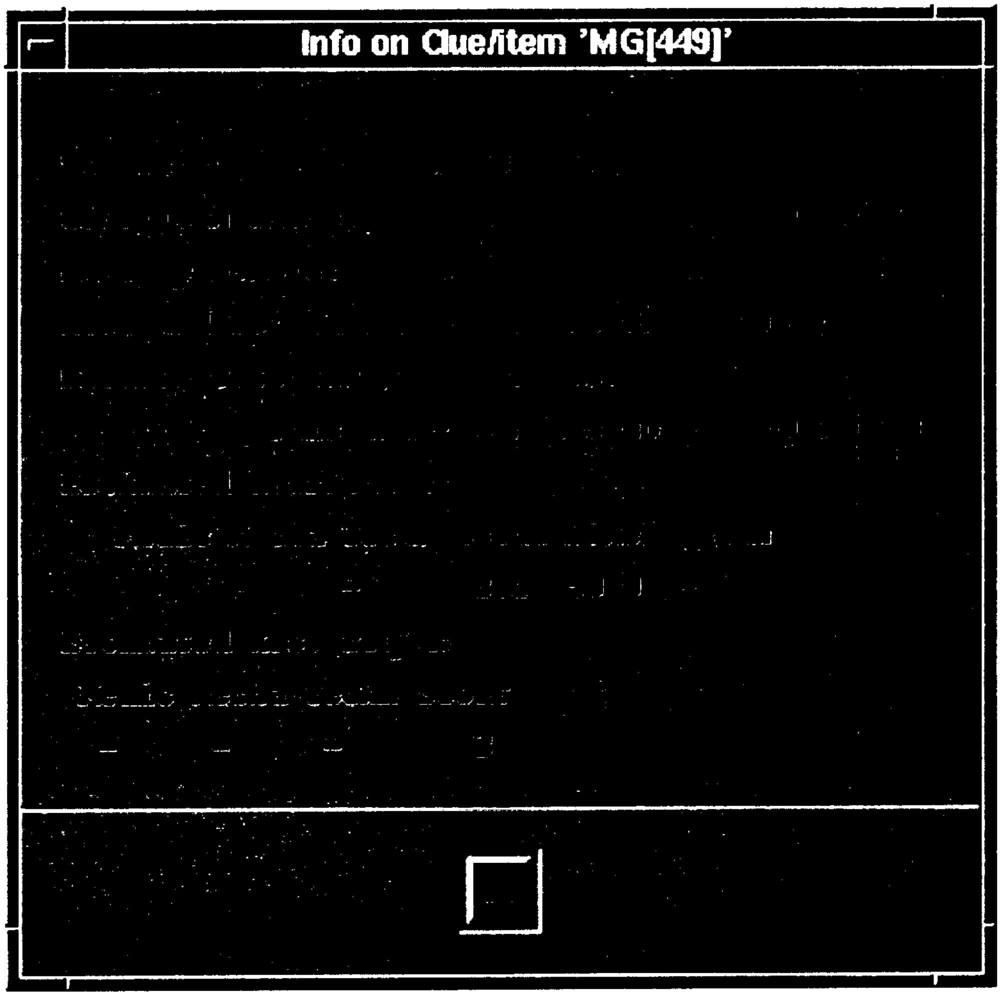


Figure 7. Info on Clue/Item window

The **Magnifying Glass**, **Lost Party**, and **Supplies** must be processed in order to extract information from them. The **Arrow**, **Man-Made Object,** and **Terrain Feature** only require reading the **Info on Clue/Item** window so you do not have to process them. Table 2 shows the icons for clues and items and their descriptions.

TABLE 2. ICONS REPRESENTING CLUES AND ITEMS.

Icon	Description
	**Magnifying glass**- This clue needs to be processed in order to gain any useful information. Once processed with the appropriate equipment or personnel, it will spawn a few other clues in the form of arrows.
	**Lost Party**- Once this item has been found, process it to end the simulation. This will complete the mission.
	**Supplies**- These are only located in the supply sheds and can be processed with any personnel or equipment to replenish supplies. To determine if you are running low on supplies, click and hold with the right mouse button on the vehicle, personnel, or equipment and select "Req Info", which will display the information window for that object. Here you will be able to tell whether or not you are running low on supplies. For example, if you see a Scout with the resource level 7 currently at a level 4, it may be to your benefit to replenish the resource if you want to be able to process clues requiring an expertise level of 5 or above. However, there is no way of knowing what resources the sheds contain, so players have to make a judgment call.
	**Arrow**- This is a clue that indicate the likelihood that the lost party is located in that direction. Reliable clues tend to have a likelihood of greater than 50, while unreliable clues are less than 50. These clues are spawned as the result of a magnifying glass being processed.
	**Man-Made object**- This clue is a possible indication that the lost party was or is near-by.
	**Feature of Terrain**- Getting information (as described above) will reveal the terrain feature number. The meaning of the map terrain features is listed in the "Map" section of this document.

4.2 PROCESSING A CLUE OR ITEM

When you see a clue or item come within your detection range, you have two options: (1) ignore it, or (2) if you think it has useful information as to the location of the lost party, you can **Process** it. To process a clue or item:

1) **Launch** the resource (see section on how to **Launch** resources) from your vehicle that you are going to use to process the clue. You cannot process a clue or item from a vehicle.

2) Bring the resource very close to the clue you want to process.

3) Click and hold with the right mouse button on the resource and select **Process** from the menu. The cursor will change.

4) Click with the left mouse button on the clue you want to process. A **Processing Clue/Item** (see Figure 8) window will pop up.

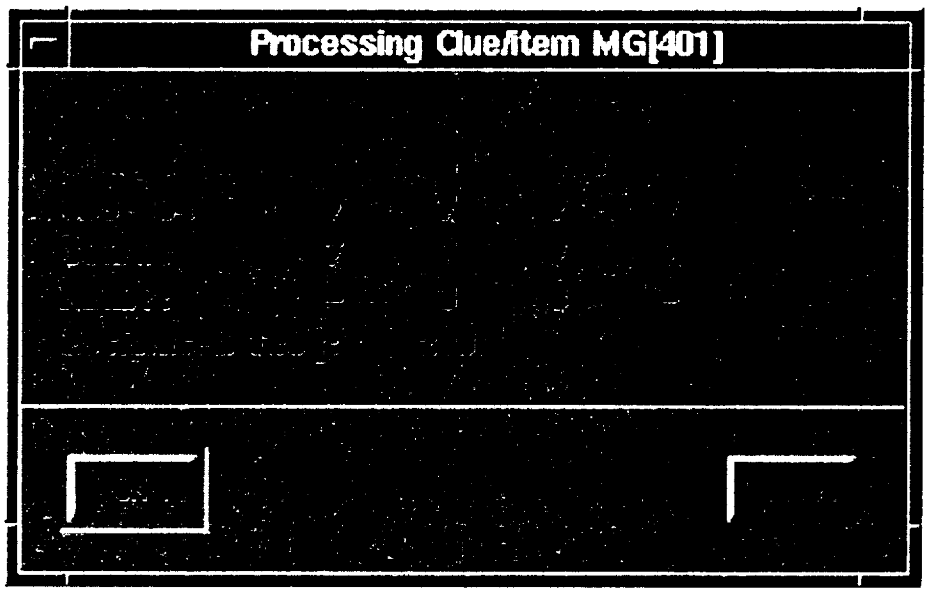


Figure 8. Processing Clue/Item window.

The line labeled **NEED?** in this window indicates the reliability level of the personnel resource that is necessary to process the clue or item. There are four columns, representing each of the personnel and their respective reliability levels. In order to process a clue reliably, the personnel expertise level must be equal to or greater than the level indicated in the window.

If you are not currently using an appropriate resource to process the clue or item, you have the opportunity to click **Cancel**. If you are using the resource you want to use, you can click **OK** and it will be processed. If a clue is processed without the appropriate resources, the resource will be tied up for the duration of the process, but the clue will not be processed.

Note: The only resources that will successfully process items are probes and scanners. In future versions, it will be possible to process items with personnel.

5) Return the personnel back to the vehicle- click and hold the right mouse button on the vehicle, select **Return**, and you will be prompted as to whether or not you want to return the resource to the vehicle. Click **OK** or **Cancel**.

6) To obtain information from the processed clues and items, click and hold with the right mouse button on the item, and select **Info On Clue/Item** and you will be able to read the likelihood numbers corresponding to the clues.

SECTION 5

COMMUNICATIONS

5.1 READING A MESSAGE

To read a message, click with the left mouse button on the message you want to read in the message list panel. A **Read Message** window will appear in the lower-right-hand corner of the screen, and you will be able to read your message. Figure 9 shows an example of a message.

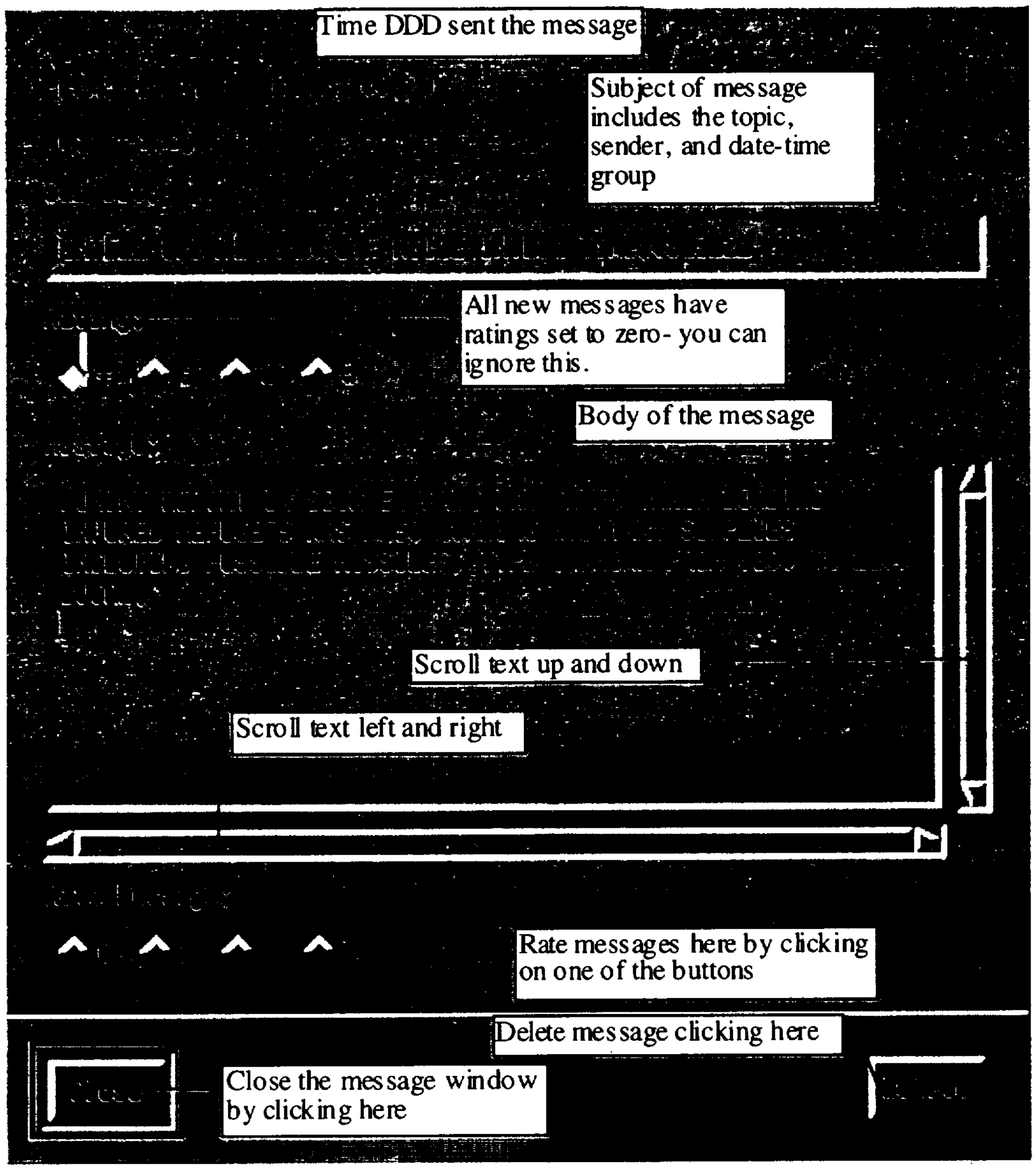


Figure 9. Read Message Window

5.2 RATING A MESSAGE

After you have read a message, you must rate it in terms of its criticality before you can close the window.

To rate a message, click with the left mouse button on one of the numbered buttons below the label **Rate Message**. The buttons indicate the following degree of importance:

3 Critical

2 Important

1 Routine

0 Irrelevant

> *Note: You MUST rate a message before closing it. You will not be able to close the message window until you have rated the message. This features allows experimenters to capture the criticality ratings of each message. It can be disabled in future versions of the DDD.*

5.3 CLOSING A MESSAGE

To close a message, click with the left mouse button on the **Close** button in the lower-left-hand corner of the **Read Message** window. Remember that you have to RATE a message before closing it.

5.4 RE-READING A MESSAGE

If you want to re-read a message that you have already read, click with the left mouse button on the message you want to read as you would click on a message to read it the first time. When re-reading a message, the criticality rating you assigned will be shown in white. If you have changed your mind about the criticality of a message you can re-rate its criticality by clicking with the left mouse button on a different criticality button before you close the message.

5.5 DELETING A MESSAGE

To delete a message, click with the left mouse button on the **Delete** button in the lower-right-hand corner of the **Read Message** window. You can delete a message without rating it.

5.6 SENDING A MESSAGE

To compose and send a message, click with the left mouse button on the **Send Message...** button, located just above the message list panel. A **Send Message** window will appear in the lower-right-hand corner of the screen, where you can compose your message. Specify the receiver(s) of the message by clicking the appropriate DM in the **To:** field. Also specify in the Subject: window the *topic* and *receiver(s)* of the message. Before typing in the **Subject**: and **Message:** windows, you need to click with the left mouse button on them to make the cursor active. Figure 10 shows a message sending window.

Before you can SEND the message, you must specify a rating for the message by clicking the appropriate button corresponding to the criticality rating you wish to assign to the message.

When you are finished composing and rating your message, click with the left mouse button on the **Send** button in the lower-left-hand corner of the **Send Message** window.

If you decide that you do not want to send a message while you are composing it, click on the **Cancel** button in the lower-right-hand corner of the window.

A record of any messages you send will appear in the message list panel with the status **Sent**.

5.7 FORWARDING A MESSAGE

You may want to FORWARD to other units in the organization part or all of a message you receive. There is not a specific forwarding function, but you can accomplish this by copying text for an existing message into a new one. Open a new **Send Message** window and copy the text from the **Read Message** window of an existing message by highlighting with the left mouse button the text you want to forward and then clicking with the middle mouse button in the Send Message window. Now you can send the text as it is, add to it, or modify it in any way. You will then be able to send this message as you would send a new message. Be sure to specify in the subject window the topic and receivers of the message.

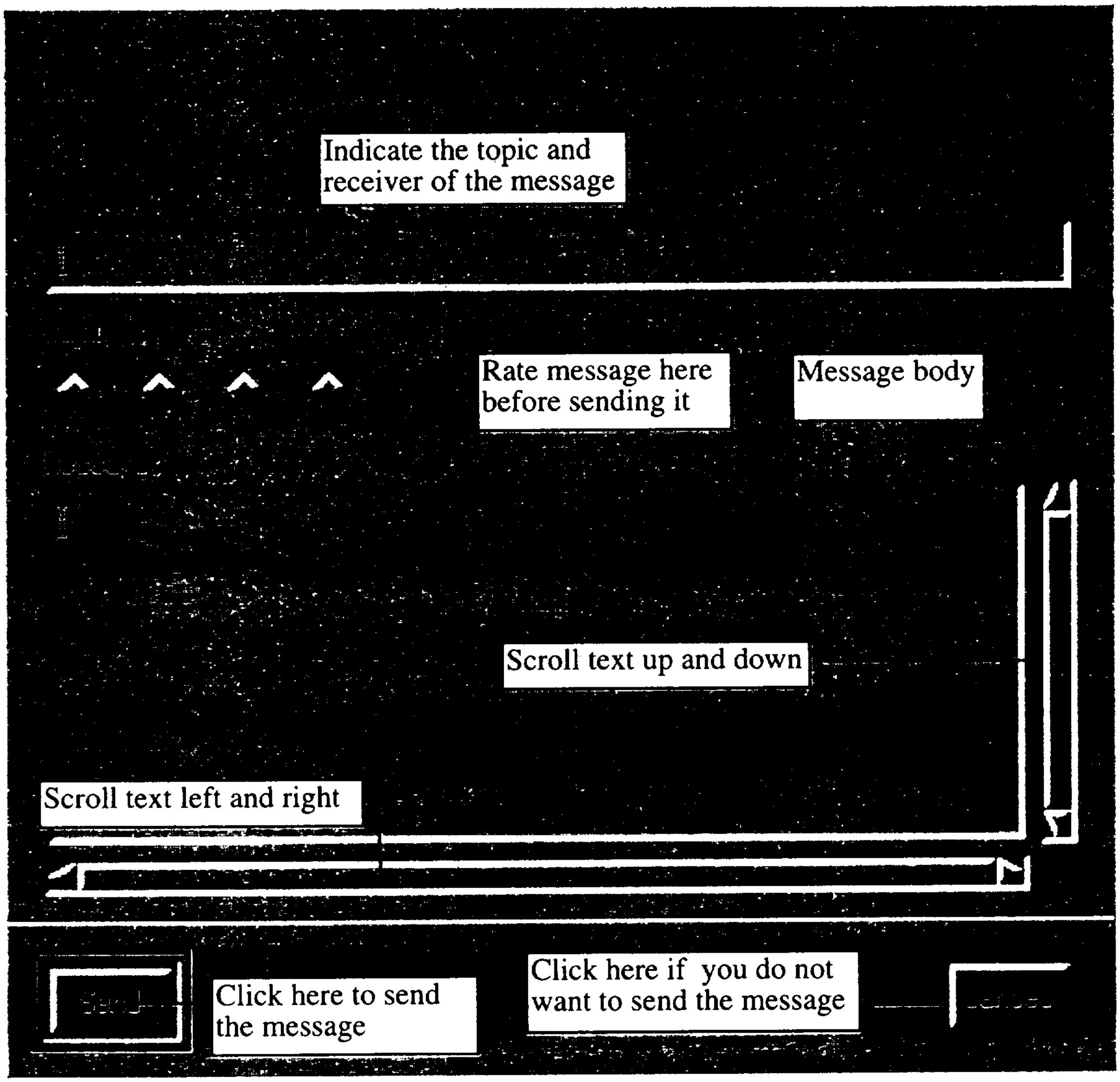


Figure 10. Send Message Window