# HUMAN ENGINEERING ANALYSIS FOR THE BATTLE GROUP TACTICAL TRAINER


L. Bruce McDonald
Grace P. Waldrop

McDonald & Associates, Inc.
988 Woodcock Rd. Suite 136
Orlando, FL 32803

Elizabeth Y. Lambert

Human Factors Laboratory
Naval Training Equipment Center
Orlando, FL 32813



## ABSTRACT

The U.S. Navy is currently developing a Battle Group Tactical Trainer (BGTT) which provides experiential war gaming exercises to Naval Officers engaged in tactical decision making and planning courses. A major design goal for the program is to simplify the man-computer interface such that players and controllers with little or no computer training can interact extensively with the BGTT data base. One step in the design process was to conduct a human engineering analysis of the BGTT's objectives, system functions, information flow, information processing requirements and user requirements, and make hardware and software recommendations that would assist in the achievement of this goal. This paper discusses the recommended hardware and software features required to simplify operator interface with the training system.


## INTRODUCTION

The U.S. Navy is currently developing a Battle Group Tactical Trainer (BGTT) which provides experiential training through war gaming exercises to Naval Officers engaged in tactical decision making and planning courses. The trainer will afford the opportunity for officers (players) to make real-time tactical decisions and experience the impact of these decisions. This tactical operation performance will be extensively monitored and evaluated by a control group (controllers) for effectiveness and fulfillment of curricula objectives.

A major design goal for the program is to simplify the man-computer interface such that players and controllers with little or no computer training can interact extensively with the BGTT data base. One step in the design process was to conduct a human engineering analysis of the BGTT's objectives, system functions, information flow, information processing requirements and user requirements and to make hardware and software recommendations that would assist in the achievement of this goal.

The human engineering analysis followed the classical approach per MIL-H-46855. System functions were determined based on the mission of the training system. These functions were allocated to players, controllers and the trainer based on general human engineering principles. An extensive analysis was performed of the information input and output requirements for both players and controllers. Hardware and software were then recommended which would provide players and controllers the most efficient and cost-effective access to the required information. Detailed discussions of the human engineering analysis leading to the architecture recommendations are contained in Waldrop, McDonald, and Barry (1983).

## SYSTEM MISSION

The BGTT system objectives will be accomplished in a unique environment which will allow experiential decision making training. This environment requires participation from players and controllers.

### Mission for Players

The participants in BGTT will be senior Naval officers and their principal assistants participating in tactical training courses. The mission for the players is to improve their operational tactical decision making skills through practicing these skills in various tactical situations including simulated, high threat environments. This gaming environment requires participants to plan, execute and evaluate tactical operations.

### Mission for Control Group

To support the BGTT objectives, a control group staff is required to instruct, monitor and assist the players. At times, designated control group personnel may also be required to participate in the war game as opposing forces to the players. The mission of the control group is to provide the players with a meaningful war game experience, monitor player performance, and provide feedback, both during and after the game, allowing players to profit from the experience and improve their operational performance.

## CRITICAL TASK ANALYSIS

A task listing for the player group which outlined the duties of the warfare commander/coordinator during the planning and execution phases of their jobs was supplied by the sponsor. A Critical Task Analysis (CTA) was required for the control group because their duties had not yet been defined with reference to the BGTT. The tasks addressed in the CTA examined the functions required of the control group to support the training objectives for BGTT. This task analysis examined the duties to be performed by the staff, the information necessary, and the additional trainer support required for task completion.

The task analysis detailed control group information requirements for completion of each task. This was a direct input to the Human Engineering System Analysis which examined how to provide access to information in an easily retrievable manner.

### Task Analysis Procedures

Data on the job requirements for the control group were systematically gathered from BGTT objectives, current duties of training personnel and other war gaming systems. In conjunction with obtaining current job specific data, the tasks of current training personnel were derived through interviews with subject matter experts (SMEs).

## SYSTEM ANALYSIS

The informational requirements for both players and controllers were identified by gaming phase (Briefing, Planning, Execution, and Debriefing). The player tasks were prepared based on operational duties and were contained in a classified document. These tasks were modified and detailed for the gaming environment in an unclassified form. The controller tasks were obtained from the Control Group CTA. The System Analysis examined architecture configurations to fulfill task requirements.

### Function Allocation

The purpose of the function allocation was to initially allocate functions to man (players and control group), machine (BGTT computer and peripherals) or both, such that the overall mission of the training system can be fulfilled in the most cost-effective manner. The functions to be allocated were obtained from the player and controller task analyses. The allocations were based on general man-machine capabilities and limitations and the mission of the BGTT Training System.

Two unique characteristics of the BGTT mission were important to the function allocation process. Since the primary mission is to allow warfare commanders/coordinators and their staffs the opportunity to make decisions, none of their decisions or actions would be allocated to the computer. However, Battle Group members above and below this level will not be included as players, and their decisions and actions must be performed by the BGTT training system (computer and control group).

A second unique characteristic concerned the fact that BGTT had been described as an experiential trainer; thus, player performance could not be evaluated based on pre-set rigid criteria. Consequently, evaluation of player performance was allocated entirely to the control group. However, the routine recording of game events, as well as provision of detailed information on student actions, was allocated to man and machine based on general human factors principles.

### Allocation of Functions to Players

After review of the human factors principles, allocation of functions to players was straightforward. All functions normally performed by the Battle Group Commander/Composite Warfare Commanders (BGC/CWC) and their immediate staffs were allocated to the players.

### Allocation of Functions to Trainer and Control Group

All functions involving the generation of information external to the BGC/CWC structure (mission, historical threat, geopolitical situation, rules of engagement, environment) were allocated to the BGTT Training System (computer and control group). All functions involving the decisions and actions normally executed (in accordance with Command Staff orders) by officers and enlisted personnel below the participating officers (platform movement, enemy engagement, logistics) were allocated to the BGTT Training System. All functions involving determination of engagement outcomes and assessment of player performance were allocated to the BGTT Training System.

Once the BGTT Training System functions were allocated based on mission, these functions were then allocated to man (control group) and machine based on human factors principles. Primary and support responsibilities for each task in the Control Group Critical Task Analysis were allocated based on the human factors principles.

### Information Flow Requirements

The initial allocation of functions led to the examination of information flow requirements. The primary functions of a warfare commander are to gather information, assess its importance, make decisions and relay this new information to other members of the battle group. Likewise, the control group personnel must access and disseminate a great deal of information in order to perform their job. Consequently, understanding BGTT player and controller information input and output requirements is critical to equipment identifications. The information input and output requirements for players and controllers were detailed and defined.

### Player Information Requirements

To perform Briefing, Planning, Execution and Debriefing Phase tasks, the players must receive and provide specific information. The BGTT Training System must provide this information in a readily usable form in order to complete its mission. Player information input and output requirements were listed for each task.

Player information requirements for each phase were presented in tabular format. Each phase had four tables associated with the information requirements for that phase, i.e., information input requirements by task, input definitions, information output requirements by task, and output definitions. Table I provides an excerpt from one set of information requirements. The player execution tasks are listed across the top (direct reference to classified task listing) and the information inputs required to complete these tasks on the left side. The X's in the table indicate what information is required to complete each separate task.

Equipment Identification

The next step in the analysis process was to provide a means to access and output the required information. The most efficient means of accessing and outputting information depended primarily on the information update rate and the form of the information. The information requirements previously detailed were analyzed for type and update rate.

This analysis led to the recommendation that each player station include the following hardware:

- o An Alphanumeric Display
- o A Standard ASCII Keyboard and Keypad
- o A Graphics Display with Touch Screen
- o An Alphanumeric Printer
- o A Game Book
- o A Secure Telephone
- o A Work Surface for Maps and Hardcopy
- o Facilities for Storing and Retrieving Hardcopy

The control group equipment identification was based on the same information access and output principles used in the player section. The analysis led to the recommendation that each station contain the same equipment as a student station plus the following hardware:

- o A Headset
- o A Graphics Printer
- o Access to a Word Processing System
- o Access to an Overhead Projector and Screen and Viewgraph Production Means

## SOFTWARE REQUIREMENTS

Once the information requirements and hardware recommendations were completed, an extensive literature search was conducted on man-computer interaction. The software recommendations in this paper represent software features shown to be effective in recent research reports and design manuals and which will provide BGTT players and controllers the most efficient and cost-effective means of accessing and manipulating the required information. Software requirements for BGTT are discussed under the heading of Query Language, Dialogue, Menu Design, Screen Formats, and Error-Handling.

Query Language

There are a number of query languages available which could conceivably be utilized by BGTT. The first option is natural language entry of requests. Unfortunately, "human communication is characterized by ungrammatical utterances and syntactic and semantic ambiguities" (Ramsey, 1979). System performance can be improved by constraining the allowable syntax of the natural language. However, the naturalness of the language encourages the user to use syntax outside the constraints, causing errors that are hard to explain to the user. Natural language input is slow, error-prone and requires use of the keyboard. Natural language input of commands is not a viable alternative.

Another option is to use some of the simple computer query languages based on a relational data base (Shneiderman, 1980; Thomas & Gould, 1975; Zloof, 1975). These query languages were developed for the infrequent user and were intended primarily for management information systems. Simple and medium complexity requests in the Query by Example approach use tables to simplify categories, and links of interest are straightforward. More complex requests require the user to remember and use special characters and symbols. This approach does not apply to BGTT because information requests are not complex enough, and there are too many categories of information to present even a small fraction of the tables on a screen at one time.

Dialogue

One of the most important considerations is the type of dialogue between the user and the training system. The three types of dialogue are computer-initiated, user-initiated and mixed-initiative. In computer-initiated dialogue all interactions are initiated by the computer through prompts for the required input. Conversely, in user-initiated dialogue, the user enters commands from memory and the computer responds. In mixed-initiative, either the user or computer may initiate the dialogue. Computer-initiated dialogue is the most effective means of interaction for the untrained user (Parrish, Gates, & Munger 1981; Ramsey & Atwood, 1979; and Shneiderman, 1980). In addition to reducing errors and number of required key strokes, computer-initiated prompts implicitly convey to the user a mental model of the system's dialogue structure and remind the user of unused commands. Thus, as the users interact with the computer, they learn where the information is and the required pathway to reach it.

However, as the users become more proficient, their need for computer-initiated dialogue diminishes. Experienced users prefer to enter a single command from memory (user-initiated dialogue) and go directly to the required unit of information. Since the BGTT will be used by inexperienced players and control group personnel, as well as experienced operators, the system should be designed for

TABLE I

INFORMATION INPUT REQUIREMENTS FOR PLAYERS DURING EXECUTING PHASE (EXCERPT)

| | COORDINATE OPERATIONS WITH TF/BG MEMBERS | | | | | | | | | COUNTER OWN FORCE THREATS | | | | | ISSUE/UPDATE REPORTS & TACTICAL ASSESSMENT | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | I | A | D | E | F | G | A | D | E | G | H | I |
| INFORMATION INPUT REQUIREMENTS | .8 .9 | .3 | .3 | .3 | .8 | .3 | .8 .9 | .3 | .2 .4 .5 | .4 | .2 | .4 | .2 | .5 | .1 .5 | .5 .6 | .6 | .2 .7 | .4 .3 | .3 |
| External Source Intelligence | | | | X | | | | | | X | | | | | X | X | | | | |
| External Source Validations | | | | | | | | | | | | | | | | | | | | |
| Planned Responses/Actions | | | | | | | | | X | X | | X | X | X | | X | X | | | |
| Degree of Expected Disclosure | | | | | | | | | | X | | | | | | | | | | |
| Delegation of Authority | X | | | | X | | X | | X | X | | | X | X | | | | | | |
| Requests for Assets | | | | | | | | | | X | | | | | | | | | | |
| Historical Plots-Contacts/ Tactical Picture | | | | | | | X | | | X | | | | | | | | X | | |
| TACNUC Authority | | | | | | | | | X | X | | | | | | | | | | |
| Force BTs, Radiosondes | | | | | | | | | | | | | | | | | | | | |
| Internal Source Intelligence | | | X | X | | | X | | | X | | X | | | X | X | X | | | |
| Internal Source Validation | | | | | | | | | | | | | | | | | | | | |
| Mission to Perform Strikes | | | | | | | | | X | X | | | X | X | | | | | | |
| Access Between WCs, COORDs | X | | X | X | | | | X | | X | X | | X | | | X | | | | |
| Reports on Specific Operations Status | X | | | | | | | | | | | | | | | | | | | |
| Current Mission Capable Resources | | | | | | | | | X | | X | X | X | X | | | | | X | |
| AIMDS Schedule/Capabilities | | | | | | | | | | | | | | | | | | | | |
| Logistics & Expendable Status | | | | | | | X | | X | | | X | | X | | | | | | |
| BDA | | | | | | | | | X | | | | | X | | | X | | | |

both computer-initiated and user-initiated dialogue.

Ramsey and Atwood (1979) indicate that a computer system that uses both computer-initiated and user-initiated dialogue works quite well except for one problem. As users become more experienced, they are annoyed by the computer-initiated dialogue but have not yet memorized the query language for user-initiated dialogue. A means is required for a smooth transition between computer-initiated and user-initiated dialogue.

It is recommended that the BGTT allow computer-initiated or user-initiated dialogue at user option. For the inexperienced user, all interactions will be menu driven and the user could select the desired option by way of a touch screen. Optional displays should be presented in a hierarchy, allowing users to work their way through the options to the desired display. When the user touches the desired display, it will appear along with its title and four letter abbreviated title. As users interact with the system, they will become familiar with the available displays and their abbreviated titles. The more experienced user may choose to type in from memory the four letter abbreviated title of a display that would require three or four steps to reach by selecting options on menus. A fully experienced operator will be able to access a desired display by typing in a single four letter command. If the operator forgets the title of a desired display, he can sequence through the menus by using the touch screen.

Menu Design

Mace, Harrison, and Sequin (1979) conducted a study of input errors in automated battlefield information systems and found that the labeling of menu options had a major impact. Labeling menu options with full English words produced the lowest error rate but tended to clutter the display and slow the responses. Using abbreviations and mnemonics produced few additional errors and reduced display clutter. The use of nonsense codes (e.g., A2) referenced in a user manual produced poor recognition and recall and led to high error rates. Abbreviations and mnemonics are generally suitable inputs in most situations, because abbreviated equivalents of English words are easily recognized. The recall of abbreviations and mnemonics can be facilitated by standardizing their length and introducing coding conventions which are consistently employed. Moses and Potash (1979) found that simple truncation is the most effective form of abbreviation and has the lowest error rate. Two studies of automated battlefield information systems found that a four letter abbreviation had the lowest error rate (Alderman, Ehrenreich, and Bindewald, 1980; Nystrom & Gividen, 1978).

For menu design in the BGTT system, it is recommended that menus of options list the names of the displays with the first four letters capitalized to indicate the abbreviated display title.

Screen Formats

One function of the CRT will be to assist the operator in entering messages for transmission to another warfare command. The following recommendations are based on extensive findings by Mace, et.al. (1979). The operator should be provided with preformatted displays matching all message formats. Each format should contain all standard words with blank spaces for entry of required information. Each blank space should contain codes (l - letter, n - number) for the legal entries in each space. The actual letters and numbers will replace the code letters as they are entered. The units of measure (e.g., nn000 yds) should appear after the blank field. The cursor should sequence to the next blank entry field after the previous field has been completed or the ENTER key is depressed. The operator should be allowed to review and edit the message before transmission. Although messages using both upper and lower case letters are easier to read, messages received at sea are all upper case. Typing messages in all upper case is faster and is the recommended approach.

Error-Handling

Since humans are error-prone and computers require error-free input data to work properly, the BGTT trainer must have extensive error-handling features in order to operate smoothly with the inexperienced user. An important requirement in error-handling is informing the user about entry item error and how the error can be corrected (Shneiderman, 1980).

During entry of a number of fields on one format (e.g., arm and fuel an aircraft), each field should be checked for legal entries as it is entered. The immediate error message allows the user to correct the error and continue. If the trainer cannot check entries by field, then the error message issued after all of the fields have been entered must clearly specify which field is in error, preferably by highlighting the field. The user should be allowed to correct that field without reentering all other fields.

Error terms such as ILLEGAL ENTRY are of limited value to the user. Error messages such as TYPE MISMATCH and OUT OF LIMITS are useful to the experienced user but do not help the inexperienced user correct errors. Field checking routines are basically a series of IF statements in the computer. The routine should have a separate error message for each IF statement. This approach will allow the trainer to display specific error messages that indicate how the error can be corrected (e.g., NUMBERS REQUIRED, LETTERS REQUIRED, NUMBER TOO LARGE).

Another requirement in error-handling is the provision of helps. If the user does not understand the error message, he should be able to enter a code (e.g., HELP, H, ?) and have displayed the legal entries for that field.

Finally, the reason for nonavailability of information should be clearly stated. If a player misspells the name of a ship, the error message should say SHIP NAME NOT FOUND. If the player requests the position of an undetected enemy submarine, the error message should say DATA UNAVAILABLE TO BLUE FORCES.

Instructional Support Features

Instructional support features can provide automated computer assistance to routine nontraining activities and direct training quality support instructional activities. Instructor tasks which are quantifiable, consume time and divert attention away from students should be automated. The automation of such tasks will free the instructors to perform necessary and relevant tasks to facilitate training. A variety of instructional support features were examined for BGTT system applicability leading to recommendations. The features examined were demonstration, malfunction simulation, freeze, hardcopy, record/rerun/replay, store/reset current conditions, remote display, automatic performance measurement, file flags, game rates, modification of events and system alerts.

Demonstration

Demonstrations are used primarily to provide standardized instruction of complex new material. Demonstrations can provide students with familiarization to sequential events, a performance model, commented practice, and a permanent record/playback, and can be used to evaluate, develop, and critique proposed tactics (Hicklin, 1980; Link Division, 1978; Semple, Cotton, & Sullivan, 1981).

The demonstration feature could assist the BGTT control group in preparing the student for the gaming exercise, learning system operations, and evaluating new tactics. However, as a primary or required instructional feature, full demonstration capabilities are not necessary since learning the operation of complex trainer scenarios is not the training objective. Preparation of full demonstrations can be time-consuming and labor-intensive. Since skills in trainer proficiency are not being taught, other features recommended in this section can fulfill any demonstration need that might arise.

Malfunction Simulation

Malfunctions can be inserted into the training scenario automatically or manually. The malfunction feature allows total or partial failure of a game parameter independent of the training scenario. The player learns malfunction-compensating skills and decision processes transferable to actual situations (Caro, Pohlmann & Isley, 1979). Semple, Vreuls, and Cotton (1979) found that instructors preferred manual capabilities over automatic. However, they used a flight trainer with automatic malfunction that was too rigid and not capable of instructor control. Cohen (1977) suggested using an index page (or menu) displaying active preprogrammed malfunctions and subsidiary pages for insertion and deletion of detailed parameters. This type of access to existing malfunctions would be beneficial during exercise preparation.

The BGTT objectives require malfunction capabilities. It is recommended that the control group be capable of preprogramming these malfunctions based on requirements and overriding the program during the exercise if necessary. An index of current malfunctions would facilitate game file modification tasks, with items retrievable by mission phase, malfunction category or type, specific name and malfunction receiver. Instructor flexibility in malfunction programming is important for tailoring exercises to meet specific objectives, such as practice of emergency tactics, or acquisition of compensatory skills.

Freeze

The freeze feature can be categorized as manual, automatic or parameter. The manual and automatic freeze permit interruption of simulation to allow for other activities and the automatic freeze is usually contingent on situational events (Caro, et.al., 1979). The parameter freeze allows the instructor to reduce simulation "clutter." This type of freeze feature is used for flight trainers and is not required for BGTT. However, the manual and automatic freeze features are recommended for the BGTT, particularly to control current events if the gaming exercise were to deviate dramatically from intended objectives or to end play for the day.

A partial freeze feature, the "snapshot," is used for compiling the game history file, for freezing the game status when file recording, or for saving game events to facilitate recovery after an interruption. This feature is recommended for BGTT.

Hardcopy

The hardcopy feature allows the instructor to reproduce alphanumeric or graphic display data on a paper medium. It provides readily usable data for supplementing the debriefing process in an efficient and cost-effective manner (Link, 1978). The alphanumeric and graphic printers can supply hardcopies of display information for use in the Game Book, retrieval of salient information, and briefing/debriefing material handouts. One graphic printer is recommended for the control group. Further workload analysis should be conducted to specify alphanumeric printer requirements based on number of control group personnel.

Record/Rerun/Replay

Event recording provides an historical file which allows controllers and players to examine performance. After file recording, game events can be reproduced as played during the game and rerun at a pace determined by the instructor. The rerun feature can utilize the recorded file in its entirety or only in salient parts. The game can be replayed from specified points to examine alternative tactics and decisions. The replay feature can be used in post-game analysis to present alternatives or during the game as a backup feature to utilize a new event sequence. A prototype Naval Training System, the Submarine Advanced Reactive Tactical Training System (SMARTTS), uses these features to compare and contrast predicted data with actual developments (Eclectech, 1979). The *record/rerun/replay* feature is a highly detailed and dynamic memory aid for controllers and is recommended for the BGTT.

If a demonstration is required, the recorded file can fulfill this requirement. The game can be rerun to demonstrate the system or to brief observers, and the replay can be used to analyze tactics used in a given set of conditions or to examine the applicability of new tactics.

Store/Reset Current Conditions

The store/reset feature permits the simulation to be returned or reset to a set of conditions that existed at an earlier point in time. The primary purpose is to return the operator to a previously encountered set of conditions to repeat performance tasks. The store/reset feature is most conducive to discrete performance tasks and therefore would not be recommended for BGTT. However, the ability to retain conditions and restart after an interruption (e.g., lunch break) is required. Features discussed in this section present alternatives to how the game can be saved and restarted through snapshot freeze and file recordings.

Remote Display

Remote display is an instructional feature that permits the controller's alphanumeric and graphic display data to be simultaneously displayed on the player's terminal. While this feature is normally used when simulation is in the freeze status (Caro, et.al., 1979), it can also be used in conjunction with the record/rerun/replay to support the post-game debriefing. The control group can present graphical and alphanumeric truth levels, alternative tactics and replays to the student without having to assemble players around the control group areas. The remote display capability will also facilitate the playing of games at remote sites. Therefore, a remote display feature is recommended for BGTT.

Automatic Performance Measurement

Automatic Performance Measurement (APM) provides the control group with player performance ratings based on preestablished criteria. The BGTT is an experiential decision making trainer, not designed to meet the rigid APM requirements for proceduralized and standardized tasks. Performance measurement and analysis have therefore been allocated to the control group rather than the trainer. However, several types of APM data files and reports can be incorporated, such as recording operator input errors in formatted operational directives (e.g., filling out forms), number and types of student information requests (including invalid force truth requests), and instructor actions. The BGTT can also provide the instructors with data files and reports which compile game records into a readily usable format. For example, Semple (1982) describes 5 types of APM data files: 1) student history (defines computer-resident *syllabus*), 2) *student and class (student* background), 3) measures collection (requires valid criteria for performance), 4) performance norms (current normative data), 5) instructor actions (records significant actions). Likewise, Hicklin (1980) describes 4 types of reports attainable from APM files: 1) summary report (last graded practice - strengths and weaknesses), 2) task performance report (actual scores in skill categories), 3) problem performance report (detailed review of a particular problem), 4) expanded task summary (used for research purposes). Summary programs of normative performance data and measures of effectiveness (MOEs) can improve the quality of player feedback on both individual and group performance.

A performance indicator display gives trainees feedback on tactical variables, such as range versus time, probability of counter-detection versus range, and solution accuracy versus time and would enhance BGTT feedback. BGTT programs may include $C^2$ MOEs for response times, lead times, detection opportunities, and support/information transfer functions. Performance information could also be provided with the alphanumeric hardcopies which contain platform status, weapon load/mix and other decision data. The ability to overlay ground truth and force truth on the graphic display is a recommended performance measurement feature. Initial programming could provide an index of available measures, which could be selected by controllers prior to the exercise. A modified and flexible means of APM is recommended for BGTT.

File Flags and Annotations

As the training system is recording game events, the file flag and annotation feature allows the control group to note salient events. This feature is used primarily to relieve the post-game analysts from having to review the entire file volume or even all the snapshots prior to debriefing. The flags and annotations key the reviewer to salient game events or important events requiring review. The ability to flag or make a short note directly on the historical record eliminates the need for extensive paper and pencil records and identifies the event precisely at the time of occurrence. Game play is not affected by this feature. Additionally, providing the flag and annotation capabilities to the players can assist their participation in the debriefing discussions. The ability to make historical file flags and annotations for players and controllers is recommended for the BGTT.

### Game Rates

An important instructional feature is the capability to manipulate the rate at which the game is played. Instructors can set the ratio of exercise time to real-time, to accelerate, decelerate, or suspend the game, or step-ahead without the intervening steps. During initial exercise stages, the game may be played at an accelerated rate while planned actions are being implemented. As the exercise progresses and rapid decisions are required, the game rate may be decelerated to achieve training objectives. If a long period of time needs to be covered quickly, controllers can step the game ahead in time. During this time step, they may or may not want to pause for salient events or record the intervening steps. This feature allows tailoring the game speed to player proficiency, game movements or actions, and training objectives. It is recommended for BGTT.

### Modification of Events

Instructional intervention allows the control group to modify automated events. Too much usage of this flexibility will negate the standardization benefits of automation. However, not allowing the control group any intervention capabilities is likely to inhibit user acceptance of the system and make it more difficult to tailor events to meet objectives (Semple, et.al., 1979). The BGTT system should allow the controllers to override the system to change, delete, delay, or suppress events. Instructors have indicated that the override capability is necessary in automated systems (McCauley and Semple, 1980). This override capability should not be used arbitrarily, but should be based on training and instructional objectives and monitored by senior personnel. For example, the control group may decide to relinquish neutrality and modify player actions to facilitate objectives. The ability to modify events is recommended for BGTT controllers.

### System Alerts

The primary purpose of system alerts is to notify the controller of problems or errors which require attention. They can notify the control group when a parameter has exceeded preestablished criteria by auditory and/or visual means. This feature frees the instructor from the tasks of continually monitoring these parameters. The BGTT control group could benefit from maintenance alerts which notify the controller of a malfunction in the system. The malfunction may or may not be critical enough to warrant immediate attention, but the controller can make that assessment. Alerts which notify the control group of excessive message format errors, "illegal" information requests, or trainer command errors by players would assist the controllers' player-monitoring tasks. Those performance parameters which are specifiable for the APM and indicate errors may require further assistance or clarification to the player. It is recommended that maintenance alerts be provided for BGTT, as well as a flexible performance parameter alert capability.

## SUMMARY AND RECOMMENDATIONS

The purpose of this initial human engineering analysis was to examine the BGTT's training requirements and objectives, then to provide comprehensive recommendations on system hardware, software, and instructional support features. The analysis was based on an extensive review of the BGTT documentation and human engineering literature, site visits to representative Naval user commands, and interviews with Fleet personnel and SMEs. The recommendations resulting from the analysis are summarized below.

(1) Provide means for player access and output of the information specified in the requirement tables.

(2) Provide means for control group access and output of the information specified in the requirement tables.

(3) Provide the following hardware at each player station:
- o An Alphanumeric Display
- o A Standard ASCII Keyboard and Keypad
- o A Graphics Display with Touch Screen
- o An Alphanumeric Printer
- o A Game Book
- o A Secure Telephone
- o A Work Surface for Maps and Hardcopy
- o Facilities for Storing and Retrieving Hardcopy
- o Chairs for Players

(4) Provide the following additional hardware at each control group station.
- o One Graphics Printer for the Control Group
- o Access to a Word Processing System
- o Access to an Overhead Projector and Screen, and Viewgraph Production Means

(5) Provide a 12-inch (or larger) diagonal standard resolution monochromatic CRT as the alphanumeric display for the player and controller stations.

(6) Design alphanumerics on the CRT per MIL-STD-1472C for a 36-inch viewing distance.

(7) Design all work surfaces for sit-stand operations per MIL-STD-1472C.

(8) Provide a touch screen (using a light bezel) as the primary means of player interaction with the CRT, as well as a training aid for operations and controllers.

(9) Provide a high resolution (1024 lines or equivalent) 21-inch color display as the graphical display, with color and shape coding of symbols (NTDS symbols for players). To locate and identify targets and platforms on the

display, a light pen or trackball is recommended. A keypad is appropriate for selection of optional display functions and simple interactions, while a standard ASCII keyboard is recommended for more complex inter-interactions by the operator.

(10) Provide a 180 CPS dot matrix printer with sound baffle and dual tractor feed and capabilities for upper and lower case letters, bold face and underlining for the warfare command stations and control group stations.

(11) Provide for tabular output of force capabilities, resource status, current policies and orders, or other quantifiable data for inclusion in the Game Book.

(12) Provide the control group access to a word processing system with storage files of Game Book data not available in the exercise data base. This word processor should be a standard commercially available system, utilizing hard or floppy disks for file storage. A medium speed (100 CPS) daisywheel printer is recommended for the printing quality needed in the Game Book.

(13) Design the software such that:

(a) The man-machine interface will be computer-initiated or user-initiated dialogue at user (player, operator, control group) option. In computer-initiated dialogue, the system will prompt the user with options on a menu, and the user will select options by touching the CRT screen. In user-initiated dialogue, the user will type an abbreviated title of the desired display on the keyboard or keypad.

(b) Menus of options list the names of the displays, and the first four letters of the names are capitalized to indicate the abbreviated title of the display.

(c) Provide preformatted displays to operators for each message between warfare commands and to the control group for task preparation. The formats should contain blanks where the information is to be inserted and provide indications of legal entries and units of measure. The cursor should sequence to the next blank field after each complete entry. All messages should be all upper case letters.

(d) Provide rapid input field error-checking routines that clearly indicate to the user the input field in error and means for correcting it without having to re-enter information in other input fields. Legal entries for each field should be available at user command. Reasons for unavailable information should be clearly stated.

(14) Provide the following instructional support features:

- Automatic Malfunction Insertion with Manual Override
- Automatic, Manual, and Snapshot Freeze
- Alphanumeric Hardcopy
- Graphic Hardcopy
- Record/Rerun/Replay
- Remote Display
- Modified Automatic Performance Measures
- File Flags and Annotations
- Game Rate Control
- Event Modification
- System Alerts

## REFERENCES


Alderman, I.N., Ehrenreich, S.L. and Bindewald, R. (U.S. Army Research Institute for the Behavioral and Social Sciences) Recent ARI Research on the Data Entry Process in Battlefield Automated Systems (Research No. 1270). Ft. Leavenworth, KS.: U.S. Army Combined Arms Combat Development Activity, September 1980. (DTIC No. AD A109-667)

Caro, P., Pohlmann, L. and Isley, R. (Seville Research Corp.) Development of Simulator Instructional Feature Design Guides. Pensacola, FL.: Air Force Office Scientific Research, Bolling Air Force Base, D.C., October 1979.

Cohen, E. (The Singer Company-Simulation Products Division) The 2F112 (F-14 WST) Instructor-Operator Station. Binghamton, N.Y.: The Singer Co., 1977.

Eclectech Associates, Inc. Profile of SMARTTS Training Potential (Contract No. N61339-79-C-00029). Orlando, FL.: Naval Training Equipment Center, December 1979.

Link Division, The Singer Co. Design Definition Study Report, Full Crew Interaction Simulation-Laboratory Model (Device X17B7) - Volume VI-Training Systems (NAVTRAEQUIPCEN 77-C-0185-001). Orlando, FL.: Naval Training Equipment Center, June 1978.

Mace, D.J., Harrison, P.C. Jr., and Seguin, E.L. (Institute for Research) Prevention and Remediation of Human Input Errors in ADP Operations (Technical Report No. 395). Alexandria, VA.: U.S. Army Research Institute for the Behavioral and Social Sciences, August 1979. (DTIC No. AD A081-730)

McCauley, M.E. and Semple, C.A. (Canyon Research Group, Inc.) Precision Approach Radar Training System (PARTS) Training Effectiveness Evaluation (NAVTRAEQUIPCEN 79-C-0042-1). Orlando, FL.: Naval Training Equipment Center, August 1980. (DTIC No. AD A091-912).

Moses, F.L. and Potash, L.M. (U.S. Army Research Institute for the Behavioral and Social Sciences) Assessment of Abbreviation Methods for Automated Tactical Systems (Technical Report No. 398). Ft.

Leavenworth, KS.: U.S. Army Combined Arms Combat Development Activity, August 1979. (DTIC No. AD A077-840).

Nystrom, C.O. and Gividen, G.M. Ease of Learning Alternative TOS Message Reference Codes (Technical Paper 326). Alexandria, VA.: U.S. Army Research Institute for the Behavioral and Social Sciences, September 1978. (DTIC No. AD A061-697).

Parrish, R.N., Gates, J.L. and Munger, S.J. (Synectics Corporation) Design Guidelines and Criteria for User/Operator Transactions with Battlefield Automated Systems. Alexandria, VA.: U.S. Army Research Institute for the Behavioral and Social Sciences, February 1981.

DTIC No. AD A115-874 Volume I: Executive Summary (Research Report No. 1320).

DTIC No. AD A116-078 Volume II: Technical Discussion (Technical Report No. 536).

DTIC No. AD A109-451 Volume III-A: Human Factors Analyses of User/Operator Transactions with TACFIRE -the Tactical Fire Direction System (Research Product No. 81-26).

DTIC No. AD A109-452 Volume III-B: Human Factors Analyses of User/Operator Transactions with TCT--Tactical Computer Terminal (Research Product 81-27).

DTIC No. AD A109-453 Volume III-C: Human Factors Analyses of User/Operator Transactions with Administration/Logistics (Research Product 81-28).

DTIC No. AD A109-454 Volume III-D: Human Factors Analysis of User/Operator Transactions with IISS-FMS --The Intelligence Information Subsystem First Milestone (Research Product 81-29).

DTIC No. AD A115-892 Volume IV: Provisional Guidelines and Criteria (Technical Report 537).

DTIC No. AD A115-905 Volume V: Background Literature (Technical Report No. 538).

Ramsey, H.R. and Atwood, M.E. (Science Applications, Inc.) Human Factors in Computer Systems: A Review of the Literature. Arlington, VA.: Office of Naval Research, September 1979. (DTIC No. AD A075-679)

Semple, C.A. (Canyon Research Group, Inc.). Instructor Pilot Evaluation of the Automated Instruction Support Station (ISS). March 1982.

Semple, C.A., Cotton, J.C., and Sullivan, D.J. (Canyon Research Group, Inc.). Aircrew Training Devices: Instructional Support Features. (AFHRL-TR-80-58) Wright Patterson AFB, OH: Air Force Human Resources Laboratory, January, 1981. (DTIC No. AD A096-234).

Semple, C.A., Vreuls, D., and Cotton, J.C. (Canyon Research) and Durfee, D.R., Hooks, J.T., and Butler, J.C. (Logicon, Inc.). Functional Design of an Automated Instructional Support System for Operational Flight Trainers (NAVTRAEQUIPCEN 76-C-0096-1). Orlando, FL.: Naval Training Equipment Center, January 1979.

Shneiderman, Ben. Software Psychology: Human Factors in Computer and Information Systems. Cambridge, MA: Winthrop Publishers, Inc., 1980.

Thomas, J.C. and Gould, J.D. "A Psychological Study of Query by Example."Proceedings of National Computer Conference, 1975, 447-52.

Waldrop, G.P., McDonald, L.B. and Barry, D. Initial Human Factors Analysis of Battle Group Tactical Trainer Human Engineering System Analysis Report - Volume I. Orlando, FL.: Naval Training Equipment Center, April 1983.

Zloof, M.M. "Query-by-Example," Proceedings of National Computer Conference. 1975, 439-45.

## ABOUT THE AUTHORS

Dr. Bruce McDonald is a Senior Human Factors Engineer and President of McDonald & Associates, Inc. He specializes in the areas of maintenance training, man-computer interaction and training equipment front-end analyses. He holds a Ph.D. degree in Industrial Engineering from Texas A&M University and an M.S. degree in Experimental Psychology from North Texas State University.

Ms. Grace P. Waldrop is an Associate Human Factors Analyst and a Project Director at McDonald & Associates, Inc. She specializes in research and human factors analysis in the areas of maintenance training, Naval war gaming, and man-computer interaction. She holds an M.S. degree in Industrial Psychology from the University of Central Florida.

Elizabeth Y. Lambert is a research psychologist in the Human Factors Laboratory of the Naval Training Equipment Center and was Technical Representative for the BGTT project.

## ACKNOWLEDGEMENT

The authors wish to acknowledge the valuable project and contractual guidance provided by L. Robert Ogus, Project Director for War Gaming at the Naval Training Equipment Center.