Technical Report 420

LEVEL II

DESIGN OF AN INTEGRATED DIVISION-LEVEL BATTLE SIMULATION FOR RESEARCH, DEVELOPMENT, AND TRAINING: Volume I

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and

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ari

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This volume describes the structured framework of the simulation and the considerations that entered into its design. Volume II, ARI Technical Paper 421, provides more detailed design information. Research was monitored by Dr. Edgar M. Johnson, Mr. Robert S. Andrews, and Dr. Thomas M. Granda of ARI.

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Decision variables	Event threads	
Interactive simulation	Performance measurement	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Requirement: (1) Develop a top-down design for an integrated family of modular division-level battle simulations which separately or jointly will exercise players performing critical functions in command and control (Vol. I). (2) Develop detailed design specifications for the Intelligence Staff module of the integrated battle simulation (Vol. II).

The design approach involved the following principles: selection of the decision variables to be manipulated by the division staff modules (Continued)

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and the event threads both within and external to the staff modules thereby fixing the event sequence and time of occurrence; and incorporating into the simulation every event thread needed to support the input/output relationship. The dynamic realism needed to place decisionmakers in a realistic environment is achieved by means of an event store technique. The five classes of events of which the event threads are composed are defined and the logical flow of the event store simulation is illustrated. A sixth class of event needed for operation in an ADP-assisted mode is also defined. The approach begins at the heart of the information system, the decisions, and then develops the simulation needed to implement them--the inverse of the usual approach.

The design concept provides for a man in the loop in that any one or any combination of five basic staff modules (Cmd Grp, G-2, G-3, G-1/G-4, FSCE) plus one enemy module (Cmd Grp) may be either occupied by human players or simulated. The module simulations are designed as "plug-in" modules any one or more of which can be replaced by players. The simulation also contains a battle outcome generator which simulates all other events within the division and the enemy force opposing it, and which feeds back to the players in slow, real, or fast time (at the option of the user) the results of their decisions. The design also provides for interfaces with higher and adjacent units. It includes the following features:

1. The modules are based on the traditional G-staff structure.

2. Nuclear battle events are included.

3. Live modules may be required to perform simultaneous planning and execution; the results of such planning may be evaluated by subsequent execution of plans.

4. Other staff elements not included in the basic five modules (e.g., engineer, signal) are "hardwired" components of the simulation.

5. The basic design provides for manual operation by live players but it is readily expandable to permit player operation in an ADP-assisted mode.

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Staff Operations and
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ARI Research Reports and Technical Reports are intended for sponsors of R&D tasks and for other research and military agencies. Any findings ready for implementation at the time of publication are presented in the last part of the Brief. Upon completion of a major phase of the task, formal recommendations for official action normally are conveyed to appropriate military agencies by briefing or Disposition Form.

FOREWORD

The Army Research Institute for the Behavioral and Social Sciences (ARI) conducts research on tactical information systems with particular emphasis on the human factor in battlefield command/control and intelligence functions and operations. The development and refinement of man-in-the-loop simulations to serve as research test-beds is a necessary step in the development of command staff aids and procedures to meet the challenge of the modern battlefield. The ARI research program in this domain is independently and jointly executed by the Human Factors Technical Area in Alexandria, Va., and the ARI Field Unit at Fort Leavenworth, Kans.

The present report describes a range of design alternatives for a man-in-the-loop simulation for research, development, and training. The basic concept developed is one of a modular simulation where one or more elements within the command staff group may be exercised, with controllers supervising play and feeding in data, etc., from unpopulated (simulated) staff elements. Pre-established event threads provide a means for realistic play of a complex scenario with a relatively small controller team. The possible role of computer support to the controllers is also discussed. Detailed design specifications are provided in ARI Technical Report 421. This effort provides part of the methodological and technological base required for development and evaluation of command group aids and procedures.

Research on staff operations and procedures is conducted both in-house and augmented contractually with organizations selected for their specialized capabilities and unique facilities. Efforts in this area are responsive to general requirements of Army Projects 2Q162722A765 and 2Q163743A774 and to special requirements of the U.S. Army Combined Arms Combat Development Activity, Fort Leavenworth, Kans., and the U.S. Army Intelligence Center and School, Fort Huachuca, Ariz. This effort is also responsive to Human Resource Need 78-85 "War Gaming of Intelligence," and was conducted under Contract DAHC19-77-C-0047 by Science Applications, Inc., monitored by both the Human Factors Technical Area and the Fort Leavenworth Field Unit of ARI.

JOSEPH ZEIDNER
Technical Director

DESIGN OF AN INTEGRATED DIVISION-LEVEL BATTLE SIMULATION FOR RESEARCH, DEVELOPMENT, AND TRAINING

BRIEF

This volume describes the structural framework of the simulation and the considerations that entered into its design. A companion volume, DETAILED DESIGN NOTES FOR DESIGN OF AN INTEGRATED DIVISION-LEVEL BATTLE SIMULATION FOR RESEARCH, DEVELOPMENT, AND TRAINING, provides more detailed design information.

Requirement:

1. Develop a top-down design for an integrated family of modular division-level battle simulations which separately or jointly will exercise players performing critical functions in command and control.

2. Develop detailed design specifications for the Intelligence Staff module of the integrated battle simulation.

The design approach involved the following principles: selection of the decision variables to be manipulated by the division staff modules and the event threads both within and external to the staff modules thereby fixing the event sequence and time of occurrence; and incorporating into the simulation every event thread needed to support the input/output relationship. The dynamic realism needed to place decision makers in a realistic environment is achieved by means of an event store technique. The five classes of events of which the event threads are composed are defined and the logical flow of the event store simulation is illustrated. A sixth class of event needed for operation in an ADP-assisted mode is also defined. The approach begins at the heart of the information system, the decisions, and then develops the simulation needed to implement them--the inverse of the usual approach.

The design concept provides for a man in the loop in that any one or any combination of five basic staff modules (Cmd Grp, G-2, G-3, G-1/G-4, FSCE) plus one enemy module (Cmd Grp) may be either occupied by human players or simulated. The module simulations are designed as "plug-in" modules any one or more of which can be replaced by players. The simulation also contains a battle outcome generator which simulates all other events within the division and the enemy force opposing it, and which feeds back to the players in slow, real, or fast time (at the option of the user) the results of their decisions. The design also provides for the interfaces with higher and adjacent units. It includes the following features:

1. The modules are based on the traditional G-staff structure.

2. Nuclear battle events are included.

3. Live modules may be required to perform simultaneous planning and execution; the results of such planning may be evaluated by subsequent execution of plans.

4. Other staff elements not included in the basic five modules (e.g., engineer, signal) are "hardwired" components of the simulation.

5. The basic design provides for manual operation by live players but it is readily expandable to permit player operation in an ADP-assisted mode.

Conclusions:

The general top-down design of the simulation has been developed as has the more detailed design of the Intelligence Staff module. However, two basic design problems were uncovered in the course of the research.

1. A fundamental problem is inherent in the modular nature of the simulation. If a populated module performs below standard (makes errors, omits or takes illogical actions) how can simulated command and control processes reflect the degraded force effectiveness that results? Although much simpler to implement, standard performance by simulated command control nodes independent of performance of populated modules would not meet simulation objectives.

2. In the interest of economy of operation and player motivation it would be desirable to eliminate or reduce the requirement for repetitive, low-skill tasks, e.g., answering radios and telephones and transmitting messages, routine filing, etc., which have little impact on the quality of decision making and are of little interest to the investigator. It may also be desirable to modify or recombine tasks in investigations of alternative procedures. This can be difficult to accommodate and still retain a credible, realistic decision-making environment.

It is concluded that both the above problems are serious enough to warrant additional analysis before implementing the simulation.

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GLOSSARY OF ACRONYMS

ADA	Air Defense Artillery
ADP	Automated Data Processing
AMORE	Analysis of Military Organization Effectiveness Methodology
APC	Armored Personnel Carrier
ARI	Army Research Institute
BICC	Battlefield Information Coordination Center
BDE	Brigade
BN	Battalion
BOG	Battle Outcome Generator
C^3	Command Control and Communications
CBRE	Chemical Biological Radiological Element
CEWI	Combat Electronic Warfare Intelligence
CG	Commanding General, Command Group
CP	Command Post
CPU	Central Processing Unit
CRT	Cathode Ray Tube
CSS	Combat Service Support
DAME	Division Airspace Management Element
DIV	Division
DTG	Date-Time-Group
EW	Electronic Warfare
EOOB	Electronic Order of Battle
EWIOC	Electronic Warfare Intelligence Operations Center
FEBA	Forward Edge of the Battle Area
FS	Fire Support
FSE	Fire Support Element Staff
G1/G4	Combat Service Support Staff
G2	Intelligence Staff
G3	Operations Staff
HQ	Headquarters

IECR	Interactive Executive Control Routine
INTREP	Intelligence Report
INTSUM	Intelligence Summary
I/O	Input/Output
LRRP	Long Range Reconnaissance Patrol
NBC	Nuclear Biological Chemical
OPLAN	Operational Plan
POL	Petrol, Oil, Lubricants
RTO	Radio Telephone Operator
SAGE	Semi-Active Ground Environment
SAI	Science Applications, Inc.
SCORES	Scenario Oriented Recurring Evaluation System
SIMTOS	Simulated Tactical Operation System
SITMAP	Situation Map
SITREP	Situation Report
SOK	State of Knowledge
SOP	Standard Operating Procedure
TAC	Tactical Command Post
TACP	Tactical Air Control Party
TASE	Tactical Air Support Element
TCAC	Technical Control and Analysis Center
TOC	Tactical Operations Center
TOE	Table of Organization and Equipment
TOS	Tactical Operations System
TRADOC	Training and Doctrine Command

Section 1

INTRODUCTION

1.1 PURPOSE AND SCOPE

This report describes the top-down design of an Integrated Division-Level Battle Simulation for Research, Development, and Training. It discusses and documents the critical trade-offs which need to be made in further development and implementation of the simulation and which underlay the numerous design decisions that have already been made. It discusses the applicability of the design to the three major areas for which such a simulation should be useful, namely:

- Behavioral science research on human performance in command and control.
- Combat developments, for the analysis and evaluation of tactics and doctrine.
- As a training device for command groups/staff.

Also discussed are the player tasks and roles in each of the modules, the general rules of play, the information flow required to support stand-alone and integrated play, controller requirements and functions, data to be obtained and evaluation criteria to be applied, and other aspects of the design necessary to allow for implementation of the simulation.

1.2 APPROACH

The approach to the design of this simulation is somewhat unique as compared to past designs of combat simulations. It involves the application of the following principles:

- Selection of the decision variables to be manipulated by the division staff modules and the associated inputs and outputs.
- Tying together the inputs and outputs by means of event threats both within and external to the staff modules thereby fixing the event sequence and time of occurrence.
- Incorporating into the simulation every event thread needed to support the input/output relationship.

This approach begins at the heart of the information system, i.e., the decisions to be made, and then develops the combat simulation needed to implement them, which is the inverse of the usual approach.

The dynamic realism needed to place decision makers in a realistic decision-making environment will be achieved by means of an event-store technique. The five classes of events of which the event threads will be composed are defined and the logical flow of the event store simulation is illustrated. A concept for incorporating a wide range of scenarios is presented and the trade-offs involved in ADP support for the controllers are discussed. A sixth class of event needed for operation in an ADP-assisted staff mode is also defined.

A basic system concept is presented in Section 4 and the relationship of the event classes to the simulation components is defined. A careful distinction is drawn between portions of the simulation that will be "hard wired" and those that will be readily addressable as inputs. Examples are given of both kinds of parameters and the discussion shows why the cost effectiveness of the simulation is determined by the wise choice of hard wired components. The data organization is outlined and the requirement for and the manner in which the real data base and the Blue and Red perceived data bases will be organized is shown. The specific features to be included in the initial implementaiton are described as are the tradeoffs involved in deferring some features for future extensions.

This is followed by a discussion of the design of live staff modules. The question of the tradeoff between module size and realism is addressed. The issue of the complexities introduced by alternative (adaptive) man-machine interface definition is raised again. It is indicated that live staff modules may be essentially a complete operating shift less the lower (communication) staff processes which will be incorporated into the simulation proper in the interest of economy. This is followed by a discussion of the control parameters that are incorporated in the design to facilitate employment of the simulation for behavioral research. The final section of the report repeats much of the preceding design information in the context of the detailed design of the live G2 module.

Appearing in a companion volume to this report is detailed design information on the staff module inputs and outputs, the detailed specifications for each of the event classes and event thread charts for all interface events.

Section 2

THE PROBLEM

2.1 STATEMENT OF THE PROBLEM

The problem addressed in this research may be stated as follows: To develop a battle simulation which will provide a cost-effective tool for use as:

- A systems measurement bed for behavioral science research on human performance in the division command group and the principle staff sections.
- An aid in analysis and evaluation of tactics and doctrine in combat developments.
- A training device for command groups and staff elements.

2.2 OBJECTIVES

The technical objectives of this effort are:

- To develop a top-down design for an integrated family of modular division-level battle simulations which separately or jointly will exercise players performing critical functions in command and control.
- To develop detailed design specifications for the Intelligence Staff module of the integrated battle simulation.
- To develop, implement, and demonstrate the Intelligence Staff module as a stand-alone battle simulation for research, development, and training of Intelligence functions and for subsequent integration with other modules.

2.3 MODELING REQUIREMENTS

Both the statement of the problem and the technical objectives require that the simulation be interactive and, thus, have man (i.e., one or more decision makers) "in the loop".

Figure 2-1 illustrates the basic elements of any interactive combat simulation. A scenario, which specifies forces, situation, and missions provides the initial conditions and the constraints imposed on the decision makers. In the general case, two opposing decision makers feed decisions to and receive feedback from a decision outcome generator. The latter also calculates the combat outcomes in terms of the measures of effectiveness being used to assess the final

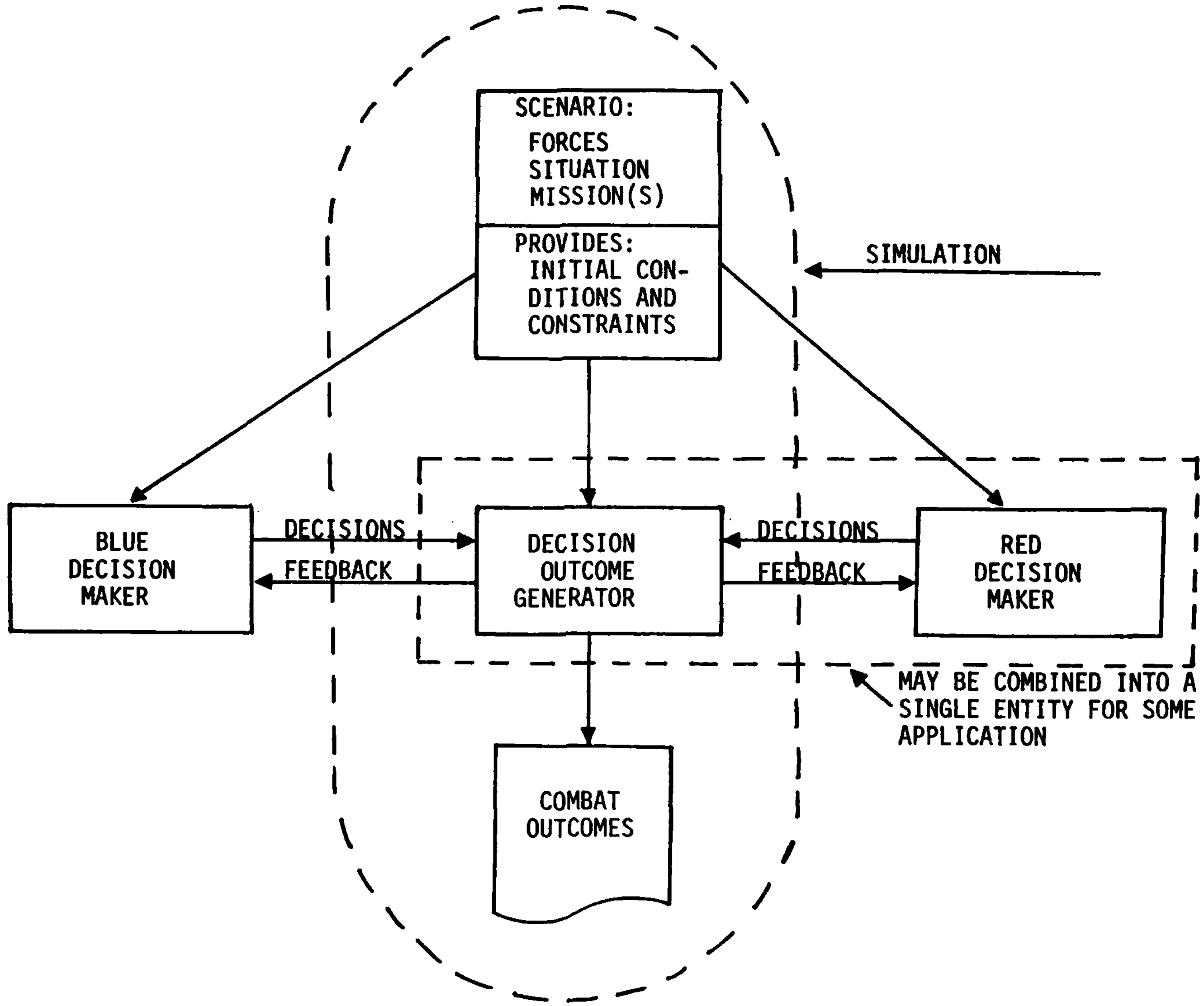


Figure 2-1. Basic Elements of "Man In The Loop" Combat Simulation.

(battle) outcomes. For some applications, the functions of the opposing (Red) decision maker may be incorporated into the decision outcome generator (usually termed "control"). Such applications might include studies of the nature of the player-invoked information processes and decisions made as a result of a predetermined sequence of tactical events. They might also include cases in which the decision maker is being trained to perform a prescribed series of information processes or indoctrinated ("programmed") to make certain decisions in response to selected tactical events.

It should be noted that for such an interactive combat simulation, the simulation proper incorporates only the scenario (input data), the decision outcome generator, and the combat outcomes (output). The boxes occupied by the decision makers are not simulated but real. This means that the data exchange between the player boxes and the simulation proper is a crucial factor in the design of the simulation. This is discussed in greater detail in the following paragraph.

2.4 DATA FLOW REQUIREMENTS

The requirements imposed by the problem and objectives stated above fall under two general headings. The first is a requirement to simulate combat and the other events that result from player decisions. The second must concern itself with the information flow and decision making inherent in the division command post. Since provision must be made for manning only a part of the command post, i.e., one or more staff modules, there is a requirement for modeling or simulating those portions of the division command group and staff sections that are not manned by human decision makers (players). In other words, there is a requirement for a simulation of portions of the division command and staff quite distinct from the requirement to simulate combat.

2.4.1 Information Flow and Decision Making

2.4.1.1 Man in the Loop. All three of the applications cited in the problem statement require that the tool or test bed be built around one or more human decision makers. This statement is, in itself, transparently obvious, but some of its implications may not be. Two functionally distinct groups can be identified in any combat force and might be called managers and effectors. Managers are concerned primarily with decision making under conditions of uncertainty and with the acquisition of data which reduce that uncertainty, i.e., provide information. Effectors are concerned primarily with the translation of data received from the managers into physical processes which can also create reportable events. A combat simulation substitutes data processes for the physical processes of real combat. In other words, the simulation accepts the data generated by the managers and, in turn, generates the data provided to them by the effectors and by other managers. The facet of the problem addressed here arises from the fact that the simulation of physical processes may not proceed at the same rate as the physical processes being simulated. Most computer simulations of combat run at many times the rate of the processes being simulated. Some manually assessed war games run at rates far slower than the combat being simulated. However, when the manager whose decision making is under scrutiny is actually "in the loop", combat interactions being simulated must, for many applications, proceed at the same pace that they would in actual combat, else the decision maker is not in a realistic decision making environment. Unfortunately, combat is not as gentlemanly as chess and interactions do not stop while decision makers make up their minds. There are, of course, exceptions to this general rule. For example, during the planning stages of a military operation, the coupling between the ongoing combat interactions and the planning process are normally not, or should not be, nearly so tight as during the implementation stage of that same plan. Hence, the combat interaction might well, in the interest of economy, run faster than a real world pace between plan completion and plan implementation. On the other hand, in a training situation, it might be desirable to slow combat interaction to facilitate the learning process.

Sackman*, from studies of the SAGE system, was the first to set forth some general principles concerning the dialogue between a human decision maker and a simulation. Although couched in the terms of the human/computer dialogue, his principles are equally applicable to the more general problem of man interfacing with any simulation:

- Real Time Parallelism: Real time digital events should operate in parallel with, and reflect the pacing of, the separate and distinct real time characteristics of the men, equipment, and relevant situation events required to meet system goals. This parallelism should hold throughout the range of system capacity and associated computer operating time. Program design and control should accordingly have a structure that results in a close empirical fit between digital timing and environmental timing as determined by empirical performance effectiveness through system testing.
- Temporal Anthropomorphism: The computer system should optimize around the characteristic variabilities of real time human norms for effective system performance rather than try to fit the human into an alien pace that may ostensibly be more convenient from program and equipment considerations.

*H. Sackman. Computers, System Science Evolving Society. New York, John Wiley, 1967.

- Conversational Principle: Human performance in man/computer dialog will vary with the similarity of the responding computer system, to the real time exchange characteristics of human conversation...As computer response time and message pattern deviate increasingly from real time parallelism...so will user performance deteriorate...(pp. 442-443).

2.4.2 Modular Structure

A fundamental requirement for this simulation is that the five basic staff elements be designed as independent modules. The basic rationale for modularity is to provide a means whereby any one or combination of modules might be populated with live decision makers while the remainder were being simulated. The modules can be described in terms of the traditional functions of the US General Staff with Troops, viz., Command Group, G-2, G-3, G-1/G-4, plus a Fire Support Element. Although the G-staff structure remains a valid basis for partitioning staff functions, it is no longer the sole basis for staff organization while operating in the field. Modifications to the original G-staff structure (borrowed from the French Army in WWI) have appeared at an increasing rate ever since the entry of the US into WW II. Two major trends have appeared: the incorporation of numerous specialized activities into the command post, e.g., fire support, air defense, signal, etc., and the evolution into a bi-functional staff consisting of operations and logistics/administration. What has happened is that the staff has become a matrix organization. Functions are assigned on a G-staff basis but are carried out in the new modular locations. After discussions with ARI and with personnel at the Combined Arms Combat Development Agency at Ft. Leavenworth, the decision was made to proceed with the traditional G-staff modules. This decision is discussed in greater detail at paragraph 3.4.

The extent to which ancillary functions such as those performed by the Chemical Biological Radiological Element (CBRE), Division Airspace Management Element (DAME), Tactical Air Control Party (TACP), Electronic Warfare Intelligence Operations Center (EWIOC), etc., are included in the principal staff modules will be determined by the selection of tactical decision variables and information messages to be incorporated in the simulation (see paragraphs 3.1 and 3.2).

2.4.3 Modular Data Flow

The problem introduced by the requirement for modularity must be defined. If the test bed is to have a "stand alone" capability for one or more (but less than the totality) of staff elements, it is not only the physical processes of combat that must be simulated, but also the data processes performed by every staff module that is not manned by human decision makers. Furthermore, this data processing must be in modules such that any single module or specified combination can be replaced by human decision makers.

The data flow in a modular staff simulation is portrayed at Figure 2-2. The figure shows a staff in which only the G-2 module is manned; all other staff modules are simulations. The outside ring of the figure shows the data transfers that must take place between each staff module and the world outside the division CP. This outside world is represented by the decision outcome simulation. Shown at the ring inside of the staff are the internal data transfers between the staff modules. Input and output arrows connect each module with the internal and exterior data transfer rings. As indicated, each such pair of arrows is an interface or a potential interface between a human decision maker and the "simulation." The data processes and the data flow within the simulated modules do not have to duplicate that of a real staff module in every detail. But, at every interface between a staff module and the information stream, the simulation must provide realistic data transfers by providing the data normally available to decision makers within the module and accepting the data* generated by such decision makers. If the simulation were to exercise only the G-2 module decision makers, only two sets of interfaces between players and simulation would need be explicitly defined. If, however, the simulation is to exercise human decision makers in any of the staff modules or combinations of the command group and one or more of the remaining modules, all ten of the indicated interfaces must be thus explicitly defined. This is true even though the data flow into and out of a given staff section need not be as detailed and complete when the module is simulated as when it is occupied. However, provision must be made in the design to handle all of the traffic that would occur in the latter case.

Furthermore, if the staff modules are to be indeed modular, e.g., the same command group (CG) module is employed regardless of which other staff module(s) is populated with human decision makers, then the CG simulation must be capable of accepting every output of every other staff section that is routed to it and it must be capable of generating every output provided by CG to every other module. By "capable" is meant that it must contain every format, every look-up table, every algorithm (procedure) needed to generate such outputs and to process such inputs. It does not mean that all would be exercised if only one of the other modules is player occupied. If the player-occupied module were the G-2 module, the G-2 simulation

*The word data is used in describing modeling procedures even though real world decision makers usually perceive that they are providing information.

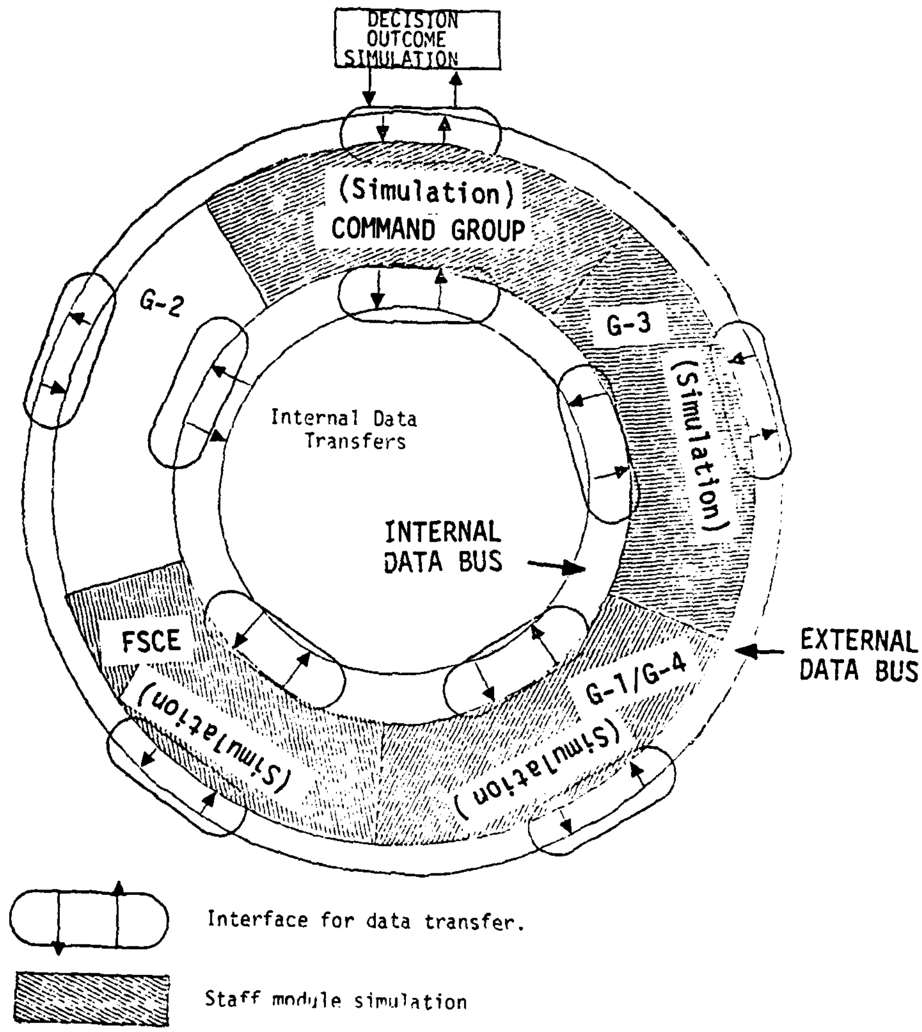


Figure 2-2. Data Flow in Modular Staff Simulation.

would need to process and generate only the data exchanges between G-2 and CG plus those exchanges with the rest of the model that had the potential of generating G-2 inputs elsewhere.

This, in turn, imposes a substantial burden on the decision implementation simulation which must be capable of generating events at the finest level of detail needed for any intended application. No division-level combat simulation has ever been built to handle interactions relating to all major staff actions at such a level of detail simultaneously. It appears feasible to design a simulation which would be sensitive to actions, hence the performance, of a principal staff officer, e.g., the G-2, but it does not appear to be feasible to design one that would at the same time be sensitive to the performance of a G-3 file clerk.

2.4.4 Performance Measurement

The need for performance measurements in a simulation of this type adds another facet to the problem. This question is further compounded by the multiple applications for which the simulation is to be used. In order to examine this question it is necessary to develop precise definitions of measures appropriate for evaluating combat effectiveness and tactical information system performance. Effectiveness measures appropriate for evaluating the outcomes of combat models are described at paragraph 2.4.6. Performance measures appropriate for comparing the performance of modules within the information system (staff modules) include measurement of the following:

- Effort required to carry out information processes.
- Time delays associated with carrying out information processes.
- Completeness of selected information sets.
- Accuracy of selected information sets.
- Validity of selected information sets.
- Numbers of personnel and equipment.

To measure the six variables identified above, it is necessary to define precisely what is to be measured. The above variables are defined for this purpose as follows:

- The effort required can be measured in man-hours of personnel effort required to perform the information processes needed to carry out specified functions such as maintenance of a specified file or preparation of a specified output and the frequency with which selected files (displays) are accessed.

- Time delays can be measured in terms of the time (usually in minutes) required to perform the information processes needed to carry out specified functions just as in measuring effort.

- Completeness of selected information sets can be measured by the presence or absence of the data elements specified to be included in the set. This implies a standard of measurement against which this count will be made and this is established below.

- Accuracy of selected information sets can be measured by comparing corresponding data elements of the selected set with a standard set. Data elements which do not match exactly are in error. This measurement standard is also discussed below.

- Validity of selected information sets is defined as the combination/intersection of the truth of the information, as compared to ground truth, and its relevance to the decision for which the information set has been assembled. This quality of information cannot be measured directly in real systems, except on a basis of experience with real or synthetic systems as will be pointed out below.

- Personnel and equipment involved can be measured directly.

Having defined the variables to be measured, it is necessary to look for the appropriate points within the system at which measurements can be made. Numbers of people and equipment pose no problem because this measurement is a property of the information system structure being investigated and not of its performance. The other five variables, however, are true performance measures and it is necessary to determine points at which or between which these variables are to be measured. This illustrated at Figure 2-3. Points at which measurable data sets exist (data inputs, files, and direct outputs) have been identified by marking them with letters a, b, or c. The input sets, files, and data extracts have been marked a to denote that data elements in these sets should be unaltered by any processing between these points. Data aggregations have been marked b to indicate that data elements contained in this class of data sets can be altered between input and output but only to the extent that output data elements can be objective combinations of input element. Objective is defined to mean an a priori rule for combinations already stored in the data base is used. Outputs marked c, however, contain subjective combinations of input data elements (combinations not stored in the data base in advance) and new data elements not contained in the data

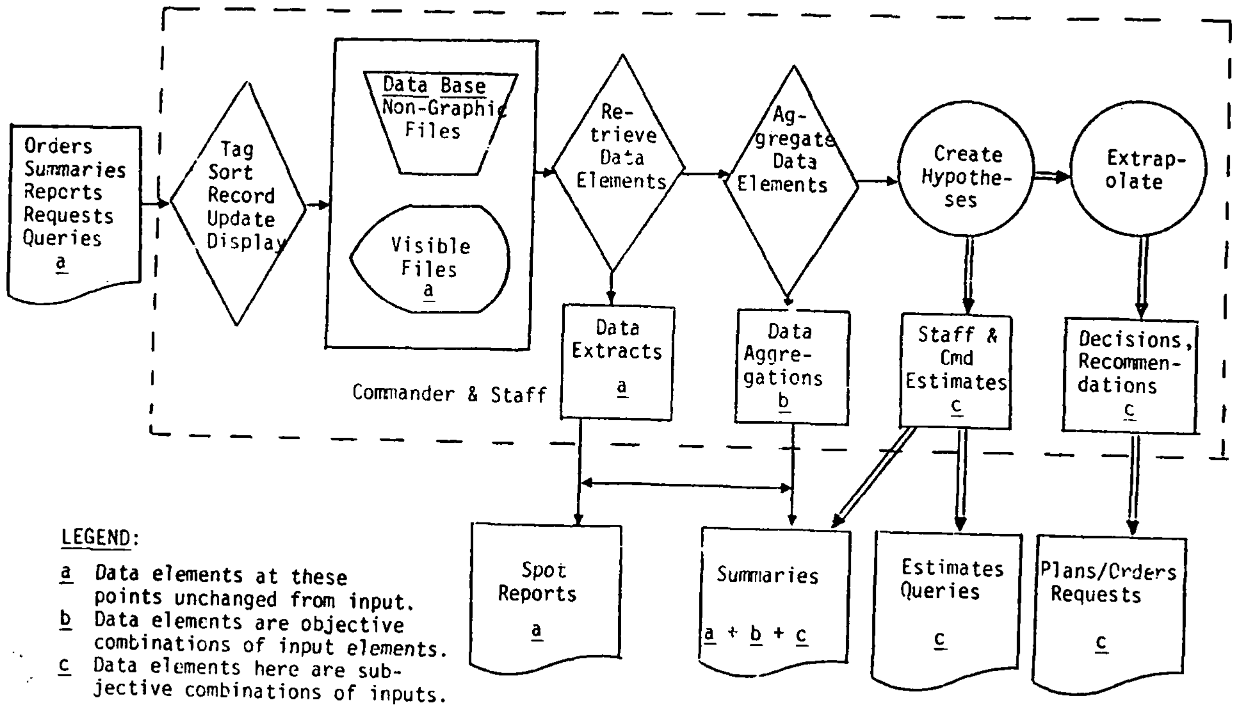


Figure 2-3. Nature of the Data Element Transformations at Points in the Decision-Making Node (CP).

base. Data sets of class c result from human decision making. The formal command/staff outputs of the decision making node are shown along the lower tier of Figure 2-3. They consist of combinations of the indirect outputs which can be designated as purely of class a, b, or c. Appropriate bases for measurements at each of the identified measurement points can now be established.

Appropriate bases for measuring each of the measurable products are summarized at Figure 2-4.

- Delay time and effort can both be measured between the inputs and the files. Such measurements provide information on the delay times between inputs and the files (especially visible files) and on the file maintenance effort. For data extracts, both can be measured either between input and extract or between file and extract--whichever is more appropriate. For the remaining output products (aggregations, estimates, decisions, and recommendations) both delay time and effort are measurable between the file and the respective output. A measurement between outputs of this type and input is not, in general, possible because the identity of the original input data elements has been lost.

- Completeness of files, data extracts, and data aggregations is directly measurable by comparison with inputs. On the other hand, the completeness of estimates, decisions, and recommendations is not measurable in terms of inputs since they contain data elements not necessarily all derived from the data base. Their completeness, therefore, can only be measured on the basis of experience (check lists) and by counting the number of requests for clarification submitted by the recipients of such outputs.

- Accuracy of files, data extracts, and data aggregations can also be measured by direct comparison with inputs. The accuracy of estimates, decisions, and recommendations, however, can be based only on experience for the same reasons as for completeness.

- The validity of the decision node outputs is not directly measurable within the information system itself. Since, by definition, validity depends on comparing the truth of information with ground truth, this factor can be measured only with respect to the physical phenomena that lie beyond the sensors originating the information at the peripheries of the information system. Only the physical

MEASURABLE PRODUCT (POINT OF MEASUREMENT)	EFFORT AND DELAY MEASURABLE BETWEEN	MEASUREMENT STANDARD FOR		
		COMPLETENESS	ACCURACY	VALIDITY
Files - Visible and Non-Graphic, a	Input and File	Input	Input	Experience
Data Extracts, a	Input and Output or File and Support	Input	Input	Experience
Data Aggregations, b	File and Output	Input	Input	Experience
Estimates, Decisions, Recommendations, c	File and Output	Experience* and Requests for Clarification	Experience	Experience

*Usually implemented through check lists.

Figure 2-4. Bases for Measurement.

results of decisions are measurable physical quantities and these again lie outside the confines of the information system. It is this factor that indeed requires an effectiveness model to relate information system performance to combat effectiveness. Any attempts at direct measurement of the validity of information outputs or of files, therefore, can be based only on experience.

The implications for performance measurement for each of the three applications listed at paragraph 2.1 can now be addressed.

- <u>Behavioral science research on human performance</u>. For this application the primary emphasis will certainly be on measurement of the performance of players in one or more staff modules in terms of the six variables defined above. Measurement of combat effectiveness will, in general, be required only for those measurements which Figure 2-4 indicates "experience" as the basis for measurement. In those cases where experience will no suffice, combat outcomes will have to be invoked. It must be noted that combat outcome is a far less sensitive measure than direct measurement of the data. Application of the simulation for this purpose will also require control of extraneous variables as closely as possible. For example, it may be desirable not to have a discrete opposing "Red" player in such a simulation, but to control Red inputs very closely so as to force the decision making situations it is desired to study. In fact, for some research of this kind it may not be necessary to have a truly interactive simulation at all; many such investigations can be performed from a completely preset, or "canned", sequence of events.

- <u>Analysis and Evaluation of Tactics and Doctrine</u>. This application can be in either of two contexts. The first is an examination of the impact of new tactics and doctrine on the staff itself. This is an extension of the behavioral research described above. In fact, it lies at the opposite extreme from the point of view of performance measurement. The evaluation of tactics and doctrine on the outcome of the battle is not accomplished by measuring the completeness, accuracy, validity, or timeliness of staff outputs, nor the effort required to produce them. For this application, one is primarily interested in combat outcomes and measurement of changes in combat effectiveness resulting from changes in tactics and doctrine. For this purpose, the presense of an opposing "Red" player is almost a necessity becuase tactics and doctrine cannot be evaluated solely in terms of their effectiveness against existing enemy doctrine, but must also consider the adjustment to new tactics and doctrine that a reasonably intelligent opponent can be expected to make. This application is truly a study of war rather than of staffing for war.

- Training device. This application encompasses features of both the above applications. For teaching staff procedures and the mechanics of staff processes, measurement of the performance of the various staff operations is paramount. On the other hand, when teaching the doctrinal and policy bases for decision making, demonstration of the relation between decisions and combat outcomes is certainly a preferred training technique. Historically, in the absence of simulations useable for this purpose, Army training in command and tactical decision making has substituted the instructor's experience and judgment for combat outcomes. Student performance was measured against the "school solution." Employing a battle simulation to evaluate the student's solution certainly offers a more efficacious training device. However, in this case, the instructor himself may prefer to act as the opponent in order to induce the particular training situation and teaching point desired. Hence, a simulation for this application needs to provide measures of performance of the kind discussed above and measured effectiveness as discussed in paragraph 2.4.6 below.

2.4.5 Automated Tools for Players

One of the requirements of the design is that it must allow for the use of automated systems and tools by the players as well as the use of an automated system to support the control and play of an exercise. This requirement adds still another dimension to the problem of information flow and decision making for the simulation. If the automated tools and system were completely self contained within one of the player occupied staff modules, it would, of course, not impact on the design of the simulation (e.g., a desk top calculator used by the G-3 in the preparation of a movement schedule). Such a restriction would, however, be very limiting and the intent is to highlight the requirement to study human factors and staff performance and to train staff members when the staff module is being assisted by an ADP system such as the Tactical Operations System (TOS) which serves more than one staff module by means of a shared data base and processing facilities.

Figure 2-5 illustrates the information flow in the elementary decision node when ADP is added to the node. It will be noted that some information continues to flow through the Level I (Receive and Transmit) processes which can be thought of as manual interface devices (radio, telephone, teletypewriter, etc.). On the other hand, for that information which comes in or is transmitted via the ADP system, new interfaces with manual processes must be developed through new input/output devices, i.e., computer terminals. It should also be noted that the information traversing these interfaces may be at levels higher than Level I and is no longer restricted to the forms associated with the manual system. In other words, the information that passes into the manual part of the decision making node from ADP terminals is already selectively retrieved and may be aggregated. As such ADP systems are currently designed, capability to use the data base for higher level operations is limited except as such information is added in free text, consequently, capability to process such information is also very limited. Nevertheless, such a combined system will now have a dual data base, part manual and part automated. Clearly, the manual process configuration will change provided the manual elements within the note perceive some advantage to using the ADP to process some portion of the information flow. It is also clear that a precisely defined standing operating procedure must specify which information will be processed manually and which will be processed in part through ADP.

The gravity of the problem raised by this requirement now becomes apparent. Clearly, any information transferred through an automated terminal must exist on the simulation side of the interface in digital form. Thus, the simulation must contain the data bases and automatic data processing that would support automated interface devices. On the other hand, if the players are operating without ADP assistance, this same information must be transferred through manual input/output devices. Thus, the interface specification must be variable to reflect varying degrees of ADP assistance to players, but the simulation must have the capability to process in digital form the maximum scope of information that it might ever be desired to provide through automated terminals.

2.4.6 Effectiveness Measures

This discussion is concerned with the requirement for measuring the outcomes of combat models as distinguished from the measurement of performance within the information and decision making simulation which was discussed at paragraph 2.4.4 above.

The outcomes of combat can be distinguished through quantitative comparisons of three factors:

- Changes in the geographic area controlled by both sides.

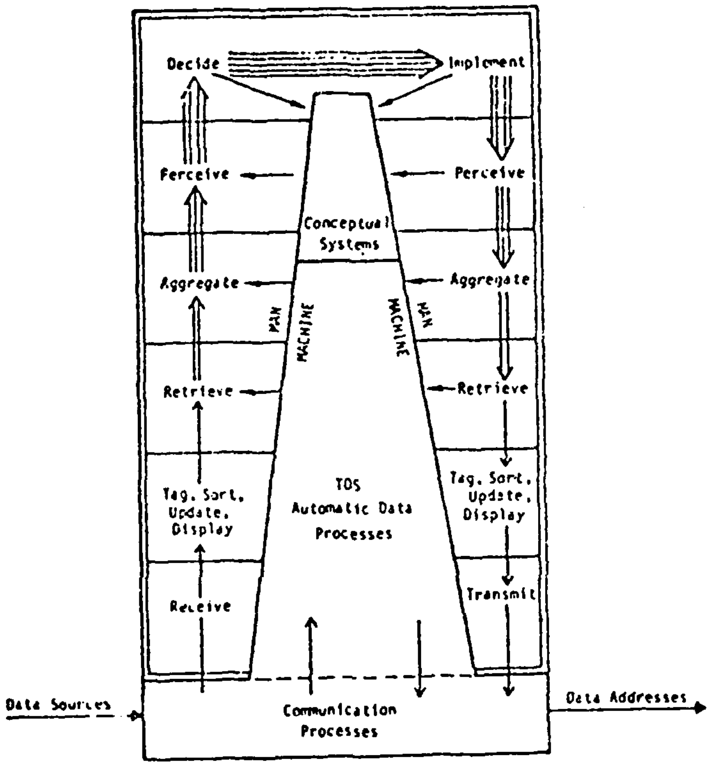


Figure 2-5. Process Types in ADP-Assisted Tactical Decision Node.

- Changes in the resources available to both sides.
- Time intervals required to effect the above changes.

Tiede (1967) has demonstrated that ground force missions specify acceptable changes, i.e., specify constraints, in these three factors.[1] The same reference also indicates that one of two objective functions may be associated with each military mission:

- Minimization of resource expenditure for missions requiring engagement of the bulk of the available force (e.g., area defense or penetration).
- Maximization of area controlled for missions requiring engagement of small portions of the force (e.g., delay or exploitation).

Comparisons of combat outcomes in these terms is conceptually simple and straightforward but the quantification of these outcomes is frequently difficult.

Measurement of time intervals poses no problem. There are no great difficulties in measuring times between events (e.g., changes in resources and in area), provided there are means for determining that those events have indeed occurred.

Measurement of changes in resources has until recently posed a fundamental difficulty even though there is no conceptual difficulty in measuring resources. The problem has been that this factor is really a multi-dimensional function with no generally accepted method of aggregating resources of different kinds. For example, a solution within constraints that expends 50 lives and 10 tanks has minimized resource expenditure with respect to one that expends 50 lives and 20 tanks. But where is one ranked that expends 55 lives and 5 tanks? "Total resources expended" cannot be calculated as a single quantity unless values are assigned to the various classes of resources. A recently developed methodology called Analysis of Military Organizational Effectiveness Methodology (AMORE)[2] does enable one to combine different classes of resources into a single measure, i.e., potential unit effectiveness.

For area controlled by a military force, there is a similar difficulty. Again, as for resources, we have really defined an area-of-control function--not a method for aggregating areas of widely different characteristics and hence military values. At this stage, this difficulty can be overcome only on a case-by-case basis, as was

[1]R.V. Tiede, "A Formulation of Ground Combat Missions in Mathematical Programming Form," RAC-TP-265, Research Analysis Corporation, July 1967.

[2]G. Page and S. Rose, "Analysis of Military Organizational Effectiveness (AMORE)," proceedings of the 42d Military Operations Research Symposium, December 1978.

suggested for varying classes of resources. It is hoped that the mission statement will specify, or a combat simulation will demonstrate, the relative vaues of controlling different subareas. Against, we know from experience that the values of certain key terrain features may be so high as to dominate a much larger area.

The preceding brief review of some of the factors involved in quantifying the outcomes of combat shed some light on the output requirements for a combat simulation. Clearly, the status of resources on both sides of the conflict must be quantified both in terms of expenditures and replacements. For division-level combat, the resources to be accounted for must include personnel, major weapons (e.g., tanks, APCs, artillery tubes and launchers), ammunition by major category (individual weapons if tactical nuclear war is to be simulated), and POL. Such resource data will permit calculation of exchange ratios which may be an important criterion for some comparisons. Maintaining resource data at a level of resolution much finer than indicated poses difficult data management problems which are justified only for special applications.

The area controlled by both forces is another needed output. This is, in general, a more complicated problem than keeping track of FEBA changes. FEBA change is an adequate measure for missions in which the division is heavily engaged in an essentially flankless environment. However, even for many conventional engagements in more open warfare (e.g., Middle East, Vietnam, or even the North German Plain) other measures must be provided. It is necessary to have means for determining which side controls key terrain features such as dominant ridge lines, bridges, defines, key roads, communication centers, etc.

Finally, if the dynamics of combat are to be simulated, as is almost always the case for studies of changes in performance within the tactical information and decision making system, there must be means for recording time intervals between events. This can be done either by recording status at predetermined time intervals or by recording the time at which selected events occur.

2.5 FUNCTIONAL REQUIREMENTS

From the preceding discussion we can now define the functional modeules that must be contained in the simulation. The simulation proper must contain a maximum of seven modules (Figure 2-6). These are :

- A Command Group Module,
- A G-2 Module,

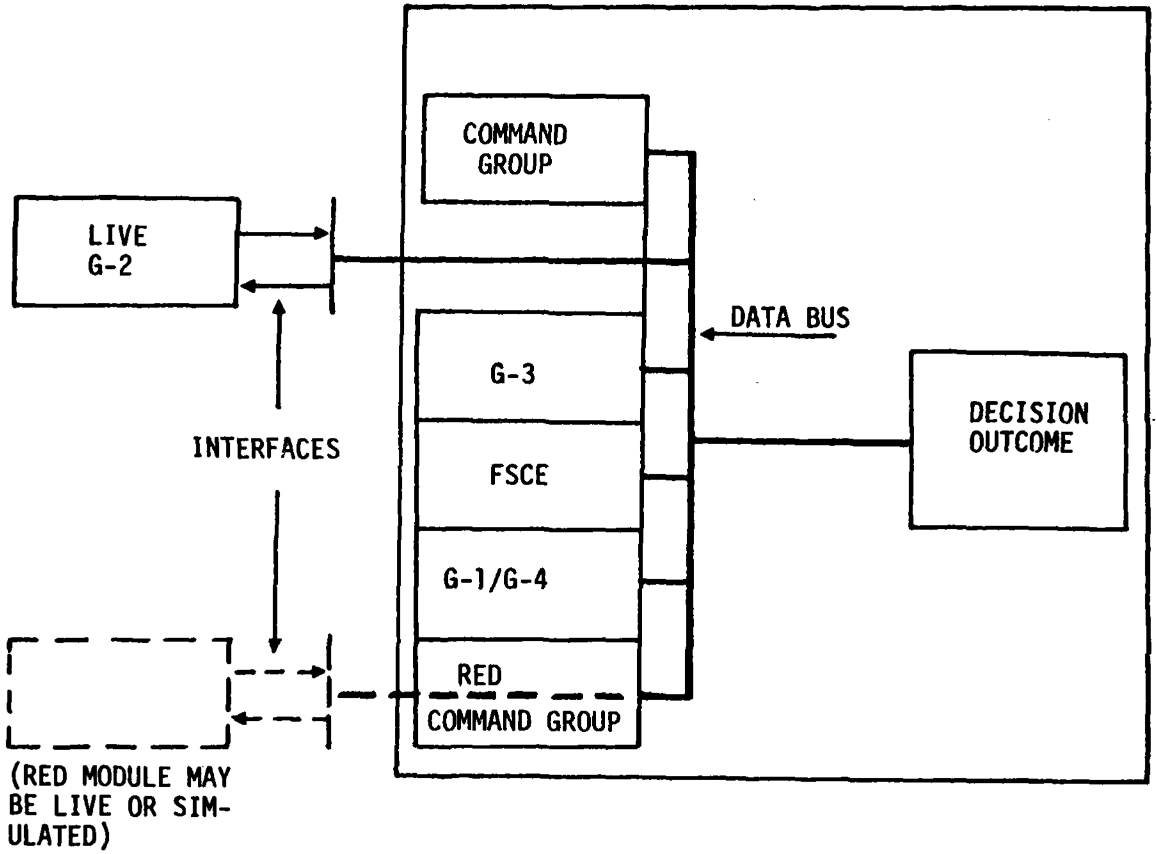


Figure 2-6. Overview of the Simulation.

- A G-3 Module,
- An FSCE Module,
- A G-1/G-4 Module,
- A Decision Outcome Module, and
- A Red Command Group Module.

The seventh, Red Command Group, module may be combined with the Decision Outcome module for some applications to reduce the overhead costs of operating the simulation, but must nevertheless be designed so that it will be available for those applications that require it.

For the live staff modules, the design must include a detailed definition of the man/simulation interface for each of the five staff modules and the Red Command Group. For the five Blue staff modules, the design must also provide the needed internal instrumentation as discussed in paragraph 2.4.5 above.

Section 3

ANALYSIS OF SIMULATION REQUIREMENTS

3.1 DESIGN PRINCIPLES

The discussion of the problem in the preceding section has made it clear that the simulation needed to achieve the design goal is a rather specialized information system. It must be capable of:

- Accepting and implementing the decisions made by human players in one or more modules of the Blue division staff.
- Simulating those processes that will produce feedback to the selected staff module(s).
- Generating and presenting the feedback at the appropriate time and in a realistic manner.
- Calculating the final outcome of the battle being simulated in terms of the selected measures.
- Measuring the human performance within the selected staff module(s).

Of these five requirements, the first four are highly interrelated and determine the design of the simulation proper. The fifth is concerned primarily with instrumenting the non-simulated portion and is related to the first four only insofar as the simulation must provide some of the data points needed to measure human performance.

In developing the design concept, the following principles have been followed:

1. <u>For each Blue staff module and for the Red command module, the selected decision variables and their associated input and output messages establish the scope of the simulation</u>.

The application of this principle requires definition of some of its terms. An input is defined as an inbound data package (message) received by a staff module. An output is defined as an outbound data package (message) transmitted outside the staff module. A decision variable is defined as any decision class or type that results in one or multiple outputs. It may be as simple as a decision to disseminate an incoming message to another staff module or as complex as a formal operations plan or order. However, once the range of decision variables to be included in the simulation has been established together with their associated outputs and the inputs needed to make those decisions, the scope of the entire simulation has been set. In order to appreciate this fact, one must realize that every input is but a report of an event whether that event was triggered exogenously to the simulation by the scenario or internally by the clock or through interaction. In a sense, the outputs and inputs selected as a result of the choice of decision variables comprise the "meta-language" through which the players and simulation communicate. It should be noted that this is the reverse of the usual approach to scoping a battle simulation or war game. The more usual approach is to select the range of scenarios and interactions to be encompassed and then to design an information system which will make it play.

2. The selected inputs, outputs, and their associated events are tied together by means of event threads which fix their sequence and time of occurrence.

The application of this second principle determines the level of resolution of the simulation in terms of the unit size of the forces carried in the data base, the state variables needed to describe those units, the unit of resolution of those state variables, as well as the needed time resolution. This follows directly from the concept that each input to a staff module is the report of an event. Thus, the reportable events determine the level of aggregation that can be tolerated. For example, it is unlikely that any selected input will require the reporting of an individual rifle shot. For purposes of reporting ammunition expenditure, aggregation of rifle firing to battalion level at three hour intervals may suffice. On the other hand, for the purpose of reporting an initial contact with the enemy, aggregation of individual rifle firing may be possible only to company level and the report may be triggered by a transition in posture from "moving (in APCs)" to "engaged," and may need to be reported to the nearest minute.

3. The simulation must contain every event thread needed for every input/event/output relationship.

This principle simply means that the simulation must be capable of accepting and implementing the totality of the selected decision/outputs. It must also be capable of triggering every reportable event whether triggered by interaction, the scenario, or the clock. While the totality of all event threats must be made explicit within the simulation, not all such event threads will necessarily be activated in every application. It is possible that some event threads will have the property of being connected to less than the full set of staff modules. Such event threads would be activated only if needed to process inputs and outputs from live staff modules.

Table 3-1 illustrates how the design requirements imposed by the application of the above principles apply to each of the seven simulation modules shown at Figure 2-6.

Table 3-1. Analysis of Functional Design Requirements.

MODULE	DESIGN REQUIREMENT
Simulated Staff Modules (Blue and Red)	• Determine Decision Variables • Determine Required Inputs • Determine Decision Outputs • Develop List of Defined Events • Determine Event Threads (Internal Processing).
Decision Outcome Module	• Develop List of Defined Events • Determine Event Threads (External Processing)
Live Staff Modules	• Instrumentation of Human Processes

3.2 DECISION VARIABLES AND INPUT/OUTPUT FORMATS

This section describes the manner in which the decision variables, staff inputs, and the formats for each were defined and selected.

3.2.1 Decision Outputs

Decision variables are defined as any decision class or type that results in one or multiple outputs. Having made that definition, it is clear that there is a one-to-one correspondence between decision variables and output classes. Table 3-2 is an example of such a listing of decision variables (or decision outputs) for the G-2 section. They have been broken down into major types with a further breakout by output content. Shown for each is the trigger event which causes each output to be produced and the usual addressees. Similar listings were prepared for each of the other modules (Cmd Grp, G-3, G-1/G-4 and FSCE) and are listed in Design Notes A, B, and C.

3.2.2 Decision Inputs

Shown at Table 3-3 is a listing of the classes of inputs to the G-2 section. Shown alongside each input class are the usual sources for each. The remainder of the table is a matrix which shows the relationship between G-2 inputs (rows) and G-2 outputs (columns). The "X" entries denote which inputs can provide data for each output. The inputs and outputs define the interface requirements for a live G-2 staff module. The matrix indicates which inputs must be connected with which outputs by event threads when the G-2 module is being simulated. Similar matrices have been prepared for all staff modules and are contained in Design Note C.

3.2.3 Rationale for Format Development

Having developed reasonably comprehensive lists of inputs and outputs of which an example is shown at Table 3-3, these were subjected to a three-stage screening process in the course of developing the simulation formats. These steps are:

- Classification with respect to simulation requirements.
- Classification with respect to running time.
- Classification by formatting requirements.

Each of the above provides a basis for reducing the number of data exchanges that will actually be required in the simulation.

Table 3-2 G-2 Decision Outputs.

OUTPUT TYPE	CONTENT	TRIGGER	DISTRIBUTION[1]
Recurring Reports	Intelligence Summary	Clock (SOP)	1, 2, 3
	Para 1, SITREP	Clock (SOP)	G-3
	Weather Forecast	Weather Forecast	2, 3
As Required Reports	Intelligence Report	Own Initiative	1, 2, 3
	INTEL Estimate[2]	CG Guidance	2
	COUNTERINTEL Est.	CG Guidance	2
	INTEL Annex[3]	CG Guidance	G-3
Spot Reports	NBC 1	NBC 1	1, 2, 3
	Retransmit Spot Rpt	Incoming Spot Rpt	2
	Query[4]	Own Initiative	1 or 2 or 3
	Response[4]	Query	1 or 2 or 3
Frag Orders	Revise EEI	CG Guidance	2, 3
	Revise Tasking	CG Guidance or Spot Report	2, 3
Special	Request	Own Initiative	2
	Response	Request	2

1. Distribution Code:

   1 - Higher HQ
   2 - All other staff modules
   3 - Subordinate Units

2. Includes Analysis of Area of Operations.

3. Includes new EEI and tasking.

4. Queries and responses may be sent to any addressee in the distribution code and may concern any legitimate area of G-2 responsibility. Coordination actions by other staff modules will also be handled as queries and responses.

Table 3-3. Input/Output Matrix for Intelligence Staff Module.

INPUT MESSAGES		SOURCE	30 and 31D QUERY	32 FRAG ORDER (I)	33D DIV INTSUM	34 NBC REPORT	35 WX FORECAST	36 INTELL INPUT TO DIVSITREP	37D INTELL EST	38D INTELL ANNEX	39 REQUEST	40 RESPONSE	XX RETRANSMIT
01	QUERY	CMD			X	X	X						X
03D	MSN ANAL	CMD		X					X	X			
04D	CMDR'S GUID	CMD		X						X			
05	CMDR'S DEC	CMD		X									
XX	RETRANSMIT	CMD		X									
10	QUERY	FSE			X	X	X						X
12	FRAG ORDER (FS)	FSE		X	X			X			X		
16	TGT LIST (ARTY)	FSE		X	X			X			X		
17	EU FIRE SPT CAP	FSE		X				X	X				
19	POST STRIKE ANAL	FSE		X	X			X					
21	REQUEST	FSE		X								X	
22	RESPONSE	FSE		X									
XX	RETRANSMIT	FSE		X	X			X					
50	QUERY	G3			X	X	X						X
52	FRAG ORDER (OPS)	G3		X	X			X			X		
53D	DIV SITREP	G3		X	X								
54	NUC WARNING ORDER	G3		X	X			X	X				
55	AD WARNING	G3			X			X	X				
57D	OP PLAN	G3		X									
58D	OP EST	G3							X	X			
59	INITIAL EN CONT	G3			X								
62	EOOB	G3		X	X			X					
63	REQUEST	G3		X								X	
64	RESPONSE	G3		X									
XX	RETRANSMIT	G3											
80	QUERY	G1/G4											X
82	FRAG ORDER (CSS)	G1/G4		X	X			X			X		
87D	CSS EST	G1/G4							X				
89	REQUEST	G1/G4		X								X	
90	RESPONSE	G1/G4		X									
XX	RETRANSMIT	G1/G4		X									
D	GENERAL SIT	CORPS							X	X			
D	SPECIAL SIT	CORPS							X	X			
34	NBC REPORT	CORPS		X		X							
44	CBT INTELL RPT	CORPS		X	X								X
49D	FRAG ORDER (I)	CORPS		X									
34	NBC REPORT	DIV				X							
35	WX FORECAST	DIV	X	X			X						X
41	BDE INTSUM	DIV	X		X								X
42	SHELL REPORT	DIV		X	X			X					X
43	SPOT REPORT	DIV		X	X			X					X
44	CBT INTELL RPT	DIV		X	X			X					X
45	POST STRIKE DAM RPT	DIV		X	X			X					X
46	EST OF EN STRENGTH	DIV	X	X	X			X					X
47	TGT LIST (I)	DIV	X	X	X			X					X
48	QUERY (I)	DIV		X									

The first classification was accomplished as shown at Table 3-4. This table indicates that there are three classes of outputs and three classes of inputs. The grouping shown is on the basis of:

- No interaction with the simulation.
- Interaction with other staff modules.
- Interaction directly with the decision outcome generator.

It will be noted immediately that the class of outputs labeled "external transmissions" do not need to be in a form assimilable by the simulation. In fact, they will be ignored by the simulation and will be generated only by live staff modules. Their content and time of submission may be useful for evaluating live staff performance. By the same token, the inputs labeled external message receipt are not generated by the simulation and can, in fact, be part of the initial scenario preparation. Such inputs would not have to be strictly formatted for entry into live staff modules, but when the staff module is simulated such entries must be assimilable by the simulation. It should be noted that all data exchanges with higher headquarters do not necessarily have to be of this type. For example, a query to corps or a request for reinforcement could be a direct entry into the decision outcome generator; in this case, a controller is simulating Corps HQ. The remaining message exchanges, transmissions, and receipts must be made explicit at the module boundaries so that any module can be populated by live players. Furthermore their interconnection with simulated events, either within or other staff modules or in in the decision outcome generator, must be established.

The second step in screening inputs/outputs involves a review of the listed data exchanges to see which ones are pertinent within the expected running time of the simulation. Since the simulation is of division level combat, it is estimated that there will be little requirement to run the simulation for a time period (real time = game time) greater than 12 hours. On this basis a number of reports generated by staff modules at periods of 24 hours (e.g., the INTSUM) can also be treated as external transmissions. Even though the INTSUM is provided to other staff modules by G-2, it is basically a compilation of past events in a convenient format for reference. Actually, the germane information would already have been passed to the affected staff modules as retransmissions of spot reports or combat intelligence reports. Thus, the INTSUM can be treated as an external transmission even though it is normally routed to higher HQ, to subordinate units, <u>and to other staff modules</u>. This means that only live staff modules will be required to produce INTSUMs and this output does not have to be entered into the simulation. If it is needed as an input to some other live staff module (e.g., G-3) it can be handled as an external message receipt, i.e., prepared in advance of the simulation, and does not need to be generated by the simulation.

Table 3-4. Input/Output Classification Based on Relationship to the Simulation.

	External Transmissions	Message Exchange	Message Transmission
OUTPUTS	Do not interact with simulation, e.g., report to higher or adjacent HQ	Message goes to another staff module, e.g., staff estimate	Message goes directly to decision outcome generator, e.g., frag order
	External Message Receipt	Message Exchange	Message Receipt
INPUTS	Message is not produced by the simulation, e.g., Corps OPORDER	Message comes from another staff module, e.g., staff estimate	Message comes directly from decision outcome generator, e.g., spot report from subordinate HQ

The third step in the process of developing the final list of formats consists of sorting based on content. It is highly likely, for example, that a number of spot reports with different names, based on content, can in fact be represented by a single format containing the basic "who, what, where, when, why" data. On the other hand, it may also be necessary to break out some of the inputs shown as single entries in Table 3-3 into multiple formats in order to accommodate different information categories. After this process was completed we were in a position to make the final format selection and definition. The formats selected appear at Design Note D.

3.3 DYNAMIC REALISM

The realistic time sequencing of events in the simulation is based on an event-store technique in which the simulated time clock is tied to a real clock so as to provide slow time, real time, or fast time play. The input to individual Blue staff modules or to the Red command module, i.e., the tactical information messages from the field (or from higher headquarters), represent one class of events whose sequencing must fit into the event-store framework. The output directives and orders from Blue staff modules to Blue units in the field or from the Red command module to its subordinate units represent a second class. In addition to these "interfacing" classes, there are three other classes of events which must also be handled by the event-store mechanism.

The five classes of events required in the simulation are defined in Table 3-5. Each class will require a separate set of rules or algorithms in the simulation, but all classes will have to fit into the general event-store framework. The separate modes for handling the events, examples of events in each class, and special simulation techniques to be employed with some classes are presented in paragraph 4.1.

The logical flow of the simulation procedures providing the time sequencing of events is illustrated in Figure 3-1. The process will require a large data storage array called the Event Table. The table will contain separate entries for all events (of all five classes) that will occur at some time in the future of the current simulated clock reading. Such entries will be called "scheduled events". They will be extracted from the table and the corresponding entries erased when the simulated clock arrives at or near the time associated with the individual events. If one or more new events arise as a consequence of the processing of a scheduled event, these new events are then put into the Event Table so that they become scheduled for processing at some future time on the simulated time clock.

Table 3-5. Event Classes for the Integrated Division-Level Battle Simulation.

1. Staff Processing Event	Action-handling event internal to a staff module; carried out by live players or else simulated
2. Message Exchange Event	The passing of tactical information from one staff module to another; never used in the Red command module
3. Message Transmission Event*	Output from an individual Blue staff module or the Red command module
4. Message Received Event*+	Input to an individual Blue staff module or the Red command module
5. Battle Event *+	Any event in the simulated combat that is not one of the above

*These events may be further qualified by the adjective "external", which means they stem from or lead to elements outside the simulation: Corps HQ, acts of God, etc.

+These events have the "not really" property; they are always scheduled in the event table, but they may not actually occur because intervening events have changed the course of the simulation.

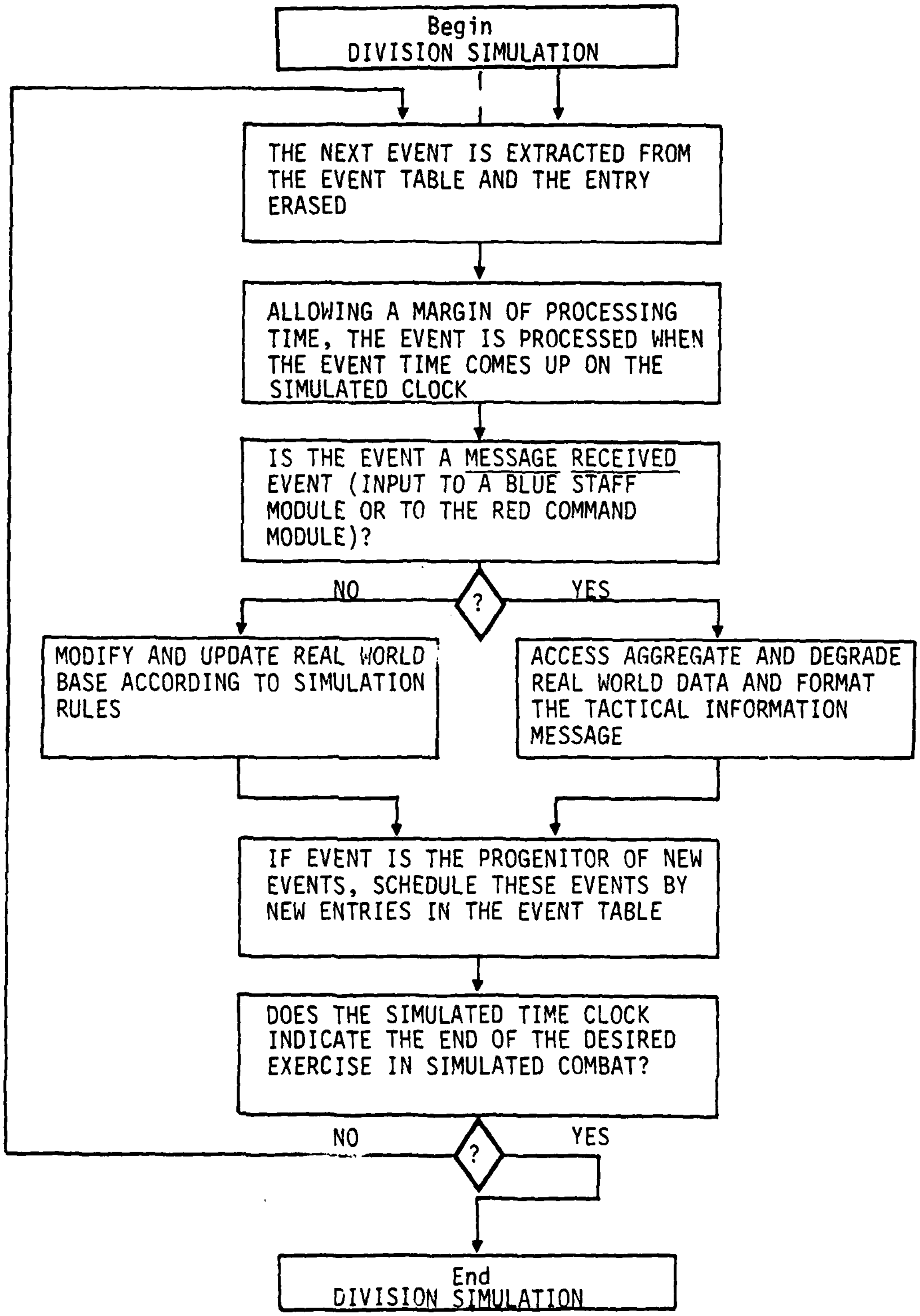


Figure 3-1. Logical Flow of the Event-Store Simulation.

The central data processing problem in implementing this event-store technique is the ordering or arranging of the scheduled events so that they may be readily extracted in the proper time sequence. It is estimated that the number of entries in the table (covering all classes of events) will range between 100 and 500 during any moment in the active play of the simulated combat. However, the loading of each new event requires that the order of arrangement of entries be modified so that the correct time sequence is preserved.

3.4 DESIGN DECISIONS

A number of questions arose during the evolution of the top down design of the simulation. The resolution of each of these questions affected the overall design concept. Most of these were resolved during Phase I of the design effort and the decision made is discussed below. However, in two cases the questions were not resolved and additional design effort is needed.

3.4.1 Traditional G Staff Versus Bi-Functional Staff

This question was raised in paragraph 2.4.2. The nature of the difficulty can best be appreciated by looking at the staff structure specified by some of the current doctrinal literature. This is illustrated in Figures 3-2 through 3-5 which have been extracted from TC 101-5, "Control and Coordination of Division Operations," April 1976. Figure 3-2 shows the configuraiton for a division tactical command post (TAC). Figure 3-3 shows the configuraiton of the Main division command post while Figure 3-4 is a blow-up of the Tactical Operations Center (TOC) contained in "Main". It is immediately apparent that the G-staff functions are not the basis for organizing the various staff activity centers. G-2, G-3, and FSE functions are being performed both at TAC and at TOC. In fact, the same is also true of command group, G-1, and G-4 functions, although to a lesser degree. Figure 3-5 is a representation of the locations in which G-2 functions are performed which have been indicated by cross-hatching. It will be seen that G-2 functions are being performed at four different activity centers, three in TOC and one in TAC. The difficulty of designing a pure G-2 module now becomes clear. If the requirements for man/simulation interface are to be met, the "players" or "subjects" must be played in a realistic operational environment. The reason for combining G-2 and G-3 elements in an Op Center at TOC is the extensive interface between these two staff elements needed for actual operations. That interface would have to be simulated by controllers for a "pure" G-2 module.

A basic principle of any modular design is to draw the boundaries around modules so as to minimize the interconnections between modules. A feasible modular structure that parallels TC 101-5 is depicted at Figure 3-6. The five modules identified are:

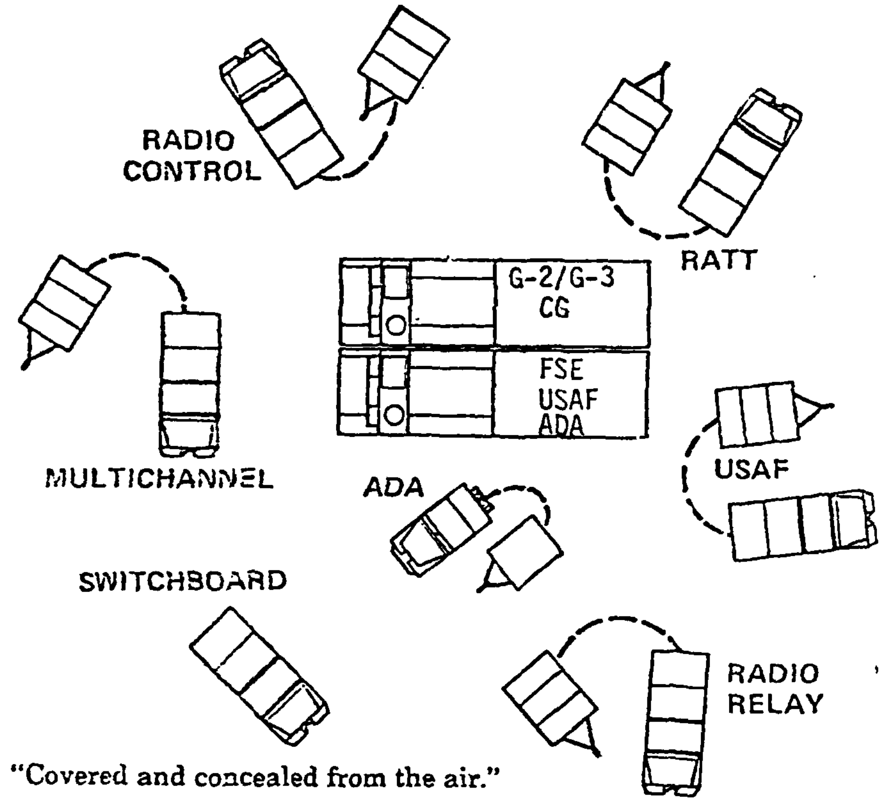


Figure 3-2. Tactical Command Post Configuration.

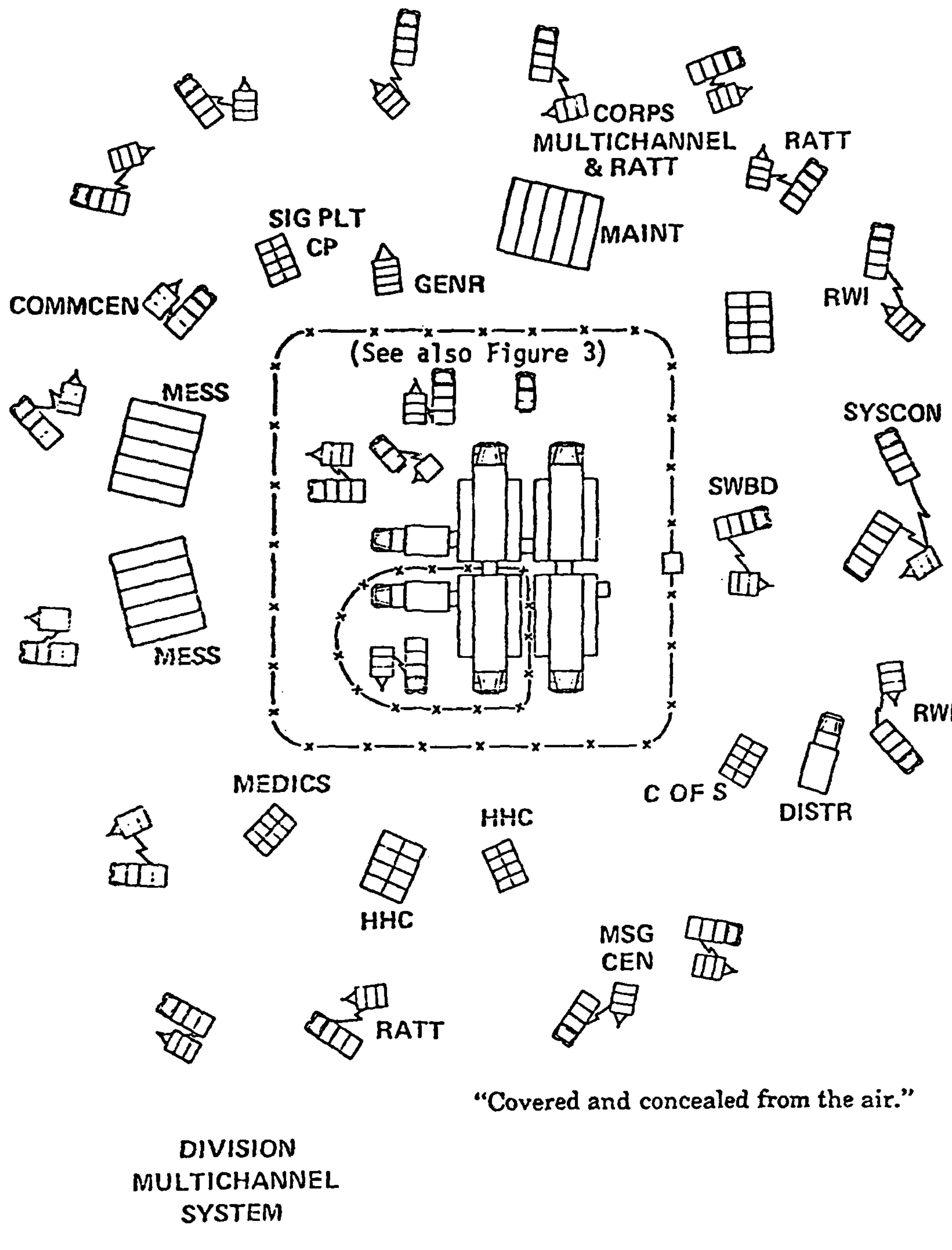


Figure 3-3. Main Command Post Configuration.

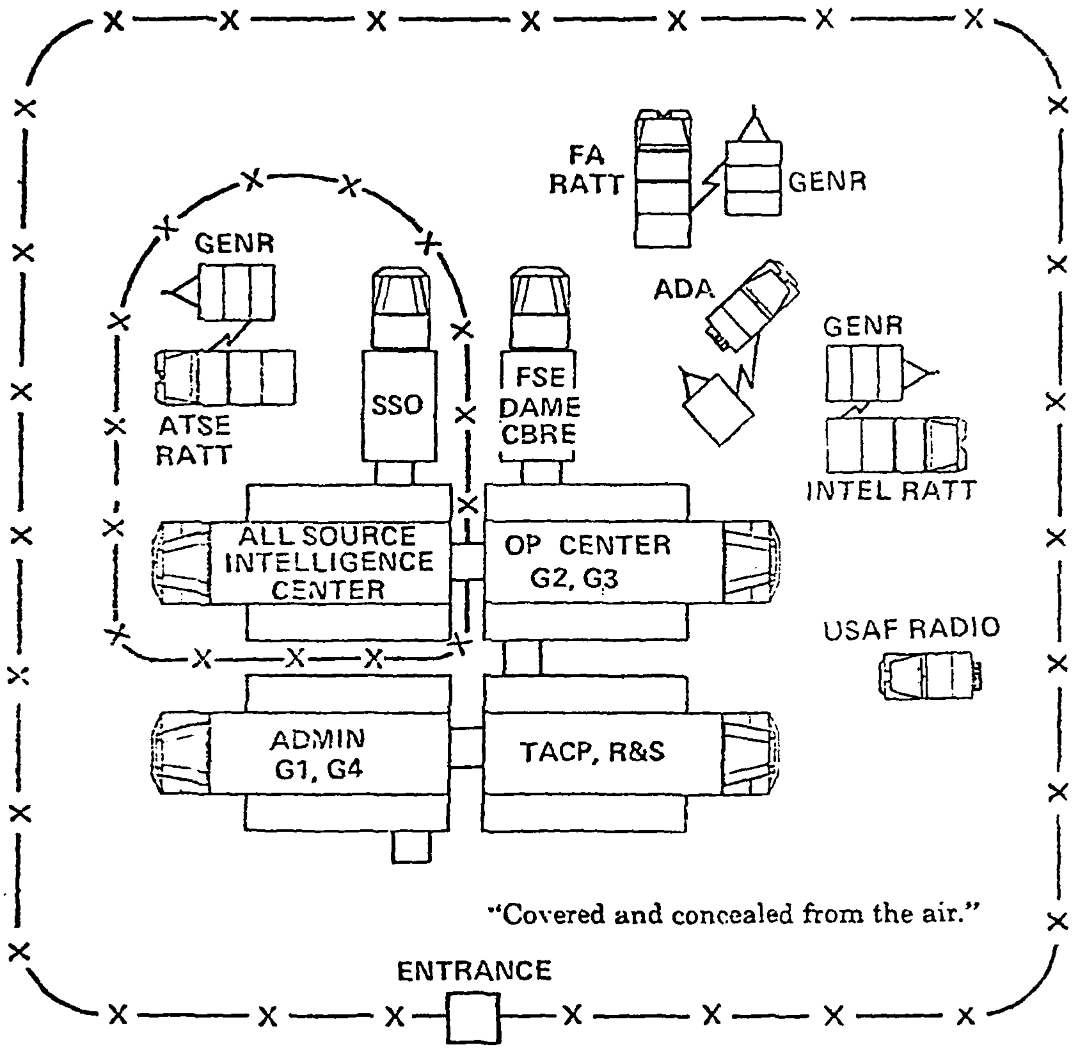


Figure 3-4. Tactical Operations Center Configuraiton, Main CP.

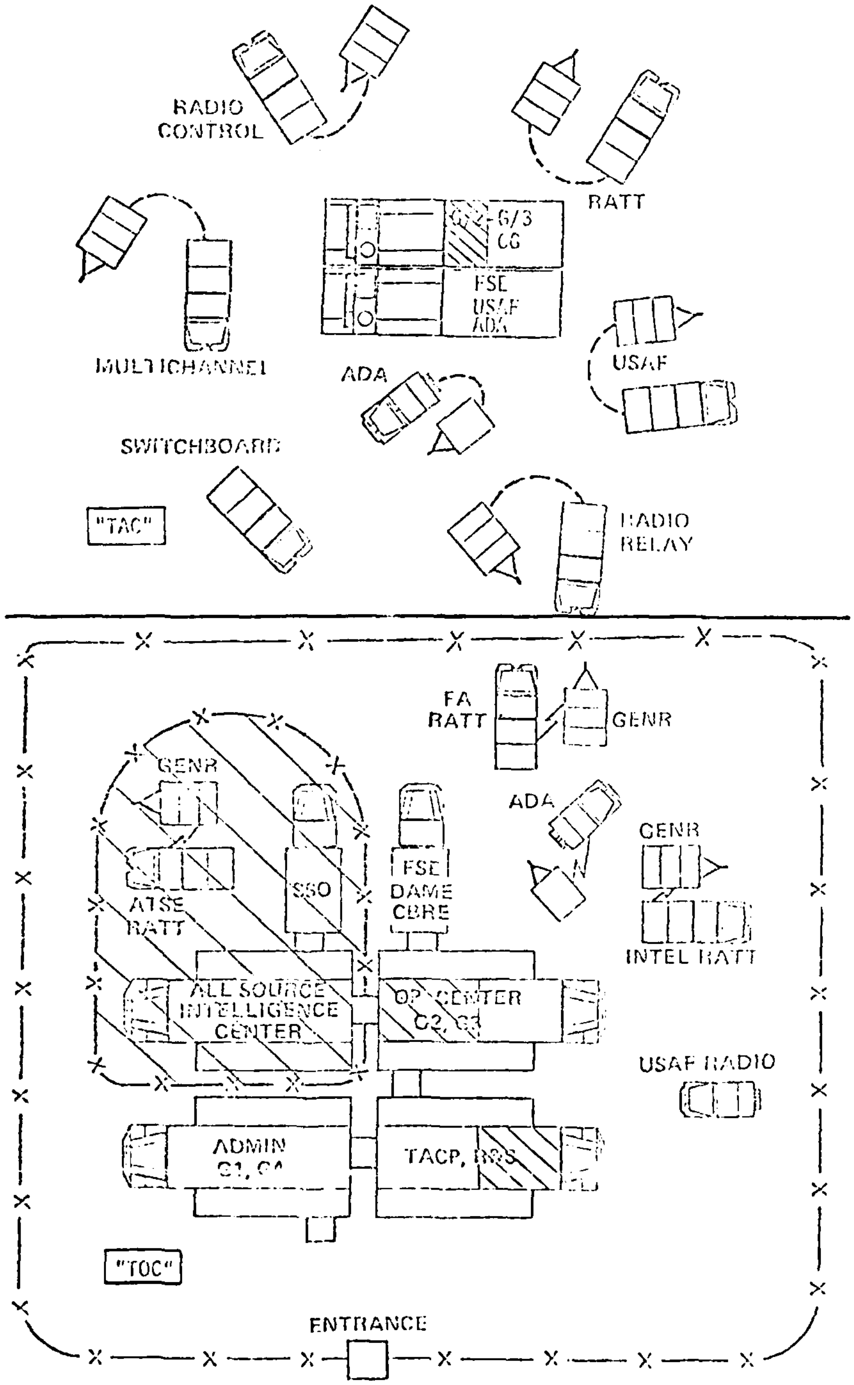


Figure 3-5. Locations of G-2 Activities.

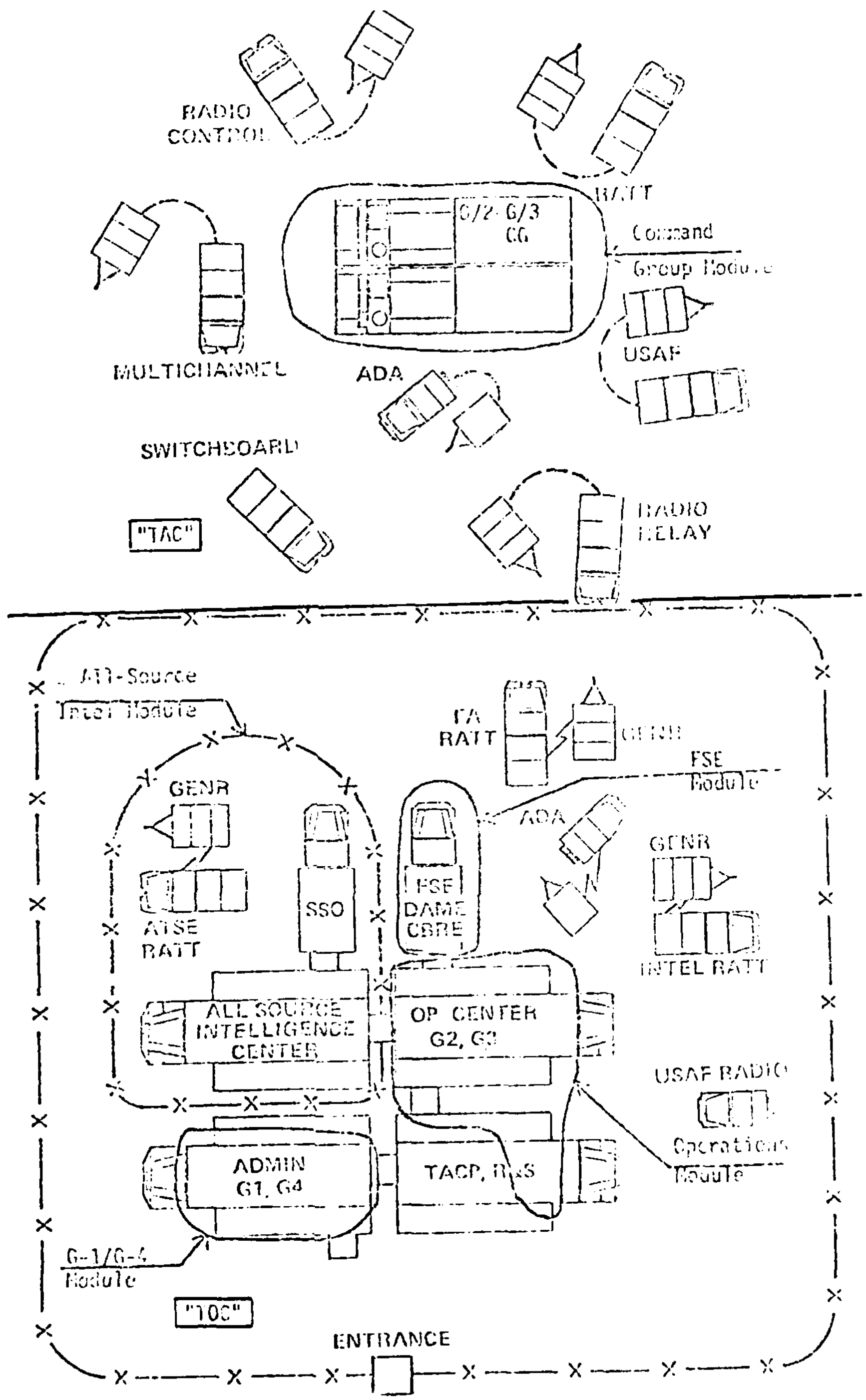


Figure 3-6. A Feasible Modular Structure.

- Command Group at TAC (to include G-2/G-3/ADA/FSE/USAF elements)
- Operations Center at TOC (to include Reconnaissance and Surveillance element)
- All-Source Intelligence Center at TOC
- FSCE at Toc
- ADMIN, G-1/G-4 at TOC.

The above discussion brings into clearer focus the problem raised in the discussion of modular structure in paragraph 2.4.2. The identification of inputs and outputs for each of the G-staff elements is fairly straightforward from the doctrinal literature. This is not the case for the bi-functional staff described in TC 101-5. The identification of the inputs and outputs for each of the staff modules in the bi-functional staff is not spelled out in the doctrinal literature and would, in fact, depend on the SOPs in effect in a particular division. In effect, one would have to make an arbitrary assignment of decision outputs to each module and determine the inputs needed to support these. This process is compounded by the fact that under this concept the module boundaries now separate portions of the same G-staff module (for example, G-2 activities would be carried on in three different modules). This means that the data exchanges between different portions of the G-2 staff element would now have to be made explicit at the new module boundaries, whereas they were implicit within G-2 when it was a single module. Thus, the module input/output matrix could, in fact be significantly larger resulting in a larger number of formats that would have to be handled by the simulation.

These considerations were discussed at some length with ARI and jointly with representatives of ARI and the Command and General Staff College at Ft. Leavenworth. The final decision was that the traditional G staff organization would be the basis for organizing the staff modules in this simulation.

3.4.2 Nuclear Events

A design decision was required with respect to including nuclear events in the simulation. The inclusion of such events imposes the following additional requirements on the design of the simulation:

- Adds the requirement for unique exchanges between staff modules (Class 2 events).
- Adds the requirement for unique outputs from the staff modules to subordinate, adjacent, and higher headquarters (Class 3 events).

- Adds the requirement for unique inputs to the staff modules from subordinate, adjacent, and higher headquarters (Class 4 events).

The above requirements, in turn, require:

- Unique events internal to the staff modules for processing decisions associated with nuclear events (Class 1 events).
- Unique events internal to the battle outcome generator and the rest of the outside world (Class 5 events).
- Unique characteristics for units within the data base, e.g.,
  - Individual nuclear rounds remaining in nuclear capable delivery units.
  - Changes to the combat effectiveness of combat units in a "warned" posture.

Despite the additional complexity incurred by including the capability to exercise the decision variables associated with nuclear warfare, this capability is of such importance that it was included in the simulation design and the associated events are included in the detailed annexes. It is, of course, not necessary to use nuclear events in any particular scenario if not required for the purpose of the investigation.

3.4.3 Simultaneous Planning, Execution, and Reporting

Another design decision concerned the requirement to exercise the staff modules simultaneously in activities associated with planning future operations and executing and reporting on current operations. A number of considerations entered into this decision. First, staff planning is normally isolated from the monitoring of current operations because:

- "Operations" is concerned with the management of the execution of a prior plan.
- The planning process is triggered by an actual or projected change in mission and is based on (and as insensitive as possible to) assumed future states (capabilities, threat, environment.
- Plans are revised (coupled to real world states) as the time for execution approaches.

Hence, there is little requirement for real time inputs from the ongoing battle purely for planning purposes.

The second consideration was that computer simulation can assist planning but not plan. This results directly from the fact that the degree of uncertainty associated with planning is even higher than that associated with execution. After all, the decisions required during execution concern the modifications required to adapt a prior plan to the realities of the world as the uncertainty is reduced through execution. If the latter decisions are too complex to simulate completely by means of computer algorithms, this is even more true of planning decisions.

Finally, the worth of a plan, once prepared, can be evaluated in only one of two ways (see also the discussion at paragraph 2.4.4):

- Comparing it the "school solution" (experience).
- Implementing it, to include simulating its execution.

The above considerations led to the basic decision that the activities associated with the preparation of complete, formal operations plans and orders, or the portions thereof assigned to a particular staff module, would be performed only by live staff modules and not by simulated staff modules. Data required by a live staff module for OPLAN/ORDER preparation can be obtained in one of two ways:

- Current situation data may be obtained "on-line" by queries to simulated staff modules or the battle outcome generator, as appropriate.
- Other data will be prepared "off-line" in advance by the controller and may be accessed by the players on request.

A completed OPLAN/ORDER (or assigned portions thereof) is transmitted by the live staff module to the controller who logs it in for later evaluation of staff module performance. Such an OPLAN/ORDER has no direct impact on the ongoing simulation. The requirement to perform such planning activities does, of course, impact on the workload, and hence the stress, imposed on a live staff module and thus effect its performance in monitoring and controlling the on-going battle.

If a completed OPLAN/ORDER is to be evaluated by executing it within the simulation, it can be introduced by the controller in the same way that he would introduce the special situation and any operations orders prepared by players in advance of the simulation, normally by means of a preprocessor, for any other kind of play. This will, however, require that the on-going play be stopped at some appropriate juncture in order to transition to a new OPLAN/ORDER.

3.4.4 Other Staff Elements

As has already been indicated in paragraph 3.4.1 above, there are many other staff elements collocated or closely associated with the five staff modules of the Blue staff being simulated. For example, much of the detailed management of the sensor systems available to the G-2 and the production of intelligence from these sources is performed at the All Source Analysis Center (ASAC) which is part of the operations center of the CEWI Battalion. Similarly, engineer information processing is performed by an engineer element, CBR processing by a CBRE, Army air activities by a DAME, Air Force air support activities by a TASE, etc. The decision was made to incorporate such activities into the battle outcome generator where they would be handled in the same way as subordinate units, i.e., their activities would not be simulated explicitly, but those of their outputs and inputs that flow across the five explicitly modeled staff modules would be made explicit as are orders to and reports from subordinate units.

3.4.5 Simulation of Command and Control

The following question arose with respect to the design of the simulated command and control elements within the simulation:

- How can the simulation of command and control actions within the simulation (non-populated staff modules, other staff elements not specifically represented, and subordinate staffs) be carried out so as to reflect a realistic, variable level of performance by populated staff modules?

This problem is best explained with reference to Figure 4-1. As shown in that figure, Class 1 events occur within staff modules; Class 2, 3, and 4 events occur at the staff module boundaries; and Class 5 events occur within the Battle Outcome Module. The design provides that these events are to be connected by event threads which cause the successive events to occur in the prescribed logical sequence. Within a populated module the players themselves carry out the Class 1 events and react to or generate the interface events. In a simulated module, these threads must be provided within the simulation. It is conceptually a simple matter to close the event threads that are routed through the simulated modules so that they are essentially insulated from any perturbations to the information flow that might occur if a populated module did not behave in the manner being simulated when the module is not populated. If the model were designed in this manner, the only abnormal behavior of a populated module that would be reflected in the simulation would be failure to close an event thread that led through that module. Such a design would not be responsive to the major objective of providing feedback to players on the results of their actions. The simulation should show the effect of degraded performance within a live staff module in all of the other command control activities being simulated. This will require very careful and detailed analysis of all event thread routing to insure that the effects of incorrect staff action by a live staff module are, in fact, portrayed as unforeseen events and delayed and/or degraded reports that would result. Examples of such degraded performance by a live G-2 module would be: faulty tasking of sensor systems that would reduce the enemy information available to the command group or the G-3; Assignment of an intelligence mission to the cavalry squadron without coordination with G3 which resulted in non-availability of the squadron for an operational mission; or faulty tasking of sensor systems that denied important target information to the FSE.

One important facet of this problem that cannot be overlooked is the real world response time to such faulty actions. For example, faulty tasking of sensors by G2 that resulted in degraded target information for the FSE would affect the on-going battle. Faulty sensor tasking that reduced intelligence available to the G3 or the command group could affect the on-going battle, but would even more likely lead to bad planning for tomorrow's battle. The latter effect is difficult to capture in a 4-12 hour scenario. Thus, the effects of faulty staff actions that lead to degraded planning for future action may be difficult to capture without implementing the faulty plan.

This problem has not been resolved in the current effort and additional design effort will be needed before a simulation can be built that will implement this design objective.

3.4.6 Task Design for Interactive Simulations-

Another question arose with respect to populated, i.e., interactive, staff modules:

- How should the tasks within a populated staff module be designed or redesigned so as to emphasize those tasks which are the subject of investigation, deemphasize those which might only increase player boredom and decrease his interest, and do this in a manner which retains realism and credibility?

This problem arises from the following consideration. If the simulation is to be a cost-effective tool for research, not only must the personnel requirements be held to a minimum in the control section, but the number of players in a live staff module must also be held to a credible minimum. One way to approach this goal is to eliminate some of the low skill level, high frequency, and hence, boring tasks within the staff module. An insight as to what this entails may be gained by viewing the staff module as a decision node and looking at the sequence of kinds of processes that it performs.

Figure 3-7 is a representation of a series of processes such as a decision node carries out on information flowing through the node. At the bottom of the figure is an external information stream--the communications network--which the node taps and to which it contributes. Six progressively more complex processing levels are depicted. The information that flows up from the external stream must first be received, a Level I or communications process. The received information in a tactical military system is in the form of orders (plans), summaries, reports, queries, or requests. These must be tagged, sorted, recorded (think of the large number of telephone and voice radio inputs), and used to update files; much of it is also displayed on situation maps or "totes." The composite of these processes may be called Level II or message center and filing processes. The Level II processes produce a data base, some part of which is in the form of visible displays for ready reference. It is pertinent to comment in passing that the graphical representation of certain kinds of information on a situation map is the substitute for the hill overlooking the battlefield and for helicopters when the latter cannot fly or see.

The next four process levels use the files in successively more complex ways. Note that they, too, update the files, but these updates are more in the nature of manipulations on the basic data added by Level II. These utilization processes begin with Level III, selective retrieval of information from the files. At Level IV, such data are aggregated by means of a priori rules, which may vary from simple arithmetic combinations to more sophisticated rules of combination such as the appearance of three or four maneuver battalions operating in the same area triggers the search for their associated fire and service support elements. The important consideration is that the rules for aggregation have been determined in advance and are stored. Process Level V also aggregates data, but the rules for aggregation are devised by the user in real time--that is, he hypothesizes, through pattern recognition, new and higher level interpretations of the data being presented. For example, the rapid increase in density of artillery in a given sector is interpreted as an indicator of enemy intent to attempt a breakthrough in that sector. Process Level 5 may also be accomplished in a succession of stages that amounts to piling hypotheses one on top of another. Furthermore, data aggregations may be extrapolated forward in time. This amounts to yet another hypothesis formulation of a different type; assumptions are made about observed rates and/or accelerations. For example, examination of present positions and rates of advance for both sides leads to a prediction that the main battle will occur at point Y at time T. Level V produces what is commonly called "perception." At the highest level, Level VI, data aggregations are compared and evaluated, and one or more are selected. This last is the culmination of the decision process.

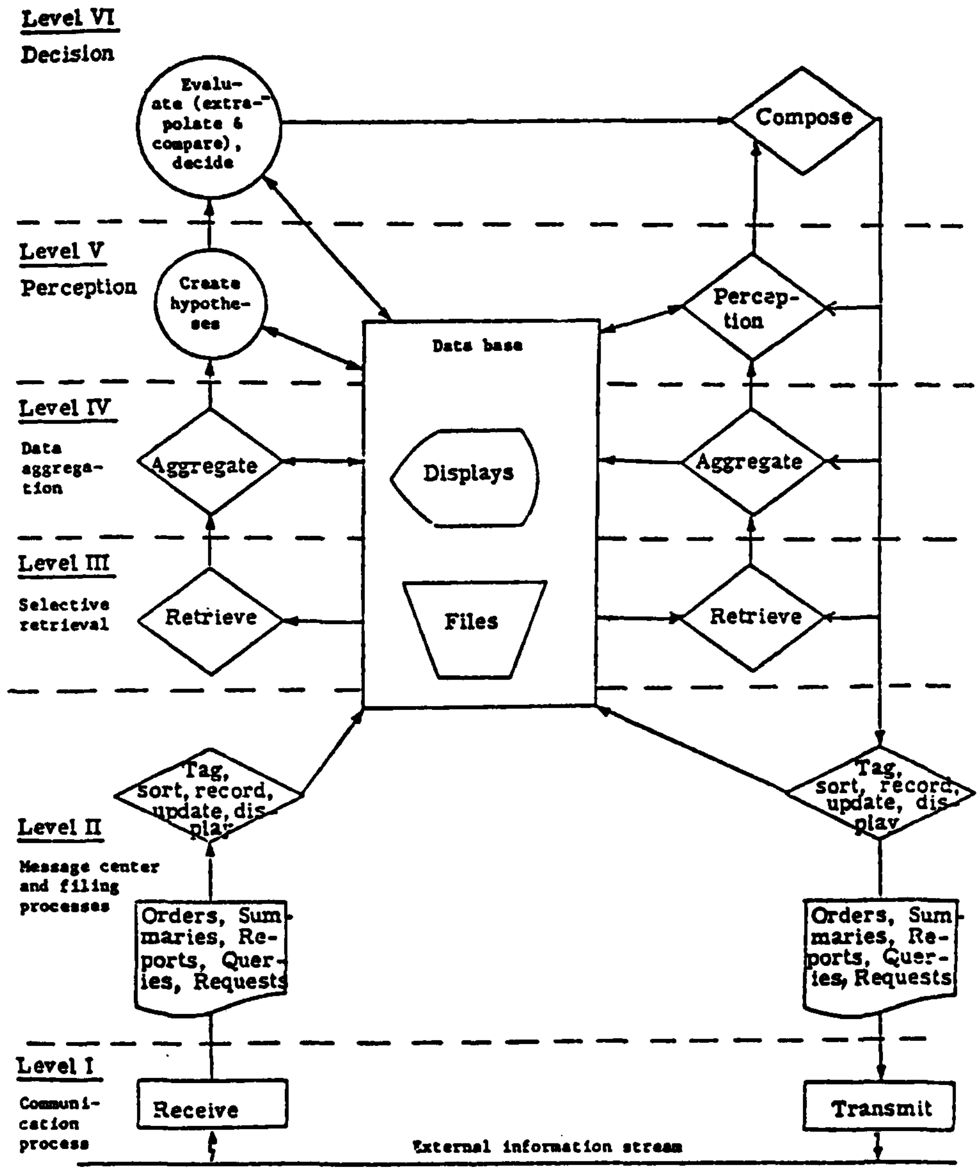


Figure 3-7. Process Levels in a Tactical Decision-Making Node

Implementation of the decision requires composing a decision node output that will be in one of the same forms as were the inputs. The more complex of these outputs can involve further utilization of the data base at Levels III through V as indicated. This implies that the basic decision acts like a new system input that triggers additional subordinate decisions necessary for the implementation of the basic decision. As the arrows show, there may therefore be reiterative cycling through the data base to complete the composition of the staff output that implements the basic decision. It will be noted that this view of the command and staff processing of information is essentially the same as that presented in Chapter 5 of FM 101-5[1] and is just another way of looking at the functional flow chart of the commander's information flow and decision processes. Note too that every output from the node involves some processing at Level VI. This may be as simple as a decision to relay an incoming message to a new addressee, which says that almost every process at every level has been a one-for-one transformation except for the selection of one or more new addressees for an incoming message.

With this view of a manual information processing system, we can gain some insights as to what might happen when we, in effect, shift the interface between the staff module and the outside world from its peripheral communication nodes and move some of the lower level communication and message center and filing functions out of the module and into the simulation. We are now faced with the problem of redefining the tasks to be conducted within the staff module in such a way that the node remains a realistic, credible, military decision-making environment, i.e., appears to the players to be a staff element and not a laboratory for studying human reactions. The problem is quite similar to that faced by the ADP assisted system designer becaust it amounts to shifting the interface between the decision maker and the outside world (see also paragraph 3.4.7 below).

This problem, too, can use additional design effort in order to assure that the simulation, when built, has maximum utility as a research tool.

3.4.7 ADP Assisted Staff

Paragraph 2.4.5 has already pointed out that providing ADP assistance to the staff substantially complicates the information flow. Not only must computer terminals be added to the populated staff modules, but the simulation data base must be expanded to provide information to players in different formats and aggregated differently. For example, much information provided players on a spot report basis in the manual mode is replaced by access to a

1U.S. Department of the Army, Staff Organization and Procedure, FM 101-5, Washington, July 1972.

special data base that is updated as a result of simulated events to reflect the current status of the forces being managed. Such a capability adds a new class of events to the simulation which is defined in Paragraph 4.1. In order to have maximum usefulness, the simulation should also be able to reflect the effects of making adaptive software available to players, thus permitting players to make changes in the amount, kind, reporting frequency, and the format of the displayed information. In order to keep the problem reasonably tractable and also within anticipated budget constraints, the initial implementation of the model will be a simulation of manual data exchanges between players and the simulation. The basic design, as will be discussed in Section 4, will permit the addition of an ADP-assisted staff capability as an increment at a later time.

3.4.8 Initial Configurations

Another design consideration that needed attention was the question of the number of staff modules that could be populated simultaneously. Although the original design concept included all possible combinations from zero to six (including the Red player module), it soom became apparent that handling a significant number of live modules simultaneously would require a substantial personnel complement within Control. More than one or two personnel within Control would make running the model prohibitively expensive and there is no immediate requirement to handle more than two populated staff modules at one time. It was therefore decided that the initial implementation would be limited to not more than two populated staff modules. The expansion of this capability to permit other and larger configurations will be considered at a later time after experience is acquired in the actual loadings that will be imposed on Control. It is also likely that the provision of ADP assistance to staff modules will reduce the requirement for Controller intervention in the data flow. This is discussed in more detail in Paragraph 4.4.

Section 4

TOP-DOWN DESIGN

This section presents, first, the general design concept, for the integrated division-level battle simulation, and second, the basic elements of the proposed initial implementation. The initial implementation will be subject to the following specific constraints on the scope of the full concept:

- One or two human controllers, aided by computerized preprocessing capabilities and an interactive executive control routine, will control the play of the game.
- Configurations of play will be limited to no more than two populated staff modules (any two out of six modules).
- Blue staff modules will operate under a manual staff system only.

The section begins with the fundamental structure of the design concept. This structure is followed by the specification of the proposed physical layout, computer capabilities, and controller functions required for the initial implementation. The basic elements of the implementation and the proposed general approach for attaining them are then described. The section concludes with two subsections: one demonstrating the manner in which the first implementation provides a framework capable of extensions and augmentations beyond the constraints shown above and the other providing insight as to the applicability of the simulation for behavioral science research, evaluation of doctrine and tactics, and training of the division command groups/staff.

4.1 DESIGN CONCEPT

The fundamental design concept of the integrated division-level battle simulation is that of an event-store simulator in which the simulated time clock is geared to a real clock so that the simulated combat may be played in slow time, real time, or fast time. The basic structure of the system as depicted in Figure 2-6 consists of seven functional "boxes" or simulation modules in which command and staff operations and the resulting division-level combat are simulated by the dynamic portrayal of the occurrence of significant events in the battle. The structure handled five classes of such events, as follows:

- Class 1 - Staff processing events.
- Class 2 - Exchange of tactical information between staff elements.

- Class 3 - Tactical information outputs from staff elements.
- Class 4 - Tactical information inputs to staff elements.
- Class 5 - All other events in the battle simulation.

The seven modules, and the places where the five event classes fitted into the conceptual structure, are shown in Figure 4-1.

Subsequent to presentation of the original concept the basic structure has been further defined to reflect the following additional components:

- An additional functional module - a module which simulates higher headquarters, adjacent division headquarters, Blue staff elements not delineated by the boxes on the left, and "acts of God" events.
- An additional defined event class - Class 6 events which are interface events between staff elements and their ADP terminal devices.
- The controller's role in the simulation.

The modified conceptual structure is shown in Figure 4-2.

4.1.1 Configurations

In the basic concept shown in the two figures, the five Blue staff modules on the left and the single Red command module on the right may consist of either a group of human players executing standard staff procedures or else a set of simulation rules or algorithms for processing the Class 1 and Class 6 events inherent in the staff procedures. The choice between the populated version of these modules or the simulated version depends on the application.

Since the simulation rules or algorithms throughout the structure will always depend on the choice of configuration being played, that is, the combination of populated modules and simulated modules in the game, the configuration number has been defined as a basic control variable in the system. The definition is embodied in Table 4-1.

Configuration number is an integer with a value zero to 63. The binary representation of configuration number delineates the populated modules and simulated modules selected for play. The control variable itself must be incorporated into the basic logic of all simulation rules in order to assure that the proper internal and external routing of tactical information messages is preserved.

It should be noted that the basic design concept, with its 64 alternative configurations, reflects a fundamental asymmetry with

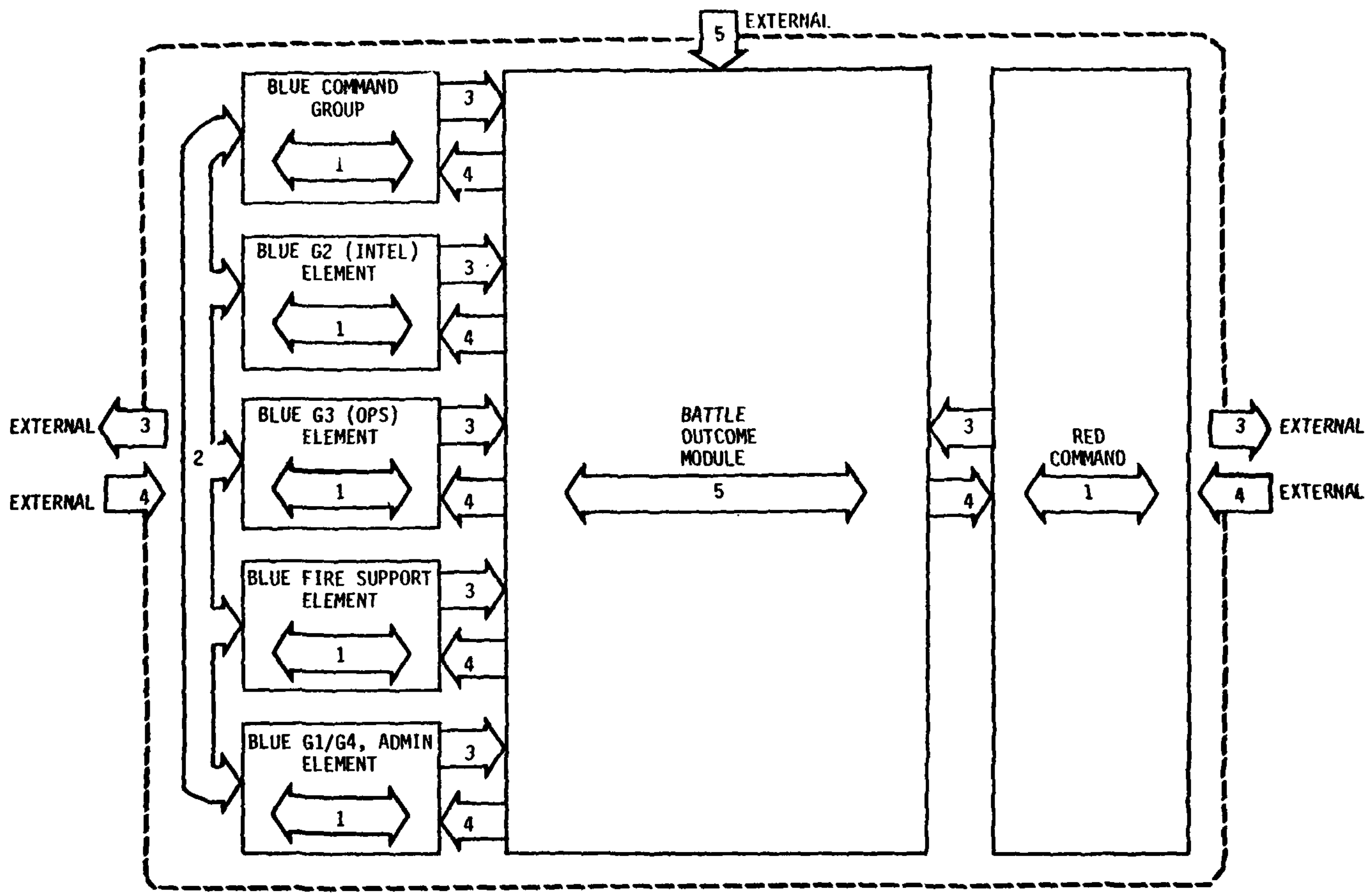


Figure 4-1. Basic Modules of the Integrated Division-Level Battle Simulation, Showing the Five Classes of Events.

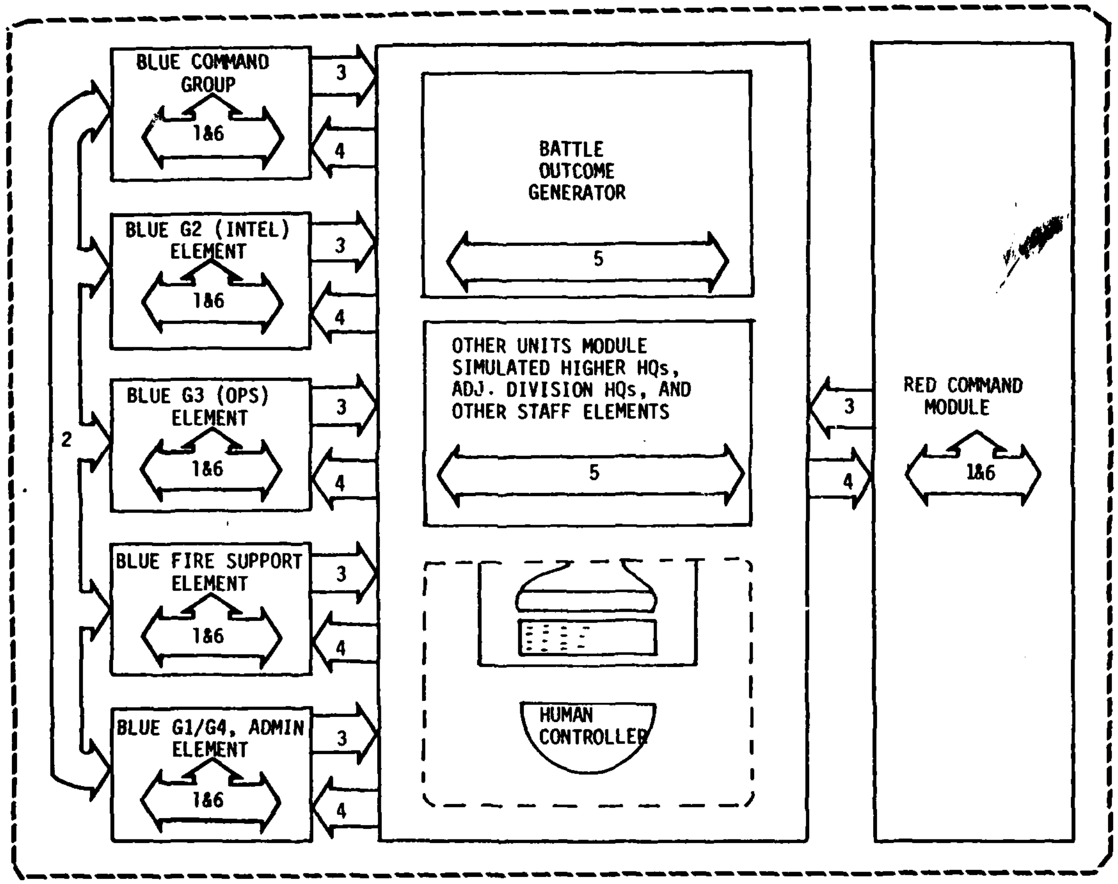


Figure 4-2. Modified Version of the Integrated Division-Level Battle Simulation Showing the Six Classes of Events.

Table 4-1. Configuration Number

CONFIGURATION NUMBER	BINARY REPRESENTATION	NUMBER OF POPULATED MODULES	IDENTIFICATION OF POPULATED MODULES
0	000000	0	(none)
1	000001	1	BLUE CG
2	000010	1	BLUE FSE
3	000011	2	BLUE CG and FSE
4	000100	1	BLUE G2
5	000101	2	BLUE CG and G2
6	000110	2	BLUE FSE and G2
7	000111	3	BLUE CG, FSE, and G2
8	001000	1	BLUE G3
9	001001	2	BLUE CG and G3
10	001010	2	BLUE FSE and G3
11	001011	3	BLUE CG, FSE, and G3
12	001100	2	BLUE G2 and G3
13	001101	3	BLUE CG, G2 and G3
14	001110	3	BLUE FSE, G2 and G3
15	001111	4	BLUE CG, FSE, G2, and G3
16	010000	1	BLUE G1/G4
17	010001	2	BLUE CG and G1/G4
18	010010	2	BLUE FSE and G1/G4
19	010011	3	BLUE CG, FSE, and G1/G4
20	010100	2	BLUE G2 and G1/G4
21	010101	3	BLUE CG, G2, and G1/G4
22	010110	3	BLUE FSE, G2, and G1/G4
23	010111	4	BLUE CG, FSE, G2, and G1/G4
24	011000	2	BLUE G3 and G1/G4
25	011001	3	BLUE CG, G3, and G1/G4
26	011010	3	BLUE FSE, G3, and G1/G4
27	011011	4	BLUE CG, FSE, G3 and G1/G4
28	011100	3	BLUE G2, G3, and G1/G4
29	011101	4	BLUE CG, G2, G3, and G1/G4
30	011110	4	BLUE FSE, G2, G3, and G1/G4
31	011111	5	BLUE CG, FSE, G2, G3, and G1/G4
32	100000	1	RED CMD only
33	100001	2	BLUE CG vs RED CMD
34	100010	2	BLUE FSE vs RED CMD
35	100011	3	BLUE CG, FSE vs RED CMD
36	100100	2	BLUE G2 vs RED CMD
37	100101	3	BLUE CG, G2, vs RED CMD
38	100110	3	BLUE FSE, G2 vs RED CMD
39	100111	4	BLUE CG, FSE, G2 vs RED CMD
40	101000	2	BLUE G3 vs RED CMD
41	101001	3	BLUE CG, G3 vs RED CMD
42	101010	3	BLUE FSE, G3 vs RED CMD

Table 4-1. Configuration Number (continued)

CONFIGURATION NUMBER	BINARY REPRESENTATION	NUMBER OF POPULATED MODULES	IDENTIFICATION OF POPULATED MODULES
43	101011	4	BLUE CG, FSE, G3 vs RED CMD
44	101100	3	BLUE G2, G3 vs RED CMD
45	101101	4	BLUE CG, G2, G3 vs RED CMD
46	101110	4	BLUE FSE, G2, G3 vs RED CMD
47	101111	5	BLUE CG, FSE, G2, G3 vs RED CMD
48	110000	2	BLUE G1/G4 vs RED CMD
49	110001	3	BLUE CG, G1/G4 vs RED CMD
50	110010	3	BLUE FSE, G1/G4 vs RED CMD
51	110011	4	BLUE CG, FSE, G1/G4 vs RED CMD
52	110100	3	BLUE G2, G1/G4 vs RED CMD
53	110101	4	BLUE CG, G2, G1/G4 vs RED CMD
54	110110	4	BLUE FSE, G2, G1/G4 vs RED CMD
55	110111	5	BLUE CG, FSE, G2, G1/G4 vs RED CMD
56	111000	3	BLUE G3, G1/G4 vs RED CMD
57	111001	4	BLUE CG, G3, G1/G4 vs RED CMD
58	111010	4	BLUE FSE, G3, G1/G4 vs RED CMD
59	111011	5	BLUE CG, FSE, G3, G1/G4 vs RED CMD
60	111100	4	BLUE G2, G3, G1/G4 vs RED CMD
61	111101	5	BLUE CG, G2, G3, G1/G4 vs RED CMD
62	111110	5	BLUE FSE, G2, G3, G1/G4 vs RED CMD
63	111111	6	BLUE CG, FSE, G2, G3, G1/G4 vs RED CMD

respect to the Blue and Red sides in the play of division-level combat. The Blue side will always consist of the division command group and principal staff sections, whether the individual staff elements are populated modules or simply simulated modules. The Red side, on the other hand, will consist of only the Red commander himself (with possibly an assistant). The Red Command Module will always present the commander with "completely staffed" alternatives for decision. He will execute his command functions without further assistance from staff elements.

4.1.2 Classes of Events

The different classes of events associated with the basic design concept are shown in Figure 4-2 by the open-faced arrows with the class numbers inside. The Class 1 events (staff processing) and the Class 6 events (staff interfacing with their field ADP terminals) are shown inside the five Blue Staff Modules and inside the single Red Command Module. The Class 2 events (staff coordination between staff sections) are shown interconnecting the five Blue Staff Modules. The Class 3 events (frag orders to subordinate units, reports to higher headquarters, and other staff outputs) are shown emanating from the staff modules and pointing into the interior modules of the simulation: the battle outcome generator (BOG) and the other units module. The Class 4 events (staff inputs; reports from the BOG or the other units module) are shown with arrow heads reversed from those of Class 3. Finally the Class 5 events (battle events and events stemming from other units) are shown wholly inside the interior modules of the simulation.

All events represent significant occurrences in the division-level combat, but Class 2, Class 3, Class 4, and Class 6 events are further qualified as "interface" events because they deal exclusively with tactical information flow. It will be shown below that the definition and numbering of interface events will always be associated with the specific tactical information messages or documents identified in Design Note A.

The position of the human controller(s) in the basic design concept is shown in Figure 4-2. As it relates to simulation events, this position suggests some controller involvement with the imposition of certain decision choices, intervention with military judgement, and the handling of staff input/output. The controller's station shown in the middle of the simulation, therefore, implies the following two design imperatives:

- One or more human controllers will always be required to run the game.
- The controllers will have to perform their functions according to the schedule of events and the simulated time clock.

A detailed specification of the controller's functions depends on the level of computer assistance used to implement the simulation and on the actual procedures followed in playing populated staff modules. This specification is given in paragraph 4.2.2 for the initial implementation.

Under any proposed implementation, however, there will always be certain Class 1 events and Class 5 events in which the controller(s) must intervene in order to supplement the logical rules of the simulation or to influence the onslaught of events on a populated staff module. These Class 1 or Class 5 events are therefore further qualified as "release" events, because the controller(s) must execute their "release," that is, complete the intervention <u>on or before the time of occurrence</u> as measured by the simulated clock. The specific release events in the initial implementation and the method provided for controller intervention are discussed further in paragraph 4.3.6.

The remainder of this subsection provides the definitions and detailed descriptions of the events in each class that have been identified for the simulation.

At the beginning of the basic design effort, an <u>event numbering convention</u> was adopted to provide a basis for organizing the large number of events anticipated to emerge in each class. The convention is shown in Table 4-2.

Table 4-2. Event Numbering Convention Used in the Basic Design.

Class 1 Events are numbered	100 to 199.
Class 2 Events are numbered	200 to 299.
Class 3 Events are numbered	300 to 399.
Class 4 Events are numbered	400 to 499.
Class 5 Events are numbered	500 to 599.
Class 6 Events are numbered	600 to 699.

It can be seen from the table that the convention is based on the a priori assumption that the design will involve no more than 100 defined events in each of the six classes. In the material that follows, only a subset of the hundred numbers have resulted in basic event definitions. Furthermore, beginning with the Class 2 events, the interface events will exhibit event numbers that are directly related to the standardized tactical messages.

4.1.2.1 Staff Processing Events

Class 1 events are the action-handling steps performed by individual members of a staff section in completing a required staff action. For every input/output relationship prescribed for the staff element (see Design Note C), there will be a standard operating procedure (SOP) spelling out the action steps required. These steps will be executed whenever the staff element is triggered to perform the staff action.

If the staff section is a populated staff module, the action steps will be executed entirely by the human players. The simulation itself will acknowledge the completion of the staff action only by means of the interface events (staff outputs) stemming from the action; it will not record the occurrence of individual action steps nor measure the performance of the players regarding conformance to the action SOP. The performance measurements on human players will be handled in a separate manner, as discussed in Section 5.

Class 1 events have meaning only for those staff sections that are simulated staff modules. Under all configurations of play except one (configuration "63" in Table 4-1), one or more staff modules will always be simulated in order to provide the full division staff environment required for a single populated staff module.

For simulated staff modules operating under a manual staff system, the action steps in each staff action will consist of, and be represented by, a thread of Class 1 events. All such event threads will contain an internal trigger, or starting, Class 1 event, and one or more terminating, or ending, Class 1 events. The number of events simulated between the trigger and the terminating action steps will depend on the individual action SOPs and on the level of detail used in simulating the staff action.

The event numbers and definitions of the Class 1 events that represent the internal triggers and the terminators of all staff actions are presented in Table 4-3. Class 1 events are specified further in Design Note I and the internal triggers and terminations are defined in Design Note J. Included in the Design Note I material is a discussion of two areas that require further research to improve the efficiency of the simulation.

The simulation will provide basic rules or algorithms that will generate the interval of simulated time taken to complete staff actions. This interval will be a function of the level of action traffic impinging on the staff section as well as the number of action steps in the staff actions.

Some staff actions will contain intermediate Class 1 events that are release events, that is, events which require controller intervention as described above. For example, in an exercise with a populated

Table 4-3. Class 1 Events.

Event Number	Definition of the Event
Internal Triggers	
100	Clock indicates that is is time to initiate staff action.
101	Receives a tactical information message from BOG or higher HQ.
102	Receives a retransmitted copy of input to another section.
103	Receives an info copy of output by another section.
104	Receives a query from another section.
105	Receives a request for concurrence[2] from another section.
106	Receives a request for consideration[3] from another section.
107	Receives a concurring response to a request for concurrence.
108	Receives a non-concurring response to a request for concurrence.
109	Receives an info copy of a request frag order.
110	Receives a non-concurring response to a request for consideration.
111	Receives a response to its query to another section.
112	Receives information from another section.
Action Steps	
(Not yet defined.)	
Terminators	
189	Sends to selected staff elements.
190	Issues frag order or warning order.
191	Initiates query[1].
192	Initiates a request for concurrence[2].
193	Initiates a request for consideration[3].
194	Initiates a report for higher headquarters.
195	Aggregates its information on file for a response.
196	Issues a concurring response to a request for concurrence.
197	Issues a non-concurring response to a request for concurrence.
198	Issues a non-concurring response to a request.
199	Retransmits copies of its input.

[1] For all staff modules except Blue CG, queries will be automatically separated into staff queries or queries to subordinate units. The Blue CG module will have the selectable option between staff queries or queries to subordinate units.

[2] A request for concurrence is based on a frag order under initiator's purview.

[3] A request for consideration is based on a frag order under recipient's purview.

G2 staff module and a simulated G3 module, the G2 player(s) might submit a request for concurrence to G3 regarding a Frag Order (Intel). The release event would occur following the trigger (Event No. 105 in Table 4-3) in the simulated G3 module. On or before the time of occurrence, the controller would have to insert the decision to reflect the choice of the alternative responses by the G3 (Event Nos. 196 or 197 in Table 4-3).

4.1.2.2 Staff Coordination Events

Class 2 events are interface events covering the exchange of tactical information between staff sections. The internal routing requirements of all staff actions, staff queries, requests, and responses will be effected through Class 2 events.

In accordance with the fundamental asymmetry of the basic design, Class 2 events will be used at the interfaces between Blue Staff Modules only; no Class 2 events will occur with respect to the single Red Command Module. The Red side, whether it is a populated module or a simulated module, will always deal with completely staffed tacticl decision alternatives and will not be concerned further with staff coodination.

Staff coordination exchanges on the Blue side, on the other hand, can occur in four different ways, depending on the combination of populated modules and simulated modules being played. The four alternative kinds are as follows:

- The initiator of the exchange is a live module; the recipient is a simulated module.
- The initiator is a simulated module; the recipient is a live module.
- Both the initiator section and the receiving staff element are simulated modules.
- The initiator and the recipient are both populated modules.

Class 2 events are defined for all four cases.

If the initiator of the exchange is a populated module (as in items 1 and 4 above), then the Class 2 event will be initiated by a pencil copy or typewritten copy of the exchange prepared by the human players, transmitted by the controller/computer, and then printed as a machine prepared message. Oral exchanges will not be permitted.

If the recipient of the exchange is a populated module (as in items 2 and 4), then the human players in the module will receive the Class 2 message from the controller/computer. The coordination exchange will always appear as a machine prepared message to the human recipients.

The times of occurrence and the tactical information message of all Class 2 events regardless of the cases above, will always be recorded and logged by the simulation in order to provide a basis for post processing analysis of the staff coordination exchanges.

The event numbers and definitions of the Class 2 events are shown in Table 4-4. The table specifies 65 different events numbered according to the numbering convention cited above. The last two digits of the event numbers are the embedded reference numbers for the standardized tactical information messages whose simulated flow will be one of the central features of the basic design. The message reference numbers will be seen to occur in one or more of the remaining interface event classes. They stem from Design Note A: The list of Individual Tactical Information Messages.

Class 2 events are further specified with respect to the manner they will be handled in Design Notes G and J. Design Note G gives the logical rules for Class 2 events. Design Note J contain the event thread charts showing the progenitors and follow-on events associated with the staff coordination exchanges.

4.1.2.3 Staff Output Events

Class 3 events are the frag orders, warning orders, and queries sent out by the staff modules to subordinate units in the field as well as the periodic reports and requests submitted by the staff sections to higher and adjacent headquarters. These staff output events are all interface events dealing exclusively with tactical information flow and corresponding to the staff output messages listed in Design Note A.

Staff outputs, like other interface events, will consist of two kinds of tactical messages in the basic design. The first type message will be one containing basic decision variables affecting the simulated combat. This type will always trigger one or more battle events (Class 5) so that the course of the simulated conflict will change in response to the frag orders issued by the staff sections.

The second type of staff output will consist of the required reports to Corps or adjacent divisions such as Preplanned Requests for Fire Support, the Division Intsum, Division Sitrep, and Division Personnel Daily Summary. These reports represent outputs stemming from required actions on the part of the different staff sections, but having no direct bearing on the simulated combat events in the BOG within the running time of a given simulation.

It will be seen that the distinction between the two kinds of staff outputs is preserved in the proposed implementation of the design. The decision variables will be incorporated into the simulation rules associated with battle events in the BOG. The tactical documents not

Table 4-4. Class 2 Events.

Event Number	Definition of Event
Initiated by Command Group	
201	Query to principal staff section.
202	Info copy: Nuclear Release Request.
203	Mission Analysis
204	Commander's Guidance
205	Commander's Decision
Initiated by Fire Support Element	
210	Query to another staff section.
212	Info copy: Frag Order (FS)
213	Info copy: Immediate Request to Corps for Fire Support.
214	Info copy: Preplanned Request to Corps for Fire Support.
215	Rexmttd copy: Arty Sitrep.
216	Rexmttd copy: Arty Target List
217	Rexmttd copy: Friendly Unit Fire Support Capability.
218	Rexmttd copy: Enemy Unit Fire Support Capability.
219	Post Strike Analysis
220	Fire Support Annex
221	Staff Request to another section.
222	Staff Response to another section.
223	Rexmttd copy: Immediate Request for Fire Support.
224	Rexmttd copy: Preplanned Request for Fire Support.
225	Rexmttd copy: Target (Intel).
226	Rexmttd copy: Fire Support Status
Initiated by G2 Section	
230	Query to another staff section.
232	Info copy: Frag Order (Intel).
233	Info copy: Division Intsum.
234	Rexmttd copy: NBC Report.
235	Rexmttd copy: Weather Forecast.
236	Intel Para Division Sitrep.
237	Intel Estimate.
238	Intel Annex.
239	Staff Request to another section.
240	Staff Response to another section.
241	Rexmttd copy: Bde Intsum.
242	Rexmttd copy: Shell Report.
243	Rexmttd copy: Spot Report.
244	Rexmttd copy: Combat Intelligence Report.
245	Rexmttd copy: Post Strike Damage Report.
246	Rexmttd copy: Estimate of Enemy Strength.
247	Rexmttd copy: Target List (Intel).

Table 4-4. Class 2 Events (Continued).

Event Number	Definition of Events
Initiated by G3 Section	
250	Query to another staff section.
252	Info copy: Frag Order (OPS)
253	Info copy: Division Sitrep.
254	Info copy: Nuclear Warning Order.
255	Info copy: Air Defense Warning Order.
257	Info copy: Operations Plan
258	Operations Estimate.
259	Rexmttd copy: Initial Enemy Contact Report.
260	Rexmttd copy: Unit Progress Report.
261	Rexmttd copy: Loss-of-Contact/Friendly Unit Report.
262	Rexmttd copy: Electronic Order of Battle.
263	Staff Request to another section.
264	Staff Response to another section.
265	Rexmttd copy: Bde Sitrep.
267	Rexmttd copy: Organic Aviation Sortie Status.
Initiated by G1/G4 Section	
280	Query to another staff section.
282	Info copy: Frag Order (CSS)
283	Info copy: Division Personnel Daily Summary.
284	Info copy: Periodic Logistic Report.
285	Info copy: Personnel Requisition.
287	Combat Service Support Estimate.
288	Combat Service Support Annex.
289	Staff Request to another section.
290	Staff Response to another section.
291	Rexmttd copy: Bde/Bn Personnel Daily Summary.
292	Rexmttd copy: CAPE Report.
296	Rexmttd copy: Discom Sitrep.

directly affecting the conflict will be "played" as part of staff actions required of players in populated staff modules, but will not be linked to the battle outcome generator.

The event numbers and definitions of the Class 3 events are shown in Table 4-5. The table specifies 27 different staff outputs, numbered according to the standard convention and with the embedded message reference numbers used with interface events.

Class 3 events are further specified in Design Notes E and J. The distinction between the two kinds of Class 3 events is not shown in Table 4-5, but is given in precise detail, first, under the message references in Design Note A, and then in the detailed specification in Design Note E. The corresponding event thread charts for Class 3 events are presented in Design Note J.

4.1.2.4 Staff Input Events

Class 4 events are the input tactical information messages to the staff modules from the interior modules of the simulation. They will be embodied in periodic reports and spot reports coming from the subordinate units simulated in the BOG, and in fragmentary orders, intelligence reports, etc. coming from the other units module.

Class 4 reports will be the basic vehicles by which the staff modules will acquire and maintain their own bodies of perceived information about the "state of the battle." All staff input messages will reflect not only certain errors and/or omissions in the message content but also simulated delays in the times of arrival in the hands of the receiving staff sections, so that the state of knowledge about the division-level combat held by the staff elements (or the single Red Command Module) will always be at variance with, and delayed from, the actual simulated battle events.

The event numbers and definitions of the Class 4 events are shown in Table 4-6. The table specifies 42 different staff inputs, numbered according to the standard convention and with embedded message reference numbers.

Class 4 events are further specified in Design Notes F and J. Staff inputs, like other interface events, are divided into two types: those which update the state of knowledge about the on-going conflict and those which serve as part of a planning activity being pursued at the same time. Staff inputs are also divided into those messages which may be "queried" and those which may not. These distinctions are drawn precisely in the specification given in Design Note F. The event thread charts covering all Class 4 events are given in Design Note J.

Table 4-5. Class 3 Events.

Event Number	Definition of Event
Issued by Command Group	
301	Query to subordinate units.
302	Nuclear Release Request.
Issued by Fire Support Element	
310	Query to subordinate units.
311	Query to Corps regarding its Frag Order (FS).
312	Fragmentary Order (FS).
313	Immediate Request to Corps for Fire Support.
314	Preplanned Request to Corps for Fire Support.
Issued by G2 Section	
330	Query to subordinate units.
331	Query to Corps regarding its Frag Order (Intel).
332	Fragmentary Order (Intel).
333	Division Intsum.
334	NBC Report.
Issued by G3 Section	
350	Query to subordinate units.
351	Query to Corps regarding its Frag Order (OPS).
352	Fragmentary Order (OPS).
353	Division Sitrep.
354	Nuclear Warning Order.
355	Air Defense Warning Order.
356	Request for Reserves.
357	Operations Plan.
Issued by G1/G4 Section	
380	Query to subordinate units.
381	Query to Corps regarding its Frag Order (CSS).
382	Fragmentary Order (CSS).
383	Division Personnel Daily Summary.
384	Periodic Logistics Report.
385	Personnel Requisition.
386	Immediate Request to Corps for Logistic Support.

Table 4-6. Class 4 Events.

Event Number	Definition of Event
Received by Command Group	
	(None of the following reports are distributed automatically to the CG, but some may be procured through "query.")
Received by Fire Support Element	
415	Arty Sitrep.
416	Arty Target List.
417	Friendly Unit Fire Support Capability.
418	Enemy Unit Fire Support Capability.
423	Immediate Request for Fire Support.
424	Preplanned Request for Fire Support.
425	Target Report (Intel).
426	Fire Support Status Report.
427	Query from addressee on issued Frag Order (FS).
428	Fire Support Estimate/Annex.
429	Frag Order (FS) from Corps.
Received by G2 Section	
434	NBC Report.
435	Weather Forecast.
441	Bde Intsum.
442	Shell Report.
443	Spot Report.
444	Combat Intelligence Report.
445	Post Strike Damage Report.
446	Estimate of Enemy Strength Report.
447	Target List (Intel).
448	Query from addressee on issued Frag Order (Intel).
449	Frag Order (Intel) from Corps.
Received by G3 Section	
459	Initial Enemy Contact Report.
460	Unit Progress Report.
461	Loss-of-Contact/Friendly Unit Report.
462	Enemy Electronic Order of Battle.
465	Bde/Bn Sitrep.
466	Air Defense Alert.
467	Aviation Sortie Status Report.
468	Query from addressee on issued Frag Order (OPS).
469	Query from addressee on issued Nuclear Warning Order.
470	Query from addressee on issued Air Defense Warning Order.
471	Frag Order (OPS) from Corps.
472	Operations Special Estimate/Annex.

Table 4-6. Class 4 Events (Continued).

Event Number	Definition of Event
Received by G1/G4 Section	
486	Immediate Request for Logistic Support.
491	Bde/Bn Personnel Daily Summary.
492	CAPE Report.
493	Preplanned Request for Logistic Support.
494	Query from addressee on issued Frag Order (CSS).
495	Frag Order (CSS) from Corps.
496	Division Support Command Sitrep.
497	CMO Estimate/Annex.

4.1.2.5 Battle Events

Class 5 events cover all significant occurrences taking place in the interior modules of the simulation. These events include not only the actual maneuvers and engagements by units of the opposing forces but also all the responses to Class 3 staff outputs and progenitors for Class 4 staff inputs.

The maneuver and combat events in the BOG, as well as certain target detection and intelligence processing events, have not yet been fully defined. It can be seen that these events have no direct relationship with the separately defined tactical information messages so that their event numbers do not conform to the rule about embedded message reference numbers. Battle events of this type are instead numbered in such a manner that they fall into the unused spaces in the range between 500-599.

The progenitors and/or follow-on events associated with specific tactical messages, on the other hand, do conform to the rule even though they are not themselves interface events. It will be seen, for example, that events defined as follows:

"Addressee received Query from Command Group.",

"Addressee received Frag Order (OPS).", and

"Corps receives Division Intsum."

are the follow-on events associated with specific staff output messages, while events defined as follows:

"Preparation of Post Strike Damage Report.",

"Corps xmits Frag Order (OPS).", and

"Prepration of CMO Estimate/Annex."

are progenitor events to their specific staff input messages. Since the progenitor or follow-on relationship is implicit for all defined tactical messages except those associated solely with staff coordination exchanges, the rule of embedded reference numbers is carried over to these Class 5 events.

The event numbers and definitions of the Class 5 events identified so far are shown in Table 4-7. The table specifies 61 events conforming to the rule for embedded reference numbers and 12 events associated with maneuvers and engagements. The latter type events are marked with asterisks. As new definitions are derived for these events, they will be inserted in the available unused spaces in the table.

Table 4-7. Class 5 Events.

Event Number	Definition of Event
Battle Events	
500*	Battefield clock indicates it is time to initiate ordered action.
501	Addressee receives Query from Command Group.
502	Corps receives Nuclear Release Request.
503*	Unit(s) begin moving.
504*	Unit(s) cross phase line or check point.
505*	Unit(s) close at destination.
508*	Enagement Phase nn; Battle Array nnn.
510	Addressee receives Query from FSE.
511	Corps receives Query on its Frag Order (FS).
512	Addressee receives Frag Order (FS).
513	Corps receives Immediate Request for Fire Support.
514	Corps receives Preplanned Request for Fire Support.
515	Preparation of Arty Sitrep.
516	Preparation of Arty Target List.
517	Preparation of Friendly Unit Fire Support Capability.
518	Preparation of Enemy Unit Fire Support Capability.
519*	Enemy target attacked by conventional weapons.
520*	Enemy target attacked by nuclear weapon.
523	Preparation of Immediate Request FS.
524	Preparation of Preplanned Request FS.
525	Preparation of Target Report (Intel).
526	Preparation of Fire Support Status Report.
528	Preparation of Fire Support Estimate/Annex.
529	Corps xmits Frag Order (FS).
530	Addressee receives Query from G2.
531	Corps receives Query on its Frag Order (Intel).
532	Addressee receives Frag Order (Intel).
533	Corps receives Division Intsum.
534	Preparation of NBC Report or Corps receipt thereof.
535	Preparation of Weather Forecast.
536*	Friendly unit(s) attacked by conventional weapons.
537*	Freindly unit(s) attacked by nuclear weapon.
538*	Assessment of damage from conventional weapons.
539*	Assessment of damage from nuclear weapons-
540*	Intelligence Received.
541	Preparation of Bue Intsum.

*Event number contains no embedded message reference number.

Table 4-7. Class 5 Events (Continued).

Event Number	Definition of Event
Battle Events - continued	
542	Preparation of Shell Report.
543	Preparation of Spot Report.
544	Preparation of Combat Intelligence Report.
545	Preparation of Post Strike Damage Report.
546	Preparation of Estimate of Enemy Strength.
547	Preparation of Target List (Intel).
549	Corps xmits Frag Order (Intel).
550	Addressee receives Query from G3.
551	Corps receives Query on its Frag Order (OPS).
552	Addressee receives Frag Order (OPS).
553	Corps receives Division Sitrep.
554	Addressee receives Nuclear Warning Order.
555	Addressee receives Air Defense Warning Order.
556	Corps receives Request for Reserves.
557	Corps receives Operations Plan.
559	Preparation of Initial Enemy Contact Report.
560	Preparation of Unit Progress Report.
561	Preparation of Loss-of-Contact/Friendly Unit Report.
562	Preparation of Enemy Electronic Order of Battle.
565	Preparation of Bde/Bn Sitrep.
566	Preparation of Air Defense Alert.
567	Preparation of Organic Aviation Sortie Status Report.
571	Corps xmits Frag Order (OPS).
572	Preparation of Operations Special Estimate/Annex.
580	Addressee receives Query from G1/G4.
581	Corps receives Query on its Frag Order (CSS).
582	Addressee receives Frag Order (CSS).
583	Corps receives Division Personnel Daily Summary.

Table 4-7. Class 5 Events (Continued).

Event Number	Definition of Event
Battle Events - continued	
584	Corps receives Periodic Logistics Report.
585	Corps receives Personnel Requisition.
586	Preparation of Immed. Req. for Logistic Support or Corps receipt.
591	Preparation of Bde/Bn Personnel Daily Summary.
592	Preparation of CAPE Report.
593	Preparation of Preplanned Request for Logistic Support.
595	Corps xmits Frag Order (CSS).
596	Preparation of DisCom Sitrep or Corps receipt thereof.
597	Preparation of CMO Estimate/Annex.

The Class 5 events are further specified in Design Notes H and J. The distinction between the various kinds of Class 5 events and their interaction for intelligence is given in detail in Design Note H. The corresponding event thread charts for Class 5 events are presented in Design Note J.

4.1.2.6 Staff Interfacing With Their ADP Terminals

Class 6 events are defined as those occurrences that take place when members of a staff seciton enter or read out tactical information while sitting at the ADP terminal. They are applicable to the design only when the simulation rules have been expanded to accommodate computerized decision-making aids and the player modules have been equipped with TOS-emulating terminals.

Class 6 events have not yet been defined.

4.1.3 Computer Assistance

Any implementation of the system design concept described so far must address the following fundamental questions regarding the organization and play of the simulated combat:

- How should the data bases be organized in order to store and to manipulate the Blue and Red division-level forces, the Blue and Red perceptions of their own and the enemy forces, the schedule of events unfolding in the scenario, and the formats used in the tactical information flow?
- What preprocessing activities are required to set up the play of a specified scenario?
- By what means do the investigators/controllers set the control parameters so that the exercise reflects the desired research objectives?
- What procedures should the controllers then use to control the play and, at the same time, maintain the desired slow time, real time, or fast time pace of events?

Each of these basic questions brings into focus a separate aspect of the role of computer assistance in making the simulation an effective tool for research, development, and training.

The system design concept could, in principle, be implemented and played as a slow time, all-manual game without any computer assistance. Indeed, the integrated battle simulation could be run using no other materials than the equipment for the populated staff modules, blackboards, preprinted message forms, maps, books or compendia of simulation rules, look-up tables, pencils, and paper. Preparation for the play and the manipulation of the simulation variables during the game would require large amounts of time and manpower. A large number of qualified controllers would be required, first, to set up the opposing force organizations on blackboards and deploy these forces on the controller's situation map, and second to modify the blackboard data bases and maintain the situation map as the events of the simulated battle unfolded. A slow time game under these circumstances is entirely feasible, but it is doubtful that the team of controllers could perform its functions and still keep up with a simulated time clock running at real time. In earlier attempts at all-manual simulations[1] it was found that it took as long as 8 hours to play 1 hour of combat.

The discussion that follows addresses the various ways in which a computer could be used to assist in (1) the preprocessing and data management of the simulation data bases, (2) the interactive control of the event-store simulator, (3) the use of interactive terminals for players (to simulate an ADP-assisted staff), and (4) the post-processing functions. The discussion begins by considering the size and basic organization of the information or data on which the exercise of the model would be based. It then follows with separate paragraphs devoted to the different computer assistance areas above and emphasizing the manner in which these areas relate to the fundamental questions.

4.1.3.1 Data Organization

One measure of the size of the model design will be the maximum number of entities and state variables (i.e., limit parameters) required to define the level of resolution of the combat units in the opposing forces, the maximum number of such units allowed on each side, the geographic size of the tactical area of play, and the table or list of scheduled events used during the play. These sizing parameters and the basic organization of the major data groups in the model must be specified whether or not the simulation is implemented simply as a manual game or as a computerized research tool. Sizing and structure considerations will determine the requirements for preprinted message forms and for blackboard space, in an all-manual implementation; they will define the basic organization of files and internal data arrays for a system that is partially or fully computerized.

The sizing estimates presented here are based on the kilobyte as the unit of measure of the system data. A kilobyte is a "chunk" of information equivalent to 1000 letters, characters, or numeric digits.

The major data groups required in the simulation are identified as follows:

- Real World Data Base
- Blue Perceived Data Base

[1]Tiede et al, Information Flow and Combat Effectiveness, Research Analysis Corps., RAC Report R-100, April 1970.

- Red Perceived Data Base
- *Event Table*
- Message Format Specifications and Data Element Dictionary.

Each of the major repositories will have its own organization of data subgroups and elementary data items. The number of entries in each subgroup will be fixed, and each such number will represent one of the basic sizing parameters of the system. All major groups except the last will be dynamic storage media in the sense that individual elementary data items in them will be capable of being accessed, updated, and/or erased during the course of the play. The message format specifications and data element dictionary alone will be "read only" data, since the formats and the data element(s)/data chains employed in simulation will be fixed and invariant.

The sizes of the major data groups, measured in kilobytes, are shown in Figure 4-3. The figure is scaled to show the relative amounts of data space required for each group. The overall requirement is approximately 316 kilobytes.

The basic functions of these major data groups, their principal subgroups, and the basis for the individual data space requirements are discussed below.

Real World Data Base. The real world data base will contain the ground truth facts of the simulated battle as it continuously unfolds by the occurrences of battle events. The basic data subgroups are (1) the Blue force table, (2) the Red force table, and (3) the battle array file.

The force tables for the opposing sides will have identical structure. Each table will be broken down into a unit-type subtable and a unit subtable. The unit-type subtable will consist of up to 25 unit type entries where each entry contains unit type identification data and the mathematical force balance coefficients associated with its weapons. Although the specific data items have not yet been defined,* it is estimated that each unit-type entry will require 120 bytes or .12 kilobytes of information, making the total requirement for the subtable .12 x 25 = 3 kilobytes.

It should be noted that the information in the unit-type subtable will remain invariant during the course of play, but that composition of the forces, in terms of the types of combat and support units, may be varied with each new scenario prepared for the play.

*See page H-11 of Detailed Design Note H in the companion volume for an example of a unit type subtable. The state variables needed for each type unit are a function of the content of the Class 3 and 4 messages to be processed and the combat interaction algorithms employed.

REAL WORLD DATA BASE

- Approximately 86 kilobytes of data
- Includes: Blue force table
  Red force table
  Battle array file

BLUE PERCEIVED DATA BASE

- Approximately 25 kilobytes of data

RED PERCEIVED DATA BASE

- Approximately 15 kilobytes of data

EVENT TABLE

- Approximately 90 kilobytes of data
- Accommodates up to 600 scheduled (projected) events at any given time
- Each scheduled event contains full message content or full event description

FORMAT SPECIFICATIONS AND DATA ELEMENT DICTIONARY

- Approximately 100 kilobytes of data
- "Read only" storage
- Includes: Standard tactical message formats
  Separate dictionaries for all format entry variables
  Rate of advance tables, etc.

Figure 4-3. Sizes of the Major Data Groups.

Examples of unit types one might use in synthesizing a Blue force are as follows:

- Mechanized Infantry Company
- Tank Company
- Armored Cavalry Troop
- Artillery Battery (Type 1)
- Artillery Battery (Type 2)
- Engineer Company (Type 1)
- Engineer Company (Type 2)
- Air Defense Battery
- Aviation Company.

Each of these unit types will reflect a different set of mathematical coefficients to be used in the force balance formulae in the battle events.

The unit subtable will consist of up to 150 unit entries where each entry contains all the data and running variables associated with a specific company-equivalent unit in the division. The specific data items necessary to cover all the data and running variables have not yet been defined, but the following categories of items have been identified:

- Unit identification and unit type designation
- Chain of command in the current organization for combat
- Posture state, location, and status of the unit
- Personnel strength and resources.

All categories but the first will be subject to modification or update during the course of the play. It is estimated that each entry will require 200 bytes or .2 kilobytes of data space to cover these categories, so that each unit subtable will require altogether .2 x 150 = 30 kilobytes.

The third subgroup in the real world data base will be the battle array file. This file will contain arrays of data identifying the specific maneuver units and combat support units on each side during the time the opposing forces are engaged in active combat. Separate arrays will exist for different battles taking place in different locations in the tactical area of play. An individual battle array will be created whenever, during the course of a simulated exercise, Blue units and opposing Red units first make contact. The array data will remain on file until the outcome of the engagement is resolved and the opposing forces have broken off contact.

The size of the battle array file is estimated to be 20 kilobytes. The limit parameters on the maximum number of separate arrays and the maximum number of units on each side that can be engaged have not yet been determined.

To summarize the sizing and data space requirements of the real world data base: the basic design will accomodate a Blue force and a Red force, each consisting of up to 150 company-sized units. The composition of the forces may consist of up to 25 different types of maneuver units, combat support units, and combat service support units. During an exercise, these forces may be grouped together in a number of separate battle arrays. The maximum number of arrays and the maximum number of opposing units in a single array have not been determined.

The data space requirements, based on these subgroups, are as follows:

Blue force table:	3 + 30 = 33 kilobytes
Red force table:	3 + 30 = 33 kilobytes
Battle array file:	20 = 20 kilobytes
Total Requirement	= 86 kilobytes

Perceived Data Bases. The perceived data base on each side consists of the side's perception of its own troop list and operations SITMAP as well as the enemy order of battle and dispositions. The real world data base and the separate perceived data bases are conceived as distinct bodies of information because neither side will ever enjoy true and full knowledge of the deployment of the units of the other side nor even up-to-date and precise knowledge of its own troops. Accordingly, the basic design concept includes a Blue and Red perceived data base each containing unaggregated information about its own troops and the enemy forces. During the course of the play, the information in these data bases will be continually modified by the occurrences of the Class 5 report generation events (see paragraph 4.1.2.5). The occurrences will usually be followed by corresponding Class 4 events at which times the staff modules will "receive" tactical information messages. The messages will be formatted according to standard message formats and based on data aggregated from the perceived data base. Thus, the "state of battle" reflected in the information will always be delayed in time and subject to errors and omissions with respect to the true facts in the real world data base.

For certain experimental or training purposes it may be desirable for RED to have access to the undegraded, undelayed data stored in the real world data base. For such applications, the controller would assume the functions of the RED player. As controller, he would already have access to real world information in order to maintain his real world situation map and could, therefore, play RED with perfect information (see paragraph 4.2.2 below).

In concept, the perceived data base will always exist in two forms: first as tabular arrays of data available ordinarily only to the controller(s) and/or computer, and second as the series of troop lists, modified organizations for combat, situation map overlays, numerous files, etc., set up and maintained by human players in populated staff modules during an exercise. The first form may be thought of as the body of facts about the conflict marshalled by the Blue or Red sides, while the second form will reflect the way the commander and his staff organize, aggregate, and sift the known facts to facilitate decision making.

The tabular array form may also be used for certain Class 1 events, executed in simulated staff modules. Whenever the simulated staff section must reference its own files, maps, or charts in order to respond to staff queries or requests, the simulated action step will entail the aggregation and formatting of data from the tabular array.

The Blue and Red perceived data bases will exhibit a fundamental asymmetry in the system design concept. Both data bases will contain the tabular arrays of unaggregated data covering the status and dispositions of their own units and the garnered intelligence about the opposing forces. But the Blue data base will contain an additional subgroup of data called the "scratch pad area."

The scratch pad area is conceived as the supplementary data space that will be required whenever the Blue Staff Modules are played using Class 6 events under an ADP-assisted staff concept. Although the precise formulation of the decision-making aids are not known at this time, it is assumed that the field computer system will eventually provide (1) access to the "raw data" in the tabular arrays and (2) the ability to aggregate, reorganize, disregard, or extrapolate the information in order to address tactical decision alternatives. The scratch pad area is the place where the data formulation will be stored.

The tabular arrays on both sides will consist of two subtables each. The subtables wll contain 150 entries each. The first subtable will be the FRENSIT table; the 150 entries will correspond to the 150 unit table entries of the real world data base friendly forces. The second subtable will be the ENSIT table; its 150 entries will correspond to the 150 units of the enemy forces. The elementary data items in FRENSIT and ENSIT tables will consist of "state-of-knowledge" indices* and data-time-group records of the last (latest) reporting times. It is estimated that individual entries will require about 50 bytes each, so that a single full tabular array will have a data space requirement of

$$150 \times (.050 + .050) = 15 \text{ kilobytes}.$$

It should be noted that the tabular arrays will contain only the current, or latest reported, data on friendly and enemy units; they will

*A state-of-knowledge (SOK) index is a one-digit integer whose value represents the current state of knowledge about an item of friendly or enemy force information.

not reflect historical or out-of-date information. If out-of-date information is, or becomes, an important part of decision formulation, these data may be saved for retrieval by "rolling out" the tabular arrays periodically on magnetic tape.

The scratch pad area on the Blue side is arbitrarily assumed to require about 10 kilobytes of data space.

To summarize the sizing and data space requirements of the perceived data bases: the basic design will include separate Blue and Red perceived data bases whose structure will match any real world data base force tables. No additional constraints will be imposed beyond those already cited for the real world data.

The Blue perceived data base, which contains both the tabular array and the scratch pad area, will have a space requirement

15 + 10 = 25 kilobytes.

The Red perceptions, consisting solely of a tabular array, will have a data space requirement of 15 kilobytes.

Event Table. The Event Table is a large data storage array necessary to implement the event-store mechanism on which the battle simulation will be based. The basic operation of the event-store technique and the role served by the Event Table are described in Section 3.3.

The Table will consist of spaces for up to 600 scheduled events. A scheduled event is a significant occurrences projected to occur at some time in the future of the current reading of the simulated clock. During the course of the play, scheduled events, that is, individual entries in the Event Table, will be continually extracted and erased, leaving empty spaces in the table. With the processing of each such event, new events are usually generated and these newly scheduled events are put into the table, inserting the data in the firt blank or empty space encountered. The central problem in implementing the technique is that of stringing the scheduled events together continually so that the correct time sequence of event processing is preserved. Under proper sequencing, the "fill" in the Event Table, that is, the number of non-blank entries, will dynamically change up and down depending on the particular event threads unfolding in the simulated battle.

Every non-blank entry in the table will contain the following data items or data subgroup:

- Event time (measured in minutes) — 10 bytes
- Event type index — 4 bytes
- Previous event index — 3 bytes
- Next event index — 3 bytes

- Event message content or battle event description — 130 bytes

The further break-down of the event message content or battle event description subgroup has not yet been made. It is proposed, however, that this subgroup contain sufficient data to fill in all the blanks in a one-page tactical information message, or alternatively, to provide full confirmation of the conditions on which a battle event is contingent.

The Event Table, under this scheme of data organization, will require altogether

$$600 \times (.010 + .004 + .003 + .003 + .130) = 90 \text{ kilobytes.}$$

Message Formats, Dictionary, and Other Tables. The last required major data group is significant primarily because it consists of all the "hard wired" data in the battle simulation. The basic system design clearly reflects two distinct kinds of elements: variable elements and hard wired elements. The variables are the input data, the selectable configurations of play, the range of alternative scenarios, and the control parameter settings for alternative research objectives. The hard wired elements, on the other hand, are the simulation rules, the sizing parameters, the event threads specifying the logical progenitors and followers of every defined event, and various categories of fixed or invariant data. The data categories are all stored together in the major data group called the format specifications and data element dictionary; they include the repertoire of tactical message formats used in all information flow in the model, the dictionaries of permissible words or phrases to be employed with the formats, the specification of the five "G" staff elements, rate of advance tables used in simulated engagements, etc.

Hard wired elements, like the steel and concrete in a building under construction, represent the underlying structural framework of the basic design. After the steel framework has been fully assembled and the concrete finally poured, any modifications or variations in the structure become a matter of expensive redesign or retrofitting.

SAI believes it is important in the pursuit of any implementation of the basic design to identify all the hard wired elements in the simulation structure and to document these elements so that they can be understood by the eventual users.

The hard wired data is estimated to require 100 kilobytes of data space. The subgroup organization of the formats, dictionaries, and tables has yet to be specified.

4.1.3.2 Preprocessing Functions

Preparation for an exercise of the simulation, regardless of whether the exercise is directed toward behavioral research, the study of new tactics, or the training of staff officers, will always have to cover three phases of preprocessing activities. Assuming the design of the experiment, the General Situation, the separate Blue and Red Special Situations have all been specified, the required preprocessing phases are as follows:

- Phase I - Creation of the Real World Data Base:
  - Specification of the Blue divisional forces.
  - Specification of the Red opposing forces.
  - Specification of the tactical area and the deployment of the forces.
- Phase II - Initialization of the Blue and Red Perceived Data Bases:
  - Specification of the state of knowledge held by the Blue side, consistent with the research objectives and the Blue Special Situation.
  - Specification of the state of knowledge held by the Red side, consistent with the research objectives and its Special Situation.
- Phase III - Scenario Event Loading and Setting the Control Parameters:
  - Specification of the exogenous trigger events, consistent with the research objectives and the desired scenario.
  - Adjustment of control parameters to emphasize special aspects of the basic objectives.
  - Creation of the Scenario File.

The final activity of Phase III consists of recording on a permanent information storage medium (magnetic tape or computer disk) all the information specified under all three phases. The Scenario File then provides the basis for repeated exercises of the same experiment, carried out under identical conditions but using different human players.

The preprocessing activities above will be the means for effecting the play of alternative scenarios and a range of different experiments under each scenario. The only constraints imposed will be the sizing parameters cited in the last subsection. It is visualized that the users of the integrated simulation will eventually create and keep on file a number of different experiment/scenario combinations to be used in various exercises of the model. The materials on file for an individual combination would include the specification of the design of the experiment, the General Situation, the Blue and Red Special Situations, and the magnetic tape Scenario File.

The use of a computer to assist in the preprocessing activities would simplify the task of setting up an exercise for play. The computer could take over entirely the functions of the data organization in the system data bases, the sizing limitations, and the creation of the Scenario Files. The required phases cited above suggest a preprocessing system consisting of three computer programs, as illustrated in Figure 4-4. The three programs could perform the separate preprocessing functions specified for Phase I, Phase II, and Phase III. The system, in effect, could provide for the progressive "building" of the Scenario File. The first program could generate an output FORCES File containing the hard wired data of the system and the fully developed Real World Data Base. The latter major data group could be synthesized by reading the input data which would contain the desired Blue and Red force information. The second program could take the FORCES File and add to it the initialized forms of the perceived data bases, creating thereby its output PERFOR File. The biasing of the states of knowledge held by the two sides could be effected by additional input data. Finally, the Phase III program could generate the fully initialized SCENARIO File, based on the scenario trigger events and the control parameter settings read from the input data.

The preprocessing system would reduce significantly the time and manpower necessary to set up the model. Furthermore, it would provide the means for "setting the switches" so that the exercise stemming from the SCENARIO File reflects the desired research objectives. The system of three computer programs can be seen to be structured to minimize the amount of back-tracking necessary to adjust an experiment to emphasize different aspects of the basic objectives. If the controller/investigator wishes to replay an exercise and change the time constraints imposed on a populated staff module for its staff actions, he may do so without any rebuilding of the SCENARIO File. If he wishes to modify the quality of the information flowing into a populated staff module, he will be required to go back to the Phase III preprocessor and create a new SCENARIO File with modified control parameter settings. If he wishes to modify the initial states of knowledge of the Blue and Red sides in the simulated conflict, he will have to go back to the Phase II preprocessor. Finally, if the experiment(s) is(are) to be oriented within a different scenario using different compositions of forces, it will be necessary to go back to the Phase I preprocessor and create a new version of the Real World Data Base.

4.1.3.3 Interactive Control of the Event-Store Simulator

Any exercise of the battle simulation will be keyed to the initial conditions and composition of the forces recorded on a fully processed SCENARIO File. The actual play of the exercise will always be directed by human controller(s). Controllers will be required not only to assure that the execution of battle events as well as information flow events occurs with the desired dynamic realism but also to intervene with certain of these events in order to influence the pursuit of the basic objectives.

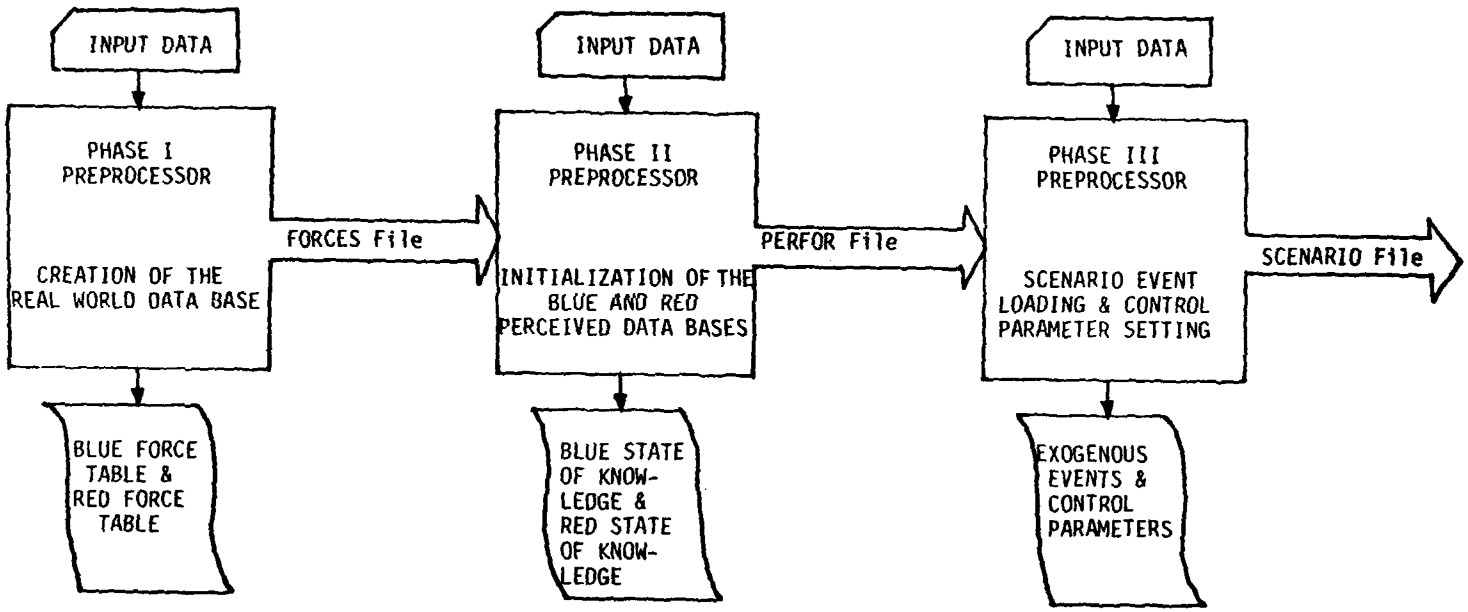


Figure 4-4. The Preprocessing System.

The number of human controllers, and the specific functions they must perform, depend on the kind of computer assistance they are given and on the actual procedures followed in playing populated staff modules. Accordingly, the basic goals of a computerized event-store simulator are (1) to minimize the number of human controllers required, (2) to relegate to the computer all the more-or-less mechanical aspects of controlling the play, and (3) to facilitate the controller's intervention so that he may effectively apply military judgement as well as principles of behavioral science during the play.

In this framework there are two alternative ways the computer assistance could be implemented. In the first method, controllers would be provided with a large number of selectable batch-processing computer programs where each program separately accessed the real world data base and the perceived data bases on the SCENARIO File. The individual programs would govern the execution of the battle events and the staff input/output. The selection of the appropriate programs to run and the timing of the runs would be handled manually (by the controllers) on the basis of a computer-printed schedule of events.

The second method would entail a continuously-running event-store control program in which the controllers are provided with interrupt/override controls so that they may insert the decision variables invoked by populated staff modules and intervene with release events to influence the information flow input to the staff players. This method would involve computer techniques beyond those of a conventional interactive program. Once the simulated battle had been set in motion, the method would have to provide a means for the continuous pace of the battle events regardless of the time of response reflected by the staff outputs from the populated modules. In short, the conflict would continue with the combat units following the most recently received operations orders, until the engagement was resolved or until the staff modules issued fragmentary orders changing the course of the battle.

Both methods would require some kind of clock display to show the controllers and populated module players the passage of simulated time during the play. These clocks, of course, have to be geared to a real clock in such a manner that the controller(s) could set the simulated clocks so that they ran at slow time, real time, or fast time according to the basic objectives of the exercise.

Both methods would also have to provide some kind of computer output media for the exclusive use of the controllers so that the controllers could be kept abreast of the details of the simulated conflict as it was reflected in the real world data base. The media could be either an automated situation map display or a printed message log. Under the latter medium, the controllers would have to set up and maintain their own situation map by preparing overlays or using simple grease pencil entries based on the tactical message traffic coming out on the message log. Since the information on the situation map would represent the ground truth facts about the simulated combat, it would ordinarily not be made available to players in populated modules.

Finally both methods must include the same logical structure for Event No. 508, the fundamental engagement event (see paragraph 4.1.2.5). An engagement event will always be associated with a battle array entry in the real world data base; the occurrence of the event will determine (1) whether the combat engagement is resolved or continues, (2) the aggregate force balance ratios obtaining during the engagement period, (3) the losses in personnel, ammunition, equipment, and the resulting fire power on both sides during the interval, and (4) the rates of advance and withdrawal by the opposing forces. In formulating the logical structures for this event, SAI plans to make every effort to effect the transfer of techniques and to use lessons learned from existing battle simulations. Such transfers and lessons, however, will necessarily be interpreted in the light of the differences between the underlying game assumptions of the existing models and those adopted here.

Computerization of the event-store simulator, and the choice between the two methods described above, clearly depend on the hardware/software resources as well as the operating system in the computer facilities designated for system installation. A trade-off also exists between the number of different functions assigned to the controllers and the facility with which a small number of qualified personnel could perform these functions. Any proposed implementation must specify exactly the particular controller functions and show how the computer hardware/software can be used to assist the controller(s) in carrying out the functions without burdening them with esoteric programming details.

4.1.3.4 Interactive Terminal for Players

If the integrated battle simulation is exercised with the assumption that the Blue division staff elements operate under a manual staff system, the transmission and receipt of tactical information by individual sections can be simulated by using conventional computer input/output equipments. A populated staff module will issue its outputs (Class 3 events or certain Class 2 events) by submitting pencil copy or typewritten copy of the tactical information messages to the controller(s). The controller(s) will then make the necessary computer data entries representing the message transmission by means of field telephone, tactical net radio, or teletype or the hand delivery by courier. The populated module will receive its inputs (Class 4 events or certain Class 2 responses) by means of ordinary teletype printers. Individual tactical information messages will be printed with their standard formats; the top line of the printed material will simulate the receipt stamp that is always associated with incoming messages. Successive messages received by the players should be torn off as the players embark on the staff actions associated with the separate inputs.

In a staff system with field ADP assistance (e.g., TOS), the battle simulation will have to be expanded to accommodate the Class 6 events and to emulate the tactical data management processes of the field computer. Populated staff modules will require terminal hardware beyond that described above. Using these enhanced field ADP facilities, the players will now not only transmit and receive a large amount of their own tactical message traffic but also employ computerized decision-making aids in executing their staff actions. The precise role of the tactical communications and the precise nature of the algorithms providing the decision-making aids have not yet been defined, but it is known that the interactive terminals for the players must match the field equipment closely with respect to the keyboard procedures, the data entry language, and the display formats. When the simulation is exercised in a TOS environment, the players in a populated staff module should see the same kind of data processing equipments and carry out the same procedures that will ultimately be applied in the field.

SAI recommends that the initial implementation of the basic design anticipate insofar as possible the data space requirements and the added simulation rules necessary for simulating division staff sections in the TOS environment, but that incorporation of TOS-emulating player's terminals be delayed until the properties of the field terminals are better defined. The simulation hardware/software requirements under a manual staff system can be fully specified at this time; those for an ADP-assisted staff cannot.

4.1.3.5 Summary Processing

The last area for computer assistance consists of computer programs which would aggregate, summarize, and format for printing the three classes of output generated by the battle simulation. The programs would accept as input data the detailed simulation results accumulated on temporary disk files from the computerized event-store simulator. They would then summarize and organize the information so that immediate and assimilable outputs could be printed. The measures of performance of the Blue Command and Staff would require certain statistical analysis routines. The measures of combat outcome would require a listing of the state variables as a function of simulated clock time. The record of Red tactical decisions would simply be a printed log of the times and new initiatives entered by the Red side.

The software development costs of these programs would be modest, once the basic system design and the computerized event-store simulator have been implemented.

The benefits associated with providing immediate printed results following an exercise on the battle simulation appear significant.

4.2 PROPOSED INITIAL IMPLEMENTATION

This subsection presents the key elements of the proposed initial implementation. The preceding discussion of the basic design concept pictured a system with six "plug-in" modules. Five of these modules represent separately the Blue Division Command Group and its four principal staff sections; the sixth module is the Red Command. The system provides for the play of a division-level war game in which the configuration of play, that is, the combination of populated modules and simulated modules among the six, can be selected. The play involves not only the simulated combat between the opposing forces but also the varying states of knowledge the opposing commanders use as the basis for their tactical decisions. The system handles the information flow of approximately 75 different kinds of tactical messages between the command elements and the combat units and provides the realistic time sequencing of approximately 350 different kinds of defined events, covering the staff actions, staff coordination, staff output, and staff input, as well as the simulated battle occurrences. The concept defines a general interactive war game simulation of sufficient scope and flexibility that can be applied alternatively to behavioral research, the development and evaluation of new tactics, or the training of staff personnel.

The proposed implementation of this design is predicted on a system that can be directed and operated by one, or at most, two human controllers. As stated in the earlier discussion, the specification of controller functions must be made in the framework of the actual procedures used in the play of the populated modules and the specific kinds of computer assistance the controllers are provided with. That specification is given below.

The proposed implementation will impose a constraint on the number of populated modules played in one exercise. The basic design stipulated that any combination of the "plug-in" modules could be selected (see Table 4-1). This means that the number of populated modules can vary from zero up to six. Since each populated module implies certain minimum computer hardware/software requirements as well as a proportionate work load imposed on the controllers, the system will therefore be limited to no more than two live staff modules in the initial proposed implementation. The selected modules may be any two out of six, but in no case may the total exceed two. This constraint limits the configurations of play to 22 out of the 64 alternative choices shown in Table 4-1.

The proposed implementation will be further constrained at this time to the exercise of Blue staff modules operating under a manual staff system only. It was shown in the preceding subsection that an interactive simulation of a division staff in a TOS environment required not only expanded logical rules covering the decision-making aids provided by the field computer but also interactive terminals for the players in populated modules. The latter hardware requirement, furthermore, had to be a reasonable match with the actual field terminals with respect to the keyboard procedures, the data entry language, and display formats. It is proposed, therefore, that the implementation of ADP-assisted staffs be deferred until the tactical data management functions and the staff procedures are better defined.

The key elements of the initial implementation are now described in the framework of these specific constraints. The description begins with the proposed physical layout of a system involving one or two populated modules and run by one or two controllers. Under this proposed architecture, the basic procedures for playing live staff modules are outlined. The description then continues with the key element, the specification of the controller functions. The role of the controllers is defined both for setting up an exercise for play and for controlling the exercise after the simulated clock starts running. The discussion is concluded with description of the computer programs that will constitute the preprocessing system, and of the interactive executive control routine that will provide the basis for the controller's functions during the play.

4.2.1 Physical Layout for Two Populated Modules

The proposed physical layout for the integrated battle simulation is shown in Figure 4-5. The figure gives the basic floor plan for the system if the simulation were configured for a populated Blue G2 Staff Module and a populated Red Command Module.*

The layout requires that the controller(s) and the populated player modules (as well as the computer main frame) occupy separate rooms during the play. The transactions and communications between the controller(s) and the player modules will be confined to exchanges of hand written or printed tactical information messages or documents passed through the Dutch door access windows. Oral exchanges will be permitted only if initiated by the controller(s) during a period when the simulated clock is not running. The display materials in the controller's room: the controller's situation map, the printed message log, and the cathode ray tube (CRT) screens should be shielded from the players so that the players cannot "cheat" by getting access to the real world data.

The basic method of play will be as follows: The staff personnel will execute the appropriate staff actions, where required, and initiate staff outputs (Class 3 events or certain Class 2 queries, responses, or requests) by passing pencil copies or typewritten copies of the tactical messages through the access windows to the controller(s). The submission of the hard copy in this manner will represent the staff section directing its radio telephone operator (RTO) to transmit or dispatch the output. The controller(s), in turn, will effect the actual

*This corresponds to Configuration No. 36, as listed in Table 4-1.

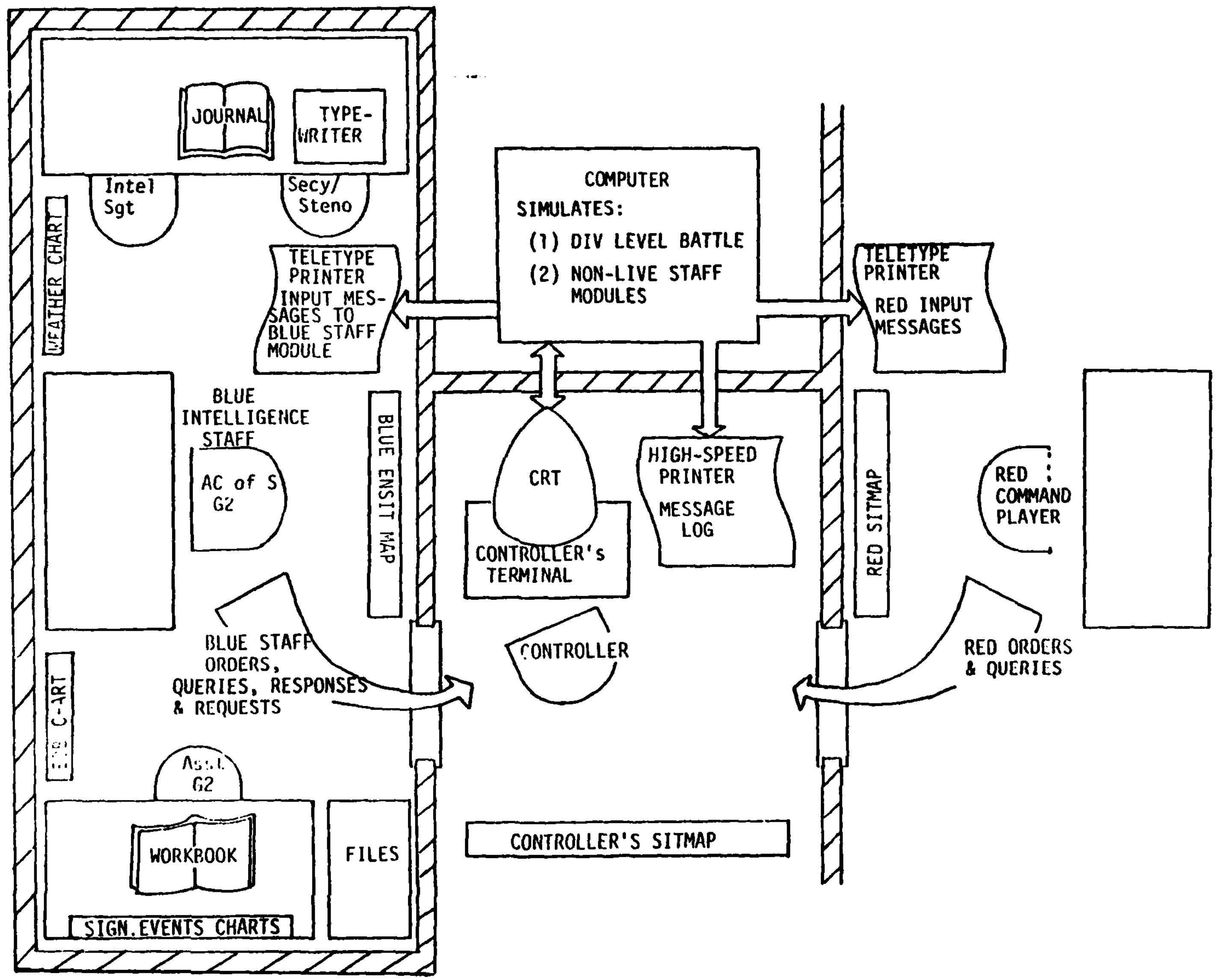


Figure 4-5. Proposed Physical Layout.

transmissions by making message data entries on the controllers keyboard. The staff personnel will receive its staff inputs (Class 4 events or certain Class 2 responses or information copies) by means of medium speed* teletype printers located in their separate rooms. The messages will be printed out in the standard tactical message formats. The top line of each communication received will contain a representation of the receipt stamp associated with the incoming message. It will show the data-time group of the moment the message is being printed. The receipt of staff inputs will provide some, but not all, of the basic triggers for the different staff actions. The staff personnel should tear off the printed messages as they are received prior to embarking on those actions.

It will be shown that the controller(s) will have a continuous display of the running simulated date-time-group at the top of their CRT. This will provide the controller(s) with a simulated clock. The players in the staff module rooms, on the other hand, will be required to judge the passage of simulated time by noting the times received on the successive input messages coming in on the teletype printers. These times will be geared to the simulated clock in the computer. Of course, if the exercise itself is geared to real time (i.e., the speed ratio is set at 1.0), then the players may synchronize their own watches and wall clocks to match the clock settings of the messages.

It should be noted that the proposed physical layout will provide the necessary computer hardware so that the simulation may be adapted to any of the 22 permissible configuration of play.** Although Figure 4-5 illustrates a system configured for a live Blue G2 Section and a live Red Command, the layout could be modified simply by rearranging the furnishing and materials in the player module rooms so that the alternative staff modules had their necessary staff equipments. The teletype printers would remain as shown except that their umbilical connectors to the computer might have to be interchanged.

4.2.2 Controller Functions

The proposed implementation focusses on a system requiring one, or at most, two human controllers to set up and run exercises in simulated division-level combat. It will be seen that the proposed computer assistance is oriented to the specific controller functions in ways that will make the running of exercises entirely manageable by only one or two qualified personnel.

The key element here is the identification of all functions to be assigned to controllers. Preparation for an exercise will require

*300 baud.

**The permissible configurations of play are those involving at most two populated modules. See Table 4-1.

not only one or more phases of preprocessing activities (as described in paragraph 4.1.3.2) but also the creation of the controller's situation map and the preparation and organization of a set of documents to be handed out to players later during the exercise. After the simulated clock starts running, the actual play of the exercise will require the keyboard entry of staff outputs, keyboard intervention on certain release events, maintenance of the real world situation map, and the passing of the documents to the players according to the basic schedule of events.

The specification of controller functions and ways the computer will facilitate their performance are presented below.

4.2.2.1 Preparatory Functions

Every individual exercise of the battle simulation will be rooted to a unique set of materials consisting of the design of the experiment, the General Situation, the separate Blue and Red Special Situations, and the magnetic tape SCENARIO File. The documents will specify the basic research objectives and the scenario for the exercise; the magnetic tape will contain data and control parameter settings consistent with these stated objectives and tactical setting. If the SCENARIO File has been fully processed, the materials will also include computer listings stemming from the preprocessing system. Furthermore, if the exercise has already been played, the materials might also include controller map overlays that were developed during the earlier run.

The controller functions in preparing for the exercise are oriented to this collection of materials. Starting with a complete or partial set, the controller(s) must perform the following preparatory functions:

- Generation of the completed form of the SCENARIO File and the accompanying computer listings.
- Validation that the stated objectives and the tactical situation are reflected in the computer listings.
- Creation of the real world situation map based on the computer listings.
- Organization of those tactical documents to be used in the play into chronological files by staff section.

It should be noted that the first function involves the running of the computer preprocessing system and that the remaining functions are wholly dependent on the computer listings stemming from the system. Although the preparatory functions will not require direct interactions with the computer, controller(s) should be familiar with the basic data card formats and card punch procedures used in the preprocessing system and should be able to assimilate quickly the printed information on the listings.

The basic structure of the proposed preprocessing system is that described in paragraph 4.1.3.2. This structure provides, through its technique of progressively building the SCENARIO File, a flexible means for executing the first preparatory function. The separate printed listings coming from the Phase I, Phase II, and Phase III Preprocessing Programs will cover, respectively, the Red and Blue force tables, the initial states of knowledge held by the two sides, and the exogenous events and parameter settings for the exercise. These listings, and the intermediate magnetic tape files, together will provide a basis for generating new or modified experiment/scenario combinations quickly, usually without requiring a complete repetition of the entire synthesis process.

It should be recognized, however, that the logical detail exhibited by the force tables, the state of knowledge tables, and the parameter settings will be complex in aggregate and will require that the controller(s) possess a reasonable understanding of the overall model operation.

4.2.2.2 Control Functions

After the stage has been set for an exercise, controller(s) will run the game using the basic facilities in the controller's room, as illustrated in Figure 4-5. He (they) will be required to carry out the following specific control functions, guided by the displays on the CRT and the printed material on the computer message log:

- Starting and stopping the simulated clock.
- Keyboard data entry of staff outputs submitted by staff players.
- Maintenance of the controller's situation map, as the simulated combat progresses.
- Keyboard data entry and execution of certain release events. Release events will be explained further below.
- Logging in/out tactical documents transmitted/received by the player modules, but not involved directly in the simulated battle.

These functions are all tied to the proposed interactive executive control routine in which the computer will control the time sequencing of battle events as well as govern the flow of tactical information to and from the populated staff modules.

The controller(s) will initiate the routine (but not the simulated clock) by means of a simple keyboard call. This call will evoke a basic control screen display on the CRT and print header lines on the controller's message log as well as on the teletype printers in the player module rooms. The control screen display, which will be the point of departure for, and the general basis of, the controller(s) functions during the play, is shown in Figure 4-6.

A more detailed discussion of the specific control functions is given below. At this point, however, a few explanatory remarks are injected about the controller's basic display shown in the figure. It should be said first that the basic display is just one out of many different formatted screens the controllers will see during the course of play. It will be shown that while executing their control functions, the controller(s) will cause the CRT to switch back and forth between a number of different displays depending on the specific functions they are addressing. All screens, however, will contain the same three top lines as those shown in the figure. These lines will display continuously the following basic items of information about the exercise:

- The name of the scenario exercise.
- The current data-time-group (DTG) in the simulation.
- The selected configuration of play.
- The simulated clock status indicator.
- The speed ratio setting in the simulation.

The computer will initialize the items from data in the SCENARIO File. After the simulated clock is set running, the clock status indicator will change and the DTG will tick off the minutes of simulated time.

Starting/Stopping the Simulation. The controller(s) will execute control of the simulated clock by means of control options (1) and (5) on the controller's basic display. Whenever the clock status indicator states that the clock is not running, the man at the terminal keyboard may start the clock by keying the digit "1" followed by a space and then either the word "END" or else the clock reading he desired for the next stop. Similarly, when the clock is running, the controller may stop it simply by keying the digit "5", notwithstanding the previously entered stopping time.

Whenever the simulated clock is inert, the controller(s) may also modify the simulation speed ratio or even the configuration of play by invoking control option (6).

The whole system may be shut down by control option (7).

Keyboard Entry of Staff Outputs. The architecture of the proposed implementation is based in part on the idea that staff outputs - including the initiation of coordination exchanges with other elements - are "transmitted" by the players' passing hardcopy messages through the access windows to the controller(s). The controller(s), in turn,

```
                         SCENARIO:  FULDA GAP - V CORPS
DTG:  010430 AUG 1982          [MINUTES = 0.0]          CONFIGURATION:  36
CLOCK IS STOPPED.                                       SPEED RATIO:   1.0

CONTROL OPTIONS:

     (1)  START THE CLOCK TO RUN UNTIL "HHMM" OR "END".

     (2)  ENTER MESSAGE TYPE "NNN".

     (3)  DISPLAY (0) PENDING CONTROLLER ACTIONS.

     (4)  EXECUTE 1ST PENDING CONTROLLER ACTION.

     (5)  STOP THE CLOCK

     (6)  CHANGE CONFIGURATION OR SPEED RATIO.

     (7)  SHUT DOWN THE SIMULATION.

TYPE:  [ ]

     THEN PRESS "RETURN" KEY
```

Figure 4-6. The Controller's Basic Display.

must bring about the transmissions by making keyboard data entries on their terminal. The key-in procedures for these orders, queries, responses, and tactical reports will be of two kinds, depending on whether the message contains basic decision variables affecting the simulated battle or is merely a tactical document to be issued by the populated staff module, but not otherwise involved in the combat simulation. In the first procedure, the controller(s) must key in the whole message through the use of a lexicon of special abbreviations and symbols that will be provided. In the latter case, the controller(s) must simply log in the document by keying in a short combination of letters and digits that post the log entry.

The controller(s) may initiate the tactical message data entry function by invoking control option (2) on the basic screen. The terminal operator may select this option whether the simulated clock is running or not. He must key in the digit "2" followed by a space and then a three-digit designator which specifies the type message he wishes to enter. The keyboard selection will cause the control screen to disappear and be replaced by a different screen format. The new display will provide the basis for the controller to key in the message. When the message has been fully entered, its transmission will then be triggered by a special key, following which the message format screen will disappear and the controllers basic display will return.

Maintenance of the Controller's Situation Map. The real world situation map, along with the controller's message log, will be the principal means for observing the unfolding battle outcomes resulting from the opposing commander's decisions. Controller(s) will maintain this situation map during the play.

As will be shown in the discussion on release events, the controller(s) will not only update the map from information presented to them by the computer but also use the map to assist them in feeding subsequent intervention data back into the computer. Practiced controllers will probably develop their own shortcut techniques for this purpose, using perhaps grease pencil entries for certain kinds of intermediate battle events and multiple map overlays for different periods of simulated combat.

Controller Intervention. In the play of an exercise, the tactical decisions imposed by the controller in order to influence the basic research objectives, the battle events in which the controller must intervene with military judgement, and the arrivals of certain tactical documents from higher headquarters to the populated staff sections are all called release events. A release event is any event in the simulation whose execution depends on controller intervention. The intervention, furthermore, should be completed on or before the time of the event, as measured by the simulated clock. Release events will be generated and scheduled for occurrence in the event-store simulator about five to twenty minutes (in simulated time) before they actually occur. The controller(s), having been warned of the forthcoming release, must effect their intervention during this short interval.

Controller(s) will handle release events by means of control options (3) and (4) in the basic display. At the time a release event is first generated, the screen will post a warning to the controller(s) by incrementing the "release queue number," which is the number exhibited in parentheses in the middle of the text in control option (3). If the release queue number is zero (as illustrated), the controller(s) will be apprised that no release events will be currently forthcoming; if the queue is 1 or more, they will be alerted to the fact that one or more interventions will be required within the next few minutes of simulated combat.

If the terminal operator selects control option (3) by keying in the digit "3," the basic control screen will disappear and a new display will present the list of forthcoming release events. The list will be arranged so that earliest forthcoming event appears at the top. The entries in the list will not only indicate the time of occurrence but also identify the type of intervention required. After the controller(s) have reviewed the queue, the operator may then erase the display and return to the controller's basic screen by pressing a single key.

If a controller selects control option (4), the computer will automatically institute the associated display format required to effect the intervention of the first (earliest) release event. The new screens will involve either simple keyboard instructions or complicated data entry procedures, depending on the type of intervention being addressed. After the controller(s) have executed the instructions or procedures, the special screens will disappear and the basic display will return to the CRT.

Release events associated with the arrival of tactical documents from corps headquarters or from adjacent divisions will involve only simple mechanical tasks on the part of the controller(s). At the time indicated for the event occurrence, the controller(s) must pass the documents through access windows to players in the staff module rooms. These actions are essentially the reverse of the procedures cited above for the keyboard entry of staff outputs.

Release events for imposing tactical decisions or supplementing the battle event logic, on the other hand, will require evaluation of the situation at hand and keeping in mind the basic objectives of the exercise. They will also entail keyboard data entry of more elaborate scope than that implied above. These types of release events are developed further in paragraph 4.3.6.

Logging of Tactical Documents. The last control function assigned to the controller(s) has been shown to be subsumed in the procedures for keyboard entry of staff outputs and the controller intervention pertaining to tactical document arrivals.

4.2.3 What the Computer Will Do

The final key element of the initial implementaion is the computer assistance proposed to facilitate setting up and running the battle simulation. The physical layout and specification of the controller functions set forth in the preceding paragraphs make reference to, and are based on, specific computer hardware components and a fundamental computer program structure for the software. The proposed computer programs consist of the three routines of the preprocessing system and a single interactive executive control routine (IECR).

The preprocessing system has already been described. The manner in which the three preprocessors will provide for the organization of simulation data was presented in paragraph 4.1.3.2, and the ways the controller(s) will be assisted by the system were shown in paragraph 4.2.2.1. The required elements for programming the system are not pursued further at this point but will be developed later in the next subsection.

The IECR, on the other hand, will be the basis for running the event-store simulator with a controllable simulated clock such that the controller(s) may execute their control functions without destroying the dynamic realism of the model. The IECR represents the second of the two approaches outlined in paragraph 4.1.3.3. It will provide for the simultaneous time sequencing of the combat events, the staff input/output events, and the keyboard data entry implicit in the controller's intervention; it will contain a software mechanism called an asynchronous trap which will accommodate this simultaneous dynamic portrayal of the on-going battle and injection of orders, queries, and controller's release events.

In pursuit of Subtask 1.6 of the basic top-down design, SAI using a part of its uncompensated efforts, has programmed and tested a skeletal interactive control system operable on a PDP-11 computer.* This routine has demonstrated successfully not only the operation of the asynchronous trap but also the automatic switching required for playing alternative configuration numbers. As a first stage test program the system merely emulates the event-store mechanism through a simple four-event scenario,

*SAI's computer routine is called Tactical Information Exchange in a Division-Level Exercise (TIEDE). The program is evoked by the keyboard instruction "CALL TIEDE." Explanatory footnote by 2nd and 3rd authors without the permission of the 1st author.

but it has shown that the simulation can be geared to any reasonable speed ratio, giving slow time, real time, or fast time play as desired.

The interactive aspects of the proposed IECR were described in some detail in the preceding paragraph. A broader perspective on the war game simulation as a whole is now presented by showing, first, how the IECR will provide staff element players with their staff inputs during an exercise, and second, how it will generate at the same time the battle event entries on the controller's message log. The perspective is based on a hypothetical scenario in which V (US) Corps is attacked by Warsaw Pact forces as part of a general Pact attack in Central Europe. The division level exercise is assumed to be configured for a populated Blue G2 Staff Module and to begin at 0430 hours on 1 August 1982.

4.2.3.1 Staff Inputs Received on the Teletype Printer

During the first twenty minutes of simulated time, the Intelligence Staff players will receive the staff inputs shown in Figure 4-7. The figure illustrates four basic entries printed on teletype paper. The first entry is simply the one-line notification to the players that the simulated clock in the exercise has begun running. The remaining entries are individual input tactical information messages that will spur the staff players to initiate the appropriate actions. The messages will be printed at different moments in simulated time, so that the players will "receive" the messages at 0437, 0438, and 0448 hours, respectively, as shown by the top line receipt stamp representations. The messages are spaced on the paper so that each successive trigger may be torn off to be used as the basis for the staff action associated with it.

The three messages shown illustrate three of the many different types of formats to be used in the IECR.

The first input is a copy of the combat intelligence report filed by elements of the covering force after initial contact. This type message (Event No. 444) is a tactical information document which is prepared beforehand as typewritten copy and passed to the players as the result of a release event execution by the controller(s). Although the G2 staff must initiate the appropriate action, the contents of the report have no direct bearing on the simulated combat events.

The second input is an information copy of an air defense warning order issued by the (simulated) G3. The message type (Event No. 255) is a Class 2 event stemming from actions by the operations staff. Receipt of this message reflects the standard procedures that all staff elements are sent information copies of fragmentary orders or warning orders issued by the cognizant sections.

INPUT MESSAGES TO BLUE G2 STAFF SECTION

```
S010430     AUG 1982    SIMULATED CLOCK BEGINS RUNNING.

S010436     AUG 1982    RECEIVED BY BLUE G2 STAFF SECTION.
F010421     AUG 1982         U N C L A S S I F I E D              (444)
   FROM:                53RD ACR
   TO:                  CG, V CORPS
   INFO:                23RD DIV, 62ND DIV, 37TH DIV
   TYPE REPORT:         COMBAT INTELLIGENCE REPORT

       (PICK UP DOCUMENT AT THE WINDOW)



S010438     AUG 1982    RECEIVED BY BLUE G2 STAFF SECTION.
F010437     AUG 1982         U N C L A S S I F I E D              (255)
   FROM:                CG, 62ND DIV/G3
   TO:                  2ND BDE
   INFO:
   TYPE REPORT:         AIR DEFENSE WARNING

        1.  WARNING:    RED
        2.  DIR ATTK:   NE
        3.  SIZE ATTK:  FEW
        4.  PRED TGT:   2ND BDE



S010448     AUG 1982    RECEIVED BY BLUE G2 STAFF SECTION.
I010443     AUG 1982         U N C L A S S I F I E D              (444)
   FROM:                ASAC
   TO:                  CG, 62ND DIV/G2
   INFO:
   TYPE REPORT:         COMBAT INTELLIGENCE REPORT

        1.  TIME:        010350 AUG 1982
        2.  LOCATION:    NA78329640
        3.  DIR MVMT:    WSW
        4.  RATE MVMT:   5 KPH
        5.  UNIT SIZE:   COMPANY
        6.  UNIT TYPE:   INF
        7.  QTY TANKS:   NA
        8.  QTY APCS:    NA
        9.  ARTY TUBES:  NA
       10.  UNK VEHS:    NA
       11.  QTY TROOPS:  125
```

Figure 4-7. Staff Inputs Received on the Teletype Printer.

The last input shown for the G2 element is another combat intelligence report, this one coming from the division all-source analysis center. An enemy LRRP has been discovered as the result of a fire fight in the 3rd Brigade area. This message (Event No. 444) has been generated as the result of a whole sequence of battle events that has occurred in the BOG.

It should be noted that after twenty minutes of play the sum total of the information on the enemy order of battle and dispositions held by G2 element will be reflected in the EOB chart, the ENSIT map, and the various element files as these things have been modified by the content of the three input messages.

4.2.3.2 Controller's Message Log

During the same twenty minute period of simulated time, the high-speed printer in the controller's room will be listing the entries of the message log, as illustrated in Figure 4-8. The listing shows ten significant events about the unfolding simulated combat. The IECR will have processed the occurrence of as many as 100 to 200 events during the simulated period, but the message log will exhibit only those events that are relevant to, and necessary for, the control of the exercise or the analysis of the results afterwards. A brief description of these relevant entries follows.

The first entry is simply the one-line notification that the simulated clock has started running.

The second entry, which will be printed after two minutes of simulated time, records the receipt of a staff input by a section that is simulated.

The third entry, printed at 0436 hours, records the receipt by the live G2 players of the copy of the combat intelligence report from the covering force to corps. This entry represents a release event that has already been executed by the controller(s), as described in the preceding paragraphs. At the time the entry is printed, the controller(s) will transfer the typewritten document from their files to the players.

The fourth entry, printed after seven minutes of play, is the first significant evidence to the controller(s) of the progress of the Warsaw Pact attack. The entry provides a basis for the controller(s) to address their situation map in anticipation of the imminent engagement between Blue and Red forces.

The fifth entry will be printed at the same time as the fourth. This entry apprises the controller(s) that a simulated staff element has initiated an action pertinent to the developing conflict.

CONTROLLERS MESSAGE LOG

```
S010430     AUG 1982    SIMULATED CLOCK BEGINS RUNNING.

S010432     AUG 1982    BLUE G3 SECTION RECEIVED AIR DEFENSE ALERT          (464)

S010436     AUG 1982    RECEIVED BY BLUE G2 STAFF SECTION.
F010421     AUG 1982          U N C L A S S I F I E D                       (444)
  FROM:                 53RD ACR
  TO:                   CG, V CORPS
  INFO:                 23RD DIV, 62ND DIV, 37TH DIV
  TYPE REPORT:          COMBAT INTELLIGENCE REPORT

      (RELEASE DOCUMENT TO PLAYERS)

S010437     AUG 1982    RED AIRMOBILE ELEMS 623 MRR LAND VIC NA69409930.

S010437     AUG 1982    BLUE G3 SECTION ISSUES AD WRNG ORDER 001          (355)

S010439     AUG 1982    RED AIRMOBILE ELEMS 623 MRR LAND VIC NA69429925

S010445     AUG 1982    ENGAGEMENT PHASE Ø; BATTLE ARRAY 0001.

S010448     AUG 1982    RECEIVED BY BLUE G2 STAFF SECTION.
I010443     AUG 1982          U N C L A S S I F I E D                     (444)
  FROM:                 ASAC
  TO:                   CG, 62ND DIV/G2
  INFO:
  TYPE REPORT:          COMBAT INTELLIGENCE REPORT

         1.  TIME:         010350
         2.  LOCATION:     NA78329640
         3.  DIR MVMT:     WSW
         4.  RATE MVMT:    5 KPH
         5.  UNIT SIZE:    COMPANY
         6.  UNIT TYPE:    INF
         7.  QTY TANKS:    NA
         8.  QTY APCS:     NA
         9.  ARTY TUBES:   NA
        10.  UNK VEHS:     NA
        11.  QTY TROOPS:   125

S010449     AUG 1982    RED ELEMS 627 TKR CROSS PHASE LINE VIC NB60100100

S010450     AUG 1982    RED AIRMOBILE ELEMS 623 MRR LAND VIC NA67009900
```

Figure 4-8. Events on the Controller's Message Log.

The sixth entry, printed two simulated minutes later, shows that the Red side is beginning to concentrate its airmobile elements.

The seventh entry denotes the first contact between the opposing forces. The controller(s) will be able to see on their situation map that the engagement involves the Red airlanded units and the Blue elements of the 2nd Bde. But concomitant with the event printing, the IECR will post a warning to the controller(s) on the CRT of the forthcoming release event representing the outcome of the first phase of this engagement. Before the next event associated with the engagement is printed, the controller(s) will have acted on the posted warning and executed the release through their terminal.

The eighth entry records the receipt of the combat intelligence report by the live G2 players. The entry is an exact duplicate of the staff input printed on the teletype in the player's room. It is part of the basic record of the tactical information flow to the players by which the staff performance may be analyzed after the end of the exercise.

The ninth and tenth entries alert the controller(s) of further developments in the unfolding simulated combat. Nineteen minutes after the start of the play, elements of the Red tank regiment cross a phase line and signal to the controller(s) the imminence of a second engagement in the division sector. The last entry in the twenty minute simulated period shows that the Red side is continuing to concentrate its forces in the area of the first point of contact.

4.2.3.3 Integrated Simulation

The fundamental characteristics of the interactive executive control routine, i.e., the features that make it the final key element of the proposed implementation, can be seen by comparing the "state of the battle" information held by one side (in this case the Blue G2 Staff Section; Figure 4-7) with the real world state seen by controller(s)/ investigators (Figure 4-8). After twenty minutes of simulated combat, the G2 players, because of the C^3 and reporting delays, are as yet completely unaware of the battle events unfolding in the 2nd Brigade area and the imminence of more fighting on the left flank. They have been informed about an enemy LRRP discovered in the 3rd Brigade area, but remain largely "in the dark" about the rapidly developing situation. The realistic portrayal of the combat events and the basic control of the flow of the tactical information to the staff players are the central features of the IECR which will facilitate the running of the simulation exercises.

4.3. BASIC COMPONENTS OF THE FIRST IMPLEMENTATION

This subsection now presents the general approach SAI proposes to use in implementing the top-down design. The key elements and basic structure described in the preceding subsection can be implemented most effectively by using a coordinated approach in which the required software and structured data bases are all developed concurrently. The following specific tasks are required:

- Concurrent programming, testing, and validation of the preprocessing system, the interactive executive control routine, and the magnetic tape SCENARIO File that links the routines together.
- Development of the computer-stored tactical message formats and other hard wired data.
- Structuring of the Real World Data Base for the first scenario.
- Development of the algorithms for initializing the Perceived Data Bases and for the degradation of tactical message content during the play.
- Development of the random-access Event Table File and the accompanying event loading routine.
- Development of the controller release event data entry procedures and display screens.

These basic components of the integrated simulation are discussed further here in the framework of the specific computer hardware requirements.

It should be borne in mind that the organization of the material which follows does not imply any particular order of importance to the various components nor suggest any task sequence in the implementation effort. The required elements will be developed and fitted together all at the same time in an integrated system development program. An implementation plan is presented in paragraph 6.6.

4.3.1 Concurrent Development of all Computer Programs

The computer software will be the principal focus of the proposed coordinated approach. SAI will embark on the development and programming of all computer programs simultaneously by employing the top-down programming technique of creating "skeletal" computer program frameworks for each of the four routines cited as the key elements of the system. A skeletal program is a routine containing sufficient computer instructions to demonstrate the overall logical structure of the desired function but without the subroutines necessary for the more subtle logical details. The technique has been successfully applied in the test program described on page 4-48 as well as in other SAI system development efforts. The four basic programs are the three routines comprising the preprocessing system and the interactive executive control routine (IECR). The skeletal framework that will emerge in the early stages of the integrated approach will be a system capable of creating by successive phases the fundamental SCENARIO File and then using this file to activate the IECR.

The system flow of the preprocessing system was illustrated in Figure 4-4.

The system flow of the IECR is shown in Figure 4-9. The operation of this program is conceived to consist of three procedural segments. In the first segment, the input magnetic tape SCENARIO File will be read in, and the simulation data on the tape will be reformatted into direct-access disk files, as shown in the figure. The second segment will be the basic event-store simulator with its asynchronous interactive control. The operation of this segment was described in paragraphs 4.2.2 and 4.2.3. The third segment will be essentially the reverse process of the first segment. In response to controller commands or to certain simulated time clock readings, this segment will take the existing data in the direct-access files and create a new, modified form of the SCENARIO File.

Beginning with these skeletal programs, the coordinated approach can best be described as the process of putting the flesh on the bones of the skeleton. As the system development proceeds, it will entail numerous reformulations of the program structures, many separate recompilations, and a large number of validation test runs. The preprocessing programs appear to present only straight-forward programming tasks except for the basic organization of their end product, the SCENARIO File. Whenever the IECR design dictates a change in the format and/or content of its input SCENARIO File, the preprocessing system will have to be revamped to reflect these new formulations.

The IECR, unlike the preprocessors, combines for the first time a number of sophisticated techniques in a logical framework tied to the computer clock. The data space required for this program has been estimated to be 316 kilobytes (see paragraph 4.1.3.1). Furthermore, the instruction space is estimated to be 1500 kilobytes. These estimates dictate that the simulation data must be organized into direct access disk files external to core and that the instructions must be handled by means of a large number of program overlay segments. The asynchronous trap that provides for the simultaneous battle event sequencing and injection of orders, queries, and controller release executions under the timing of the adjustable simulated clock will be part of the root segment for the overlays.

SAI proposes to use its test program (see page 4-48) as the starting framework for the IECR. This routine has already successfully demonstrated the operation of the asynchonous interactive control coupled with event sequence timing based on the computer clock.

The development of the programs will be based on the following specific computer hardware/software requirements:

- PDP-11 computer with a CPU with sufficient memory management capabilities to provide 64 kilobytes for task areas.

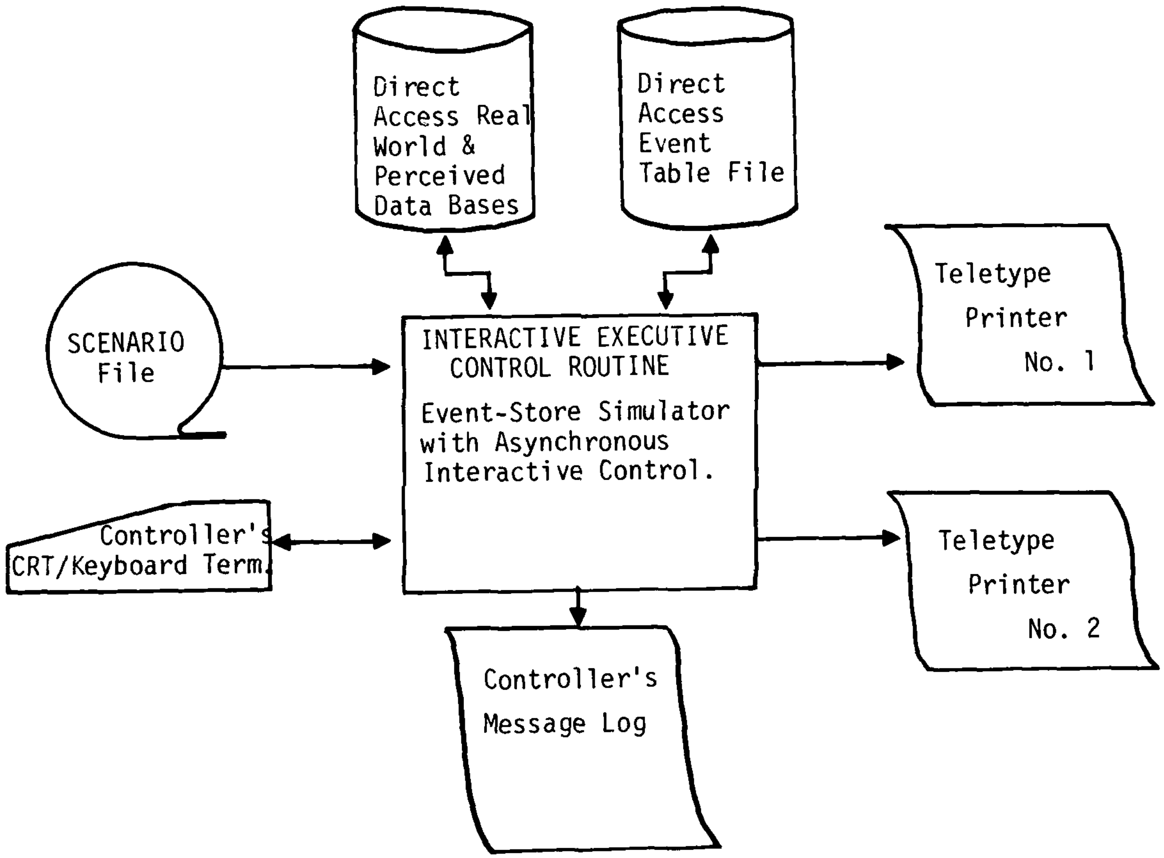


Figure 4-9. System Flow Chart of the Interactive Executive Control Routine.

- Standard peripherals, including high speed printer, magnetic tape unit(s), card reader, and disk storage. This system will require its own disk pack (100 megabytes) as well as a small number of magnetic tapes.
- Three teletype printers.
- One CRT/keyboard terminal, possessing "escape sequence" controls for locking and unlocking the keyboard, remote locating and repositioning of the cursor, and clearing the screen.
- The RSX-11M VØ3 Operating System with its standard utilities.
- The FORTRAN-IV-PLUS compilers and supporting library. This compiler requires a floating point arithmetic hardware unit in the CPU.

All programs, and subroutines except the I/O control and asynchronous trap routines will be written in FORTRAN-IV-PLUS language.

4.3.2 Tactical Message Formats and Other Hard Wired Data

It was stated previously in this section that the hard wired data used in the simulation would be stored together in one major repository in the computer. The repository would contain the repertoire of tactical message formats, the dictionaries of permissible words or phrases to be used with the formats, the rate of advance and withdrawal tables, etc. and would require approximately 100 kilobytes of data space.

In the light of the basic design choices made for the implementation these preliminary determinations did not take into account the CRT screen formats required for interactive control nor the program overlay structure to be used with the IECR. The screen formats, which will be collected together within the major repository, may increase the data space requirement. The individual tactical message formats, on the other hand, will not be stored together but instead will reside as hard wired program data in the separate overlay segments.

The tactical message formats to be used in the simulation are given in Design Note D.

The lists or dictionaries of permissible words or phrases to be used in the tactical messages will be composed and will be stored as program data in one or more files external to core.

The tables of combat frontages, troop movement rates, rates of advance for successful attackers, etc. to be used in executing battle events will also be composed and stored in external files.

A special file will also be created to contain the various screen formats required to provide the controller/operator with instructions for data entry.

These data will be fixed or invariant and as internally stored information will not ordinarily be readily visible to users or players of the simulated war game. SAI will make every attempt to render the black box magic as visible as possible by providing printed lists and parameter tables as part of the basic documentation for the model.

4.3.3 First Scenario

In the integrated approach, SAI proposes to have the first scenario that is developed to exercise the model serve also as the test data vehicle for the structuring of the Real World Data Base and the composition of the list of exogenous events. Although the basic design will eventually permit the synthesis and play of any experiment/scenario combination within the sizing parameter limitation, the computer programs will be developed around this test scenario.

SAI proposed that this first scenario reflect a European setting similar to TRADOC's "Standard Scenario for Combat Developments (U)" (SCORES) with translation sufficient to make the scenario unclassified as structured and played. In general terms, the scenario will describe a non-nuclear attack by Warsaw Pact forces ("RED") against the US V Corps ("BLUE") in the Fulda area of West Germany. Blue covering forces are deployed and make first contact with leading Red elements forward of the defensive positions of the simulated Blue division. Initial reports and actions are those found in the sample message log and material presented in paragraph 4.2.3. The scenario continues to completion with conventional action as the Blue division becomes engaged and fights its battle.

The Real World Data Base for the model will be structured around the composition of the Blue and Red forces in this scenario. This means that the input data card formats, the SCENARIO File records, and direct-access files of the IECR will tie together the basic force tables reflecting the Fulda Gap-V Corps division-level combat.

The list of exogenous events associated with the scenario will likewise provide the basis for the test input data in the Phase III Preprocessor.

4.3.4 The Perceived Data Base

In the structuring of the perceived data bases for the computer, SAI proposes to take advantage of the relationship between the FRENSIT and ENSIT tables in the tabular arrays and the force tables of the Real World Data Base. Since the unit-by-unit state of knowledge data in the FRENSIT and ENSIT tables match the unit-by-unit real world status variables, the tabular arrays and the force tables will be combined into a single direct-access disk file keyed by a unit index. The structure of this file is illustrated in Figure 4-10.

The file will consist of 300 records of approximately 300 bytes or characters each. The records will be keyed by a unit index varying between 1 and 300. Unit indices 1 to 150 will cover the company-sized units of the Blue force; the indices 151 to 300 the Red force. Each record will contain approximately 200 bytes of real world status information plus 50 bytes each for the FRENSIT data and ENSIT data associated with the unit. In the sample entries shown in the figure, record 53 will contain the status, location, etc. of the 53rd Blue unit as well as the Blue and Red perceptions of the same unit. Similarly, record 195 will contain the corresponding groups of information for the 45th Red unit in the war game. The tabular array of data heretofore identified as the Blue Perceived Data Base in now more fully defined as the FRENSIT information over the first 150 records and the ENSIT data in the last 150 records. It is shown by the shaded boxes. The Red Perceived Data Base is simply the remaining unshaded portion on the right.

It can be seen by comparing the relative sizes of the real world status variables and the FRENSIT or ENSIT data that the state of knowledge material is stored by the use of special coded variables and is not simply a biased or degraded version of the same data on the left. The special variables will consist of state-of-knowledge indices and reporting time parameters. A state-of-knowledge (SOK) index will be a one-digit integer whose value will be a quantitative measure of the current state of knowledge about an item of friendly or enemy force information. The reporting time parameters will be simply the recorded date-time-groups when the state-of-knowledge indices were last updated by means of reporting events or intelligence processing events. The special codes will provide the basis for a compressed data storage format as well as for the algorithms which will govern the biasing or degrading of the tactical information held by the two sides.

The algorithms or routines controlling the SOKs will be rooted to a set of internal tables relating the SOK values to the amount or interpretation of the error by which the perceived facts depart from the real facts. There will be a separate table for each identified item of friendly or enemy force information. For example, there will be a location SOK table showing the range of probable location errors ascribed to each of the ten values of the location SOK index. By reference to these tables, the routines will be able to generate or change aspects of the state of knowledge held by the Blue or Red sides.

A special routine of this type will be required in the Phase II Preprocessor Program because the basic preprocessing function of the program is the initialization of the SOK indices to reflect the state of knowledge held by the two sides at the beginning of the simulated conflict. One feature of this routine will be the use of standardized

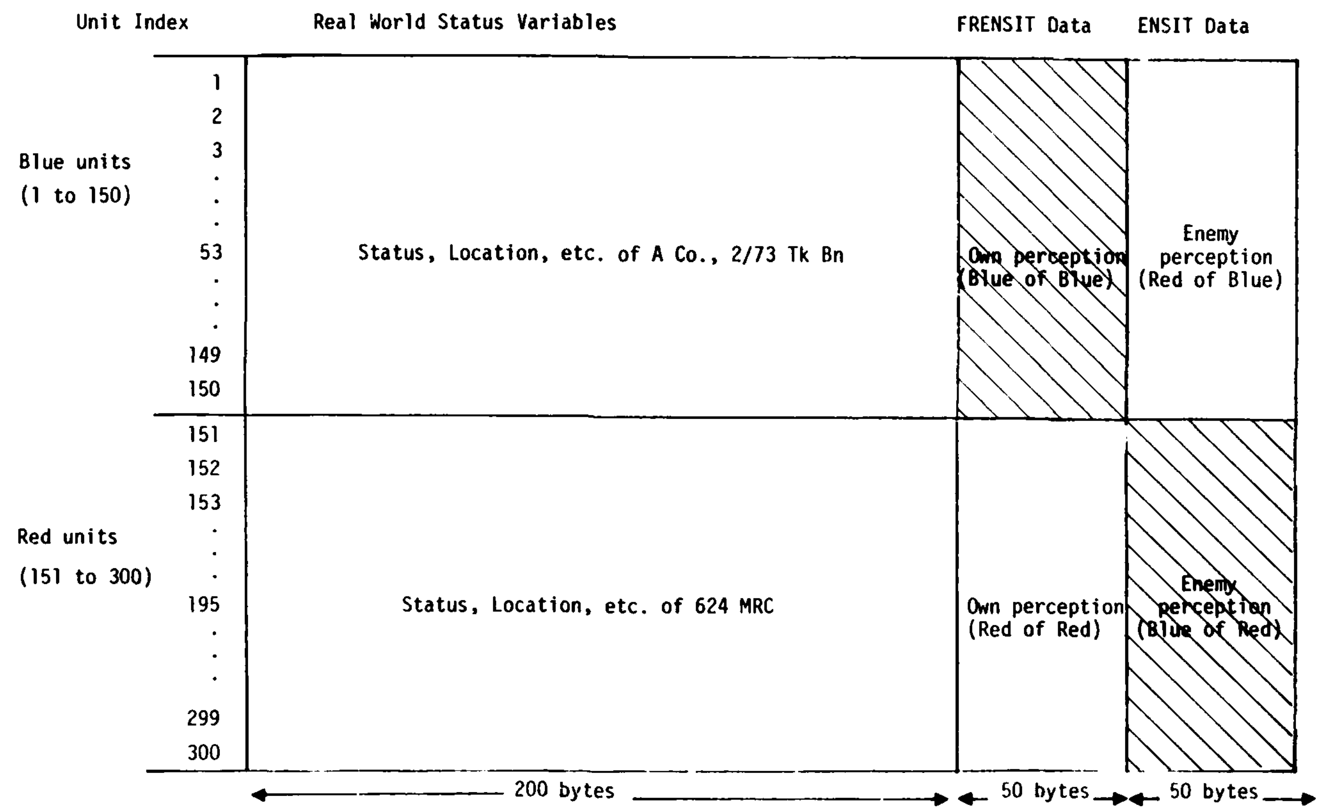


Figure 4-10. Structure of File Combining Principal Data Groups of the Three Data Bases.

or "default" values for the various categories of the SOK indices. Thus, if the user/controller wishes to set up an exercise reflecting the standard levels of knowledge held by the two sides, he would not be required to feed input data cards into the program. Alternatively, if for the purposes of a special experiment he wished to slant or bias the states of knowledge, he would have to have input data cards prepared which would modify the standard SOK values as desired.

The logical structure of all SOK routines and the internal SOK tables will end up, like the tactical message formats and battle event tables, as hard wired elements not readily visible to the users or players of the game. Here again, SAI will describe these otherwise hidden subtleties of the simulation through the system documentation.

4.3.5 Event-Store Simulator

The direct-access Event Table File shown in Figure 4-9 will provide the continuously changing schedule of events on which the battle simulation will be based. After the file has been created and loaded in the first procedural segment of the IECR, the program, during the running segment, will access and update the file in two separate places in the basic control loop. The first access and update processes will occur preparatory to the execution of the occurrence of an event. The second will occur whenever a newly-generated event must be scheduled for future occurrence by loading it into the file and then rearranging the time sequence among all the event records to preserve the correct order of occurrence.

The first process involves accessing and updating just two records in the file, while the second will entail numerous random-access reads. The second process will be embodied in a key subroutine called the event loading routine. The development of this subroutine will necessarily depart from the conventional logical structure of event loaders and will be oriented to an external direct-access file instead of an internally stored event list.

4.3.6 Release Events

Controller intervention by means of release events is one of the key features of the model. Although some types of release events are simply a convenient means for handling certain kinds of staff inputs to populated modules, the basic reasoning behind most release events is as follows:

- Release events provide a means for the investigator/controller to influence the play in order to direct the exercise toward the research objectives.
- Release events provide a means for a human being to provide certain processes such as terrain analysis,

identification of routes of advance, etc. which would otherwise call for much larger computer data requirements.

- Release events provide a means for the controller(s) to invoke military judgement in certain parts of the simulated battle.

The implementation of release events will begin by identifying all those occurrences among the Class 1 and Class 5 events where controller intervention is required. Provision must then be made that the progenitors of these events trigger the pending action warning to the terminal operator, as described in paragraph 4.2.2.2. Each identified release event must then be provided with its own formatted screen and edit/update routine through which the terminal operator will enter the requisite data for release.

In the development of the separate edit/update routines and screens, the trade-off between the human engineering requirements for simple keyboard procedures and the tight instruction space limitations in the computer will be addressed. The different screen formats will be collected together in a file external to core, but the individual routines will have their own edit tests and input format rules.

4.4 FUTURE EXTENSIONS

This subsection addresses the question of how amenable the proposed system will be to specific future extensions. The preceding discussion has identified three basic areas where the proposed implementation will fall short of the full scope of the design concept and whose future incorporation in the model might be considered. The areas are as follows:

- ADP-assisted staff operations.
- Postprocessing computer programs providing (1) statistical summary analysis of the action-handling effectiveness of live and/or simulated staff sections and (2) event trace analysis identifying the sequence of events which led to specific staff actions during the exercise.
- The play of any configuration of populated and simulated modules, including that of up to 5 live Blue Staff Modules versus the live Red Command Module.

For each of these areas, the flexibility of the current design structure is examined to give a perspective on the amount of effort required to extend the model. The discussions follow below. In the examination of these areas, or while considering other possible directions for model extensions, however, the reader is cautioned that in computer simulations of this kind there always exists a point where the most cost/effective approach to further extensions is simply a new basic design concept.

4.4.1 ADP-Assisted Staff Operations

The extension of the model to cover the simulation of ADP-assisted staff operations will involve computer hardware additions, software changes in the existing computer programs, additional programming, and the development of new staff action procedures (SOPs) to be followed by the live staff modules. The following specific items will be required:

- Two ADP-assistance terminals which duplicate, or match, the terminals to be used in the field with respect to the keyboard procedures, the display characters, and the attendant signal lights and switches.
- The definition of the Class 6 events and the specification of the alternative tactical information displays that will be associated with the events.
- Modification of the IECR so that the software accommodates asynchronous interactive data entry from three different CRT/keyboard terminals.
- Modification of the hard wired event thread sequences so that a large fraction of the staff input/output now goes through the player terminals.
- Added programming for the computerized decision-making aids, including the employment of the "scratch pad" data area for the formulation of tactical decision alternatives.

The incorporation of these items will not alter the basic structure significantly, but will clearly change the way the live staff modules will execute their staff actions. It will also alleviate some of the workload implied in the controller functions, since the controller(s) will now be required to perform the tactical data entry function for only the remaining fraction of the staff outputs not handled automatically by the divisional tactical data system.

It is recommended that when this extension is undertaken, the new version of the battle simulation be stored on a separate disk pack independent of the manual staff version described above. This expedient would provide the means for alternative exercises of simulated combat, first, under manual staff procedures, and second, under ADP-assisted staff operations. Such comparisions may serve to identify further some of the basic features and problem areas of a field ADP system.

4.4.2 Postprocessing Computer Programs

The extension of the model to provide statistical summaries of simulated and live staff performance and the chains of events whose simulated occurrences triggered the staff actions will involve little more than the design and implementation of the supplementary computer programs performing these functions. The IECR software will require only minimal modification to provide a suitable output processed event file which will serve as the basis for the postprocessing.

The postprocessing functions will be oriented to the measures of performance described in paragraphs 2.4.4 and 2.4.6, but the computer programs will stress the statistical population of the measures over the simulated period of time in which they occurred. Thus the postprocessor will find the average values and indicated distributions of amounts of time taken by the separate staff sections to complete their information processes. The measures will be applied to both simulated and live modules in order to provide, for comparison purposes, the statistical norm reflected by simulated staff sections and the actual performance by populated sections.

The postprocessor will also help identify and analyze the specific sequence of battle events that led up to periods of concentrated staff activity on the part of populated staff modules. The behavioral performance measures will be facilitated by the ability to distinguish between the periods when the staff is merely pursuing routine staff actions and those times when it becomes heavily loaded with a large number of required actions at once.

The future development of postprocessing software depends primarily on the identification of the desired performance measures to be handled in the new computer program. After a certain amount of experience has been attained in running the research tool, the specification of these desired measures will be better defined. The actual programming and the modifications to the IECR will represent relatively modest extension efforts.

4.4.3 The Play of More Than Two Populated Modules

The extension of the model so that it permits the play of 3 or more populated staff modules will involve the reexamination of the controller's functions and the basic computer assistance he (they) are given. The increased staff output message traffic will probably dictate a controllers team of more than two people as well as additional hardware to cover the added volume of message data entry traffic. If the basic architecture were expended to cover 6 player modules (5 Blue Staff Modules and one Red Command Module), the overall computer hardware requirements for a manual staff version would be as follows:

- Two or more controller's CRT/keyboard terminals.
- The message log printer.
- Six teletype printers for the player's input messages.

This requirement would have to be augmented by the six player's terminals if it also covered the ADP-assisted staff operations.

. Modifications to the IECR software would be required in order to provide the correct switching and routing of tactical message traffic among the various devices. Unfortunately, the expanded software would also require added provision for the coordination of separate control functions applied at different CRT/keyboard terminals. Programmatic coordination interlocks of this kind often compound the problems of software development.

Except for the added computer hardware and software, the extension to accommodate any configuration number shown in Table 4-1 would not affect the underlying simulation structure described in this section.

4.5 APPLICATIONS OF THE TOP-DOWN DESIGN

Paragraph 2.1 stated that the simulated being developed should be a cost effective tool for behavioral science research on human performance in the division command group/staff, for combat developments evaluation of tactics and doctrine, and for training command groups/staff elements. The applicability of the design to the first of these, i.e., to behavioral science research is discussed at length in Section 5 as it applied to any populated module. It is discussed again in Section 6 as it applies to the G2 module. The remainder of this subsection discusses the applicability of the design as a tool for combat developments, evaluation of tactics, and doctrine, and as a training tool.

4.5.1 Combat Development Applications

A simulation of the nature described in this section clearly has application in the general area of evaluation of tactics and doctrine. It is, basically, a simulation that is sensitive in terms of combat outcomes to the decisions made by a commander and his staff at division level. These combat outcomes are especially sensitive to decisions that affect:

- The amount of combat (fire) power applied.
- The conditions under which it is applied (terrain, posture, etc.).
- The time and duration of its application.

Because it is an event store simulation, it is very sensitive to the time of occurrence of battle events and therefore an eminently suitable vehicle for studying the dynamics of division level combat. It is a very detailed representation of the command and control processes at division level and how these are affected by the performance of the subsystems that comprise the division (maneuver, fire support, intelligence, EW, communications, logistics, personnel, etc.). It is also sensitive to the interactions among these subsystems that are established through decisions affecting organization for combat, fire support management, intelligence, communications, EW, and the other support systems as well as their interactions with the enemy. It is, therefore, an excellent vehicle for studying the command and control of division assets, but it is dependent on inputs to the simulation which specify the performance parameters of the subsystems being managed. These parameters can be varied to alter initial performance at the beginning of the simulation run and will be altered as the battle progresses to reflect changes that may occur, e.g., attrition. The simulation is not useful for developing the performance parameters of the building blocks of the model (units and subsystems that comprise the force). It can, however, be used to examine how the decision making process is altered as a result of changes in performance parameters and how the changes affect the outcomes of combat, e.g., changes in the performance of the information system that feeds the decision making elements of the staff.

Figure 4-11 is a representation of a dynamic combat model of the kind described in the preceding paragraph. The entire friendly and enemy forces are defined in terms of their personnel, materiel, and operational concepts as these determine their organization and procedures. Together these determine the performance parameters of the subsystems that comprise the force. Unless these simulation inputs are modified by extraneous changes (by players) the interaction between the forces is a stationary process, i.e., force capabilities are modified only by interaction with the enemy and the outcome is "limiting" in the sense that no effort has been made to optimize the outcome by altering operational concepts (tactics and doctrine). If, however, the loop is opened periodically so that the results of combat are fed back to players who have an opportunity to alter the operational concepts, and compare them with old or standard concepts or to compare, e.g., Soviet and NATO organization, tactics, doctrine, and C^3 capabilities and procedures. For this reason the connection between proposed doctrine and changes to operational concept is a double headed arrow. Just as important in such an investigation as the comabt outcomes in terms of area exhanged, resources consumed, and time expended in terms of probable set of changes in operational concept developed by an alert enemy as he learns to cope with new and unexpected threat behavior. The simulation described prevously in this section is precisely of this kind.

Among the kinds of tactical and doctrinal questions that can be examined effectively by this division level battle simulation are:

- Maneuver Force

  -Task organization
  -Missions
  -Echelonment
  -Dispositions
  -TOEs (must first be transformed into performance parameters acceptable by the model, e.g., firepower, movement rates, response time, etc.)

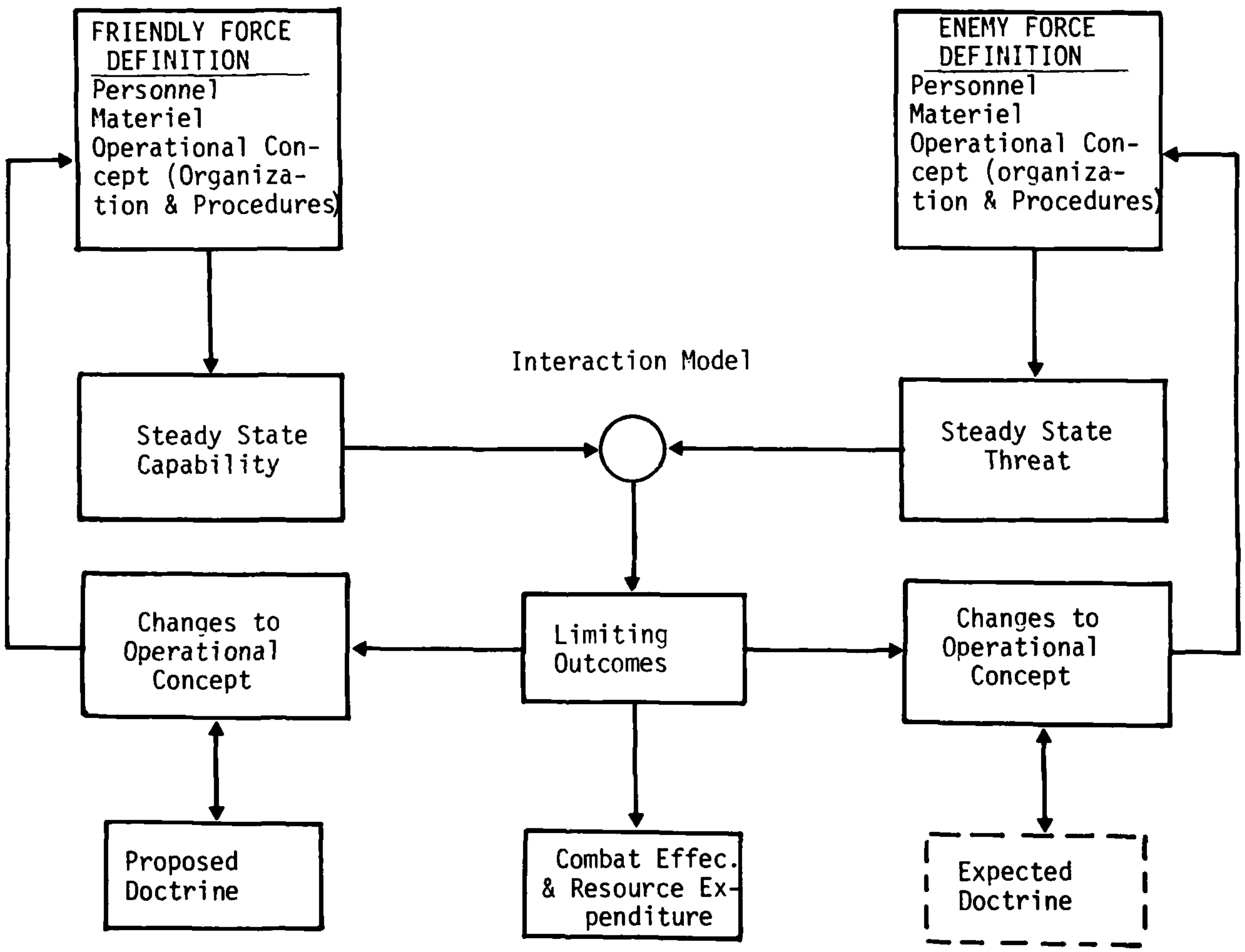


Figure 4-11. Dynamic Ground Combat Model.

- Fire Support Units

  -Allocation of artillery support (DS/GS)
  -Allocation of Army assets
  -Allocation of close air support (CAS)
  -Targeting priorities
  -TOEs (as reflected in performance parameters)
  -Nuclear planning and execution

- Other Support Systems

  -Allocation of Intelligence assets
  -Intelligence reporting procedures (as reflected in performance parameters)
  -Communication policy (as reflected in performance parameters to include effects of enemy jamming)
  -EW policy (to include effects on friendly communications)
  -Allocation of Army air assets to transportation tasks.

Since such a simulation is designed to run for periods not normally exceeding 12 hours of combat, it will not be sensitive to most personnel and logistic decisions except as these influence the status of forces at the opening of hostilities. Most such decisions, except for limited redistribution of assets by Army air, will not affect the battle outcome within such a short time frame.

4.5.2 Training Applications

As has already been discussed in paragraph 2.4.4, the application of such a simulation to the task of training command group/staffs involves features of the model already discussed and provided for the first two applications. A simulation is clearly applicable primarily to those steps in the education process that involve application of information and principles a student has already learned, to evaluation of his performance after application, and to reinforcement of such learning. As such there are two distinct levels of training to which it would be applicable.

- Teaching staff procedures and the mechanics of staff processing.
- Teaching the doctrinal or policy basis for decision making.

These are described in the following subsections.

4.5.2.1 Procedural Instruction

The simulation is obviously applicable for the purpose of teaching a small group of staff personnel the mechanics of routine staff procedures. It can be used to provide the triggers for generating the information processing required to produce specified outputs, whether these be provided by sources external to the staff module or generated by the clock and a Standing Operating Procedure. The necessary information inputs can be provided either on an automatic distribution basis or accessed as required by the students. This can cover as much as or as little of the available repertoire of message types (decision variables) as desired.

Evaluation of the performance of individuals within the staff module or of the entire module involves a combination of measurements made of individual staff operations procedures and measurements made in the information stream at the module boundaries. Such measurements can be made of the time, effort (in terms of man-hours or man-minutes), completeness, and accuracy of the information outputs, files, or displays. Paragraph 5.2.1 contains a detailed discussion of the measures appropriate and available at the boundaries of the module; paragraph 5.2.2 outlines the techniques for internal measurement of these quantities.

4.5.2.2 Training in Doctrine or Policy

The simulation is also an excellent vehicle for this higher level of training in that it puts student decision makers into a realistic combat environment and requires that they make the same kinds of decisions that must be made in actual combat. The evaluation of student performance and reinforcement of preferred tactis and doctrine are provided through realistic combat outcomes which indicate to the student the validity of his decisions by showing him their effect on mission performance. Such a tool will provide far more credible reinforcement than does the "school solution" in a classroom situation. The applicable combat outcome parameters are also discussed in paragraph 5.2.1. The strong parallel between evaluation of new tactics and doctrine and the evaluation of student decision makers should be noted.

Section 5

INSTRUMENTATION OF LIVE MODULES

5.1 COST OF REALISM

In designing the live staff module there is an important tradeoff that must be considered. This tradeoff is between the realism of the decision-making environment and the size (hence, complexity and cost) of running the simulation. The facet of realism being addressed here is the third principle enunciated by Sackman* i.e., the Conversational Principle. For this application his statement is paraphased as follows:

- Conversational Principle: Human performance in man/ (simulation) dialog will vary with the similarity of the responding (simulation) to the real time exchange characteristics of human conversation ... As (simulation) response time and message pattern deviate increasingly from real time parallelism ... so will user performance (vary).

The difference in conversational realism occasioned by the size of the live staff module can be appreciated by comparing two extremes. At one extreme are the staff section workshops conducted at Ft. Hood in 1974 under the auspices of HQ MASSTER. For these workshops the normal daytime "shift" of a staff section was assembled together with its TOE equipment down to the last telephone and radio and disposed in replicas of their vans and tents in the field. The simulation of outside world, to include other staff sections, was provided by a group of controllers. Everything was done to try to place the staff section in an environment that allowed internal data processing to proceed just as it does when the unit is in the field and which would make the outside world (as painted by the message traffic) appear as it would in combat. This was truly an iconic model in that it certainly looked like the real thing. The conversational principle was adhered to very strictly. However, the cost of conducting extensive experimentation in this manner is prohibitive. It required the services of more than 75 military personnel to man one staff section and to provide controllers and data collectors.

At the other extreme is SIMTOS which required only a single player within the staff section and virtually no human control. In a sense, this is not a fair comparison, for the workshops were simulations that permitted a staff to operate in a manual mode while SIMTOS was a simulation designed to permit a decision maker to operate aided only by a computer and I/O devices which could present to him the aggregated, evaluated, and synthesized information that would have been presented to him by the other members of his staff. Nevertheless, if one were to attempt the SIMTOS approach to building a simulation for study of a staff operating in the manual mode the conversational principle would certainly be violated. Yet, the operating costs would be minimal.

*H. Sackman. Computers, Systems Science and Evolving Society. New York, John Wiley, 1967

The nature of the trade-off can be appreciated by referring to Figure 2-5. This figure illustrates the nature of the data processes for both manual and ADP-assisted operations. The interface between staff and communication processes, i.e., the simulation, occurs at the bottom of the figure in the purely manual mode. Much of the time and effort of a manual staff module is consumed in the lower staff processes, e.g., receiving, transmitting, tagging, sorting, updating, etc. Thus, if the interface between the simulation and the manual processes is moved up to the higher process levels, much manpower can be saved, but the farther one moves the interface in this direction, the less realistic the "manual" operation becomes.

On the other hand, if the live staff module is operating in an ADP-assisted mode one faces a different design problem. The simulation must now perform the ADP processing that would be performed by a TOS, thus, the interface between the live players and the simulation has moved to the man/machine interface illustrated in the figure. Clearly, such an ADP-assisted staff can be substantially smaller than a purely manual staff if the simulation is doing much of the lower level data processing. The problem now is not one of manpower costs for the operation, but one of accommodating a range of different man-machine interfaces. Presumably, one would want to use such a simulation to investigate the effectiveness of alternative software and hardware combinations. This has already been alluded to in Section 3.4.6. Even if the rest of the simulation is essentially hard-wired, the software development costs for simulating a wide range of ADP assistance would be substantial.

The following approach will be used in addressing these problems. Every effort will be made to design the live staff module so that it can operate as realistically as possible in both the manual and ADP-assisted modes. The impact on simulation structure is that provision must be made for a "perceived data base" for both Blue and Red in addition to the real data base which will represent ground truth. Such a perceived data base is required for any ADP-assisted operation in which the players are permitted to query a data base in order to retrieve sorted, updated, and aggregated data. This feature will also be useful in the manual mode if the player wants to query subordinate units, for example, for such information.

In designing the purely manual module, consideration will be given to reducing the number of the required players by including some lower level processing within the simulation. For example, much of the message traffic which would ordinarily require players to sit at radio and telephone instruments in order to transcribe or transmit hardcopy can be provided to or accepted from the players in hardcopy form. This does not necessarily mean that all traffic with the outside world would be in hardcopy, because that would seriously violate the conversational principle. Some filing and recording activities may also be performed by the simulation in order to reduce manpower requirements.

In designing the ADP-assisted provisions, every effort will be made to make the basic simulation structure as flexible as possible, so that many different interfaces can be supported. The initial design will provide for a minimal number of different kinds of man-machine interfaces with provisions, however, for proliferation later as new problems and funds to support them may arise.

5.2 PERFORMANCE MEASUREMENT

Some of the pertinent considerations affecting live staff performance measurement have already been addressed in paragraph 2.4.4. There it was pointed out that measurements within the information network are limited to measurements of time and effort associated with the preparation of specified staff outputs and measurements of information content of such outputs such as completeness, accuracy and validity for a very limited portion. It was further pointed out that complete measurements of the quality of information content cannot be made entirely within the information system but must be inferred from the outcomes of the combat simulation. Points between which certain classes of measurement can be made were also defined.

In view of the modular nature of this simulation and the basic design concept which provides that every information transfer across the boundaries of a staff module must be made explicity, the measurement of staff performance can be divided into measurements made at the boundaries of live staff modules and measurements within staff modules. Each of these is discussed in the following subparagraphs.

5.2.1 Measurement Outside the Staff Module

The top-down design outlined in Section 4 provides for the following kinds of measurements at the module boundaries:

- Logging the time of entry into the simulation of every staff output. This includes out puts which are entered into the computer and those outputs which are simply recorded and filed.

- Logging the time of delivery of every staff input provided to live players whether those are generated by the computer or delivered by the controller from the file of previously prepared written entries.

- Recording the content of every staff input and output whether processed by the computer or hand processed by Control.

From these recorded data the following kinds of performance measurements can readily be extracted:

- Time delays between selected inputs and outputs
- Time delays between selected triggers and outputs
- Completeness of selected staff outputs with respect to inputs provided
- Accuracy of selected staff outputs with respect inputs provided
- Numbers of selected outputs generated
- Numbers of selected inputs provided
- Numbers of queries generated for selected classes of information.

Measurement of the quality of the content of staff module decisions, as evidenced by the outputs, must be made in terms of their effects on the battle outcome. The discussion at paragraph 2.4.6 indicated the effectiveness measures that can be used to measure the relative mission accomplishment of alternative solutions to battlefield management. These are:

- Changes in geographic area controlled by each side
- Changes in the resources consumed and available
- Time intervals required to effect above changes

The design delineated in Section 4 provides these output measures as follows:

- Changes in geographic area are available as unit locations both in the Real Data Base and on the Controllers SITMAP
- Changes in resources are available as characteristics of the units whose status is maintained in the Real Data Base

- Time to effect these changes is inherent in an event store simulation which records the time every change in unit characteristics (to include location) is effective.

5.2.2 Measurements Inside the Staff Modules

Dynamic processes such as the data processing performed within a live staff module can be studied in either or a combination of two modes: by time of occurrence of observable events, or by observing behavior at time increments. The latter technique is particularly applicable to the study of human behavior when the subject is engaged in repetitive, mechanical tasks (time and motion studies) for which motion pictures provide an excellent recording and measurement medium. However, this technique has severe limitations when applied to the study of information processing. It fails to capture significant data, e.g., the content of the information stream, and the very volume of data collected poses a formidable data reduction problem.

An alternative, event-oriented approach to the study of information processing has been used with some success in defining such processes.[1] This involved breaking staff processes down into a series of elementary operations such as those listed at Table 5-1. The initiation and completion of each such elementary operation is an observable event as is entry of an action into a players' queue or removal from queue. Recording the sequence of such operations, the time required for each, the time spent in queue, the player who performs each and the station at which an operation is performed plus a copy of the information transferred, recorded, plotted, etc., provides one useful means for describing the information process. The results of such a study can be plotted in flow chart form as at Figure 5-1. Such data are particularly useful for the simulation of information processes. There remain problems of designing instrumentation which does not interfere or interact with the information processing.

The discussion at paragraph 2.4.4 has already indicated that the measurement of data processing is limited to:

- Effort and delay times for individual processes (from which the process sequence can also be deduced).

- Completeness of data outputs which are a priori combinations of input data.

- Accuracy of data outputs which are a priori combinations of input data.

[1]Tiede, R. V., et al, "The Integrated Battlefield Control System (IBCS) Third Refinement Final Report," Science Applications, Inc., 31 March 1975.

Table 5-1. Elementary Operations

THROUGHPUT OPERATIONS

Receive Radio (Rcv Rad): All action steps required to produce a written copy of an incoming message via radio to include required radio operating procedures.

Receive Telephone (Rcv TP): All action steps required to produce a written copy of an incoming message via telephone to include required telephone operating procedures.

Receive RATT (Rcv RATT): All action steps required to produce a written copy of an incoming message via RATT to include required RATT operating procedures.

Receive Aurally (Rcv Aur): Reduction of an oral transmission to a written form.

Transmit Orally (Xmit Oral): All action steps required to convey a written message by unaided, human voice to a predesignated addressee(s).

Plot on Map (Plot): Post or update symbols on map.

Enter in Journal (Enter): Physical process of recording in journal, workbook or list.

Retrieve (Rtrv): (Must be associated with a specific file or display.) Locating and extracting from a particular file or display.

Compose: Prepare a draft of a product or portion of a product.

Make Overlay (Overlay): Physical preparation of map overlay.

Post Display (Post): Enter or update data on visual display.

BRANCHING OPERATIONS

Determine Internal Routing (DIR): Read for content and select addresses/station routing within element for further processing of that product.

Table 5-1. Elementary Operations (Continued).

Determine External Routing (DER): Read for content and select external addressee(s).

Reproduce, Manual (Repro, Man): Production of an exact handwritten copy (may be multiple copies using carbon paper).

Reproduce, Machine (Repro, Mach): Production of an exact copy (or copies) utilizing copy machine.

Type: Production of an exact copy using a typewriter. (May be multiple copies using carbon paper.)

COLLECTION OPERATIONS

Consolidate and Approve (C&A): Accept, integrate, edit portions of a product produced by more than one source and release final product for distribution (normally to external addressees). The same operation is used for approval only in which case there is a single input.

TERMINATING OPERATIONS

File: (Must be associated with a specific station.) To place a product or extract therefrom in a designated, closed (nondisplay) storage place or to update a permanent (nondisplay) record

Terminate (Term): This copy goes no further and is placed in File 13 or convenience file.

Transmit Radio (Xmit Rad): All action steps required to convey a written message via radio to a predesignated addressee to include required radio operating procedures.

Transmit Telephone (Xmit TP): All action steps required to convey a written message via telephone to a predesignated addressee to include required telephone operating procedures.

Transmit RATT (Xmit RATT): All action steps required to convey a written message via RATT to a predesignated addressee to include required RATT operating procedures.

Transmit Courier (Xmit Cour): Picking up an action from an outbox, courier, other staff member, or self and delivering it to a predetermined addressee/station or his inbox.

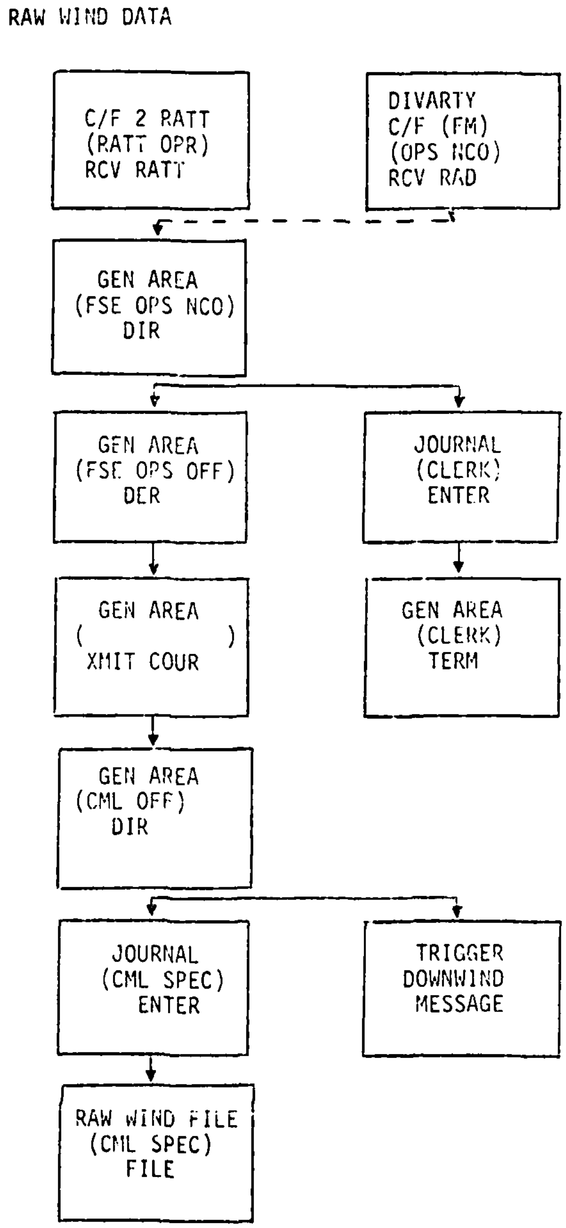


Figure 5-1. SOP Flow Chart.

The completeness and accuracy of all other outputs and the validity of all outputs cannot be measured directly and must be inferred from the battle outcomes.

One technique that has been used to make time and effort measurements is the installation of time clocks at every operator/station. The time clock stamp also contains a unique identifier for every operator/station. The requirement to insert every message into the time clock for every elementary operation does introduce some extraneous "noise" into the operation, but the alternative problem of data reduction that accompany collecting such data by means of movie cameras is indeed formidable. Clearly the time clock technique would be useful only for tracking the flow of hardcopy. In the same way, completeness and accuracy of files and displays can also be measured by comparison with data inputs, but this again is limited to hardcopy. For special imited applications it would be possible to capture some of these data by some combination of cameras and sound recording. For an ADP-assisted staff, the measurement problem is substantially easier since the I/O devices can be used to collect much of the needed data.

There is at least one other approach to the study of information processing which concentrates on the process rather than on the events. This involves some combination of individual interview, group discussions, questionnaires, etc., to collect data directly from the subjects. The pitfalls inherent in such subjective and introspective techniques are only too well known to behavioral scientists if data collected in this manner are not confirmed by experimental evidence. In the case of the study cited above, data were also collected by such subjective means. Some general observations as to the validity of the data collected by these means are pertinent.

- The sequence of operations defined in this manner tended to be very complete, highly stylized, and "by the book."

- Job assignments were on a basis of primary skills and an unofficial "pecking order". For example, principal staff officers did not answer telephones or radios,or hand-deliver messages.

- Job assignments were made without regard to individual loadings on either personnel or equipment. Standing Operations Procedures (SOPs) indicated, for example, that all outgoing traffic would be validated by the senior staff officer present.

- The sequence of individual operations tended to be linear with minimal parallel processing.

- In short, SOPs developed in this manner tended to be idealized representations that could be followed only under "no-load" conditions.

Experimental data collected by more objective mans showed marked changes in these procedures when staffs were subjected to live loads.

- A live load tended to streamline processing procedures. Unnecessary frills were eliminated and there was evidence of much greater parallel processing.

- Job assignment became much more "democratic". Tasks tended to be performed by whatever qulaified person was available. Officers answered telephones and radios.

- The sequence of elementary operations was altered to route traffic around large bottlenecks and long queues or the sequence was inverted to keep the action moving.

- More traffic was handled orally.

- Under severe loading, processing became so curtailed that significant information was, indeed, ignored and some queues, e.g., that of the file clerk, became ever-increasing.

The above experience does not mean that subjective methods have no value. They can be of significant help in making *preliminary process* definitions, but they must be corroborated or modified as the result of objective experimentation.

In summary, our consideration of possible alternatives to live staff instrumentation leads us to the following conclusions:

- The collection of data regarding player performance in the manned staff modules can be accomplished either on a time increment basis or through event-oriented techniques. At this time, some combination of both alternatives seems desirable.

- Subjective techniques (interview, questionnaires, group discussions, etc.) may be useful for formulating initial concepts as to staff behavior, but must be verified or modified through objective experiment.

5.3 CONTROL PARAMETERS

To be useful for human factors research on the behavior of decision makers within populated staff modules, the simulation must provide control parameters to the experimenter that can adjust the quality and quantity of information used by the decision maker (player). A number of categories of such control can be identified. These include:

- Control of the amount and kind of information provided to populated staff modules for a specified scenario.
- Control of the availability of "source identity" to a populated G2 module.
- Control the time constraints imposed on a populated staff module for its decision making.
- Control the quality of the information provided to a populated staff module.

The top-down design described in Section 4 provides one or more basic control parameters for each of these categories. These are described in the following paragraphs.

5.3.1 Amount and Kind of Information

The basic control parameters for this category are:

1. Change the distribution of message types provided automatically to a populated staff module (Automatic Distribution)

2. Change the message types which can be accessed by a populated staff module on a query basis (Query Distribution)

3. Change the threshold values for submission of event triggered reports (Reporting Threshold)

4. Change the period for submission of periodic reports (Reporting Period)

5.3.2 Availability of "Source Identity"

The basic control parameter for this category is:

5. Selectively delete "source identity" from spot reports submitted to the populated G2 module (Source Identity)

5.3.3 Time Constraints for Decision Making

The basic control parameters for this category are:

6. Change the requirements for submission of "record" outputs, i.e., outputs that are not entered directly into the simulation, from a populated staff module (Record Requirement)

7. Change the pace of the simulated combat by altering the ratio between game clock time and wall clock time (Speed Ratio)

5.3.4 Quality of Information

The basic control parameters for this category are:

8. Change the delay times between trigger event and message receipt (Message Delay)

9 Change the error rate in message generation (Error Rate)

10. Change the rate at which blank or random alphanumerics are introducted into messages (Omission Rate)

5.3.5 Research Applications

The ten basic control parameters enumerated above permit a wide range of research subjects to be investigated by means of the model. A small number of these is indicated in Table 5-2 together with the pertinent basic control parameters.

5.3.6 Adaptive Behavior

The discussion of control parameters to this point has been limited to the study of manual staff performance, i.e., without ADP assistance. Providing ADP assistance opens up a whole new vista of staff performance study. In the ADP mode it becomes feasible to provide the player himself some degree of control over the form in which it is presented -- normally by means of visual displays. Such an adaptive capability can be provided by means of adaptive software that can be made available with "smart Terminals." This capability will not be incorporated in the intial implementation of the simulation, but can be added later as additional resources become available. A major advantage of ADP staff operation from the point of view of the expermenter is that so much of the internal information flow within the staff module now appears at the I/O terminal provided the player. Much of the internal instrumentation that had to be superimposed on the manual staff is now inherent in the terminal which can record the frequency of access to the data base by information category, the kinds of and frequency with which information processes are invoked, and the forms selected by the player for information display.

Table 5-2. Possible ARI Research Applications.

	APPLICABLE BASIC CONTROL PARAMETER									
APPLICATION	AUTOMATIC DISTRIBUTION	QUERY DISTRIBUTION	REPORTING THRESHOLD	REPORTING PERIOD	SOURCE IDENTITY	RECORD REQUIREMENT	SPEED RATIO	MESSAGE DELAY	ERROR RATE	OMMISSION RATE
EVALUATE PLAYER PERFORMANCE AS FUNCTION OF AMOUNT AND KIND OF INFORMATION PROVIDED	X	X	X	X						
EVALUATE G2 PLAYER PERFORMANCE AS FUNCTION OF SOURCE IDENTITY PROVIDED					X					
EVALUATE PLAYER PERFORMANCE AS FUNCTION OF TIME CONSTRAINTS IMPOSED ON DECISION MAKING						X	X			
ESTABLISH CORRELATION BETWEEN COMBAT OUTCOME AND AMOUNT/KIND OF INFORMATION REQUESTED BY "ACTIVE" VS "PASSIVE" PLAYERS	X	X	X	X						
ESTABLISH CORRELATION BETWEEN COMBAT OUTCOME AND AGE/ACCURACY/ COMPLETENESS OF INFORMATION PROVIDED TO PLAYERS								X	X	X

Section 6

DESIGN OF THE INITIAL IMPLEMENTATION (LIVE INTELLIGENCE (G2) MODULE)

This section pulls together the design features that apply to the initial implementation of the simulation in the configuration consisting of two live modules (Blue G2 vs Red Command Module -- Configuration Number 36) or one live module (Blue G2 -- Configuration Number 4). As such it will repeat or reference materiel already presented elsewhere in the report in the more general context of multiple configurations.

6.1 PHYSICAL LAYOUT

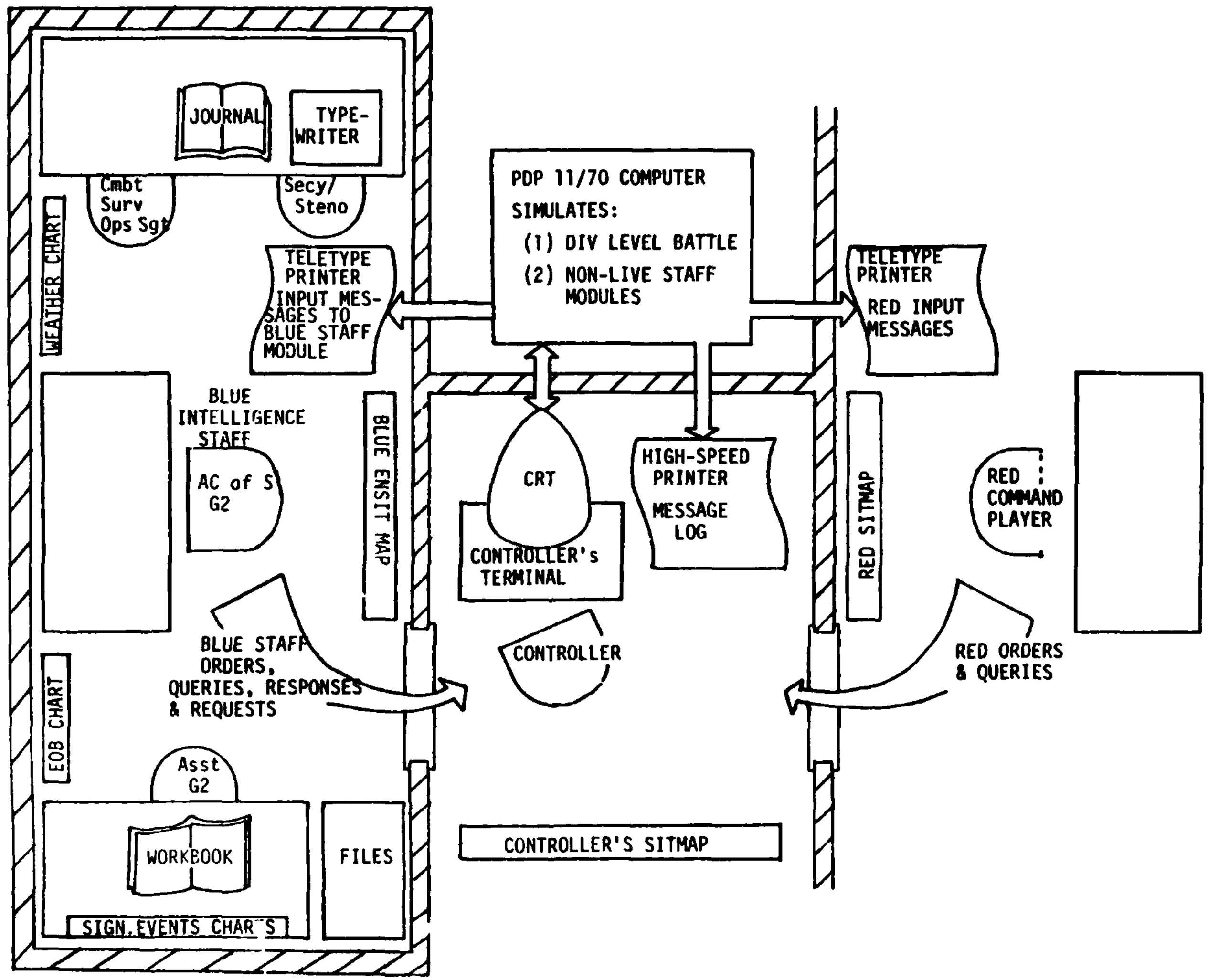
A feasible physical layout of the simulation in Configuration Number 36 is shown at Figure 6-1, which is a repetition of the layout shown at Figure 4-5. At the left of the figure is the live G2 module showing stations for four personnel and typical equipment (files, workbook, journal, displays) for operation in the manual mode. The two pieces of equipment unique to the simulation are the teletype printer (for incoming traffic generated by the Battle Outcome Generator) and the pass through window for incoming traffic generated outside the Battle Outcome Generator and for all outputs of the G2 staff module (orders, queries, responses, and requests). The center section of the figure shows the simulation proper with the computer at the top and the human controllers in the lower portion. Physical equipment in the controllers section consists of a cathode ray terminal, a high speed printer, and a Controller's Situation Map. Shown at the right is the live Red command module. It also contains the two simulation unique equipments, the teletype printer and the pass through window.

It should be noted that the initial implementation can also be played in Configuration 4 (live G2 module only). In this case the functions of the Red player are taken over by the Controller(s) if the experiment objective requires interaction on the part of the Red side i.e., that Red orders, requests, etc. be dependent on the actual status of the force interactions at any particular time. If Red interaction is not required, the outputs from the Red side can simply be scheduled and treated as if they were scenario events.

6.2 PERSONNEL REQUIREMENTS

6.2.1 Blue G2 Module

The TOE of the Armored or Mechanized Infantry Division (TOE 17-4H) provides a G2 section consisting of 6 officers and 9 enlisted men. There is, however, a much larger group within the division



Fiqure 6-1. Physical Layout in Live G2 Configuration.

involved in both intelligence and EW activities, much of it at division level. This is the Combat Electronic Warfare Intelligence (CEWI) battalion whose HQ company maintains an Electronic Warfare Intelligence Operations Center (EWIOC) for the production and dissemination of integrated all-source intelligence, mission management for intelligence and electronic warfare operations and performance of the SSO function. As such, this center works closely with both the G2 and G3 sections of the division general staff. It is profitable to look more carefully at the organization, mission, and functions of the CEWI battalion in order to develop a rationale for how much of its activities, if any, should be included in the G2 staff module, quite aside from the pragmatic consideration that the G2 module could easily become so large as to be unmanageable and unaffordable. The following is an extract from the draft document, Training Text 30-115T, COMBAT ELECTRONIC WARFARE INTELLIGENCE BATTALION (CEWI BN) DIVISION, prepared by the US Army Intelligence Center and School, Fort Huachuca, Arizona, 15 June 1976.

"COMBAT ELECTRONIC WARFARE INTELLIGENCE BATTALION, DIVISION

"2-1. ORGANIZATION. TOE 30-115T was developed in response to the Chief of Staff's decisions to integrate intelligence and electronic warfare assets at the tactical echelon. Organic to this battalion are three companies: Headquarters and Operations Company, TOE 30-116T; Electronic Warfare Company, TOE 30-117T; and Ground Surveillance Company, TOE 30-118T.

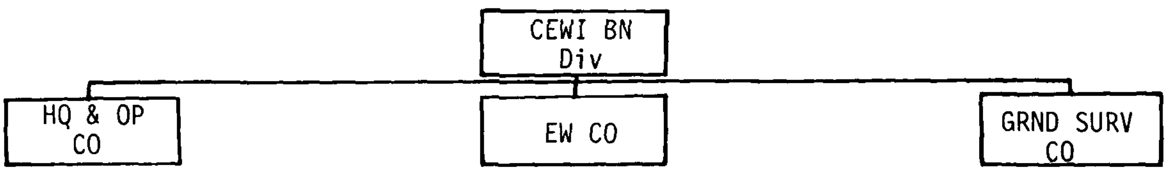


Figure 1-1

"2-2. MISSION. This battalion, organic to an armored or infantry (mechanized) division, provides combat intelligence and electronic warfare functions in support of the division.

"2-3. FUNCTIONS. The CEWI battalion provides integrated intelligence analysis and production, timely intelligence dissemination, integrated mission planning and management, command and control, centralized logistics and administrative support for intelligence assets, and intelligence skills in the three basis disciplines: HUMINT, Imagery, and Electromagnetic. The battalion provides electronic warfare planning, coordination and execution.

a. The CEWI Bn supports the division by providing electronic warfare and combat intelligence in the fields of signals intelligence, imagery interpretation, interrogation and ground surveillance. The battalion, through the Electronic Warfare Intelligence Operations Center (EWI Op Ctr), which is comprised of the Mission Management and Dissemination Section (MMDS), All-Source Production Section (ASPS) and the Electronic Warfare Section (EWS), provides electronic warfare support and integrated all-source intelligence to the commander. In addition, the functions of counterintelligence (CI) and signals security (SIGSEC) are also provided by elements of the battalion. A US Air Force Weather Section (USAF WX SEC) is attached to the battalion to provide weather support for the division.

b. The CEWI Bn provides a single intelligence and electronic warfare commander who is responsible for the integrated management of all assets in his command. He is responsible for the execution of intelligence tasks, to include analysis, production, dissemination, and collection planning, and for the execution of EW mission planning and execution. The battalion operates under the general staff supervision of the G2, and responds to the G2 in matters of intelligence and to the G3 in matters pertaining to EW. The commander also exercises centralized command, control and supervision of the administrative and logistical support functions of the battalion.

c. The battalion provides RATT/AM/SSB communications during initial employment of the battalion, and as an alternate, FM/AM/SSB for command and control. Area multichannel communications provided by the division signal battalion are used to the maximum extent possible for intelligence operational traffic.

d. This organization is capable of providing direct support (DS) maintenance on communications and electronic equipment, less RADIAC, and general maintenance support (GS) on electronic warfare (EW) equipment. The battalion performs organizational maintenance on all other items of equipment. The battalion is dependent upon appropriate elements of the division for medical, religious, financial, legal, and personnel administrative services, the divisional signal organization for service into the area communications system, areas."

From the above extract, it is clear that the CEWI battalion provides a formal structure for two separate but highly integrated support systems for the division: the intelligence support system and the electronic warfare support system. Further, the intelligence system is under staff supervision of the G2 and the EW system under the supervision of the G3. Thus, the CEWI battalion provides special staff services and executes operations in much the same way as other specialized support organizations, e.g., division artillery, the engineer battalion, or the signal battalion. The general staff, on the other hand, assists the commander in carrying out what have been called the integrating functions: see, plan, allocate, fight, sustain, and communicate. There is, thus, a philosophical basis for distinguishing between carrying out such integrating functions and the performance of specialized support functions by the support systems. This distinction is made clear in the Combined Arms Combat Development Agencies (CACDA) current approach to the Technical Interface Concept (TIC) of the Corps Battlefield.[1]

On this basis, then, there is no more reason for including elements of the CEWI battalion, to include the all source analysis and the EW components of the EWIOC, in the general staff modules than for the engineer battalion or the signal battalion. The simulation will, therefore, threat the components of the EWIOC as a part of the battle outcome generator and not as a component of either the G2 or G3 staff modules. The activities of the all-source analysis center will be included in the algorithms which generate the perceived data base from the real data base.

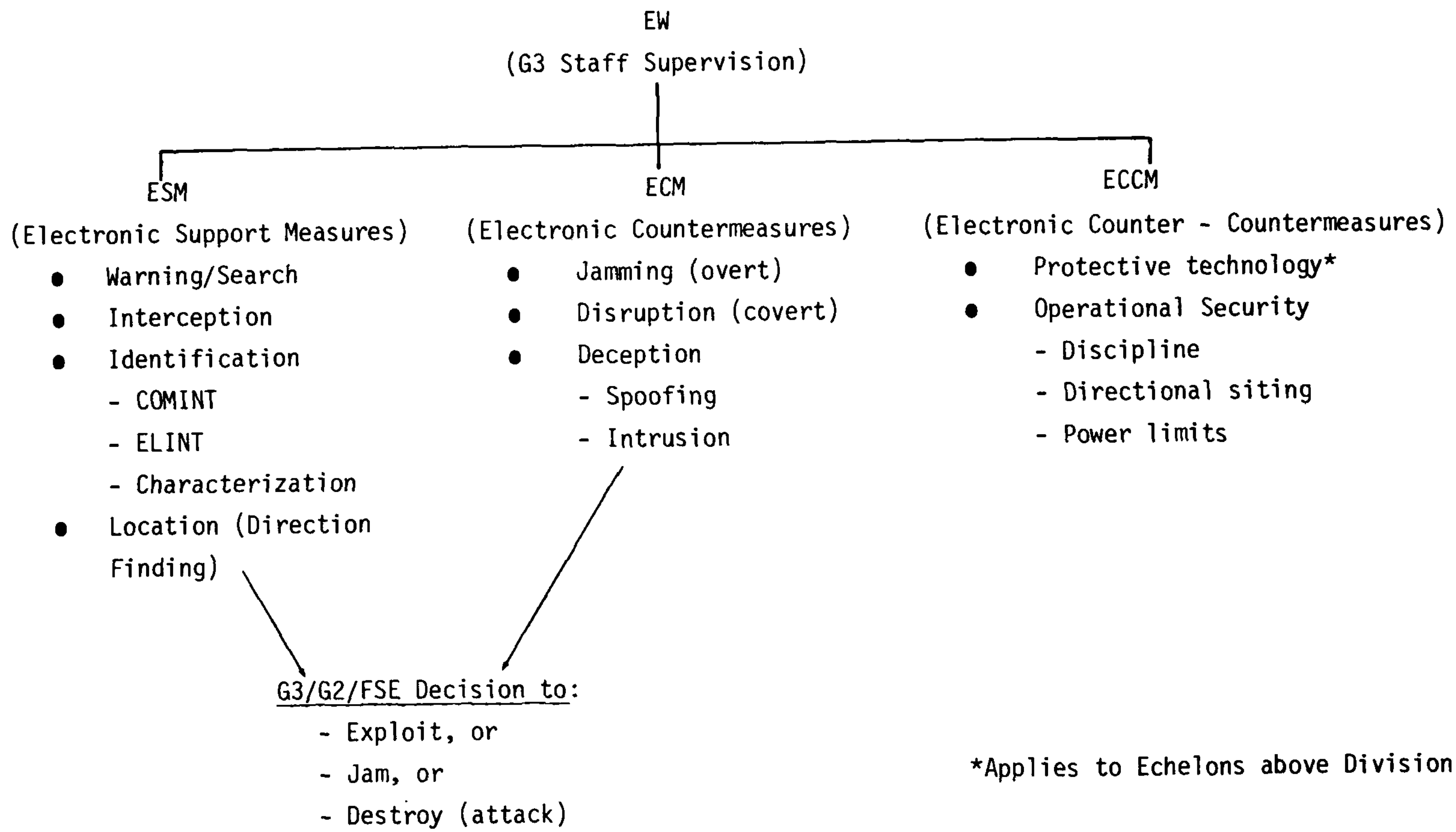
Having made this design decision, it is clear that no simulated special intelligence will appear in any of the message traffic generated by the simulation because all of the intelligence produced by the EWIOC and flowing to G2 will be "sanitized" so as not to disclose sources of special intelligence. This needs further consideration in view of Task 2b of the contract which states that, "Explicit consideration shall be given . . . . . . to the tradeoffs involved in the inclusion of special intelligence." A number of factors apply to such consideration. The first factor is that current policy provides that information available at division level from special intelligence sources of higher HQs will normally be sanitized at corps level (e.g., SI from national sources) so that such SI is not normally available in any case at division level. SI from sources within the division (CEWI battalion) is, of course, available within the EWIOC and would normally be accessible to the commander, the G2 and G3. However, properly processed intelligence will indicate the level of uncertainty associated with a given report -- a level assigned on the basis of known performance of the source. It will be assumed that the simulated all-source analysis processing will satisfactorily assign such uncertainties. It should be pointed out, however, that this does not preclude consideration of "sources" from the evaluation of G2 module performance because special intelligence is not the only component of battlefield intelligence. The G2 must consider dat from many other sources available to him, e.g., the reconnaissance squadron, the maneuver units, and division artillery, to name but a few. These, too, must be evaluated and result in an assignment of uncertainty

[1] Solicitation Number PAAK 21-79-R-9010, study entitled "Technical Interface Concept (TIC) on the Corps Battlefield," Harry Diamond Laboratories, 18 Dec 78.

based on known performance of such sources, so that availability of source identity remains a feasible control variable for G2 evaluation.

The task statement cited above also provides that explicit attention be given to the play of EW in the simulation. It is pertinent to examine the various components of EW as illustrated in Figure 6-2. The three major components are electronic support measures (ESM), electronic countermeasures (ECM) and electronic counter-counter measures (ECCM). As indicated in the figure this activity is under the staff supervision of the G3 which, in the simulation, means that staff inputs such as the Enemy Electronic Order of Battle (EEOB) flow from the EWIOC to the G3 staff module and that decision outputs to jam appear as frag orders to engage in jamming from the G3 module. However, as shown in the figure, inputs are required from both ESM and ECM in order to make decisions as to whether enemy electronic emitter should be exploited, jammed, or destroyed. Such decisions involve not only the G3, but also the G2 and the FSE. The necessary intra-module staff coordination for such decisions is provided by means of the "request" procedures described in Design Note G. This procedure provides that a simulated G3 module would provide a copy of a frag order directing jamming operations to the G2 for concurrence prior to submitting it to the BPG for implementation. Similarly, FSE would coordinate with both G3 and G2 prior to issuing a frag order for destruction of an electronic target. It is also possible for a live G2 module to write a frag order directing jamming operations to begin and forward it to G3 for implementation. This amounts to a recommendation to initiate jamming. In a similar vein, the simulation will provide that a simulated G3 module will, on receipt of the EEOB from the EWIOC provide an information copy to the live G2. Thus, although EW is technically under the purview of the G3, the model does provide for the live G2 to participate in the EW decision processes.

Having established a sound basis for populating the G2 module only with TOE personnel, we are finally able to address the question of the size of the G2 module personnel complement. Something less than half of the authorized personnel strength (6 officers, 9 enlisted men) would be on shift at any one time. As has already been discussed in paragraph 3.4.5, providing players with hard copy eliminates many of the lower level communication and message center processes required for oral communication, thus further reducing the manpower requirements. On this basis, we visualize the personnel complement of the populated G2 module will be from 3 - 5 persons depending upon the objectives of a given experiment.



*Applies to Echelons above Division.

Figure 6-2. Components of EW.

6.2.2 Control Module

As has already been stated in paragraph 4.2, the proposed initial implementation is predicated on a maximum of two persons in the Control module to direct and operate the system. Although some scenarios could probably be run with only one person in Control, it is considered unlikely that very many experiments involving interaction between a live G2 and a live Red command module could be run with less than one controller maintaining the Controller's SITMAP and another operating the machine terminal.

6.2.3 Red Command Module

For those experiments for which a live Red command module is required, this module will need one player. The tactical information messages to include the possible outputs from and the simulation inputs into the Red Command module have been identified at Design Note A by an asterisk. This number has been adjusted so that the decisions required from a Red player should be within the capability of a single player.

6.3 OUTPUTS AND INPUTS

The specific list of allowable outputs (Class 3 only) of a live G2 module and the list of possible input messages (Class 4 only) to such a model is shown at Table 6-1. This has been extracted from Design Note A. The outputs are at the top of the table and the inputs at the bottom.

The permissible list of modular addressees for the G2 staff module outputs is shown at Table 6-2. This has been extracted from Design Note B. Which of these permissible addressees will in fact receive a copy of a selected output is determined by the players. Table 6-2 also lists only Class 3 outputs.

The relation between inputs and outputs of the live G2 module is shown in input/output matrix form in Table 6-3 which had been extracted from Design Note C. This lists all Class 2, 3, and 4 events. Whether this relation is in fact observed by live players is, of course, a matter of their choice.

6.4 CONTROL PARAMETERS

To be useful for human factors research on the behavior of decision makers within the populated G2 module, the simulation will provide a number of control parameters to the experimenter that can be used to control the quality and quantity of the information available to the decision maker. These have already been discussed in a

Table 6-1. Intelligence Staff Module.

REF NO		TACTICAL INFORMATION MESSAGE	
		INTELLIGENCE STAFF MODULE	
30		QUERY BY INTELLIGENCE STAFF	
31 D		QUERY ON CORPS FRAG ORDER (INTELLIGENCE)	
32		FRAG ORDER (INTELLIGENCE)	
33 D		DIVISION INTELLIGENCE SUMMARY	
34	*	NUCLEAR, BIOLOGICAL, CHEMICAL REPORT	(ALSO INPUT)
35	*	WEATHER FORECAST	(ALSO INPUT)
36		INTELLIGENCE PARAGRAPH OF DIVISION SITUATION REPORT	
37 D		INTELLIGENCE ESTIMATE	
38 D		INTELLIGENCE ANNEX	
39		REQUEST BY INTELLIGENCE STAFF	
		FOR RELEASE	
		FOR CONCURRENCE	
40		RESPONSE TO REQUEST	
		RELEASE/HOLD	
		CONCURRENCE/NON-CONCURRENCE	
(XX)		(Retransmittal of a Received Message)	
41		BRIGADE INTELLIGENCE SUMMARY	
42		SHELL REPORT	
43		SPOT REPORT	
44	*	COMBAT INTELLIGENCE REPORT	
45		POST STRIKE DAMAGE REPORT	
		CONVENTIONAL	
		NUCLEAR	
46	*	ESTIMATE OF ENEMY STRENGTH/DISPOSITION	
47		AGGREGATED TARGET LIST (INTELLIGENCE)	
48		QUERY ON FRAG ORDER (INTELLIGENCE)	
49 D		CORPS FRAG ORDER (INTELLIGENCE)	
(XX)		(Response to Intelligence Staff Query)	

Table 6-2. Module Outputs and Their Modular Addresses.

TACTICAL INFORMATION MESSAGE	CORPS	ADJ DIV	CMD	FSE	G2	G3	G1/G4	DIV
INTELLIGENCE STAFF								
30 QUERY				X		X	X	X
31D QUERY	X							
32 FRAG ORDER(I)	X	X	X	X		X	X	X
33D DIV INTSUM	X		X	X		X	X	
34 NBC REPORT	X	X	X	X		X	X	
35 WX FORECAST			X	X		X	X	
36 INTELL INPUT TO DIV SITREP						X		
37D INTELL EST			X	X		X	X	
38D INTELL ANNEX						X		
39 REQUEST			X	X		X	X	
40 RESPONSE				X		X	X	
XX RETRANSMIT			X	X		X	X	

Table 6-3. Input/Output Matrix for Intelligence Staff Module

INPUT MESSAGES		SOURCE	30 and 31D QUERY	32 FRAG ORDER (I)	33D DIV INTSUM	34 NBC REPORT	35 WX FORECAST	36 INTELL INPUT TO DIVSITREP	37D INTELL EST	38D INTELL ANNEX	39 REQUEST	40 RESPONSE	XX RETRANSMIT
01	QUERY	CMD			X	X	X						X
03D	MSN ANAL	CMD		X					X	X			
04D	CMDR'S GUID	CMD		X						X			
05	CMDR'S DEC	CMD		X									
XX	RETRANSMIT	CMD		X									
10	QUERY	FSE			X	X	X						X
12	FRAG ORDER (FS)	FSE		X	X			X			X		
16	TGT LIST (ARTY)	FSE		X	X			X			X		
17	EU FIRE SPT CAP	FSE		X				X	X				
19	POST STRIKE ANAL	FSE		X	X			X					
21	REQUEST	FSE		X								X	
22	RESPONSE	FSE		X									
XX	RETRANSMIT	FSE		X	X			X					
50	QUERY	G3			X	X	X						X
52	FRAG ORDER (OPS)	G3		X	X			X			X		
53D	DIV SITREP	G3		X	X								
54	NUC WARNING ORDER	G3		X	X			X	X				
55	AD WARNING	G3			X			X	X				
57D	OP PLAN	G3		X									
58D	OP EST	G3							X	X			
59	INITIAL EN CONT	G3			X								
62	EOOB	G3		X	X			X					
63	REQUEST	G3		X								X	
64	RESPONSE	G3		X									
XX	RETRANSMIT	G3											
80	QUERY	G1/G4											X
82	FRAG ORDER (CSS)	G1/G4		X	X			X			X		
87D	CSS EST	G1/G4							X				
89	REQUEST	G1/G4		X								X	
90	RESPONSE	G1/G4		X									
XX	RETRANSMIT	G1/G4		X									
D	GENERAL SIT	CORPS							X	X			
D	SPECIAL SIT	CORPS							X	X			
34	NBC REPORT	CORPS		X		X							
44	CBT INTELL RPT	CORPS		X	X								X
49D	FRAG ORDER (I)	CORPS		X									
34	NBC REPORT	DIV				X							
35	WX FORECAST	DIV	X	X			X						X
41	BDE INTSUM	DIV	X		X								X
42	SHELL REPORT	DIV		X	X			X					X
43	SPOT REPORT	DIV		X	X			X					X
44	CBT INTELL RPT	DIV		X	X			X					X
45	POST STRIKE DAM RPT	DIV		X	X			X					X
46	EST OF EN STRENGTH	DIV	X	X	X			X					X
47	TGT LIST (I)	DIV	X	X	X			X					X
48	QUERY (I)	DIV		X									

more general context in paragraph 5.3 but are repeated here for the sake of completeness. The top-down design described in Section 4 provides the following control parameters:

6.4.1 Amount and Kind of Information

The basic control parameters for this category are:

1. Change the distribution of message types provided automatically to the populated G2 staff module (Automatic Distribution)

2. Change the message types which can be accessed by a populated G2 staff module on a query basis (Query Distribution)

3. Change the threshold values for submission of event triggered reports (Reporting Threshold)

4. Change the period for submission of periodic reports (Reporting Period).

6.4.2 Availability of "Source Identity"

The basic control parameter for this category is:

5. Selectively delete "source identity" from spot reports submitted to the populated G2 module. (Source Identity)

6.4.3 Time Constraints for Decision Making

The basic control parameters for this category are:

6. Change the requirements for submission of "record" outputs, i.e., outputs that are not entered directly into the simulation, from the populated G2 staff module (Record Requirement).

7. Change the pace of the simulated combat by altering the ratio between game clock time and wall clock time (Speed Ratio).

6.4.4 Quality of Information

The basic control parameters for this category are:

8. Change the delay times between trigger event and message receipt (Message Delay).

9. Change the error rate in message generation (Error Rate).

10. Change the rate at which blank or random alphanumerics are introduced into messages (Omission Rate).

6.4.5 Research Applications

The ten basic control parameters enumerated above permit a wide range of research subjects to be investigated by means of the model. A small number of these is indicated in Table 6-4 together with the pertinent basic control parameters.

6.5 MEASUREMENTS AND EVALUATION

The previous discussion at paragraph 5.2 is equally valid for the live G2 module and is repeated here for the sake of completeness. Some of the pertinent considerations affecting live staff performance measurement have already been addressed in paragraph 2.4.4. There it was pointed out that measurements within the information network are limited to measurements of time and effort associated with the preparation of specified staff outputs and measurements of information content of such outputs such as completeness, accuracy and validity for a very limited portion. It was further pointed out that complete measurements of the quality of information content cannot be made entirely within the information system but must be inferred from the outcomes of the combat simulation. Points between which certain classes of measurement can be made were also defined.

In view of the modular nature of this simulation and the basic concept which provides that every information transfer across the boundaries of a staff module must be made explicit, the measurement of staff performance can be divided into measurements made at the boundaries of live staff modules and measurements within staff modules. Each of these is discussed in the following subparagraphs.

6.5.1 Measurements Outside the Staff Module

The top-down design outlined in Section 4 provides for the following kinds of measurements at the live G2 module boundary:

- Logging the time of entry into the simulation of every G2 staff output. This includes outputs which are entered into the computer and those outputs which are simply recorded and filed.

Table 6-4. Possible ARI Research Applications.

	APPLICABLE BASIC CONTROL PARAMETER									
APPLICATION	AUTOMATIC DISTRIBUTION	QUERY DISTRIBUTION	REPORTING THRESHOLD	REPORTING PERIOD	SOURCE IDENTITY	RECORD REQUIREMENT	SPEED RATIO	MESSAGE DELAY	ERROR RATE	OMMISSION RATE
EVALUATE PLAYER PERFORMANCE AS FUNCTION OF AMOUNT AND KIND OF INFORMATION PROVIDED	X	X	X	X						
EVALUATE G2 PLAYER PERFORMANCE AS FUNCTION OF SOURCE IDENTITY PROVIDED					X					
EVALUATE PLAYER PERFORMANCE AS FUNCTION OF TIME CONSTRAINTS IMPOSED ON DECISION MAKING						X	X			
ESTABLISH CORRELATION BETWEEN COMBAT OUTCOME AND AMOUNT/KIND OF INFORMATION REQUESTED BY "ACTIVE" VS "PASSIVE" PLAYERS	X	X	X	X						
ESTABLISH CORRELATION BETWEEN COMBAT OUTCOME AND AGE/ACCURACY/ COMPLETENESS OF INFORMATION PROVIDED TO PLAYERS								X	X	X

- Logging the time of delivery of every staff input provided to the live G2 players whether those are generated by the computer or delivered by the controller from the file of previously prepared written entries.

- Recording the content of every G2 module input and output whether processed by the computer or hand processed by Control.

From these recorded data the following kinds of performance measurements can readily be extracted:

- Time delays between selected inputs and outputs.
- Time delays between selected triggers and outputs.
- Completeness of selected staff outputs with respect to inputs provided.
- Accuracy of selected staff outputs with respect inputs provided.
- Numbers of selected outputs generated.
- Numbers of selected inputs provided.
- Numbers of queries generated for selected classes of information.

Measurement of the quality of the content of G2 staff module decisions, as evidenced by the outputs, must be made in terms of their effects on the battle outcome. The discussion at paragraph 2.4.6 indicated the effectiveness measures that can be used to measure the relative mission accomplishment of alternative solutions to battlefield management. These are:

- Changes in geographic area controlled by each side.
- Changes in the resources consumed and available.
- Time intervals required to effect above changes.

The design delineated in Section 4 provides these output measures as follows:

- Changes in geographic area are available as unit locations both in the Real Data Base and on the Controllers SITMAP.

- Changes in resources are available as characteristics of the units whose status is maintained in the Real Data Base.

6.5.2 Measurements Inside the G2 Staff Module

The discussion at paragraph 5.2.2 covered the question of performance measurements inside the staff module in some detail and applies equally to the populated G2 staff module. Because of its length it will not be repeated here.

In summary, SAI's consideration of possible alternatives to instrumentation inside the live G2 module leads us to the following conclusions:

- The collection of data regarding player performance in the manned staff modules can be accomplished either on a time increment basis or through event-oriented techniques. At this time, some combination of both alternatives seems desirable.
- Subjective techniques (interviews, questionnaires, group discussions, etc.) may be useful for formulating initial concepts as to staff behavior, but must be verified or modified through objective experiment.

6.6 PLAN FOR INITIAL IMPLEMENTATION

6.6.1 Major Tasks to be Accomplished

1. Prepare Model Description

   Description of the model from the user's point of view. Includes description of the capabilities and limitations of the prototype version (G2 live), general information flow, macro-logic, data base organization, required and feasible pre-play inputs, general operating procedures, model outputs, instrumentation of live modules, complete listing of all English language formats.

   Level of Effort: 5 TMM

2. Prepare Controller's Manual

   Detailed instructions for the Controllers to include:

   - Pre-loading instructions, to include terminal operation
   - Operating instructions, to include terminal operation
   - Terminating and re-start instructions

- Special instructions for Control when Red command module is simulated.

Level of Effort: 5 TMM

3. Prepare G2 Player's Manual:

Detailed instructions for live players in the G2 module to include:

- Permissible decision variables
- Detailed division staff SOP
- English language input and output formats

Level of Effort: 5 TMM

4. Prepare Red Player's Manual

Detailed instructions for live player in Red Command module to include:

- Permissible decision variables
- Detailed division staff SOP
- English language input and output formats

Level of Effort: 2 TMM

5. Scenario Preparation

This task involves the following:

- General instructions on preparation of a scenario (preloading of model) to address typical test objectives
- Preparation of a test scenario which addresses a specific ARI test objective.

Level of Effort: 5 TMM

6. Develop and Test the ADP Portion of the Model

This task covers the programming and testing of the ADP software required to load, operate, stop, and re-start the model, as well as any required post-processing.

7. Model Demonstration

This model will be demonstrated using the test scenario in two phases:

- Initial demonstration of SAI facilities
- Final demonstration of model on ARI facilities

Level of Effort: 10 TMM

8. Prepare Technical Documentation

This task involves preparation of the complete technical documentation of the ADP programs developed in Task 6 in accordance with prescribed standards.

Level of Effort: 12 TMM

Total Estimated Effort: 66 TMM

Estimated Computer Costs: $10,000.00

6.6.2 Schedule for Completion of Initial Implementation

The tasks listed above would be completed in a period of 18-24 months after initiation. The critical path that determines this time length involves software preparation (Task 6) and the demonstration of the completed model (Tasks 7 and 8). The schedule for implementing the initial version of the simulation is shown at Figure 6-3. This figure shows the completion schedule for the eight tasks enumerated above in Gantt Chart form. Also shown are the major milestones.

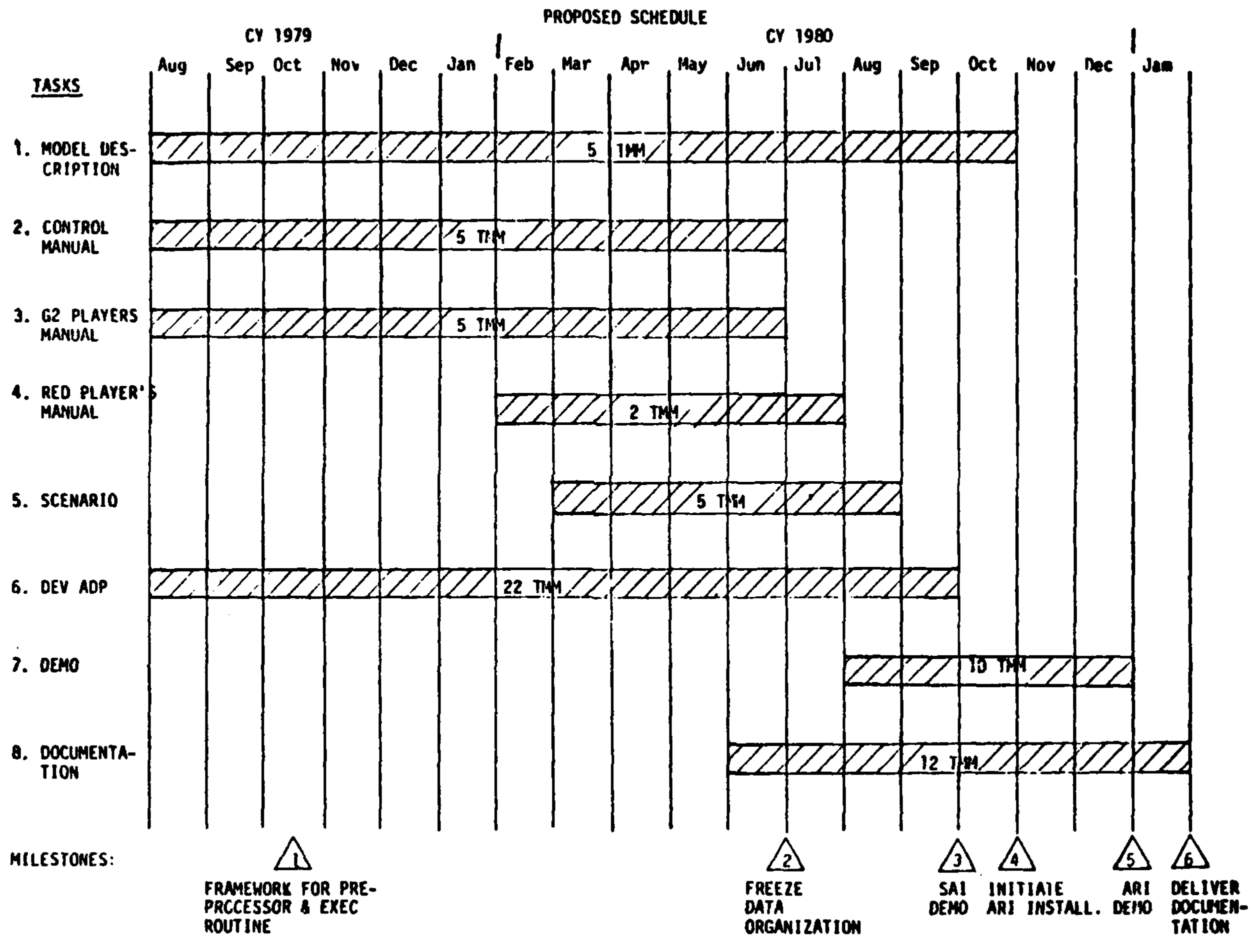


Figure 6-3. Schedule for Initial Implementation.

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