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SUPERKEATS: A SYSTEM TO SUPPORT TRAINING FOR DECISION-MAKING SKILLS

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This report has been reviewed and is approved for publication.

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Logistics and Human Factors Division

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Training in decision-making skills contributes directly to the combat readiness of battle managers. More affordable, accessible, and effective technologies are required to supplement the Command Post Exercise technologies currently in use. This report covers the third phase of a project aimed toward the development of such new technologies. During the preceding phases, a Knowledge Engineering and Training System (KEATS) was developed and used to acquire task knowledge employed by experts during decision-making in a specific tactical domain. In the third and final phase of the project, the acquired knowledge was used to develop a practice environment for decision-making. The practice environment, called SuperKEATS, is an object-oriented, simulated practice module written in KEE which runs on workstations. SuperKEATS generates a functionally realistic, reactive exercise scenario where decisions produce plausible, natural feedback as well as explanatory artificial feedback. Optional prompts provide general suggestions and/or specific options. SuperKEATS was subjected to a 2-day evaluation trial with one expert and one novice. The trial provided a successful demonstration of the concepts of a responsive system for decision training. The results are described, and conclusions and recommendations are offered.

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SUMMARY

Battle managers assigned to Air Force Tactical Air Control Systems must be competent decision-makers. Improved technologies are required to develop and deliver training in decision-making skills at an affordable cost. Training should be available at peacetime duty stations, run on microcomputers available at the squadron level, and not require instructors.

A preceding report described a technology for acquiring the instructional content for a target decision training task. A computer-based (Smalltalk and PC/AT) Knowledge Engineering and Training System (KEATS) (Brecke et al., 1989) was developed and applied to a specific tactical decision domain. KEATS helped identify schemas for situation assessment and plans, and decision rules for tasking of air requests.

The present report focuses on the development of a practice environment for decision-making. This environment, called SuperKEATS, was implemented as a stand-alone prototype with content previously acquired through the use of KEATS. The report describes a 2-day, two-subject preliminary evaluation of SuperKEATS and ends with a discussion and conclusions regarding the viability of the training methodology represented by SuperKEATS.

PREFACE

With its establishment in 1980, the Logistics and Human Factors Division's Ground Operations Branch, a part of the Air Force Human Resources Laboratory (AFHRL/LRG) at Wright-Patterson AFB, began a comprehensive program to develop advanced technology to improve training for USAF Tactical Command and Control (C^2) Battle Staff personnel.

This report covers the final phase of a research project which developed methods and principles for cost-effective tactical C^2 decision-making training. A previous phase centered around the use of knowledge engineering techniques to acquire instructional content by means of a Knowledge Engineering and Training System (KEATS). The system was effective in generating the decision task knowledge needed for the final phase of the project. During the final phase, a practice environment for tactical decision-making, called SuperKEATS, was implemented as a stand-alone prototype. The system incorporated the decision task knowledge previously acquired through the use of KEATS.

The project was guided by Mr. Michael J. Young of AFHRL/LRG and executed by Logicon's Tactical and Training Systems Division in San Diego, California, under the direction of Fritz H. Brecke. Logicon team members included: Patrick Hays, Donald Johnston, Gail Slemon, Jane McGarvey, and Susan Peters. Particularly heartfelt thanks go to the Air Force subject-matter experts: Lt Col Fred Wilson, Lt Col Lynn Weber, Lt Col Matt Szczepanek, and Maj Ken Dekay.

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Project Background and Objectives

Rapid and accurate decision-making under time constraints, combat stress and the uncertainty of the "fog of war" is a critical combat skill. High levels of proficiency in decision-making are particularly important for tactical battle staff officers assigned to Tactical Command and Control (TC2) systems in the military services. These officers manage high-value tactical combat assets. Their decisions determine how effectively the available assets are assigned to objectives or targets.

Tactical battle staff officers currently practice decision-making skills during manpower-intensive Command Post Exercises (CPXs), which are supported by computer-based simulations running on medium- and large-scale computer systems. Participation in such exercises is sporadic and expensive. It is therefore difficult for battle staff officers to achieve and maintain the skill levels required for successful combat operations. As a result, current training for decision-making skills is basically not cost-effective (Brecke, Jacobs, & Krebs, 1988). There is a clear need to make decision training more accessible, more affordable, and less manpower-intensive.

This need has been recognized, and a technology base that can provide easily accessible and affordable training at the unit level is emerging. Affordability is achieved through the use of increasingly powerful microprocessor-based computers. The need for instructors and live participants is reduced through advanced modeling techniques made possible by expert systems technology. Wilson (1982) described an "Interactive Micro-Computer Wargame for an Air Battle" running on an Apple III and written in UCSD Pascal. Obermayer, Johnston, Slemon, and Hicklin (1984) developed a micro-based (WICAT System 150) multi-user system which simulated a simple Anti-Submarine Warfare (ASW) scenario. The system featured one simulated, knowledge-based team member. Madni, Ahlers, and Chu (1987) demonstrated the modeling of an intelligent opponent in a knowledge-based simulation prototype running on a Symbolics 3670 workstation. The prototype was designed to train Tactical Action Officers in the kind of decision-making skills needed during naval surface warfare. The Army Research Institute for the Behavioral and Social Sciences (ARI) has focused on experimental Computer-Aided Instruction (CAI) in the training of decision-making skills for armor officers. One result of this work is the "Armor Tactical Concepts Tutor (ARTACT)," which runs on the Army's microcomputer-based Electronic Information Delivery System (EIDS). Stoddard, Kern, and Emerson (1986) announced the development of a cognitive skills tutor which continues and expands the ARTACT work.

The overall goal of the present effort is to add to this emerging technology base. More precisely, the project is designed to produce training and training design technologies for interactive training experiences which reliably result in the acquisition of decision-making skills and are presented by means of microcomputer media without a human instructor. The specific objectives of the project were defined as follows:

Objective 1:	Develop a methodology to externalize expert task knowledge for decision-making tasks.
Objective 2:	Develop training methodologies which facilitate achievement of reliable and high performance of decision-making tasks.

Perspective

The project in its entirety is viewed as an Instructional Systems Design (ISD) problem where a generic training design solution for a class of skills (decision-making) is sought. An ISD problem exists if some of the variables that define an instructional event or product are "given" and others are "unknown" or "to be determined." Merrill and Wood (1974) identified four "relatively independent" facets of instruction representing sets of instructional variables: Learner Aptitude, Content (or subject matter), Instructional Strategy, and Delivery System. Frank (1969), in a more formal cybernetic theory of instruction, used basically the same variable sets or dimensions and added two more: Purpose (or Objective) of Instruction and Environment within which instruction is to take place.

The ISD problem to be solved by this project can thus be specified as one where four variable sets or dimensions (in Frank's terms) are given and two are sought. The following variables are given or predetermined:

1.	The *Training Objective*	Specified as a class of skills to be trained: Decision-Making Skills
2.	The *Learners*	Battle Staff Officers assigned to Tactical Command and Control Systems
3.	The *Delivery System*	Microcomputer media
4.	The *Environment*	In-house environment at Tactical Command and Control Units

Solving the ISD problem involves defining the two remaining dimensions which are required to completely specify an instructional event:

5.	The *Content*	Classes and instances of domain knowledge
6.	The *Instructional Strategy*	Types of instructional actions and their sequencing.

Prior Work in Phases I and II

The focus of the first two phases of this three-phase project was on the acquisition of instructional content (Objective 1). Instructional content for decision training consists of the task knowledge employed by experts during the act of making decisions. This task knowledge resides not in books, regulations, or pamphlets but in the minds of experts. One way to make this knowledge explicit is with the aid of knowledge engineering techniques. More traditional task analysis techniques have proven to be ineffective for this purpose (Brecke et al., 1988). Unaided, interview-type knowledge engineering methods were successful up to a point but encountered significant problems.

A computer-based (Smalltalk and PC/AT) Knowledge Engineering and Training System (KEATS) was developed to aid in the knowledge acquisition process and to overcome the problems encountered (Brecke et al., 1989). During two evaluation trials, KEATS-aided knowledge engineering sessions recorded 135 justifications for 28 decision instances. Subsequent analysis produced 64 decision rules. These results were interpreted as a proof of concept for computer-aided acquisition of instructional content for decision-making tasks. Approximately 70% of the KEATS software is generic. Domain-specific KEATS applications for other domains can therefore be generated at relatively low cost. The methodology represented by KEATS thus satisfies the first project objective.

Phase III Problem and Objective

In Phase III, the focus of the project was on the second project objective: the development of training methodologies which facilitate acquisition of decision-making skills. Attention in this phase thus shifted away from the content variable of the instructional problem to the instructional strategy variable. Within the overall context of instructional strategy, Phase III efforts concentrated on the strategy components *practice* and *feedback*, which are essential elements of any instructional strategy for any type of training objective. Specifically, the objective of Phase III was to design and develop an affordable computer-based practice environment that would promote the acquisition of specific decision-making skills in the target domain of a Fighter Duty Officer (FDO) at an Air Support Operations Center (ASOC).

Report Scope

The present report covers Phase III. It shows how the requirements for the practice environment were derived, how the system (called SuperKEATS) was developed, and how decision-making practice in SuperKEATS occurs. This description includes SuperKEATS' facilities to modulate practice and feedback strategies to accommodate variations in learner abilities and needs, as well as to permit experimental research. The report also describes a 2-day, two-subject evaluation of SuperKEATS, and ends with a discussion and conclusions regarding the viability of the training methodology represented by SuperKEATS.

II. APPROACH

This section describes the approach followed in designing and developing a practice environment for decision-making in a specific tactical decision domain. We show first how specific requirements for the practice environment were derived. The design, development and implementation steps are described next. This is followed by a description of the internal structure of the system called SuperKEATS. Finally, SuperKEATS is described in terms of how it is used, both from the perspective of the student practicing decision-making skills and from the perspective of the researcher experimenting with instructional strategies.

Requirements for a Decision Practice Environment

KEATS provided a means to acquire the *content* that should be communicated by a decision training system. The issue of how this communication should be structured is a matter of defining an appropriate *instructional strategy*. Below we examine the concept of instructional strategy in general, focus on the *practice* component which must be present in any instructional strategy, and derive a set of molecular strategy requirements which must be satisfied by a practice environment for decision-making skills.

The Concept of Instructional Strategy

An instructional strategy is basically a set of rules which prescribe a particular sequence of instructional elements. Frank (1969) used the term "teaching algorithm" to describe the notion of an instructional strategy. Aagard and Braby (1976) spoke of "Learning Guidelines and Algorithms for Twelve Types of Training Objectives." They presented flowcharts depicting sequences of learner and instructional system activities which have the flavor, albeit not the rigor, of formal algorithms. Merrill (1983) favored the term "organizational strategy" and defined it as "decisions involved in the design of learning activities, including the types of displays to be presented to the student, the sequence of these displays, the topics to be included, the sequence and structure of these topics, the type of practice, the nature of feedback, and other decisions regarding the nature of the presentation."

Instructional strategies can be defined at various levels of resolution. Frank (1969) and Merrill (1983) distinguished between macro and micro strategies. Macro strategies define the sequence of subject-matter topics (Merrill, 1983) or objectives (Brecke, 1976). Micro strategies define the sequence and form of instructional events within an instructional module for a topic or objective (Brecke, 1973). Other authors spoke of *molar* and *molecular* levels of instructional strategy (e.g., Gropper, 1974). In essence, instructional strategies can be defined on a continuum of granularity: on the level of a curriculum as a sequence of courses; on the level of a syllabus as a sequence of lessons; on the level of a lesson as a sequence of objectives; and, finally, on the level of an objective as a sequence of instructional activities or elements. Here the terms *molar* and *molecular* will be employed to avoid confusion with the macro and micro aspects of the target training task that will be introduced later.

On the molecular level, instructional strategy follows a basic and universal paradigm of three successive phases: Presentation, Practice and Testing (Merrill, 1983). Variations in instructional strategies occur one level below this paradigm within each of the phases. In Phase III (of this *project*), we focused on the molecular levels of both instruction and the practice phase of instruction. As indicated before, our goal was to design a suitable practice environment for decision-making skills. We were therefore concerned with the relatively narrow problem of defining molecular instructional strategies that would optimize learning of decision-making skills during the practice phase of instruction.

Instructional Strategy Based on Component Display Theory

Prescriptions for instructional strategies can be obtained from two sources: Instructional Design Theories and Task Analyses. Instructional design theories and prescriptive theories are generally founded on two types of descriptive theories: theories of learning or skill acquisition, and theories of skill performance.[1] The strategy prescriptions which can be derived from instructional design theories generally address molar as well as molecular levels.

The most detailed instructional design theory that is currently available for the molecular level is Merrill's Component Display Theory or CDT (Merrill, 1983). CDT is based on Gagné's postulate (1965) that different types of learner outcomes require different conditions of learning and on a classification scheme for learner outcomes which is known as the *Performance Content* Matrix (Figure 1). Each cell of the matrix defines a different class of learner outcome or type of training objective. CDT offers

[1]For an interesting discussion of the differences between descriptive and prescriptive theories of learning and instruction, see Reigeluth, 1983, pp. 21-25.

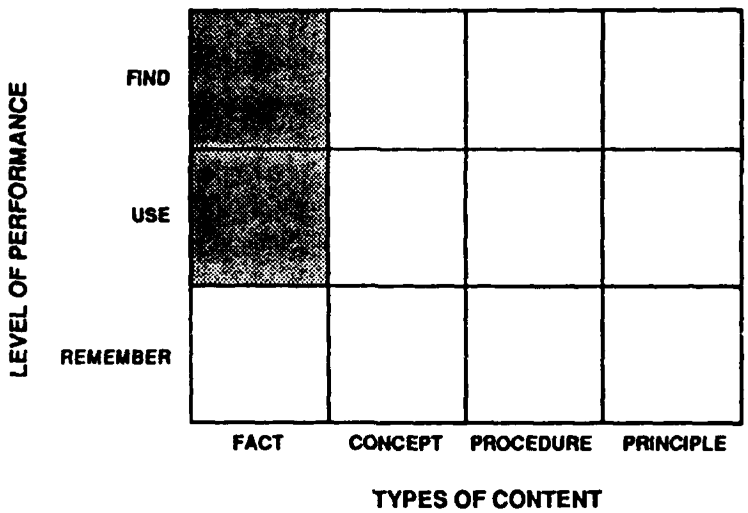

Figure 1. Performance-Content Matrix (Merrill, 1983).

instructional strategy prescriptions for each type of objective, where the prescriptions are formulated in a "language" that includes four *primary presentation forms and eight secondary presentation forms.*

Training objectives aimed at the acquisition of decision-making skills can be classified in terms of Merrill's Performance-Content Matrix, which means that a corresponding molecular strategy for decision-making objectives should accordingly be available. The most appropriate category for decision-making objectives is the *USE-PRINCIPLE* cell.[2] For the performance category *USE*, CDT prescribes (regardless of content category) Iegs.N for the practice phase; i.e., the use of a set of two or more "*Inquisitory*" examples (*egs*) or instances. The specific form of these practice items is prescribed as follows:

> The instance practice for a *principle* entails the presentation of a problem situation to the student. The name of the principle may or may not be given, and the student is asked to explain what happens. This explanation may take the form of a prediction about the outcome, or it may take the form of a solution to the problem. Representation [again] plays an important role. If it is impossible to have the actual objects and events present, then they must be represented. The representation must be sufficient so that all of the critical aspects of the cause-and-effect relationship are represented to the student. (Merrill, 1983, p. 318)

[2]"Use means to use a general rule to process specific information" (Merrill, 1983, p. 303). "Principles are those cause-and-effect or correlational relationships that are used to interpret events or circumstances" (Ibid., p. 288).

This is an admirably detailed prescription if one considers the myriad of different learning outcomes that might fall under the USE-PRINCIPLE class. It is, however, far too imprecise to serve as a principled design specification for a particular subclass of skills such as decision-making skills.

Cognitive Task Analysis

At this point, the second source of instructional strategy prescriptions, Task Analysis, becomes useful. Decision-making tasks require a particular type of task analysis. The conventional methods of successive task decomposition into smaller and smaller steps (resulting in hierarchical and/or flowchart representations) have been found to be ineffective (Brecke et al., 1988) for complex cognitive (and thus covert) tasks. These types of tasks require a method that elucidates the essential cognitive events that occur during task performance. Lesgold et al. (1986) called this type of analysis "Cognitive Task Analysis" (see also Means & Gott, 1988).

A cognitive task analysis of the targeted decision-making skill emerged as a byproduct of the knowledge acquisition efforts during Phase II of the project. The intent of the knowledge acquisition phase was to obtain, in explicit form, expert knowledge employed during task performance. Such knowledge was obtained and, in the course of its acquisition, a model of the cognitive events involved in the target task emerged. Thus, there was neither the intent to perform a cognitive task analysis nor a desire to follow Lesgold's methods, yet the initial interviews naturally focused on the technical and cognitive aspects of the target decision domain and the specific decision task. The product of these efforts was a detailed understanding of the target domain and a cognitive model of the target decision task. This product is briefly outlined below.

The Study Domain. The general target domain for the project is the Tactical Command and Control System of the Air Force. Within the general domain of Air Force Tactical Command and Control, the focus is on a specific type of Tactical Command and Control node called the Air Support Operations Center (ASOC). The ASOC is an Air Force Tactical Command and Control unit which is "assigned" to and co-located with an Army Corps Headquarters (see Figure 2). Its basic role is to supply air support missions in response to demands originating from the Army Corps' front-line divisions. The ASOC thus has to solve a problem which, in general terms, can be viewed as a supply management problem. The problem is nontrivial because the demand for air support may exceed the supply of available aircraft, and both supply and demand vary independently over time in ways that are only partially predictable.

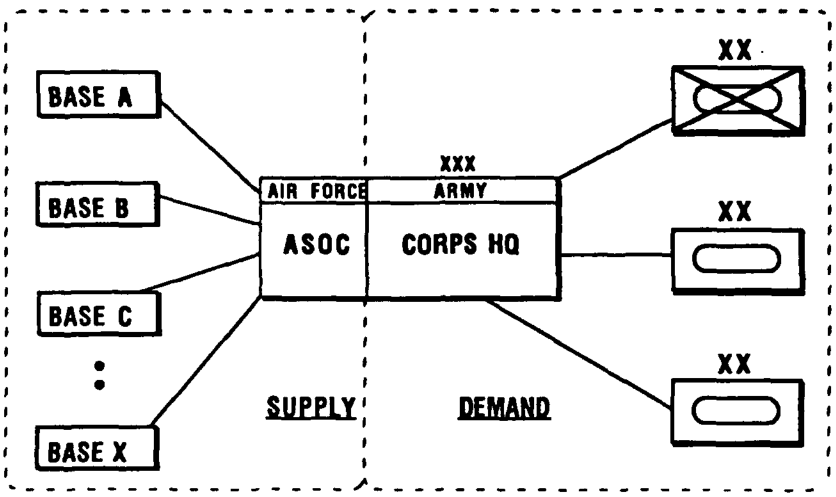

Figure 2. Project Study Domain: Air Support Operations Center (ASOC).

The ASOC's method for solving this supply management problem is a combination of advance planning and subsequent plan execution with ad-hoc adjustments. Advance planning is done during the night shift when little or no combat action is occurring. Plan execution, often referred to as "operations," occurs during the daylight hours when most tactical combat action occurs.

The plan produced by the night shift crew is basically a schedule that maps predicted supplies of available sorties into anticipated demands for air support for each of the corps' front-line divisions. This plan or schedule covers the daylight hours; i.e., the time from first light to last light. Information for the supply side of the plan comes primarily from the Air Force Air Tasking Order (ATO) and Operations Order (OO). Information for the demand side of the plan comes primarily from the Army Corps' plans and from intelligence sources. The Army has the prerogative of determining the "priority of fire," which is defined in percentage allocations of the total available sorties to each of the front-line divisions. The ASOC determines the details of time frames, squadron assignments, and tasking modes.

Plan execution is essentially the responsibility of the day shift crew. The day crew uses the plan as a baseline which usually has to be modified in view of the most recent information regarding the available assets and the battlefield situation. The plan is adjusted and readjusted throughout the day in response to changes in the tactical situation and as preparation for anticipated developments in the near future. The key to successful air support service from the ASOC to the corps is to manage sortie generation and sortie expenditure such that the corps receives optimal support in the present, throughout the day, and over the foreseeable length of a conflict.

Our focus was on the decision problems of the day crew; i.e., on the "OPERATIONS" side of the ASOC. The day crew deals both with the present and with the near future, and with actual and anticipated supply and demand problems. The decision problems faced by the day crew thus occur on two levels: on the level of specific and immediate decisions regarding particular requests, and on the level of an overall plan that takes into account the "big picture" over a longer time horizon. We refer to these two levels as the *micro* and *macro* levels of decision-making at the ASOC. The two levels are interdependent: Micro-level decisions are made under the constraints of macro guidance, and micro events lead to adjustment decisions on the macro or plan level.

The ASOC operations team consists of six officers and three noncommissioned officers (NCOs) called "technicians." The NCOs share in the officers' workload of decision-making tasks and implement the officers' orders and provide other assistance as needed. The *Director* oversees the entire ASOC operation. He is primarily concerned with overall situation assessment and advance planning, and issues guidelines to the rest of the team. The *Fighter Duty Officer 1* (and Technician), referred to as the FDO (FIDO), assists the Director in situation assessment and planning and assigns air resources to air requests. He also coordinates mission support requirements between Army and Air Force in conjunction with the G-3 Air. The *Fighter Duty Officer II* (and Technician) is essentially an apprentice FDO. In addition, there are a *Reconnaissance Duty Officer*, a *G-3 Air*, and an *Intelligence Officer (and Technician)*.

The following examples illustrate the types of decision-making skills that need to be trained.

Example 1:

The ASOC Fighter Duty Officer 1 (FDO I) receives an air request to neutralize eight tanks within the next hour. The request has been verified by the appropriate officers. The FDO I must now decide which of the available aircraft assets should be tasked to satisfy this request. If he has no assets to task, he must refuse the request. If weather or threats make mission success questionable, he has to weigh risks against benefits.

Example 2:

The ASOC receives a Corps request to neutralize a large number of tanks attacking along a highway. This type of request generally requires tasking of a fairly large number of aircraft, some of which will be the actual attackers and some of which will fly support missions. This type of request may include participating Army assets. This sort of decision problem is usually handled by the ASOC Director, who decides on force composition, timing, coordination, and other relevant factors.

In either of the examples above, the decision-maker has to consider multiple factors. Some of the most important factors are depicted in Figure 3.

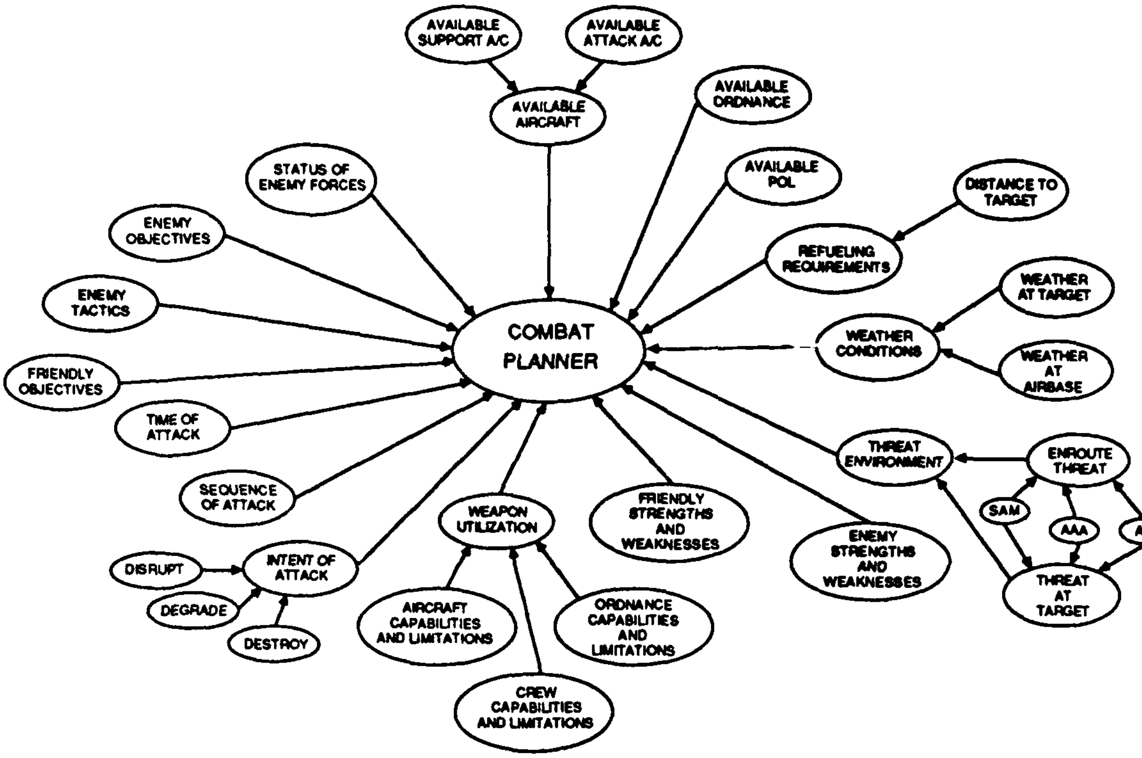

Figure 3. Factors Considered by Tactical Command and Control Decision Makers.

The Target Training Objective. In order to keep the effort within manageable limits, the prototype system had to be aimed at a single and specific target training objective. This objective had to be representative of the decision skills exercised on the offensive side of tactical command and control in the Air Force. In earlier work (Brecke et al., 1988), task analyses were performed for a number of positions at the Allied Tactical Operations Center (ATOC). These analyses and the work performed in Phase II of this project (Brecke et al., 1989) showed that the ASOC FDO performs a task which is nearly identical to several tasks occurring in the ATOC. This task was used as a basis for specifying the following specific training objective as the target objective for the training system prototype:

> *Decide on the disposition of air requests over an entire day operations shift, given a simulated tactical situation for an ASOC and the Army Corps it supports.*

This objective is valid not only for the FDO but for all officers in the ASOC van. It represents the essence of what the ASOC does and it is an activity to which all must contribute in a coordinated fashion. The ASOC van team must, in fact, have a shared mental model as to how to do this task. The objective is therefore generic as far as the ASOC is concerned. The objective also generalizes easily to decision tasks performed in the ATOC.

The objective does not state a performance standard. The measurement and evaluation of decision-making performance was left open as a research issue that should be investigated with the prototype training system.

Cognitive Model of the Target Task. A cognitive model of the task represented by the objective above is presented in Figure 4 and the description that follows.

The FDO's decision-making task is initiated by *Eliciting Stimuli* which consist of messages passed to the ASOC via a number of communication links. These messages consist of air requests (i.e., requests for air support from units of the Army Corps supported by the ASOC) and other messages which inform the ASOC of changes in the availability of air assets. The messages also include feedback on the results of previously tasked missions. We focus here on air request messages.

These messages elicit a *Decision Process,* which is roughly subdivided into four stages. During the first stage, a verification and priority *filtering* process takes place in which other members of the ASOC team participate. The request must be verified as legitimate and its priority in terms of time and competing requests must be determined. The request may at this point be refused or further clarification may be requested. If the filter is passed successfully, the FDO locates and selects suitable *primary assets* (aircraft). The FDO then determines whether *support assets* (e.g., electronic warfare and other defense suppression assets from either the Army or the Air Force) are required and available. Finally, *coordination details* regarding timing, contact points, and radio frequencies are determined. The request may get refused anywhere along this process, depending on asset availability and mission priority.

During this entire process, the FDO must have access to an *information environment* which must contain at least the following major types of information: Air Asset Status (available from status boards and directly from Wing Operations Centers or WOCs); Air Force Orders (Air Tasking Order or ATO, Daily Operations Order or DOO); Army Corps Guidance (plans and fire priorities); Intelligence (on enemy plans and movements); and, finally, an image of the tactical situation represented by means of maps.

Also, along the way through this process the FDO must be aware of the *current operations plan.* His decisions regarding particular air requests (i.e., his decisions on the micro level) should be guided by the current overall plan, which is a reflection of macro decisions. He must constantly reassess this plan for its continued viability in the face of new incoming information and decide whether it is time to change the plan and how it should be changed. This *macro* decision process goes on in the background while the FDO deals with the *micro* decisions required to satisfy particular requests.

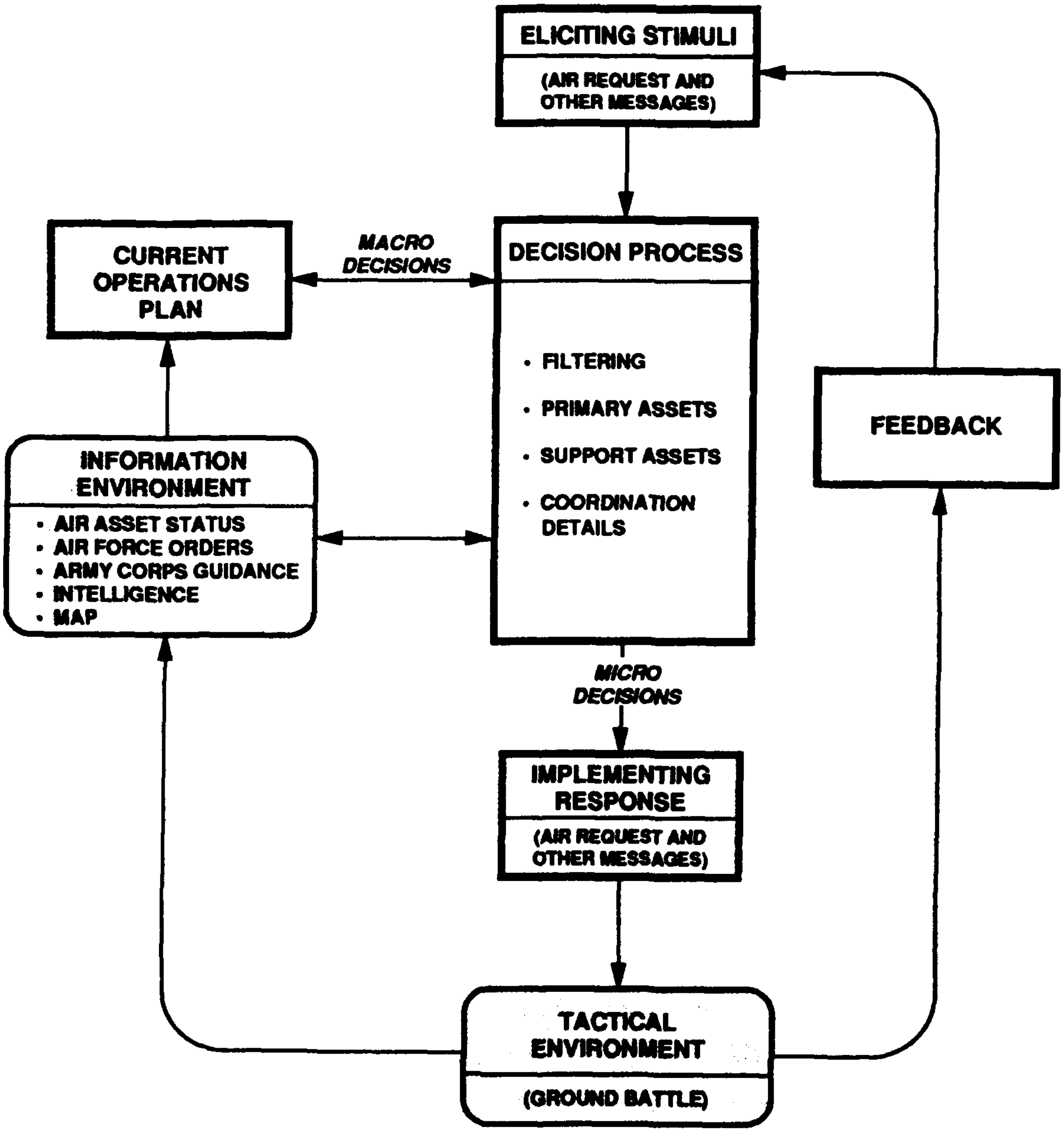

Figure 4. Cognitive Model of the Target Decision Task.

The output of the decision process is an *Implementing Response*, which consists of various types of air tasking messages that are sent via communication nets to the operational units (WOCs or squadrons) that own the airplanes which will fly the air support missions.

The implementing response thus triggers an operational response which has some effect on the *Tactical Environment*; i.e., on the course of the ground battle. If airplanes are lost during missions, the air asset status is affected as well.

Feedback on the effects of the operational responses reaches the FDO by way of mission reports, which are issued either while missions are still airborne or after their return to their base of origin or to an alternate base. Further feedback reaches the FDO via intelligence reports and via changing plans and fire priorities from the Army Corps.

A particularly important source of feedback is the changing pattern of subsequent air requests. For example, an area may previously have produced very frequent requests on targets that seemed to be moving more and more into friendly territory. The FDO has responded to these demands with high levels of air support. If, as a consequence, the frequency of requests decreases and if the targets appear to be moving out of friendly and into hostile territory, then the FDO can legitimately deduce that his decisions were effective.

Functional Specifications for the Prototype Decision Practice System

The cognitive model described above furnished a level of detail beyond Merrill's fairly global prescriptions for USE-PRINCIPLE objectives. In essence, it provides the rationale for constructing a representation of decision problems that is "sufficient so that all of the critical aspects of the cause-and-effect relationship are represented to the student" (Merrill, 1983, p. 318). It allows the formulation of specific functional requirements that a system for decision-making practice should satisfy.

We make two important assumptions at this point. The first assumption is that a practice environment which replicates the ASOC environment with all its essential objects in a functional rather than literal sense, and which allows the student to exercise the cognitive model described above, will have a positive effect on the acquisition of the target decision-making skill and that there will be positive transfer from the skill so acquired in the practice environment to performance in the real-world operational environment.

The second assumption is that practice is most effective if it is modulated in complexity and supported by instructional features like prompts (which are secondary presentation forms in Merrill's CDT) and artificial instructional feedback. Such modulations and support should occur on the basis of changes in student skill level.

Both of these assumptions need to be tested empirically. The prototype practice environment must therefore functionally replicate the ASOC environment and permit experimentation with different complexity schedules and levels of instructional support.

Together these assumptions and the cognitive model led directly to the functional specifications presented in Table 1. The functional specifications had to be tempered against those development constraints described in the next section.

Development Constraints

The primary resource constraints were time, funding, and the hardware/software selected for implementation. The calendar time available from design start to evaluation was 12 months. The software to be used, Knowledge Engineering Environment (KEE), had been selected and purchased during Phase I of the project. The hardware (Table 2), two Sun 3/60 workstations, was purchased, in place, and configured to run KEE prior to starting the design.

To build, under these constraints, a system that meets the above goals meant that certain limitations on the capabilities of the simulation environment had to be accepted. These limitations, given in Table 3, were chosen to simplify the simulation modeling while retaining all essential FDO decision-making parameters.

Development of the SuperKEATS Practice Environment

Development of SuperKEATS initially concentrated on the simulation portion of the system. After a rudimentary simulation was implemented such that a user could "play the ASOC game," instructional features were added. The development followed a straightforward sequence of design, implement/integrate, and test. These development steps are described briefly below.

The design featured an object-oriented approach much like that of the precursor KEATS system. Objects were grouped as simulation, Army, Air Force, interface, event, and other objects. Associated with each object were its attributes, input messages, a brief description of the processing of each input, and output messages. Attributes define the state of an object. In an object-oriented paradigm, all objects communicate with each other via messages. Hence, the input messages define what an object must respond to and the output messages define what the object will send or ask of other objects.

Table 1. Functional Specifications for the Prototype Decision Practice Environment (SuperKEATS)

ELEMENTS	FUNCTIONAL SPECIFICATIONS	
	MACRO-LEVEL	MICRO-LEVEL
ELICITING STIMULI	PROVIDE MESSAGES THAT ELICIT CHANGES TO SITUATION ASSESSMENT AND PLANNING	PROVIDE MESSAGES THAT ELICIT DECISIONS ON AIR REQUEST DISPOSITION
DECISION PROCESS	PROVIDE ACCESS TO CURRENT OPERATING PLAN FOR REVIEW PROVIDE ACCESS TO AN INFORMATION ENVIRONMENT CONTAINING AT A MINIMUM • AIR ASSET STATUS • AIR FORCE ORDERS • ARMY CORPS GUIDANCE • INTELLIGENCE • MAP	PROVIDE ACCESS TO CURRENT OPERATING PLAN FOR REVIEW PROVIDE ACCESS TO AN INFORMATION ENVIRONMENT CONTAINING AT A MINIMUM • AIR ASSET STATUS • ARMY CORPS GUIDANCE • MAP
IMPLEMENTING RESPONSE	PROVIDE CAPABILITY TO CHANGE CURRENT OPERATIONS PLAN	PROVIDE CAPABILITY TO: • CHANGE AIR STATUS • TASK MISSIONS • REFUSE MISSIONS • REQUEST SUPPORT ASSETS
FEEDBACK (NATURAL)	PROVIDE A SIMULATION OF THE TACTICAL ENVIRONMENT WHICH SHOWS PLAUSIBLE EFFECTS OF AIR SUPPORT	PROVIDE A SIMULATION OF AIR FORCE OPERATIONAL UNITS WHICH GIVE PLAUSIBLE RESPONSES TO TASKINGS
FEEDBACK (ARTIFICIAL)	PROVIDE "BEAN COUNTING" SCORES ON OVERALL AIR SUPPORT EFFECTIVENESS PROVIDE MAP WITH AUTOMATIC DISPLAYS OF TARGETS	PROVIDE FOR TRIAL FEEDBACK PRIOR TO DECISION IMPLEMENTATION PROVIDE CRITIQUE OF TASKING WITH EXPLANATIONS AFTER DECISION IMPLEMENTATION PROVIDE CAPABILITY TO TURN THE ABOVE TYPES OF FEEDBACK ON AND OFF
PROMPTS	PROVIDE HINTS FOR PLAN CHANGES PROVIDE PLAN OPTIONS PROVIDE MEANS TO TURN THE ABOVE PROMPTS ON AND OFF *(THIS CELL NOT IMPLEMENTED!)*	PROVIDE SUGGESTIONS FOR TYPES OF AIRCRAFT TO USE WITH RATIONALES PROVIDE SPECIFIC OPTIONS FOR TASKING PROVIDE FOR CAPABILITY TO TURN THE ABOVE PROMPTS ON AND OFF
MODIFICATION	PROVIDE AN EXERCISE BUILDING CAPACITY WHICH PERMITS GENERATION OF MORE OR LESS COMPLEX PRACTICE GAMES OR OF GAMES WHICH FOCUS ON PARTICULAR VARIABLES (AIRPLANE TYPE, BASE CLOSURE, TASKING MODE, ETC.)	
USER INTERFACE	PROVIDE CAPABILITY TO PERMIT STUDENTS TO CONFIGURE SCREEN TO THEIR NEEDS PROVIDE TO OPERATIONAL INFORMATION DISPLAYS AN INTERFACE THAT IS EASY TO LEARN AND USE, ELIMINATES TEDIOUS BOOKKEEPING TASKS AND RETAINS FUNCTIONAL RATHER THAN LITERAL FIDELITY TO OPERATIONAL INFORMATION DISPLAYS	

Table 2. SuperKEATS Development Environment

SuperKEATS	o Knowledge Bases o LISP Function Files o Application Image (25 MB)
Programming Environment	o KEE ™ 3.1.104 o Sun Common LISP 2.1.3 o Unix 3.5 (100 MB SWAP)
Hardware Platform	o Sun 3/60 Workstation o 24-MB RAM o 327-MB Hard Drive o 1152 x 900 Color Monitor o HP Laser Jet Plus Printer

Table 3. Simulation Limitations

- o Terrain is represented by a featureless plane. Spatial considerations include position relative to and distance from the Forward Line of Own Troops (FLOT).
- o There is no weather. (Base attacks may, however, be used to close bases.)
- o There are no complex strategies for Army units (i.e., no autonomous Army units).
- o There are no complex Army unit movements (i.e., units move in tracks).
- o There are no front-line Army unit interactions between units in the same Corps (i.e., tracks do not intersect).
- o The front-line units are always in "contact" with their opposing units.
- o The only type of Army units are tank units.
- o The only air request targets are tanks.
- o The ASOC has direct tasking authority, with no interference or help from higher levels in the Air Force command and control hierarchy.
- o The WOC does not optimize the allocation of aircraft to missions.

In certain cases the processing for a particular input message was more extensive than could be briefly described in a sentence or two. These cases were called *algorithms* and were written up in the detail necessary to permit implementation. In addition, because SuperKEATS would be developed using the KEE software shell, technical notes were written about how required interface features could be most efficiently implemented in this software.

Upon completion of the design phase, implementation started with a brief period of prototyping. During this phase, the simulation objects were entered into the KEE shell and typical displays with very limited functionality were produced for review. Prototyping provided the framework for later development, and allowed a feasibility and usability check of interface concepts.

Prototyping was followed by detailed implementation. First, the models for the Army and Air Force were developed in parallel with the interface for running a game. Then functionality was added to allow building a game and running a game in real time. Also at this point, the instructional features for suggestions and feedback were introduced based on the rules obtained through knowledge acquisition from ASOC experts using KEATS. Added late in the development was the display sequence for game selection, assessment, planning, and setup before starting the game.

Testing occurred at intervals during the later stages of development by having a person who was not implementing SuperKEATS but was familiar with ASOC actions run the latest version, list bugs that were found, and recommend improvements. Another test was conducted by having a user-interface expert try the system and recommend improvements. SuperKEATS was first shown to members of AFHRL/LRG for their review. Improvements, upgrades, and additions were then made before the ASOC members used the system and made their evaluations.

Internal Structure of SuperKEATS

The software, based on KEE's object-oriented programming environment, is organized into files called *knowledge bases*. Each knowledge base contains a group of objects, called *units* in KEE. Functionally equivalent to an object, frame or schema in other object-oriented programming environments, a KEE unit represents the definable attributes and behaviors of a physical or conceptual object. Appendix A lists the SuperKEATS knowledge bases and major units.

SuperKEATS' internal structure is most easily described by grouping the software into four functionally related areas (each of which comprises a set of knowledge bases):

1. *Simple Simulation (SIMSIM)*: Simulates ground and air forces.
2. *User Interface*: Displays textual and graphical information in windows, and responds to mouse-button and menu selection.
3. *Instructional Features:* Allow user control over gaming level and mode, artificial feedback, suggestions and options, and gaming measures.
4. *Support Tools:* Aid game building and SuperKEATS system loading.

SIMSIM

SIMSIM is an object-oriented, agenda-based simulation of air and ground forces. Included are Army objects from the corps level down to the company level, and Air Force objects such as WOCs, squadrons, and aircraft. During game execution, the objects send messages to each other and the User Interface to trigger ground and air forces activity. Simulation events placed on an agenda trigger time-delayed or scheduled activity. The modeling and agenda processing are described in more detail below.

Army Models. The ground forces are modeled as two opposing Army Corps -- a Red Corps and a Blue Corps -- with reserve and front-line tank units at the division level down to the company level.. All front-line companies and their opposing companies move together in close contact along straightline paths. Their rate of movement depends on the objectives of opposing companies and relative strength ratios.

Strength ratios change as the companies incur battlefield losses and receive reserve reinforcements. Ground battle attrition depends on the division objectives, strength ratios, and the actual number of tanks. Losses due to close air support depend on the number of aircraft, the aircraft type, and the type of ordnance used.

Army objects are updated periodically at game-builder-defined simulation update intervals (typically 15 or 30 minutes). During each update, front-line companies evaluate their resources. If needed, they generate requests for reserves and air support. The arrival of reinforcements and the arrival of requests for support are both scheduled as agenda events. Base attacks, duration of base closures due to air or ground attacks, and ground-based aircraft losses are also determined periodically at simulation update time.

Other Army actions respond to aperiodic events. Mission aircraft losses and tank losses resulting from missions are calculated when mission aircraft arrive over their targets. Division Air Liaison Officer (ALO) objects respond to air request refusal and requests for Suppression of Enemy Air Defenses (SEAD) coordination.

The modeling of most Army actions required complex probabilistic algorithms.

Air Force Model. The Air Force model has Blue (friendly) Air Force objects which work closely with the ASOC. Because the ASOC is assumed to have direct tasking authority with no interference or help from levels higher up in the command and control hierarchy, the objects include WOCs, squadrons, missions, aircraft and bases. The user communicates directly with a WOC via the User Interface.

WOCs and squadron objects manage and account for air assets as directed by the user. WOCs respond to user-generated messages for:

1. Tasking, diverting, and canceling Close Air Support (CAS) missions.
2. Scheduling, diverting, or canceling a flow of missions to a division area.
3. Establishing, changing, and canceling aircraft alerts.

A WOC either refuses or accepts a message. A WOC refuses a message if the message violates any of the aircraft resource constraints associated with that message. Refused messages have no effect on the Air Force. Accepted messages result in agenda event creation and/or accounting updates. When a WOC accepts a tasking message, mission-related agenda events are created and the mission is posted to the schedule of each mission-assigned aircraft.

Additional messages sent by the Army trigger the accounting for aircraft lost during base attacks and the inability of missions to take off or land while a base is closed.

The Air Force algorithms are deterministic, involving no probabilistic effects.

Agenda Event Processing. There are 18 types of simulation events (Appendix A's Agenda Knowledge Bases). SIMSIM objects create and place events on the agenda by sending messages to an agenda manager object. The agenda manager maintains the events as a time-sorted list. When the simulation time matches the time of the first listed event, the agenda manager removes the event and sends the event an execution message.

The simulation runs in several modes: a user-paced mode and three real-time modes. In the user-paced mode, the user forwards the simulation to the next event time. In the real-time modes, a system timer increments the simulation time at rates of 1, 2, or 10 times real time.

User Interface

The User Interface facilitates user interactions with SIMSIM and Instructional Features. SIMSIM information is displayed in a tactical situation map and as text in user-controllable windows. The user communicates with SIMSIM primarily via message forms. Textual and graphical (graphs and plots) displays and mouse-selectable menus support Instructional Features.

SIMSIM Information Displays. As shown starting from the top of Figure 5, SIMSIM generates air requests, which are eventually displayed in a message log, in an air request display, and on a map. A brief summary of the air request is logged in the message log, as are all messages received by the ASOC. A more detailed version of the request is displayed, if the user so chooses, in a separate air request display. The air request display logs all missions tasked for the air request, as well as mission results. The map displays the position of the ground force unit which generated the air request, as well as corps, division, boundary line, and Air Force base positions.

Other displays include information summaries, briefings, orders, and status boards. Up-to-date summaries for corps, divisions, and bases, and factual summaries on aircraft and ordnance performance, are generated as textual displays upon user request. A FDO shift change briefing, a G-3 Air briefing, an Intelligence briefing, and an Air Tasking Order reflect the state of the tactical environment at the start of the simulation. Status boards show base, squadron, and mission status much like the operational status boards in the ASOC. These boards are continually updated by SuperKEATS.

The user can perform a variety of information display window management actions, such as open, close, shrink, expand, reshape, and move individual display windows.

Transmission of User Communications to SIMSIM. Figure 6 traces the message chain triggered by user input in response to an air request displayed in the message log. The user fills in a message form to task missions via mouse selections from menus, and keyboard text entries. SIMSIM responds to the completed message form by generating an appropriate response for display in the message log and, if needed, updates status boards and schedules SIMSIM events for future processing.

User Interface for Instructional Features. Information displays explain SuperKEATS use and give suggestions, options, and game summaries. The user controls these features by selecting buttons and choosing options from pop-up menus using a mouse. The user fills in forms to select a game, and to record an assessment of the tactical situation and a plan of action.

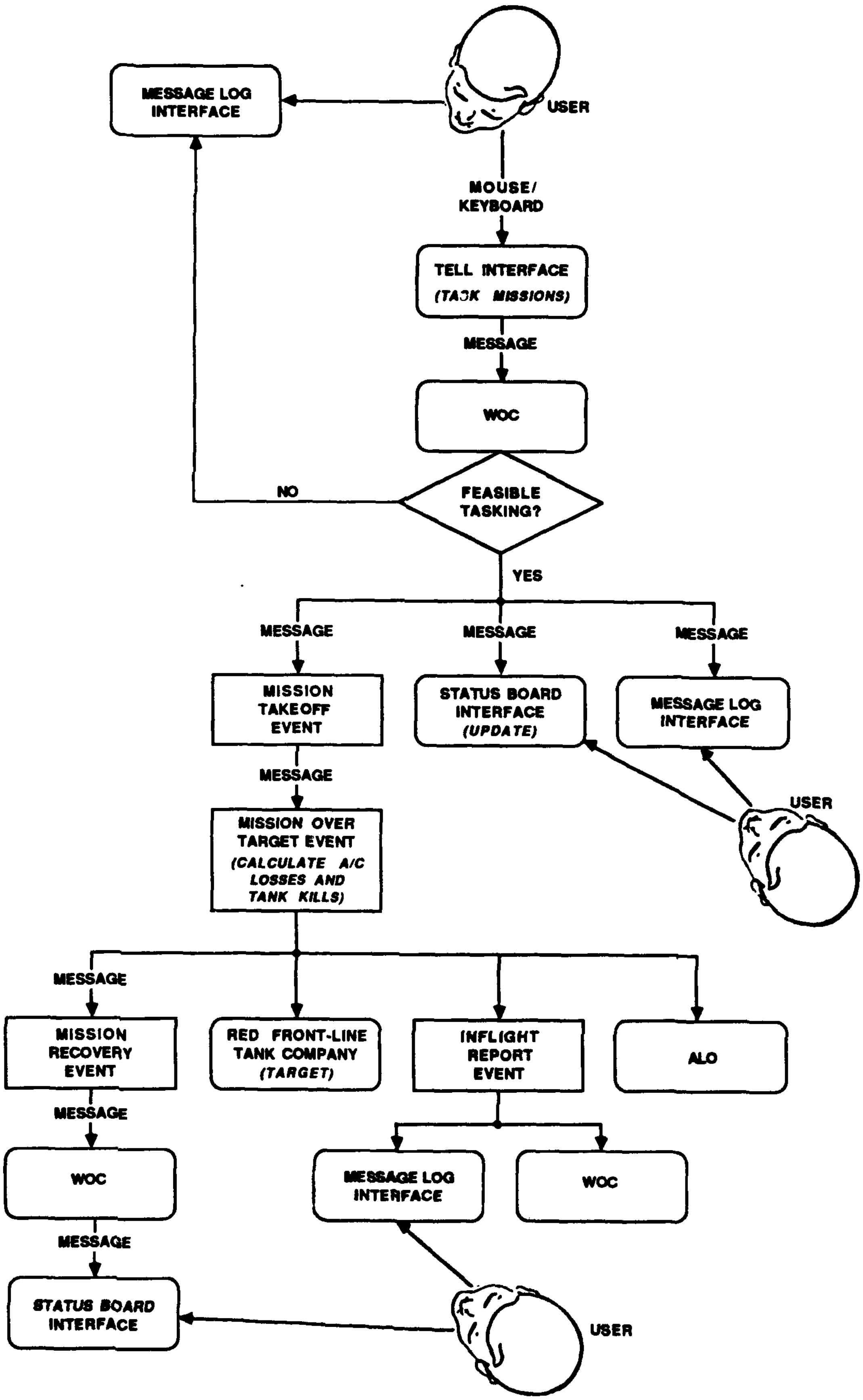

Figure 5. SIMSIM: Tracing the Generation of an Air Request.

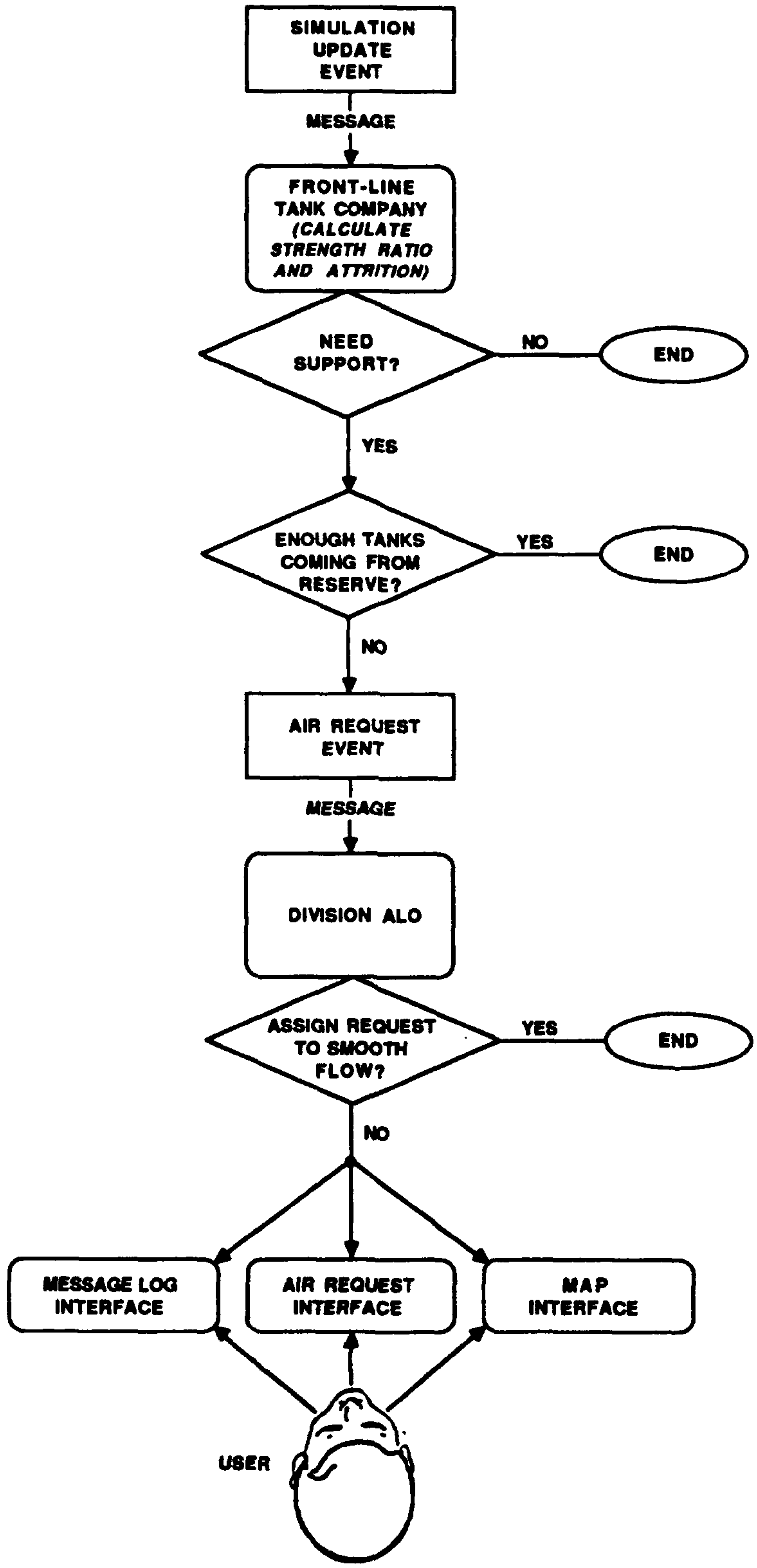

Figure 6. SIMSIM: Tracing the Processing of an Air Request.

Instructional Features

Instructional features include game control, suggestions, options, and artificial feedback generation.

Game Control. Game control prompts a user to select a game and then prepares SIMSIM to run the selected game. Game control then guides a user through the initial gaming setup steps, prompting and disabling/enabling User Interface options appropriate for each gaming step. Just prior to and during the operations phase of the game, game control supports user selection and deselection of instructional features and the setting of user-driven or real-time playing modes. Game control allows the user to end the game or quit SuperKEATS at any time.

Suggestions. Suggestions are generated by applying some of the rules-of-thumb extracted from KEATS knowledge acquisition activities. The rules are expressed as IF-THEN statements. IF conditions reference SIMSIM object attributes such as the number of tanks targeted in an air request; THEN actions may change the value of bookkeeping object attributes or generate a suggestion (e.g., a sample paraphrased rule: "IF the number of tanks is greater than 20, THEN task more than 1 mission."). If the suggestions feature is selected, the suggestion rules are applied each time the ASOC receives an air request. The results are displayed in a tasking suggestions and options window.

Options. Mission tasking options are also produced and displayed for each air request if the suggestions feature is selected. Both suggestions and options are generated by the Air Liaison Officer (ALO) who receives the air request, before passing the request on to the ASOC. The ALO queries selected WOCs and squadrons (in accordance with the user's plan) to find available missions to meet air request requirements.

Artificial Feedback. There are two types of artificial feedback: mission-tasking-specific feedback and game performance summary measures. Mission tasking feedback is generated by comparing the ALO-suggested tasking options with user-entered taskings. If the feedback feature is turned on, the tasking evaluations window is displayed immediately after the user transmits mission taskings to a WOC. Summary measures can be displayed at any time. These summary measures consist of histograms of air request disposition and mission results, graphs of asset allocations to Army divisions (fire priorities), and other numerical measures expressed using text, level meters, and strip charts.

Support Tools

System support tools include software for building exercises. A building interface and building functions allow system developers and researchers to adjust SIMSIM object attributes for the SIMPLE, INTERMEDIATE, and COMPLEX game levels.

Using SuperKEATS for Student Practice

A student user acquires and improves decision-making skills through repeated game playing in the reactive, simulated microworld. Student actions, system reactions, and simulation probabilities make each gaming session unique.

The student first selects a game. The SuperKEATS game then unfolds in two phases: an initial orientation phase and a subsequent operations phase.

Beginning the orientation phase, SuperKEATS prompts the student to assess the tactical situation and to develop a macro-level plan of action. After the student implements an initial plan, he starts the game clock and enters the operations phase. During the operations phase, the student makes micro-level decisions and replans at the macro-level in response to incoming tactical messages. We discuss these actions below in greater detail, referencing the actions in Figure 7.

Game Selection

The student selects from among the SuperKEATS games built by the SuperKEATS researcher. Three basic SuperKEATS games were developed to support the initial SuperKEATS evaluation. The simple game offers a single type of aircraft asset, with no loss of assets during the game. The intermediate game provides three asset types and some loss of assets due to air attacks on bases and air defense attacks on missions. The complex game features six asset types, an added air request type, and asset losses resulting from increased probabilities of air attacks on bases, small unit ground attacks on bases, and air defense attacks on missions. A researcher may add many more games to this set to experiment with how games can be built and sequenced to meet specific training objectives.

Orientation Phase

Situation Study. During the orientation phase of a game, the student first familiarizes himself with the overall tactical situation. This initial step simulates the beginning of the day shift in the real world. This familiarization process is enabled by making available the same information resources that are present in the real world:

1. Information summaries for corps, divisions, bases, and squadrons.
2. Status boards for base, asset allocation, and mission.
3. ASOC briefings and orders.
4. Factual information on aircraft types, ordnance types, and ordnance loads.
5. A map of the tactical situation.

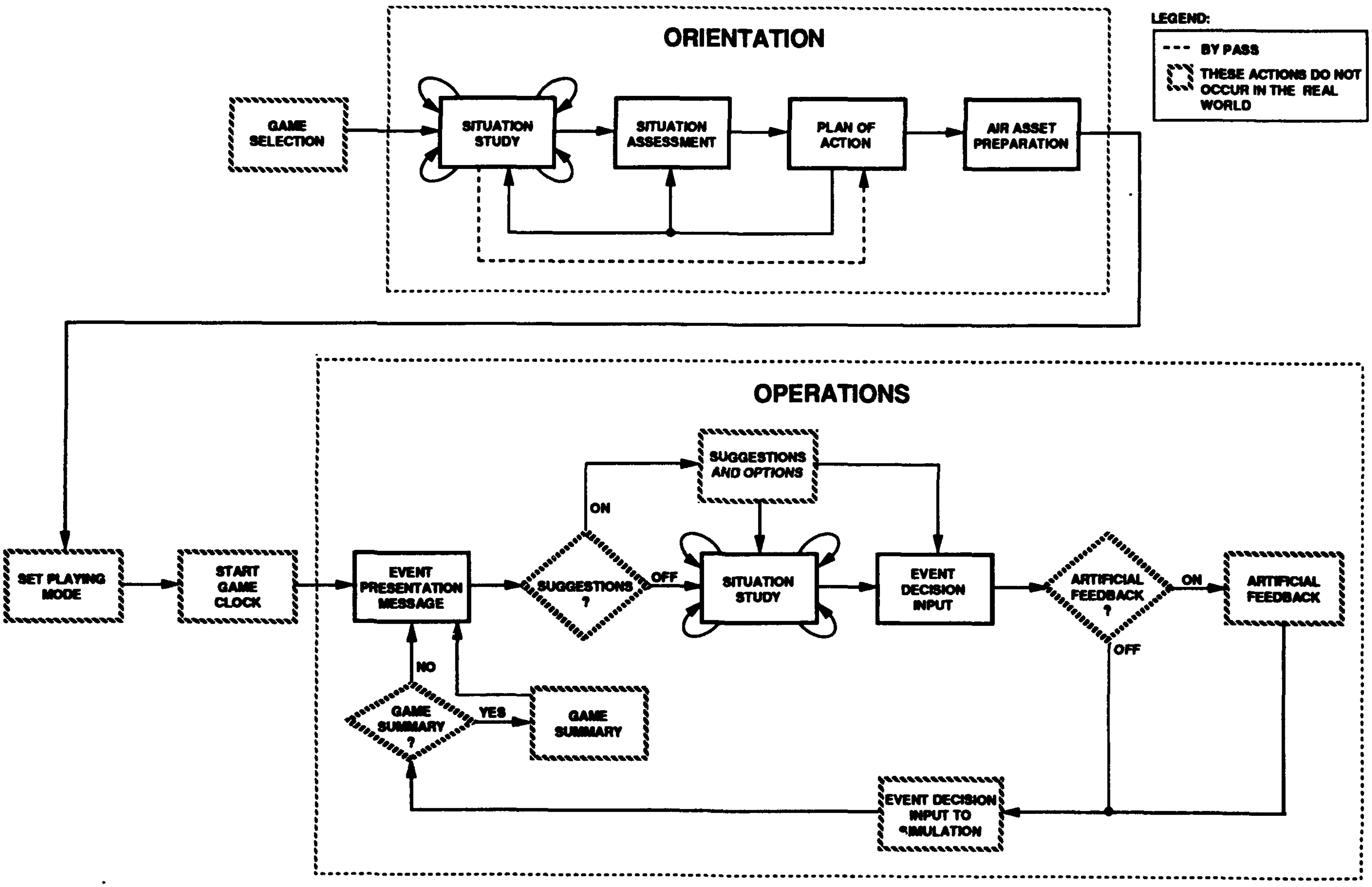

Figure 7. SuperKEATS Gaming Session Flow.

Situation Assessment. Much as the FDO does in the ASOC, the student can formulate a "big picture" assessment which anticipates the air support needs of the ground forces for the day and accurately accounts for aircraft assets by performing a thorough situation study. This initial situation assessment in turn leads to an initial plan of action.

Plan of Action. The plan assigns air assets to primary and alternate Army divisions in either an alert or smooth flow mode. Because SuperKEATS realistically simulates the delays necessary to prepare assets for missions,it is critical that the student first formulate and implement such a plan. Alerts prepare air assets for immediate tasking by putting them on various levels of readiness. Smooth flows preplan mission times in "airline schedule" style for predetermined time blocks and mission intervals.

The student enters the situation assessment and plan of action on an Initial Assessment and Plan form (Figure 8).

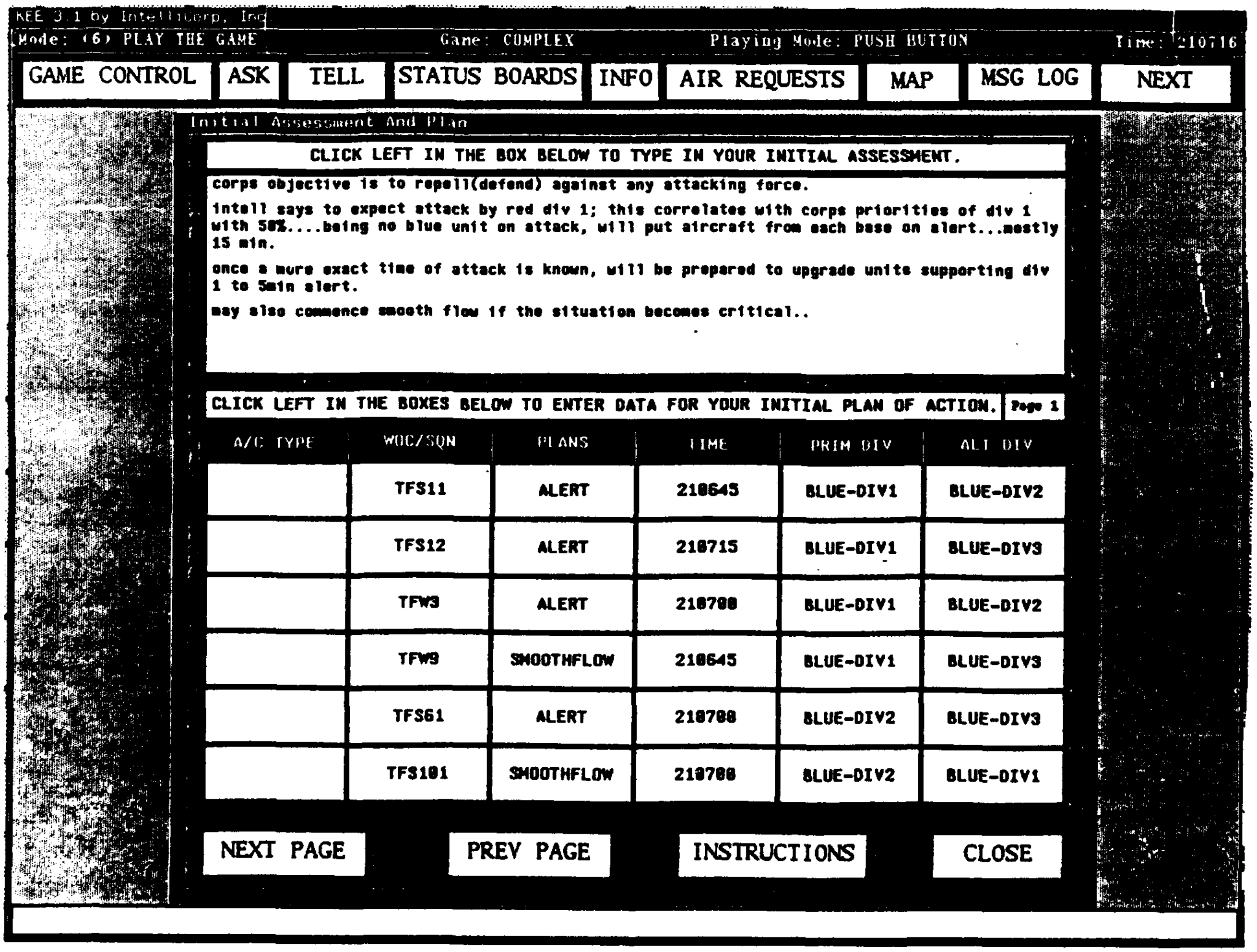

Figure 8. A Sample Assessment and Partial Game Plan.

Air Asset Preparation. The student then begins to implement the plan by telling WOCs to put aircraft on alert or to schedule a flow of missions, specifying additional details such as timing and numbers of aircraft. During game playing, the student receives suggestions and feedback based on the implemented plan. If the student neglects to implement a plan or implements a deficient plan before running the game, the simulation will provide appropriate feedback. For example, if the student does not put aircraft on alert before starting the game, the WOC will refuse mission taskings for requests received early in the game. The student can take as much time as he wants to complete the orientation phase.

Set Playing Mode and Start Game Clock

The student begins a game and enters the operations phase by setting the playing mode to one of four modes and pushing the NEXT button to start the game clock. The playing modes are: a pushbutton mode which advances the clock whenever the student pushes the NEXT button and the real-time modes which automatically advance the clock at 1, 2, or 10 times real time.

Operations Phase

During the operations phase of the game, the student reacts to events as he or the SuperKEATS simulation triggers them over time. Events show up as ASOC-received messages displayed in a message log. On the macro level, the student may reassess the overall tactical situation for the ASOC and may decide to change the plan of action to one which is consistent with the new assessment. On the micro level, the student decides what to do about a specific event. Decisions on this level are guided and constrained by decisions made on the planning or macro level.

For example, the student receives an air request event message at 7:16 a.m. as a brief message from the Blue Division 3 ALO to neutralize 15 tanks as soon as possible (ASAP), and not later than (NLT) 8:15 a.m. He may also receive SuperKEATS-generated mission tasking suggestions and options at the same time to aid his decision-making. He then reacts to events as he would in the real world by accessing various information sources to confirm the event, to gather additional information about it, and to determine solution options. After this period of "cogitation," he enters the event decision input by telling a WOC to task four alert aircraft from squadron TFS11 to meet the air request. If artificial feedback is turned on, he receives an evaluation of the event decision input based on a comparison with the SuperKEATS-generated suggestions and options. The event decision is then input to the simulation. SuperKEATS' simulation evaluates the student's input by checking for violation of physical constraints. SuperKEATS checks whether these airplanes are indeed available at that squadron and whether they can make the desired NLT. The results of constraint checking are returned to the student as feedback messages. If the tasked mission does not violate any physical constraints, the user receives a message which indicates that the WOC accepts the tasking. Otherwise, the WOC sends a refusal message to the student. The student can elect to display a game summary displaying his overall performance at any time during the operations phase. The student may also reassess the tactical situation and decide to implement a new plan; for example, the request may confirm the student's assessment of an offensive push against Blue Division 3 and cause him to schedule a smooth flow of missions to Blue Division 3, thereby revising his plan to use alert aircraft to support Blue Division 3.

The individual steps constituting the operations phase are described below.

Event Presentation Message. As simulation time advances, the student learns of the occurrences of events through messages displayed in the message log (Figure 9). If the event is an air request, the target position associated with the request is plotted on the map. The student can also examine data on the air request itself.

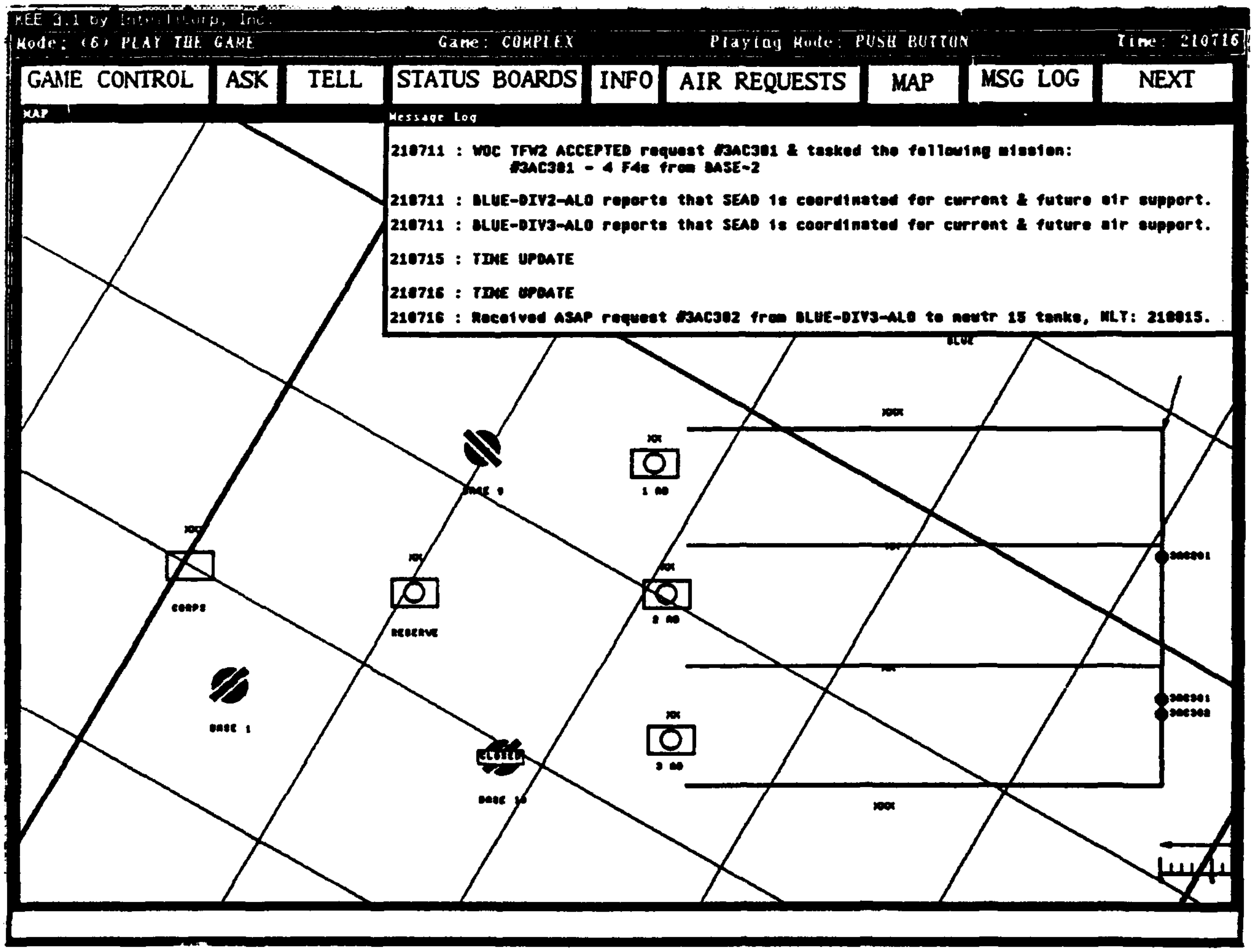

Figure 9. Typical Student Display for Playing a Game.

Suggestions and Options. Suggestions and options may be turned on or off. Researchers may choose on for a novice, off for an advanced student, or leave it up to the student. A novice student may receive both tasking suggestions and options for maximal SuperKEATS guidance (Figure 10). A proficient student may use the same feature as a decision aid which keeps track of the feasible set of options. An expert student may choose not to use the feature. In any case, whenever the suggestions and options are turned on and an air request is received, the Tasking Suggestions/Options display gives the student guidance and/or specific tasking options for the air request. The student may also access suggestions and options via the AIR REQUESTS display for a particular air request.

Situation Study. For further information, the student can request and/or monitor information from the same sources that were available in the orientation phase (i.e., ASK, STATUS BOARDS, and INFO). All status boards update automatically and continuously as bases close and reopen, aircraft take off and return, aircraft change status, and aircraft are lost. Briefings, orders, and factual information never change during a game.

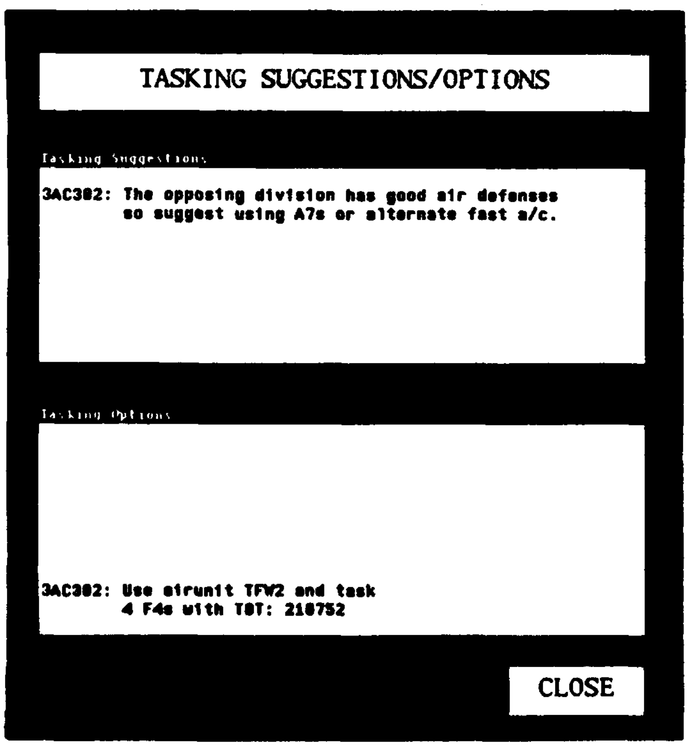

Figure 10. Sample Tasking Suggestions and Options Display.

Event Decision Input. When the student decides on assets to task for a request, the student tells a WOC to perform an action via a tasking message (Figure 11). The message references the air request number and specifies the number of aircraft, the aircraft type, the air unit, and the aircraft pool. The information content of the message is fundamentally the same as that transmitted by an FDO in the operational environment. When the message is complete, the student transmits the message to the WOC.

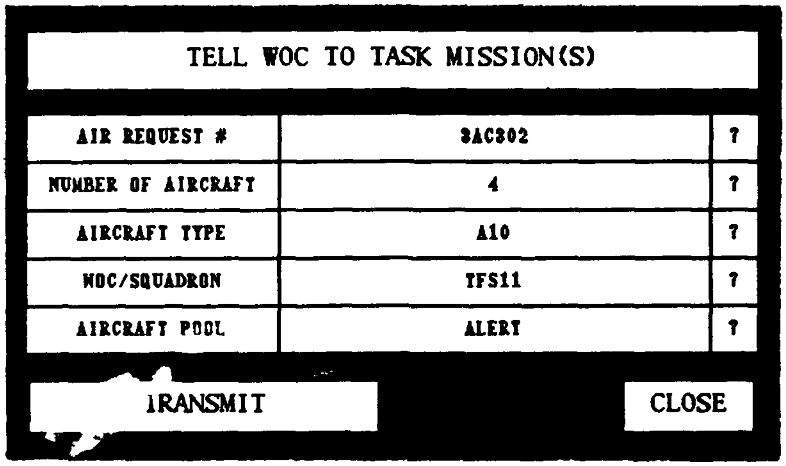

Figure 11. Sample Mission Tasking Display.

Artificial Feedback. Artificial feedback may be turned on or off. The feedback option gives immediate feedback on an air request tasking decision (Figure 12). When the student tells the WOC to task a mission, the feedback is first displayed instead of an immediate WOC response. The student then has the option to either change the decision or forward it on for a WOC response.

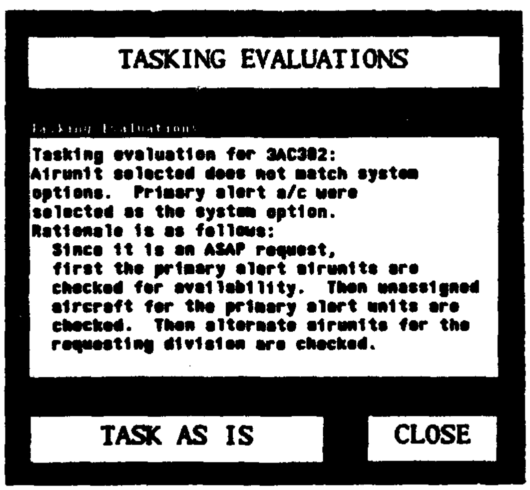

Figure 12. Sample Tasking Evaluations Display.

Event Decision Input to Simulation. The immediate natural feedback comes in the form of acceptance/refusal responses from the WOC which are immediately displayed as messages in the message log. The WOC performs feasible actions and refuses impossible ones. All affected Status Board displays are then automatically updated.

Additional feedback comes from the simulation after a typically expected time delay. For example, air support mission results are displayed in the message log as an in-flight report transmitted as the mission aircraft return to base. The student can easily associate the feedback with the tasking decision. The other longer-term consequences of the tasking, such as changes in Army force ratios, division movement, and air request generation, are more difficult to directly correlate with a particular tasking decision. However, the student may receive additional requests for air support and notice trends in either target sizes (the number of tanks targeted) or target positions.

Game Summary. A game summary (Figure 13) displays histograms of air request disposition and tasking results and gaming effectiveness measures (GEMS). Additional displays include:

1. Graphs comparing Corps division priorities with ASOC taskings.
2. An explanation of GEMS.
3. GEMS Meters.
4. GEMS Plots.

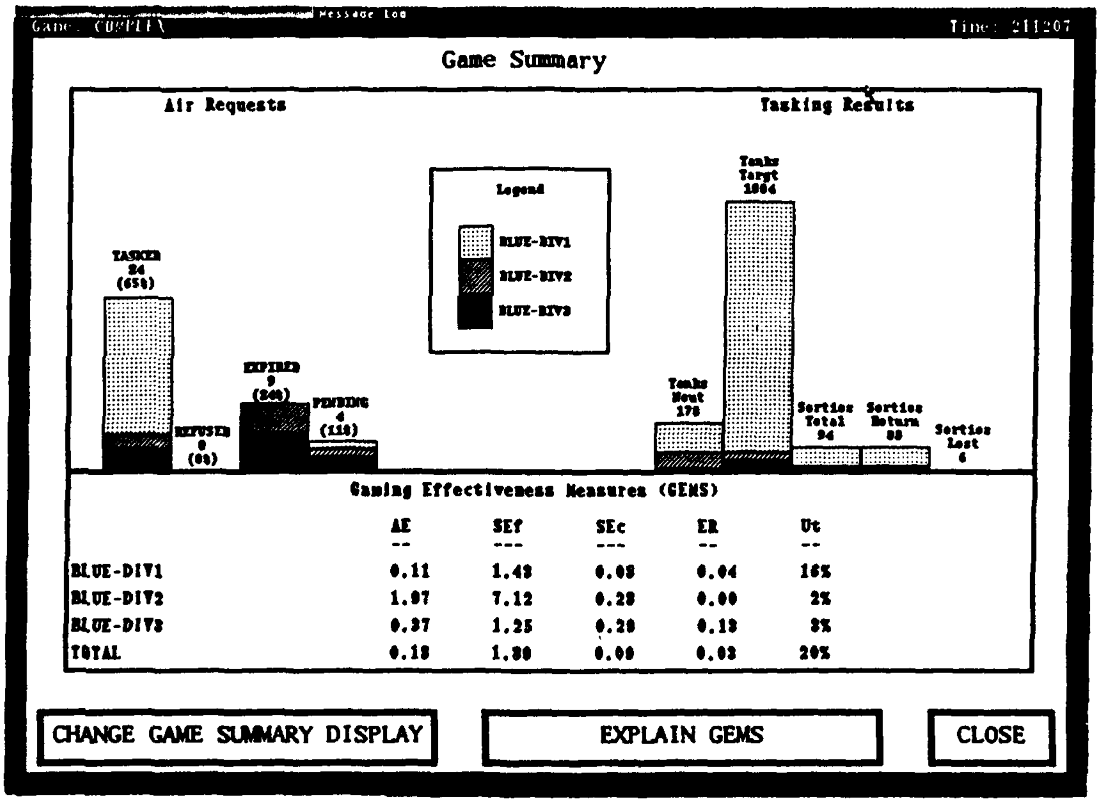

Figure 13. Sample Game Summary Display.

GEMS are nonjudgmental, quantitative scores for student performance during a game. SuperKEATS calculates GEMS ratios using completed missions data (Table 4).

Table 4. Explanation of Gaming Effectiveness Measures (GEMS)

1. AE = Air Effectiveness = Tanks Neutralized/Tanks Targeted. The greater the value of AE the better. AE sometimes exceeds 1 when reserves are neutralized in addition to the tanks originally targeted on the air request.

2. SEf = Sorties Effectiveness = Tanks Neutralized/Sorties Total. The greater the value of SEf the better. This value reflects the aircraft type mix, the presence of Red air defenses, and air/ground coordination.

3. SEc = Sorties Economy = Sorties Total/Tanks Targeted. A low SEc shows economical use of sorties.

4. ER = Exchange Ratio = Sorties Lost/Tanks Neutralized. A low ER is desirable. Higher ERs occur with poor mission configuration, good Red air defenses, and lack of air/ground coordination.

5. Ut = Utilization = Sorties Total/Sorties Projected. Ut should ideally approach 100% at the end of the game to show full utilization of all available resources.

GEMS meters and plots are separate, compact displays which support continuous performance monitoring. GEMS meters consist of a stack of five small meter boxes showing the current GEMS levels. GEMS plots consist of a stack of five small strip charts which plot past and current GEMS values. GEMS meters and plots are updated automatically whenever mission results are reported.

The student or researcher may request a full game summary or display GEMS meters and GEMS plots at any point during game playing.

Using SuperKEATS for Researcher Experimentation

A researcher builds and modifies SuperKEATS games and controls SuperKEATS instructional parameters to evaluate their effect upon training. Instructional macro-strategies are easily tuned by adjusting game complexity and introducing new games. During gaming sessions, a researcher formulates micro-strategies for instruction by turning instructional displays on and off, and adjusting the game pace. The researcher may also permit the student user to manage the displays and the pace of the game exercise.

Building Games

The ISD researcher can build tailored games to achieve desired training objectives using the SuperKEATS exercise building tools. Table 5 lists the differences in complexity parameters among the currently developed games which represent the three gaming levels.

Table 5. Game Complexity Parameters

Parameter	Effect	Gaming Levels		
		Simple	Intermediate	Complex
Air status	Base air attacks	Supremacy	Superiority	Parity
Small Unit Attack Capability	Base ground attacks	False[a]	False[a]	True[b]
Joint Air Attack Team (JAAT) Capability	Type of requests Air support effectiveness	False[a]	False[a]	True[b]
Red Air Defense	Aircraf. losses	None[c]	Good[d]	Good[d]
Number of WOCs	Aircraft types	1	3	6
Base Defense Forces	Base attack effectiveness	True[e]	True[e]	Varies[f]
Number of Turns	Asset use/ availability	Same[g]	Varies[h]	Varies[h]

[a] False implies that the capability does not exist.
[b] True implies that the capability exists.
[c] None implies that there are no Red Air Defenses.
[d] Good implies that the Red Air Defense exists and its capability is good.
[e] True implies that the bases all have defense forces.
[f] Varies means that bases may or may not have defense forces -- the parameter is set for each base in a particular game.
[g] Same means that all aircraft will have same number of turns.
[h] Varies means that squadrons will have assigned turns depending on the exercise.

The researcher can change the complexity by building new games with different values. The researcher can regulate the length of a game, its start time, and the frequency of simulation updates. Games can be a mini-game covering a single time block, or a full game covering an entire day.

In addition to the parameters above, the division priorities of fire, the corps/division/company objectives, the numbers of tanks in companies, and the numbers of tanks in reserve can all be modified to produce dramatically different games. Existing SuperKEATS games all put the Blue Corps on the defensive; the researcher can build offensive scenarios.

The researcher can change the complexity by building new games with different values. The researcher can regulate the length of a game, its start time, and the frequency of simulation updates. Games can be a mini-game covering a single time block, or a full game covering an entire day.

On the asset side, there may be up to 10 WOCs with 3 squadrons each. Each squadron has an associated aircraft type, number of aircraft, and base location. Furthermore, up to 10 bases with differing aircraft maintenance capabilities may be created.

Instructional Feature Control

Throughout a gaming session, suggestions and options, feedback, and GEMS may be turned on and off. The researcher can explore individual student preferences for the features, the student's utilization of the features, and the instructional effectiveness of the features. Variables in this exploration can include the student's level of skill acquisition and learning style.

III. RESULTS

SuperKEATS has been used once by ASOC personnel during this project phase. The methods used during this trial and the results obtained are reported here.

Evaluation Method

Two 712th ASOC personnel used the system over a 2-day period at the contractor's facility. One subject was an 8-year veteran of the 712th ASOC, with experience in all aspects of the FDO job; the other had only 1 year of limited experience, having never worked the day shift during an exercise. This difference in experience presented the opportunity to compare novice and expert gaming behavior and effectiveness.

Each subject used the system for 1 day. Neither subject was present while the other used the system. First, contractor personnel instructed the subject on system use. Second, the subject examined a simple game to achieve system familiarity. Third, the subject played a complex game to evaluate the system. Finally, at the end of the day, the subject completed an evaluation form.

Gaming Results

The expert processed more than twice as many events as the novice while playing the complex game (see Table 6). The expert focused on the FDO task and started in the real-time mode then moved to 10 times the real-time mode. The novice explored interface features while playing in real time. SuperKEATS actually ran slower than real time as the game progressed.

The elapsed game minutes do not include the time both subjects devoted to the initial assessment, planning, and setup phase. These times are included in real-time hours. Appendix B contains the protocol of the expert playing the SuperKEATS complex game.

Table 6. Complex Game Results

	Novice	Expert
Elapsed game minutes	124	249
Real-time hours	4	5
Message log pages	8	20

Macro-Level Performance

Both subjects began the complex game with the same tactical situation. The expert produced a 9-line initial situation assessment (ISA) and a plan of action (POA). The novice did not enter an assessment but did complete a POA.

An analysis of the expert's ISA found common content elements with previously analyzed KEATS exercises (Brecke et al., 1989) in three areas: statements defining the probable demand for air support, statements evaluating the anticipated supply of air resources, and identification of replanning triggers or factors that should be watched because they might trigger a revision of the initial plans (see Table 7).

Plans consisted of a mapping of air resources by either wings or squadrons to front-line divisions. The two POAs are shown in graphic form in Figure 14. They represent clearly very different ways of dealing with the same situation.

Table 7. Content Elements in Situation Assessment

Element	Expert using SuperKEATS	Expert using KEATS
Demand assessment		
Corps objectives	X	X
Division objectives	X	X
Attack times	X	X
Corps priorities	X	X
Supply assessment		
Type of a/c	X	X
Ordnance		X
Preplanned allocation[a]		X
Time to target area		X
Replanning triggers	X	X

[a]No preplanned allocations in SuperKEATS.

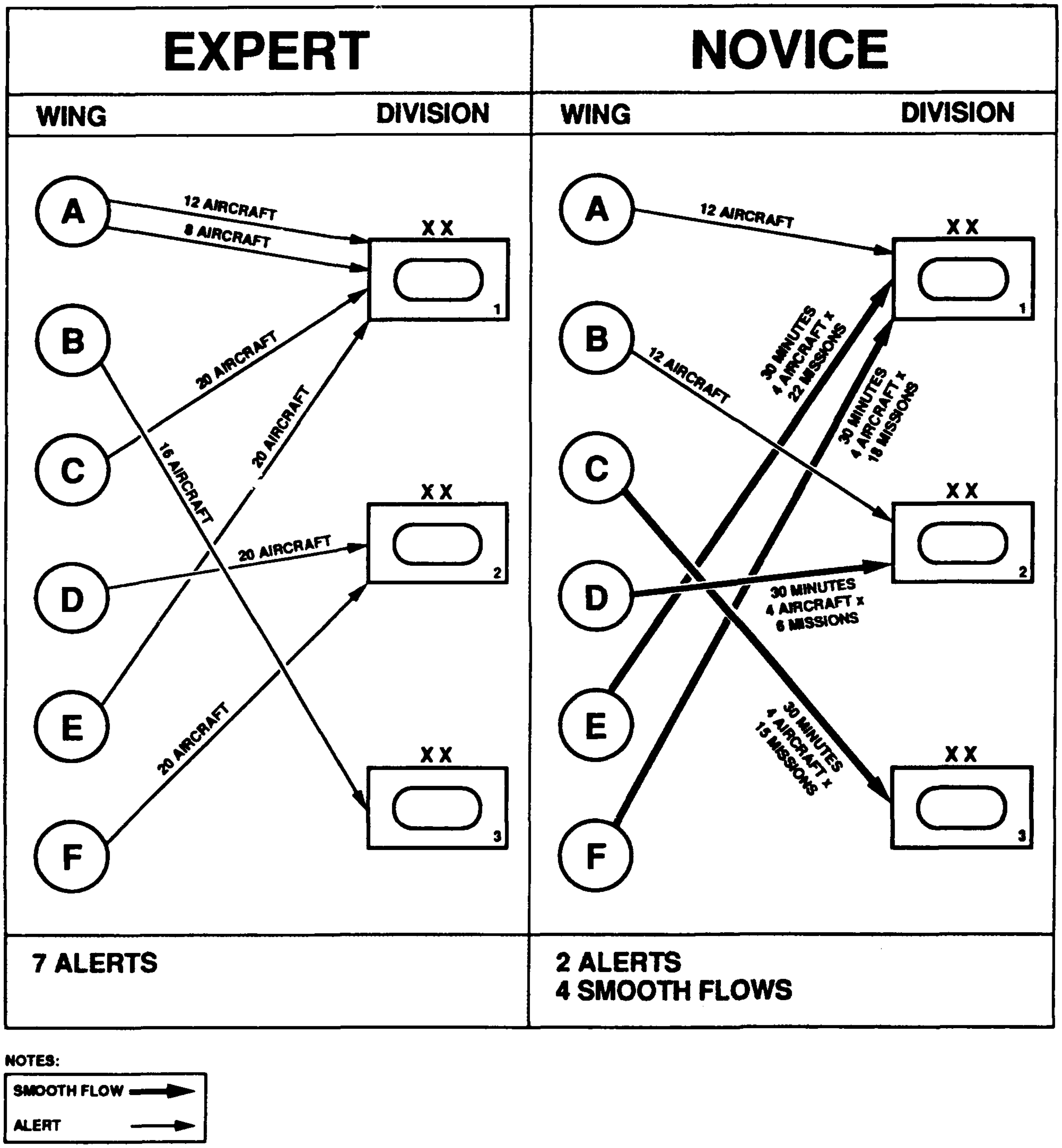

Figure 14. Plan of Action Differences in Identical Situation.

Both subjects implemented their initial plan before starting the game. After [illegible] game minutes, the novice cancelled the Wing E smooth flow to Division 1 and then unsuccessfully attempted to put those aircraft on alert. He put eight more Wing A aircraft on alert status 30 game minutes later. The expert did not implement any alert changes nor did he initiate any smooth flows during his gaming session.

The expert tasked 92% (166 out of 180) of sorties to primary and alternate divisions, compared to 89% (80 out of 90) for the novice (Table 8). Of the sorties directly tasked by the novice, [illegible]7% (20 out of 30) adhered to his plan.

Table 8. Sorties Tasked According to Plan

	Novice after 119 minutes	Expert after 249 minutes
Smooth flow sorties	60	0
Directly tasked sorties	30	180
Directly tasked to primary	12	140
Directly tasked to alternate	8	26
Sorties Aborted	4	0
Sorties Diverted	4	0

Micro-Level Performance

Gaming sessions for both subjects included the same typical events: The same two bases were attacked at the start of the game, resulting in identical losses and base closure times. Subsequent aircraft losses occurred only when flying missions.

Air request statistics (Table 9) were similar only in terms of system generation rates and targets. The novice's smooth flow plan substantially reduced the number of requests received by the ASOC.

Table 9. Air Request Statistics

	Novice	Expert
Request Generated/Game Hour	8.5	7.75
Number of Target Tanks/Request	20	26
Number Received by ASOC/Game Hour	1.5	7.75

Gaming measures and division movement demonstrated the expert's tasking prowess (Table 10). The expert neutralized twice as many tanks per request (AE) and per sortie (SEf) as did the novice. This tasking effectiveness was most evident in the Division 1 sector, where the expert held the attack to a 1-kilometer advance compared to the novice's 10 kilometers. An examination of game protocols showed that the novice's failure to use more effective aircraft to supplement the smooth flow sorties in the Division 1 area was a major contributing factor.

Sorties Economy (SEc) and Exchange Ratio (ER) measures were comparable for both subjects, indicating the economical use of sorties with minimal inflight sortie losses to achieve tank neutralization. Sortie utilization (Ut) was conservative for both subjects if compared to an expected linear utilization rate of 9% per each of 11 game hours. However, the expert, after 4 hours of play, was only 5% below the expected linear value. This can be explained in part by flight time delays at the start of the game in that Ut accounts only for sorties that have actually reached the target and not for tasked sorties in preparation or enroute.

Table 10. Gaming Measures[a] and Division Movement Comparisons

	Novice after 119 minutes	Expert after 141 minutes	Expert after 249 minutes
Number of Requests	10	14	25
Tanks Neutralized	44	160	279
Tanks Targeted	200	299	634
Sorties Over Target	44	88	144
Sorties Lost	2	5	11
Air Effectiveness (AE)	0.22	0.54	0.44
Sorties Effectiveness (SEf)	1.00	1.82	1.94
Sorties Economy (SEc)	0.22	0.29	0.23
Exchange Ratio (ER)	0.05	0.03	0.04
Utilization (Ut)	10%	19%	31%
Enemy Advances in Kilometers			
Division 1	10	1	1
Division 2	0	0	0
Division 3	0	0	0

[a] refer to Table 4.

Written Evaluation Results

Overall, SuperKEATS was judged useful to the ASOC, with an overall high rating of 4 on a scale of 1 to 5. The expert particularly liked the ACTION REACTION-RESULT chain introduced by SuperKEATS, underscoring the achievement of the major SuperKEATS objective to furnish a reactive environment which was lacking in KEATS. The expert's evaluation is provided in Appendix C. Both expert and novice disliked display functionality, recommending more compact and complete information displays. Both subjects encouraged further development and suggested the use of SuperKEATS in operational exercises.

Fidelity of Simulation

Responses were generally favorable (4 on a scale of 1 to 5) for inclusion of expected objects, events, availability of information, and ability to communicate with other agents. Extensions suggested include:

1. Weather events.
2. Maintenance downtime events.
3. Longer base closures.
4. Requests with non-worthwhile targets for FDO to reject.
5. Quick access to available aircraft for tasking.
6. Communications with G-3 Air concerning priorities.

The simulation response to user decisions, system response times, and information display management received lower ratings. Of special concern was the replacement time for ground force losses. During the gaming session, the simulation replaced losses within hours instead of the expected day or days. Also, the initial conditions for the complex game were set to initially generate requests from all divisions rather than the expected concentration of requests from one area then another. The expert thought that losses were instantly replaced and that the replacement "did not allow the FDO to change focus to another area." The expert recommended replacement of losses in unit increments over longer time frames.

A large number of targets, such as 72 tanks, on an air request was judged unrealistic and sortie effectiveness was thought too high with up to eight targets neutralized by one sortie. (A final release modification to SuperKEATS has since reduced sortie effectiveness.)

Both subjects indicated trouble with arranging information displays to facilitate quick and easy access. Both users seemed to prefer a functional rather than a physical replication of ASOC sources of information to support gaming operations. A dual screen or larger display was recommended.

SuperKEATS for Training

A Novice's Perspective. The novice awarded the SuperKEATS feedback feature his highest rating and gave training coverage, validity and efficiency of training, and the suggestions/options feature lower ratings. He commented that SuperKEATS did not reinforce procedural actions that a FDO is expected to perform and did not cover European ASOC operations. He suggested an expansion of the suggestions and options feature to include additional information such as base, WOC, alternate selection, missions to divert, retasking, and smooth flow options.

An Expert's Perspective. SuperKEATS received overall high ratings for training a novice in all aspects except for coverage. The expert recommended improvements to simulation fidelity that were closely coupled with training. Elements he considered important for training a novice included:

1. Events/requests that would be disapproved.
2. Actions to have or not have positive effects in particular sectors (allowing shifting of emphasis/concern).
3. Closing bases for at least a period of time that would affect request servicing, an hour instead of a half hour.

He added that more complex events would be required for training an experienced FDO.

The expert liked the suggestions/options and tasking feedback features for the novice learner. He wrote that suggestions/options could be a useful tool for real-world tasking. He also wrote that feedback could be used for experienced users after reacting to complex events, as a means to review all areas to be considered.

IV. DISCUSSION AND CONCLUSIONS

In this section, SuperKEATS is discussed from two perspectives: its relationship to earlier technologies for training decision-making skills, and lessons learned in building and using it. SuperKEATS has received a minimal amount of use by ASOC personnel during this project phase. Hence a discussion of the effectiveness of SuperKEATS for training decision-making skills and for instructional strategy experimentation awaits further work.

Comparison with Earlier Microcomputer Systems

In Section I, earlier work on small-scale, inexpensive decision-training systems was referenced. The question now is how SuperKEATS compares with these earlier systems in terms of scope, objectives, and domain. In terms of scope and objectives, only SuperKEATS has had training as its main objective. It provides training on the macro level by allowing modification of exercise complexity, and on the micro level by using prompting and artificial feedback. The work of Madni, Ahlers, and Chu (1987) focused mainly on the modeling of an intelligent adversary and allowed modification of the model as a means to train various objectives. Obermayer, Johnston, Slemon, and Hicklin (1984) showed that modeling with an expert system could reduce the labor intensity of training, but the "Game Environment Simulator" they built was a simulation and not intended as a training system. Wilson (1982) created a wargame that might have training utility as a secondary feature. Stoddard, Kern, and Emerson (1986) had a long-term goal of producing an intelligent tutoring system for tactical decision-making but, at this stage, report only the design for a knowledge extraction tool, serving a purpose much like KEATS, without explicit training features.

In terms of the domain, SuperKEATS attempted to model a more complex domain than have any of the earlier systems, although it does impose limitations on weather modeling and terrain. SuperKEATS needed to model Army unit actions from the corps level down to the front-line company, Air Force units from the wing operation center to individual aircraft, and the interaction of air units attacking ground targets. Madni et al. (1987) simulated a one-on-one interaction of two surface ships. Obermayer et al. (1984) had a complex environment with ships, a helicopter, a submarine, sonobuoys, torpedos, etc., but the game was based only on anti-submarine warfare (ASW) concepts and did not attempt fidelity to a real ASW environment. Wilson (1982) modeled only the air battle and Stoddard et al. (1986) were interested in the Army armor officer directing platoons of tanks in a land battle.

SuperKEATS, then, advances the technology base for decision-making training by tackling a complex domain intent on producing a training system with real-world operational use, where completeness and fidelity are key issues. That it has succeeded is evidenced by the positive responses of the ASOC members who have used it.

Comparison with an Intelligent Tutoring System

SuperKEATS is not, and was not intended to be, an intelligent tutoring system (ITS). Because SuperKEATS does provide an automated environment for practicing (and learning) decision-making skills, a comparison with an ITS puts the capabilities of SuperKEATS in perspective. In this discussion, the ITS for a gaming environment (Burton & Brown, 1982; Goldstein, 1982) will be used for comparison.

Typically, an ITS will have a model of an expert that generates responses and solutions that are compared with the student's responses. Although a stand-alone expert model was not built for SuperKEATS, rules-of-thumb and generation of tasking options are implemented that use rules obtained from ASOC experts. A key difference between the complex ASOC environment and most previous ITS environments is the existence of multiple acceptable solutions for air asset tasking. It was important for prompting that all reasonable options be presented and, for feedback, that choosing a reasonable option be accepted. Hence, an expert ASOC FDO model, as such, that always arrived at a specific tasking solution, was not necessary or useful for training in this environment.

SuperKEATS does not provide a tutor/instructor model as would be present in an ITS to direct, at the macro level, the topics of instruction, and at the micro level, to set the level and amount of prompting and feedback. SuperKEATS also does not provide a student model (also expected in an ITS) to keep track of the student's current level of expertise and topics learned. Viewed from its perspective as the practice environment in a larger decision training system, these tutoring and student model capabilities would, in one form or another, have to be included in this larger system, of which SuperKEATS is a part.

Stability of the Environment

A major concern with any automated system is its brittleness as the world for which it was built changes. To try to build an automated system that can cope with any changes in its area of operation would be very expensive, if even possible. If the environment is changing so rapidly that between the time the system is designed and completed it has become obsolete or at least needs major upgrades, then building the system in the first place must be questioned. Among the major concerns with Intelligent Tutoring Systems (ITSs) is how difficult they are to build and then how easily they fail if the environment changes. Because SuperKEATS was built as a simulation practice environment and is an alternative to a traditional ITS, its brittleness is of interest. With SuperKEATS, brittleness depends on the type of change, and various possibilities are discussed below.

Changes to equipment such as aircraft or ordnance that affect only model parameters can be easily accommodated in SuperKEATS. The changed parameters are readily modified in the "fact" knowledge base. If equipment changes affect the suggestion/feedback rules about when to use the equipment, then changes to the rules will need to be made. These rule changes must be based on expert knowledge and will likely be somewhat involved.

Changes in the ASOC tactics that have been captured in the suggestion/feedback rules will likewise require changes in the rules. If the change is fairly basic, then the rules may need be acquired anew, possibly by using KEATS. If the change is minor, it may affect only the conditions and actions of a limited group of rules.

Changes to the functions of the command units (WOC, ATOC, Army G-3, even the ASOC) will typically have a major effect on the models of those units. Due to the fact that the models are built to perform specific functions under certain conditions, changing those functions could conceivably require a redesign and redevelopment of the model. At the very least, the code controlling a particular function would have to change.

In summary, then, the more stable the environment is, the less it will cost to maintain a SuperKEATS system. Every system that works in the real world where changes occur will require maintenance and upgrades. There is no evidence that a simulation practice environment will necessarily require either more or less maintenance than a traditional ITS.

Prerequisites for Modeling

Though the design and development of SuperKEATS occurred over a 12-month period, important and necessary work preceded this effort. The first and most obvious prerequisite was to acquire knowledge of the ASOC domain. Designing SuperKEATS required knowing what people, organizations, and things affected ASOC decision-making during a battle and how these objects interacted with the ASOC and among themselves. This knowledge acquisition work on the ASOC domain was the focus of the second phase of this project (Brecke et al., 1989) and occurred over a period of about 1 year. Starting with interviews of ASOC personnel to obtain the general structure of the ASOC environment, the acquisition activity then proceeded to build a model of ASOC decision-making in the KEATS system. Refinement of the models in KEATS, so that the basis for ASOC decision-making (e.g., rules) could be obtained, became the starting point for the models in SuperKEATS.

As the design of SuperKEATS proceeded, it became clear that, for realistic modeling, knowledge of the operations of other decision-making organizations in the immediate ASOC environment was important. For example, the model of a WOC had to respond to ASOC tasking requests. But to know how the WOC would respond in every circumstance of alert status, lost aircraft, and previous smooth flow commitments would require a very detailed understanding of how a WOC operates. This level of detail would also be needed for the ALO submitting air requests to the ASOC and assigning smooth flow missions to requests, and for corps commanders changing air support fire priorities. In the case of SuperKEATS, support of a WOC expert was requested but was unobtainable. The knowledge of how these decision-making nodes operated came either from what the ASOC members knew and expected of a WOC or otherwise from making the developer's best guess.

Besides the models requiring extensive detail, assumptions had to be made as to how much fidelity was necessary for modeling all other objects in the environment. In the case of SuperKEATS, the simulation limitations (Table 3) were chosen to simplify the modeling of Army units so that only actions important to the ASOC would result.

As a final note on prerequisites, it is suggested that having an in-house expert (e.g., a retired ASOC member) available during the building of SuperKEATS would have resolved many "developer best guess" problems. That SuperKEATS was built without this help, and was readily accepted by ASOC personnel, shows that it can be done successfully with very limited access to the experts. However, the product can be no better than the knowledge it contains. It will probably require one or more iterations of expert-use/model-revision to correct developer misconceptions. Having an expert always available would surely have speeded or eliminated the iterative process.

Transfer to Other Domains

The modeling in SuperKEATS should be easily transferable to other positions in the ASOC such as G-3 Air, Intel, or the Director. In that the members of the ASOC function as a team, they would all receive the same briefings as the FDO and be concerned with the same air requests. The Intel and G-3 Air decisions about air requests are not concerned with tasking specific air assets but are accept/reject decisions based on request validity. There would need to be additional modeling so that spurious requests were generated occasionally.

The ATOC also makes decisions about supply and demand of aircraft; in certain theaters the ATOC even subsumes the ASOC role of tasking air assets. Hence, the decision-making about CAS built into SuperKEATS should be directly usable by ATOC personnel making those same decisions. If it was desired to task Battlefield Air Interdiction (BAI) as well as CAS, then the modeling would need to be expanded.

The Army modeling in SuperKEATS is designed such that Army units request support when objectives are not being met. Transfer to other decision environments without the need for Army requests would require different models. For example, a node for air defense would require models of enemy air units launching attacks, and models for results of air encounters.

Implementation Lessons

During a multiyear project, there are likely to be changes in both the initial concepts (although not the goals) and the available tools. The original concept for this project was that to train decision-making in a tactical environment requires some kind of an intelligent tutoring system (ITS). As instructional design theories were studied and as results from existing ITSs became available, this concept changed to one of developing, as the product of this effort, a simulation practice environment. During the early stages of this project, the need for a fast prototyping environment was recognized but it was also considered that a rule-based expert system would be required in the ITS. Based on these considerations and on the need to gain familiarity with the software, the Knowledge Engineering Environment (KEE) was purchased during the first phase of the project.

During the second phase of the project, when knowledge acquisition was the area of activity, the KEATS system was built. Because KEATS had no requirement for an expert system and but did have the goal to place the system physically in the ASOC for their use, it was decided to use the object-oriented Smalltalk V, which had just become available and ran on personal computer (PC) hardware. KEATS was developed successfully in Smalltalk V, which proved to be an excellent environment for rapid prototyping. The only drawbacks were that response time was somewhat slow on AT (80286-based) machines (but 80386 machines were significantly better) and the medium-resolution graphics limited the amount of information that could be presented on the screen at one time.

When the third phase started, it was recognized that using software already developed in KEATS would represent a savings for SuperKEATS. However, the necessity to write rules, and the investment in KEE and the hardware to run it, led to developing SuperKEATS in KEE. Although KEE did have an object-oriented environment, a nice graphical interface, and an easy-to-use knowledge base editor with capabilities for multiple inheritance, it was not well-suited for a simulation environment for these reasons:

1. The simulation was procedural and algorithmic whereas KEE is based in Lisp, which is a symbolic language. Hence, writing the algorithms was clumsy.
2. The programming support tools, such as the editor and debugger, for the Lisp code were poor compared to those for Smalltalk V.
3. Garbage collection (the standard means of recovering unused memory with the Lisp language) was to virtual memory on disk and hence very slow --typically on the order of minutes. This is not acceptable in a real-time interactive environment.

4. Memory fragmentation occurred after running for several hours of an exercise and this slowed system response down considerably. Each workstation was configured with 16 MBytes of main memory, but for the final evaluation, 8 MBytes was moved from one system to the "demo" system, giving it 24 MBytes (the workstation limit). Even then, later in the exercise the expert found system response to be slower than desired.

5. The rule system proved to be awkward for the kind of rules needed for suggestions and feedback. Many rules involved comparisons of values (number of tanks, number of aircraft, etc.) and this required going into Lisp code. The syntax of the rules probably could not be read and understood by an ASOC expert.

The objected-oriented approach to building a decision-making environment proved to be very effective in SuperKEATS, as it was in KEATS. Despite the drawbacks to rule implementation in KEE mentioned above, rules were a simple and efficient way to represent ASOC tasking knowledge within SuperKEATS. Rules typically reason about the current state of specific objects and are easily added to the object-oriented simulation environment.

ASOC Use of SuperKEATS

From the data presented earlier in Section III, two items that particularly stand out are: (a) the large difference between expert and novice performance; and (b) the expressed feeling of both expert and novice that suggestions and feedback are very useful for training.

That SuperKEATS is clearly responsive to differences in expertise was shown by comparing the results of the ASOC expert and novice on the complex game. This is illustrated by Figure 15 where the enemy has penetrated 10 kilometers into Blue territory in 2 hours with novice support, whereas in 4 hours with expert support, the enemy has been held to within 1 kilometer of Blue territory. Though the sample size is too small to generalize, it should be noted that both ASOC members who used SuperKEATS were on active duty and would be in combat if the need arose. If, in an emergency, the novice were thrust into the position of ASOC decision-maker, the results here indicate that the air support effectiveness would be much lower than with a well-trained expert and this condition might have a deleterious effect on the course of a battle.

Although the effectiveness of the suggestions and feedback have not been tested, the enthusiasm of the ASOC personnel for this aid to training is noted. The novice thought that the feedback was the best feature of SuperKEATS and suggested even more extensive suggestion and feedback information. The expert thought that feedback was important for the training of novices and for the practice of experts. He also thought suggestions would be useful for real-world (i.e., combat) tasking.

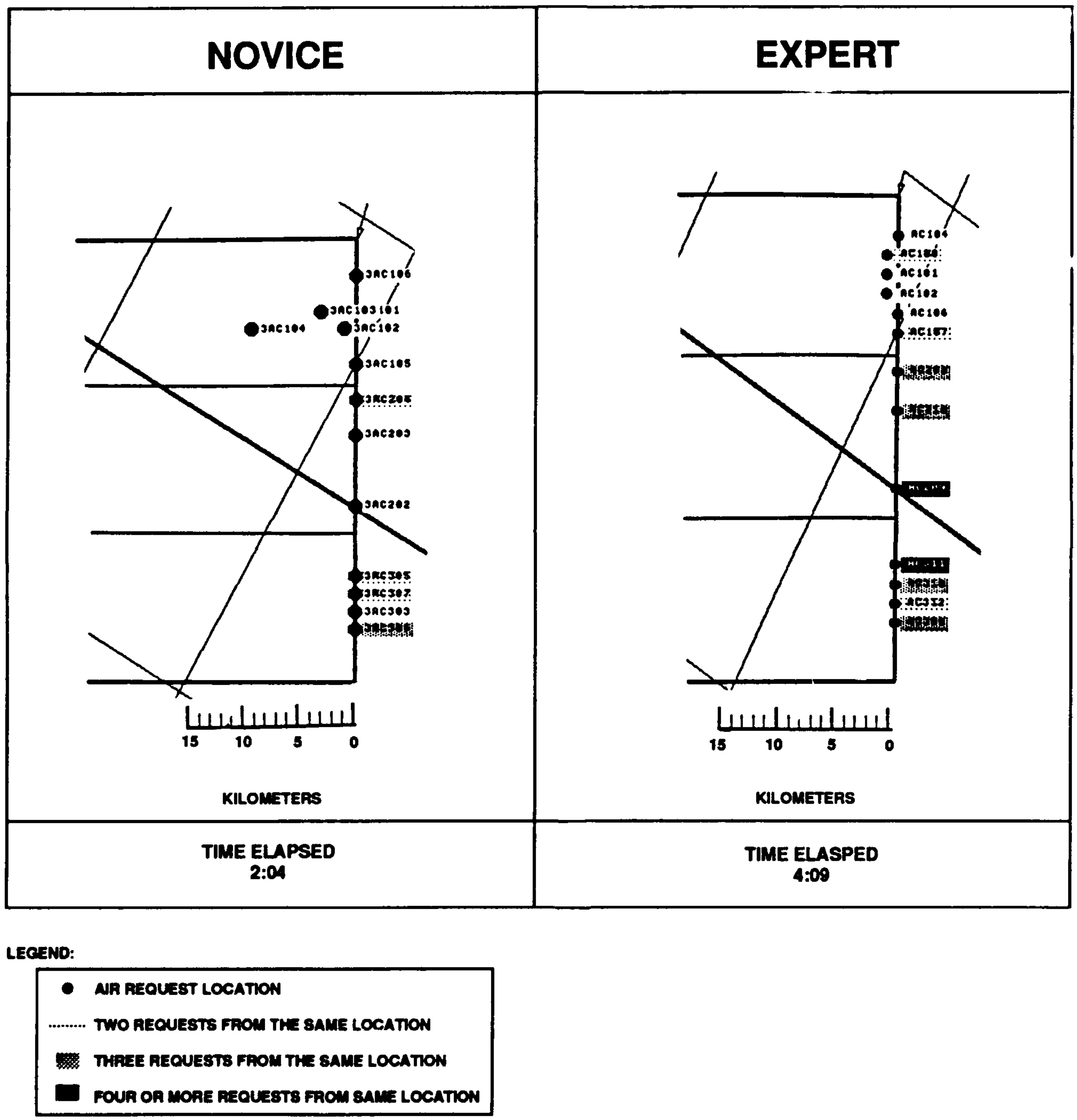

Figure 15. Results of Expert vs Novice Tactical Decision-Making.

Conclusions

It has been demonstrated that it is feasible to build a single-user simulation environment for practicing tactical decision-making skills that runs on a microprocessor-based computer. It is noted that the current prototype can also function as a vehicle for training research to find optimum strategies for decision training. The effectiveness of training with the prototype has not been tested nor has any training research been done at this time. The initial evaluation by users from the operational community was that the prototype would be useful for their training.

It is recommended, when building a simulation practice environment, that the simulation be built first using an object-oriented approach with instructional features added later. Developing a credible simulation that is easy-to-use and that motivates the user was the major technical challenge of this work. Once the simulation was operational, it was a straightforward process to add instructional features based on domain knowledge represented as rules.

It is recommended that if a knowledge engineering tool (e.g., KEATS) is built first, then the simulation practice environment (e.g., SuperKEATS) that follows should be built using software developed in the precursor. If another simulation practice environment is built or if SuperKEATS is to be rehosted to another machine, it is not recommended that it be developed in KEE, with its problems of Lisp garbage collection to virtual memory on disk and memory fragmentation slowing system response times.

A key prerequisite for building a simulation practice environment is having good access to experts. The ideal situation for both knowledge acquisition and training system development is to have the expert in-house. Other factors to consider in building a simulation practice environment are the stability of the environment over the time it takes to build the system and how general, and hence transferable to other command and control nodes, is the environment.

V. FUTURE DIRECTIONS

The main objective of this project phase was to build a prototype simulation environment that allows the user to practice decision-making skills and permits experimentation with instructional strategies. Building that prototype, SuperKEATS, has been the main topic of this report. SuperKEATS meets its goals in providing a reactive environment to make decisions. Although the ASOC members indicated that SuperKEATS should be useful to the ASOC, it remains to be shown that it provides effective training for decision-making. Only resource constraints prevented this more complete testing and evaluation from being done during this project phase. It is recommended that SuperKEATS be tested, after minor modifications suggested by the ASOC expert, to see how effectively the embedded decision-making knowledge is learned. This testing should be thorough and complete, using a statistically sufficient number of novice students, and include a control group that does not use SuperKEATS.

Adding more ASOC decision-making knowledge to SuperKEATS before testing should also be considered. Knowledge acquisition using KEATS was very abbreviated during this project and we are concerned that the knowledge currently embedded in SuperKEATS may not provide the breadth of training that would be needed in combat. Knowledge acquisition with KEATS could be extended, particularly using exercises built by ASOC experts. The resulting rules could then be incorporated into SuperKEATS and form the basis for evaluation of training effectiveness.

Any new, prototype system offers many opportunities for improvement, and SuperKEATS is no exception. During the ASOC evaluation, numerous suggestions were obtained that would make an easier-to-use system and provide additional information. In addition, extensions beyond the current capabilities include: (a) provide multiple screens to display the large amount of data that must be accessed for decision-making; (b) make available to an exercise builder certain simulation parameters that are now in code, such as time between fire priority updates, chance of base closures, average length of base closures, etc.; (c) add a weather model so that weather becomes a factor in decisions; and (d) use real maps and add simple terrain rules for Army movement.

The original concept was to field a decision training system on a microcomputer that would be available at the operation centers themselves. Because SuperKEATS was developed on a workstation with Lisp-based, expensive KEE software that has heavy requirements for memory and disk space, a possible direction would be to port it to the personal computer environment using an object-oriented language such as Smalltalk V, in which KEATS was developed. The disadvantages to such a machine would be that the lower-resolution screen would not support windowing, as on a workstation, and it would also require a considerable amount of memory.

SuperKEATS could also be extended to other environments of decision-making both within the ASOC, as at the G-3 Air and Intel positions, and at nodes that are involved with supply and demand air support decisions such as at an ATOC. It is recommended that the approaches and technology developed here be applied to an ATOC. Starting from the beginning, knowledge engineering should begin with interviews to scope the domain. A KEATS-like system, with scripted events, would be developed to do detailed knowledge acquisition and provide a training quid pro quo. SuperKEATS would then evolve on the same hardware/software platform as KEATS, providing the simulation practice environment and retaining the knowledge engineering capabilities of KEATS. This would provide the capability to maintain and upgrade SuperKEATS by doing knowledge engineering as the environment changes and immediately incorporating the new knowledge into the system.

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ABBREVIATIONS AND ACRONYMS

ALO	Air Liaison Officer
ASOC	Air Support Operations Center
ASW	Anti-Submarine Warfare
ATOC	Allied Tactical Operations Center
C^2	Command and Control
CAS	Close Air Support
CDT	Component Display Theory
FDO	Fighter Duty Officer
ISA	Initial Situation Assessment
ISD	Instructional Systems Design
ITS	Intelligent Tutoring System
KEATS	Knowledge Engineering and Training System
KEE	Knowledge Engineering Environment
POA	Plan of Action
UCSD	University of California at San Diego
WOC	Wing Operations Center

APPENDIX A

SuperKEATS Knowledge Bases

SuperKEATS knowledge bases contain objects, called units in KEE. Functionally equivalent to an object, frame, or schema in other object-oriented programming environments, a KEE unit represents the definable attributes and behaviors of a physical or conceptual object. Units which share the same attributes and behaviors are grouped into classes. All SuperKEATS knowledge bases and their major classes and units follow.

AGENDA KB

Contains all event objects; initiates timed events and keeps track of pending events.

AGENDA-MANAGER
DATE-TIME
EVENT
  ADD-ALERT-EVENT
  ADD-SMOOTHFLOW-EVENT
  ADJUST-DOWN-TIME-EVENT
  AIR-REQUEST-EVENT
  AIRCRAFT-AT-X-MINUTE-READINESS-EVENT
  AIRCRAFT-GET-READY-EVENT
  AIRCRAFT-ON-5-MINUTE-ALERT-EVENT
  AIRCRAFT-RETURNS-HOME-EVENT
  AIRCRAFT-SCHEDULED-FOR-ALERT-EVENT
  CANCEL-SMOOTHFLOW-EVENT
  CHANGE-RESERVE-SUPPORT-EVENT
  IN-FLIGHT-REPORT-EVENT
  MISSION-OVER-CONTACT-POINT-EVENT
  MISSION-OVER-TARGET-EVENT
  MISSION-RECOVERY-EVENT
  MISSION-TAKE-OFF-EVENT
  SIMULATION-UPDATE-EVENT
  TANKS-HAVE-ARRIVED-EVENT

AIR-FORCE KB

Contains classes for air force objects and their behavior.

AIR-FORCE-ADMIN
  AF-GAME-INITIALIZER
  WOC-RECOVERY-SCRATCHPAD
  WOC-SCRATCHPAD
AIR-FORCE-CONSTRAINTS
  WOC-CONSTRAINT-CHECKER
AIR-FORCE-UNIT
  AIRCRAFT
  SQUADRONS
  WOCS
BASES
MISSIONS
SMOOTHFLOW-DONE-CONDITIONS
  ENOUGH-MISSIONS-DONE-CONDITION
  LAST-NLT-DONE-CONDITION
  NO-SORTIES-DONE-CONDITION
WOC-CONSTRAINTS
  CANCEL-ALERT-CONSTRAINTS
    ALERT-CANCELLED-CONSTRAINT
CHANGE-ALERT-GROSS-CONSTRAINTS
    ALERT-CANCELLED-CONSTRAINT
    BASE-NOT-OPERATIONAL-FOR-ALERT
      CONSTRAINT
    BASE-NOT-REOPENED-FOR-ALERT-
      CONSTRAINT
    CHANGE-ALERT-EXCEEDS-
      MAXIMUM-CONSTRAINT
CANCEL-MISSION-CONSTRAINTS
    CANCEL-TOO-LATE-CONSTRAINT
    MISSION-CANCELLED-CONSTRAINT
CANCEL-SMOOTHFLOW-CONSTRAINTS
    CANCEL-SMOOTHFLOW-MISSION-
      TOO- LATE-CONSTRAINT
    CANCEL-SMOOTHFLOW-MISSION-
      UNKNOWN-CONSTRAINT
    CANCEL-SMOOTHFLOW-TOO-LATE-
      CONSTRAINT
    SMOOTHFLOW-CANCELLED-CONSTRAINT
CHANGE-ALERT-AVAIL-CONSTRAINTS
    CHANGE-ALERT-PRIOR-COMMITMENTS-
      CONSTRAINT
CHANGE-ALERT-AVAIL-QUAL-CONSTRAINTS
    CHANGE-ALERT-EXCEEDS-MAXIMUM-
      SHORTAGE-CONSTRAINT
CHANGE-ALERT-GROSS-CONSTRAINTS
    CHANGE-ALERT-INVALID-CONSTRAINT
    CHANGE-ALERT-NO-SORTIES-CONSTRAINT
    CHANGE-ALERT-NUMBER-UNAVAILABLE-
      CONSTRAINT
CHANGE-ALERT-QUAL-CONSTRAINTS
    CHANGE-ALERT-QUALIFIED-BASE-
      CONSTRAINT
    CHANGE-ALERT-QUALIFIED-PILE-
      CONSTRAINT
    CHANGE-ALERT-QUALIFIED-SQUADRON-
      CONSTRAINT
DIVERT-MISSION-CONSTRAINTS
    BASE-NOT-REOPENED-FOR-
      REDIRECTED-TAKEOFF-
      CONSTRAINT
    DIVERT-TOO-LATE-CONSTRAINT
    INTERFERES-WITH-COMMITMENTS-
      CONSTRAINT
    MISSION-CANCELLED-CONSTRAINT
    WONT-MAKE-NLT-CONSTRAINT
DIVERT-SMOOTHFLOW-CONSTRAINTS
    DIVERT-SMOOTHFLOW-MISSION-
      TOO-LATE-CONSTRAINT
    DIVERT-SMOOTHFLOW-MISSION-
      UNKNOWN-CONSTRAINT
    DIVERT-SMOOTHFLOW-TOO-LATE-
      CONSTRAINT
    SMOOTHFLOW-CANCELLED-CONSTRAINT
FLOW-AVAIL-CONSTRAINTS
    CANT-MAKE-NLT-CONSTRAINT
    FUDGED-PRIOR-COMMITMENTS-

CONSTRAINT
NOT-ENOUGH-MISSIONS-CONSTRAINT
FLOW-GROSS-CONSTRAINTS
BASE-NOT-REOPENED-FOR-TAKEOFF-CONSTRAINT
BEFORE-FIRST-LIGHT-CONSTRAINT
BELOW-THREAT-MIN-CONSTRAINT
FUDGED-NO-SORTIES-CONSTRAINT
FUDGED-NUMBER-UNAVAILABLE-CONSTRAINT
LAST-LIGHT-CONSTRAINT
NLT-BEFORE-TOT-CONSTRAINT
NO-JAAT-CONSTRAINT
FLOW-QUAL-CONSTRAINTS
QUALIFIED-FOR-JAAT-CONSTRAINT
QUALIFIED-TASKING-BASE-CONSTRAINT
QUALIFIED-TASKING-PILE-CONSTRAINT
PUT-ON-ALERT-AVAIL-CONSTRAINTS
PRIOR-COMMITMENTS-CONSTRAINTS
PUT-ON-ALERT-AVAIL-QUAL-CONSTRAINTS
EXCEEDS-MAXIMUM-SHORTAGE-CONSTRAINT
PUT-ON-ALERT-GROSS-CONSTRAINTS
ALERT-TOO-EARLY-CONSTRAINT
ALERT-TOO-LATE-CONSTRAINT
ALL-SQUADRONS-ALERT-CONSTRAINT
BASE-NOT-OPERATIONAL-FOR-ALERT-CONSTRAINT
BASE-NOT-REOPENED-FOR-ALERT-CONSTRAINT
EXCEEDS-MAXIMUM-CONSTRAINT
NO-SORTIES-CONSTRAINT
NUMBER-UNAVAILABLE-CONSTRAINT
PAST-ALERT-TIME-CONSTRAINT
SQUADRON-ASSIGNED-ALERT-CONSTRAINT
PUT-ON-ALERT-QUAL-CONSTRAINTS
QUALIFIED-ALERT-BASE-CONSTRAINT
QUALIFIED-ALERT-PILE-CONSTRAINT
QUALIFIED-ALERT-SQUADRON-CONSTRAINT
TASKING-AVAIL-CONSTRAINTS
CANT-MAKE-NLT-CONSTRAINT
FUDGED-PRIOR-COMMITMENTS-CONSTRAINT
TASKING-GROSS-CONSTRAINTS
BASE-NOT-REOPENED-FOR-TAKEOFF-CONSTRAINT
BEFORE-FIRST-LIGHT-CONSTRAINT
BELOW-THREAT-MIN-CONSTRAINT
FUDGED-NO-SORTIES-CONSTRAINT
FUDGED-NUMBER-UNAVAILABLE-CONSTRAINT
LAST-LIGHT-CONSTRAINT
NO-JAAT-CONSTRAINT
TASKING-QUAL-CONSTRAINTS
QUALIFIED-FOR-JAAT-CONSTRAINT
QUALIFIED-TASKING-BASE-CONSTRAINT
QUALIFIED-TASKING-PILE-CONSTRAINT

ANSWER KB

Contains objects used to format and display information accessed via the ASK button.

ANSWER-MAN
INIT
SQUADRON-WINDOW
WINDOW

ARMY KB

Contains classes for army objects and their behavior.

ALO
ARMY-UNIT
COMMAND-UNIT
CORPS
BLUE-CORPS
RED-CORPS
FRONT-LINE-DIVISION
BLUE-FRONT-LINE-DIVISION
RED-FRONT-LINE-DIVISION
FRONT-LINE-TANK-BATTALION
FRONT-LINE-TANK-BRIGADE
FIGHTING-UNIT
FRONT-LINE-TANK-COMPANY
BLUE-FRONT-LINE-TANK-COMPANY
RED-FRONT-LINE-TANK-COMPANY
RESERVE-UNIT
RESERVE-DIVISION
RESERVE-TANK-BATTALION
RESERVE-TANK-BRIGADE
RESERVE-TANK-COMPANY

COMPLEX KB

Contains an object which describes the game with the highest complexity level.

COMPLEX

FACTS KB

Contains classes for aircraft types, ordnances, and SCLs which are used in the display of factual information accessed via the INFO button.

- AIRCRAFT-TYPES
- LOAD-COMPONENTS
  - GUNS
  - ORDNANCE
    - BOMBS
    - CBUS
      - ANTI-ARMOUR-CBUS
      - GENERAL-PURPOSE-CBUS
    - MISSILES
- SCLS

GAME-CONTROL KB

Contains objects which describe the currently selected game and objects used in the management of game "mode" changes (game selection, plan and assessment, etc.).

- CB-WINDOW
- ERR-WINDOW
- GAMES
- GAMES-MANAGER
- INIT
- INITIAL-WINDOW
- INSTRUCTIONS-INFO-WINDOW
- INSTRUCTIONS-TEXT
- LOAD-GAME-FORM
- PLANNING-SCRATCHPAD-CONTROL
- SUM-WINDOW

GAME-STUFF KB

Contains classes and instances of objects created dynamically during a game.

- AIR-REQUEST
- ALERT-REQUEST
- ASK-TELL-WOC
  - ASOC-TELLS-WOC
  - RULES-ASK-WOC
    - RULES-TASKING-REQUEST
- GAME-STATE
- PREPLANNED-REQUEST
  - SMOOTHFLOW-REQUEST
- WOC-RESPONSES
  - OTHER-RESPONSE PUT-ON-ALERT-RESPONSE
  - TASKING-RESPONSE

GAME-SUM KB

Contains objects used to create and display game summary displays (text, stripcharts, bar graphs, etc.)

- GAME-SUM-VALUES
- GC-SUM-STRIPCHARTS
- GC-SUM-VERTICAL-BAR-GRAPH-ACTUATORS

INFO KB

Contains objects used to format and display briefings, orders, and factual information which is accessed via the INFO button.

- FACTS-WINDOW
- FDO-SHIFT-CHANGE-WINDOW
- G3-AIR-WINDOW
- INFO-MAN
- INIT
- INTEL-WINDOW
- ORDERS-WINDOW

INTERF KB

Contains objects defining the Top Bar buttons and the message handler between the ASOC and the army/wocs.

- ASOC-INPUT-HANDLER
- BUTTON
  - MENU-BUTTONS
    - AIR-REQUEST-BUTTON
    - ASK-BUTTON
    - GAME-CONTROL-BUTTON
    - INFO-BUTTON
    - MSG-LOG-BUTTON
    - STATUS-BOARD-BUTTON
    - TELL-BUTTON
  - METHOD-BUTTONS
    - MAP-BUTTON
    - NEXT-BUTTON
- INIT
- INTERF-GAME-INIT

INTERMEDIATE KB

Contains an object which describes the game with an intermediate level of complexity.

- INTERMEDIATE

MAP KB

Contains objects to display positional information for air requests, bases, corps, and divisions on a grid.

MAP-MAKER

MSG-LOG KB

Contains objects used to format and display WOC responses to actions initiated by the user; also handles the display of air request information.

AIR-REQUEST-MAN
FEEDBACK-WINDOW
INIT
MSG-LOG-MAN
MSG-WINDOW
REQUEST-WINDOW
TEXT-BOX

SIMPLE KB

Contains an object which describes the game with the lowest level of complexity.

SIMPLE

SIM-UPDATE KB

Performs simulation updates at game-specified intervals.

INIT
SIMULATION-UPDATE

SKEATS KB

Handles initialization of other KBs on start-up.

SKEATS-MANAGER

SOME-RULES KB

Contains rules for tasking and smoothflow suggestions.

END-OF-GAME-CLEAN-UP
SMOOTHFLOW-INFO
SMOOTHFLOW-RULES
  DETERMINING-SMOOTHFLOW-NEED
    CHECK-REQUEST-TYPE
    CHECK-TIME-CONSTRAINT1
    COUNT-SMOOTHFLOW-TYPE-REQUESTS
    DIVISION-NEEDS-SMOOTHFLOW
  DETERMINING-SMOOTHFLOW-RESOURCES
    SELECTION-OF-SQN-FOR-SMOOTHFLOW
SOME-RULES-INFO
TASKING-RULES
  DIVERT-RULES
    DIVERT-SMOOTHFLOW
  ORDER-OF-TASKING
    REQUESTS-FOR-DIFFERENT-DIVISIONS
    SAME-TIME-REQUESTS
    SERVICE-IN-CONTACT-FIRST
    SERVICE-PRIORITY-FIRST
  REQUEST-REFUSAL
    REFUSE-DUE-TO-SHORT-TIME
  SELECTION-OF-ASSETS
      AMOUNT-OF-SUPPORT
        MANY-TANKS
    THREAT-PROBLEMS
      CHOOSE-BEST-AGAINST-THREAT
    USE-NOT-ON-ALERT-AC
      NOT-ASAP-WITH-TIME

STATUS-BOARD KB

Contains objects used to format and display data for the Summary Status Board, the Mission Status Boards and the Base Summary Board (formerly known as the Intel Board).

IN-WINDOW
INIT
MB-WINDOW
SB-WINDOW
STATUS-BOARD-MAN

TELL KB AND TELL2 KB

Contains objects which provide the means for the user to interface with a WOC or an ALO (e.g., to TELL the WOC to put aircraft on alert).

TELL-COMMUNIQUES
  TELL-CANCEL-ALERT
  TELL-CANCEL-MISSION
  TELL-CANCEL-SMOOTHFLOW
  TELL-CHANGE-ALERT
  TELL-DIVERT-MISSION
  TELL-DIVERT-SMOOTHFLOW
  TELL-NEED-SEAD
  TELL-PUT-ON-ALERT
  TELL-REFUSE-TO-TASK
  TELL-TASK-MISSIONS
    TELL-SMOOTHFLOW-MISSIONS
      TELL-MULTIPLE-MISSIONS
TELL-MAN
TELL-WINDOW-MANAGER
TELL-COMMUNIQUES-PART2
  TELL-CHANGE-ALERT
TELL-ERROR

APPENDIX B

Protocol of the Expert Playing the SuperKEATS Complex Game

210000 : WOC TFW1 ACCEPTED request to put 12 A10s on alert at 210645.

210000 : WOC TFW1 REFUSED request to put 12 A10s on alert at 210645.
REASON: * NOT ENOUGH FACILITIES AT BASE FOR REQUESTED NUMBER OF ALERTS
(See Base Summary Board for maximum alert allocations.)

210000 : WOC TFW1 ACCEPTED request to put 8 A10s on alert at 210645.

210000 : WOC TFW3 ACCEPTED request to put 20 A7s on alert at 210700.

210000 : WOC TFW9 ACCEPTED request to put 20 AJETs on alert at 210645.

210000 : WOC TFW6 ACCEPTED request to put 20 F5s on alert at 210700.

210000 : WOC TFW10 ACCEPTED request to put 20 HARs on alert at 210700.

210000 : The following mandatory information is missing from the request:
WOC/SQUADRON

210000 : WOC TFW2 ACCEPTED request to put 16 F4s on alert at 210645.

210445 : TIME UPDATE

210500 : TIME UPDATE

210505 : TIME UPDATE

210515 : TIME UPDATE

210520 : TIME UPDATE

210530 : TIME UPDATE

210545 : TIME UPDATE

210645 : TIME UPDATE

210700 : TIME UPDATE

210700 : BASE-3 has been closed by a ground attack. Estimated reopen time: 210730.
(For details on mission cancellations, etc. see the Mission Status Boards.)

210700 : GROUND attack on BASE-3 has resulted in the loss of 1 a/c from squadron TFS32.

210700 : BASE-10 has been closed by a ground attack. Estimated reopen time: 210730.
(For details on mission cancellations, etc. see the Mission Status Boards.)

210700 : TFW10 will assign only 6 of the 8 planned a/c to 30M alert until more become available.

210700 : GROUND attack on BASE-10 has resulted in the loss of 6 a/c from squadron TFS101.

210711 : TIME UPDATE

210711 : Received ASAP request #3AC201 from BLUE-DIV2-ALO to neutr 15 tanks, NLT: 210900.

210711 : Received ASAP request #3AC301 from BLUE-DIV3-ALO to neutr 14 tanks, NLT: 210810.

210711 : TFW6 will assign only 4 of the 8 planned a/c to 30M alert until more become available.

210711 : WOC TFW6 ACCEPTED request to task multiple missions for request #3AC201.
#3AC201 - 4 F5s from BASE-6
#3AC201A - 4 F5s from BASE-6

210711 : TFW2 will assign only 2 of the 4 planned a/c to 30M alert until more become available.

210711 : WOC TFW2 ACCEPTED request #3AC301 & tasked the following mission:
#3AC301 - 4 F4s from BASE-2

210711 : BLUE-DIV2-ALO reports that SEAD is coordinated for current & future air support.

210711 : BLUE-DIV3-ALO reports that SEAD is coordinated for current & future air support.

210715 : TIME UPDATE

210716 : TIME UPDATE

210716 : Received ASAP request #3AC302 from BLUE-DIV3-ALO to neutr 15 tanks, NLT: 210815.

210716 : Mission #3AC201 in support of request #3AC201 is TAKING OFF.

210716 : Mission #3AC301 in support of request #3AC301 is TAKING OFF.

210716 : TFW2 will assign only 6 of the 8 planned a/c to 15M alert until more become available.

210716 : TFW2 will assign none of the 4 planned a/c to 30M alert until more become available.

210716 : WOC TFW2 ACCEPTED request #3AC302 & tasked the following mission:
#3AC302 - 4 F4s from BASE-2

210719 : TIME UPDATE

210719 : Received ASAP request #3AC101 from BLUE-DIV1-ALO to neutr 39 tanks, NLT: 210820.

210720 : TFW1 will assign only 4 of the 8 planned a/c to 15M alert until more become available.

210720 : WOC TFW1 ACCEPTED request #3AC101 & tasked the following mission:
#3AC101 - 4 A10s from BASE-1

210721 : TIME UPDATE

210721 : WOC TFW1 ACCEPTED request #3AC101 & tasked the following mission:
#3AC101A - 4 A10s from BASE-1

210725 : TIME UPDATE

210725 : Mission #3AC101 in support of request #3AC101 is TAKING OFF.

210726 : TIME UPDATE

210726 : Mission #3AC302 in support of request #3AC302 is TAKING OFF.

210728 : TIME UPDATE

210728 : Received ASAP request #3AC202 from BLUE-DIV2-ALO to neutr 14 tanks, NLT: 210930.

210729 : TIME UPDATE

210729 : Received ASAP request #3AC303 from BLUE-DIV3-ALO to neutr 12 tanks, NLT: 210830.

210730 : TIME UPDATE

210730 : BASE-3 has reopened.

210730 : TFW6 will assign only 4 of the 8 planned a/c to 15M alert until more become available.

210730 : TFW6 will assign none of the 8 planned a/c to 30M alert until more become available.

210730 : WOC TFW6 ACCEPTED request #3AC202 & tasked the following missions:
#3AC202 - 4 F5s from BASE-6
#3AC202A - 4 F5s from BASE-6

210730 : BASE-10 has reopened.

210731 : TIME UPDATE

210731 : Mission #3AC201A in support of request #3AC201 is TAKING OFF.

210732 : TFW2 will assign only 2 of the 4 planned a/c to 5M alert until more become available.

210732 : TFW2 will assign none of the 8 planned a/c to 15M alert until more become available.

210732 : TFW2 will assign none of the 4 planned a/c to 30M alert until more become available.

210732 : WOC TFW2 ACCEPTED request #3AC303 & tasked the following missions:
#3AC303 - 4 F4s from BASE-2
#3AC303A - 4 F4s from BASE-2

210735 : TIME UPDATE

210735 : Received ASAP request #3AC304 from BLUE-DIV3-ALO to neutr 13 tanks, NLT: 210835.

210735 : Mission #3AC202 in support of request #3AC202 is TAKING OFF.

210737 : TIME UPDATE

210737 : Mission #3AC303 in support of request #3AC303 is TAKING OFF.

210740 : TIME UPDATE

210741 : TIME UPDATE

210742 : TIME UPDATE

210742 : Mission #3AC201 in support of request #3AC201 is RETURNING.
TOT: 210737, 3 tanks neutr, no a/c lost.

210743 : TFW9 will assign only 2 of the 6 planned a/c to 30M alert until more become available.

210743 : WOC TFW9 ACCEPTED request #3AC304 & tasked the following mission:
#3AC304 - 4 AJETs from BASE-9

210745 : TIME UPDATE

210745 : Mission #3AC202A in support of request #3AC202 is TAKING OFF.

210747 : TIME UPDATE

210747 : Mission #3AC303A in support of request #3AC303 is TAKING OFF.

210747 : Mission #3AC301 in support of request #3AC301 is RETURNING.
TOT: 210742, 2 tanks neutr, no a/c lost.

210748 : TIME UPDATE

210748 : Mission #3AC304 in support of request #3AC304 is TAKING OFF.

210751 : TIME UPDATE

210751 : Received ASAP request #3AC102 from BLUE-DIV1-ALO to neutr 43 tanks, NLT: 210850.

210751 : Mission #3AC101A in support of request #3AC101 is TAKING OFF.

210751 : TFW1 will assign none of the 4 planned a/c to 5M alert until more become available.

210751 : TFW1 will assign none of the 8 planned a/c to 15M alert until more become available.

210751 : WOC TFW1 ACCEPTED request #3AC102 & tasked the following missions:
#3AC102 - 4 A10s from BASE-1
#3AC102A - 4 A10s from BASE-1

210752 : TIME UPDATE

210753 : TIME UPDATE

210755 : TIME UPDATE

210755 : Received ASAP request #3AC203 from BLUE-DIV2-ALO to neutr 18 tanks, NLT: 210955.

210756 : TIME UPDATE

210756 : Mission #3AC102 in support of request #3AC102 is TAKING OFF.

210757 : TIME UPDATE

210757 : TFW10 will assign only 6 of the 8 planned a/c to 15M alert until more become available.

210757 : TFW10 will assign none of the 8 planned a/c to 30M alert until more become available.

210757 : WOC TFW10 ACCEPTED request #3AC203 & tasked the following missions:
#3AC203 - 4 HARs from BASE-10
#3AC203A - 4 HARs from BASE-10

210757 : Mission #3AC302 in support of request #3AC302 is RETURNING.
TOT: 210752, 2 tanks neutr, no a/c lost.

210757 : Mission #3AC201A in support of request #3AC201 is RETURNING.
TOT: 210752, 5 tanks neutr, no a/c lost.

210758 : TIME UPDATE

210758 : Mission #3AC201 recovered at BASE-6.

210758 : TFW6 will assign none of the 8 planned a/c to 30M alert until more become available.

210759 : TIME UPDATE

210800 : TIME UPDATE

210800 : WOC TFW3 switching alert aircraft for squadron TFS31.

210802 : TIME UPDATE

210802 : Mission #3AC101 in support of request #3AC101 is RETURNING.
TOT: 210752, 32 tanks neutr, 1 a/c lost.

210802 : Mission #3AC203 in support of request #3AC203 is TAKING OFF.

210803 : TIME UPDATE

210804 : TIME UPDATE

210804 : Mission #3AC202 in support of request #3AC202 is RETURNING.
TOT: 210759, 5 tanks neutr, no a/c lost.

210806 : TIME UPDATE

210806 : Mission #3AC102A in support of request #3AC102 is TAKING OFF.

210807 : TIME UPDATE

210808 : TIME UPDATE

210808 : Mission #3AC301 recovered at BASE-2.

210808 : TFW2 will assign only 2 of the 8 planned a/c to 15M alert until more become available.

210808 : TFW2 will assign none of the 4 planned a/c to 30M alert until more become available.

210808 : Mission #3AC303 in support of request #3AC303 is RETURNING.
TOT: 210803, 2 tanks neutr, 1 a/c lost.

210809 : TIME UPDATE

210810 : TIME UPDATE

210812 : TIME UPDATE

210812 : Mission #3AC203A in support of request #3AC203 is TAKING OFF.

210812 : Mission #3AC304 in support of request #3AC304 is RETURNING.
TOT: 210807, 3 tanks neutr, 1 a/c lost.

210813 : TIME UPDATE

210813 : Mission #3AC201A recovered at BASE-6.

210813 : TFW6 will assign only 4 of the 8 planned a/c to 30M alert until more become available.

210814 : TIME UPDATE

210814 : Mission #3AC202A in support of request #3AC202 is RETURNING.
TOT: 210809, 4 tanks neutr, no a/c lost.

210815 : TIME UPDATE

210816 : TIME UPDATE

210816 : Received ASAP request #3AC305 from BLUE-DIV3-ALO to neutr 12 tanks, NLT: 210930.

210818 : TIME UPDATE

210818 : Mission #3AC302 recovered at BASE-2.

210818 : TFW2 will assign only 6 of the 8 planned a/c to 15M alert until more become available.

210818 : TFW2 will assign none of the 4 planned a/c to 30M alert until more become available.

210818 : Mission #3AC303A in support of request #3AC303 is RETURNING.
TOT: 210813, 1 tanks neutr, no a/c lost.

210818 : TFW2 will assign only 4 of the 8 planned a/c to 15M alert until more become available.

210818 : TFW2 will assign none of the 4 planned a/c to 30M alert until more become available.

210818 : WOC TFW2 ACCEPTED request #3AC305 & tasked the following mission:
#3AC305 - 2 F4s from BASE-2

210821 : TIME UPDATE

210822 : TIME UPDATE

210822 : TFW3 will assign only 4 of the 6 planned a/c to 30M alert until more become available.

210822 : WOC TFW3 ACCEPTED request #3AC305 & tasked the following mission:
#3AC305A - 2 A7s from BASE-3

210823 : TIME UPDATE

210823 : Mission #3AC202 recovered at BASE-6.

210823 : Mission #3AC305 in support of request #3AC305 is TAKING OFF.

210824 : TIME UPDATE

210824 : Mission #3AC101 recovered at BASE-1.

210824 : TFW1 will assign only 3 of the 4 planned a/c to 5M alert until more become available.

210824 : TFW1 will assign none of the 8 planned a/c to 15M alert until more become available.

210826 : TIME UPDATE

210826 : Mission #3AC304 recovered at BASE-9.

210826 : TFW9 will assign only 5 of the 6 planned a/c to 30M alert until more become available.

210827 : TIME UPDATE

210827 : Mission #3AC305A in support of request #3AC305 is TAKING OFF.

210827 : Mission #3AC203 in support of request #3AC203 is RETURNING.
TOT: 210822, 6 tanks neutr, no a/c lost.

210828 : TIME UPDATE

210828 : Mission #3AC101A in support of request #3AC101 is RETURNING.
TOT: 210818, 6 tanks neutr, no a/c lost.

210829 : TIME UPDATE

210829 : Mission #3AC303 recovered at BASE-2.

210829 : TFW2 will assign only 7 of the 8 planned a/c to 15M alert until more become available.

210829 : TFW2 will assign none of the 4 planned a/c to 30M alert until more become available.

210830 : TIME UPDATE

210830 : Received ASAP request #3AC103 from BLUE-DIV1-ALO to neutr 52 tanks, NLT: 211020.

210832 : TIME UPDATE

210833 : TIME UPDATE

210833 : Mission #3AC202A recovered at BASE-6.

210833 : TFW3 will assign none of the 6 planned a/c to 30M alert until more become available.

210833 : WOC TFW3 ACCEPTED request #3AC103 & tasked the following mission:
#3AC103 - 4 A7s from BASE-3

210833 : Received ASAP request #3AC204 from BLUE-DIV2-ALO to neutr 20 tanks, NLT: 211005.

210833 : TFW1 will assign only 4 of the 8 planned a/c to 30M alert until more become available.

210833 : WOC TFW1 ACCEPTED request #3AC103 & tasked the following mission:
#3AC103A - 4 A10s from BASE-1

210833 : Mission #3AC102 in support of request #3AC102 is RETURNING.
TOT: 210823, 28 tanks neutr, 1 a/c lost.

210836 : TIME UPDATE

210836 : Received ASAP request #3AC205 from BLUE-DIV2-ALO to neutr 22 tanks, NLT: 211010.

210836 : TFW10 will assign only 2 of the 4 planned a/c to 5M alert until more become available.

210836 : TFW10 will assign none of the 8 planned a/c to 15M alert until more become available.

210836 : TFW10 will assign none of the 8 planned a/c to 30M alert until more become available.

210836 : WOC TFW10 ACCEPTED request #3AC204 & tasked the following missions:
#3AC204 - 4 HARs from BASE-10
#3AC204A - 2 HARs from BASE-10
#3AC204B - 2 HARs from BASE-10

210837 : TIME UPDATE

210837 : TFW6 will assign only 4 of the 8 planned a/c to 30M alert until more become available.

210837 : WOC TFW6 ACCEPTED request #3AC205 & tasked the following missions:
#3AC205 - 4 F5s from BASE-6
#3AC205A - 4 F5s from BASE-6

210837 : Mission #3AC203A in support of request #3AC203 is RETURNING.
TOT: 210832, 8 tanks neutr, no a/c lost.

210838 : TIME UPDATE

210838 : Mission #3AC103 in support of request #3AC103 is TAKING OFF.

210839 : TIME UPDATE

210839 : Mission #3AC303A recovered at BASE-2.

210839 : TFW2 will assign only 3 of the 4 planned a/c to 30M alert until more become available.

210840 : TIME UPDATE

210841 : TIME UPDATE

210841 : Mission #3AC204 in support of request #3AC204 is TAKING OFF.

210842 : TIME UPDATE

210842 : Mission #3AC203 recovered at BASE-10.

210842 : TFW10 will assign only 2 of the 8 planned a/c to 15M alert until more become available.

210842 : TFW10 will assign none of the 8 planned a/c to 30M alert until more become available.

210842 : Mission #3AC205 in support of request #3AC205 is TAKING OFF.

210843 : TIME UPDATE

210843 : Mission #3AC102A in support of request #3AC102 is RETURNING.
TOT: 210833, 13 tanks neutr, no a/c lost.

210844 : TIME UPDATE

210844 : Received ASAP request #3AC104 from BLUE-DIV1-ALO to neutr 50 tanks, NLT: 211025.

210845 : TIME UPDATE

210846 : TIME UPDATE

210846 : Received ASAP request #3AC306 from BLUE-DIV3-ALO to neutr 10 tanks, NLT: 211010.

210848 : TIME UPDATE

210848 : Received ASAP request #3AC307 from BLUE-DIV3-ALO to neutr 13 tanks, NLT: 211005.

210849 : TIME UPDATE

210850 : TIME UPDATE

210850 : Mission #3AC101A recovered at BASE-1.

210850 : TFW1 will assign only 4 of the 8 planned a/c to 30M alert until more become available.

210850 : WOC TFW1 ACCEPTED request #3AC104 & tasked the following mission:
#3AC104 - 4 A10s from BASE-1

210851 : TIME UPDATE

210851 : Mission #3AC204A in support of request #3AC204 is TAKING OFF.

210851 : Mission #3AC204B in support of request #3AC204 is TAKING OFF.

210851 : TFW3 will assign only 4 of the 8 planned a/c to 15M alert until more become available.

210851 : TFW3 will assign none of the 6 planned a/c to 30M alert until more become available.

210851 : WOC TFW3 ACCEPTED request #3AC104 & tasked the following mission:
#3AC104A - 4 A7s from BASE-3

210852 : TIME UPDATE

210852 : TFW9 will assign only 1 of the 6 planned a/c to 30M alert until more become available.

210852 : WOC TFW9 ACCEPTED request #3AC306 & tasked the following mission:
#3A 306 - 4 AJETs from BASE-9

210852 : TFW9 wi l assign only 5 of the 8 planned a/c to 15M alert until more become available.

210852 : TFW9 will assign none of the 6 planned a/c to 30M alert until more become available.

210852 : WOC TFW9 ACCEPTED request #3AC307 & tasked the following mission:
#3A 307 - 4 AJETs from BASE-9

210852 : Mission #3AC203A recovered at BASE-10.

210852 : TFW10 will assign only 6 of the 8 planned a/c to 15M alert until more become available.

210852 : TFW10 will assign none of the 8 planned a/c to 30M alert until more become available.

210852 : Mission #3AC205A in support of request #3AC205 is TAKING OFF.

210853 : TIME UPDATE

210854 : TIME UPDATE

210854 : Mission #3AC305 in support of request #3AC305 is RETURNING.
TOT: 210849, 1 tanks neutr, no a/c lost.

210855 : TIME UPDATE

210855 : Mission #3AC102 recovered at BASE-1.

210855 : TFW1 will assign only 2 of the 8 planned a/c to 15M alert until more become available.

210856 : TIME UPDATE

210856 : Mission #3AC104A in support of request #3AC104 is TAKING OFF.

210857 : TIME UPDATE

210857 : Mission #3AC306 in support of request #3AC306 is TAKING OFF.

210858 : TIME UPDATE

210900 : TIME UPDATE

210901 : TIME UPDATE

210901 : WOC TFW3 ACCEPTED request #3AC104 & tasked the following mission:
#3AC104B - 2 A7s from BASE-3

210902 : TIME UPDATE

210903 : TIME UPDATE

210903 : Mission #3AC103A in support of request #3AC103 is TAKING OFF.

210905 : TIME UPDATE

210905 : Mission #3AC102A recovered at BASE-1.

210905 : TFW1 will assign only 6 of the 8 planned a/c to 15M alert until more become available.

210906 : TIME UPDATE

210906 : Mission #3AC305A in support of request #3AC305 is RETURNING.
TOT: 210856, 5 tanks neutr, no a/c lost.

210906 : Mission #3AC204 in support of request #3AC204 is RETURNING.
TOT: 210901, 4 tanks neutr, no a/c lost.

210907 : TIME UPDATE

210907 : Mission #3AC307 in support of request #3AC307 is TAKING OFF.

210908 : TIME UPDATE

210908 : Received ASAP request #3AC206 from BLUE-DIV2-ALO to neutr 16 tanks, NLT: 211045.

210910 : TIME UPDATE

210911 : TIME UPDATE

210911 : Mission #3AC205 in support of request #3AC205 is RETURNING.
TOT: 210906, 5 tanks neutr, no a/c lost.

210912 : TIME UPDATE

210915 : TIME UPDATE

210915 : Mission #3AC305 recovered at BASE-2.

210916 : TIME UPDATE

210916 : Mission #3AC204A in support of request #3AC204 is RETURNING.
TOT: 210911, 3 tanks neutr, no a/c lost.

210916 : TFW10 will assign only 4 of the 8 planned a/c to 15M alert until more become available.

210916 : TFW10 will assign none of the 8 planned a/c to 30M alert until more become available.

210916 : WOC TFW10 ACCEPTED request #3AC206 & tasked the following mission:
#3AC206 - 2 HARs from BASE-10

210916 : Mission #3AC204B in support of request #3AC204 is RETURNING.
TOT: 210911, 2 tanks neutr, no a/c lost.

210917 : TIME UPDATE

210917 : Mission #3AC103 in support of request #3AC103 is RETURNING.
TOT: 210907, 9 tanks neutr, no a/c lost.

210917 : TFW9 will assign only 1 of the 8 planned a/c to 15M alert until more become available.

210917 : TFW9 will assign none of the 6 planned a/c to 30M alert until more become available.

210917 : WOC TFW9 ACCEPTED request #3AC206 & tasked the following mission:
#3AC206A - 4 AJETs from BASE-9

210920 : TIME UPDATE

210920 : Mission #3AC104 in support of request #3AC104 is TAKING OFF.

210920 : Received ASAP request #3AC207 from BLUE-DIV2-ALO to neutr 17 tanks, NLT: 211050.

210921 : TIME UPDATE

210921 : Mission #3AC204 recovered at BASE-10.

210921 : TFW10 will assign none of the 8 planned a/c to 30M alert until more become available.

210921 : Mission #3AC205A in support of request #3AC205 is RETURNING.
TOT: 210916, 5 tanks neutr, no a/c lost.

210921 : Mission #3AC306 in support of request #3AC306 is RETURNING.
TOT: 210916, 6 tanks neutr, 1 a/c lost.

210921 : Mission #3AC206 in support of request #3AC206 is TAKING OFF.

210922 : TIME UPDATE

210922 : TFW9 will assign only 3 of the 4 planned a/c to 5M alert until more become available.

210922 : TFW9 will assign none of the 8 planned a/c to 15M alert until more become available.

210922 : TFW9 will assign none of the 6 planned a/c to 30M alert until more become available.

210922 : WOC TFW9 ACCEPTED request #3AC207 & tasked the following mission:
#3AC207 - 2 AJETs from BASE-9

210922 : Mission #3AC206A in support of request #3AC206 is TAKING OFF.

210925 : TIME UPDATE

210926 : TIME UPDATE

210926 : Received ASAP request #3AC308 from BLUE-DIV3-ALO to neutr 20 tanks, NLT: 211035.

210926 : Received ASAP request #3AC105 from BLUE-DIV1-ALO to neutr 61 tanks, NLT: 211050.

210927 : TIME UPDATE

210930 : TIME UPDATE

210930 : Mission #3AC305A recovered at BASE-3.

210930 : TFW3 will assign only 6 of the 8 planned a/c to 15M alert until more become available.

210930 : TFW3 will assign none of the 6 planned a/c to 30M alert until more become available.

210930 : Mission #3AC205 recovered at BASE-6.

210931 : TIME UPDATE

210931 : TFW3 will assign only 2 of the 4 planned a/c to 5M alert until more become available.

210931 : TFW3 will assign none of the 8 planned a/c to 15M alert until more become available.

210931 : TFW3 will assign none of the 6 planned a/c to 30M alert until more become available.

210931 : WOC TFW3 ACCEPTED request #3AC105 & tasked the following missions:
#3AC105 - 4 A7s from BASE-3
#3AC105A - 4 A7s from BASE-3

210931 : Mission #3AC104B in support of request #3AC104 is TAKING OFF.

210931 : Mission #3AC204A recovered at BASE-10.

210931 : TFW10 will assign only 2 of the 8 planned a/c to 30M alert until more become available.

210931 : Mission #3AC204B recovered at BASE-10.

210931 : TFW10 will assign only 4 of the 8 planned a/c to 30M alert until more become available.

210931 : Mission #3AC307 in support of request #3AC307 is RETURNING.
TOT: 210926, 5 tanks neutr, no a/c lost.

210932 : TIME UPDATE

210932 : Received ASAP request #3AC208 from BLUE-DIV2-ALO to neutr 14 tanks, NLT: 211110.

210932 : WOC TFW3 ACCEPTED request #3AC308 & tasked the following mission:
#3AC308 - 2 A7s from BASE-3

210932 : Mission #3AC207 in support of request #3AC207 is TAKING OFF.

210932 : WOC TFW9 ACCEPTED request #3AC308 & tasked the following mission:
#3AC308A - 2 AJETs from BASE-9

210934 : TIME UPDATE

210934 : Received ASAP request #3AC309 from BLUE-DIV3-ALO to neutr 27 tanks, NLT: 211050.

210935 : TIME UPDATE

210935 : TIME UPDATE

210935 : Mission #3AC306 recovered at BASE-9.

210935 : TFW9 will assign only 2 of the 8 planned a/c to 15M alert until more become available.

210935 : TFW9 will assign none of the 6 planned a/c to 30M alert until more become available.

210935 : Mission #3AC104A in support of request #3AC104 is RETURNING.
TOT: 210925, 6 tanks neutr, no a/c lost.

210936 : TIME UPDATE

210936 : Mission #3AC105 in support of request #3AC105 is TAKING OFF.

210937 : TIME UPDATE

210940 : TIME UPDATE

210940 : Mission #3AC205A recovered at BASE-6.

210940 : Mission #3AC103A in support of request #3AC103 is RETURNING.
TOT: 210930, 30 tanks neutr, 1 a/c lost.

210941 : TIME UPDATE

210941 : Mission #3AC103 recovered at BASE-3.

210941 : TFW3 will assign only 2 of the 8 planned a/c to 15M alert until more become available.

210941 : TFW3 will assign none of the 6 planned a/c to 30M alert until more become available.

210943 : TIME UPDATE

210945 : TIME UPDATE

210945 : TFW2 will assign only 1 of the 4 planned a/c to 30M alert until more become available.

210945 : WOC TFW2 ACCEPTED request #3AC208 & tasked the following missions:
#3AC208 - 2 F4s from BASE-2
#3AC208A - 2 F4s from BASE-2

210945 : Mission #3AC307 recovered at BASE-9.

210945 : TFW9 will assign only 6 of the 8 planned a/c to 15M alert until more become available.

210945 : TFW9 will assign none of the 6 planned a/c to 30M alert until more become available.

210946 : TIME UPDATE

210946 : Mission #3AC105A in support of request #3AC105 is TAKING OFF.

210946 : Mission #3AC206 in support of request #3AC206 is RETURNING.
TOT: 210941, 2 tanks neutr, no a/c lost.

210946 : Mission #3AC206A in support of request #3AC206 is RETURNING.
TOT: 210941, 2 tanks neutr, no a/c lost.

210947 : TIME UPDATE

210947 : WOC TFW1 REFUSED request #3AC309 which was for 4 A10s NLT: 211050.

REASON: * NOT ENOUGH AIRCRAFT AVAILABLE TO MEET THE NLT

210948 : TIME UPDATE

210948 : Received ASAP request #3AC310 from BLUE-DIV3-ALO to neutr 19 tanks, NLT: 211115.

210948 : WOC TFW1 REFUSED request #3AC309 which was for 4 A10s NLT: 211050.

REASON: * NOT ENOUGH AIRCRAFT AVAILABLE TO MEET THE NLT

210951 : TIME UPDATE

210951 : WOC TFW3 REFUSED request #3AC309 which was for 4 A7s NLT: 211050.

REASON: * NOT ENOUGH AIRCRAFT AVAILABLE TO MEET THE NLT

210956 : TIME UPDATE

210956 : Mission #3AC207 in support of request #3AC207 is RETURNING.
TOT: 210951, 1 tanks neutr, no a/c lost.

210957 : TIME UPDATE

210957 : WOC TFW6 REFUSED request #3AC309 which was for 4 F5s NLT: 211050.

REASON: * NOT ENOUGH AIRCRAFT AVAILABLE TO MEET THE NLT

210957 : Mission #3AC104 in support of request #3AC104 is RETURNING.
TOT: 210947, 35 tanks neutr, 2 a/c lost.

210957 : WOC TFW6 ACCEPTED request #3AC309 & tasked the following missions:
#3AC309 - 2 F5s from BASE-6
#3AC309A - 2 F5s from BASE-6

210958 : TIME UPDATE

210959 : TIME UPDATE

210959 : Mission #3AC104A recovered at BASE-3.

210959 : TFW3 will assign only 6 of the 8 planned a/c to 15M alert until more become available.

210959 : TFW3 will assign none of the 6 planned a/c to 30M alert until more become available.

210959 : WOC TFW10 REFUSED request #3AC310 which was for 4 HARs NLT: 211115.

REASON: * NOT ENOUGH AIRCRAFT AVAILABLE TO MEET THE NLT

211000 : TIME UPDATE

211000 : Mission #3AC206A recovered at BASE-9.

211000 : TFW9 will assign only 2 of the 6 planned a/c to 30M alert until more become available.

211000 : TFW6 will assign only 4 of the 8 planned a/c to 30M alert until more become available.

211000 : WOC TFW6 ACCEPTED request #3AC310 & tasked the following missions:
#3AC310 - 2 F5s from BASE-6
#3AC310A - 2 F5s from BASE-6

211001 : TIME UPDATE

211001 : Mission #3AC206 recovered at BASE-10.

211001 : TFW10 will assign only 6 of the 8 planned a/c to 30M alert until more become available.

211002 : TIME UPDATE

211002 : Mission #3AC103A recovered at BASE-1.

211002 : TFW1 will assign only 7 of the 8 planned a/c to 30M alert until more become available.

211002 : Mission #3AC308 in support of request #3AC308 is TAKING OFF.

211002 : Mission #3AC308A in support of request #3AC308 is TAKING OFF.

211005 : TIME UPDATE

211006 : TIME UPDATE

211007 : TIME UPDATE

211008 : TIME UPDATE

211009 : TIME UPDATE

211010 : TIME UPDATE

211010 : Mission #3AC207 recovered at BASE-9.

211010 : TFW9 will assign only 4 of the 6 planned a/c to 30M alert until more become available.

211010 : Mission #3AC104B in support of request #3AC104 is RETURNING.
TOT: 211000, 2 tanks neutr, no a/c lost.

211011 : TIME UPDATE

211012 : TIME UPDATE

211013 : TIME UPDATE

211013 : Received ASAP request #3AC209 from BLUE-DIV2-ALO to neutr 20 tanks, NLT: 211140.

211015 : TIME UPDATE

211015 : Received JAAT request #3AC106 from BLUE-DIV1-ALO, TOT: 211215 NLT: 211315.

211015 : Mission #3AC105 in support of request #3AC105 is RETURNING.
TOT: 211005, 7 tanks neutr, no a/c lost.

211016 : TIME UPDATE

211017 : TIME UPDATE

211019 : TIME UPDATE

211019 : TFW6 will assign none of the 8 planned a/c to 30M alert until more become available.

211019 : WOC TFW6 ACCEPTED request #3AC209 & tasked the following missions:
#3AC209 - 2 F5s from BASE-6
#3AC209A - 2 F5s from BASE-6

211019 : Mission #3AC104 recovered at BASE-1.

211021 : TIME UPDATE

211021 : Mission #3AC309 in support of request #3AC309 is TAKING OFF.

211021 : TFW1 will assign only 5 of the 8 planned a/c to 30M alert until more become available.

211021 : WOC TFW1 ACCEPTED request #3AC106 & tasked the following mission:
#3AC106 - 4 A10s from BASE-1

211022 : TIME UPDATE

211023 : TIME UPDATE

211023 : Received ASAP request #3AC107 from BLUE-DIV1-ALO to neutr 61 tanks, NLT: 211205.

211024 : TIME UPDATE

211025 : TIME UPDATE

211025 : Mission #3AC105A in support of request #3AC105 is RETURNING.
TOT: 211015, 5 tanks neutr, 1 a/c lost.

211026 : TIME UPDATE

211026 : Mission #3AC308A in support of request #3AC308 is RETURNING.
TOT: 211021, 2 tanks neutr, no a/c lost.

211026 : TFW1 will assign only 2 of the 8 planned a/c to 15M alert until more become available.

211026 : WOC TFW1 ACCEPTED request #3AC106 & tasked the following mission:
#3AC106A - 4 A10s from BASE-1

211027 : TIME UPDATE

211027 : TFW9 will assign only 2 of the 6 planned a/c to 30M alert until more become available.

211027 : WOC TFW9 ACCEPTED request #3AC107 & tasked the following missions:
#3AC107 - 2 AJETs from BASE-9
#3AC107A - 2 AJETs from BASE-9

211027 : WOC TFW3 ACCEPTED request #3AC107 & tasked the following mission:
#3AC107B - 2 A7s from BASE-3

211027 : Mission #3AC309A in support of request #3AC309 is TAKING OFF.

211028 : TIME UPDATE

211028 : Mission #3AC310 in support of request #3AC310 is TAKING OFF.

211029 : TIME UPDATE

211030 : TIME UPDATE

211031 : TIME UPDATE

211031 : Mission #3AC208 in support of request #3AC208 is TAKING OFF.

211032 : TIME UPDATE

211032 : Received ASAP request #3AC210 from BLUE-DIV2-ALO to neutr 26 tanks, NLT: 211210.

211033 : TIME UPDATE

211033 : Mission #3AC208A in support of request #3AC208 is TAKING OFF.

211033 : TFW6 will assign only 4 of the 8 planned a/c to 15M alert until more become available.

211033 : TFW6 will assign none of the 8 planned a/c to 30M alert until more become available.

211033 : WOC TFW6 ACCEPTED request #3AC210 & tasked the following missions:
#3AC210 - 2 F5s from BASE-6
#3AC210A - 2 F5s from BASE-6

211034 : TIME UPDATE

211034 : Mission #3AC104B recovered at BASE-3.

211035 : TIME UPDATE

211036 : TIME UPDATE

211036 : Received ASAP request #3AC311 from BLUE-DIV3-ALO to neutr 17 tanks, NLT: 211145.

211037 : TIME UPDATE

211038 : TIME UPDATE

211038 : TFW2 will assign only 5 of the 8 planned a/c to 15M alert until more become available.

211038 : TFW2 will assign none of the 4 planned a/c to 30M alert until more become available.

211038 : WOC TFW2 ACCEPTED request #3AC311 & tasked the following missions:
#3AC311 - 2 F4s from BASE-2
#3AC311A - 2 F4s from BASE-2

211038 : Mission #3AC310A in support of request #3AC310 is TAKING OFF.

211038 : Received ASAP request #3AC108 from BLUE-DIV1-ALO to neutr 72 tanks, NLT: 211215.

211039 : TIME UPDATE

211039 : Mission #3AC105 recovered at BASE-3.

211039 : TFW3 will assign only 2 of the 6 planned a/c to 30M alert until more become available.

211039 : TFW1 will assign only 2 of the 4 planned a/c to 5M alert until more become available.

211039 : TFW1 will assign none of the 8 planned a/c to 15M alert until more become available.

211039 : WOC TFW1 ACCEPTED request #3AC108 & tasked the following missions:
#3AC108 - 2 A10s from BASE-1
#3AC108A - 2 A10s from BASE-1

211039 : Mission #3AC209 in support of request #3AC209 is TAKING OFF.

211039 : TFW10 will assign only 2 of the 8 planned a/c to 30M alert until more become available.

211039 : WOC TFW10 ACCEPTED request #3AC108 & tasked the following missions:
#3AC108B - 2 HARs from BASE-10
#3AC108C - 2 HARs from BASE-10

211040 : TIME UPDATE

211040 : Mission #3AC308A recovered at BASE-9.

211041 : TIME UPDATE

211041 : Mission #3AC308 in support of request #3AC308 is RETURNING.
TOT: 211031, 4 tanks neutr, no a/c lost.

211043 : TIME UPDATE

211043 : Mission #3AC311 in support of request #3AC311 is TAKING OFF.

211044 : TIME UPDATE

211045 : TIME UPDATE

211045 : Mission #3AC107 in support of request #3AC107 is TAKING OFF.

211046 : TIME UPDATE

211046 : Mission #3AC108 in support of request #3AC108 is TAKING OFF.

211047 : TIME UPDATE

211048 : TIME UPDATE

211048 : Mission #3AC311A in support of request #3AC311 is TAKING OFF.

211049 : TIME UPDATE

211049 : Mission #3AC105A recovered at BASE-3.

211049 : TFW3 will assign only 5 of the 6 planned a/c to 30M alert until more become available.

211050 : TIME UPDATE

211050 : Mission #3AC309 in support of request #3AC309 is RETURNING.
TOT: 211045, 2 tanks neutr, no a/c lost.

211051 : TIME UPDATE

211052 : TIME UPDATE

211053 : TIME UPDATE

211053 : Mission #3AC209A in support of request #3AC209 is TAKING OFF.

211054 : TIME UPDATE

211055 : TIME UPDATE

211056 : TIME UPDATE

211056 : Mission #3AC309A in support of request #3AC309 is RETURNING.
TOT: 211051, 2 tanks neutr, 1 a/c lost.

211057 : TIME UPDATE

211057 : Received ASAP request #3AC312 from BLUE-DIV3-ALO to neutr 23 tanks, NLT: 211215.

211057 : Mission #3AC107A in support of request #3AC107 is TAKING OFF.

211057 : Mission #3AC107B in support of request #3AC107 is TAKING OFF.

211057 : Mission #3AC310 in support of request #3AC310 is RETURNING.
TOT: 211052, 2 tanks neutr, no a/c lost.

211058 : TIME UPDATE

211059 : TIME UPDATE

211059 : TFW2 will assign only 1 of the 4 planned a/c to 5M alert until more become available.

211059 : TFW2 will assign none of the 8 planned a/c to 15M alert until more become available.

211059 : TFW2 will assign none of the 4 planned a/c to 30M alert until more become available.

211059 : WOC TFW2 ACCEPTED request #3AC312 & tasked the following missions:
#3AC312 - 2 F4s from BASE-2
#3AC312A - 2 F4s from BASE-2
#3AC312B - 2 F4s from BASE-2
#3AC312C - 2 F4s from BASE-2

211059 : Mission #3AC210 in support of request #3AC210 is TAKING OFF.

211100 : TIME UPDATE

211101 : TIME UPDATE

211102 : TIME UPDATE

211102 : Mission #3AC210A in support of request #3AC210 is TAKING OFF.

211103 : TIME UPDATE

211103 : Mission #3AC208 in support of request #3AC208 is RETURNING.
TOT: 211058, 2 tanks neutr, no a/c lost.

211104 : TIME UPDATE

211104 : Mission #3AC312 in support of request #3AC312 is TAKING OFF.

211105 : TIME UPDATE

211105 : Mission #3AC308 recovered at BASE-3.

211105 : Mission #3AC208A in support of request #3AC208 is RETURNING.
TOT: 211100, 1 tanks neutr, no a/c lost.

211106 : TIME UPDATE

211106 : Mission #3AC108B in support of request #3AC108 is TAKING OFF.

211107 : TIME UPDATE

211107 : Mission #3AC310A in support of request #3AC310 is RETURNING.
TOT: 211102, 3 tanks neutr, no a/c lost.

211108 : TIME UPDATE

211108 : Mission #3AC108C in support of request #3AC108 is TAKING OFF.

211108 : Mission #3AC209 in support of request #3AC209 is RETURNING.
TOT: 211103, 4 tanks neutr, no a/c lost.

211109 : TIME UPDATE

211109 : Mission #3AC309 recovered at BASE-6.

211109 : TFW6 will assign only 6 of the 8 planned a/c to 15M alert until more become available.

211109 : TFW6 will assign none of the 8 planned a/c to 30M alert until more become available.

211109 : Mission #3AC312A in support of request #3AC312 is TAKING OFF.

211109 : Mission #3AC107 in support of request #3AC107 is RETURNING.
TOT: 211104, 2 tanks neutr, 1 a/c lost.

APPENDIX C

SuperKEATS Evaluation by an Expert

Expert Evaluation
9/13/89

SUPERKEATS EVALUATION

SuperKEATS was designed as a simulation environment to allow the Fighter Duty Officer (FDO) in the 712th ASOC to make decisions about Close Air Support (CAS). The primary goal in using SuperKEATS is to provide decision-making training to the FDO. Below we would like you to evaluate the quality of the simulation environment and training capability of SuperKEATS.

I. SIMULATION ENVIRONMENT

Rate the simulation environment in SuperKEATS based on the parameters below. Please explain your rating by answering the questions and adding any additional comments you care to.

[Rating scale: 1 to 5 where 1 = poor/disagree/no and 5 = excellent/agree/yes]

	RATING 1	2	3	4	5
A. Completeness of the representation - overall rating: SuperKEATS attempts to reduce the ASOC environment to just those elements required for the task at hand -- decision-making about CAS.					
1. Were all the objects (people, organizations, things) that you would expect to see included in the simulation? If not, what was missing? Please indicate the importance of the missing items. (rating: 1 = low importance, 5 = very important)				X	
2. Were all the types of events that you might expect to encounter included in the simulation? If not, which event types were missing? Please rate missing types as to importance. (rating: 1 = low importance, 5 = very important)				X	

Non-worthwhile targets -- need to train FDO to think about target types -- and reject/disapprove.

	RATING 1	2	3	4	5
3. Were you able to access all the information you thought you should? If not, what was missing and please rate its importance.					
Need quick access to available aircraft for tasking. Put column on Status Board.					X
4. Were you able to communicate all the information you needed to tell? If not, what was missing and please rate its importance.					
Cannot communicate with G-3 Air concerning priorities and possible need to change.				X	
B. **Correctness of the simulation - overall rating:**					
1. Did the objects in the simulation react as you would expect them to in a real situation? If not, how did they differ and how important is the difference?			X		
The ground force losses were instantly replaced - Do not think that replacement armor avail reserves - (at least not during course of day) if major replacements needed, that unit would be replaced. This did not allow FDO to change focus to another area -- too many tanks/APCs encountered/destroyed in given area.					
2. In KEATS we tried to make things look and work the same as in the ASOC environment -- e.g., status boards, briefings, and air request 8001 forms. In SuperKEATS we tried to retain the functionality but let the forms and status boards be implemented in manner more natural to the computer terminal. Did you find this functional representation in SuperKEATS to be easily understood coming from the "real world"? If not, what were the problems and how did they distort or confuse your view of what was going on?				X	

RATING

C. Usable simulation - overall rating:

1. Did the Top Bar function selection allow you to easily take the required actions? If not, what were the problems in using the Top Bar?

1	2	3	4	5
		X		

Most of time took too long and put display over something else needed -- much more functional to create windows, size, and place where easily/ quickly accessible.

2. Did the user configurable screen with windows allow you to easily set up and access information when you needed it? If not, what problems did you have? Do you have suggestions to make it easier to use?

1	2	3	4	5
			X	

Could get very busy at times -- still recommend dual screen or larger display.

3. Was the system response time to user input actions reasonably fast? If not, which actions were disturbingly slow?

1	2	3	4	5
		X		

As the game progressed, the responses slowed. However, this not totally unrealistic because real-world ADP speed slows as the battle tempo increases.

II. DECISION-MAKING TRAINING

A. Coverage of material - overall rating:

1. Are all the important areas of decision-making training for a FDO doing CAS covered in SuperKEATS? If not, please indicate the missing areas that should be included.

1	2	3	4	5
	X			

   a. *Need events/requests that would be disapproved.*

   b. *Need actions to <u>have</u> and <u>not have</u> positive effects on war in particular division sectors (allow shifting of emphasis/concern).*

   c. *Take out a base for an hour (a period of time that will effect decisions on tasking/servicing requests).*

	RATING				
	1	2	3	4	5
B. Validity of the training - overall rating:					
1. Does what a novice learns about FDO decision-making from using SuperKEATS represent what you would expect them to use in the ASOC? If not, how does it differ?				*X*	
C. Efficiency of training - overall rating:					
1. Is the time spent running a SuperKEATS game well used? For a novice? For an expert? How could it be changed to provide more training in less time? *Could be improved, of course. Okay now for novice (with some additions previously listed).* *Some more complex events could be generated for the experienced FDO.*				*X*	
D. Usefulness of suggestions/options					
1. Did you feel that tasking suggestions/tasking option was a useful feature for training? If not, what are your objections and/or how would you have done it differently? *Yes, for the novice. And it could be a useful tool for real-world tasking.*				*X*	
E. Usefulness of tasking feedback					
1. Did you feel that the optional feedback to tasking was a useful feature for training. If not, why not and/or how might it have been done differently?				*X*	

Good for the novice/learner.

May for complex events for the experienced if using for review and let him know if all areas considered.

IV. GENERAL EVALUATION AND COMMENTS

A. Do you see uses for SuperKEATS besides training? If so, please elaborate.

Would require major work to interface with other systems if want something operational. Those efforts are already in progress -- maybe a tie to other simulation systems. Again, for training.

B. What are the features that you like most about SuperKEATS? How could they be made even better?

Action -- Reaction -- Result.

C. What are the features that you like least about SuperKEATS? Could they be changed to improve its usefulness? If so, how?

Some displays could be changed to be more functional and complete with information.

User Build Mode? Is there one? Needs to be.

	RATING				
	1	2	3	4	5
D. Rate SuperKEATS in its present form in terms of usefulness to the ASOC.				X	
E. Rate SuperKEATS modified as you specify (here or as in B and C above) in terms of its potential usefulness to the ASOC.				X	

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