WARGAME-BASED TRAINING SYSTEMS

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ABSTRACT

This paper introduces a candidate model for development of wargame-based training systems and describes the application of that concept during development of the Naval Tactical Game (NAVTAG) Training System. A wargame-based training system combines the inherent educational advantages of simulation and gaming with the best features of more formal or conventional methods of instruction. Research indicates that gaming simulation has the potential to afford significant advantages over conventional classroom methods of training. This appears to be particularly true for complex skills such as goal-oriented decision-making. Wargames can be made more effective by using an integrated development approach based upon the systems approach to instructional development, and the addition of a complete set of courseware.

Some key features, or characteristics of wargame-based training systems are that they:

- Utilize an Instructional Systems Development Approach
- Provide a Complete Wargame Training Package
- Are Usable in Game or Nongame Modes
- Are Scenario-Independent
- Provide Realistic Threat Portrayal
- Provide Basic and Advanced Modes
- Are Easily Modified

Other design features include a reasonable level of complexity, realism and playability, and a requirement for a minimum-number of support personnel.

Wargame-based training systems are a unique approach to the special challenges of tactical decision-making training. The concept is applicable to all services and easily can be expanded to accommodate the introduction of new technologies, weapons systems, and tactics.

The authors illustrate how the design and development of a wargame-based training system is accomplished by reference to NAVTAG (Naval Tactical Game). NAVTAG will be used aboard ship, probably in the wardroom, to afford officers an opportunity to enhance through practice (or to learn, then practice) skills associated with tactics and tactical decision-making. The NAVTAG Training System is intended to complement other methods of tactical and team training, but will not attempt to simulate the physical environment or provide a basis for team training.

1. INTRODUCTION

Tactical training was an early casualty of the restrictive budgets and decreased operational tempo of this past decade. As valuable operational training time declined, the initial tendency was to compensate through increased use of real-time simulation techniques for team and subteam training; with tactical training an adjunct to other types of training. In the face of accelerating technological advances and new systems introductions, tactical training itself has become more complex and, therefore increasingly more expensive. Wargaming has been recognized as one way in which to complement and enhance the overall value of tactical decision-making training. In

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fact, wargames have been used for training, in a variety of forms, for a long time.

Published literature contains many articles in the area of instructional system development and the use of simulation and games for training purposes. There is however, very little in the literature on the development of wargames to be used for training. Recent developments and growing interest in the use of wargames for tactical training applications have underscored the need for a model for development of wargames and related instructional materials. This paper presents a candidate model for development and implementation of wargame-based training systems, within the general framework of the systems approach to development of instruction. For our purposes here, a wargame-based training system is defined as an instructional system which has a wargame as an integral part. The wargame may be used as instructional media requiring direct interface with students, or as support for a simulation exercise, based on indirect interface with students.

2. BACKGROUND

Wargames combine the elements of both simulation and games in a military context. Simulations involve the imitation of real-life systems or operations through the use of a variety of techniques including terrain boards, computers, and other aids. Games involve some element or level of competition among individuals for the purpose of achieving certain pre-specified goals. Wargames bring together the two concepts of simulation and games in applications that include operational planning, analysis, and evaluation, as well as training. Wargames used for training can be of several basic types, including manual wargames and computer-assisted, or automated wargames (Abt 1970).

Conflict simulations have long been used to prepare for combat. One of the better-known accounts of the use of wargames is that of the Japanese preparations for the Battle of Midway. The wargame developed a matrix of probable U.S. forces and tactics against Japanese forces and planned tactics, with the Japanese side losing. When the losing side challenged the outcome, the rules of the game were changed in order to inhibit specific U.S. tactics. This resulted in a Japanese victory during subsequent game play. During the actual battle, the U.S. forces used the tactics which were disallowed during game play and the result was a victory for U.S. Naval forces (Boocock 1966).

The development of computers has added another dimension to the design and use of wargames. Our Defense and State Departments make extensive use of computer wargames to plan and analyze policy decisions and options. Foreign policy crises have also been gamed by civilian and military planners. A more recent example of this application of wargaming was the use of gaming by both military and political planners prior to the Israeli raid on Entebbe.

Today, manual and automated wargames are in use by all the services. The cost/benefit advantages of games for training are becoming increasingly apparent as instructional designers become more familiar with the medium and its applications; often in what might be considered as new or non-traditional settings.

3. TRAINING WITH WARGAMES

An understanding of some of the characteristic features of wargames is important to an understanding of their use for training.

Wargames but players in situations that model real world systems or portions of systems. The intention is not to completely duplicate reality, but to provide experiences which are transferable to an actual operational problem. The important point is that wargames are intentionally not totally realistic, at least in terms of physical realism. Just as we would not want to rely upon a wargame to specifically predict the outcome of future conflicts (primarily because of the number of variables modeled and the assumptions made), we also would not want our wargame players/students to assume that their performance in a game, and a specific outcome, are totally transferable to the real world. Therefore, an understanding of the artificialities imposed by the wargame is essential to successful transfer from the game to the real-world operational setting.

Wargames may involve only one player or they may involve groups of many players. The players strive to achieve certain goals through their participation. At the same time, players are constrained by the scenario and operating procedures. Successful play sometimes involves agreement to abide by conditions which may not exist in the real world. For example, time may be expanded or compressed during play of the game. In addition, players may be assigned roles in the game which do not necessarily conform to those assumed in real life. Regardless of other characteristics, most wargames include some method to record events, decisions and results; and to determine winners.

In the past, wargames often have been viewed as valuable analytical tools, but lacking in sufficient effectiveness for serious training applications. It is the authors' contention that this view is not supported by recent experience with the use of wargames by the various services.

4. WARGAME-SPECIFIC ISSUES

Although answering questions about the effectiveness of wargaming as an instructional medium is outside the scope of this paper, a brief discussion of the advantages and limitations of wargames may help to set the context for the discussion of the development of wargame-based training systems that follows.

Wargames used for training exhibit advantages that may be considered in two broad categories: (1) enhancements of the learning environment; and (2) improvements in instructional management.

Instructional wargames provide opportunities for students to experience in a controlled environment the consequences of decisions which may be encountered in an operational setting. A wargame can provide the valuable experiences of learning through participation that otherwise could be obtained only through real-time, full-scale simulations, field exercises, or actual combat operations. Wargames can help avoid/reduce the costs and difficulties often associated with full-scale simulations, exercises and operations, while providing much of the training value of the more expensive alternatives.

Proponents of games or wargames for instruction point to advantages of increased student motivation. Actually, little is known about the motivational power of games beyond the indications that the elements of change, competition and excitement tend to stimulate learning (Cherryholmes 1966). There is little disagreement that, at a minimum, these elements stimulate participation and, therefore, can enhance the opportunities and potential for learning.

Because wargames establish situations that evolve with student interactions, they seem to be an effective way to teach the structure and operation of systems (Interservice Procedures for Instructional Systems Development 1975). Decision-making skills can be strengthened through opportunities to see the results of a series of decisions unfold. The availability of such results in the form of near real-life feedback is an advantage of wargaming that does not always exist in other instructional media; even including field exercises.

In addition to the potential for enhancements to the learning environment, the use of wargames for instructional purposes has physical and logistic support advantages for instructional management. Wargames can be designed to be both exportable and transportable. In fact, the entire instructional system package can be made relatively small and light-weight for ease of transportation and use in the field or aboard ship. Small packaging also can ease maintenance and repair support requirements.

In certain applications, wargaming can be more cost-effective than other media. The potentials to bring the instructional package to the individual, and to require minimal instructor-resources, are examples of the cost benefits of wargames.

Wargaming complements other forms of decision-making or tactical training. A wargame can provide opportunities to review tactical experiences or to prepare for future exercises. Areas of individual weakness in prerequisite knowledge can be easily identified in a wargame environment. Wargames may also be tailored to specific needs; such as time available for training. Thus, wargames can provide for regular proficiency and refresher training for tactical decision-makers, working easily around other demands on an individual's or group's time.

Although there are numerous advantages, there are also limitations to the use of wargames for training. Research indicates that instructional simulations are successful, but not superior to, more conventional techniques for teaching facts or bodies of knowledge (Kapper 1981a). Simulation requirements also can be expensive, and, therefore, cost-prohibitive in certain applications.

Wargames can also be time-consuming and difficult to learn how to play. While this limitation has in large measure been overcome by computer automation, automation has its own limitations. Computer automation is expensive and can introduce additional artificialities as obstacles to transfer of training.

Unless a wargame is carefully constructed and monitored as part of an instructional system, it may have a tendency to lead student players to develop unrealistic attitudes toward the real-world operational environment or their own abilities. Of related concern is the fact that the outcomes of models incorporated in a wargame rarely can be fully validated. Empirical validation of models through a "preponderance of evidence" is perhaps the best means available to validate wargame models.

In addition to the potential for development of unrealistic attitudes, or expectations, there exists with wargames the potential that students will use the game to reinforce existing biases. The student thus may bring to the game a "favorite" solution, regardless of the nature of the problem or may tend to view all problems as being essentially identical (Somers 1979). Kapper has noted that "the most blatant abuse (of wargames) today... is advocacy" (Kapper 1981b). This includes the use of wargames to "sell" programs where vested interests are at stake, or to denigrate programs over which there is disagreement or uncertainty. An example of this could be the justification of a new tactical doctrine through the "results" of the wargame.

The possibility that these limitations and potential disadvantages will have negative impacts on training can be lessened through a systems approach to development of wargame-based training systems.

5. IMPORTANCE OF A SYSTEMS APPROACH

The development of instructional systems has long been recognized as a complex process. Systems engineering accounts for and demands a reasoned transition from precise needs statements, to validation of problem environment and situation, through identification of all alternative solution candidates and optimal selection, implementation and continuing refinement. The instructional systems development procedures followed by the various services are, in fact, the application of systems engineering principles to the problems of training systems development. The application of these procedures represents the transition from art to quasi-science in the development of instructional systems. When the problems of the unique characteristics and varied implementational philosophies of wargame-based training systems were confronted, it was logical that the instructional systems development model be utilized as the basis for development of a tailored model.

One of the challenges in the adaptation of the instructional systems development model is that the media selection process often has been obviated by decisions which preceded analysis of the training needs. Validation of the results of wargame exercises presents yet another challenge. This situation is further exacerbated by the paucity of real data to validate model and strategy effectiveness. For these reasons, considerable effort has gone into ensuring significant subject matter expert inputs and reviews during the development process. Futher, because of the additional impact of new weapons/ sensors technology, much more emphasis has been placed on the evaluation and management phases after implementation of the wargame-based training system. The known complexity and problems in the development of cost/training effective and efficient instructional systems, when coupled with the unique problems and characteristics of wargaming, underscore the requirement that the technology of instructional systems development be adapted to produce an operational model for development of wargame-based training systems.

The authors have developed a candidate model for development of wargame-based training systems. This model includes appropriate parts of the model for the systems approach to development of training materials. As currently configured, there are 12 steps in the model, as discussed in the following section.

6. DEVELOPMENT OF WARGAME-BASED TRAINING SYSTEMS

Fig. 1 illustrates the 12 steps in the development of wargame-based training systems. Although the model is portrayed in a linear fashion, it is not a requirement that each step be conducted sequentially. Some activities may be accomplished concurrently, or even out of sequence.

Discussion of the model will focus on the activities to be accomplished during each step, and the products which will result from those activities. Where the model closely follows the instructional systems development, little information will be presented, as this information is available elsewhere. Instead, unique activities and/or products of this model will be described in some detail. Considerations for development of automated systems are also presented.

6.1 Analysis of the Training Problem

Step 1.0 involves the analysis of the training problem, and is similar to the first two steps outlined in MIL-T-29053A (Military Specification-Training Requirements for Aviation Weapon Systems). The primary products of this step are a Problem Analysis Report and a Training System Development Plan, which together specify the approach required for development and implementation of the training system.

6.2 Training Analysis and Design

Step 2.0, training analysis and design, involves the analysis activities included in Phases I and II of the instructional systems development model.

The primary products of Steps 1.0 and 2.0, then, should be a list of tasks selected for training and a list of hierarchical, or sequenced, learning objectives. These become primary inputs to Step 3.0, design of the wargame-based training system.

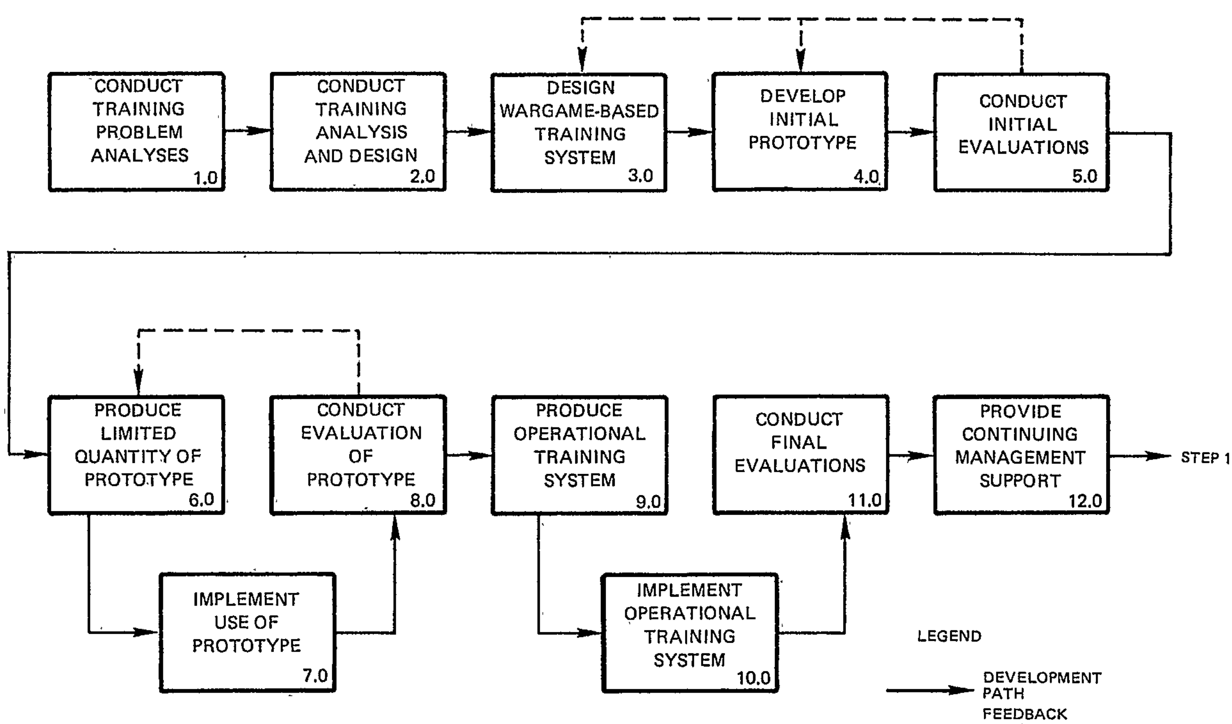

Figure 1. Steps in Development of a Wargame-Based Training System

Although not unique to the development of this type of training system, it is important for the reader to recognize that, given the exigencies of operating in the "real world," it is possible that some decisions - including media selection - may be made outside the model or imposed upon the instructional developer. It is also possible that the results of earlier analysis efforts may be used in place of original research. If the activities required in Steps 1.0 and 2.0 have been completed (or the need for such activities obviated by decisions imposed on the use of the model) the development of a wargame-based training system may begin with Step 3.0. A considerable stress, however, will be placed on the development process (and on the developers of the system), since the results of the decisions, or the lack of sufficient analysis, can create problems later in the process.

6.3 Design Wargame-Based Training System

The activities that take place during Step 3.0 are illustrated in Fig. 2. Activities 3.1 and 3.2 involve the specification of learning activities (emphasizing the type and methods of feedback to be provided to students) and specification of the instructional management plan. Through these activities, the instructional developer should look to verify the selections and appropriateness of the wargame medium and to determine how the instructional system is to be packaged and implemented.

Activity 3.3 focuses on the wargame, itself. The functional characteristics of the wargame (and the total system) should reflect the results of many decisions, all made in the context of the learning objectives. Some of these decisions include resolution of these issues:

- Is the game to be used for practice only or will it also be used as an instructional delivery device?
- Should the game be manual, computer-assisted or fully automated?
- Should the wargame be free-play or scripted?
- Should the wargame be one-sided or two-sided?
- Should the game be in the open or closed mode?

The game functional characteristics, instructional management plan, and learning objectives will serve as the primary inputs to the design of the training system. The remaining steps involve the design of various subsystems of the training system. The subsystems of a wargame-based training system, illustrated in Fig. 3, include:

- Instructional Subsystem
- Simulation/Game Subsystem
- Critique/Feedback Subsystem
- Implementation Subsystem

Activity 3.4, design of the Instructional Subsystem, results in the curriculum outline, lesson plan and scenario requirements, and design criteria for the Implementation Subsystem.

The specification of the simulation/gaming requirements (Activity 3.5) results in design criteria for the wargame, using as primary inputs the wargame functional characteristics and the planned curriculum outline.

Prior to completion of the design of the Simulation/Game Subsystem, the model requires development of various models of reality. This development requires a definition of reality in the form of a conceptual model (Activity 3.6), the development and documentation of an operational model (Activity 3.7) and the evaluation of the

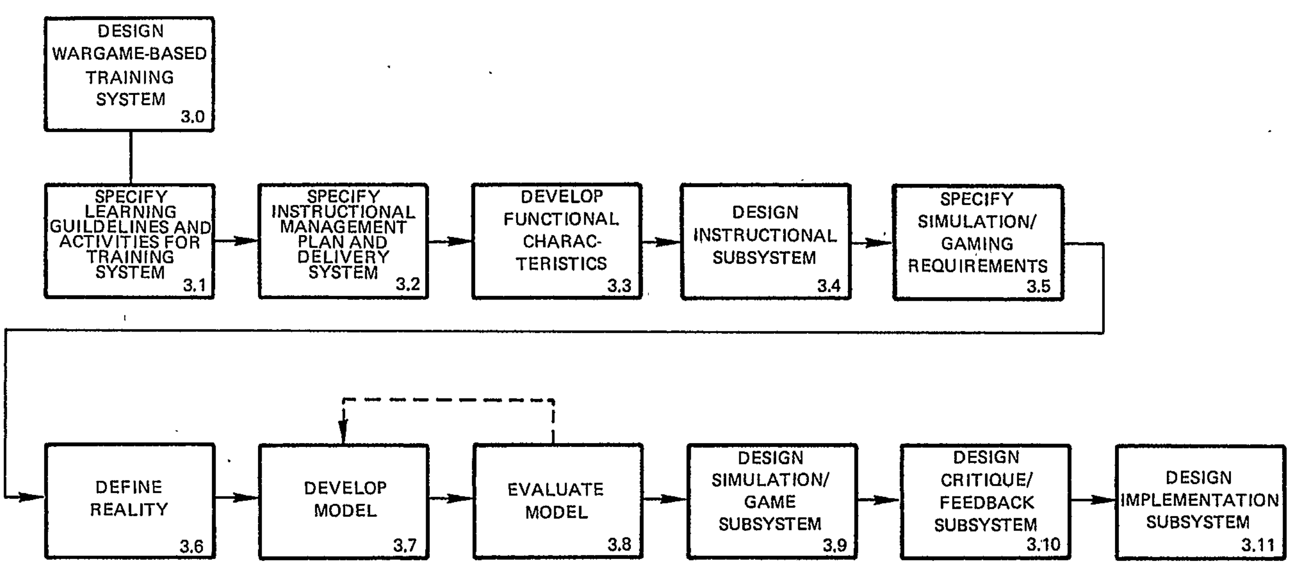

Figure 2. Step 3.0 - Design the Wargame-Based Training System

model, in terms of completeness, content validity, level of specificity, and fidelity (Activity 3.8). Once again, throughout the activities culminating in the Simulation/Game Subsystem design, there should be constant reference to the goal of the system as evidenced by the learning objectives and other products of earlier activities. In addition, it is essential that these activities result in detailed documentation for the model, including a bibliography and list of references and a record of the decision processes involved in model development (i.e., assumptions and rationale).

The Critique/Feedback Subsystem is primarily concerned with student and game performance monitoring and evaluation. The design of the Critique/Feedback Subsystem should provide preliminary answers to such questions as: How will the instructor/controller use the game and instructional materials to best instructional advantage? What should be the methods of recording critical events, decisions and outcomes?

The Implementation Subsystem design should provide for complete implementation guidance for instructors, controllers and players. The design therefore should include development of a list of tasks selected for training and a set of learning objectives for those positions.

6.4 Develop Initial Prototype

Step 4.0 is illustrated in Fig. 4. The subsystem designs from 3.0 provide the primary inputs to the development activities in Step 4.0.

The Simulation/Game Subsystem development should result in development of the game rules and procedures and physical components. Model hardware and software, as required, will also be developed during this activity. Before completion of development of the Instructional Subsystem, Activity 4.3, the Simulation/Game Subsystem should be evaluated in relation to the design criteria of workability, playability, validity and fidelity. The Simulation/Game Subsystem evaluation report will provide valuable input to the development of the Instructional Subsystem; particularly in the development of system training capabilities and limitations.

In addition to the lesson plans, scenarios, and training capabilities and limitations, the Instructional Subsystem should provide a matrix, or cross-index, of learning objectives and lesson plans.

The development of the Critique/Feedback Subsystem in Activity 4.4 will result in the instructions and procedures necessary to evaluate student performance. Because the instructors and controllers, as well as players, will be principal users of the Critique/Feedback Subsystem, the development of this subsystem can be expected to impact the development of learning objectives for these positions and, therefore, the design and development of the Implementation Subsystem.

The Implementation Subsystem developed through Activity 4.5 will consist of instructor's guides, controller's guides, player's guides and the executive guide or executive summary.

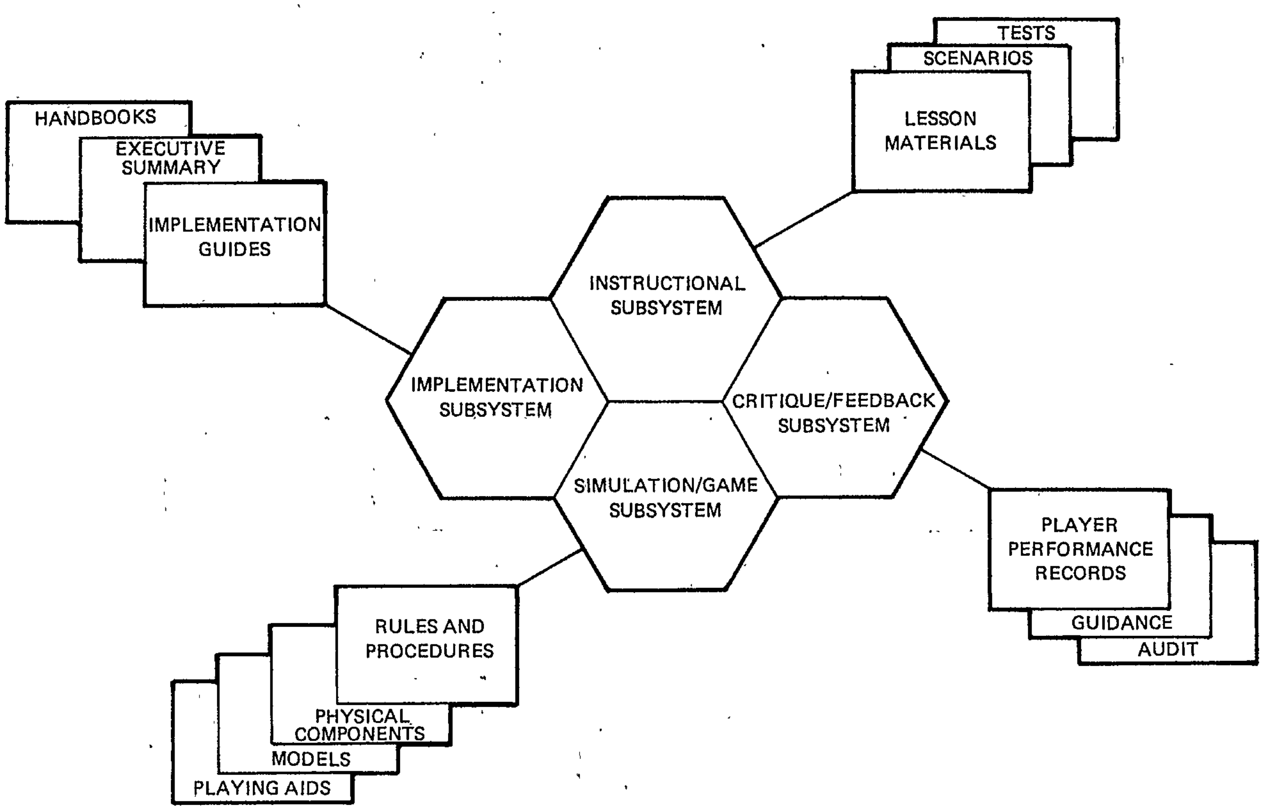

Figure 3. Wargame-Based Training Systems Subsystems and Components

Upon completion of initial subsystems development, the subsystems must be integrated into an initial prototype training system. Integration activity should point to additional changes required in the initial prototype subsystems and components prior to comencement of initial prototype evaluation in Step 5.0.

6.5 Conduct Initial Evaluations

The primary purpose of Step 5.0 is to evaluate the overall effectiveness of the initial prototype system prior to a decision to produce limited quanities of the prototype. These evaluations can best be arranged in three phases: (1) in-house evaluations; (2) appraisal by subject matter experts; and (3) one or more sets of external evaluations.

The initial evaluations should be directed toward answering questions such as:

- Are the lesson materials and game mutually supportive of the prescribed learning objectives?
- Do the instructor, controller and player guides provide sufficient guidance for game play, player performance evaluation and critique?
- Is the game reliable in that the simulation model yields consistent results?
- Does the system exhibit the degree of fidelity intended (i.e., are the simulations realistic and reflective of the real world)?
- Is the system playable in a physical sense? Are the procedures easily understood and does the system meet prescribed criteria for such considerations as readability, time to play, and physical characteristics? Is the game/simulation interesting?
- Does the system have validity in terms of reasonableness, realism, and comprehensiveness? Is the appropriate mix of simulation, automation, activity and player interaction provided?

In-house evaluation should be an extension of the interactive processes of design, develop, test and revise begun in earlier steps. A design review checklist should be developed for use in this activity, which can, and should, begin prior to completion of the initial prototype system.

Subject-matter expert appraisal can be accomplished with the assistance of the Fleet Project Team, Reserve Training Units, Tactical Training Groups, or similar activities, as appropriate. It will be necessary to carefully plan and schedule this activity, as well as to provide a complete package of data collection materials and appraisal guidance.

The third activity in this step requires one or more series of external evaluations. Actually, "external evaluation" is a misnomer in that these activities involve implementation of the system using representative members of the target population. An intensive data collection effort is required, focusing on each aspect of the training system. Depending upon the results of the first

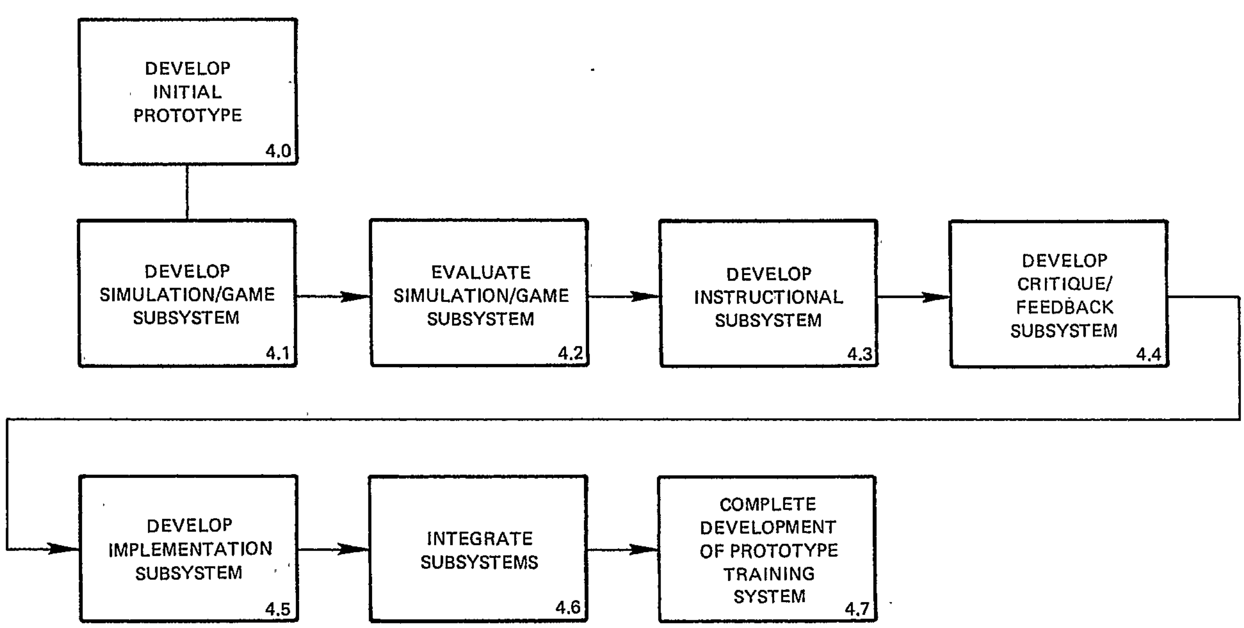

Figure 4. Step 4.0 - Develop the Initial Prototype

external evaluations, a second or even third evaluation may be required.

6.6 Production of Limited Numbers of the Prototype System

Step 6.0 involves production of limited numbers of the prototype system. The initial activity is the development of a production strategy, to include identification of government- and contractor-furnished material requirements and a production plan. Subsequent activities require the preparation of procurement packages and tasking for cognizant government activities. The remaining activities in this step involve contract management and completion of the prototypes. Step 6.0 is an adaptation of the "fly before buy concept" employed with success in other areas.

6.7 Implementation of the Prototype Training System

The prototype training system is implemented in Step 7.0. The first activity is to develop an implementation plan that will establish the schedule and procedures, and assign responsibilities for prototype implementation. Prior to distribution of the prototype systems, one or more courses of instruction will be required for those personnel assigned as instructors/controllers.

6.8 Evaluation

A second evaluation step (Step 8.0) should follow distribution of the prototype games to selected units. This evaluation should be conducted by unbiased sample groups from the target population. The primary purpose here is to evaluate the training system in its intended setting and without interference on the part of the system developers. Final modifications to the training system may be required, based on analysis of the utilization data.

6.9 Production and Implementation of Operational Training System

Steps 9.0 and 10.0 of the development model involve production and implementation of the operational training system. Step 11.0 provides for "final" evaluation over the long-term following full-scale implementation. This evaluation can, and should, be conducted using a variety of information sources, including regular feedback, periodic sampling of users, questionnaires and personal observations. A specific goal of the ongoing evaluation activities should be to ensure that the system game, scenarios and courseware continue to accurately reflect real-world operational capabilities and doctrine.

6.10 Provision of Management Support

Step 12.0 involves the various well-established activities associated with providing continuing management support/services to the users of the training system.

7. DEVELOPMENT OF DATA PROCESSING REQUIREMENTS

As mentioned earlier, the design of a wargame-based training system may require use of a digital computer. Use of the computer is generally specified for many reasons: to speed up play; to allow for utilization of more sophisticated models; to permit storage and use of much more data; to provide for more complex interaction with the player; to allow for easier employment of stochastic models; for ease of gathering statistical and analytical performance data, and/or to eliminate the need for many human player/decision-makers.

Automated wargames fall into three general categories of increasing difficulty and implementational sophistication: Computer Assisted, Interactive and Computerized wargames. In each of these categories, the data processing (DP) requirements that must be addressed are: processing, fast memory, mass memory, input, output, software language, and operating system. This section will address a method for developing an accurate needs estimate for a generic wargame-based training system's data processing requirements. It is assumed that once an accurate data processing needs estimate has been developed, implementation of these requirements will be accomplished in the generally accepted fashion for computerized training devices (or training devices with embedded computers), and according to the established procedures for such devices, Military Standard for Trainer System Software Development, MIL-STD-1644 (TD) 7 March 1979.

Proper development of the device data processing requirements requires integrated analysis performed in a linear, staged fashion of increasing effort and sophistication. The authors have developed a nine-step model defining the data processing requirements effort (see Fig. 5). This process will answer the critical questions in the seven data processing areas detailed above.

In the processor area, analysis and tests are conducted which integrate size and weight limitations with model complexities to determine the required speed of computation. These tests must necessarily also address the issues of language, operating system, mass, and fast memory. These processes will define, for example, whether a micro-, mini- or main-frame computer is required. The issues of higher order language vs. machine language and standard off-the-shelf vs. a tailored operating system will also be addressed. The wargame model complexity, supporting data requirements, number and sophistication of participants, and environment will be analyzed to provide inputs to the mass and fast memory requirements. Options available for player/participant inputs include typewriter keyboard, joysticks, light pens, trackballs, resistance pots, push buttons/switches, graphics tablets and voice recognition. These capabilities must be matched against the wargame's input requirements and user skills. Typical output characteristics include printer/hardcopy and cathode ray tube units; their speed of operation, number of lines and characters per line, graphics resolutions (line drawing or raster), colors and the number of words/phrases for voice output. Output requirements address the system's need for communication of instructions, computation and interaction results, and situation reports/plots to the players and controllers. Data access speeds and transfer rates within the processor and to its various peripheral devices are important concerns for processor timing, mass and fast memory selection, and input/output operations.

Referring back to Fig. 5, the first step in the development of the wargame-based training system's data processing requirements is integration and analysis of the device operational requirements. This activity will result in a list of automation tasks and an initial DP needs estimate. For NAVTAG, this process resulted in preliminary selection of a micro-computer using a high order language in an off-the-shelf operating system environment.

In Step 2, the list of automation tasks is reviewed in the context of the initial DP needs estimate to identify the high risk areas for the chosen approach. The list of high risk areas for the NAVTAG device included the capability of a micro-computer to store, position update and legibly geographically plot the positions of an adequate number of platforms within reasonable time and memory limitations, and the capability of micro-computer peripheral storage devices to store all of the required information.

The third step of the development effort designs tests which will aid in resolution of the high risk issues. A representative micro-computer and disk storage system was selected to implement test programs for NAVTAG. Software design specifications were developed which addressed the storage, position update and geographic plotting of a variable number of platforms. In general, this step results in test specifications designed to generate the timing, storage and graphics data necessary to adequately lower the initial risk level for the identified tasks.

In the fourth step, the test specifications from the previous step are implemented in software and performed on the presentative hardware. The timing, storage and graphics data and results generated by the test are captured and documented. These data are analyzed and used to refine the initial estimates of the DP requirements in the fifth step. The outputs from this stage are the interim DP needs estimate and the documentation of the resolution of the high risk issues. It is at this stage, that high risk automation tasks can be dropped, modified or used to justify more capable equipment/software, depending upon their priority and complexity. Analysis of the results of the NAVTAG high risk area software demonstrated that reasonable, effective and low cost solutions existed for these issues.

With the high risk automation issues resolved, the sixth step addresses the identification of the major automation tasks that require integrated feasibility testing. In this step, the interrelationship and dependencies of the major automation tasks and the special input/output requirements are analyzed. This study produces a list of those critical links and input/output functions that require feasibility testing to more completely define the system DP requirements. For the NAVTAG training device, the major automation tasks were movement, electronics, weapons utilization and damage assessment. The feasibility issues concerned the interrelationship of these varied tasks through the rules of the manual game and the common database required. Of concern was the computer reaction and computation times for the varied tasks, and the form and format of communication with the system user.

The design of a limited, yet integrated feasibility automation and test plan is accomplished in the seventh step. The tests are constructed to validate the interim DP requirements and to eval-

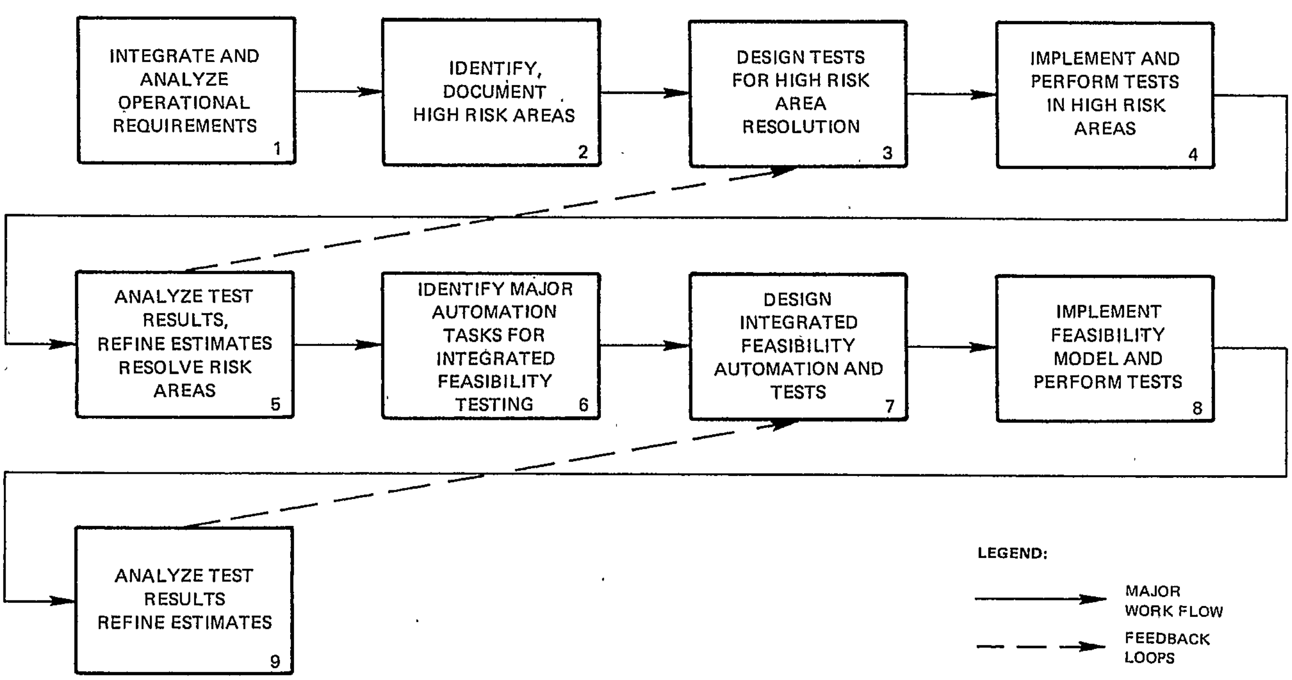

Figure 5. Development of Data Processing Requirements

uate the feasibility of the critical linkage and communication concepts contained in the system design. The automation tests and design for the NAVTAG feasibility model were developed in an iteractive fashion between computer scientists, training and education specialists and a naval systems subject matter expert. This approach assured validity of design prior to feasibility model inplementation. It was decided to model two ships for suface interactions only because of time and cost considerations. The game, however, still contained all of the major automation tasks to be tested.

The eighth step is the implementation of the feasibility model, as designed in the previous step, and utilization of that model to accomplish the limited testing specified. The output of this step is the feasibility model and documentation of the success of the tests, including data on the performance and acceptability of the critical automation tasks, linkages and communication strategies. It is interesting to note that, in spite of considerable subject matter expert input in development of the NAVTAG feasibility model, significant rework was required after the initial implementation. Redesign was necessary to achieve correct terminology usage; to assure straightforward and complete presentation of the results of computer activities, background data and options available to the user. The requirement for this redesign pointed to the need for a model for development of wargame-based training systems.

The ninth and final step includes analysis of the feasibility model test results and documentation. This analysis refines and completes the estimate of the wargame-based training system's DP requirements. This step also results in the identification of interrelationships and system overall integration and communication (input/output) requirements. The analysis of the NAVTAG feasibility model produced many significant results that dramatically aided in procurement of the preproduction prototype. It was at this stage that the need for use of a compilable higher order language, instead of an interpreted language; and the need for an 80 column (rather than a 40 column) display was demonstrated. Other important results included an accurate data base, fast memory and source code estimates. This information proved to be of great use during the competiton prior to award of the contract.

Utilization of this procedure to define the wargame-based training system data processing requirements produces a low-risk, low-cost system, while maintaining the desired level of performance. This process saves money and lowers risk through studied efforts to improve the device through early identification of high risk areas and refinement of DP requirements, based on hardware evaluations and software development and testing. A further benefit is that the amount and complexity of the device's final source code can be much more accurately estimated.

8. CONCLUSIONS

This paper has presented a candidate model for the development of wargame-based training systems. This model is evolutionary; its application to real world situations has been limited. It is undergoing revision as it is currently being used and evaluated for future applications.

The model was developed based upon the broader principles exemplified by the instructional system development model and the large body of research already completed on instructional games and simulations. The experiences of both the Army and Navy in developing wargames for training during the past ten years was also a significant factor.

The need for a detailed development model for wargame-based training systems was recognized by the authors after they jointly became involved with the development of the Navy Tactical Game (NAVTAG). It was also considered to be of benefit to the various services and to industry because of the increased interest in the use of wargames for training and the numerous potential applications for such systems throughout the Department of Defense.

The need for regular proficiency training for tactical decision-making has long been recognized. Wargames are one way of providing combat leaders with experience in the operational impact of their decisions. When properly developed and implemented, wargames can provide valuable training to tactical commanders in all the services. However, it is important that the reader understand the authors do not offer wargame-based training systems as a panacea for all tactical training problems. Application of this model (or appropriate variations) will increase the probability that such instruction will be both cost and training effective/efficient. The use of the instructional systems development model as a basis for this model allows for simultaneous optimization of both the wargame and the instructional system.

Variations of this model are being used as the basis for development of a number of wargame-based training systems at the Naval Training Equipment Center. The success achieved through application of the model to date has been excellent, with the Navy Tactical Game (NAVTAG) the most notable. Specific examples of the application of this model to the NAVTAG development program have been included in this paper, where appropriate, to further explain and demonstrate the intent of this model. Notable benefits to that program from use of this model have been reported. A subsequent effort will address the application of a variation of this model, including each of the twelve steps to the development of a manual wargame-based training system for the USMC.

Consideration should also be given to utilizing the model presented in this paper for defining the data processing requirements whenever computers are used as part of the training system.

As noted earlier, this paper does not attempt to define all the advantages and disadvantages for using wargame-based training systems, nor to describe in any great detail the media selection process which would result in identification of the need for a wargame-based system. It is the authors' opinion that the criticality of the duties of our tactical decision makers - in all the services - requires that any and all reasonably effective approaches be pursued, and that no one solution be offered as a panacea to the problems of training those combat leaders. The fact that wargames - or wargame-based training systems - can be used to provide a partial solution to those needs is well recognized. The model presented herein provides one possible framework for achieving those goals in a cost/training effective and efficient manner. The validity of this model will be tested in the cauldron of real world application during the coming year, and the results reported on in a subsequent paper.

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