Proceedings of the 1986 Winter Simulation Conference
J. Wilson, J. Henriksen, S. Roberts (eds.)

USE OF SEMINAR GAMING TO SPECIFY AND VALIDATE SIMULATION MODELS

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ABSTRACT

Seminar gaming can be a useful method to use in specifying and validating a simulation model. It provides an interactive forum where a real or proposed system associated with a complex problem domain can be systematically studied by a variety of expert participants. It allows the proper integration of various technical, operational, and social/political considerations into the specification of the simulation model. Due to the visibility of the gaming process and the personal involvement of expert participants, a seminar game can contribute to model validation simultaneously with its specification. The method is especially useful in establishing model credibility and acceptability from the outset of its development. This paper describes the seminar gaming process and its application in specifying a simulation model to varying level of detail. The contribution of the process to model validation is outlined.

1. INTRODUCTION

The seminar game is an open game in which the problem to be addressed is imbedded in a realistic scenario and then dynamically played in time and space with each game participant having full access to game information. It does not have the competitive nature of a closed game in which information available to a participant is limited to that appropriate for his role in the game. Its purpose is usually analysis and understanding of a problem rather than training. The function of the game is to bring varied expertise and viewpoints to bear on a problem in a structured yet flexible format. These features make it an excellent vehicle for simulation model specification and validation in the sense to be defined below. An especially useful aspect of the gaming method is that model specification and validation can occur simultaneously.

The seminar game has been used extensively at the Applied Physics Laboratory over the last 25 years in a variety of formats appropriate to the problems under study. These have ranged from manual hand-play of small games involving a few players to large ones involving many players. Over the years various props have been developed to facilitate play. Also, computerized support has been developed for the more formal games. Generally, a seminar game that addresses a complex problem is an iterative process of successive plays that can span several months of calendar time. When the game is used for model specification, these iterations may correspond to various stages in the specification and validation process.

We have found the seminar game to be a useful technique in developing the specifications for a simulation model, either a new model or modifications to an existing model. The systems being modeled were both existing ones as well as ones yet to be built. In several cases the specification process involved the translation of engineering specifications into appropriate model specifications. The seminar game provided a method of demonstrating the validity of the translation.

Simulation model specification is the process of systematically defining model characteristics in sufficient detail so that a computerized model can be built. This process includes conceptual modeling as defined by Sargent (1985) as well as the logical, or flow chart model, described by Hoover (1985). Various levels or degrees of specification are defined later in this paper.

Simulation model validation is that part of the modeling process which substantiates that the model within its domain of applicability is a satisfactory representation of reality consistent with its intended application. This definition is a general paraphrasing of the one given by Schlesinger, et al. (1979) and adopted by Sargent (1984). Their definition is more specific in that it refers to a "satisfactory range of accuracy" for the computerized model. This is certainly the goal of the validation process but must be preceded by validation of the model at the specification stage of development. As is well known, properly specified models are easier to reduce to a computer model. They are also easier to validate at the conceptual and logical level. In addition, a demonstration of model validity at this level can establish the belief that the model adequately represents reality and build confidence that,

if properly programmed in some computer language, the model can be expected to produce sufficiently accurate quantitative results.

2. SEMINAR GAMING

Given a problem to study, the essential elements for a game are an appropriate group of participants, a place to meet and the commitment of the time required to play the game. The gaming process is facilitated by having prepared in advance the props to be used: maps, charts, plotting boards, diagrams, etc., and by having at least one person experienced in directing a game. The props may be problem specific; however, some are generic such as the game log to record events that occur during play as well as discussions of key issues. Computer support to access databases, make computations and provide displays can expedite game play. Automated game logging can aid in the rapid editing, analysis and reporting of game results. Even so, gaming can be a tedious, time consuming process. Yet, if properly directed the insights gained into the problem under consideration usually make the effort very cost effective. There is no substitute for the synergistic effects that can occur during game play among experts from various disciplines.

THE SEMINAR GAMING CONCEPT

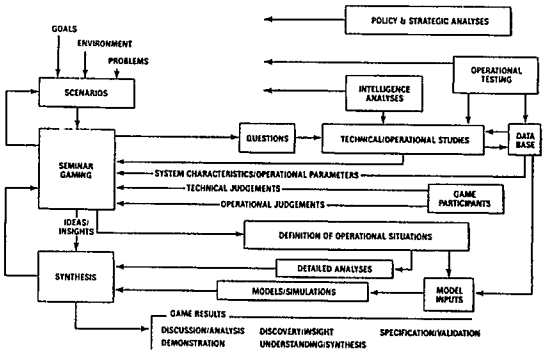

Figure 1

Figure 1 illustrates the concept of seminar gaming. A scenario is developed which properly imbeds the problem under study together with overall goals and environmental factors pertinent to the problem. These may be derived from policy analyses, intelligence studies, and operational tests. The game then proceeds as an interaction among the participants following the script of the scenario and using any technical and operational information that is available from previous studies, databases, or the experience of the participants. Questions that arise are discussed and either resolved or postponed for more detailed study with the results made available to later plays of the game. The role of the game director is crucial in making decisions in use of game resources (time and personnel) so that the game is kept moving toward its defined objectives.

The selection of game participants must be carefully done to support the goal of the game. The goal may be to simply discuss and qualitatively analyze a problem within a structured forum so that technical and operational questions are more clearly defined. It may be to demonstrate where and how a given system or given tactics and procedures might be useful. It may be to discover new tactics or improved operating procedures. Or, it may be to understand the total system as it might operate in complex environments. In each case, appropriate technical experts and operating personnel should necessarily participate in the game. Generally, the game continues over several sessions. The participants may vary from session to session depending on the expertise needed to meet the objectives of each play. One result of a gaming session might be the identification of the need for a model to address certain performance questions. In that event, gaming sessions could be held to specify and validate the needed model. For these sessions it would be appropriate to include modelers among the participants.

Figure 1 indicates the role of modeling in support of the gaming process by its use in technical and operational studies and in detailed quantitative analyses and simulations of operational situations that are extracted from the game play. However, the roles can be reversed making the seminar game a tool for simulation model specification and validation.

Figure 2 shows the procedure for play of the game for model specification and validation. It is similar to the simulation paradigm: Start the game clock. What happens first? When? How? Why? Expert discussion, computational support and interactive analysis provide the answers to these questions. Insights, questions and conclusions are recorded. Then, what happens next? And so forth. At each game event questions may be raised. Some of which may not be immediately answerable by game participants using information at hand. If the game cannot continue without an answer to a question, it is adjourned and an investigation undertaken to determine the answer. This is done through appropriate technical and operational studies. Once the needed results are available the game can be resumed. On the other hand, it is often possible to assume an answer to the question and continue the game. If it is later determined that the assumption is not valid, the

game may have to be replayed from that point. Such branch points in game play often occur. They are duly noted for possible play at a later date if analysis indicates their importance. This is one of the values of seminar gaming. The total picture of alternatives, possibly pertinent details, scenario variants, etc., is kept in mind at all times as the play proceeds along paths that are determined by the participants to be most important.

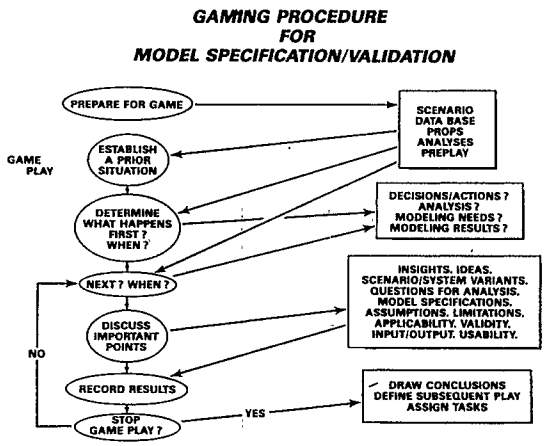

Figure 2

To be successful the game must be carefully planned and executed. The necessary preparatory work must be done to define the game including a rapid pre-play by the game director and his team to uncover missing information in the database, inconsistencies in the scenario, or additional expertise that should be located and invited to participate. The preparation phase can require a large effort. It must define in detail the initial play of the game.

3. MODEL SPECIFICATION

Simulation model specification is the process of defining the model in successive levels of detail leading to a document that can be used to program a computerized model. The specification should include a statement of the model's purpose: its problem domain, intended use and user of the model. It should enumerate and describe the processes that make up the model including any parameters and algorithms that characterize them. The model's structure should be clearly shown, its connectivity, flow and logic. At some point pseudo-code should be provided for the model's processing logic. Assumptions built into the model and limitations on its use should be clearly stated. Inputs and outputs should be listed and defined. The computing environment, including interactive features, graphics, etc., should be defined. Finally, the procedure for model validation should be prescribed in sufficient detail.

It is useful to define four levels of model specification:

1) Level-0 specification which defines the general concept for the model, its domain of applicability, its outputs, and its intended use.

2) Level-1 specification which defines the model's functional content, the processes and effects to be included in the model, algorithms and parameters to be used, input/output of the model, and its expected validation.

3) Level-2 specification which defines logical structure, events, algorithms, and process flow so that the level of aggregation and the operational aspects of the model are clearly visible including its assumptions, limitations and details of input/output.

4) Level-3 specification which provides the details of the model logic appropriate for use in creating the computerized model including the computing environment and validation procedures.

Seminar gaming is most useful in formulating the first three of these although its format is useful for walk-throughs of level-3 specifications, e.g., pseudo-code, to validate the model at that stage.

During game play questions concerning system or subsystem performance may arise that require quantitative answers so that game results can be synthesized to support decisions concerning the problem under study. If an appropriate model is available, it can be used. However, if one is not available, then a level-0 specification for the model could be written based on the need generated during game play. This is a concise statement of the conceptual content of the model, the types of output to be generated and the required accuracy needed for these outputs. The genesis of the modeling need in the context of the seminar game allows a more precise specification of the accuracy required since the game participants should know the other types of information that will be combined with the model's output and the type of decision that is to be supported.

Once the level-0 specification has been prepared the game participants can formulate a level-1 specification. Using the technical, operational and modeling expertise of the participants, the system to be modeled can be bounded and functionally decomposed. The processes to be considered for incorporation in the model can be defined and the physical effects that are expected to play

an important role can be identified. The quality of the resulting specification depends heavily on the expertise available. The seminar game establishes the context for the model and focuses attention on the functional aspects of the system that should be modeled.

Although the use of seminar gaming in the specification process could be terminated with the level-1 specification it is not a desirable stopping point for the game. The next level of specification is the key to using the gaming method to properly specify the model and to establish model validity at the specification stage. The level-1 specification defines what seems to be appropriate for inclusion in the model. It does not indicate how processes and effects are to be represented. The purpose of the level-2 specification is to develop these representations.

The above procedure is the ideal one for using the seminar game to specify a simulation model. However, it can be very time consuming for game participants, especially subsystem experts that may be involved only marginally in some discussions. Two alternatives exist: one is to carefully design gaming sessions to address modeling of selected subsystems and assemble only the expertise pertinent to those subsystems; the other is to have modelers play the game, prepare the level-2 specification using the level-1 specification and other available system documentation, and then present the results for critique and modification in later gaming sessions with all or selected groups of participants present. Both alternatives have been used.

4. MODEL VALIDATION

As described by Sargent (1985) validation is not a single step in the model development process but rather a continuing effort throughout model development and use. The goal is to establish the belief by experts in the field and by potential model users that the model is an adequate representation of reality for its intended use and that results obtained from it can be used with confidence to support certain types of decisions. The use of seminar gaming as described above can contribute to the achievement of this goal. Since persons expert in the various aspects of the problem area and in the associated systems are directly involved in its specification, the model at that stage of development has been validated. Validation of the model occurs simultaneously with its specification.

An alternative to the direct validation of the specification is for modelers to develop the level-2 specification of the proposed simulation model and to then present it, demonstrate its operation and use it during play of the game with a full array of expert participants. Validation then occurs in the process of gaming as the model's assumptions and limitations are exposed and examined in the context of the game scenario. The gaming forum allows the various experts to argue various key issues, to propose modifications to the model specification, and to reach a consensus as to model validity. The game can be repeated with different participants to increase model validation.

The seminar gaming approach is especially useful in achieving an understanding of what the model is to do, how it is to do it, and why it should do it that way. In addition, the game format can be used to teach the intended user the proper use of the model and provide valuable insights into the problem area that are difficult to achieve through normal discourse or presentation.

5. APPLICATION OF THE METHOD

The use of seminar gaming for model specification and validation has been found to be particularly useful in studies of existing system performance under special conditions that require use of data and procedural logic that are not straightforward. One example where this approach was used is a problem in command and control of a shipboard combat system: what are the possibilities for use of certain radio-frequency signal intercepts to support engagement actions? Specifically, what are the procedures to perform this mode of action? What is the expected gain in system performance? In this case, simulation models of system operation under normal conditions were available. The problem was to define alternative modes of operation under the special conditions and to modify the models so that they could be used to obtain performance results. The seminar game was found to be an effective method of analysis. Scenarios were developed and the game played to determine opportunities for use of the special modes of operation. The logic of the new procedures was devised through interaction of the expert participants in the context of the game. Then, existing model specifications were modified appropriately and later used to modify computer models so that the effectiveness of the new modes of operation could be studied by simulation.

There are a variety of techniques that are useful in portraying and documenting the specification of a simulation as developed in the game. One is functional flow diagrams and descriptions (F^2D^2). This technique is an extension of the function flow diagram (FFD) technique that has been

used for many years by ship system designers. For a brief description of the FFD technique see Enos and Tilburg (1979). The F^2D^2 technique (Lurcott 1973) adds descriptions of each function as well as its connectivity to other functions performed by the system. The technique is similar to data flow diagrams used in software engineering except that it includes functions performed by people and hardware as well as software. The diagrams can be prepared at various levels of detail (tiers) with the highest level showing the principal functions of the system. In the example cited, the tier-0 diagram could simply be: "detect signal", "evaluate signal" and "order engagement action". More detail for each of these functions would be given in successive tiers of the F^2D^2 procedure. Since this technique is a system engineering design tool, it may prove useful to the technical experts participating in the game. It is used in preparing the level-1 specification of the model: diagrams of functional flow as well as concise operational descriptions of processes and effects that are included in each function. The written descriptions are essential for later use by simulation modelers.

SIMPLIFIED EVENT SEQUENCE DIAGRAM FOR COMMAND & CONTROL MODEL

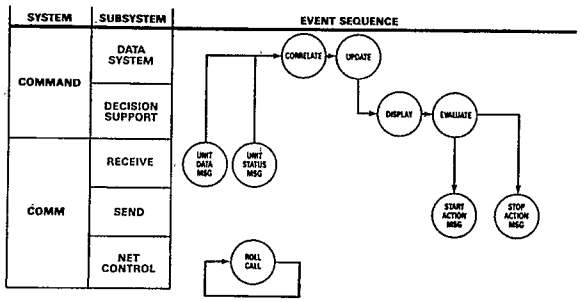

Figure 3

To develop the level-2 specification for a simulation, the author has developed a technique called event sequence diagrams and descriptions (ESD^2). This technique moves from functional definition of the model to specifying its event structure. Figure 3 is an illustration of the ESD concept for a part of the command and control model in the cited example. The events that occur during system and subsystem operation are identified by the expert participants using the context generated in the game. The connectivity and time sequencing of events are indicated in the ESD which can be prepared at varying levels of detail. The description of the event sequence includes the logic of determining when and how events are to occur, the algorithms to be used, etc. The purpose of the ESD is to provide a visible, concise specification of model content. The details are provided in the associated written descriptions. Experience has shown that a voluminous engineering specification document can be reduced to a few ESD charts plus descriptive material.

The development of ESD^2 for a model is an iterative process. The game participants identify events and processes involved in the operation of the system and subsystems. Trial sets of ESDs are prepared and discussed by the players. The goal is to find the proper aggregation of details to specify a model adequate for its intended use. For each process the expert participants must decide whether its effects are to be explicitly represented in the model, implicitly represented through variation in parameter values associated with another process or completely neglected. For each event sequence, algorithms and computations must be defined. Also, for each future event it must be decided whether occurrence can be directly computed or must be determined through an iterative time stepping procedure. The gaming forum supports this analysis by allowing the context of system operation to be kept in mind, especially constraints on system operation and interaction with other systems in the scenario. It often occurs that further detailed analysis is required to decide some of these questions. In that case, the question is assigned to appropriate experts for study with the results to be reported at a future gaming session.

The seminar game for the command and control problem was played using the concepts and procedures outlined above. Careful preparation was done for the game so that active play of expert participants would be most fruitful. The ESDs were prepared in advance for the existing model, then modified through game play to reflect the operational sequences for the new command and control mode. The results of the game provided a validated model specification which was used to modify the simulation model so that system performance could be computed for use in an ongoing study for the U.S. Navy. As noted in Section 3, the seminar gaming process can be labor intensive. In this simple example of simulation modification, two persons spent about four weeks gathering and preparing materials for the game and identifying game participants. Full-up game play with about a dozen participants occurred on a single day although two to three days would be more typical for a seminar game. Summarizing results of the game required about a week of effort by two people. More complex applications of the method, for example, full-scale simulation model development, would require proportionally more effort involving a

sequence of preparation and gaming sessions. Two alternatives to reduce the overall workload were given in Section 3. Both keep the use of expert participants to a reasonable level while achieving the principal benefits of the seminar gaming method: the insights obtained through synergistic interaction of appropriately chosen experts and their approval (validation) of the model at the specification stage. To make the method most effective the gaming sessions must be carefully prepared and then skillfully carried out by a game director who can keep the game moving toward its defined objectives.

6. CONCLUSION

The model specification and validation process using seminar gaming is portrayed in Figure 4. A multi-faceted, complex problem is first imbedded in an appropriate scenario with its concept of operation. Game play then refines the scenario, defines system options and characteristics, and uncovers performance questions concerning various facets of system operation in the scenario situations. Models are specified that are just sufficient to address these individual facets of the larger problem, thus keeping each model as simple as possible. Model specification and validation develop through iterations of the game. Model implementation can also proceed as part of the process, as appropriate.

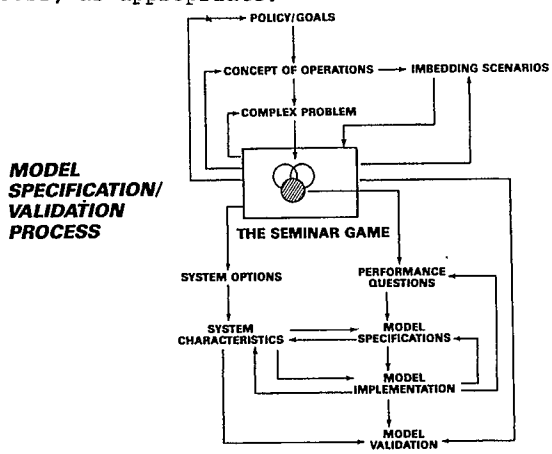

Figure 4

This paper argues that seminar gaming together with appropriate diagrammatic techniques can be a useful method in specifying a simulation model and simultaneously validating it to that point in its development. Although it can be labor intensive, gaming can be effective in providing a forum where various expert disciplines as well as intended users can interact and formulate model content and use. Their direct involvement helps establish model credibility and acceptability, its validity, from the outset of its development.

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