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**RESEARCH
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**Pros and Cons
of War Gaming and Simulation**



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Dear Sir:

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Sincerely yours,

A handwritten signature in cursive script, appearing to read "E. J. Suto", with a small "cto" written to the left of the main signature.
E. J. SUTO
Supervisor

Security and Documents

WEAPONS SYSTEMS EVALUATION DIVISION

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PROS AND CONS OF WAR GAMING AND SIMULATION

ABSTRACT

This paper explores the attributes of war games and simulations in order to delineate the contribution of each as a tool of research in problems of decision and planning. Comparisons are made on the basis of quality control, repeatability, and potential use of the results for statistical inference. The increasing use of war games as a means for measuring important military factors makes it paramount that these games be examined critically for general validity and utility.

The war game usually has nothing in common with game theory, but "war game," for better or worse, has become a common word in the vocabulary of analysts and has assumed a staggering symbolic representation as a quick and easy method for studying difficult problems, as a charm to ward off evil spirits, and as a "get-rich-quick" scheme where data are concerned.

There are serious analysts who swear by war gaming, and there are serious analysts who swear at war gaming, and certainly if the method is going to consume time and money in great quantities yearly a critical evaluation of its attributes is essential.

The results of methods of analysis are only as good as the models that produce them, and in the complex realm of planning factors and pay-off functions there is no room for inexactness or compromise with integrity. Both the realm of values and the decision process are being probed by mathematicians and philosophers driven by curiosity or necessity to discover techniques for predicting behavior patterns and choices in the complex world of budgets, weapons systems, profits, and personal values. The role of simulation and gaming may be an important one in these difficult areas of metamathematical research, and the objective of this paper is to stimulate concern over research tools in general and simulation and the war game in particular.

WHY SIMULATIONS AND WAR GAMES

By rights both simulations and war games should have the same origin in scientific inquiry as an outgrowth of the scientific process. To a large degree the simulation is inspired and constructed on the basis of the four-step scientific method, i.e., the verification of hypotheses that may lead to generalization as a law. But the war game, by the process of its singular use in military problems and because of its origin in military history, does not share the scientific certitude of its younger relation and does not share the general validity and high confidence awarded the simulation. At least one can say the arguments are always about war games and rarely about simulations.

Both simulations and war games are efforts to represent a system or organization in such a way that it can be studied precisely to yield data from which general relations can be declared, or from which a greater detail or level of comprehension is afforded the analyst in his efforts to uncover parametric interactions. Why has the war game then fallen so far behind the technique of simulation as a method of influencing and abetting the decision process? The reasons are varied and stem from weaknesses that are considered in detail in the following sections.

It is necessary at this point to note that both simulations and war games can be used successfully as training aids, or to demonstrate principles, etc., but the serious discussion is about the use of either as a tool of research in problems of effectiveness, procurement or planning actions, the study of war plans, or whatever affects profits or national security. It is precisely these problem areas of study that require analysts to find some way of determining a course of action and to be able to substantiate their recommendations by some demonstration of validity. Thus enters the war game or the simulation. Problems often arise for solution for which no direct measure or observation can be made of important factors, and effects and causes are often inseparable or indistinguishable. Either out of ignorance, or pressure, or from there being no advanced mathematical techniques for closed solutions, the analyst, requiring support, turns to the war game or simulation for assistance in his desperate need to produce a convincing treatment of his problem.

Requirements for analysis by means of simulation or war gaming may arise from among the following: (a) study of some system that is not beyond the concept stage of development, i.e., the analysis of proposals and systems in research and development; (b) consideration of alternatives in complex decision processes (much work is being done with dynamic programming and decision models, but most is far beyond being a simple application by a person not working in the field); (c) determination of levels of effectiveness of systems that cannot be used directly, such as the evaluation of NIKE defenses emplaced around cities; (d) study of systems that may be too expensive or unavailable for use in direct experimentation; (e) analysis of the underlying sources of observed effects when the usual techniques of mathematical description of phenomena are not possible; (f) closed forms of solutions that are either too aggregated or imprecise to fulfill the requirements of the study; and last, but extremely important, (g) analysis of the relations that may exist between a multitude of poorly described or poorly understood parameters. All these study requirements have perforce made the simulation and the war game very general and widespread techniques for getting into the guts of different problems, but the simulation has proved to be by far the more potent of the two.

MODELS, THEIR FORM AND SUBSTANCE

Before the differences between simulations and war games can be properly delineated a thorough description of the kinds of models and their constitution and objectives must be made in order to evaluate each on the basis of the elements of a model in theory. Although both are developments of the scientific inquiry there are more than subtle distinctions between simulation and the war game.

There are only three separate forms that a model can take and all models are one of these: (1) models developed for laboratory experimentation; (2) models expressed as logical forms, and in this is included the mathematical description; and (3) models created by the inquiries of statisticians. Actually these three are only variations of a single underlying form of logical organization and synthesis to bring into being a description of phenomena, abstract or

real, that require analysis. This single underlying bedrock on which all models have their foundation is the scientific method.

The scientific method comprises (a) the analysis of a concept (or system), (b) a construction of hypotheses regarding system parameter interrelations, (c) a test of these hypotheses, and (d) the formulation of these relations into the structure of a law that enjoys general validity. From this, then, springs the development of a model either in the form of an experiment in the laboratory; in the form of a logically connected statement about the concept that can be programmed for a computer or studied with truth tables or propositions; in a form that admits closed mathematical solution; or in a form designed for comparisons using statistics. Through a very slight alteration in terminology a general description of the essence and form of all models can be made, and from this the simulation and the war game have their origin. Construction of models may be broken down into these steps:

(1) Developing sub or component parts that describe the parameters of interest in the analysis.

(2) Integrating or synthesizing the component parts into a whole that represents the inner workings of the system in its totality.

(3) Testing the validity of the integration of Step 2 and returning to Step 1 or Step 2 if the original submodels are lacking in what is desired, or if the integration is in any way incorrect. This is repeated until the integration of components is achieved according to stated objectives.

(4) Playing or using the model with actual data in order to generate parametric relations that result from model integration, which corresponds to the test of hypotheses in the scientific method. The model integration is the step in which the analyst wishes to relate the submodels to his concept of the parameter interactions.

(5) Formulating the results into data groups from which inferences may be drawn or laws formulated.

If this description is accepted as correct, it is apparent that the simulation and the war game have no basic differences in theory, but in practice the war game has had a long history of abuse that stems from the absence of a properly designed set of game hypotheses or objectives. The simulation is most precisely designed for the analysis of a limited, controllable number of parameters, whereas war games are often ill-defined and obscure and completely lack definite hypotheses for study.

This brings into consideration the purpose and objective of models and how both influence the design of the model. Any model that is representing a research effort must be under the complete control of its clearly defined objectives, and "control" here is used in the most strict scientific and statistical sense. In the development of any model the hypotheses for testing exist prior to the model and should determine completely the ultimate form of the model. In war gaming the opposite is more often the case wherein the war-game format may determine what is analyzed. Statistical analysis is a prime example of the proper development of a model to test hypotheses or to reveal relations between causal factors, and all simulations and war games should have their basic elements founded in the desire for statistical control, objectivity, and clarity. Consequently the main goal of the model is to yield the greatest accuracy possible, or to ensure that sufficient material is available to enable the proper comparisons to be made with significance.

In the ideal experiment only the parameters under analysis are allowed to vary, other conditions being controlled as closely as possible. If control of the factors and residual by-products of their interactions is not completely possible then repetitions of the experiment are necessary in order to estimate the extent and influence of these residual effects and to separate these from the correlations of the main factors. It is here that the war game reveals its most glaring and often egregious weakness, i.e., the absence of repeatability and rigid test conditions.

The design of a model is virtually useless if it does not provide for reliable comparisons of results, sensitivity evaluations, the nature of the input sources of data, and precise control of parameter evaluation. Sadly, most war games are conducted under such circumstances that rarely are any of these satisfied, let alone all of them. A quotation from Kendall, The Advanced Theory of Statistics, Vol II, seems appropriate as a summary to this section, "A great number of intercomparisons fall to be made, and the process of design is essentially that of finding a form of experiment which will permit all these comparisons and yet save as much unnecessary labor as possible."

BASIC DIFFERENCES BETWEEN WAR GAMES AND SIMULATIONS

The explication of the form of the war game vis-à-vis the simulation has shown there is no basic difference between them in theory. The present form of the war game has, however, been completely shaped by the habits engrained through continual use and from historical precedents. The differences can be said to have their origin in the historical development and utility of the technique. The weaknesses that are concomitant to the war game also exist in the business game but to a lesser degree.

The major differences between war games and simulations stem from the nature of the design and management. It should surprise no one, on reflection, that the war game is often developed as it goes on and rarely experiences more than one replication, and that is usually done under new rules or altered assumptions, making any reliable conclusions impossible. In order to describe these basic differences the paragraphs below first make a statement about an attribute of simulation followed by a comment that describes how this attribute fares in the war game, as follows:

The simulation has precise parameter control. In the war game the nature of the problems, the reliability of the data, the player-game relation, and the rules of play all introduce experimental errors that are difficult if not impossible to separate from the resulting output data.

The simulation has no human interventions. The war game need not have any direct human factors in it but such factors are almost unavoidable when the format of the game includes teams and referees making decisions in the course of play, and the exchange of information coupled with the learning processes of the players cannot be avoided.

The simulation has no rule modification or data changes during the course of utilization. The war game often undergoes rules changes as a part of its development, and, since the initial set of rules rarely covers all the cases that arise in play, rule modification is inevitable. If the effect of the change is

known some harm may be avoided, but the rule change may affect the players' attitudes very markedly and influence the outcome adversely or in some undefined but significant way.

The simulation is designed for replication and for the generation of statistical data from which comparisons can be made with confidence. The simulation shows this advantage by being less ambitious and more precisely designed than the war games. The simulation model is developed from primal hypotheses that are to be tested. Hence the simulation model is created after the fact of designated objectives. In principle this can also be done with the war game and can be successful only if confusion and obscurity are eliminated and the objectives kept reasonable and well defined. But the indisputable fact that war games are, more often than not, developed as they are played makes the realization of this attribute very unlikely. These four points comprise the basic differences.

The computer-assisted simulation has undisputed advantages and there is no reason why the computer-assisted war game cannot enjoy greater reliability, but an important point must be realized. The simulation that is programmed for a high-speed computer is created entirely as a computer operation. But for the war games the computer acts in general only as a high-speed bookkeeping pad for the players that relieves them of tedious calculations but does not actually eliminate many of the basic weaknesses. Perhaps new developments in computer-language techniques will remove this objection.

DISADVANTAGES OF WAR GAMING

In all fairness the disadvantages of war games should be described as being of two different kinds, those that are inherent and those that accrue from the management and the conditions under which the management must operate.

The inherent weaknesses derive from the player-game relations; from the players' attitudes, behavior, and intent; and from the lack of clearly defined test hypotheses and their measurement. Players often assume roles in the game they never even approximated in real life and are presented with a concocted situation that will reveal only the players' degrees of ignorance or competence with respect to the problem under study. The rules of play can stifle a player's originality or cause undue confusion because they are incomplete or vaguely stated. Rules cannot be substantial if the test hypotheses are entirely lacking or cannot be surely measured by the model. The certain influence of players' attitudes toward their roles in the game will influence decisions and consequently the results. In the course of playing subsequent replications the player's learning process will again influence his decision perhaps in a different way from the influence of learning during the play of a single game. In the simulation the design allows residual biases to be studied; in the war game the residual effects are not generally known or measurable because of the influence of the players on the response of the model to variations. In other words the player, by being in the play, becomes an integral and unmeasurable part of the model and represents a dynamic variable, if not a stochastic one, that becomes merged with the output data. As the player changes so does the model. The role of the referee, if it is more than seeing that the rules are obeyed, only adds to the confusion and noise level in the final data.

Some of the weaknesses that derive from the management of the war game are the compromises that are made in order to meet deadlines. Often constraining rules are imposed that supposedly describe complex interactions that are actually many rules in themselves. The lack of repetitions, the possible tendency to prove what is desired, the lack of absolute judgment as to what is a "right" or "wrong" outcome, and the creation of submodels that inherently contain gross assumptions and compromises all combine to demonstrate dramatically the absolute necessity of control. Certainly the simulation is susceptible to these undesirable influences, and care must be taken in the model design to see that they are eliminated, but note carefully that the simulation, if properly designed, will have statistical checks on the errors that derive from noise and experimentation whereas the war game usually does not. There is no guard against prejudice except integrity.

There are four questions that all advocates of war games should consider seriously. How does the game itself influence the measures of the results? Would different results occur with a different set of players? Are the players really competent to fulfill their roles in games, and if not, what is a practicable substitute? To what extent does the learning process of the players influence the outcome, and if replications are possible, what can be said about the learning process from game to game, and the tendency to "play the game" against itself?

SECONDARY ASPECTS OF GAMES

The value of the game as a training device or a psychometric tool is recognized, but application of either is not widespread. There are arguments in favor of more development along these lines.

As a training device the concentration of events and decisions in a game creates an interest in the subject that may be lacking in other means of communications. Besides aiding a common basis for exchange between players, the war game (or business game) sparks the critical analysis of specific assumptions on which the problem is founded. Weaknesses may turn to advantages by focusing attention on the more confounding problems in the real world situation and on what approaches appear to have value. Games may provide, although this is somewhat in the future, a laboratory for studying responses of a player to his game responsibilities and yield a psychological index for his potential as an executive or in a command function.

SUMMING UP

The war game, by nature of its derivation, becomes a tool to study problems of military planning, tactics, and strategy. There is a paradox at the moment that makes the users of war games rather uneasy. On the one hand more and more study directives include a specific statement that the problem will be "war-gamed," and on the other hand a growing chorus of voices impugns the validity of the method. Even large corporations that employ the game as a training and psychometric tool make no claim that gaming is a

substitute for other forms of analysis or that it is anything but a tool under development that has limited utility. Political gaming is by far the most obscure and undelimitable problem and has weaknesses that go well beyond those defined here for war gaming.

Most of the difficulty with war gaming lies in the essentially imponderable and unmeasurable spheres of human decisions that are in part required as a reaction to a military situation and to certain assumptions concerning enemy choices of action. In principle the area is susceptible to analysis but the unsolved problems of player-game interaction, the description of the situation, and the unpredictable circumstance that arises in reality and often determines the victor all predicate against the success of the war game, as it is now used, as a serious tool.

Planning factors, either in the business world or military world, are derived from initial conditions that either remain fairly constant throughout the period of interest or are only transitory in nature and have a marked effect at the outset but change character as time passes. The success of an operation in the early phases of its employment either in war or the competitive market may depend on the proper choices in the transient phase of engaging the opposition as well as the longer-term steady-state attrition. Some estimates of the causes to be studied in the steady-state phases can and usually are studied in meticulous detail, but the real effort should be made on the interaction of the initial transitory stage and its impact on the steady-state condition and the profits entailed. The impact of advertising is a good example of this phase of the initial transitory effects on the eventual survival of two competitive products that may have insignificant differences.

It is critically important that military analysis undertake the study of initial transient effects on planning factors, for, the nature of war being what it is today, the planning factors based on steady-state or ergodic models may be purely academic exercises. The simulation appears to be the best research tool available at the moment for undertaking these problems, and may provide insight to more advanced techniques.