AN INTRODUCTION TO WAR GAMES

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SUMMARY

This paper is the initial form of Chapter 11 of a book entitled "Sequential Decisions and Simulation," edited by Rosenstiehl and Ghouila-Houri, to be published in France by Dunod, Paris. The book describes various aspects of simulation. The purpose of Chapter 11 is to present some general information on war games. This paper provides a short history of war games and an introduction to the various characteristics, techniques, and types of war games. An illustration of the steps in an umpired war game is included.

AN INTRODUCTION TO WAR GAMES

The term "war game" covers a large number of different activities. To some it means a game in which two opposing players move "pieces" on a board. To some it means a matrix denoting the "payoffs" of two opposing sets of strategies. To some it means hypothetical military operations carried out on a map or sand table. And, to still others, it means "mock" exercises in which thousands of troops assault a beach as part of their training. All of these uses have many things in common, but there are also some important differences between them. In order to limit the subject matter covered in this chapter, two of the activities to which the term "war game" is sometimes applied will only be briefly included. The first of these is the type of game that is subject to analysis by game-theoretical techniques. There is a large amount of excellent literature on game-theory already available, to which the reader is referred for further information (3,8,9). The second activity are those exercises in which actual troops are used. Although this type of war game is an important form of simulation device it is well recorded in the military journals. Between these two, the representation of military operations in the form of strategies in a matrix, and the detailed simulation of a military exercise, there are a large number of activities that are called war games which have as one of their major characteristics the representation of military operations in some symbolic or abstract form. It is this type of war game which will form the central topic for this chapter.

Partly because warfare is one of the oldest and most important of human activities and partly because it represents an activity in which the professional has limited opportunity to practice, it is not surprising that

substitutes for military operations have developed. War games are one of the major substitutes. As simulations of military conflict they have provided experience and training in military planning, tactics, troop maneuver, and other aspects of military operations. In more recent years they have also been adapted to serve other ends. They have been employed as research tools for a variety of problems in the military field. In this chapter section I is a short history of war gaming. Section II indicates the characteristics and various techniques of war gaming. Section III discusses the uses of war games and develops an hypothetical example.

Section I. A Short History of War Gaming

The origins of war games are not clear. There have been a number of different speculations on the way and manner in which they originated with some basis for each of the speculations. Without going into the evidence for these various viewpoints the major ones are:

1. War games originated as devices for planning military operations. This viewpoint assumes that some military commander, perhaps an Oriental general, planned his operations by representing his own forces and those of the enemy on a map or by scribbles in the sand, and tried to work out various moves or actions that might be taken by each side. He was, in a sense, constructing a model in which he could examine the major moves that he could make and those that the enemy could make in order to find the most effective course of action. He may even have applied rules which his experience had taught him were characteristic of military operations. Perhaps he even found it advantageous to introduce another person to "play" the enemy so that he would have the benefit of another point of view or not overlook something important to the battle outcome. Whatever form it took, this early development is regarded as an attempt to symbolize in an explicit

manner the interplay of two opposing military forces.

2. War games originated as instructional devices. According to this viewpoint early games were developed and used to instruct poorly trained and illiterate troops in the actions that they were to take in the forthcoming battle. The military commander sketched the position of the enemy and his own position and indicated to the troops various moves that might be made by both sides. He then demonstrated in this graphic manner the actions that his troops were to carry out under each contingency that might arise. In both this and the preceding speculation on the origins of war games the emphasis was on the "war" aspect, i.e., the gaming was adapted to the game situations.

3. War games originated as symbolic equivalents. There are several varieties of this point of view. They include the speculation that the games were used as "moral equivalents" for war during periods of leisure. In particular, it has been proposed that early forms of chess provided safety valves for the belligerent Hindus. Another version assumes that the games have a mystical or religious significance. They were used by the players as a method of understanding the workings of fate, since the outcomes of the games were presumed to be determined by the forces of destiny. Players who mastered a game were regarded as having achieved some control over fate and were held in esteem.

4. War games originated as a form of organized play. This speculation is similar to the preceding one in assuming a non-military origin and in emphasis on the use of leisure time. The difference is that the games were social in nature and occupied much the same position in earlier societies that parlor games do in our present society, i.e., they are socially acceptable forms of competition.

Although it is not possible to be definite about the origin of war games it seems clear that the games very early took on a formal and abstract character. By formal is meant that there were definite rules covering what the players could do and what the immediate outcomes of each action would be. By abstract is meant that the rules, the playing board, the pieces, etc., were not specific representations of real life phenomena. The earliest games may have been board games, i.e. games played on a specially defined surface. There are many different types of games played on boards not all of which are classified as war games. There are, for example, alignment games of which tic-tac-toe is a modern example. There are similarly hunt games and race games of which pachesi or backgammon are modern types. Board war games are distinguished from the others by the manner in which a "win" is determined. In board war games there are three types of wins. One is the "capture" type in which the objective of the game is to capture all or certain critical pieces and win is defined in terms of the player who first accomplishes this objective. Chess and checkers are examples of this type. A second is the "control" type in which the objective of the game is to surround sections of the board and win is defined in the terms of the amount of area controlled by each side at the end of the game. The games of ki or go are modern versions of control type games. A third, less well known, type is the blockade type in which the objective is to confine the enemy to a particular section of the board. The Indian game of Do-guti is an example of this type.

There are many variations in the size of the board, in the number and form of pieces available to each side and in the rules of play of these board war games. The apparent military similarities of some of these games indicate that they may be related to military operations or military forces

of long periods ago. Most of these military similarities, however, are extremely superficial. Although these board games are classified as war games, it was not until the games were modified to represent specific military forces on specific military terrain that games began to approach the type of war games that are used at the present time.

Early attempts to adapt board games to military action occur in the 1600s and took the form of adapting chess-type games to military operations by increasing the number of pieces on each side and increasing the size of the board. There were also changes in the rules. Most of these early games were considered as "military chess" games, since they followed the general pattern of chess games. An excellent historical survey of war games and detailed descriptions of many of the early forms is presented in Young(10).In the 1700s further military adaptation of chess-type games took place. The size of the board was further extended and the squares were tinted to mark various terrain features and buildings. The forces or pieces of each of the players were taken to represent battalions or squadrons and assigned a military mission. The rules were a mixture of chess-type rules and standard principles regarding methods of employment. For example, infantry pieces could move only in a straight line but they could be grouped before the start of the game in any standard military formation that a player desired.

The development of the chess-type war games continued throughout the 1700s. There were many different forms of games, of which the most notable was developed by Georg Vinturinus, a military writer. The game initially involved a board of 3600 squares with distinctions in the marking on the board to represent different types of terrain. An actual section of the Franco-Prussian border was represented on the board, although the lakes

and hills were all square. In later versions a chart or map replaced the board. The chart was very stylized but it was a move away from the use of ruled boards and opened the way toward the use of actual terrain maps. The moves of the pieces, which represented infantry and cavalry, were made in a manner that corresponded to actual rates of march over the terrain on the map. The game also included supply and logistics operations, and communications. The game was played according to an elaborate and detailed set of rules which covered 60 pages.

In subsequent years additional developments in the field of war gaming took place, particularly in developing more detailed rules and including the addition of dice to represent "chance" events. The next major development occurred in 1811 when Von Reisswitz, the Prussian War Counselor at Breslaw, transferred the war game to a sand table which modeled actual terrain at a scale of 1:2373. On the sand table the troops, represented by wooden symbols, were allowed to move without being restricted to chessboard-type squares. With a break away from stylized terrain and with great freedom in the capability of movement and maneuver, the war game now presented much greater possibilities as a useful device for military training.

The work of producing war games as we recognize them today was done by Von Reisswitz, Jr. who adapted the work of his father still further. The contributions that he made were such that he is regarded as the "father of modern war gaming." His game was played on maps drawn to a scale of 1:8000, and representing many terrain features in a realistic fashion. The troops were little squares of lead and were colored blue for one side and red for the other, the colors that even at the present time are characteristically assigned to the two sides of a war game. The game included a commander for the blue and red sides and a third person who served as an umpire.

The umpire enforced an elaborate system of rules which followed actual military regulations. He also provided rulings or decisions based on his own experience for any cases not covered by the rules. In addition, he provided both sides with information as to certain actions of the opposition giving only such information as he regarded would be available based on normal wartime methods of obtaining information. In this way "intelligence play" was introduced into war games. Among the other contributions of this game was the fact that the game started with a general hypothesis and a special theme, which corresponded to the "general situation" and "special situation" of most modern war games. The general hypothesis gave background to the military operations that were to be represented in the game, i.e. the events and moves prior to the start of the game. The special theme was the specific information for the particular play that was to take place and included such information as the strength and composition of the opposing military forces, and the assigned missions, Each game had a different special theme i.e. each game started from a different arrangement of military forces and missions. The time required to prepare and transmit the orders of the commander to the troops was included in the playing time. Once the game had started, play proceeded according to the stated rules as well as any procedure or regulation of current military doctrine. The rules and regulations were enforced by an umpire who also made decisions about any situation not specifically covered. Chance devices, specially prepared dice, and the decisions of the umpire also contributed to making the play more realistic. After each game, which was stopped at a predetermined result or by the umpire, a discussion of the military operation was conducted and the moves of both sides were critically reviewed.

In 1824, von Meffling, then chief of the German General Staff, consented to witness an exhibition of the game. He received the players somewhat coldly, but as the operations expanded on the map, the old general's face lighted up, and at last he broke out with enthusiasm, "It is not a game at all! It's a training for war! I shall recommend it most emphatically to the whole army." (10)

Von Meffling kept his word and issued a letter formally introducing the game to the Prussian Army. Subsequently each regiment was given the equipment and instructions for the game.

Following the development of the Von Reisswitz, Jr., game, a number of modifications and variations of this type of war game developed. Having achieved the degree of realism represented by using maps of actual terrain and by using pieces that acted and were employed in the manner of real military forces, subsequent developments in general contributed to adding more and more complex rules to cover the various contingencies and special situations that might arise in the course of actual military operations. The rules became so complex that game play was tedious and complicated and long periods of time had to be spent in learning the rules. In 1876 Col. Von Verdy du Vernois, an instructor in the German Army, called for a break with the rigid and detailed rules of existing games and the development of war games in which greater freedom would be allowed in the play of the game, particularly in the use of new tactical concepts. In order to achieve this degree of freedom, it was necessary to discard much of the complicated and detailed rule system that existed and allow the umpire or game director greater latitude in determining the outcome of moves not covered by the rules. The change was gradually introduced. Although many of the rules were maintained they were greatly simplified, and the players were given greater

freedom in undertaking actions for which appropriate rules did not exist. The change lead to a division of war games into two basic forms; the "rigid war game" with its detailed rules and precise computations, and the "free war game" with its emphasis on tactical freedom and the use of experienced umpires and directors to judge the outcome of the military engagements where rules were incomplete.

Along with the changes in the form, the emphasis in the use of war gaming as a training device increased. With the opportunity for greater freedom in the selection of situation that could be examined, and in the type of military operations and tactical concepts that could be represented, the use of war gaming as part of military training became accepted throughout the world. By the late 1800s and early 1900s practically every major country included war games in the training curriculum of advanced military professionals. Although their introduction was initially into the training programs it was not long before war games were being used in the development and evaluation of actual military plans. The games simulated actual attack or defense operations under definite conditions of time, place, military forces, weather, terrain, etc. And, in many cases, the conclusions drawn were included in the actual military plans being drawn up.

Perhaps the greatest use of games in the development of real military plans occurred in Germany. For the Germans the war game became an important device for examining existing plans for possible difficulties or limitations that might be encountered in the military operations and for developing new plans. Prior to World War I, for example, one form of the Schlieffen Plan on which the 1918 Spring offensive was based, received critical scrutiny through a series of war games. Similarly, other military

operations were reviewed by war games. In the period between World War I and World War II war games became a standard technique for practicing military operations by the professional soldiers whose armed forces had been restricted by treaty. And in the period of World War II many of the major operations were tested by war gaming, including Barbarossa, the Russian Campaign, and Seeloewe, the contemplated invasion of Britain. Similarly in the Far East the Japanese carried out extensive gaming prior to their entry into World War II. In other countries some war games were used for planning military actions but not to the same extent.

At the present time the two major forms of war games, the free play and the rigid play, still exist. Both have been employed as techniques for analyzing and evaluating military tactics, equipment, procedures, etc. The free play game has received support because of its versatility in dealing with complex problems of tactics and strategy and because of the ease with which it can be adapted to various training, planning and evaluation ends. The rigid play game has received support because of the consistency and detail of its rule structure and its computational rigor. In addition, the developments of large capacity computing machines has made it possible to carry out detailed computations with great rapidity and made it possible to go through many different plays of a game. With these developments the number and types of war games have increased.

Section II. Structure and Types of War Games

Despite the fact that a number of different types of war games have developed most of them have the same basic structure. This section describes the major characteristics of this structure and indicates the way in which it has been adapted for different types of games. Fig. 1 presents

a schematic of this structure, which can be used as the basis for a definition of a war game. A war game may be defined as the military interplay under a system of more or less definite rules of two (or more) sides with conflicting objectives. There are four important aspects to this definition, the nature of the sides, the nature of the conflict, the nature of the rules, and the nature of the interplay. Although these four aspects are interrelated, each one is sufficiently independent so that it can be described separately.

1. The nature of the sides. Each side in a war game consists of at least two different parts. One part is the forces or resources which the side has available. In some cases these may consist of nothing more than an aircraft for one side and one anti-aircraft gun with two potential targets to defend for the other side. In other games the resources or forces — the terms are used interchangeably — of each side may consist

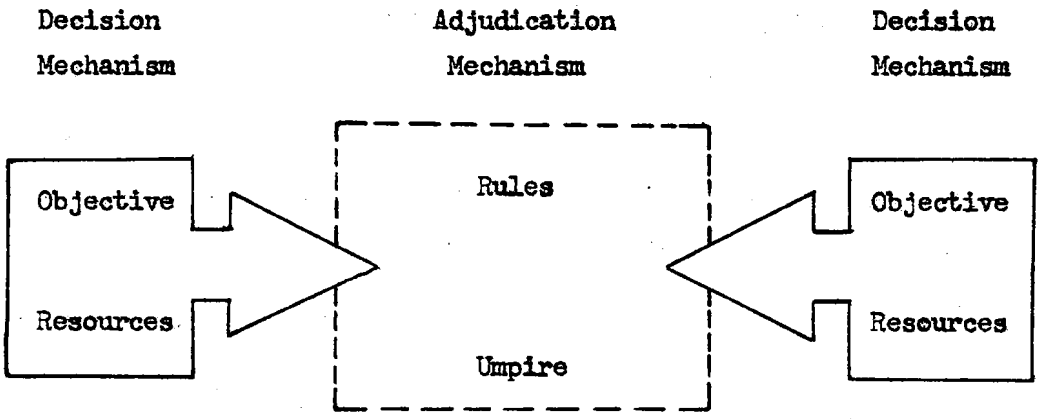

Fig. 1 Structure of a War Game

of the entire armies, air forces, navies, economic stockpiles, production capabilities, etc. of twenty different nations. In addition there may be wide differences in the ways in which the resources are represented in the games. The single aircraft in the first game may be represented as the weight of bombs that can be delivered to either of the opposition's targets. In the multi-county game every one of the aircraft, every army division, every ship, may be represented in terms of its location, operating characteristics, speed of movement, combat capability, etc. Similarly, every major factory, railroad, storage or supply depot may be represented in terms of its location, input and output capabilities, etc.. The number, type, and nature of the resources and the ways in which they interact with each other is one rough measure of the complexity of a game.

In addition to each side being defined as a set of resources it is defined as having a preference for a particular outcome to the game. In broad terms each side has an objective which it wishes to attain. In some games the objective may be very simple and clearly defined for each side. For example, the objective of the side with the single aircraft may be to attain a specified percent of target damage. In other games the objectives of each side may be very general and imprecise. In the multi-county game, for example, the objective of each side may be to destroy the opposition's will to fight, an objective difficult to represent in numerical terms. Each side commits its resources in ways which it regards as appropriate to attaining its objective. Thus, as indicated in Fig. 1 it operates as a "decision mechanism" relating available resources to desired objective.

2. The nature of the conflict situation. Based on the nature of the sides, i.e. on whether they have few resources and well-defined

objectives or many resources and objectives stated in very general terms, the resulting conflict situation may be very restricted or very large. Four major types may be identified, somewhat arbitrarily, with each having somewhat different simulation requirements. Fig. 2 presents these types and the factors included in the simulation. The simplest form would be a two-sided DUEL with the objectives of the opponents clearly stated and the characteristics of their weapons clearly defined. In this situation there is little difficulty in relating the resources to the objectives of the sides.

Type of Factors Included in Simulation	Type of Conflict Situation			
	Duel	Battle	Campaign	War
Resources	X	X	X	X
Objectives	X	X	X	X
Military Intelligence	X	X	X	X
Environment Characteristics		X	X	X
Background Information		X	X	X
Logistics			X	X
Economic			X	X
Psychological			X	X
Political				X
Additional Sides				X

Fig. 2 Schematic of Major Types of Factors Included in Simulation of Various Conflict Situations.

There are a number of (military) intelligence aspects such as the timing of the firing, and the information each duelist has about the other, etc. that make this a reasonably complex situation. The second type of conflict situation is the BATTLE. In the type of game conflict that simulates a battle situation the objectives and the resources of both sides may be more imperfectly defined, and it may be necessary to include some background information so that both sides have a knowledge of the events that lead up to the particular battle situation. Similarly more of the characteristics of the environment such as weather, terrain, etc. may be included. The battle, however, is an interaction of the two sides over a relatively short period of time compared to the third type, the CAMPAIGN. In this type of conflict situation the resources of the sides may show considerable variation over a period of time and such aspects as logistics, supply lines, maintenance, etc., may be introduced into the simulation. With a longer time period and changing resources the objectives of the opposing sides may vary throughout the campaign and political and psychological factors may be introduced. The final type of conflict situation is the WAR. In this type of simulation the preceding factors are present with economic and political factors receiving increased importance, and with the possible inclusion of many more than two sides. Although the term war game is applied to all four types of conflict simulations the factors that are included in each of the four are sufficiently different so that the task of constructing an adequate representation of the conflict varies considerably from one to the other.

3. The nature of the rules. As was indicated in Section I, a distinction is made between rigid-play and free-play, i.e., games in which there are relatively complete sets of stated rules and in which the play is

limited by the extent to which any action or choice is covered by the rules, and games in which the rules are incomplete and those actions or decisions not covered by the stated rules are judged by an umpire or game director. The "adjudication mechanism" whether it is a stated rule or the judgment of an umpire, is usually made up of two major types of rules, those covering the capabilities of the forces or resources used in the game, sometimes called "planning factors," and those which indicate the outcome of each engagement between the forces.

Some simplified examples of the first type of rule would include:

a. Each weapon fires 20 rounds per minute.

b. On Class D roads the rate of movement is 10 miles per hour.

c. Factory output is six units per week.

Some simplified examples of the second type would include:

a. Three defending aircraft kill one attacking aircraft.

b. Each sortie produces .6 casualties.

c. 80% loss reduces the combat capability of a unit to 0.

The distinction between the two types of rules is based on the fact that the first type applied whether or not there is an opposing side in the game. The second is applied only when an engagement between opposing sides occurs. Since the type, number, and completeness of the rules is one of the critical parts of any war game further discussion of the rules occurs in Section III.

4. The nature of the interplay. The interplay, or interaction, of the two sides is the most outstanding characteristic of a war game. It consists of two parts. One part is the decision of each side to make a particular move (the choice of a specific course of action), and the

second part is bringing these two decisions together and examining the consequences (the confrontation). The particular move made by each side is based on many things, including the forces or resources available, the uncertainties produced by external factors such as weather, and the uncertainties produced by what the opposition can do. As an example, consider a situation in which one side has to examine the following in order to decide on what move to make:

What is the objective of the move?

What forces are available?

What is a preferred combination or allocation of forces?

What is the situation in terms of weather, terrain, etc.?

What can the opposition do to effect the outcome.

Even if there are just a few possible alternatives for each question, such as, the forces may be either fighters or bombers, they may be assigned to one of three targets, they may make an attack at high level or at low level, the opposition may defend one or all of the targets, the weather may or may not be favorable, etc., the number of possible combinations becomes very large. From all of the combinations or alternative courses of action only one can be selected and that choice represents the move that the side will make.

After the choice of one course of action by each side, the two choices or moves of the sides are brought together. This confrontation of the two choices, plus the action of external factors is the second part of the interplay and is diagrammed in Fig. 3. Fig. 3 indicates the major aspects of the dynamics of a war game: the selection of one of several courses of action by each side and the confrontation of the two choices leading to

the determination of an outcome that in turn establishes another set of choices. A war game can thus be regarded as representing a series of successive states (S-1, S-2...S-T). Each state after the initial one is determined by the selection of one alternative out of a number of possible alternatives by each of the sides. This process continues until a defined termination state is reached.

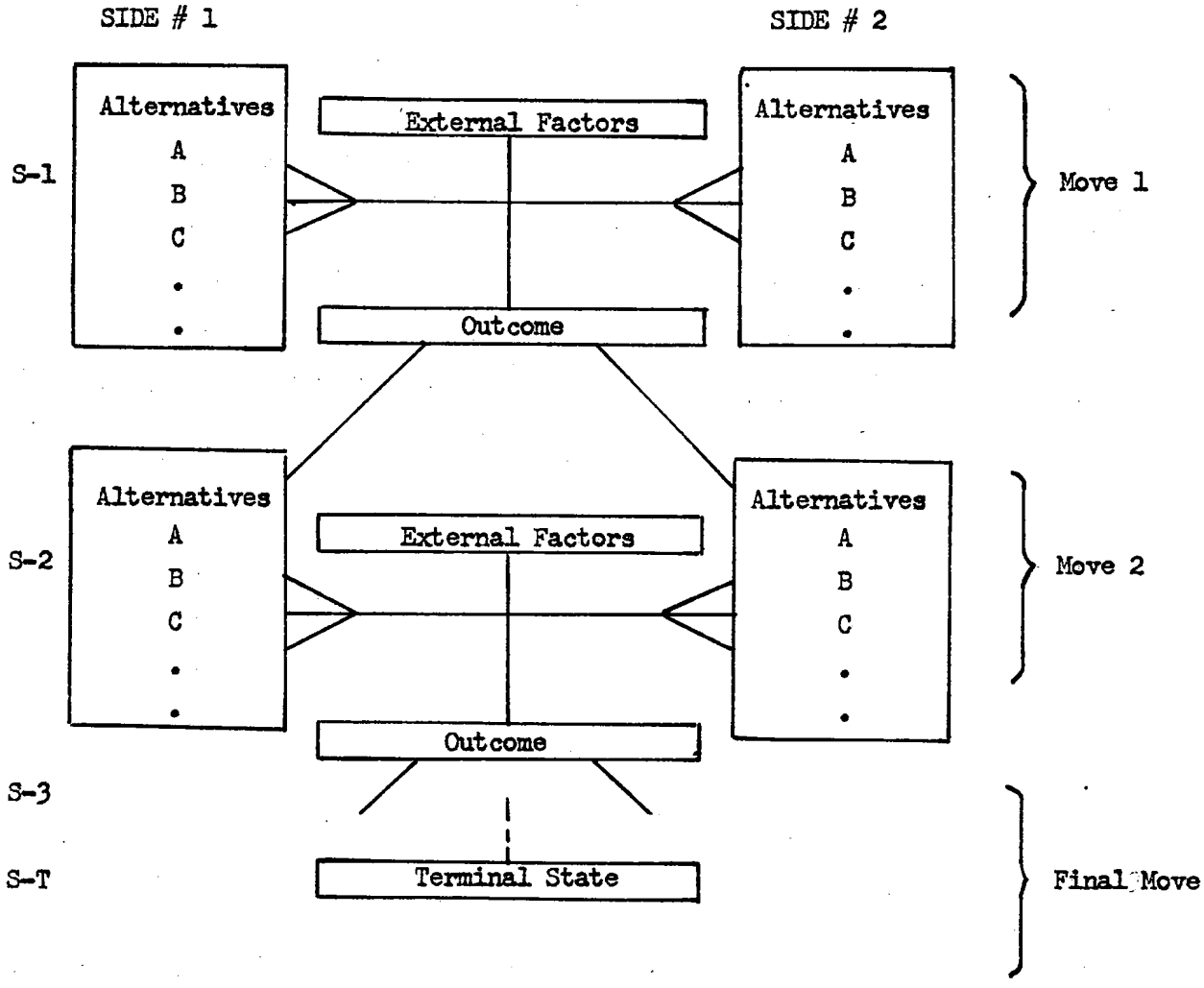

Fig. 3 Dynamics of Interplay

The characteristics listed above are combined in various ways in the different types of war games.

In some types emphasis is placed on problems of selecting the best course of action (i.e. strategy), in others emphasis is placed on determining the effect of employing one type of resource rather than another, in others the emphasis is placed on examining the consequences of one choice rather than another, etc. In the following portions of this section four major types of war gaming are described briefly and the characteristics of each technique are indicated. The four types are:

Mathematical games

Machine and man-machine games

Board and bookkeeping games

Umpired games

1. Under the mathematical games are included games subject to analysis by game-theoretical techniques. In these games each course of action available to one side is matched in a matrix by a course of action available to the other side and the expected outcome for each combination is specified. As an example, the following matrix shows two strategies for Blue and two for Red with the expected outcome for each combination.

		RED Strategies	
		A	B
BLUE	A	2	2
Strategies	B	1	3

We can give the matrix an apparent military meaning if we assume that the situation is one in which Red is trying to move up his troops for an attack on a Blue position. He has a choice of routes, one through a

mountain road which offers concealment, but is difficult for men and equipment (Strategy A), the other across a desert road which is easy to travel, but offers no concealment (Strategy B). Blue knows the attack is coming, but he does not know which route, mountain or desert, will be used by Red. Blue has a number of bombers ready to prevent the move of the Red troops. He has divided his bomber force into a large force and a small force, and he can use the large force against one axis and the small force against the other. His strategies can be: large force against mountain road, small against desert road (Strategy A), or large force against desert road, small against mountain road (Strategy B).

The outcomes of the various combinations are shown in the matrix. The numbers represent the number of regiments the Blue will destroy. They are, in a sense, a gain to Blue and a loss to Red. Examining the combinations shows:

If Red chooses Strategy A (mountain road with concealment) and Blue chooses Strategy A (main attack on this road) Red will lose two regiments.

If Red chooses Strategy A and Blue chooses Strategy B (large force on desert road) Red will lose one regiment (from Blue's small force).

If Red chooses strategy B (desert road with no concealment)and Blue chooses Strategy A (mountain road with concealment) Red will lose two regiments (from the small force).

If Red chooses strategy B and Blue chooses strategy B, Red will lose three regiments.

In mathematical games of this type it is possible to deduce the strategy which each side should employ. It can be shown in this example that Blue should choose his Strategy A and Red should choose his Strategy A,

with a resulting loss to Red (gain to Blue) of two regiments. In some cases such as this one the solutions indicate a single best strategy which each side should choose. In other games, however, each side has to choose strategies according to a calculated probability.

Several characteristics of games of this type can be noted in the example. The situation assumes that the choices indicated were the only ones available to Blue and Red. It assumes that it is possible to determine or specify a precise pay-off, and that the "units" in which the payoff is expressed are adequate measures of the outcome. It also assumes that the units in each cell are equivalent, i.e. all the numbers refer to regiments. Assumptions of this type are basic to game-theory. Many military situations, however, cannot ordinarily be characterized in this manner. An examination of this point is presented in Haywood (2) from which the above illustration was adapted. Although game theory has had only a limited number of applications to date, a considerable amount of effort is being devoted to further development of the theory and to extensions to more complex military situations, and it promises to become an increasingly useful technique.

Another type of mathematical game is one in which a series of choices on allocation of forces is available to each side. One example of this type is an allocation problem in which each side can choose between allocating his aircraft to one of three roles: counterair, counterground, or close support. The problem for analysis is to deduce throughout the campaign a correct allocation for each side. One form of this problem is presented by Fulkerson and Johnson (1). In this situation, as in the preceding one, the conditions must be defined very precisely and the choices available are limited and definite.

2. Next are games that involve computing machines. An example of this type might be an air attack game which traces through the history of each attack and determines the outcome of the attack on a specific target or target complex.

Such a game might take into account the following types of factors:

a. Take-off factors
   Bomb Load
   Abort

b. En-route factors
   Operational failure
   Navigational error

c. Enemy opposition factors
   Area Defense survival
   Local Defense survival

d. Target factors
   Identification
   Bombing error
   Degradation

e. Return to base factors

The numerical values or probability distributions for each of the factors might be obtained from any of several sources. They might be obtained from empirical data. For example, the abort rates of the particular aircraft used in the study might be based on information available from actual military operations or from training exercises. Other factors may use values based on analytic studies such as amount of target destruction as a function of bombing error.

The computing machines, using Monte Carlo techniques, could play through a large number of attacks. The factors for each side would be varied and the analysis would indicate the extent to which some of the factors were critical to the outcome of the attacks.

A variation of the machine methods is the inclusion of one or

more human participants in the game. In this type of man-machine game the human player may select the attacks that are to be made in terms of the size of the force to be used, the composition of the force, the nature and type of attacks to be flown, etc. The human player serves as a decision-making mechanism and the machine carries out the computations based on his decisions. The situation may even be expanded so that two players, in opposition, are each allowed to make offensive or defensive choices. The addition of human decision sources increases the complexity of the game, but may serve to reduce machine requirements since the human player can establish a priority system or ordering of decisions and thus eliminate many possibilities which the machine would otherwise work out routinely.

3. A third type are the board and bookkeeping games. These games have definite rules but they use human participants on the sides to select courses of action and allocate resources. The board games are like chess games played on a grand scale with the board representing large geographical areas and the pieces representing many different types of forces with different capabilities. The bookkeeping games are similar to the board games except that the forces are represented by bookkeeping-type entries on tally sheets. Both of these games differ from the machine games in that the number of possible actions by the sides and their consequences over a period of time become so numerous or interact so much that they exceed any reasonable machine capacity.

4. Finally we have games which involve human umpires. These include the games where a human "adjudication mechanism" is used because the rules are incomplete. Games of this type cover a very broad spectrum, primarily because of the great freedom in play permitted. At one end of

the spectrum we have the "one-sided" game. This is the type that has been quite popular in military establishments and involves one side playing against the umpire who represents both Nature and the opposition. The umpire is usually a senior officer with a large amount of military experience. The game is of value since it allows the participants to discuss all of the decisions made and the reasons for the outcome as decided by the umpire, and thus provides the players with a way of obtaining experience from senior professionals.

Further along the spectrum are two-sided games in which the sides play through a human adjudication mechanism (now generally called "Control") which decides on the outcome of each of the interplays using standard, numerical, or mutually agreeable factors wherever possible, and judgment or experience when necessary. Games of this type can become very large with each side being represented by a staff of players and control being composed of a large number of specialists and experienced personnel for making the necessary decisions. These games may include a large amount of special equipment both for the playing of the game, for example, communication equipment to simulate the actual transmission of orders, or computers for special bookkeeping, computations, or analysis related to the moves made.

The four different types of games cover a broad spectrum in terms of the amount of freedom available for each side, the completeness of the rules and the way in which the outcome of each engagement is determined. These aspects for each of the four types are presented in Fig. 4. Fig. 4 is a highly schematic representation since the aspects are interdependent, and the differences between the games are not as clearly marked as they appear. Most war games actually played are a combination of types. For

example, most of the umpired war games have some portion of the game in which either manual bookkeeping or machine computations are used. Similarly, the aspects cited are highly interdependent. Nevertheless Fig. 4 does schematize the position of each type and provides a reference for several parts of the following section.

Fig. 4 Characteristics of Four Types of War Games

TYPE OF GAME	COURSES OF ACTION	RULES	OUTCOME
Mathematic	Specified: Limited	Complete	Deduced
Machine	Specified: Limited	Complete	Computed
Man-machine	Selected: Limited	Complete	Computed
Board/Bookkeeping	Selected: Many	Complete	Computed
Umpired	Selected: Many	Incomplete	Judged

Section III. Uses of War Games and an Example

Over the years war games have been used in many different ways. Because they simulate one of the most important of human activities, the conflict situation, they have always had considerable interest. In addition, the minimum requirements of two sides, a contrived conflict, and a few rules (some of which can be the arbitrary decisions of an umpire) are easily met. With this combination of interest in a basic human phenomenon and ease of representing this phenomenon it is not surprising that so many varieties of war games exist. In the symbolic and social form of parlor games, like chess and checkers; in the active and concrete games of children, like "cowboys and indians"; in the map maneuvers of the military staff; in the campaign studies of the research analyst; and in the mock exercises of military training are found examples of the appeal and use of war games. Since any attempt to catalog all of the possible uses of war games would have to encompass all of these diverse activities we have restricted the list to the four uses of interest to analysts of military operations. These four uses are:

1. As training devices
2. As organizing devices
3. As research and evaluation techniques
4. As stepping-stones to theory.

1. The use of war games as training devices. This is the time-honored use of war games extending back at least to the inclusion of the board-type games of von Reisswitz, Jr. in the training curriculum of German officers. It is still the most widely recognized use. All of the training-type games attempt to create an environment in which experience can be obtained that will reduce or prevent dangerous and costly mistakes in real combat situations. The hope is that the simulated environment presented by the game

will create in the student an awareness of the many factors and actions that influence military operations, and provide skill in planning, maneuver, tactics, etc. Training games come in various sizes and forms and the way in which the objectives of the games are achieved may be very specific or very general. In one type of game the student may be required to become familiar with the command of combat units by practicing communication procedures, writing orders to subordinate commanders, and specifying such other activities as are appropriate to the simulated military situation. In other games the emphasis may be on the calculation and planning necessary to maintain an adequate logistic situation and the student may be required to determine the amount and types of supplies that will be needed, how they will be loaded, transported and delivered in the face of enemy opposition.

In still other games the objective may be to develop an understanding of particular geographical areas and an appreciation of the ways in which terrain, weather, time, and local conditions influence military operations. The simulated environment or model, developed for any one of these objectives will differ from the model developed for others. In one game the communication net may be represented in great detail and a large set of rules covering the use of the net may be included. In another, the entire communication structure may be represented as a time-delay in the military operations. The particular model will be appropriate to the type of training that is being conducted and those aspects deemed unnecessary will be reduced or eliminated. At times the simulation may deliberately distort the phenomenon or situation that is being represented, in order to achieve greater usefulness in meeting the training objective.

2. The use of war games as organizing devices. Frequently it is

desirable to devise a situation in which the experiences and judgments of a number of different military analysts can be brought together. By creating a specific situation the relevant factors will be seen in a definite context and inter-relations that might have been ignored or overlooked are brought into group consideration. War games provide a method for getting mutual insights into the complexity of the problem and some of the major aspects that influence the outcome and therefore require study. This use of gaming as a self-educating or organizing device is not generally carried out in a very formal way. A conference or seminar technique may be used to explore the problem from different points of view in order to apprehend its magnitude and nature, to pool the judgments of the various specialists, and to provide a specific and concrete example for discussion. Many military studies which are not war games have an initial period in which a crude form of gaming is undertaken. These studies start by listing the important factors in the military situation, the choices available to each side, and the kinds of constraints or limitations that will influence the choices of each side. These are then examined to determine whether important elements have been overlooked. This use of war gaming provides a definiteness and concreteness to many studies that can be of great value.

3. The use of war games as research and evaluation techniques. The objectives of this use of war games is the same as the objectives of any other research technique. These include determining what factors are important, discovering of important relationships in the phenomenon under investigation, drawing conclusions, etc. In the case of war games these are in the area of military plans and their outcomes, military tactics or doctrine and their effect on military operations, or the performance of specific military weapons or weapons systems. There are three general procedures that are

associated with the use of war games for research. The first of these is the use of war games as observation techniques. In this use an hypothetical military situation is established and considerable freedom is allowed in the playing of the war game. The purpose is to attempt to uncover significant relationships or to obtain insight into the particular situation. The free-play form of game is particularly adapted to this type of study. A second research use is as a comparison technique. This is the standard technique of experimentation in which two situations that differ in only one major aspect are created and an attempt is made to determine whether the difference is significant or critical. In this use, it is two military plans, policies or weapon systems that are being compared. One of the plans, policies, or weapons in the comparison is usually the one that exists currently and the other is some proposed change. The third type is use as a development technique. In this use, the game is played with the purpose of examining a particular plan, policy, or weapon system in order to see how it will perform in various situations or circumstances, and in this way to draw conclusions about modifications or adaptations that should be made in order to improve the plan or weapon. A similar use is to examine situations in order to determine what new plans, doctrine or weapons might be required or desirable.

4. The use of war games as a stepping stone to theory. Games with this objective are usually attempts to obtain a more useful and general model of military operations. They are used to examine the various parameters that influence the outcome of the operations in the hope that the important ones can be isolated and better defined and that some numerical value or distribution can be assigned. The games represent a preliminary step towards a more precise formulation which would then become part of a broader theoretical structure and have still greater value and convenience.

An Illustrative War Game

With the large variety of uses, techniques, and characteristics of war games no single example can encompass the entire range. The example that follows is therefore more of an example of the steps involved in a war game than an illustration of a specific game. Like any other simulation technique, war gaming involves a number of different steps. These can, somewhat arbitrarily be divided into:

1. Determining the objective or purpose of the game
2. Preparing the inputs and boundary conditions
3. Establishing the adjudication mechanism
4. Playing the game
5. Analyzing the game

To illustrate some of the considerations that are important for each of these steps let us assume that we are going to use war gaming techniques to evaluate the military effectiveness of a weapon system.

It is assumed that the weapon system — a completely fictitious one — has well defined technical characteristics, but that its capabilities in a military situation are largely unknown. The war game is to provide some indication of the effectiveness of the system.

1. Determining the objective of the game. Determining the objective of the game sets the format for all of the subsequent steps. It is the objective that establishes the magnitude of our simulation, i.e. how large a hunk of the world we will try to represent. It determines the complexity of the game, the level of detail that will be included and the magnitude of the play and of the analysis. This is one of those self-evident statements that are evidenced over and over again in the course of gaming and almost any other simulation technique. It seems <u>particularly</u>

true of gaming because the types of problems that are chosen are usually fairly broad in scope, difficult to keep limited and subject to many possible interpretations by the designers.

The hypothetical problem we have chosen can be set up for analysis in a large number of ways. We may formulate very well defined military situations with very limited conditions. We may even be able to establish the important parameters and assign reasonable values or probabilities to them. We may then evaluate the weapon system in this specific situation without regard to preceding events or actions in the situation and without concern for the outcome of the situation as part of a broader military campaign, i.e. our evaluation may be very static from the viewpoint of taking place outside of the context of a full-scale military operation. If we were to do this and present our findings to any reasonable audience they would immediately, and quite correctly, raise questions about the findings. They would point out that we had only looked at a single situation, that we could easily have chosen other situations in which the results would have been different, that we had not established that the specific situation was a reasonable one to consider, etc., that we had not, in fact, been very complete or comprehensive in out study.

Aware of this possibility we could consider the problem in a broader way. We might decide to investigate a number of situations with different possible operations of the weapon system. But what possibilities? At this point, as with any analysis, we would have to consider a large number of alternatives and make an initial judgment on which possibilities were the most important. The various situations which we would consider represent judgments on the part of the analysts. For many reasons these

judgments may be unavoidable, but it should not stop us from recognizing that these are judgments. Similarly the selection of some of the situations for study, to the exclusion of others, is also a judgment. And it is a particular type of judgment: it is a judgment that the specific situations which have been selected have a more reasonable chance of occurring than the ones that have been eliminated. So it is a prediction about the future. We might try to justify this by saying that we are not trying to predict that the situations will occur, but only to examine the effectiveness of the weapon system if they did occur. In a sense this is one of the major problems with war gaming. We are forced, because of real limits of time, technique and personnel, to restrict our choices of situations for study. But even if these restrictions were eased, we might find that to explore all of the possible situations which could be imagined, either realistically or not, would take such a long time that our weapon system would have become obsolete by the time we had enough data to evaluate it.

We might try something entirely different: we might move our analysis into a time period in the future which is sufficiently advanced so that even though we require a longer period of time to examine a larger number of possible situations and factors by game means we are capable of ending up with more comprehensive results. There is a lot of discussion, both pro and con, on the use of war gaming for periods somewhat far removed into the future. At the present time, no clear answer on the applicability of gaming to remote future time is possible. What we do know is that as we move into the future the problems of prediction affect a number of different aspects of the game and increase our difficulties.

These problems of determining an objective do get solved. Sometimes the solution is based on defining the objective of our analysis in

terms of the best available evidence and judgment that the situations chosen for study are appropriate. Sometimes the solution is based on an arbitrary decision that is influenced by the resources available to the gaming staff. And sometimes it is merely based on the "pious hope" that the selection is sound.

2. Preparing the inputs and boundary conditions. The next step in gaming is the preparation of the inputs. With the determination of the objective and the selection of situations which will be considered, the inputs must be established. Three main types can be distinguished: the inputs that define the environment or context in which the weapon system will be used; the inputs that establish the operating characteristics of the weapon system; and the inputs that establish the effectiveness of the weapon system.

In attempting to define the locale or context, several major choices appear immediately. They are related to the original choice of objective, but take on new meaning at this point. The choices include such questions as:

- Is our primary concern with evaluating the effectiveness of our system as part of a grand strategy, a limited strategy, or in tactical combat, or — what amounts to a somewhat similar question — in a battle, campaign, or war?
- Based on our choice, how complex a pattern of political, military, economic, logistic, and intelligence events or conditions should be included?
- To what extent shall we limit or constrain the actions of each side?

The answers that we give to these questions determine the boundary conditions of a war game.

If the war game is concerned with a grand strategy situation the inputs will include more than just military forces and targets. They will include in some form or other the characteristics cited in Fig. 2. If, on the other hand, the game is concerned with limited situations, there is a large selection of locales possible with factors in each locale that will very likely influence the evaluation of the effectiveness of our hypothetical weapon system. For example, a clear, dry desert-type environment may present entirely different problems to our weapon system than a wet, overgrown jungle-type environment.

The second type of inputs, the operating characteristics of the weapon systems, present additional requirements; it is not sufficient to know the technical characteristics. There will be many other factors that will become important: the deployment and employment capabilities, schedules, and limitations, the tactical procedures, the operational requirements, the serviceability, maintenance rates, and similar factors will have to be established. And if our weapon system is one of many that will be included in the game in order to see its relation to other weapon systems and forces, similar inputs will have to be established for the other systems.

A third type of inputs, those required to establish the effectiveness of the weapon, will be required. And here again there are several major problems which appear. One is that for many of our weapons we do not have the type of data or information that is necessary. We have had little experience with certain types of military situations and although it is possible to make many inferences from tests, simulated exercises, and field studies, we must approach the application of these results to actual warfare

with some caution. The noncombat conditions are always different, and we have no acceptable and precise way of relating them to combat. Secondly, most of what we do know on the basis of prior military experience, is in the nature of results or values for particular situations. But in our gaming we may be dealing with specific situations having characteristics that differ from those to which the available results or values apply.

These are some of the requirements that must be met in preparing the inputs. The boundary conditions and inputs are obviously "rules" of the game, i.e. they are statements based on real world conditions or characteristics which are not to be violated during the play of the game. In every case where it is possible quantitative statements are used, but there are many cases where it is not possible and here reasonable judgments have to be made. In some cases only the very broadest statements are sufficient, while in other cases it is necessary to be as precise and definite as the data and information permit. The amount of detail will differ from game to game depending on the particular problem being analyzed, but, unlike many other techniques, the uncertainty about how the play of a game will develop makes it difficult to determine the correct detail for all of the inputs in advance. This requires obtaining or developing additional inputs as the game progresses.

3. Establishing the adjudication mechanism. Following the preparation of the inputs and related to them is the establishment of the adjudication mechanism that will be used to supplement these rules. In some cases the rules are completely prescribed in advance, i.e. no additional adjudication mechanism is needed but a bookkeeping and rule enforcement mechanism is used. In the majority of games the rules are not completely specified and the adjudication mechanism takes the form of an umpire or control

function which decides on all cases where the rules are inadequate for the situation. The control function is a way of filling in our lack of knowledge with judgments. The judgments are based on whatever evidence exists, plus as much expert opinion as can be produced. In many cases the judgments are not particularly critical to the outcome of the game, but are necessary to keep the game from bogging down when a situation arises where the rules are not complete or clear. In two kinds of cases, however, the judgments can be very critical. One case is when the judgment applies to a particular event or situation that is so important as to affect the entire outcome of the game and the evaluation that is being conducted. The other case is when the judgment applies to some set of effects or actions that occur with great frequency in the game such that over the entire game they can accumulate in a manner that affects the evaluation. For example, judgments about the casualty producing effect of our hypothetical weapon system which may be used a number of times in the game may be in this category. It may be possible to establish what the effect will be within several orders of magnitude. If the analysis depends very heavily on the judgment it may be necessary to review the game, taking several different values for the effect to determine how sensitive the evaluation is to the judgment.

4. Playing the game. As was indicated in the preceding, there are many different techniques for carrying out game play depending on the magnitude of the conflict situation, the number of forces involved, etc.. For the example of our hypothetical weapon system we will assume that the game will be one in which human participants are to be used as the decision mechanisms (Blue and Red) and the adjudication mechanism (CONTROL). We can play the game by several different methods. We can separate the two sides, perhaps using a different room for each side, and present them with the

military situation. Each side then examines the situation and decides on a preferred course of action. The course of action of each side is presented to CONTROL which then decides on the outcome, using the available rules supplemented by judgment as necessary, and informs each side of the outcome. In this method of play, called 2-sided play, the players do not interact with each other directly, only through CONTROL. This permits the game to include intelligence play, i.e., moves made without the opposition knowing about them except through normal (game) intelligence channels. It thus allows a considerable amount of uncertainty to enter the game since one side may move its forces or plan its operations with some degree of secrecy. However, this method with intelligence play allowed generally develops a great amount of detail since the value of intelligence depends on using relatively small units of time for each game move.

Another method, called the joint adjudication method, allows each side to prepare its move separately, but both sides and CONTROL work out the interplays together. In this way the game is speeded up with some cost in detailed play. A third method, called the seminar method, has the sides and CONTROL mutually deciding on which move to be made and what the outcome will be. This "cards-up" type of game can be very rapid, but it loses a great deal of detail and all intelligence play. In theory, no CONTROL is required in this method of play, but in most cases one is included in order to provide direction and guidance to the game.

In the case of our weapon system evaluation we would probably choose the 2-sided game for several reasons. One is that we wish to examine the performance of the system in a military situation in which one side is actively attempting to reduce the effectiveness of the system, or exploit any vulnerability that it develops. Secondly, we do not wish to overlook

any advantage to be achieved by being able to deploy or initially employ the system without the opposition's knowledge. And finally, we may wish to examine any characteristics of the system against which the opposition could take appropriate counter actions if aware of them.

A final point about playing the game concerns the termination of the game. In all of our parlor and athletic games we have some form of stop rule, like the "checkmate" of chess or the ninth inning without a tie score in baseball. We know when the game is over and we know who has won. In war gaming we sometimes know neither. It is true that the games come to an end and that this end is sometimes definite. For example, our weapon system might have completely destroyed the capability of the enemy to fight further in any effective military manner. There still may be questions about the long-term solution, but these are not critical to the evaluation of the system. This type of termination is very rare; we are usually left with a situation in which there has been destruction of part of the military capability of both sides, but a residual capability exists and it is possible to indicate ways in which military operations could continue and could affect our evaluation. The most frequent termination of a war game, therefore, usually occurs on the administrative level where it is felt that the game will reveal no more significant material for analysis. Although this may not be completely adequate, the present state of our knowledge offers no satisfactory substitute.

5. Analyzing the game. The final step in the gaming is analysis. During the course of a game a large amount of information has been accumulated but it is of many different kinds. Each move in the game involved actions taken by both sides. If there were a large number of moves there may be a sizable body of data about the allocations of friendly forces, weapons, and resources, the objective of the allocations, the enemy allocation of forces,

weapons and resources and their objectives, and the outcome of each interplay. If the gaming situation is very broad these military move cycles will be accompanied by logistics, political, intelligence, and economic moves and outcomes. With this much data, different types of analyses can be made.

One type of analysis may be the overall evaluation of the game, showing how various moves contributed to the final outcome. This is sometimes satisfied by a critical narrative of the game indicating the actions and counteractions of each side, particularly those related to the weapons system. The narrative may have several functions. It can provide a synthetic history in which the various conditions, circumstances, and actions affecting the use of the weapon system can be appreciated, or in some cases, re-examined to determine their influence. Or it may provide a test-bed in which, by changing some of the initial assumptions, other alternatives in the use of the weapon system or perhaps other weapon systems can be explored.

Related to this overall evaluation, or in some cases, quite independent, may be an analysis of some particular aspect. In the case of the weapon system it may be the effectiveness of the system under the different conditions that arose during the course of the game. For example, we may be interested in such things as the number of times there was an opportunity to commit the system, the number of casualties produced per unit committed, the logistics requirements to obtain a given level of effectiveness, etc.. In these types of analysis much of the more general material of the game will not be significant.

Another type of analysis might be concerned with the factors which influenced the effectiveness of the system, varying from political constraints, intelligence requirements, to weather and terrain conditions. This type of analysis may be quite independent of the particular moves made, simply

examining each of the many situations that developed in terms of weapon effectiveness. It may also highlight those situations in which the weapon system was not used and provide some indications of why the system was not used or how the situation might have been changed to make it more usable

Still a fourth type of analysis might be concerned with identifying problems. For example, problems that arise in the deployment, employment or operation of our hypothetical weapon system. In these cases the main function of the analysis may be to indicate the problem area so that it can be investigated further and, perhaps, lead to a technical study of ways of surmounting it.

These different types of analysis are possible because a war game of the type that has been described in a very rich source of data as well as of opinions and judgments. It is this characteristic that produces the many different types and uses of war games. In some of the games, as indicated in the preceding section, emphasis is placed on obtaining data, while in others the emphasis is on providing a focus for different judgments and opinions. Thus war games have been used in research and evaluation as well as in training and indoctrination. As a simulation technique their use in training has been longstanding and unquestioned. And with the development of more complex weapons, organizations, and procedures they will undoubtedly find increasing usefulness in the training area. As research devices war games have both benefits and limitations. Some of these, as discussed by Specht (6), and Thomas and Deemer (7), are inherent in the war gaming technique. As games come into wider use and receive greater scrutiny they will, like other simulation techniques, become more effective research devices.

BIBLIOGRAPHY

1. Fulkerson, D. R. and Johnson, S. M., A Tactical Air Game, J. Opns. Res. Soc. Am. 5 704-712, 1957

2. Haywood, O. G., Jr., Military Decision and Game Theory, J. Opns, Res. Soc. Am. 2, 365-385, 1954

3. Luce, R. and Raiffa, H., Games and Decision, John Wiley and Sons, Inc. N. Y., 1957

4. McKinsey, J. C., Introduction to the Theory of Games, The RAND Corporation, McGraw Hill, New York, 1952

5. Murray, H. J. R., A History of Board Games, University Press, Oxford, 1952

6. Specht, R. D., War Games, in Davis, M. and Verhulst, M. (Eds.) Operations Research in Practice, Permagon Press, N. J., 1958

7. Thomas, C. J. and Defmer, W. L. Jr., The Role of Operational Gaming in Operations Research, J. Opns, Res. Soc. Am., 5, 1-27, 1957

8. von Neumann, J. and Morganstern, O., Theory of Games and Economic Behavior, Princeton Univ. Press, Princeton, N. J., 1947

9. Williams, J. D., The Compleat Strategyst, McGraw Hill, New York, 1954

10. Young, J. P., A Survey of Historical Developments in War Games, Staff Paper ORO-SP-98, Operations Research Office, The Johns Hopkins Univ. 1959