WAR GAMING AS A TECHNIQUE OF ANALYSIS

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War gaming is the traditional final step after the preparation of a war plan; it is universally regarded as the best peacetime test of a plan. Recently, the technique of war gaming has been modified to make it a method for solving problems previously thought to be beyond analysis and answerable only by appeal to the judgment of experts.

THE CONTEXT OF MILITARY PROBLEMS

The problems we have in mind are those problems which cannot be detached, for purposes of investigation, from their natural context. As an example of a detachable problem, one might determine the best size for a bomber cell* given various reasonable assumptions regarding enemy defenses, target lists, electronic countermeasures, and so on. The cell-size question can be studied intelligently and a dependable answer can be obtained without getting involved in an examination of the entire course of a possible war. The question of what is the appropriate target list, however, is not readily detachable from the entire war. Destruction of certain targets may have a profound effect on ground warfare in the main theater of operations, for example, while destruction of others are vital for neutralization of enemy air power. It is possible to assign

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*A cell is a small group of bombers which flies together over enemy territory and attacks one or a few targets.

relative priorities to these two kinds of targets in a limited context; they must be assigned in consideration of the war as a whole.

Problems which can be abstracted from their general context are said to be "factorable." The solution of such problems is called a "sub-optimization" [1] and depends on an arbitrary choice of a simple generally acceptable criterion. Thus one might find the optimum bomber cell size using some such criterion as:

(a) minimize crew losses

(b) maximize number of targets destroyed

(c) maximize probability of destroying first hundred targets on the list

These criteria are obviously chosen with the given problem in mind; they are not national war objectives or even logically deductible from those objectives. But if a problem is properly factorable, any such reasonable criterion can be expected to give a reasonable answer and, in fact, about the same answer as any other reasonable criterion. A nonfactorable problem involves much more general considerations. It can be encompassed by no simple easily applied criterion.

As might be expected, the simple dichotomy between factorable and nonfactorable problems is a useful concept but probably not a fact of the real world. Problems are never completely factorable — just more or less factorable. All must have a certain amount of context; some require very little whereas others require a very elaborate context. The question of how much context a given

problem requires appears to be largely a matter of judgment. For example, the question of allocating sorties between air superiority missions and close support missions probably can be done in the context of the theater war and in terms of theater objectives. But the allocation of weapons between strategic and tactical target systems surely must be done in the context of the entire war and in consideration of national objectives.

The war gaming techniques to be discussed here are devised to deal with problems whose analysis appears to require appreciable context — problems which cannot safely be factored out of that context.

GAMES

It is almost certain that any nonfactorable problem involves elements of conflict too important to be ignored. That is, there are elements in the situation which have a significant effect and which are in the control of the enemy. Such elements can be neglected only when the enemy strategy is clearly fixed and known — a condition which sometimes obtains in the case of simple factorable problems but rarely in the case of the more complex problems with which we are here concerned.

During the past ten years there has been much theoretical investigation of games and rational modes of behavior in conflict situations. This research began with the publication of "The Theory of Games and Economic Behavior" [2] in 1944; it has developed a considerable body of clarifying ideas and a technique

which can analyze quite simple economic and tactical problems. These techniques are not even remotely capable, however, of dealing with complex military problems.

In an attempt to deal with these problems, analysts (particularly at RAND and the Operations Research Office) have turned to the military war game and adapted it to analytical purposes. The conventional war game is a rather exhaustive examination of a specific war plan with a view to uncovering flaws in that plan. Three teams (Red, Blue, and the Umpire Team) play through a war in detail on maps. Blue's strategy is fixed by the plan. Red devises a strategy particularly intended to expose weaknesses in the plan. The results of the players' moves are adjudicated (after a certain amount of debate) by the Umpire Team. It is not a game in the ordinary sense in which players freely choose their strategies and the outcomes of their moves are determined by written rules.

GAMES FOR ANALYSIS

For purposes of analysis, a game needs to be more like a parlor game. The solution to a given problem usually means finding a sound strategy. The game representing the problem must be easily playable and must be played numerous times by the same players so that they can develop a knowledge of the structure of the game and a feel for good strategies. A game that is to be replayed many times needs a fixed set of rules so that experience gained in one play is valid in other plays.

If a complete set of written rules is needed, then the game cannot represent a detailed global war; at least that possibility must lie many years in the future. The game should include whatever context is needed for a proper treatment of the problem at hand, but no more. Further, those aspects which are retained in the game must be severly simplified and combined into easily manipulable factors in the interest of having a playable and understandable game.

The writing of a set of rules for a game is a major project involving decisions mentioned above, compilations of planning factors, specification of interactions of various factors, numerous side studies to fill in areas where rules are necessary but knowledge is not existent. It is difficult to justify such a project for a specific problem, and the tendency has been to develop general purpose games which can be readily adapted to various problems by the addition of a few extra factors and rules.

A general purpose game is set up at some particular level in the command structure and includes only such details as are appropriate for a commander at that level. Thus there are being developed at RAND three games at the levels of:

1. divisional commander
2. theater commander
3. commander-in-chief

The first game is suitable, for example, for studying problems related to deployment and tactics of small troop units on a small sector of a front, problems having to do with the detailed

investigation of the role of close support sorties in ground combat, problems associated with the military value in detail of air superiority, and so on. In the third game, for example, military forces are included only in very gross classification and the national economy is as much a part of the game as the military forces; that game is suitable or can be readily adapted to the study of such problems as budget allocation between air, ground, and sea forces; allocation of the Air budget between strategic, tactical, and defense missions; the priority of "tactical" versus "strategic" targets; the effects of defection of allies; and so on.

WHY GAME?

The construction of a game involves judgment at every turn: in the scope of the game, the level of detail, the content of the rules, the adequacy of its representation of reality, the opinions of players as to what are good strategies. Why not just answer the questions the game is supposed to analyze by referring to a military expert in the area of the given problem? What does the game do that an expert cannot do?

The game pools the knowledge of numerous experts. The more complex a problem is the less the likelihood that a person can be found who is expert in all its facets. And even if such a person could be found, he would himself have to integrate in his mind all this special knowledge into one coherent structure and analyze that structure. A slightly different problem would require a different expert adept at most of the original facts and perhaps one or two others. But his structure might be vastly different.

For a very complex problem it certainly is necessary to combine the knowledge and experience of many experts. It is a plausible assumption that a carefully organized combination of their knowledge into a single self-consistent whole would provide a much firmer basis for decisions than, say, a round-table discussion among the experts. Of course, it is a great deal more trouble too, but the military establishment faces many problems that easily justify the effort.

A game is an endeavor to put down in writing a basic structure which must necessarily be a part of any intelligent consideration of any nonfactorable military problem. People can then see it and study it and debate it, and over a period of time arrive at some sort of general agreement about it. Even when that has been accomplished gaming is admittedly an inexact analytical tool beside the methods that chemists and physicists use, for example. But it is a wide step beyond armchair judgment in the sense that it provides an operational and roughly verifiable (repeatable by other persons) technique for dealing with problems not otherwise amenable to quantitative analysis.

NATURE OF THE GAMES

Games presently under development have taken a great variety of forms so that very few general statements can be made about them. Of course, all of them have two opposing teams which make a succession of moves. The outcomes of moves are determined by rules, not by umpires. Generally the teams are small, often just one or two

persons. Because it is envisaged that a game must be played frequently if it is to be understood, every effort is made to keep the playing time short; most games can be played through once in a few hours or a few days.

The number of quantities that players can manipulate and keep reasonably well in mind is limited probably to some number less than a hundred. One game at RAND has about sixty quantities each player must come to some decision about on each move; the various interactions of these quantities with themselves and with the corresponding enemy quantities raises the actual number of decisions per move to several hundred.

A game designed to study intensively a limited part of a war, such as, for example, a sector assigned to a division on the front line, can deal with such factors as tanks, companies, artillery batteries, geographical details, individual close support missions, and so on. A game designed to study problems at the level of the theater commander cannot deal with military forces and actions in such detail if the number of factors in the game is to be kept down to a reasonable number. Such a game must deal with aggregated factors. Whereas a player of the intensive game might send a single aircraft to attack a specific enemy tank at a specific location, the theater game might merely direct that 600 close support sorties be flown against all armored divisions without specifying targets in any more detail or locations at all; the result of this action might be expressed only in the form of a percentage representing temporary decreased effectiveness of the attacked divisions.

A more general game designed to study problems at the level of the Joint Chiefs of Staff, for example, would deal with even more aggregated and perhaps abstract factors, such as index numbers representing munitions productions, consumption of military stockpiles, gross attrition of military forces, gross tonnage of the overseas transportation system, and the like. The intensive game might be played with interesting objects like toy tanks, planes, soldiers moved by hand on a sand table; the global game would have only such things as the summary statistical tables of the War Production Board of World War II, periodic communiqués of theater commanders, priority headaches, and so forth.

THE PROMISE OF GAMES

Most games now in existence need further development and refinement before they can be said to represent reality well enough to provide a basis for decisions. And until that time comes one cannot be certain of what the games will accomplish. Nevertheless, the people working on these games are motivated by very interesting and important potentialities.

It should be mentioned that the question of how correctly games can reflect reality does not trouble game makers for two reasons. In the first place, they feel that the number of significant factors in any given situation is not so large as to be out of the question in the game representation. In the second place, modern high-speed computers will enable the number of factors which can be included in a game to be increased

tremendously, if necessary, without adding to the complexity of the game from the player's standpoint. The computer can be made to make a host of minor decisions on the basis of certain general instructions from the player. One game at RAND uses the IBM 704 computer in this manner.

Turning now to applications of gaming — we have already mentioned allocation problems of which there are an endless number ranging all the way from the budget allocation between ground, sea, and air forces to allocation of fire of one antitank gun between two enemy tanks. Apart from a few very special cases where the economic principle of equal marginal utilities can be applied there is no way to attack these problems analytically except via gaming techniques.

A game is the perfect vehicle for studying strategy and tactics. A good high-level game, for example, would be of immense value in the formulation of war plans. One could try dozens of plans in the time it would take to play dozens of games, and the play of each would test not only its efficacy but its feasibility. The flexibility of a given plan could easily be tested by playing it in the game against a variety of enemy strategies. The sensitivity of a plan to unpredictable factors could be tested by changing those factors over a wide range in the rules of the game.

In intelligence, games would be useful in narrowing the range of intelligence estimates. Thus hardware estimates are often of the form "that nation could build up to 100 submarines per year

with intensive effort"; "2000 long-range bombers per year with intensive effort"; "10,000 fighters per year with intensive effort." That is, we have maxima which if achieved in one item will certainly not be achieved in others. A collection of reasonable looking ground strategies for a potential enemy will give a very good indication of areas in which the "intensive effort" is likely to be made and approximate magnitudes of efforts in other areas. Also, such a collection of strategies would indicate fields in which more intelligence would be particularly important to indicate which ones of the collection were in fact close to what the potential enemy has in mind.

A secondary application of simplified games is in training and educational programs; a game can easily be made to illustrate and clarify complex and subtle relationships. RAND has constructed one such training game known as STRAW (strategic air war) for personnel of Air Intelligence. Lt. Col. Jesse C. Peaslee constructed a very effective training game at Oberammergau, Germany, to instruct NATO officers in certain principles of atomic ground warfare.

More generally, gaming will for the first time give military planners a quantitative grip on the "balanced force" concept or the "military worth" concept. Everyone knows that in actual warfare economic worth may be a poor measure of military worth; a hundred-dollar rifle may be more effective than a ten-thousand-dollar truck. But one cannot say how much more in the absence

of a knowledge of the existing situation. Certainly one cannot put all his money in rifles; if he did he would soon be ready to trade, say, ten thousand of them for one truck. This is the basis of the balanced force concept, but outside the simplest situations it is a hazy and imprecise concept to apply. Gaming can give one correct exchange ratios between rifles and trucks, or air bases and steel plants, or merchant ships and atom bombs, in terms of a given situation.

REFERENCES

[1] Charles Hitch, "Sub-optimization in operations problems," Jour. Operations Research Society of America, Vol. 1 (1953), pp. 87-99.

[2] J. von Neumann and O. Morgenstern, "The Theory of Games and Economic Behavior," Princeton University Press, Princeton, N. J., 2nd edition 1947.