A Value for Information

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A method to measure the worth of different items of intelligence about strategic forces.

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Which is more valuable: our knowing the exact number of Soviet ICBMs, or our knowing the exact number of Soviet ABM interceptors? Is it worth more to us to learn the precise location of Soviet ICBMs or to learn the exact range of Soviet defensive fighter planes? Answers to questions like these are important determinants in decisions about procurement and use of intelligence collection systems. One method to help reach the answers to such questions in the field of strategic capability is described in this paper.

The War Game in Planning

The strategic capability of a country depends in the main on its weapon systems, the potential target systems and forces opposing it, and the quality of its information about these targets and forces. Ideally, the weapon systems are selected on the basis of estimates as to which alternative systems contribute more to a favorable outcome in strategic war. One technique to compare the contributions of alternatives is the strategic war game. Many scenarios involving different strategies on both sides are tried in order to cover as wide as possible a range of variation. Different strategies might include attacking the enemy's forces or alternatively attacking targets of intrinsic value to him, acting to limit damage to oneself or to assure a desired level of destruction to one's opponent. One simplified example of ..a strategic war game scenario is illustrated by Figure 5 in the Annex at the end of this article.

Similar techniques are used to help the force operator allocate specific weapons to specific targets and to help R&D managers improve the allocation of their effort in the strategic field. These processes rest on the assumption that the value of a system is measured by its performance in simulated war. This same assumption is fundamental in using a strategic war game for determining the relative value of various kinds of information about an enemy's targets or forces.

The outcome of a war game scenario can be expressed in terms of damage to the value targets of the two adversaries—in fatalities, total floor space destroyed, manufacturing facilities destroyed, or some combination of these. It has been found that all of these units of measure tend to have the same properties: as the Soviet force is increased, for example, the U.S. damage goes up, regardless which measure is used. The damage to both forces and value targets is estimated from the results of weapons effects tests as well as the experience of World War II. Because of the large numbers and types of forces and targets involved, a computer is generally used in measuring the outcome of the war game.

For planning the composition of U.S. forces the predicted outcomes of the many scenarios for various alternative forces, together with the costs of the alternative forces, are displayed as an aid to men who must make decisions about future forces.

One assumption characteristic of most strategic war games is that each side has complete knowledge of the forces and targets of his adversary. This assumption, though not reflecting real life, can be defended on the basis that changes in force procurement probably do not change the state of knowledge about the enemy, and further that one is looking only at changes in outcome which occur in a fixed intelligence environment.

Relative Value of Information

In order to obtain changes in outcome due to changed information when the forces are held constant, a modification of the usual scenario is necessary. Instead of various alternative U.S. forces, alternative U.S. information states are compared. (See illustration in Figure 6 of the Annex.) This is accomplished by forcing the U.S. planner to allocate his force against an estimate of the Soviet force (for example, the number of Soviet ICBMs) which is in error by a chosen, adjustable percentage. Then the impact of this particular error in information is measured by comparing the outcome with that when fully correct information is available.

The results of applying this process can be expressed in graphic form as in Figure 1.

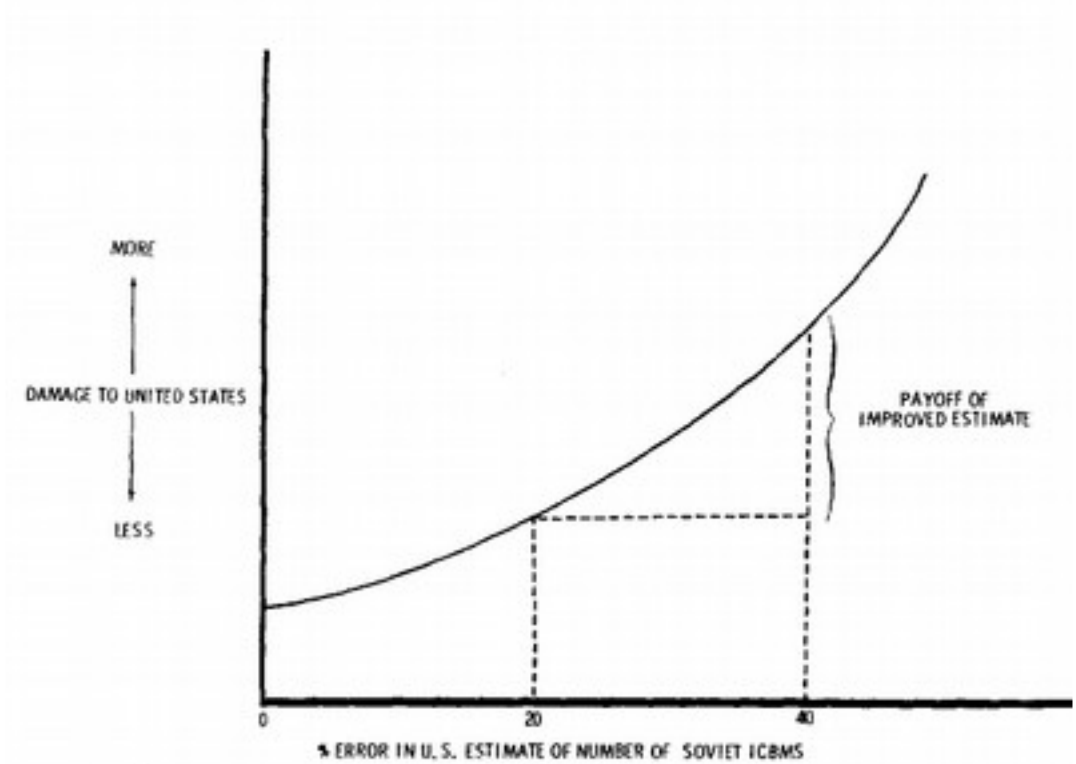

FIGURE I

As the accuracy of our estimate of the number of Soviet ICBMs increases from 40 percent error to 20 percent error along the horizontal axis, the payoff for the improvement, measured in reduction of U.S. damage, can be read on the vertical axis. Repeating this process, one can determine the payoff, measured in the same units, of improvements in the accuracy of our estimate of, say, the number of Soviet ABM interceptors. A comparison of these two payoffs, one for improving our knowledge of the number of Soviet ICBMs and the other for improving our knowledge of the number of Soviet ABM interceptors, then furnishes guidance for the best allocation of information collection resources to these two problems. One can extend this process to consider the relative payoff of many other kinds of information—ICBM accuracy, ICBM reliability, weapon yield, and so on.

These comparisons must, of course, be made over a range of possible war sequences. Also, just as the relative value of forces changes over the years, one could expect the relative value of different types of intelligence to change with time. Judgments based on the relative value of various types of intelligence must thus take into account the long term, recognizing R&D and procurement times for forces as well as for intelligence collection systems. Another factor of importance in the allocation of intelligence collection resources is the relative cost of achieving specific improvements in the accuracy of estimates. Determining these costs is, in most cases, a complex and difficult problem.

Sample Results

One of the particular aspects of intelligence which have been studied in detail is the degree of exactitude with which the location of Soviet ICBM launch sites needs to be known. Under approximate force levels for 1970, the value to the United States of increasing accuracy with respect to the location of these sites is shown in Figure 2.

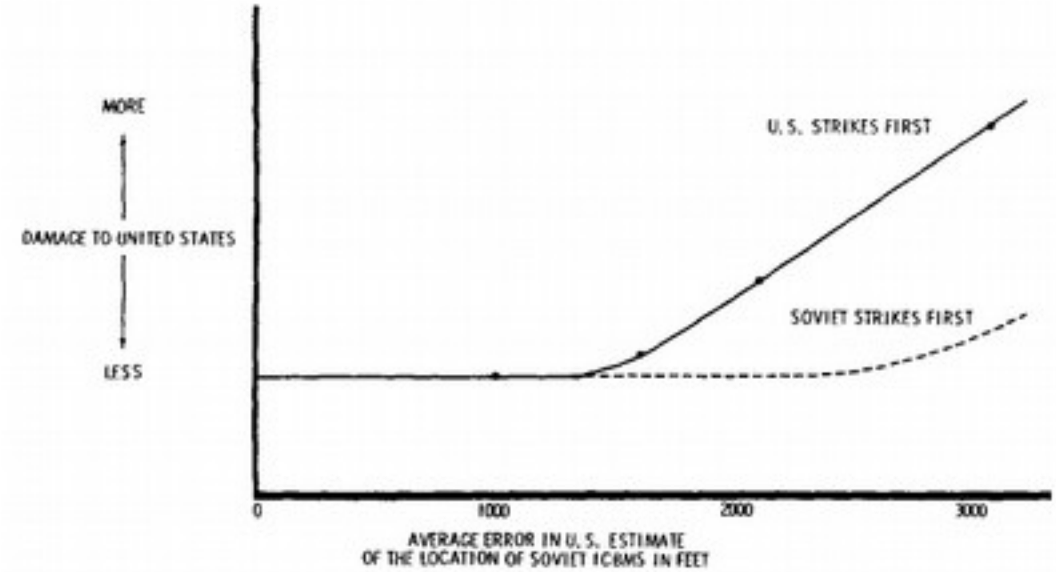

FIGURE 2

Though this is generically like the curve of Figure 1, it has the interesting property of returning no value to the United States for eliminating an average error about the location of Soviet ICBM launch sites of less than some 1,500 feet, regardless of which side strikes first. Thus one might conclude that intelligence collection, however inexpensive, should not be used to improve accuracy in this matter to better than within 1,500 feet. But there are possible changes in the composition of forces which could change this conclusion, as shown below. The importance of accuracy about location is related to the hardness of the target and the yield and accuracy of the attacking weapons. The curve of Figure 2 was therefore recomputed with average U.S. weapon yields reduced by a factor of 10, average U.S. weapon CEPS reduced by a factor of 5, and Soviet site hardness in creased by a factor of 5, conditions which are believed to represent reasonable extremes. Now the curve of Figure 2 is changed to that in Figure 3.

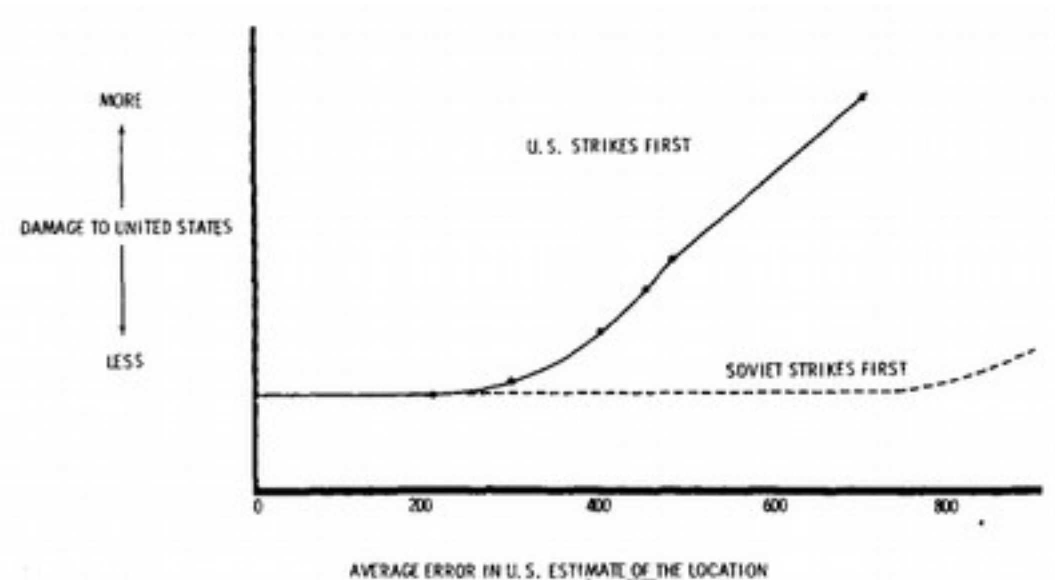

FIGURE 3

Under these extreme conditions values are changed so that collection efforts to improve U.S. knowledge of the location of Soviet ICBM launch sites might be justified down to an average error of about 300 feet, but beyond that there is no further payoff.

Value in Dollars

The damage yardstick for measuring relative value, while satisfactory for some purposes, does not give a basis for comparing the value of improved information with the cost of obtaining it. Since collection cost is generally measured in dollars, it is desirable to put a dollar measure on the value of improved information. This would permit a direct profit-or-loss comparison between costs and results and throw light on decisions about specific collection programs.

One method currently being programmed from which the dollar value of improved information can be derived is illustrated in Figure 4.

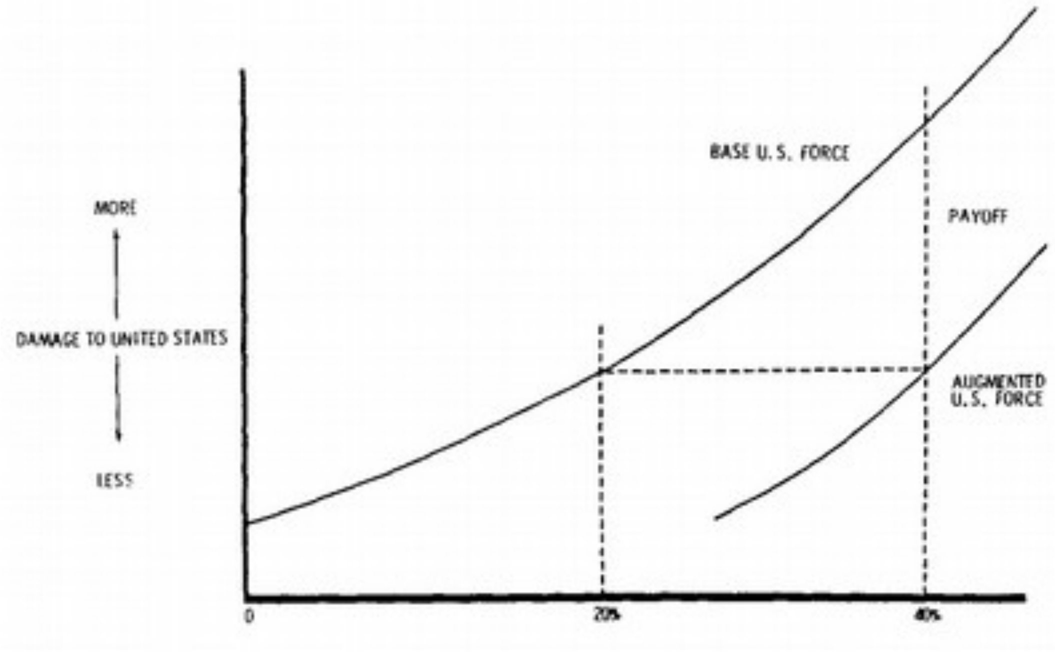

FIGURE 4

A basic curve like that of Figure 1 is generated and the improvement in outcome (measured in reduction of damage) is derived for an information improvement of, say, from 40 percent error to 20 percent. Now this same improvement in outcome can be achieved *without* improving information by giving the United States more forces. Assuming that this improvement in outcome is desired, the value in dollars of decreasing the information error from 40 percent to 20 percent is equal to the dollar cost of the optimized additional force required to achieve the identical effect. This dollar value for more accurate information may now be compared with the cost of collecting that more accurate information, assuming such collection feasible.

So far only a few results have been obtained, but a flexible computer program to place dollar values on improvements in information should be available in the near future.

Problems

Strategic war is complex and has a large number of variations. No war game can cover the myriad detail and variations of real life. Therefore the results must be carefully evaluated for reasonableness, the sensitivity of outcomes to variable inputs must be explored, and an adequate understanding of the applicability and limitations of war games must be developed. A strategic war game is a tool that could be misused. Even with a sound war game concept, the major role of computers requires the backing oE.extensive human evaluation and judgment during the entire process. Used with proper care and attention to detail, war games, like computers, can be a tremendous help.

If this concept, model, and methodology with respect to strategic forces prove useful, there still remains a question—and challenge—with respect to similar treatment of opposing forces on a broader front. Can we develop a process of engagement analysis which might help set relative values on various types of information about ground forces? Are any non-military areas amenable to the application of engagement analysis techniques? As yet these questions have not been explored.

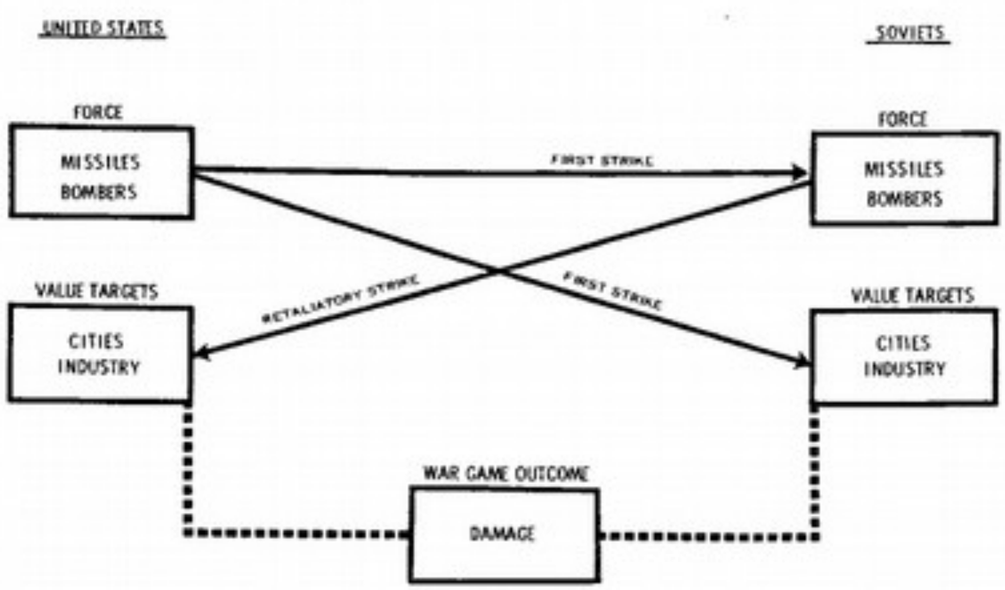

FIGURE 5

In this illustrative scenario the United States makes a first strike, allocating its weapons against Soviet forces and targets judged to be of intrinsic value to the Soviets. The Soviets then retaliate, applying the undestroyed portion of their weapons to U.S. value targets. U.S. objectives in this scenario include achievement of a preselected damage to Soviet value targets together with a maximum attack on Soviet forces in order to hold to a minimum the damage subsequently suffered by the U.S. value targets. The damage level to the Soviet value targets which is chosen by the United States thus tends to determine the relative allocation of U.S. weapons to Soviet forces and to Soviet value targets. The matching of specific weapons to individual targets to maximize the effectiveness of the U.S. force depends on weapon and target characteristics as well as the composition and size of the U.S. force.

This scenario can be modified so that the impact of less than perfect information can be measured. This modification is shown schematically in Figure 6.

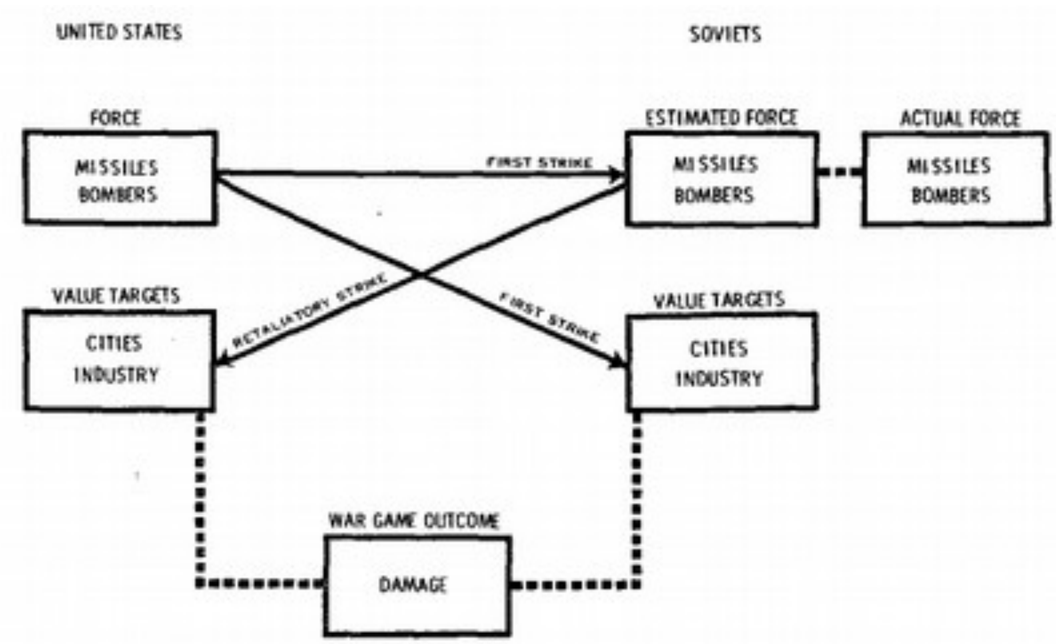

FIGURE 6

In planning and optimizing its attack the United States allocates its forces against value targets and an estimated Soviet force. The difference between the actual Soviet force and the U.S. estimate of it, with the effect of this error on the outcome, can be varied in order to permit the generation of curves like those in Figures 1, 2, 3, and 4.

BIBLIOGRAPHY

1 Many have contributed to the buildup of strategic war gaming techniques—RAND, Stanford Research Institute, and the armed services, to name just a few. Of particular importance and deserving special mention are Mr. Joseph Bosevich of Martin Company and Mr. Hugh Everett of the Lambda Corporation, both of whom have made important contributions without which this paper could not have been written.

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