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*"[There] has been a tendency on the part of some staff people to use systems analysis as a cover for what is really subjective judgment . . . I am determined not to let what is essentially a helpful tool, and systems analysis can be a helpful tool, become the overriding force in driving decisions, particularly in the dark."—The Honorable W. Graham Claytor, Jr., Secretary of the Navy, Keynote Address of the Naval War College Current Strategy Forum, 27 March 1978. What is this helpful tool? What may we ask of it? What must we not ask of it?*

## DEFENSE SYSTEMS ANALYSIS . . . ONE MORE TIME

by

George F. Brown, Jr.

**Imperfect Roots.** The roots of defense systems analysis can be found in a wide variety of attempts to apply quantitative economic theory to operational problems confronting business enterprises. While generalization is made difficult by the wide variety of business problems for which quantitative economic theory has proved applicable, five characteristics of private enterprise can be identified that facilitated the rapid success of quantitative approaches to management.

First, virtually all business investment decisions can be evaluated in terms of a single-dimensioned measure—dollar profitability. Both revenues and costs can be expressed in this unit, and thus, while difficulties in analysis might arise, the potential always exists to reduce the debate among alternative choices to the measure of profitability.

The second key characteristic is a corollary of the first: because of the

existence of the profit measure, a general consensus regarding preferences is built into business problems. Greater profits are preferred to lesser profits, and alternatives can be readily ranked along this scale.

Third, the systems being analyzed can be reasonably defined and boundaries can be drawn enabling discrete problems to emerge. One product can be analyzed separately from another unless there are interrelationships within the demand or production functions. One plant's operations can be separated effectively from another plant's operations. Even in the cases in which interrelationships exist, these are relatively transparent enabling the analyst to correctly define the system for study.

Fourth, while uncertainty is present in most business decisions, the areas of uncertainty typically can be defined and permit the application of standard methods of analysis. Ranges of

consumer demand or of raw materials cost, for example, can be expressed using probability theory and analyzed accordingly.

Finally, the data necessary for the analysis of business decisions are usually readily obtained. In many cases, historical data can be studied to provide forecasts of future characteristics. Even in those cases in which little historical data is available, analysts of business decisions have been able to draw upon such techniques as market surveys to build a data base.

While this short synthesis does injustice to the complexities of a subset of analyses of business decisions, (e.g., those falling into the realm of long-range corporate strategy), these five characteristics are present in the majority of the problems which have been chosen for analysis. As a result, the application of tools of analysis to business decisions has expanded rapidly. A survey of most present textbooks in the quantitative management field will reveal a state-of-the-art that has reached near cookbook character for many recurring management decisions.

As a result of the successes in business, a natural extension to the problems of defense decisionmaking was suggested. Attempts at this extension began in earnest in the early 1960s. At one level, these attempts met with successes similar to those experienced in business. These efforts, however, were mostly ones in which direct analogies could be drawn between defense operations and business counterparts—scheduling industrial activities, planning inventories and maintenance strategies, etc.

The more important problems facing defense planners, however, are those relating to force structure choices. Here, the application of analysis required facing problems totally different from that experienced by the early practitioners of quantitative management disciplines. The differences are strongly

highlighted by a comparison with the five characteristics of private enterprise from which defense systems analysis evolved.

First, unlike the relatively clean measure of dollar profitability, defense systems analysts are faced with problems in which the two sides of the equation—costs and effectiveness—are fundamentally incommensurate. While costs of alternatives frequently have a dollar component, effectiveness is almost never measured in monetary terms. Rather, effectiveness of alternatives must be related, directly or through proxies, to the provision of national security and the achievement of national objectives. Further complicating this problem is that for most force planning problems, the relevant measures of effectiveness (and sometimes also of cost) are multiple in nature. Rarely can a force alternative be evaluated using a single dimension of effectiveness. Thus defense systems analysts must begin an evaluation of force choices by confronting three difficult problems: attempting to define effectiveness measures that adequately reflect force contributions to national security and objectives, attempting to define effectiveness measures which adequately reflect the multiple dimensions of potential force contributions, and recognizing the fundamental inability to combine cost and effectiveness measures into a single index of interest. Nowhere are these problems more clearly apparent than in attempts to analyze military force alternatives.

As a result of these difficulties, defense systems analysis is rendered unable to lead to unarguable preferences among alternatives, a situation again distinct from the profitability ranking scheme available to business analysts. The classic question of "How much is enough?" suggested by the inability to combine cost and effectiveness cannot be answered by analysis. Only experience, subjective judgment, and the

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other factors that enter into the political decisionmaking process can be called upon to weigh, for example, the dollar worth of an improvement in force effectiveness. As a result, final choices regarding forces are removed from the realm of formal systems analysis.

Even the classic ploys of formulating systems analysis problems in such frameworks as "maximize effectiveness for a fixed cost" or "minimize the cost of attaining a given effectiveness" are typically doomed to the same fate. First, the "fixed costs" and "given effectiveness" within such frameworks are themselves arbitrary; one must always debate whether these levels were chosen correctly. Further, the presence of multiple effectiveness measures for most force planning problems again leads to situations in which only judgment can lead to final choices. Much like trade-offs between cost and effectiveness, the trade-offs across dimensions of effectiveness cannot be synthesized into a single measure like profitability.

Third, the problem of defining appropriate systems for analysis introduces complexities in force planning beyond those in most other problems. In a very real sense, force units cannot be easily segregated into discrete categories for analytical purposes; rather, most force alternatives must be viewed within the total structure. Furthermore, even when systems can be defined with reasonable boundaries, the problem of multiple relevant systems emerges. The varying employment alternatives and potential conflict scenarios within which forces might be allocated make any single system chosen (and any single effectiveness measure) suspect. Finally, relevant systems definitions frequently require the incorporation of national and international political considerations along with strictly military ones. As a result, the systems relevant for evaluating force choices grow to immense proportions in many instances.

Fourth, uncertainty, rather than being merely one facet of the problem, is perhaps the central facet in force planning. Who will be the enemy in the future conflict? What will be his objectives? Where and when will the conflict take place? What type of conflict will it be? What capabilities will the enemy have? How will various force options affect his decisions? How will other nations react? The list of such uncertainties can be expanded far beyond the questions suggested above, and these types of uncertainties must be central in any analysis of force choices. Furthermore, attempts at addressing these questions are far more complex than, for example, specifying potential levels of consumer demand. It is difficult merely to list the potential range of possibilities, let alone attach concrete probabilities to each.

Finally, the hard data frequently available for business analyses is often absent for defense systems analysis. For some inputs to analysis, such as those relating to the interests and intentions of potential adversaries, only subjective informed judgment is available. In other instances, such as the outcome of a conflict, no real data can ever be available until the conflict takes place. Thus the data base available to the defense systems analyst is built to a significant extent on subjective judgment, past experience, proxy attempts at modeling conflicts, and similar foundations.

In summary, none of the five ingredients that contributed to the success of other analyses are fully present in force planning. Realistically, defense systems analysis, particularly when applied to force planning decisions, must be viewed as a discipline that draws only a modest amount of support from its roots.

**Two Key Contributions.** Allowing that systems analysis will never lead to force planning cookbooks similar to those that have evolved for some other

business and defense decisions, the contributions of the discipline to force planners can be reduced to two dimensions.

First, the economic foundations of defense systems analysis have forced a recognition that cost is an essential consideration in force choices. Every force choice under consideration has a relevant cost component. At the highest level, spending on defense implies lesser resources available to the private sector of society or to other government programs. Advocates of defense spending must therefore argue that the benefits so obtained outweigh those foregone. More pragmatically, this factor leads to the conclusion that defense budgets will always be "tight"; there will never be funds available for all programs of potential interest. Once budgets are set, force choices must still be considered in terms of their cost. The selection of one option implies that others are foregone; this fact applies throughout force planning decisions. Spending on one weapons system will be at the expense of another; spending on readiness will be at the expense of modernization; allocating resources to one command will be at the expense of some alternative command; deploying forces in one area will make them less available in another.

One consequence of the inevitability of cost considerations is that defense program advocates are forever destined to operate in an adversary relationship. At the highest level, the requirement exists to demonstrate the desirability of defense spending over other ways of spending (or not spending) federal government funds. At the service level, program advocates must make arguments showing the relative merits of their programs over those of the other services. Within each service, the same requirement exists: successful programs will be those which can be argued to be superior to their competitors.

It is as a result of this forced

competition that defense systems analysis makes its second contribution to force planning. It provides a framework within which rational debate can occur, one which forces program advocates to state their cases in a form which other decisionmakers can review and evaluate. While debate regarding force options is nothing new to military planning, the attempt to impose a structure of logical analysis onto the debate is a significant change within the past two decades.

**The Debate.** Defense systems analysis, perhaps to a greater extent than any other discipline, has been scrutinized, criticized, and attacked by force planners in a wide variety of forums. Initially, perhaps, such actions might be viewed as the natural consequence of unfulfilled expectations; the tools which proved such a success in earlier applications found force planning a task not so readily confronted. No profit measure was present; instead, defense systems analysts were forced to try to develop effectiveness measures capturing the contributions of alternative forces. Preferences and choices were in no way removed from the judgmental and political realms by the presence of systems analysis. Attempts to draw boundaries around force planning problems proved difficult at best. Fundamental uncertainties found their way to the head of each force issue. Judgment, guesstimates, and proxy data proved essential as inputs to defense systems analyses. Numbers, the ultimate instruments of precision in other sciences, became merely the best way of communicating such judgments and estimates. All of these realizations had to be a disappointment to analysts who were able to progress rapidly towards cookbooks for solving other problems. These facts simultaneously proved—to both the analysts and the users of analysis—that the ground upon which force analyses were built was shaky at best.

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But all of this is—or certainly should be—well recognized by professional analysts and the decisionmakers alike who draw upon analysis. The early disappointments of the transition to force planning are now history, and the viewpoint that systems analysis can only hope to make a contribution to debate is well established.

As a result, military decisionmakers are left with only one realistic viewpoint regarding the discipline. This view accepts defense systems analysis, and attempts to use its principles as a foundation for developing and defending positions in the inevitable debate over force choices. The alternative of rejecting systems analysis reduces to the rejection of the process of effective argument. Those who argue that the framework of systems analysis leads the debate away from the important issues underlying force planning decisions are left with a position somewhat similar to arguing that the use of accounting methodologies leads to embezzlement; the truth is merely that embezzlement went undetected before books were kept. The framework of defense systems analysis consists only of identifying the measures of cost and effectiveness relevant to the choice among alternatives in view of the underlying objectives and interests, constructing models of the relevant problems requiring decisions, assembling the information prerequisite to the analysis, and evaluating the performance of the various alternatives under consideration as an input to the final decisionmaking process. Expanded discussions of this framework emphasize the need for careful sensitivity and contingency testing throughout this process. Systems analysis allows—and even invites—debate over the correct ways to measure force effectiveness, the use of subjective and experience-based inputs to the analysis, arguments over the likely future environment, and so forth. Thus in any particular application criticisms along

such lines represent a tacit acceptance of the science. While the potential for inept and incomplete use of the framework of defense systems analysis certainly exists as strongly as in any other discipline, the framework itself represents only the formalization of sound intuitive structures of reasoning. In fact, viewing defense systems analysis as it actually is—and not as analysts (incorrectly) envisioned it to be in the early 1960s—leaves little room for argument over the merits of the discipline. As long as the need for effective argument exists in a cost-constrained environment, the contribution of defense systems analysis in providing a framework for argument and debate will persist.

Even allowing for the fact that time will allow the current view of the most modest contributions of defense systems analysis to replace the overly optimistic predictions of the early practitioners, however, criticism of defense systems analysis will continue. Unlike most other disciplines, defense systems analysis is blessed with at least three schools of critics likely to remain permanently within the Defense Establishment.

First are those unwilling to expose and defend force alternatives in the rigorous manner required by the discipline. Specifying the dimensions of effectiveness relevant to force choices, attempting to measure the contributions of alternative force structures along these dimensions, announcing judgments regarding the critical uncertainties, placing bets on their likelihoods, and similar activities such as are required within the framework of defense systems analysis are difficult and sometimes unpleasant tasks. There will always exist a cadre of planners who wish to avoid laying out their cases in a manner so readily scrutinized.

Secondly, the continuing flow of analysts and decisionmakers whose education was obtained in business

schools and in business into defense planning implies that the disconnect between business and defense systems analysis will continue to be a problem. Both the mistakes and the disappointments suggested earlier are likely to be repeated continually by those familiar with business analysis but not with the additional complexities of force planning.

Finally, the adversary nature within which cost-constrained defense planners operate guarantees that there will always be losers among the competitors. Human nature being what it is, there will be those who find it easier to denigrate the process of argument than to admit their inability to construct a compelling argument.

**Using Defense Systems Analysis.** The previous comments suggest a view that defense systems analysis, for better or worse, is likely to remain a fixture of force planning. Several key lessons have emerged regarding the effective use of this tool.

The most important of these lessons are suggested by the framework of defense systems analysis itself and by the characteristics of force planning described earlier. First, analysts (and critics of the analyses of others) should key on the measures of effectiveness and cost used to support choices among alternative forces. Unlike the clean profit measure, the choice of measures for defense analysis is pure art. Questioning whether the measures chosen truly reflect the underlying objectives for which forces are bought and whether the measures adequately reflect all of the multiple dimensions of contributions must be standard practice within force planning. Few arguments are more compelling than ones which demonstrate that key dimensions of a problem have been ignored in an analysis.

Secondly, the same critical review should be placed on comparisons

between cost and effectiveness or among various dimensions of effectiveness; as a general rule, such comparisons are outside the realm of formal analysis as they essentially involve debate over the nature of national interests and objectives. Careful attempts to define the relation of force effectiveness to national interests are therefore an essential part of the adversary relationship.

Third, users of analyses should examine carefully the system defined for analysis. The appropriateness of its boundaries (are essential considerations excluded?) and the existence of alternative relevant systems (are there alternative missions of relevance or alternative scenarios of interest?) must be examined. Such questions are central in force planning as most force elements are truly multimission in nature.

Fourth, defense systems analysis must address specifically the key uncertainties. Have important potential conflict scenarios been ignored? Can debate be raised regarding assumptions relating to these uncertainties? Are new viewpoints required relating to the capabilities and intentions of potential adversaries? Uncertainty, fundamental to force planning, must be fully debated among analysts, critics, and decision-makers. In fact, it is largely the role of the experienced operator to provide the basis for analytical assumptions regarding these critical uncertainties.

In this regard, one further caveat is appropriate. The presence of significant uncertainties in the future should not be used as a means of avoiding arguing within the framework of defense systems analysis. The old comparison between the worth of a bird in the hand and those in the bush provides useful guidance here. In the cost-constrained defense competition, there will always be a bird in hand to compete against those potentially in some future bush. The tendency will likely persist among defense decisionmakers to choose a force alternative that confronts some

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clear and present danger (or, at another level, a government program that confronts some clear social problem) over an alternative that might prove useful against some as yet undetermined future threat. At minimum, force planners concerned about future uncertainties should strive to define the likely shapes of future bushes, the likely number of them that might appear, and the probable bird count therein. To do less is to invite openly the categorization of such arguments as vague and ineffective.

Finally, recognizing the general lack of hard data with which defense systems analysis must operate, it is necessary to scrutinize the inputs carefully. While judgmental inputs per se should not be attacked (as in most cases the critic can do no better than to supply his own judgmental inputs), the necessity exists to solicit as fully as possible the information necessary to provide the best possible judgment. While even the best of all possible systems analyses will never allow the decisionmaker to "know" he has reached the correct answer, effective and careful debate over these inputs can lead in this direction.

The above guidance can be seen to relate directly back to the contributions

attributed to defense systems analysis. It suggests nothing more than the need for a careful debate among force alternatives in a cost-constrained environment. Defense systems analysis provides the framework within which this debate can occur. It is more art than science; it draws upon and invites judgment and opinion rather than replacing it; it provides a format within which arguments can be developed and dissected. To expect defense systems analysis to be anything more than this has been proven pointless; to deny the contributions which it can make is to deny the realities it reflects.

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#### BIOGRAPHIC SUMMARY



Professor George Brown has been a member of the Management Department, Naval War College since 1973. He received his Ph.D. in Economics from Carnegie-Mellon University and has written widely on operations research, financial and quantitative analysis, statistics, and management matters. Prior to joining the faculty, he was a Study Director at the Center for Naval Analysis.

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