Chapter 4

DEVELOPMENT OF MILITARY SYSTEM EVALUATION CRITERIA

1.0 INTRODUCTION AND PURPOSE

As pointed out in Chapter 3.1, communications between hardware systems engineers, force designers and tactical commanders all depend on some form of *combat effectiveness*. The degree to which these three classes of people can communicate and cooperate will have a major impact on the future success of the military forces of the United States. Successful communication, a prerequisite to cooperation, requires a common language, including common units of measurement.

The decision process of new system acquisition involves qualitative and quantitative decisions which also look to some measure of operational utility or *combat effectiveness* as a criterion.

This chapter defines a set of evaluation criteria and indicates their application in evaluating military systems. They are:

CAPABILITY
VULNERABILITY
COMPATIBILITY
COST
FEASIBILITY
GROWTH POTENTIAL

The usage of these criteria in any specific investigation is dependent on the question being considered and the level at which substantive conclusions are needed

The purpose herein is to develop a set of evaluation criteria and indicate their application in assessing military systems with the intent of selecting a *best* concept based upon a credible measure of worth.

The search for suitable evaluation criteria in the development of individual or organizational offensive and defensive systems has been going on since the dawn of time. Many criteria have been proposed, for example *Cost Effectiveness*, and used in the quest for some elusive *Figure of Merit*, attempting to provide indisputable proof that the system in question should be undertaken.

This has not come to pass because there are several criteria that must be examined in arriving at needed technology, procurement, and programming decisions. The utilization of these criteria in the decision process is not simple and is dependent, in the end, on professional judgment based upon the evidence gathered and organized under each of the criteria which will be identified herein.

Evidence must be developed, whatever the criteria, to answer a triad of questions that should be addressed at some level by different sets of individuals on any new concept (or business) undertaking. These are:

1. What SHOULD the nation do? The Rational World

2. What WILL the nation do? The Marketing World

3. What CAN BE DONE at a profit? The Technology & Management World

These questions could be applied to almost any project requiring developmental business interests to interface with another entity. The term *nation* could easily be replaced with *state*, *corporation*, etc. Our subject matter restricts us to the interface between the military services, federal government and hardware systems developers.

The first of these questions bears on the true or natural characteristics of the military need and is properly addressed by the Operations Analyst in a study of requirements. The second question deals with the military and political acceptance that the proposed hardware system, in fact, should be undertaken and is a subject for the Marketing Analyst. The third question bears on whether or not industry can profitably undertake development and production of the proposed system and is the purview of the Systems Analyst.

Solutions to each of these questions can be represented as three overlapping planes shown here.

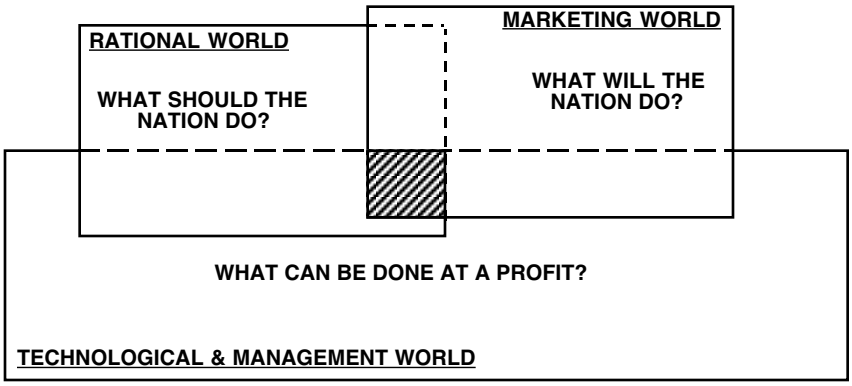

Figure 4-1 - The Trinity.

The organizable facts on each issue should be presented and considered by management in order that a conscious decision on a new product or system concept can be made. There will be few instances in which a concept will clearly fall in the congruent (hatched) area where no compromise will be necessary for a GO decision - - all will agree. Other GO decisions will be needed where one or more NO answers exist, but hopefully in an atmosphere of enlightened understanding. Should a GO decision be made on a program that sours, as some will, altered or contingency courses of action can be undertaken without trauma.

We will focus on the first question in order to develop the criteria for military systems evaluation. The Department of Defense/Industry Environment is discussed in section 2.0 to indicate the reasons why the selection of evaluation criteria is difficult at best and to develop the need for the separation of COST and VALUE.

What is a requirement? and *What is a system?* are examined in sections 3.0 and 4.0, respectively. Section 5.0 defines the recommended evaluation criteria. A measure of worth and the need for a common unit of measure are developed in sections 6.0 and 7.0. This need is met in section 8.0 and the application of the evaluation criteria is discussed in section 9.0.

2.0 DOD/INDUSTRY ENVIRONMENT

The defense of the Nation is a large and complicated task with no tangible measure of success short of engaging in and winning a war. Defense has been broken down into the areas of responsibility of the three major services, with roles and missions assigned which necessarily are discussed and revised on a continual basis. The responsibility of each individual service is in itself too large to be manageable without further sub-division of effort into specialized combat and support fields. No requirement or area of endeavor can be overlooked and all of the elements must add up to a complete defense structure without too many redundancies.

Since there is no tangible measure of success in peacetime, each echelon or unit tries to assure its senior commands that the Nation will not suffer defeat through any error of omission or lack of effort in its assigned area. In their eyes, available funding is usually inadequate for assurance of success in their assigned field. Thus, competition for funds among many reasonably worthwhile projects is the normal state of affairs. Whether or not such competition is in the best interest of the Nation becomes incidental. This is not to imply that any individual or unit knowingly works against the best interests of the Nation; through rationalization and salesmanship, he honestly feels that his way is best and that his unit or service is the most competent to handle the job.

The following explains the government/industry dilemma in the establishment of Needs and Goals for new acquisition military programs. There are three principal problems in the way needs and goals for major system acquisition programs are established:

First: The statement of need does not clearly separate the problem from the solution. Early acquisition plans concentrate on a "needed" new system and a preferred system approach with inadequate attention to why any new capability is needed at all and what that capability is worth.

Second: Needs are defined by each military service with little or no formal agency wide coordination. Needs are subject to individual service views of priorities, weighting of goals, and inter-service rivalry. This contributes to unplanned duplication in system capabilities and the multi-mission character of expensive new systems.

Third: Congress does not have oversight into the need for new acquisition programs. Although Congress can see the defense program in terms of missions and systems already chosen to perform them, it does not review the start of the acquisition process, the establishment

> of needs and goals that precedes the search for alternatives. Issues on mission need first emerge for congressional review after the search for alternative systems essentially has been completed and a specific system is proposed for funding in the final stages of development in preparation for production. This makes control of agency budgets and allocation of resources to meet national needs difficult at best.

These concerns and the difficulties they cause in the development and acquisition process are delineated in Figure 4-2. Plans, Policy and Fiscal Guideline are issued to the Agency Components in terms of Needs and Goals. The Private Sector provides input technology information, from which focus is usually directed to a single system approach with limited options and submitted to the Agency Head for program approval. Development and Production funds are then requested of the Congress with little or no options. Selected systems drive budgets, set priorities and debates are focused on proposed systems, not on mission needs or priorities.

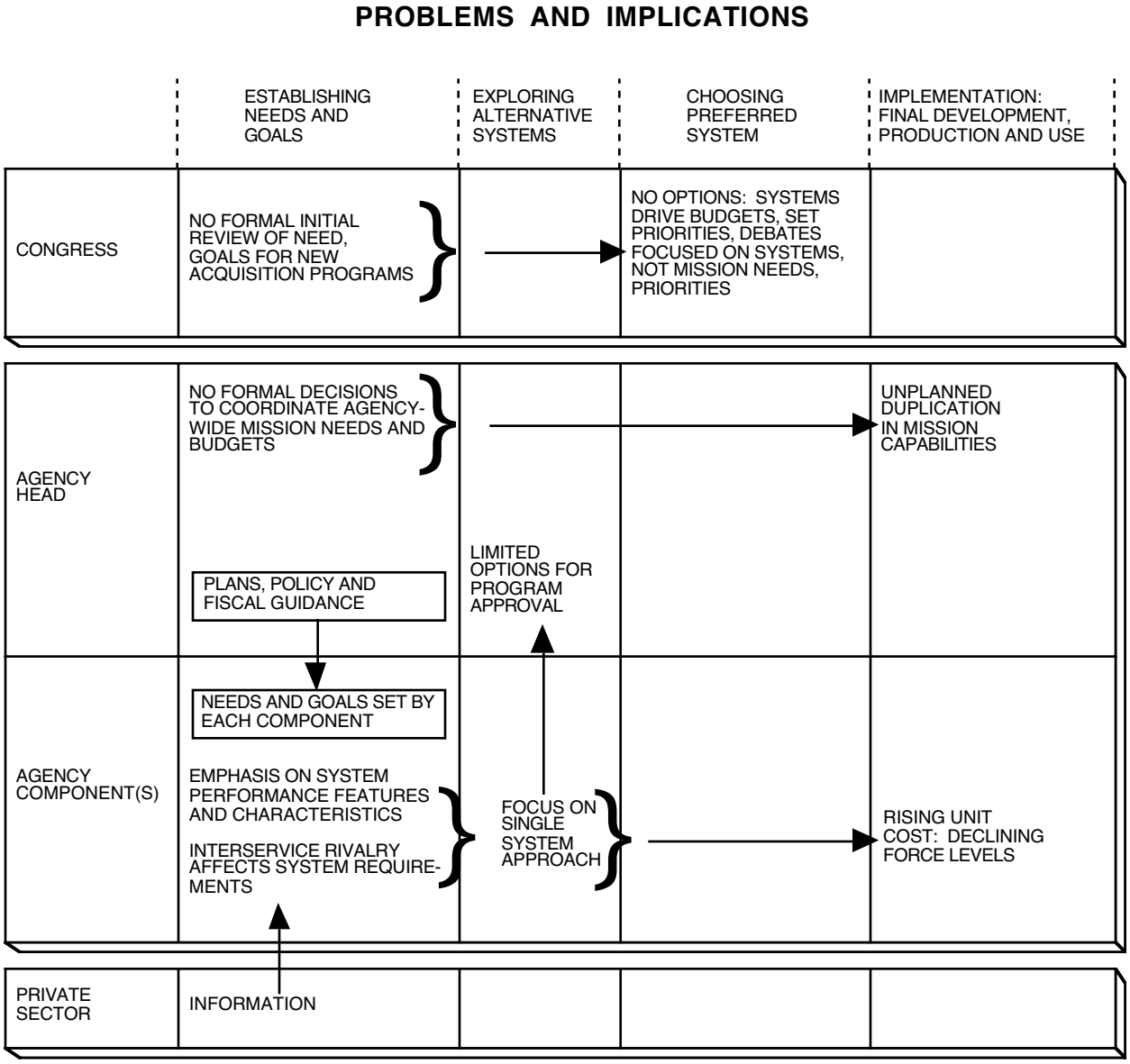

Figure 4-2 - Historic Pattern of Establishing Needs.

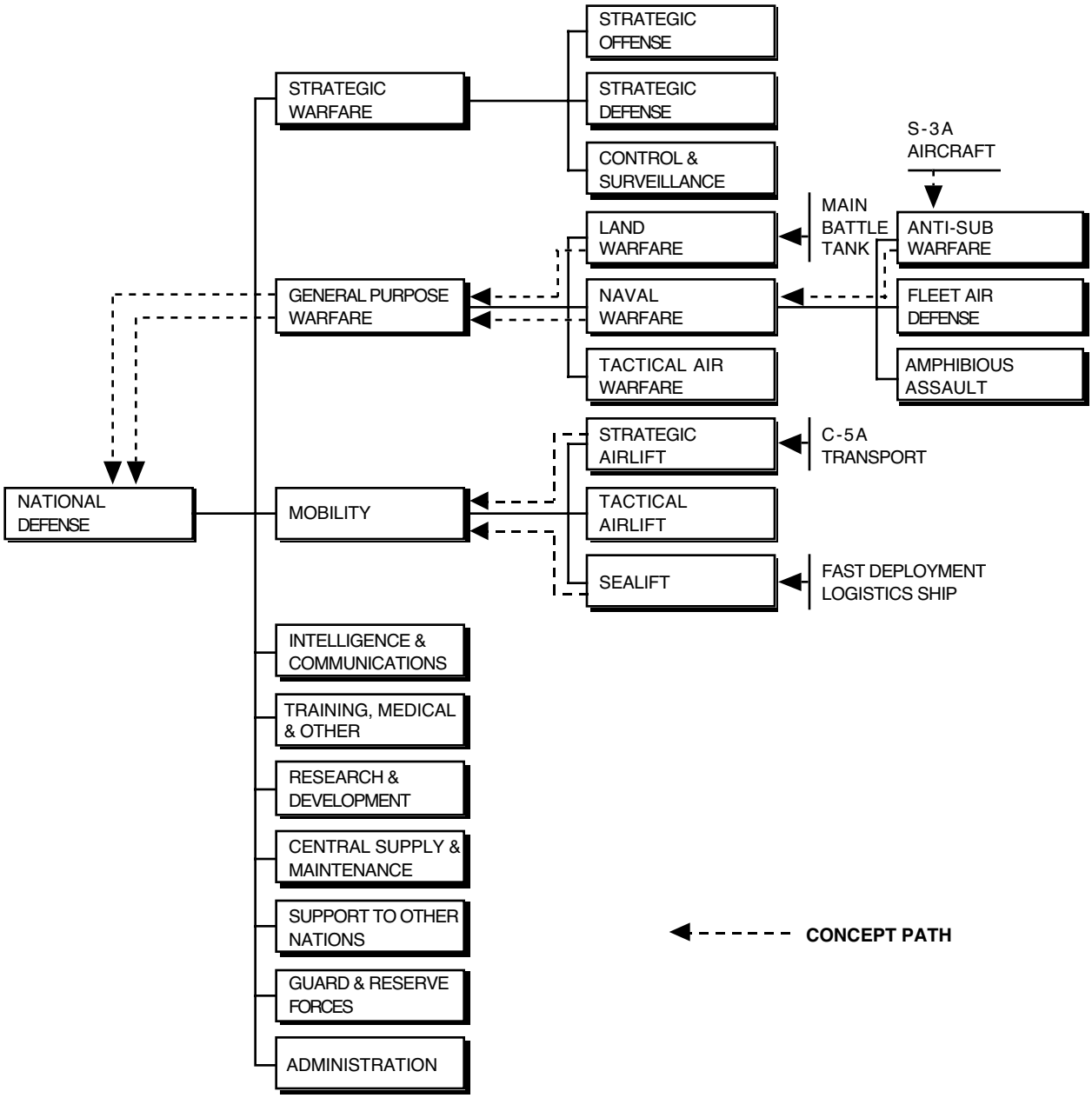

Figure 4-3 - Typical Defense Mission Hierarchy.

In the quest for solutions to the hierarchy of defense mission needs, represented in Figure 4-3, Government has historically looked to industry and the laboratories for new inventions or innovations around which a new weapons system requirement can be written. Unfortunately, in periods of budgetary restriction, the emphasis is placed on near-term complete system solutions . This sometimes results in premature incorporation of advanced state-of-the-art technology into specific systems, and in combination with the continued quest for the ultimate (100% single-missile

kill probability) system has resulted in highly sophisticated and costly weapons. At the other extreme, many weapons system specifications either explicitly state or imply that nothing that has not already been developed need be proposed and literally excludes innovation on the part of industry.

Further prose on how difficult it is will serve no useful purpose. The reader will probably agree that it is difficult and can add chapter and verse of personal experience to the mountain of evidence. As one delves further, it becomes evident that the greatest source of difficulty in arriving at a sensible acquisition decision for any system concept lies in the confusion surrounding the questions:

"What are the system performance requirements?"

and even more basic:

"What are the system operational requirements?"

In other words, the basic problems relate to WHAT is to be accomplished and WHY? Once that is established, HOW to accomplish the task is a reasonably straightforward application of technology and engineering ingenuity to provide a system capability.

Before addressing the question, *What is a requirement?*, let us first get system COST and VALUE in proper perspective by referring to Figure 4-4.

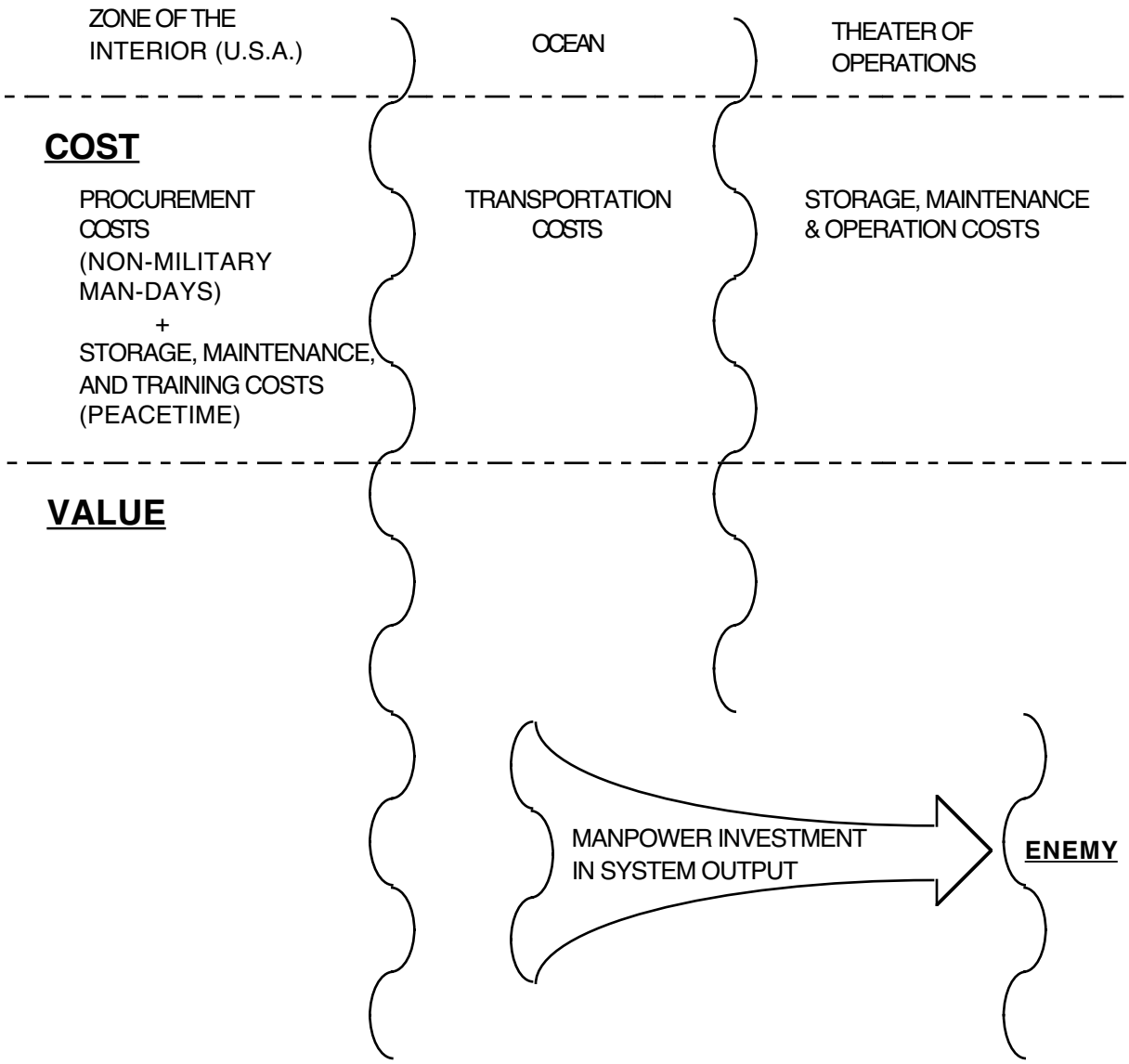

Figure 4-4 - Separation of System COST and VALUE.

There is no question that weapon system peacetime costs are incurred in the Zone of the Interior (ZI), in overseas transportation, and in the theater of operations. However, the VALUE will be realized only in the theater of operations in terms of the manpower investment in weapons system output against the enemy. Hence, a system study should undertake first to identify the operational requirements of weapon systems which are of VALUE in the theater of operations with attention directed to answering the questions:

1. Is weapon effectiveness commensurate with wartime manpower expenditure in theater ?

2. What will be the penalty for weapons system failure?

What should be spent in peacetime for an effective system? is then addressed only for those weapons that are shown to be of value in the theater of operations. It is true, of course, that more weapons of value probably can be identified than a reasonable, practical peacetime budget can support. Then the relative value of the various weapons becomes quite important in the decision as to what weapon types can be eliminated with least risk in future *threat* situations.

3.0 WHAT IS A REQUIREMENT?

As mentioned above the first problem in the way needs and goals for major system acquisition programs are established is that the statement of need does not clearly separate the problem from the solution.

Confusion frequently results in whether the requirement states what the service would like to be able to do (a military need) or what the service believes it can do (system capability) in the light of limits imposed by technology state-of-the-art. In practice, as Figure 4-5 indicates,

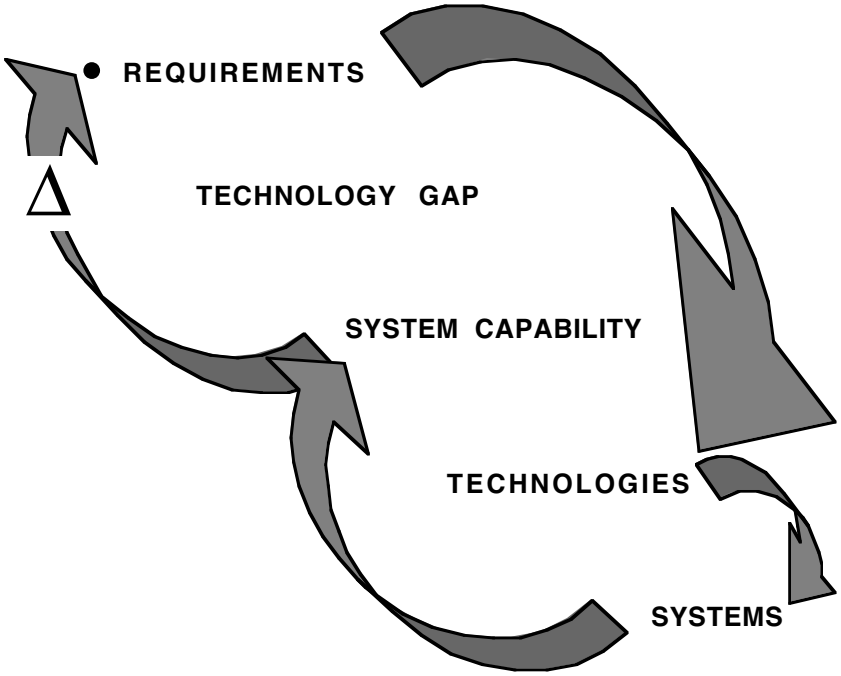

Figure 4-5 - Any System

a requirement (military need) frequently leads directly to an assessment of the available technologies which are assembled in some system (concept) that has a system capability which thereafter is frequently used interchangeably with the term "Requirement" -- overlooking possible

technology gaps between what is possible (a capability) and What is needed (a requirement) . Be aware that not all gaps between capability and requirement are due to technology -- sometimes it is simply a lack of imagination.

3.1 Requirements FOR

Requirements FOR a military system relate to WHAT is wanted and WHY. Requirements FOR a system to perform a certain function or functions arise in several ways:

1. Some functions, notably target acquisition, are presently so poorly performed that a requirement for improvement will exist until very considerable progress has been made. The *requirement* exists because improvement in this function will result in a dramatic increase in efficiency of performance of another function.

2. A new or potential enemy capability may result in the degradation of our capability to continue satisfactory performance of certain functions. A requirement then exists to restore performance.

3. A new capability for our side may result in a requirement for a supporting capability.

4. A *new* (usually previously-unrecognized) mission for our side may result in system requirements. Of this type are the *counter-insurgency* system requirements.

Requirements FOR should be stated in general fashion -- preferably in terms of the desired effect or function to be performed or improved.

3.2 Requirements ON

A stated Requirement FOR then elicits a range of conceptual solutions. These concepts of course must be compared as to potential. In order to do this, we must specify the Requirements ON the system -- the levels of performance which are calculated to represent satisfactory fulfillment of the Requirements FOR.

Requirements ON the system should be stated quantitatively and precisely, so that they can be used for comparative evaluation of concepts. The quantitative formulation also enables translation of the system requirements into requirements on sub-systems.

3.3 An Illustration

The continuing development of anti-aircraft defenses make it likely that operation of aircraft over at least certain areas behind enemy lines will be prohibitively expensive. Therefore, there may exist a Requirement FOR performance by other than manned aircraft of *all* those functions presently performed in such areas by manned aircraft These functions are delivery of FIRE, collection of INTELLIGENCE, and delivery of people (airborne or air mobile operations in execution of schemes of MANEUVER). Various concepts may be formulated which satisfy these requirements -- the systems designed may be single or multiple-function. For instance: intelligence may be gathered by a combination of ground means and satellites, fire delivery may be by surface-to-surface or stand-off missiles, and troop delivery may be by low-flying helicopters to "safe" areas in the outskirts of the dangerous area.

Or alternatively, the concept may be to solve the problem by removal of the defense, after which manned aircraft can proceed to business as before. This might lead to a concept of Remotely Piloted Vehicles (RPVs) or drones, attacking air superiority targets in a concentrated campaign.

For these and other conceptual solutions to the Requirement FOR replacement of the functions now performed by manned aircraft in high-risk areas, it becomes necessary to derive Requirements ON such systems.

This is done by developing one or more assumed sets of scenarios or engagement conditions. The scenarios should make sense in terms of overall enemy balance of forces and missions; i.e., the postulated threat should not be exaggerated.

Requirements ON each of the postulated concepts would then be quantitatively set at a level adequate to restore functional performance in each area to that now achieved by manned aircraft. Comparison between concepts would be on the basis of performance (tactical utility), cost (in both dollars and other critical investments), technical feasibility and growth potential (to be discussed later in section 5.0).

4.0 WHAT IS A SYSTEM?

A standard definition of a major system, recognized by all Federal agencies, does not exist. The word *system* has become a catchall term to connote a concept, and anything that fits the concept can be called a *system*. For our purposes, a major system to be procured by the Federal Government is a collection of interrelated parts that combine to perform a specific function to meet a national need.

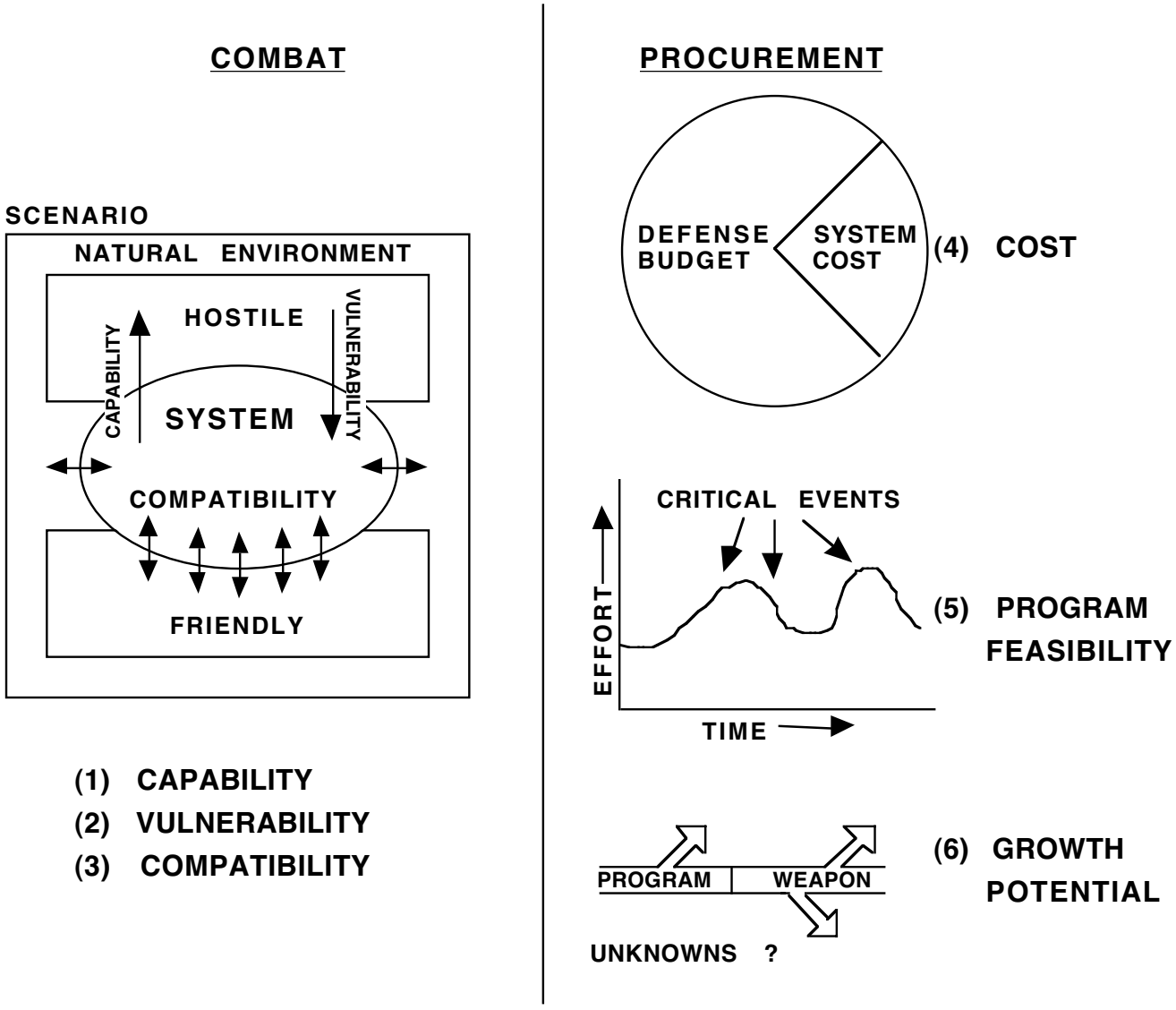

Figure 4-6 - System Decisions are Base on Six Criteria.

A system acquisition program is a special kind of problem solving process that responds to a Federal need by collecting and applying the relevant products of technology. The system that results is of such high cost and complexity that it warrants special management attention. Hence, a military SYSTEM is an assemblage or combination of things or parts forming a complex or unitary whole that accomplishes some specific function or functions within some combat scenario

In Figure 4-6, the scenario describes the circumstances of a conflict and the three-part environment -- Natural, Enemy, and Friendly -- in which the system under design must operate. The Natural Environment is described by specifying the Theater of Conflict and a starting date. This identifies a store of terrain and climate (by season) information which can be utilized to the level of detail required. The Enemy Environment is man-made and can be likened to a Red Force against which the System is designed to have some CAPABILITY. In defense against the use of the System, the Enemy exerts opposing force that affects the VULNERABILITY (survivability) of the System. The System has an interface also with the friendly Blue Force of which the System is a part. This interface with the Friendly Environment (also man-made) provides a number of constraints on the utility of the System (indicated by the double-ended arrows). The System must be capable of existing and operating in harmony with all other elements of the Blue Force and the natural environment. This is defined as COMPATIBILITY.

5.0 EVALUATION CRITERIA DEFINED

In the process of defining a System, three of the six categories of criteria necessary for evaluation have been mentioned; CAPABILITY, VULNERABILITY arid COMPATIBILITY. The other three; COST, FEASIBILITY, and GROWTH POTENTIAL, were alluded to in the previous illustration. All of these criteria are displayed in Figure 4-6.

Evidence is required in all six of these criteria categories in order to answer each of the triad of questions that characterize the decision or recommendation statement on any new concept:

l.	What SHOULD be done?	Requirements Analysis
2.	What WILL be done?	Marketing Analysis
3.	What CAN be done at a profit?	Systems and Business Analysis

As indicated earlier, the emphasis on the six criteria vary depending on the question being addressed. The first question deals primarily with CAPABILITY, VULNERABILITY, and COMPATIBILITY -- the Combat problems of the User. The second question emphasizes COST and GROWTH POTENTIAL issues; whereas, the third question relates primarily to the FEASIBILITY and COST issues -- the Procurement problems of the Developer.

The evaluation criteria are grouped under the Field Commander's (User) and Developer's interests and defined in greater detail as follows.

5.1 Combat Criteria

The definitions below embrace all those characteristics bearing on COMBAT EFFECTIVENESS of the system -- the matters of interest to a tactical commander.

1. CAPABILITY -- covers the general effectiveness and/or rate at which the system can perform its primary function. In the case of weapons systems the capability is expressed in terms of *target kill* which is broadly defined as denial or degradation of the functioning of hostile elements. Useful quantitative measures of capability can normally be developed.

2. VULNERABILITY -- is the inverse; it represents the capability of all hostile systems to prevent the functioning of the system under consideration. For analytic convenience, one exception is made to this rule; enemy counter-measures applied after launch of a weapon are treated as a degradation of capability.

   Some quantification of VULNERABILITY and of its effect on system worth can be achieved by two-sided simulations or by application of capability models from the enemy's viewpoint.

   Vulnerability requirements will be established by comparison with other friendly systems. If the vulnerability of the system to credible counter-measures, combined with its worth in terms of damage to the enemy's interest, are sufficient to make it a preferred target[1], it will not be considered acceptable from the point of view of vulnerability.

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[1] Except when such credible counter-measures as require enemy manpower expenditure at a level sufficient to pose a dilemma to Blue. In such an instance, Blue should threaten mightily and shoot little (or as a wag might put it, -- "walk stickily and carry a big soft!"

The credibility of the postulated counter-measures, and their consistency with enemy force structure and operation must be carefully examined. It is too easy to assume an enemy *ten feet tall*; the real problem is to establish the height for which it is reasonable to prepare.

3. COMPATIBILITY -- includes all relations of the system under consideration with the natural environment and with other friendly elements and systems. Of specific interest under this heading are the requirements for support from these other elements or systems. The nature, quantity and timing of support requirements are to be compared with the functional capability of supporting systems in the projected force structure. If the candidate system imposes no major unusual demands, it is judged compatible; if not, the nature and scale of effort required to satisfy these compatibility demands must be quantified as part of the total system cost.

5.2 Procurement Criteria

Unfortunately the tactical commander has not been in a position to design and procure his own arms since the days of chivalry. These functions are performed by procurement agencies, which attempt to balance combat effectiveness against the following valid concerns of their own:

1. COST -- is a valid consideration since the sums available for expenditure will be established by echelons above the actual procurement agency, to include the American people and their legislative representatives. In the work on Requirements FOR systems, cost should not enter the picture. In the subsequent work (Requirements ON, concept generation, and system evaluation) *comparative* costs are established by estimating effort required for development and production. Post-production costs (operation, maintenance, training, etc.) are better measured by manpower investment. This approach is recommended to the extent that single system demands can be distinguished from the general manpower investment in the appropriate functional fields.

2. PROGRAM FEASIBILITY -- focuses on the general question: *Can the proposed concept or system be implemented through design, production, and deployment phases in time to achieve the expected benefits to national defense?* This is a matter for technical judgment with attendant cost and program risk analyses.

3. GROWTH POTENTIAL -- the properties included under this heading are those bearing on answers to two fundamental questions:

   a) Is the conceptual or candidate system of a type which may be expected to be effective under widely varying conditions and have capability to meet presently unforeseen requirements?

   b) Will the necessary development program provide collateral benefits to the other desirable military developments?

6.0 MEASURE OF WORTH

To recapitulate, the CAPABILITY of the weapon system to do damage to the enemy, its VULNERABILITY against enemy defensive actions and the system's COMPATIBILITY with friendly force elements and the natural environment are of particular interest to the Field Commander. The criteria of COST, FEASIBILITY from a technological standpoint, and the GROWTH POTENTIAL of the weapon system are of more concern to the Developer (e.g., Army Missile Command, Air Force Armament Test Laboratory, Naval Weapons Center, etc.). CAPABILITY, VULNERABILITY, and COST are reasonably quantifiable. GROWTH POTENTIAL and COMPATIBILITY are semi-quantifiable, with the latter being largely a matter of military judgment. The remaining item, PROGRAM FEASIBILITY, is a matter of technical judgment.

The interrelation of the quantifiable criteria is represented in Figure 4-7; wherein

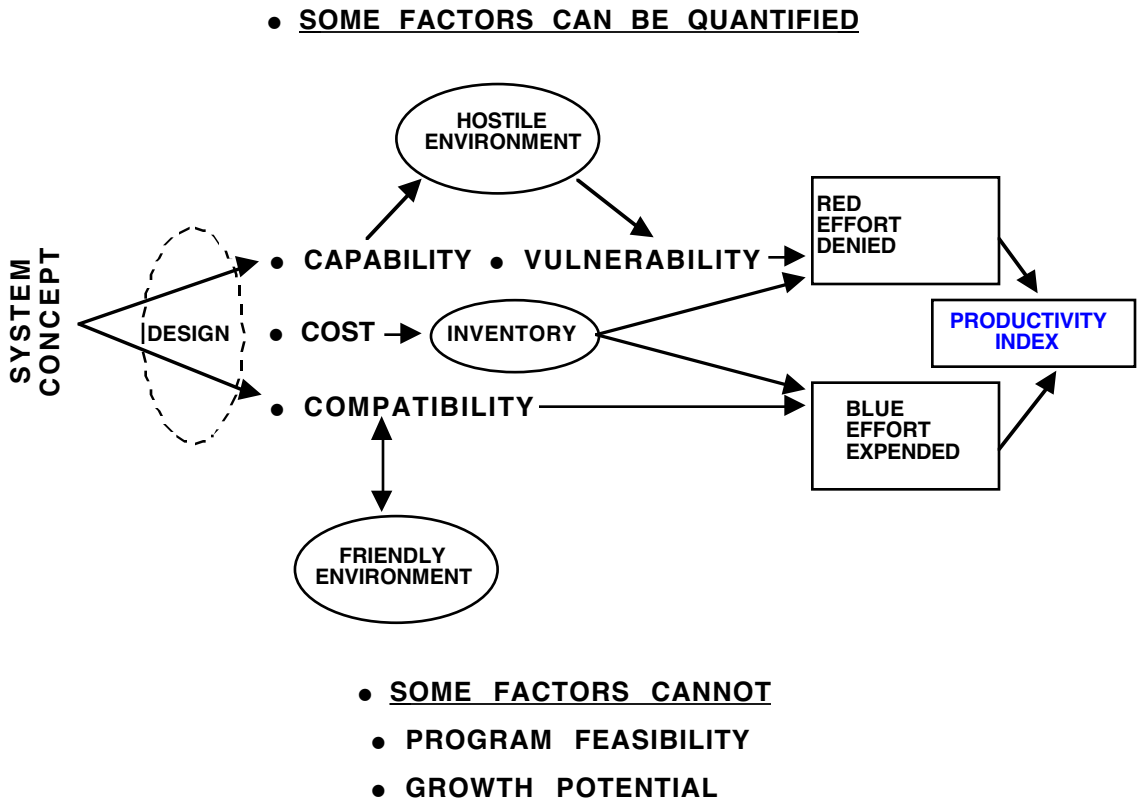

Figure 4-7 - All Criteria Must Be Examined.

any System Concept carried through the design phase will result in some CAPABILITY and a VULNERABILITY in some hostile environment resulting in Red Effort Denied. The unit COST will govern the number procured and thus, the INVENTORY in-theater. The inventory will have a modifying effect on Red Effort Denied and Blue Effort Expended. Blue Effort Expended is also influenced by system COMPATIBILITY with the friendly environment. Quantification of these parameters leads to a credible measure of worth, called the PRODUCTIVITY INDEX, which is expressed as the ratio:

$$\text{PRODUCTIVITY INDEX} = \frac{\text{RED EFFORT DENIED}}{\text{BLUE EFFORT EXPENDED}}$$

and both numerator and denominator can be expressed in terms of equivalent man-days in theater.

7.0 A COMMON MEASUREMENT UNIT

There are two primary reasons man-days has been adopted as the common unit of measure.

First, all military elements within the action zone provide or affect Fire, Maneuver, or Intelligence combat functions, either singly or in some combination. Most development efforts to date have been concentrated on increasing lethality of Fire. In practice though, large amounts of Fire are delivered for suppression and area denial purposes. Fighter-bomber pilots (especially in Viet Nam) indicate that the highest percentage of strike sorties were directed against "suspected enemy locations" rather than the specific military elements that appear on the customary *Target Lists* used by the analyst. Hence, it is necessary to put a value on delay (maneuver) and disruption of military plans (intelligence) as well as on *killing* or damaging a target in order to assess the relative worth or tactical utility of military systems.

Second, a great deal of technical effort is devoted to such configuration-oriented tactical system studies which assess anticipated state-of-the-art advances in related technological disciplines to establish HOW future weapons capabilities can be improved over those currently available. Although these studies are essential in many respects, the proposed weapons system program frequently encounters delays, redirection, or cancellation before it can be implemented because the justification for the operational requirement was considered inadequate. One reason for a system program's delay, redirection or cancellation is that two or more services are generally involved in each function for which a tactical system is proposed (See Figure 2-6). Also, there are at least two or three plausible technical solutions, each with its own set of advantages and limitations. Hence, it isn't difficult to arrive at a list of 50 to 100 system designs that are offered for consideration. Give each solution its protagonists and no objective basis for judging relative priorities between their basic functions, and the stage is set for a situation which has been labeled by some as a *proliferation of tactical systems*. The common unit of measurement, man-days of effort, assists in establishing an objective basis for assigning need priorities.

8.0 SIX LEVELS OF ANALYSIS

The use of human effort, expressed in man-days (or equivalent), as a common unit of measure is a significant concept. Not only does this make it possible to represent time as being of value in conflict situations, but it also enables quantitative analytic relations between seemingly disparate military functions.

The procurement and employment of military hardware systems and military forces involves people and agencies of varying primary concerns. Figure 1-6 presented one simplified view of the hierarchy of force designers, tactical commanders, and system engineers involved in the total process of procurement and employment of military systems.

Referring back to Figure 1-6, Levels I and VI continuously interface in the justification and execution of the defense budget and quite normally communicate in the language of dollars.

At Level I, defense budget dollars are allocated to provide military forces which are then incorporated in the national military strategy formulated at Level II. Superior strength in manpower and equipment will decide the outcome of military operations in many, perhaps most cases; however, there is no favorable ratio which will guarantee victory due to the imponderables of human performance.

The dollar language tends to obscure the fact that a much more important investment is being made -- the time and men committed to implement the military strategy. Effective use of this manpower, assisted by the previously procured equipment, and of time, determines the outcome in the theater of conflict, the details of which are the concern of Levels III, IV, and V. The man-day is a common unit of measurement.

As pointed out in Chapter 3, the man-day is also a suitable unit for budgetary considerations. The cost of an item in man-days fluctuates only with productivity. When the same calculation is made in dollars, PRICE rather than COST is often the output and extraneous factors such as profit, overhead rate, and inflation obscure the issues. Contracting Officers must be concerned with PRICE comparisons, Developers should attempt to identify true COST.

The Level VI system engineer is concerned with cost, which is naturally expressed in dollars. He is also concerned with schedule, total effort, critical tasks, and skilled manpower. The Level VI system engineer is also concerned with combat effectiveness, but must be informed on this subject by representatives of the Level III, IV, and V users. Combat effectiveness is produced by total combination of a great many system qualities and performance variables. Quantitative measures are available for some, but not all, of these variables; these measure are incommensurable. There is no way to establish the ideal balance among the variables except in the context of some specific combat situation. However, various. situations produce different answers.

The use of man-days to compare input with output in several scenario contexts has been shown to produce useful evidence regarding the best balance of system qualities. (See Chapters 8.1, 8.5 and 8.6.)

To reiterate:

> Man-days appears to be the most sensible common unit interconnecting the concerns of Levels II through V. On examination, we find they are also of meaning at Levels I and VI and when used may clarify procurement and design alternatives.

9.0 APPLICATION

This chapter has developed the criteria for evaluation of military systems, which was its intent; however, the usage of these criteria in any specific investigation (e.g., see Chapter 8) is quite dependent on the question being considered and the level at which substantive conclusions are needed. In the ultimate, many concept decisions are dependent on force structure and mix considerations that occur at the Department of Defense, the Joint Chiefs of Staff, and Theater Levels (I, II, and III).

Force structuring addresses the question of what mix of military units should be provided in view of the Services' assigned missions, the estimate of the threat, and accounting for budget constraints. One would like to provide a *best* mix; but what is the *best* mix? The answer to this question is probably indeterminate. Differing situations will probably call for different *best* mixes, so in the end one must compromise and select a mix that is not *best* for any situation. However, this mix is satisfactory in all situations - at some level of risk. One would expect to find several, perhaps many mixes, all of which are reasonably satisfactory.

The above assumes that procurement and operating funds are limiting; hence, one cannot have all he wants or even needs.

Now we have provided a conceptual Descriptive Model of Combat (in Chapter 3) and a road map of how these conceptual ideas can be used in establishing requirements and evaluating conceptual solutions that may meet the Requirements.

We must move on now to an approach to quantifiable values for military elements. In Chapter 5, the general development of elemental values is pictured as a process of adding on to *Residual Values,* furnished by the next higher command, a *Situational Value* derived from the element's contribution to combat potential for a chosen course of action.

The method, as explained therein and illustrated by simple low-level tactical situations, appears applicable for practical analysis of system effectiveness.

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