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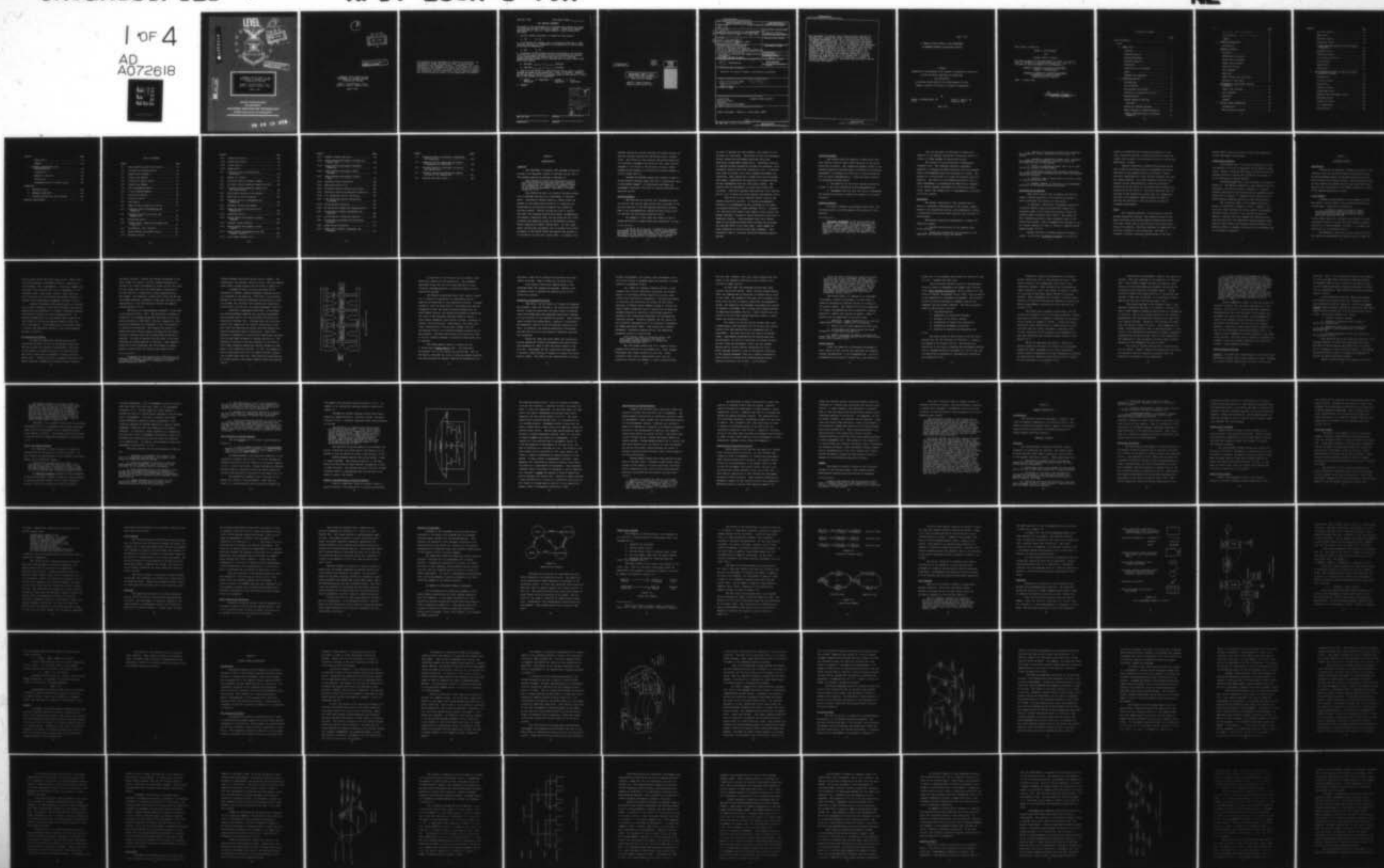

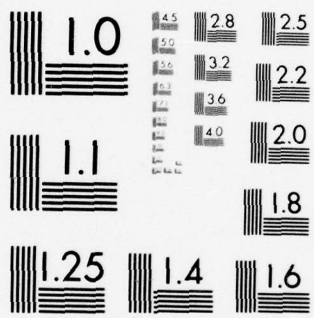
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A DYNAMIC POLICY MODEL OF THE DEPARTMENT OF DEFENSE SYSTEMS ACQUISITION PROCESS

Susan A. Kaffenberger, GS-12
David P. Martin, Captain, USAF

LSSR 1-79A

UNITED STATES AIR FORCE
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Wright-Patterson Air Force Base, Ohio

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The Department of Defense (DOD) weapon systems acquisition process has a complex and dynamic nature which continually challenges management's ability to develop effective policy to support decision-making. With the invaluable assistance of key managers within DOD, Office of Management and Budget, and Congress, a policy model of the process has been developed using the system dynamics concept. The formal and informal system structure and policies which currently exist for the weapon systems acquisition process are addressed in the research. The purpose of the dynamic policy model is to provide a tool to assist DOD strategic managers in understanding the complex nature of the system and to identify the most important areas that are sensitive to changes in either structure or policy. The model thus provides a device for policy development.

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A DYNAMIC POLICY MODEL OF THE DEPARTMENT OF DEFENSE SYSTEMS ACQUISITION PROCESS

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Logistics Management

By

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June 1979

This thesis, written by

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and

Captain David P. Martin

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MASTER OF SCIENCE IN LOGISTICS MANAGEMENT
(Susan A. Kaffenberger)

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT
(ACQUISITION LOGISTICS MAJOR)
(Captain David P. Martin)

DATE: 13 June 1979

Thomas W. Clark Jr.
COMMITTEE CHAIRMAN

TABLE OF CONTENTS

Chapter Page

Chapter		Page

LIST OF FIGURES

Figure | Page

Chapter 1

INTRODUCTION

Overview

The Department of Defense (DOD) systems acquisition process is an important element of national policy (48:1). The systems acquisition process is defined as:

> The sequence of activities starting with reconciliation of mission needs and goals with capabilities, priorities, and resources and extends through the introduction of a system into operational use or the otherwise successful achievement of program objectives [20:3].

This definition does not consider the much broader role of systems acquisition in achievement of national goals. Secretary of Defense Harold S. Brown stated the purpose of the acquisition process is to translate our technological and productive capacity into effective military posture. Several actions he cited to achieve this goal were planning mission area needs, strengthening the domestic industrial base, and utilizing the full technological and industrial power of the National Atlantic Treaty Organization (NATO) (68:307-308). In this larger sense, the national government acts to promote the welfare of people of the United States and support the welfare of its allies in its role as a world power. In essence, the systems acquisition process provides the bridge between the national defense industry and the United States' defense force. This force not only protects the United States and its interests throughout the world but also lends credible strength to the forces of United States allies, either through direct presence or allocation of weapon systems to allied forces (68:1-4).

Because the systems acquisition process is used to satisfy several national goals and takes a significant share of the Federal budget[1], it continually challenges top government executives' abilities to develop consistent and effective policy.

Problem Analysis

The difficulties involved with implementing effective policy were noted in many reviews and criticisms of the policies relative to the DOD systems acquisition process. Many of the recommendations offered by these studies have not provided the anticipated benefits (26:1).

For example, in the 1950s the length of time to design and develop a weapon system was considered too long.

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[1]In FY 79, $12.6 billion is budgeted for Research, Development, Test and Evaluation. This is approximately ten percent of the total DOD budget, but does not include the portion of the acquisition process that is funded in Procurement Appropriation or Personnel Costs (68:15).

In order to shorten the time schedule, the concept of concurrency was instituted. Concurrency called for overlapping several design and development functions which were previously accomplished sequentially. Concurrency resulted in numerous system integration problems and redesigns, which ultimately drove up the total acquisition cost. To reverse this trend of rising costs, Total Package Procurement was instituted. This concept set a fixed price for the design, development, engineering and production of weapons systems and was implemented with the C-5A cargo aircraft. The results were not successful, as costs rose rather than decreased. Historical analysis indicates the "real" problem was not cost overruns but poorly defined requirements (26:6).

This story has been repeated several times in the systems acquisition process. It indicates management's difficulty in determining the real problems or the impact of proposed solutions to these problems (26:10). Forrester (25) indicated this behavior was common to many complex and dynamic systems. Outcomes of policy decisions often lead to unexpected results. Decision-makers work with a mental image of the system structure which includes the processes and problems which affect their jobs. These images are based primarily on intuition and human judgement. This frequently leads to incorrect decisions regarding complex systems.

Problem Statement

The counter-intuitive behavior of many social systems creates a need for more formal analysis of the policy decisional structure. The complex and dynamic nature of the systems acquisition process makes it difficult for strategic management[2] to determine the effect(s) of policy decisions prior to policy implementation. Given this major problem, two secondary problems result:

1. The behavior of the entire systems acquisition process is not fully understood by DOD management; and

2. Management does not have the tools to understand the acquisition process or measure the impact of its policy decisions.

Research Question

In order to address the problems stated above, the following question provided purpose and direction to this research.

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[2]Strategic management is the most current term to describe top corporate policy making in private and public organizations. Strategic management is concerned with the long-range goals of an organization and with the appropriate course or courses of action to achieve them, considering environmental conditions, available resources, and degree of risk [75:1].

Can a policy model be developed to capture the behavior of the systems acquisition process and serve as a vehicle to study changes in acquisition policy?

The concept of policy modeling is addressed by Forrester (22). The technique requires a systematic approach to studying the system structure and relationships which link management goals and decisions to actions. The purpose of a policy model is to make the decision structure explicit. The result of this modeling provides a tool to assist management in determining the behavior and response of the system through experimentation with policy situations, issues, and changes prior to implementation of policy in the real system.

Objectives

The general objectives of this research were to develop a conceptual understanding of the complex, dynamic nature of the acquisition process, and subsequently, develop a computerized policy model which reflects the structure of this process.

The specific objectives established to conduct the research included:

1. identify the structure of the systems acquisition process;

2. isolate the interactions and influence of the components and variables within the system;

3. describe the decision structure that determines the information, money, and material flows within the system;

4. construct a mathematical model which represents the components, relationships, information flows, and decisional policies of the system;

5. develop a computerized model which can be used for policy analysis and development;

6. verify and validate that the model represents the structure and decision-making process within the systems acquisition process;

7. identify areas of sensitivity or critical issues in acquisition policy; and

8. suggest changes, if required, in the management structure of the systems acquisition process.

Justification of Research

Many recent sources have recognized the need for taking a systems approach to the acquisition process to better understand the behavior of this system.

In response to the Federal Procurement Institute's (currently Federal Acquisition Institute) desire for a conceptual model of the acquisition process, Lawson and Osterhus began to develop such a model. The results of their research provided a broad conceptual model of the acquisition process. Their recommendations included a call for further research in order to develop a complete system dynamics model (40:117).

Another advocate of further research is Robert F. Coulam. In his book, Illusions of Choice, he called for studies to understand the influence and behavior of the total acquisition system, to identify sensitive areas and trends, and to assist in developing policies for reform and improvement (15:389).

Finally, Secretary of Defense Harold Brown stated that attention was being focused on management and policy functions of the systems acquisition process to ensure effective transformation of the limited resources into useful output products. In a major departure from past procedures, he has consolidated all functions relating to acquisition in the Office of the Deputy Under Secretary for Acquisition Policy (68:311). This move indicates that the problems of the acquisition process have not disappeared, and that a more aggregate approach should be taken to identify the structure of the acquisition process and recommend improvements.

Scope

This research develops a policy model of the DOD systems acquisition process. The research focuses on the major structural and decision-making elements which exist over time, rather than on the detailed, day-to-day operations of the system. This macro approach is consistent with the basic concepts of policy modeling. The model is intended to provide increased understanding of the basic system behavior and can be used to assist DOD managers in policy development and analysis.

Presentation Approach

The presentation of the research generally follows the sequence of activities discussed in the research objectives. Chapter 2 develops the concept of policy within the systems acquisition process and introduces the reader to policy modeling for complex systems.

The methodology used in this research is outlined in Chapter 3. The specific approach to this research effort is discussed in the first section of Chapter 3. A system dynamics application of policy modeling is presented in the second part of Chapter 3. Readers who are familiar with system dynamics modeling may wish to omit this section.

The conceptual model of the systems acquisition process is developed in Chapters 4 and 5. Chapter 4 contains the verbal descriptions of the system relationships and major issues relative to the acquisition process. Chapter 5 contains the flow diagrams and equations which were developed into the computerized system dynamics model. Based on these results and insights gained throughout the research conduct, a summary, conclusions and recommendations are contained in Chapter 6.

Chapter 2

LITERATURE REVIEW

Introduction

The search for pertinent information related to this research effort was directed along two distinctive lines: the policy-making process for systems acquisition and the tools available for problem solving. The following sections in this chapter will address these topics individually and show how each contributes to the overall purpose of a model of the systems acquisition process.

Policy Making

A general understanding of policy making is necessary before a policy model of the acquisition process can be developed. Policy can be defined as:

> . . . a definite course or method of action selected from among alternatives and in light of given conditions to guide and determine present and future decisions [72:656].

In this sense, policy is a decision rule applied to select a particular course of action from the "options or means available to a decision-maker, by which, it is hoped, the objectives can be attained [49:47]."

Unfortunately, objectives are not always clear and the conditions surrounding the decision may be clouded by multi-faceted issues and conflicting forces. Thus, effective policy making is extremely difficult, especially at the strategic level of management. Intuition, judgment and experience have long been the tools of management at the strategic level. Many times, however, these tools are quite unreliable for anticipating the dynamic behavior of complex, multi-dimensional management processes (21:99).

Despite the dynamic and complex nature of strategic level policy, Forrester claims that strategic level policy making could be understood if a formal, deliberate approach were taken to discover the true "guiding policy". He defined guiding policy as that process which captures the real nature of the decision-making framework within the total environment. Policy modeling is an excellent means to reflect the behavioral aspects of the decision-making process (21:96-101).

The Acquisition Process

In order to capture the guiding policy of the acquisition process, the role of the process within the DOD and national policy must be established. The acquisition process is a major function in the DOD which has been used to facilitate achievement of various national goals (4:81). Pressure for social programs within the last decade resulted in competition between national security and social welfare. Despite the reduced percentage of the total budget allocated to the DOD, defense spending continues to be a major determinant in fiscal policy (48:1,233). For the fiscal year 1979, the USAF budget contains $15.2 billion (66:107) in acquisition related appropriations. This budget, once executed, creates jobs within the DOD and the defense industry, stimulates technology, and contributes significantly to the Gross National Product and general economic growth (7:1-2).

DOD policy for acquiring major systems[1] is contained in DOD Directive 5000.1 (69). The Secretary of Defense is responsible for designating systems which must follow the policy contained in DODD 5000.1; however, managers of other acquisition programs are encouraged to use this directive to guide policy decisions. The acquisition process is broken down into distinct phases starting with the identification of mission need and finishing when production is complete. In order to proceed from one phase to the next, Secretary of Defense approval is required. These approval points are called milestones and are preceded by comprehensive reviews within the services and finally by the

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[1]Programs with anticipated cost of $75 million for research, development, test and evaluation or $300 million in production are considered for designation as major system acquisition (69:5).

Defense Systems Acquisition Review Council (DSARC). The sequencing of the process, decision pcints, and key elements which affect systems acquisition are shown in Figure 2-1.

Although the major decisions are made by the Secretary of Defense, program management responsibilities are delegated to the Services. DODD 5000.1 also provides guidance to the Services concerning the evaluation of need for systems, the interface with industry and educational institutions, and the type of program management (69:5-10).

DODD 5000.2 supplements DODD 5000.1 by providing the decision-making framework and reporting requirements that surround each of the four milestone reviews by the Secretary of Defense (70). Although these two directives provide the largest part of official acquisition policy, many other DOD publications contain policies dealing with specific functional areas of acquisition. DODD 5000.1 contains 26 references to other policy regulations concerned with various types or phases of systems acquisition. The diffusion of policy is even more apparent at the Service level where countless regulations provide guidance on segments of the acquisition process. In 1971, for example, an officer associated with the F-15 fighter aircraft acquisition claimed there were over 1,282 directives which applied to various phases of the weapon systems acquisition process (26:14).

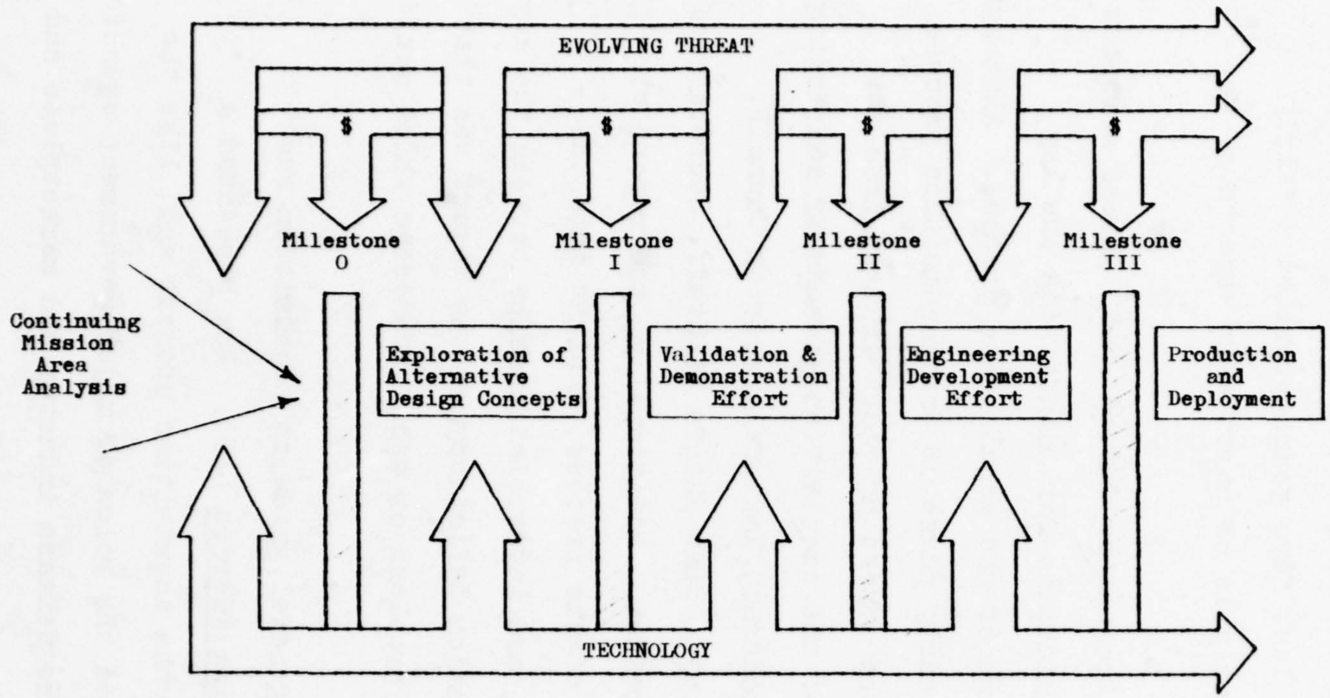

Figure 2-1

Major System Acquisition Process

In addition to the official policy, several other guidelines address the DOD acquisition. Two documents published within the last five years provided a fairly broad but thorough analysis of particular aspects of the acquisition process.

The General Accounting Office (GAO) issued a report (71) to serve as a guideline for identifying the key agencies and functions of the acquisition process. Although limited to only the early phase of the acquisition process recognized by DOD, the report provided insight into the much broader scope of the acquisition process by addressing the roles of the President, National Security Council, Intelligence Community, Joint Chiefs of Staff, Secretary of Defense, and the Services. Additionally, the report provided a description of the process, insight into the influencing factors, and interrelationships between the key participants. The major deficiency of the report was that it did not identify problems or sensitive areas which could be improved.

The second general guide to acquisition was J. Ronald Fox's <u>Arming America</u> (26). Fox presented a procurement view of the acquisition process and, like the GAO Report, described the roles of major government agencies. Fox also analyzed the defense industry and marketplace and provided a long list of acquisition problems with recommended solutions. Many of these will be noted later.

Both reports contributed significantly to the knowledge about the acquisition process. However, both documents failed to address the dynamic nature of the acquisition process.

Evolution of Acquisition Policy

DODD 5000.1 was the result of 25 years of changing philosophies, needs and reforms to the acquisition process. Several categories which were the focal points of problem areas and reforms have been addressed continually throughout the evolution of the acquisition process. These primary areas included the technological, financial, contractural, and managerial aspects of the DOD systems acquisition process. In addition, the Defense marketplace relationship with DOD and its role in the national industrial base was also addressed.

During the 1950s and early 1960s, the acquisition process emphasized technical performance and short production schedules in order to meet the Soviet threat in the Cold War. Concurrency was the acquisition strategy used to provide a rapid buildup of weapons to counter the Soviet missile threat. The 1950s era was characterized by poorly defined requirements, cost growth, poor performance, duplication and overlap of programs among the Services, and high turnover of personnel (6:68).

As a result of extensive research efforts by DOD, Congress and civilian researchers concerning the economic aspects of the weapon systems acquisition process, many reforms were instituted in management, training, performance of contracts, and accountability within the DOD (6:69). Secretary of Defense Robert McNamara sought to reverse the trend towards increasing costs of acquisition by improving program planning and selection, instituting innovative management and contracting technology, and reforming the budgeting process. Secretary McNamara was well known for the successful implementation of the Planning, Programming and Budgeting System (PPBS). PPBS centralized financial management, increased planning efforts, and emphasized management aspects of acquisition.

> After several years of sustained effort, however, serious cost, schedule, and technical performance problems continued to disrupt the acquisition process [26:2].

The C-5A cargo aircraft and F-111 fighter aircraft programs were products of the McNamara era. Total Package Procurement was a major disaster on the C-5A. Prime contractor costs rose so significantly that the C-5A fixed-price contract was amended to cover a projected $500 million loss. However, cost was a minor problem when compared to the technical difficulties with cracks in the aircraft's wings (26:3-4).

In late 1969, two promising actions were taken towards acquisition reform. First, the Blue Ribbon Defense Panel was commissioned by Secretary of Defense Melvin Laird in July 1969. The purpose of the panel was to examine very broad areas related to defense acquisition and management. Second, the Commission on Government Procurement was created by Congress in November 1969 to study and recommend methods of improving procurement (32:3-4). These studies were considered to be the first systems approaches taken to investigate the acquisition process.

The results of the Blue Ribbon Defense Panel were disappointing, since the panel did little more than restate obvious facts and provided few new recommendations for improvement. The Panel did point out several noteworthy items: requirements determination was unstructured and uncoordinated, the Office of Secretary of Defense decision process lacked any meaningful review, and the program manager had no clearly defined responsibility (32:4). Other findings included a lack of training and continuity in the program management task and a complex bureaucratic source selection process which hindered making timely, objective decisions (26:191,270). As Fox stated:

> While the panel successfully identified several problem areas in the procurement process, their report did not explain why previous recommendations along the same lines have never been successfully implemented. Many procurement officials in the Defense Department are, after all, aware that the present system has faults. But despite a steady succession of studies and recommendations, the procurement process has remained impervious to structural reform [26:457].

The second study, the Commission on Government Procurement, looked at procurement in broad terms to identify consequential problems instead of focusing on the surface issues. The Committee's work was summarized in 12 major recommendations which formulated a systems approach to improve the acquisition system. These 12 points could be summarized in four basic aims:

1. Establish a common framework for all involved organizations to have a common set of procedures;

2. Define the role each organization must play;

3. Give Congress and agency heads the needed information to make key decisions; and

4. Improve the means for public accountability rather than have a burdensome administrative reporting and surveillance procedure (6:92).

Recent Reports

Since the Committee on Government Procurement's final report in 1972, the GAO has monitored the progress towards implementation of the recommendations. Of the 57 recommendations calling for legislation, only seven have become law, 21 are pending, and 29 have not been acted upon (51:4-5). Progress has been slow.

One of the most positive actions is the implementation of Office of Management and Budget (OMB) Circular A-109, Major Systems Acquisition, and the formation of the Office of Federal Procurement Policy (OFPP), both off-shoots of the Commission on Government Procurement. OMB Circular A-109 has received affirmative response from the DOD, Congress, and the defense industry. The basic principles found in OMB Circular A-109 are:

1. Validated Mission;
2. Comparison of Alternative Systems;
3. Reliance on the Private Sector;
4. Maintenance of Competitive Opportunity;
5. Integrated Government Action; and
6. Equation of Authority and Responsibility

(51:6).

The basic intent of OMB Circular A-109 was incorporated into the 1977 revision of DODD 5000.1. However, the reform is not without critics. Major points for concern are in the area of research and development funding (34:2), extended production leadtime (9:7; 52:4), and loss of flexibility as bureaucratic implementation procedures are formulated (51:8).

Additional concern was addressed by the Defense Science Board Task Force on the acquisition cycle. Their report focused on the lengthening "front end" of the acquisition process. They concluded that the system was highly structured, costly, and lacked the sense of urgency for acquiring or modifying weapon systems for national defense. Their recommendations included a flexible implementation of OMB A-109 with special emphasis on reconciling mission requirements, and priorities with resource constraints (17).

The recent policy changes in DODD 5000.1 and OMB Circular A-109 appear to be in the right direction. However, many authorities still recognize a resistance of the acquisition process to respond to reform. A recent GAO report stated that major acquisitions at completion cost 72 percent more than the initial estimates. Technical difficulties, inflation, faulty planning, poor management and poor cost estimating were offered as major causes of cost growth (70:1).

Why do the same problems recycle? Why do new problems appear as the result of "fixes" to old problems? Perhaps the "real" problems are not really understood. Coulam offered an explanation for the recurrences of problems by indicating the chosen solutions have failed to evaluate all the influences of the process (15:5).

Coulam used two paradigms to explain the acquisition process. The first paradigm is the analytical or "Rational Man". This concept assumes that Man has complete information in the decision-making environment and selects the alternative which provides the highest payoff. Coulam noted that despite the inapplicability of the Rational Man concept to many real situations, it is continually used to make policy decisions and develop plans (15:6).

The second paradigm is the cybernetic model. This approach recognizes that Man is not perfect. Man does not have or seek complete information and filters the information he receives. One of the reasons offered for the cybernetic paradigm was that individuals and organizations cannot deal with complex problems. Therefore, the problems are broken down into smaller pieces (15:25-27). This fragmented, but highly structured approach leads to suboptimization at lower levels of the organization and places an enormous integrative responsibility on the strategic levels of the organization. The complexity of this integrative process simply furthers ambiguity in the management process (15:338).

The close of Coulam's book paints a gloomy picture for the future. However, despite this prediction, he called for reform of the total acquisition process after the behavior of the system is fully understood:

> It is folly to speak of reforming the acquisition process without understanding the influence and behavior of the many organizations to be changed, yet in fact reform efforts have been forced to proceed without much detailed understanding. Partially as a result, past reform efforts have concentrated on the manipulation of conspicuous summary features of the process, like contract types, which, our study and others suggest, are not likely to be fruitful avenues of reform. Successful reform will require sensitivity to complex details of behavior in the acquisition process. Future studies can aid reform efforts by providing knowledge of these details [15:389].

Lorette suggested a means to study the acquisition process to uncover the true nature and behavior of the process. He called for a new and different approach in determining the style and conceptual relationships that encompass the acquisition process. He recommended the scope of the research include the basic philosophy of government and democracy, the political and economic systems, in addition to areas traditionally considered as part of the DOD systems acquisition process (43:6). In essence, Lorette suggested a systems approach to the acquisition process. The next section contains a discussion of a means to apply the systems approach to the acquisition process: system dynamics modeling.

System Dynamics Modeling

Overview. The quest for a methodology to solve complicated problems has always been a major objective of man. Throughout history several methods have evolved to better solve problems. Prior to the seventeenth century, man attempted to solve problems almost entirely by deductive methods. Philosophers such as Plato, Aristotle, and Euclid sought to solve complex problems by drawing analogies from everyday life experiences. This method often yielded erroneous results (47:4-5).

In the seventeenth century, English philosopher and scientist Sir Francis Bacon led a movement toward a more structured scientific approach. In his book, Novum Organum, Bacon proposed a method for observation and logical deduction which allowed man to solve problems more effectively. This method embodied four steps:

1. Observe a physical system;

2. Formulate a hypothesis that attempts to explain the observations;

3. Predict the behavior of the system based on the hypothesis by using mathematical or logical deduction; and

4. Perform experiments to test the validity of the hypothesis (47:5).

Beer advocated use of the scientific method to solve problems; however, he stated that many times the wrong problems are solved because the boundaries of the system did not encompass the whole problem (3:50,92). The systems approach provides a vehicle to expand the boundaries to include the entire system environment.

Russell Ackoff describes the approach as follows:

The systems approach to problems focuses on systems taken as a whole, not on their parts taken separately. Such an approach is concerned with total-system performance even when a change in only one or a few of its parts is contemplated because there are some properties of systems that can only be treated adequately from a holistic point of view. These properties derive from the relationships between parts of systems: how the parts interact and fit together [1:27]

Churchman adds to Ackoff's description by including considerations for the management and resource subsystems which affect the performance of the components and the entire system (12:29-30). The systems approach has become a critical part of contemporary management science models (1:27).

Models for Complex Systems

The term model is used to denote "a simplified representation or abstraction of reality [63:19]." In this context, any system used to aid a manager in decision-making can be considered a model.

> Planners deal continuously with models . . . . They may not be aware that they are using a model, and their models are not necessarily correct. They are simply constructs to substitute in our thinking for the real system that is being represented [47:8].

In Industrial Dynamics Forrester stated management science has developed a number of models to assist managers in solving problems; however, few of these techniques provide a basis for dealing with complex problems of strategic management. Much of management science's achievements have dealt with the lower levels of the management structure (21:3). He challenged the future manager to improve his ability to handle major problems at the strategic level of management. To do this, Forrester prescribed system dynamics--a simulation modeling approach. This technique combined the systems approach to complex, dynamic management situations with the capabilities of digital computers. It provided a single framework for integrating the functional areas of management and offered a vehicle to determine how information and policy create the character of an organization. In essence, system dynamics models are "management laboratories" (21:vii).

The basic premises of the system dynamics technique are:

1. Decisions in management and economics take place in a framework that belongs to the general class known as information-feedback systems.

2. Intuitive judgment is unreliable about how these systems will change with time, even with a good knowledge of the individual parts of the system.

3. Model experimentation is now possible to fill the gap where judgment and knowledge are weakest--by showing the way in which the known separate system parts can interact to produce unexpected and troublesome overall system results.

4. Enough information is available for this experimental model building approach without great expense and delay in further data gathering.

5. The "mechanistic" view of decision-making implied by such model experiments is true enough so that the main structure of controlling policies and decision streams of an organization can be represented.

6. Systems are constructed internally in such a way that they create for themselves many of the troubles that are often attributed to outside and independent causes.

7. Policy and structure changes are feasible that will produce substantial improvement in industrial and economic behavior; and system performance is often so far from what it can be that initial system design changes can improve all factors of interest without a compromise that causes losses in one area in exchange for gains in another (21:13-14).

<u>Basic Concepts of System Dynamics</u>

The term <u>system</u>, as it is used in system dynamics refers to:

> . . . a set of <u>objects</u> together with <u>relationships</u> between the objects . . . <u>connected or related to each other</u> and to their <u>environment</u> in such a manner as to form an entity or whole [56:238].

In system dynamics, the principle foundation is the information feedback loop (21:14). It is the information feedback loop which ties the objects of the system together so that it acts as an entity. Without information feedback, systems operate as uncontrolled devices where outputs are isolated from and have no influence on the inputs (23:1-5).

The information feedback loop is the part of the system that reacts to the environment. This reaction results in a system decision which ultimately changes the environment and influences future decisions (21:14). An example of an information feedback system is depicted in Figure 2-2.

Information feedback systems contain three basic behavioral characteristics: structure, delays, and amplification (21:15). Forrester explained these characteristics as follows:

> The structure of a system tells how the parts are related to one another. Delays always exist in the availability of information, and in taking action on the decisions. Amplification usually exists throughout such systems, especially in the decision policies of our industrial and social systems. Amplification is manifested when an action is more forceful than might at first seem to be implied by the information inputs to the governing decisions [21:15-16].

The objective of policy makers is to determine the policy or decision rule which control the dynamics of the system so that the system can reach a desired goal (15:30).

System dynamics applies this policy making concept to complex systems. When properly applied, it can help define how decisions are made and what information is used to make decisions. The feedback decision structure becomes extremely useful in determining what actions need to be taken to control the system.

Special Considerations for Systems Dynamics

Like all techniques, there are several issues of special concern in the application of simulation modeling.

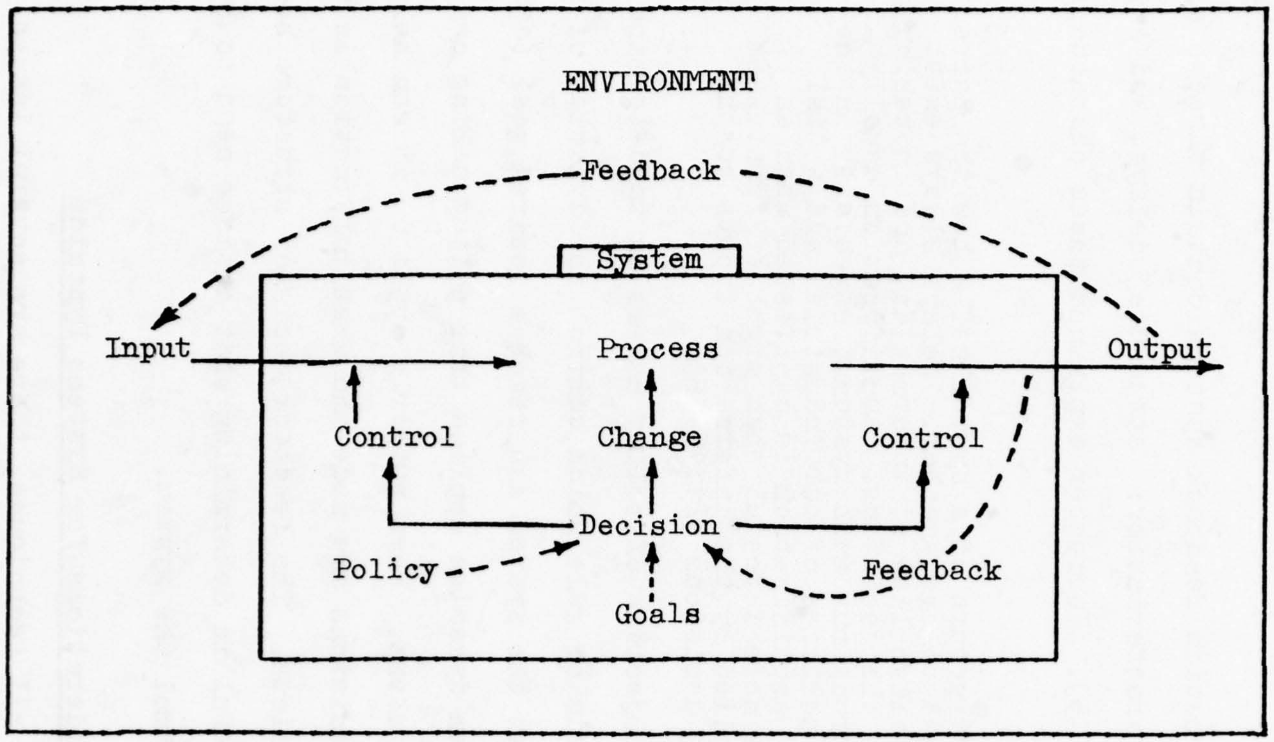

Figure 2-2

Information Feedback System

The modeling process draws a fine line between oversimplification and overdetail. Omission of detail can cause the model to loose its robustness. On the other hand, too much detail can cause a burdensome and wasteful model which disguises the true system behavior (24:112). The model should seek to provide enough detail to be persuasive for its intended purpose. Management should believe that the level of model detail takes account for important issues and problem areas (54:29). Because many system dynamics models pertain to complex management systems, there is a reliance on expert judgment and intuition of management. In the absence of a well-defined body of management theory, or clear-cut measures of performance in the real world, the task of modeling is a challenge (41:19). The results of the model should not be construed as "the" right answer, but rather, a means to understand the general behavior of the system. A final concern is management's attitude. Many managers feel threatened by simulation models, envisioning the models as a replacement for management. This misunderstanding leads to reluctance of managers to use an important tool designed to <u>assist</u> the manager's decision making and policy analysis--not replace him. Simulation simply provides a rapid evaluation of a series of alternatives and variables that cannot be accomplished by man due to the complex and dynamic nature of management situations (21:99).

Applications of System Dynamics

Despite the concerns about simulation, models can provide a forceful and effective tool to management. The system dynamics application of simulation provides a means for management to gain insight into the underlying behavior of their management systems. Modeling also provides a vehicle for systematic evaluation of alternative management policies or the consequences of specific environmental issues which effect the system (53:293). The system logic is built around the goal seeking and growth aspects of complex systems. System dynamics models try to imitate the real-world system in all its faults, so that the manager can see how the overall system operates and reacts to changes in policy without having to apply these changes to the real-world system.

System dynamics models have been applied successfully to diverse areas. Forrester listed several applications of the concept to various real-world situations such as corporate policy, social forces affecting drug addiction, and growth and development of urban areas (24:13).

> The value of a model is that it can be used to improve our understanding of the ways in which a system behaves in circumstances where it is not possible (for technical, economic, political or moral reasons) to construct or experiment with a real world system [41:7].

The usefulness of models becomes more evident when applied to research by more than one person. Kadanoff modified Forrester's urban model to study changes to urban communities (24:133). Kadanoff then went on to enlarge the system and produce different results. His explanation for this difference provided a noteworthy insight into the value of models: "He (Forrester) and I have each used the model to explain our different point of view and to put our reasoning in numerical form [37:79]." Therefore, the application of the urban model provided both Kadanoff and Forrester an arena in which their theories could be presented in clear, unambiguous language without going into semantics.

Application to Acquisition Policy

System dynamics modeling has been applied to several areas of the acquisition process. In 1964, Roberts published his study of management of research and development (R&D) projects using system dynamics. His primary contribution was an understanding of the dynamic nature of R&D in both the government and private sector, as well as an invitation for future research in the area of R&D (55). A more specific application to DOD research and development was made by Elder and Nixon. Their research addressed the managerial aspects of R&D conducted within the Aeronautical Systems Division in the Air Force Systems Command (19).

Lawson and Osterhus applied the system dynamics modeling technique to a broader area associated with the DOD acquisition. In their research, they developed a conceptual model of the DOD acquisition process which centered on the interrelationships of six sectors: the Congress, the DOD, the Enemy, Industry, the President and the Populace. From these six sectors they developed a causal loop diagram[2] of the interaction among these sectors of the weapon systems acquisition process (40). Their research provided a conceptualization of the acquisition process; however, conceptualization is only the first step towards providing a useful management tool. The purpose of this research is to refine Lawson and Osterhus' conceptual effort, incorporate the research of Roberts, Elder and Nixon, develop a mathematical representation of the total system, and, finally, analyze the model to assess the implications of policy changes in the DOD systems acquisition process.

Summary

This chapter contains a review of the literature relevant to the two-fold scope of the research effort: understanding acquisition policy and use of modeling.

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[2]Causal loops identify the relationships between pairs of avriables which are linked together in a loop (29:11). A detailed discussion of causal loops is provided in Chapter 3 of this thesis.

The task of modeling complex, dynamic systems is extremely difficult; however, the system dynamics technique is specifically designed to accommodate these situations. Forrester, in the conclusion of the discussion of his world dynamics model states:

> Men would never attempt to send a space ship to the moon without first testing the equipment by constructing prototype models and by computer simulation of the anticipated space trajectories. No company would put a new kind of household appliance or electronic computer into production without first making laboratory tests. Such models and laboratory tests do not guarantee against failure, but they do identify many weaknesses which can then be corrected before they cause full-scale disasters.
>
> Our social systems are far more complex and harder to understand than our technological systems. Why, then do we not use the same approach of making models of social systems and conducting laboratory experiments on those models before we try new laws and government programs in real life? The answer is often stated that our knowledge of social systems is insufficient for constructing useful models. But what justification can there be for the apparent assumption that we do not know enough to directly design new social systems by passing laws and starting new social programs? I am suggesting that we do indeed know enough to make useful models of social systems. Conversely, we do not know enough to design the most effective social systems directly without first going through a model-building experimental phase. But I am confident, and substantial supporting evidence is beginning to accumulate, that the proper use of models of social systems can lead to far better systems and to laws and programs that are far more effective than those created in the past [25:126].

Chapter 3

RESEARCH METHODOLOGY

Introduction

The research objectives presented in Chapter 1 provided the general framework for the research effort. This chapter outlines the approach used to complete the research objectives and also provides a condensed description of system dynamics modeling technique.

RESEARCH APPROACH

Procedure

The system dynamics technique provided a logical framework for conducting the research. The study focused on seven specific areas aimed at producing a policy model of the systems acquisition process. These seven areas were:

1. Describing the general system, determining boundaries and basic interrelationships between the major system sectors (subsystems);

2. Developing causal loop diagrams for each system sector in order to show the interaction of system variables;

3. Conversion of the causal loop diagrams into detailed flow diagrams to show how money, material and information move throughout the system and decisions are made to regulate the flows;

4. Developing and verifying mathematical equations which represent the flow diagram concepts. These equations used the DYNAMO simulation language;

5. Validating the model concept to ensure reasonable and logical representation of the real world system structure;

6. Analyzing the system to identify areas sensitive to change and possible system deficiencies; and

7. Recommending changes to the system to improve the structure or information flow and identify areas requiring further study (56:246-247).

A general discussion of these seven steps is provided in the first portion of this chapter. This is followed by a brief application of the system dynamics modeling technology to a simplified model of the acquisition process. This is provided for illustrative purposes and may be skipped by those readers familiar with system dynamics.

Describing the System

The first step in development of the policy model of the systems acquisition process was to describe the system as it related to the specific research problem and objectives (21:21). This descriptive effort began with the review of literature discussed in Chapter 2 and was supplemented with formal classroom study and initial discussions with acquisition managers from the Aeronautical Systems Division and the Air Force Acquisition Logistics Division. Additionally, both Lawson and Osterhus were interviewed regarding their development of the initial conceptual model (40). This initial search for verbal and written descriptions of the acquisition process served as a starting point for determining the system boundaries. The information gathered from the descriptive model of the system was used to identify and classify important variables required for the more formalized research. Using this information, the conceptual model was described through the use of a system sector diagram, causal loop diagrams, and flow diagrams.

System Sector Diagrams

System sectors provided a useful method for the first analysis of the acquisition process. Sectors divided the system into subsystems which have some degree of unity. This provided a means to group like concepts, processes, and resources together.

The relationships between sectors were defined by networks of materials, information, or money which flow from one sector to another. Forrester stated that capital equipment and human resource flows may be treated implicitly, rather than explicitly within the model (21:139). It was upon this advice that these two factors were removed from the explicit definition of the system.

Causal Loop Diagrams

Causal loop diagrams provided a more detailed analysis of the relationships between system sectors and also identified the variables and relationships within the system sectors. Through the development of causal loop diagrams, the preliminary system structure was identified in easily understood symbology. This technique facilitated transformation of the system sector diagram and verbal description into a general feedback structure which characterized the behavior of the systems acquisition process (29:12).

Interview Process

The causal loop diagrams, as well as the sector diagram, provided a useful method for displaying ideas about the conceptual model to others for review and discussion. Using these diagrams as the preliminary representation of the model, top executives within the acquisition process were interviewed in order to provide a richer understanding of the decision process and issues. These interviews also provided a means to justify or change variables and interactions described in the initial conceptual model.

The objective of this interview process was to develop additional information about the decision process of policy makers in the acquisition system. Over thirty individuals responsible for the various policy and procedural aspects of the DOD systems acquisition process were contacted. Among those organizations represented in the research sample were:

Congressional Budget Office
House Budget Committee, U.S. Congress
Office of the Secretary of Defense
Office of Management and Budget
Office of Federal Procurement Policy
Headquarters, United States Air Force
Air Force Systems Command
Aeronautical Systems Division
Air Force Wright Aeronautical Laboratories
Air Force Acquisition Logistics Division.

A complete list of the individuals who were interviewed is contained in Appendix B.

The interviews were conducted using an interview guide which was designed to provide a consistent, but unstructured arena for discussion (see Appendix A). Questions were designed to prompt discussion about the specific system elements which were the responsibility of the respondent; however, the unstructured approach did not restrain the respondent from offering insights and observations about other areas not within his specific responsibility. The questions were designed to provide specific information about goals and missions, important issues and problem areas, the information network, the decision structure, performance measures, and feedback, delays, and timing of dynamic situations. In addition to specific details about the system, the interviews provided a means to detect bias and gain insight into the general management philosophies characterized by policy makers within the systems acquisition process.

Flow Diagrams

The interview process provided sufficient knowledge and confirmation about the system to expand the causal loop diagrams into a more structured format called flow diagrams. Flow diagrams are based on the philosophy that systems can be modeled as a series of states or levels which change as the result of varying rates of flow within the system. The decision structure is super-imposed on the rate and level system and serves to regulate the system. The nature of this structure determines the basic behavioral characteristics (53:242).

The flows of money, raw materials, weapon systems, technology, and information are specifically identified in the modeling effort. These flow diagrams provided a basis for developing the equations used in the simulation model.

Equations

The equations developed for the model represent beliefs about the relative relationships between system variables. The development of equations required a conscious analysis of measurement criteria and dimensions applicable to system variables. In many cases, concepts and surrogate measurement devices were developed in order to represent ideas which had no formal measurement devices within the DOD systems acquisition system. Equations provided the mechanism to translate such statements as "Capability is a function of . . . ." The nature of policy modeling does not always allow precise measurement. The focus was to provide qualitative measurement of the system. Forrester stressed the purpose of equations are to represent significant relationships within the system in a manner which captures the overall behavior. Costly and time consuming data collection to develop detailed measurements of the system should not be pursued until a valid initial model is developed and the system is understood (21:141).

Once the equations of the systems acquisition model were formulated, the next step was verification. This ensured that the computer program ran as intended. To verify the model, the DYNAMO equations were compared to the flow diagram to ensure that the equations mathematically reproduce the meaning of the levels and flow rates defined by the flow diagrams.

Model Testing and Validation

The model validation process involved comparison of the model's behavior with the actual system behavior. Due to the iterative nature of model building, validation was an integral part of each step within the research.

The validation approach used a combination of methods recommended by Forrester (21), Coyle (16), and Roberts (55): well known experts in system dynamics applications. The primary objective of model validation was to ensure that model structure adequately represented the system described by the research and provided results consistent with observed system behavior. Borrowing from Coyle, the following definition provided the basis for validation: the process by which we establish sufficient confidence in a model to be prepared to use it for some particular purpose (16:18).

Specific emphasis was placed on content validity to ensure that the system boundaries and system structure and relationships were adequately described. In the earlier stages of the model building, validation consisted of justifying hypotheses and assumptions using common sense, logic, and knowledge gained from the literature search. The interviews also assisted in validating the functional relationships contained in the system equations and specifying the relative magnitude of several essential system parameters.

Detailed statistical study using empirical evidence was not accomplished. As was discussed earlier, once the model has been tested and certain sensitive areas discovered, these highly sensitive areas should be considered for continued model validation.

Analysis of the Model

Analysis of the conceptual and structural models contained in the causal loop diagrams and flow diagrams provided useful insight into the system behavior. This analysis was essential to the internal validation of the system structure and served as a baseline for preliminary determination of sensitive areas and increased understanding of the possible impact of policy changes.

The simulation capability developed in this research provides a valuable tool for management use in policy analysis. Although the operation of the model was beyond the scope of this research, the preliminary analysis which resulted from this research should be used as a basis for system experiments. Two types of experiments are envisioned: tests involving changes in equation parameters, and tests involving changes in the system structure.

AN EXAMPLE OF THE SYSTEM DYNAMICS TECHNIQUE

The following section provides an example of the system dynamics methodology for those readers unfamiliar with the technique. A very simple presentation of the acquisition process showing four sectors and three types of flows is depicted in Figure 3-1. This general model will be used to explain the specific technology required to develop sector diagrams, causal loop diagrams, flow diagrams and DYNAMO equations.

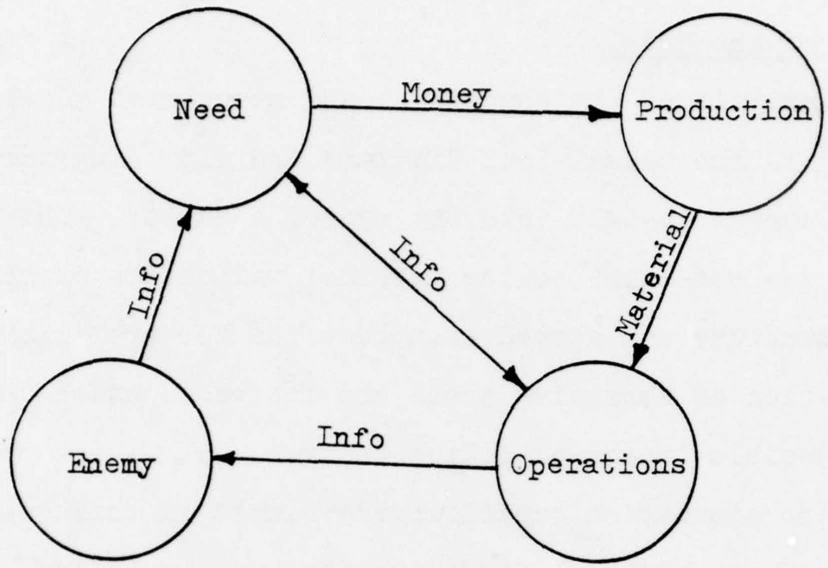

Figure 3-1

System Sector Example

The need sector defines the requirement and provides financing to the production sector. The production sector manufactures weapon systems for deployment in the operations sector. In turn, the operations sector generates additional need to replace weapons that become obsolete or wear out. The operations sector also uses these weapons to create threat which is perceived by the enemy. The U.S. threat to the enemy is countered by enemy weapons production. Subsequently, the counterthreat creates additional requirements. This system typifies the classical "arms race."

Causal Loop Diagrams

The mechanics of drawing causal loop diagrams are not difficult. The procedures for developing causal loop diagrams are to:

1. Identify the variables;
2. Develop causal links[1];
3. Use the causal links to develop causal loops;
4. Join the causal loops into the entire system;
5. Determine the behavior resulting from the causal loop diagrams (40:27).

The basic element of the causal loop diagram is the causal link. This is a pairwise relationship where the cause-effect relationship is depicted by means of an arrow. An example is provided in Figure 3-2.

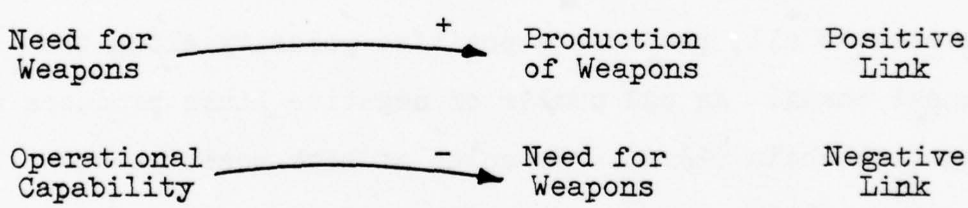

Figure 3-2

Causal Link Example

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[1] Coyle (16) refers to causal links as influence links, and to causal loop diagrams as "influence diagrams."

The nature of the relationship is noted by the plus (+) or minus (-) sign which indicates a positive or negative change between the two variables. A positive sign shows that, all other things held constant, both variables increase or decrease simultaneously: as the first variable increases, the second increases; likewise, as the first variable decreases, the second variable also decreases. On the other hand, a negative relationship means that the variables move in opposite directions: as the first variable increases, the second variable decreases, and vice versa (29:7).

The sign of the relationship is called polarity. For causal links that contain more than two variables, the polarity is determined by counting the number of negative pairwise relationships. An even number of negative links, or none at all, produces a positive polarity along the causal chain. An odd number of negative links produces a negative chain (29:8). Examples of both positive and negative chains are shown in Figure 3-3.

The next step in developing causal loop diagrams entails grouping the causal links into complete loops. The polarity of the loop is determined using the same procedures as for causal links. The loop polarity is denoted by the sign in parentheses in the center of the loop (29:9-10). Examples of positive and negative loops are shown in Figure 3-4.

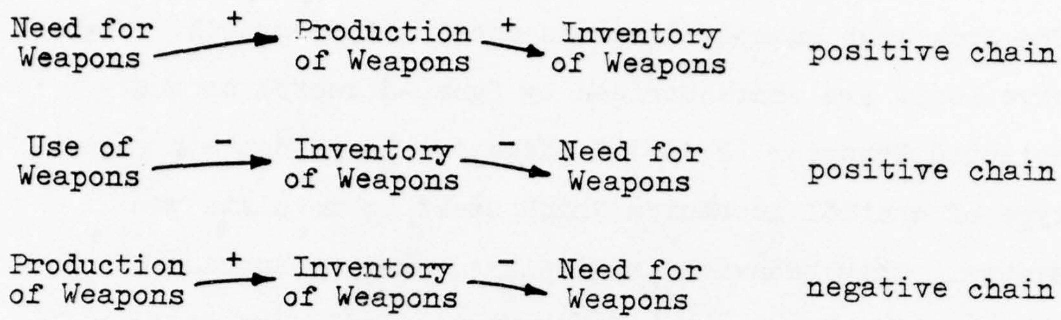

Figure 3-3

Polarity of Causal Chains

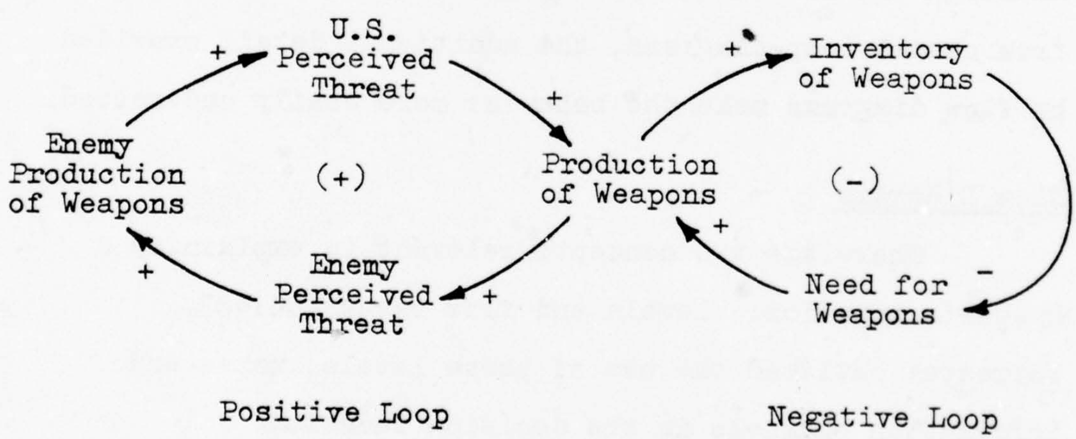

Figure 3-4

Causal Loop Example

Positive loops exhibit uncontrolled growth or decay. The arms race example displays uncontrolled growth. Negative loops are characterized by "goal-directed or goal-oriented behavior [29:37]." Negative loops contain some type of control mechanism which seeks to regulate the system. This behavior is displayed when production of weapons is reduced as needs are satisfied. The basic difference between positive and negative loops is the existence of the control mechanism within the negative feedback loop (29:39).

The overall structure of feedback loops creates the behavior of the system as it moves through time. Although the trends in system behavior can be determined from causal loop diagrams, the additional detail provided by flow diagrams make the behavior more easily understood.

Flow Diagrams

There are two concepts relevant in explaining a system's behavior: levels and flow rates (56:48). Forrester outlined the use of these levels, rates and information channels in the decision function.

> The flow channels transport the contents of one level to another, and the flow rates themselves are controlled by the levels. The decision functions are the relationships that describe how the levels control the flow rates. Information channels connect the levels to the decision functions [21:13].

The symbology used in flow diagramming decision functions is depicted in Figure 3-5.

In Figure 3-6, the flow diagramming symbols have been combined into an example. The weapons inventory level is shown as a function of the input rate (production) and a constant output rate (attrition). The actual inventory level is compared to the desired inventory level to determine whether the production rate is sufficient to maintain the desired inventory level.

All the variables in the flow diagram must have an operational definition which can be quantified. Without operational definitions, it is impossible to accurately construct the flow diagrams since all terms are measured as amounts in levels and units per unit time period in flow rates.

Equations

Formulation of equations is the transition step between flow diagramming and simulation. The equations become the basis for a DYNAMO computer model which is used to simulate the systems acquisition process through time.

There are six basic classes of equations used in DYNAMO: level (L), rate (R), auxiliary (A), initial value (N), constant (C), and supplementary (S) equations. Levels, rates, and auxiliary equations all have time dimensions.

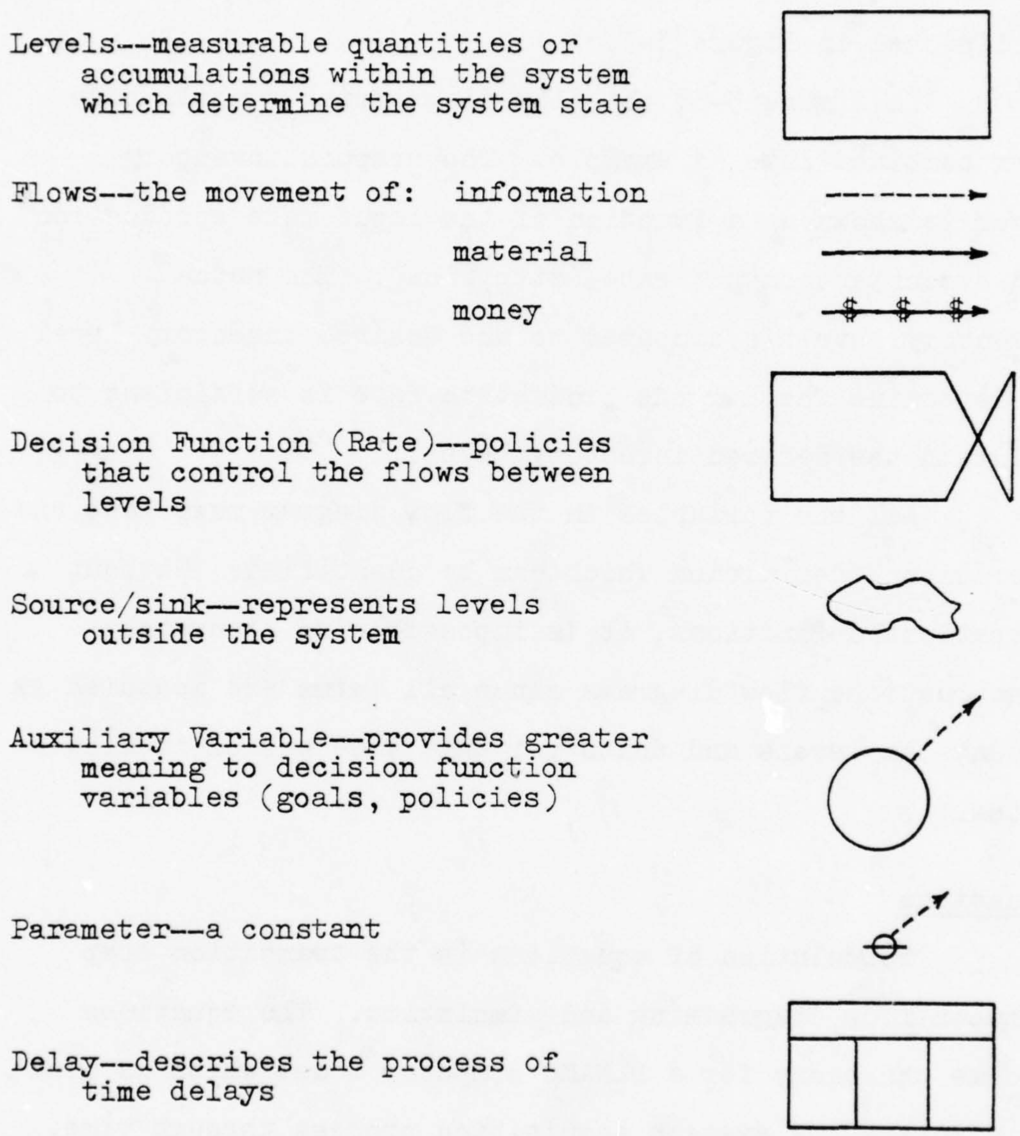

Figure 3-5

Flow Diagramming Symbols (21:82-84)

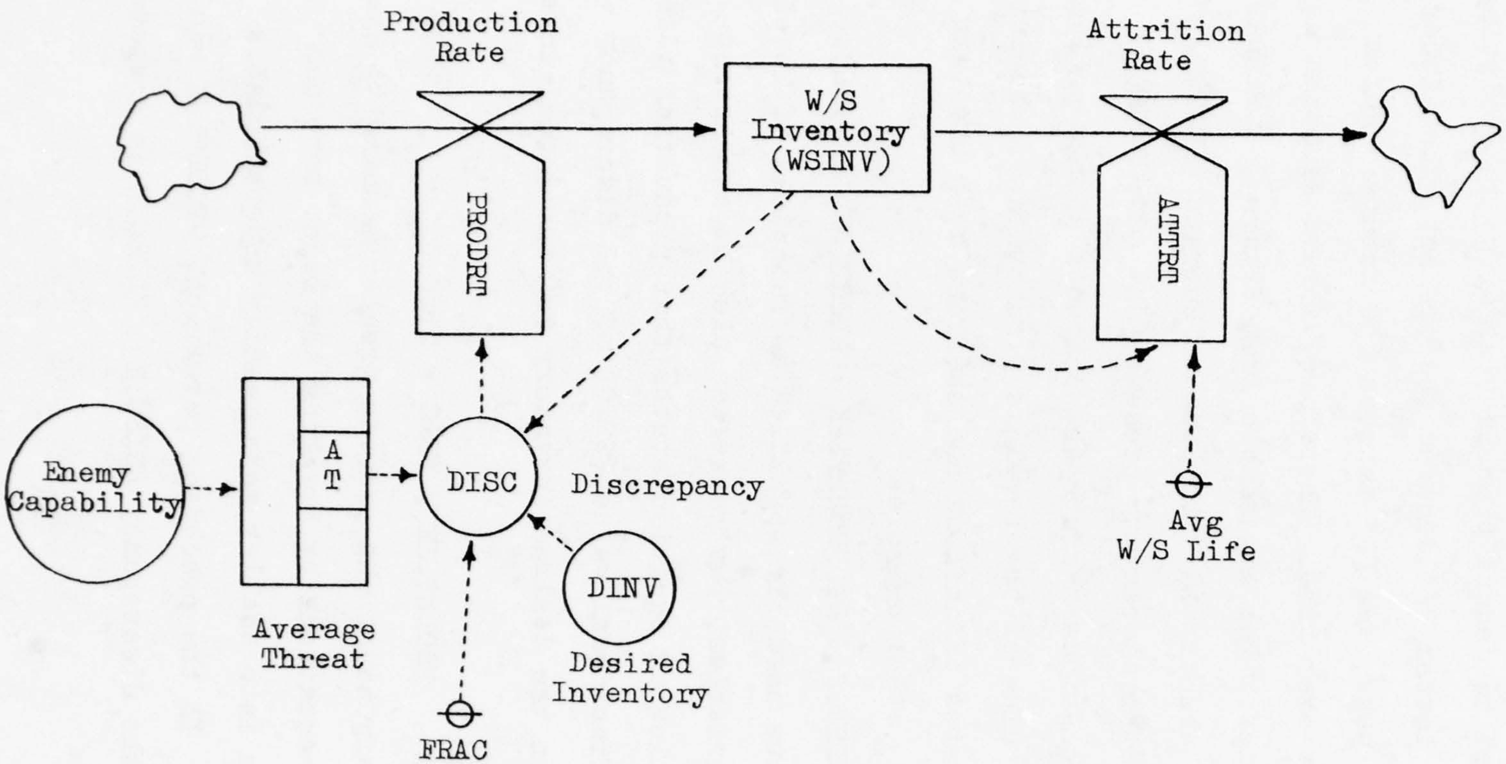

Figure 3-6

A Flow Diagram Example

The notation used to denote time is similar to subscripting variables. The letter "K" denotes the present, the letter "J" denotes the past, and "L" denotes the future. Rates measure movement over time. Therefore, a rate equation uses a double subscript. For an example from Figure 3-6 PRODRT.JK is the variable associated with production rate (PRODRT) over the time interval past to present (JK) (21:73-76).

Level equations measure the contents at the present time (K). The value of the level is a function of the prior level and the rates of inflows and outflows over the last time period (DT). For example:

L WSINV.K = WSINV.J + DT(PRODRT.JK + ATTRT.JK) (21:76).

Rates are normally specified as functions of levels or auxiliary variables, but rates can also be a constant value. The following equation states that production rate is equal to a fractional value (FRAC) of the discrepancy (DISC.K) between the desired inventory and the actual inventory (21:77-78).

R PRODRT.JK = FRAC * DISC.K

Auxiliary equations provide greater meaning to the rate and level equations by breaking the major rate and level equations into smaller more readily understandable equation sets. In the preceding paragraph, PRODRT.JK was a function of the discrepancy (DISC.K). DISC.K is computed by an auxiliary equation that compares the desired and actual inventory:

A DISC.K = DINV - WSINV.K (21:78-79).

Initial value equations set the initial conditions for all levels. If the initial value of the weapons system inventory was 100 aircraft, the equation would be:

N WSINV = 100 (21:79-80).

Constants set the value of a variable for the entire DYNAMO simulation. For example, the desired inventory (DINV) could be set at 120 weapon systems.

C DINV = 120

Supplementary equations or SPEC cards are required in DYNAMO to specify instructions required to print and plot model values. They do not influence the computed values that influence the behavior of the system (21:79).

Summary

In summary, the system dynamics methodology provided the basic research approach to develop a dynamic policy model of the acquisition process. This chapter has outlined the basic steps that were taken during the research process and also provided an example of the system dynamics applied to a simple system. Although the steps infer a sequential approach, the nature of the model building was iterative. Many of the steps were reaccomplished as new information became available to enrich the model.

The results of the research follow in the next three chapters. These chapters present the conceptual model, structural model, analysis, recommendations and conclusions relative to the policy model and issues within the systems acquisition process.

Chapter 4

INITIAL MODEL FORMULATION

Introduction

The primary purpose of this chapter is to provide a conceptual model of the systems acquisition process through the use of a system sector diagram, causal loop diagrams, and an explanation of the apparent goals, cause and effect relationships, and key issues relative to each sector. The information contained in the diagrams and discussions results from the literature review and the subsequent interview process. This chapter will focus on providing a general understanding of the concepts which affect the elements within the acquisition process. A more detailed discussion of specific structural elements will be presented in Chapter 5.

The Acquisition System

The acquisition system is characterized by a group of interrelated processes designed to provide weapon systems necessary for DOD missions. The processes are interconnected by the flow of material, money, and most importantly, information. The information network is essential to the system, because it provides the feedback and policy structure which determine system behavior. Ten system sectors were developed in order to study the systems acquisition process. These first will be discussed as a group to provide an overview of the entire system structure and relationships within the system.

As noted in Chapter 1, the acquisition process is an important element of both national security and economic policy. The goals and objectives of the political system have a significant effect on the relative importance given to DOD missions. The purpose of the political system is to determine the desired mix of policies required to meet military, economic, and political objectives. The decision structure within the political system is influenced by pressures from the various environmental elements, as well as pressures from DOD.

In DOD, the concern of the acquisition system is to identify and justify needs based on the threat perceived from enemy capabilities and political intentions. Needs are identified through continuing mission area analysis. For major systems acquisitions, a formal approval process is required. This process culminates with the Defense Systems Acquisition Review Council approval. As needs are validated, demands for financial resources are forwarded through the Planning, Programming, and Budgeting System. During this process, financial requirements are rank ordered and allocated to the various DOD programs.

The approval of acquisition needs and subsequent funding provide the authority to proceed with research and development. This process transforms the financial and technology inputs into development plans required to produce weapon systems. The product of the research and development effort provides the necessary technical ability required for weapons production. In addition to this input, the production process draws from both the resource and technology bases in order to complete the task of producing weapon systems. As the process continues, weapons are delivered to the operating commands within DOD and also transferred to allied nations.

The U.S. operational forces impact the acquisition process in a number of ways. One of the most significant effects is the impact that weapon system deliveries have on threat reduction. This is due to the increase in capability which reduces U.S. and allied deficiencies. Conversely, as U.S. and allied capabilities increase, the threat to the enemy also increases. In addition to the indirect support to allied nations through increases in U.S. capability, allied defense is affected directly when arms are transferred from U.S. operational forces. In addition to the capability provided from the operational forces, delivery of weapon systems to the commands creates a demand for support.

This demand is eventually supplemented with requirements for new systems necessary to replace the operational force as it ages through time. This final demand serves to complete one system life cycle as a new system need is generated. The concept of the systems acquisition life cycle is represented in the system sector diagram contained in Figure 4-1.

As indicated in the preceeding discussion, the systems acquisition process is typical of multi-looped feedback systems. The goal seeking portion of this system revolves around the identification and subsequent satisfaction of needs. This is accomplished through the development of weapon systems and maintenance of operating forces required to produce desired military capability. The second major loop exhibits the growth aspects of the system, classically named the "arms race". This feedback structure is inclined to perpetuate arms development as the enemy, allied, and U.S. forces seek adequate military protection. Growth is disrupted only as resources, technology, money, or political constraints become factors in the decision process.

The links between the Technology, Weapon System Development, and Production Sectors depict the area of the model which is traditionally associated with the acquisition process. These three sectors contain the central processes

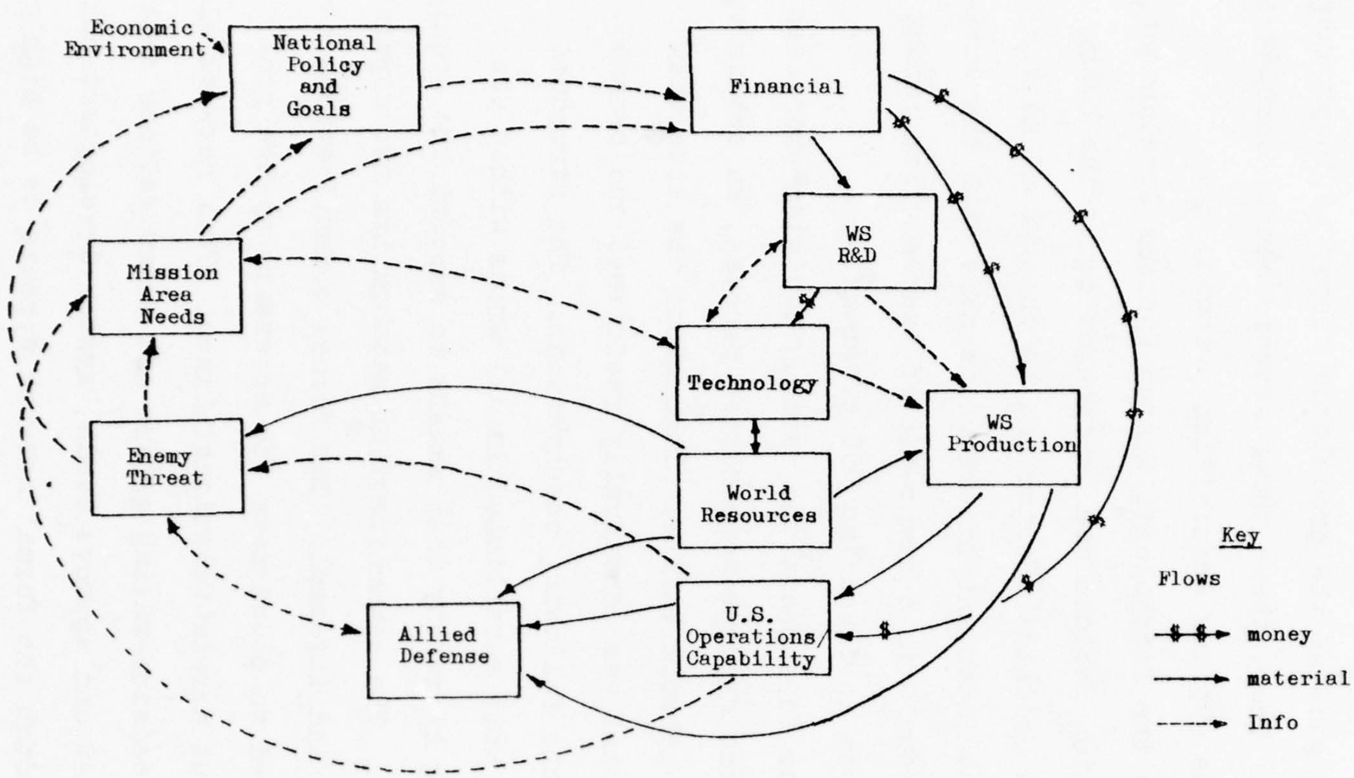

Figure 4-1

Acquisition System

of the system, around which the remainder of the sectors are organized. The goal of the production sector is to produce weapon systems. Thus, these three sectors can be considered the heart of the systems acquisition process.

Just as the Technology, Weapon Systems Development, and the Production Sectors can be thought of as the heart of the system, the Political Sector can be thought of as the brain. Here the important interface is made with the environment. The result is a trade-off of issues which impact the support given to financing DOD programs.

In order to support the various decision processes that occur in the systems acquisition process, an extensive communications network exists. Throughout the interview process this point was continually reaffirmed and became the basis for the following observations. The structure appeared to be well established in all areas within the decision-making hierarchy that exists to support the acquisition process. The communications network has two separate parts: formal and informal. The formal communications network is required to coordinate the necessary system processes which cut across functional lines. This network also includes the decision-making groups and organizations established to review and approve needs, system development and funding. Although the formal network appears to be highly structured, set procedures were established to monitor the flow of information between individuals and organizations. The informal communications network is far more complex. Informal communications networks provide a means to enrich the information base; but they also increase the total amount of exposure to information by each manager. One manager estimated that he received much more data from the formal network than he required to make decisions; however, the data did not provide the information he believed was necessary to accomplish his job (13). Because of this, he sought out informal information sources.

The decision-making process for systems acquisition is more fully understood when the system's participants, the positions on key issues, and the general behavioral trends can be analyzed. The remainder of this chapter will provide a more extensive discussion of each system sector and the relevant issues and relationships which influence the sector behavior.

Political Sector

The role of politics is essential to understanding the behavior of the systems acquisition process. The decisions and policies made at the national level determine the general policy environment and constraints within DOD, and more specifically, the acquisition process. In essence, this political environment, as presented in Figure 4-2,

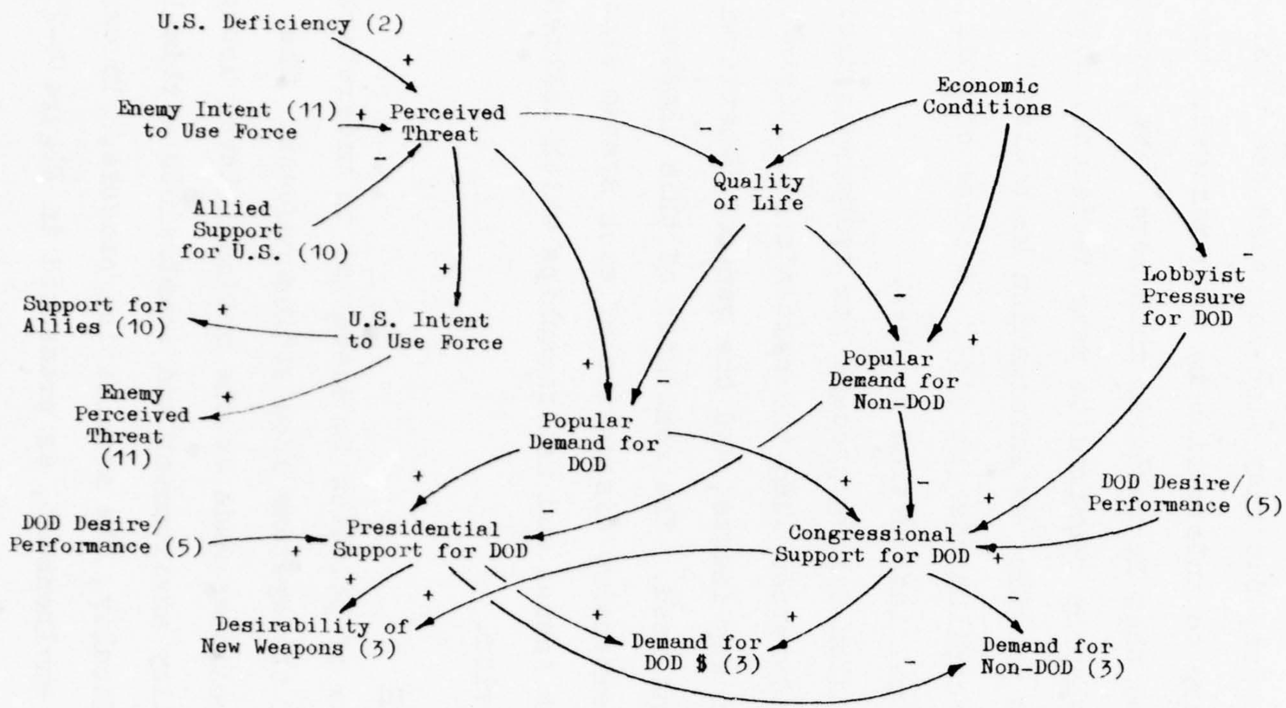

Figure 4–2

Political Sector

serves to balance the pressures and influences from within the DOD with other national goals and objectives. In addition, many of the variables provide the link to other sectors within the model. For example, the perceived threat and intent to use force variables depend upon the Allied and Enemy Sectors, as military and international situations change throughout the world.

The relative pressures which exist in the military, economic, and international arena determine the tone of the political environment. During the interview process, it was noted that these pressures were normally evaluated in terms of dollars. The "power of the purse" appears to be a relatively well understood concept; however, the structure which supports the actual decisions is not as easy to interpret. The pervasiveness of this structure appears to result from an attempt to satisfy many national goals simultaneously. This involves determining the balance between the security and economic goals of the nation and implementing consistent policy to achieve these goals which is a difficult task. A recent analysis of the U.S. power position within the world addressed the failure of the U.S. to recognize the full relationships between political, military, and economic events in order to develop coherent policy to deal with multi-faceted issues in an integrated fashion (62:38).

For military issues, the result of the political tradeoffs made between military, economic, and international demands determines the overall funding and force levels within DOD. In addition, specific decisions are made which impact individual acquisition programs.

In order to deal effectively with military issues, it is necessary to analyze the relationships between the major components of the political system to determine the influence and pressures which result from the political process. Although the precise relationships between the issues and participants within the process were not discussed in this research, the major relationships were confirmed during the interview process. The issues of threat, economic conditions, and the quality of life were found to relate to decision-making within the political environment.

The pressure for DOD programs begins with U.S. deficiencies. These deficiencies are amplified by the threat the U.S. perceives relative to the enemy's capabilities, enemy intent to use force, and the amount of support the U.S. believes the allies will supply in case of war. In this sense, perceived threat is a function of both the size of the deficiency and the political tone of events which occur in the international environment.

Threat is a perception of military capabilities and international environment. The perception is based on the continual evaluation of the trends in military capabilities and intentions. In this respect, the actual threat may not be consistent with what is perceived. The concept is difficult to develop due to both the problems associated with measuring capability and the changing world alliances.

Economic conditions also affect the pressures and influences determining decisions on military issues. As economic conditions such as falling Gross National Product, inflation, and unemployment become concerns within the political environment, demands for non-DOD programs increase.

Borrowing from Forrester (25), military and economic goals can be combined into the concept of the quality of life. This concept represents the relative degree of contentment in the populace. It provides the basis for the guns and butter trade-offs made within the executive and legislative branches of the government. The quality of life has an inverse effect on the demand for DOD programs. As Americans enjoy favorable economic conditions and feel no threat to their security, little popular support is evident for DOD programs. The Vietnam War provides a historical example of this phenomena. Little direct threat was perceived; therefore, many Americans were unwilling to support DOD demands. The electoral process partially ensures consideration of public wishes during the policy implementation process. The research revealed the defense spending patterns were closely associated with the political pattern. The biggest increases in defense spending occur in the two years prior to the presidential election and the biggest cuts occur in the two years after the election (10).

Public officials, although apparently concerned about the public's desires, also shape their opinions on information and influence resulting from other sources. Specific favoritism and support for selected issues and programs are common within all management structures. Managers have pet projects which become more important than any other management concern. Because the program or issue is important, the manager seeks to highlight the program merits in order to receive support from other areas in the decision-making hierarchy. In the systems acquisition process, weapon systems are advocated by many individuals and alliances. The defense industry, DOD, and the executive and legislative branches all participate in the selling of weapon system programs. Few controversial programs are approved without a coalition of supporters from all levels in the process. Advocacy may result from a desire to keep specific geographic locations or contractors healthy, sincere belief that one program approach is more desirable than another, or unusual pressure to pursue a particular course of action from other participants in the system.

The interview process revealed that the informal communications network serves the advocacy concept well. It is important to know where top decision-makers stand on specific issues and also to establish information sources to provide continuing status on political positions. Most managers believed these sources were essential to their personal data base.

One form of advocacy readily apparent in the acquisition process is lobbying accomplished by the defense industry. In this discussion, the term lobbyist represents both formal and informal pressures by the defense contractors. The pressure results from contacts with industry in formal meetings, as well as informal visits and discussions with defense contractors. Lobbyist pressure intensified as economic conditions required the defense industry to seek new business (36:135).

Another source of influence upon the political decision-makers results from DOD. The services explicitly lobby for support of specific programs. In addition to this explicit influence, the past and current performance of DOD acquisitions also impacts the political support for DOD and specific acquisition programs. Many of the staffs stated that specific technical and cost measures were evaluated in the decision-making process. For example, cost growth on the B-1 bomber provided one of the reasons for cancellation of the program. In other cases, decision-makers within Congress, OMB, and OSD withheld funds in order to force policy or procedural changes. This activity provides additional influence which affects the DOD environment.

In summary, the political environment which surrounds the acquisition process is important to understand, although it is unwieldy and difficult to anticipate. The decisions made by the people in the executive and legislative branches of government are influenced by three separate forces: popular support measured in terms of the quality of life, specific interest groups and personal advocacy positions, and the influence and performance of DOD. The relative importance of players who participate in the process, as well as their environment, determines the policy positions which affect the acquisition process. To the extent that the system dynamics methodology is concerned with the interrelationships among the components in the system, the political process is both people and program related, where many situational variables appear to affect the policy outcomes.

Need Sector

The demand for defense systems is the basic input to the acquisition process. The Need Sector depicted in

Figure 4-3 provides a model of the DOD process for identifying mission requirements, evaluating alternative means to satisfy the requirements, and reflecting the decisions which result in a force plan. The output of the force plan is the demand for dollars to the Financial Sector in order to meet the requirements for research and development, production and modification of weapon systems, and continued support for operating forces. The Need Sector behavior is goal seeking in that it strives to satisfy specific needs; however, this sector also provides the input to the arms race concept.

Needs are identified by the intelligence community and the operating commands. The process by which deficiencies are identified is called mission area analysis. Mission areas relate to the basic missions assigned to military forces such as strategic attack or force mobility. The objective of mission area analysis is to compare the enemy capabilities with allied and U.S. capabilities to determine valid deficiencies (74:1-2).

There are several key issues that relate to the identification and planning of needs. Specifically, the issues revolve around DOD's ability to assess capabilities in order to determine deficiencies, the process by which alternatives are evaluated to meet deficiencies, and the role of politics in the planning process.

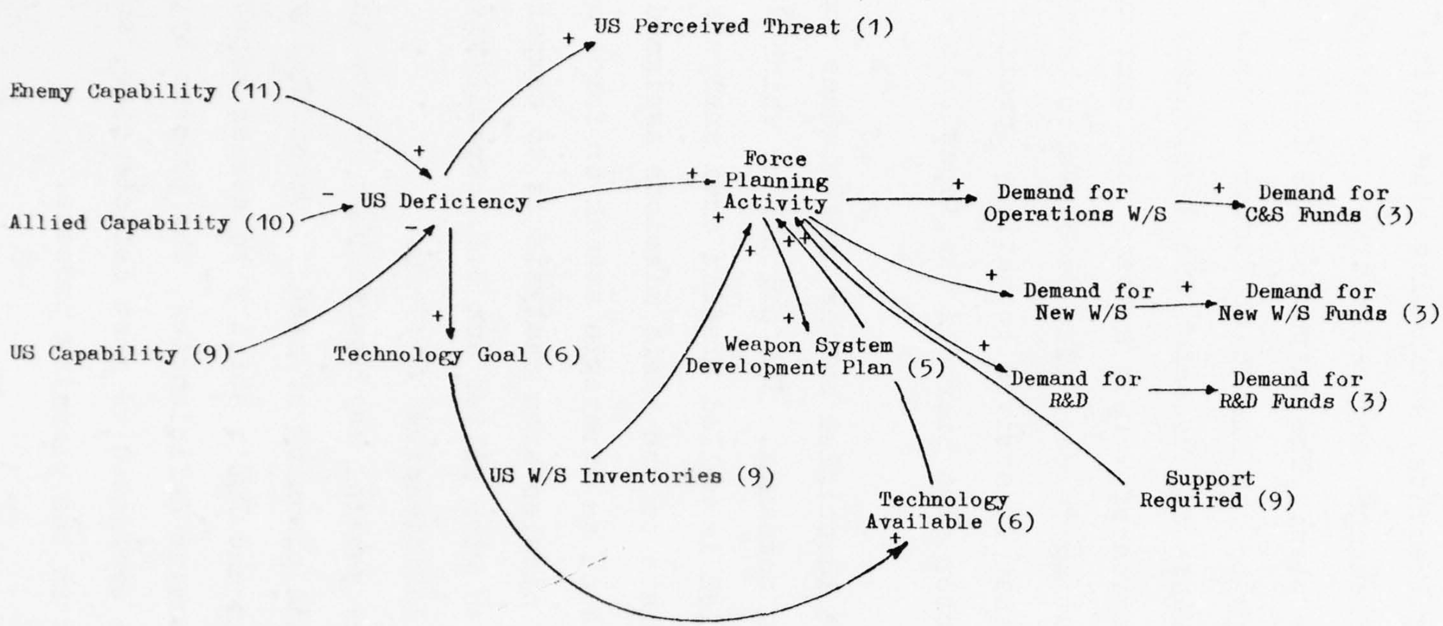

Figure 4-3

Need Sector

The concept of capability can be thought of in terms of a quantity and quality dimension (46:42). Determining the number of forces in DOD, allied, and enemy forces is straight-forward; however, the combination of quantitative and qualitative features of military forces makes the determination of capabilities difficult. Several different agencies have developed capability models, although there is no universally accepted definition or model for assessing capability (5).

One technique developed by the HQ USAF Force Capability Integration Division appears to hold promise. The method requires that individual experts in specific mission areas weigh the importance of subelements within each area and then evaluate the status of existing and planned capability. To facilitate this procedure, a mission area profile is developed in the form of a tree and the results are compared to the known threat for each mission area (Figure 4-4). Deficiencies are noted using a color coding scheme which highlights inadequate and marginal areas of the tree. The final analysis determines the relative importance of the deficiencies within each mission area branch. This results in a comprehensive review of needs which provides a subjective, but logical approach to the difficult concept of capability and deficiency analysis (33:4-7).

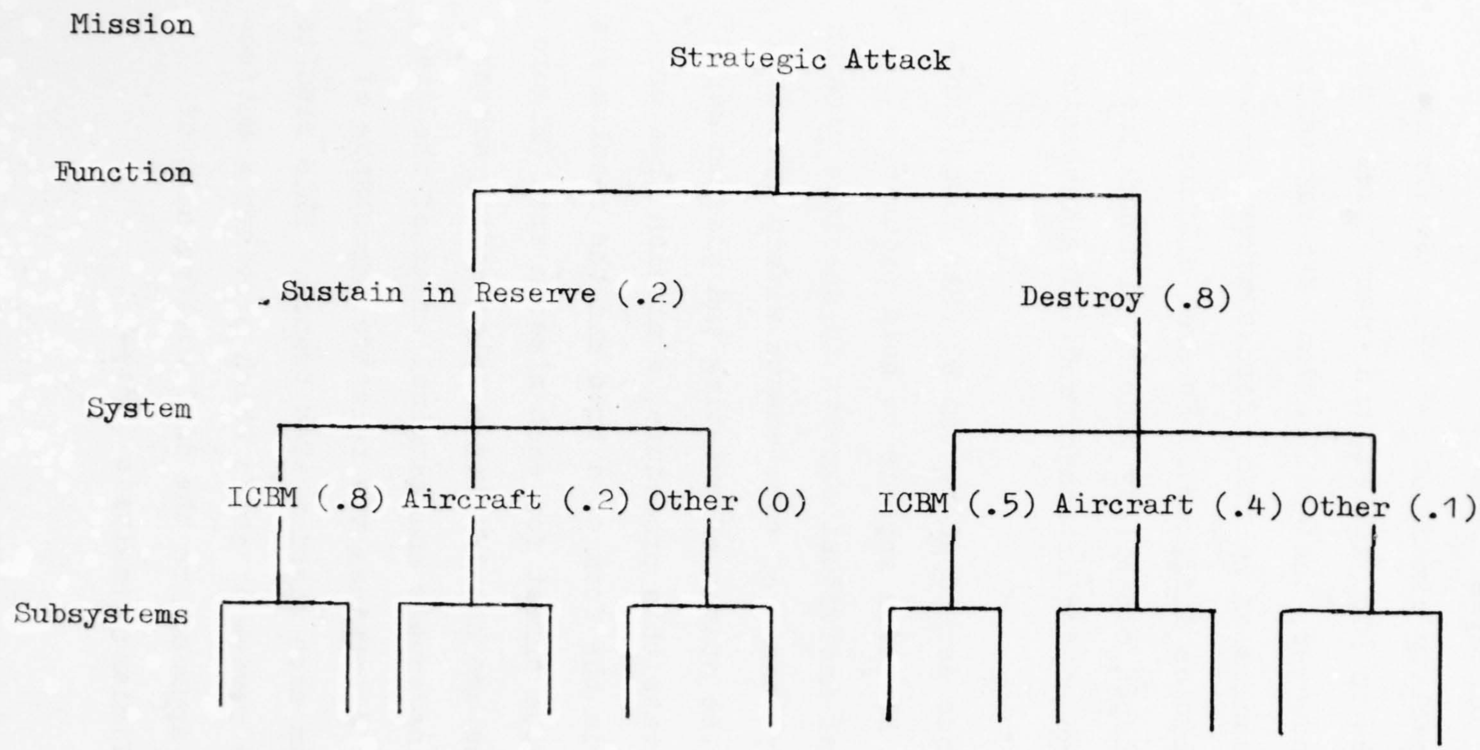

Figure 4-4

Sample Mission Capability Profile

Once deficiencies are identified, development planning defines alternative solutions for reducing the deficiencies. Among the list of alternatives that are considered are: providing additional support for existing forces; modifying current weapons; procuring additional weapons in production or the operational inventory; and developing new systems. Each alternative is evaluated in terms of mission performance, schedule, and costs.

During the interview process, an apparent conflict was noted in the relative importance that decision-makers placed on the performance, schedule, and cost features of needs. In addition to this conflict, the statement of the requirement differed as the need moved through the validation process. At the major command level, great emphasis was placed on the performance requirement. The operating commands focus on specific capabilities, usually relating their requirements to deficiencies in specific hardware terms. The commands are often accused of "gold plating" their requirements by asking for too much performance to satisfy the deficiencies that exist. The rebuttal to this accusation addresses the risk of being caught short at wartime. DOD components argue that the quality dimension of U.S. capability must be maintained by developing technologically advanced systems (46:42). The search for technology to meet requirements within the Air Force is primarily the responsibility of the Air Force Systems Command (AFSC). AFSC's primary focus is to develop the technological know-how for specific performance needs; however, AFSC also maintains the technology base required to provide answers to needs when they arise (2). Due to the cost of funding research, few projects continue if a sizeable investment is required or if no validated need exists.

Needs requiring a significant investment must be approved by the Defense System Acquisition Review Council (DSARC). These needs are formally documented on a Mission Element Need Statement (MENS). The DSARC consideration of the MENS marks the end of a lengthy coordination process which requires concurrence by many panels and review groups. During the approval process, the primary focus shifts from performance to timing, cost, and other business considerations. The statement of the need also shifts from a specific to general requirement. The corporate structure within HQ USAF and OSD currently requires an estimation of life cycle cost before new acquisitions are approved. This appears to be a difficult task for USAF--where estimates are poor even when specific details are known about the program (71). Although most managers believed cost was still third to performance and time considerations; they also believed cost had increased its importance in the decision-making process within the acquisition process.

The statement of needs in a general format, not specifically tied to hardware, has been of concern to the USAF as the new policy resulting from OMB A-109 was implemented. The policy intended to link requirements to validated needs, evaluate various alternatives, and maintain flexibility in developing systems once the needs were approved (20). Currently, few new systems have been approved. This appears to be due to the long bureaucratic cycle involved to implement the policy rather than a selection of other alternatives in lieu of acquisition. The average time to approve a MENS is approximately eight months (33). This analysis of OMB A-109 implementation was voiced throughout the interviews with managers, as well as in reports discussed in the literature review. The majority of individuals believed the intent of the policy was good; but implementation within the services was poor.

Most needs are identified through the formal decision-making structure established to approve needs included in the force plan. In addition to the structure that exists to generate and evaluate needs, needs are also generated by political advocacy from within DOD as well as from external sources. The entire needs process can be pushed out of routine when programs are changed by individuals who have significant influence over the ultimate decisions to approve or cancel weapon systems acquisitions.

An excellent example of this phenomena was President Carter's order that the B-1 bomber be cancelled in favor of the cruise missile. This caused a reorientation of needs, a restructuring of acquisition programs, and a change in the scheduled time to meet needs. Although the cruise missile did not create a significant problem in the financial arena because funds were transferred from the B-1 program, significant schedule changes were made to meet President Carter's promised date for the cruise missile's initial operational capability.

In summary, the Need Sector attempts to translate deficiencies in military capability into force structure plans and alternative means to meet these plans. In addition, the Need Sector must include political considerations which may alter the initial Force Planning documents. The changes to the planning documents must consider the overall financial constraints within DOD. In the next section, the financial processes designed to match funds to mission plans will be addressed.

Financial Sector

The flow of money is controlled in the Financial Sector. This sector can be described by four specific activities: programming, budgeting, allocation, and expenditure. The demand for financial resources results from the requirement to implement the force plan described in the previous section. The objective of programming is to link the plans and mission requirements with demands for available dollars. Once dollars are assigned to missions, a budget documents the formal request for funds and the DOD budget is forwarded to Congress for authorization and appropriation (66). Here the most important debate occurs: how much money for DOD; how much money for non-DOD programs (11)? The causal loop diagram in Figure 4-5 portrays the nature of the trade-offs and pressures between these two areas.

Programming and budgeting issues center around the process which rank orders and consolidates financial requirements. This process is accomplished through a series of reviews which aim to match anticipated dollars with mission requirements. Because requirements normally exceed financial resources, some programs are cancelled or delayed, causing revision to the force plan. The decisions to remove or revise programs in the force plan require analysis of the various programming and budgeting alternatives. The analysis seeks to weigh the relative merits and problems associated with all the programs and provide a balanced plan consistent with dollar constraints. Throughout the interview process, managers indicated that few real trade-offs are evaluated either within or among mission areas and

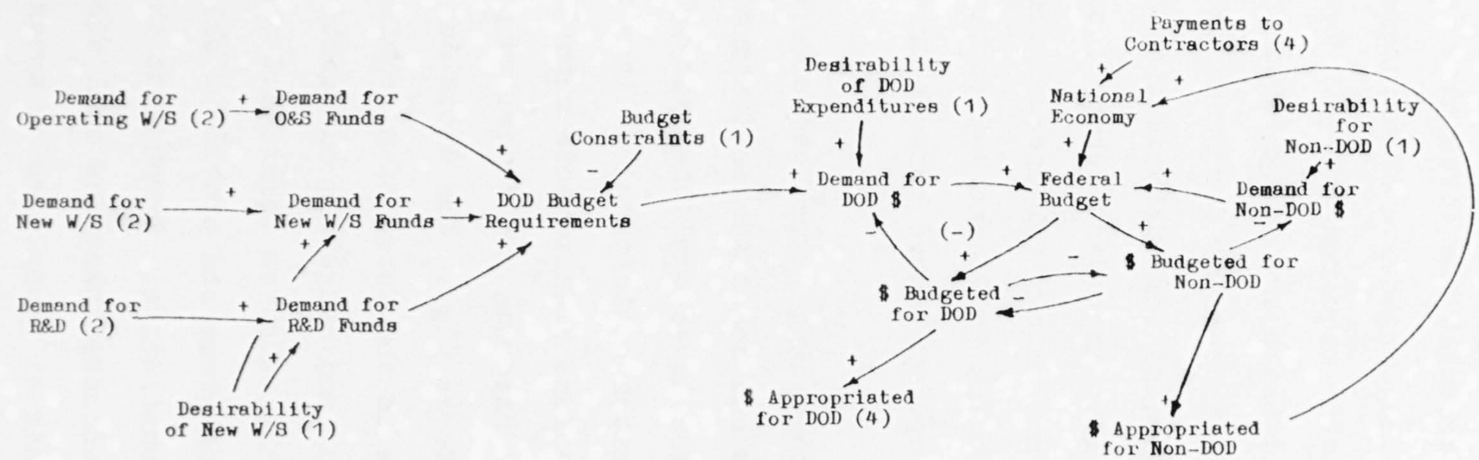

Figure 4-5

Financial Sector--Programming and Budgeting budget programs. Thus, the goal to provide balanced support is seldom achieved. The reasons provided for the lack of trade-offs within the programming and budgeting cycles involved two specific areas: (1) the extensive information provided to the decision-making body, and (2) the effect of the changing system environment.

Decision-makers in the corporate review structure are provided with extensive data on each program requiring funds. As noted in the introduction of this chapter, one manager received six to eight times more data than he used in decision-making (13). Because of the sheer volume of information provided during the review process, thorough evaluations regarding program trade-offs are difficult. In order to cope with the volume of data, only five to ten percent of the programs are reviewed extensively. These programs relate to the portion of the priority list which may not be funded. In addition to limited alternatives between programs, there appeared to be little resurfacing of initial development alternatives considered for individual programs.

The interview process also revealed that trade-off decisions are difficult due to the changing need environment. The normal procedures call for a lengthy decision cycle extending over approximately two years. This cycle is disrupted when urgent requirements surface. Financial requirements related to these urgent programs must be force-fit into the budget, leading to last minute decisions with little analysis of the impact on the budget. This last minute restructuring of priorities is further complicated by the influence of program advocacy in the programming and budgeting cycles. Several managers noted the last minute inclusion of "gold watches" or "boss says" requirements into the budget.

Congress is responsible for the debate that determines the overall spending patterns required to meet national objectives (11). The debate becomes difficult when the economic conditions require financial sacrifices by some federal agencies. The results of the debate are specific appropriations based on the budget review. Several managers indicated that the debate often centered around small details relative to specific programs, rather than the macro level trade-offs which should be made in Congress. Although Congress must vote on overall economic goals and other key budget issues prior to the appropriation of dollars, information volume and the dynamic environment create the same problems as discussed for the other decision-making organizations within the acquisition process. Thus, few real trade-offs are made, even at the top levels of the decision-making structure.

Once the decisions are made for the budget, it is executed by expenditures resulting from allocations made to

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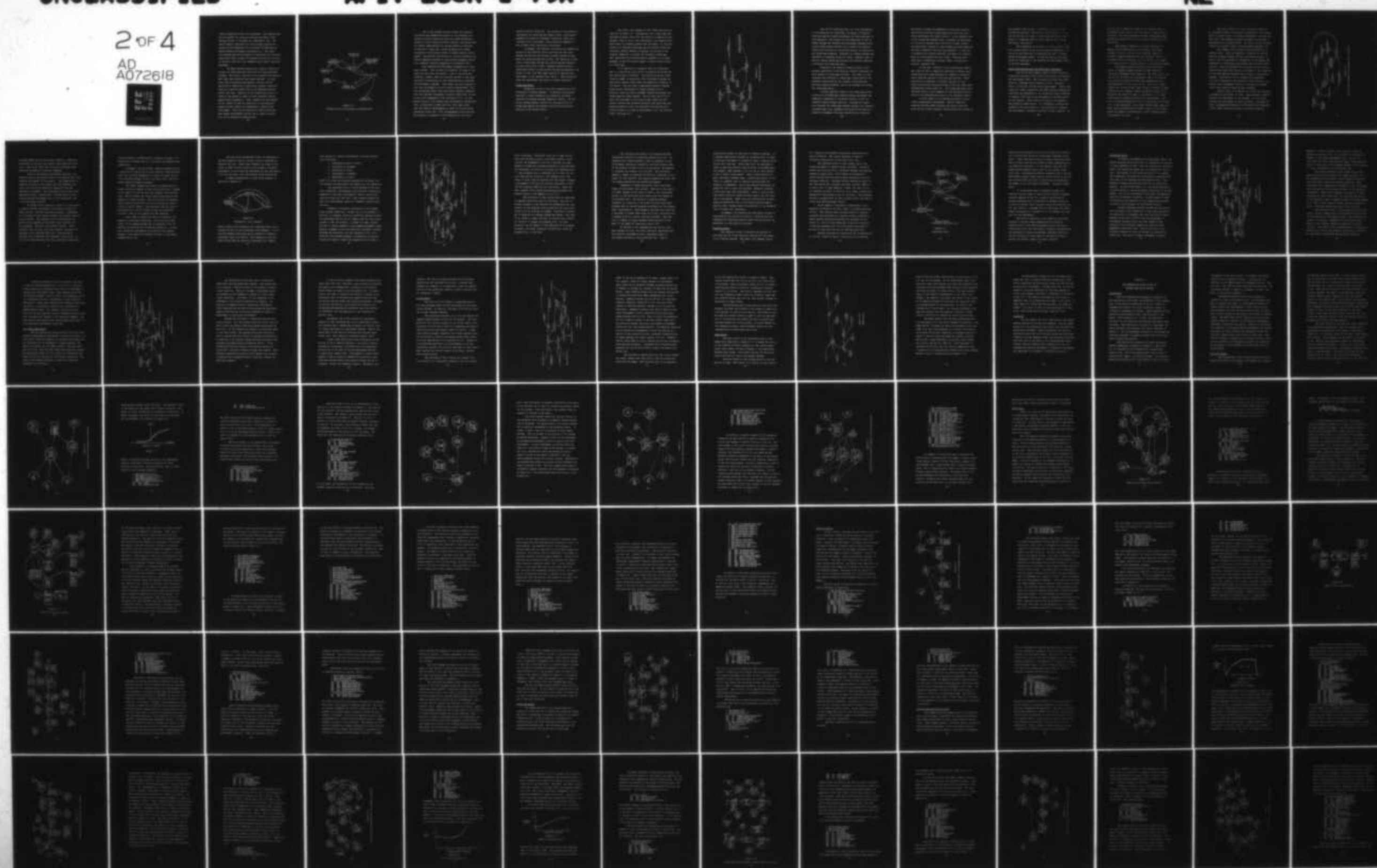

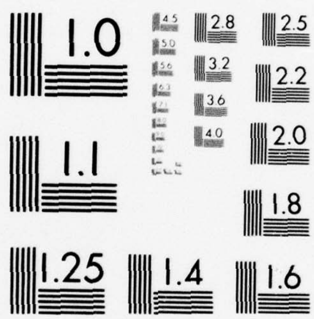
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various components within the government. The expenditures provide payment for goods and services provided to DOD through contract or internal DOD commitments (66). The costs normally associated with the systems acquisition process involve payments for contractual obligations for weapon systems development and production. The causal loop diagram depicted in Figure 4-6 represents the relationships which exist between the appropriated dollars, dollars on contract, and the actual payments which result from work performed.

For major systems acquisition, specific amounts of dollars are associated and controlled for each individual program. This control applies to both research and development (R&D) and production and weapon systems. In other areas such as operating and support, dollars are not specifically identified to individual systems, therefore, there is a greater flexibility in the spending patterns within this area. There is little flexibility within all areas of the system in terms of funds transfers between appropriation categories. Thus, research and development dollars cannot be used for production or operating and support dollars cannot be transferred to research and development. This lack of flexibility creates problems when urgent requirements surface and no funds are available in the designated appropriation.

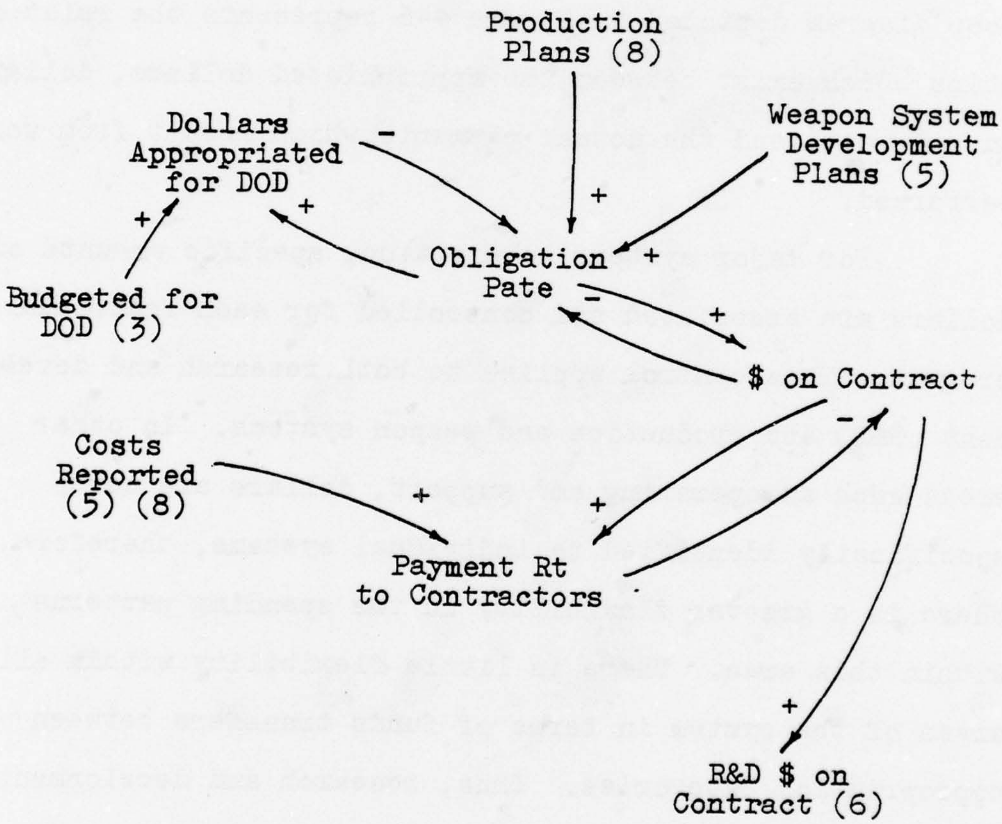


Figure 4-6

Financial Sector—Allocation and Expenditure

One of the primary concepts within the financial allocation and expenditure process is the spending rule. Financial policy legislation does not permit spending in excess of total dollars available; however, the system does not reward organizations for saving financial resources. In addition to this rule, recent pressures for timely obligation of dollars may result in rushed contract development. The quality and the type of contract determine the overall expenses incurred on acquisitions programs; therefore, adequate contract preparation is essential (73).

Most research and development programs use a cost-type contract. This creates the potential for many of the risks involved with cost growth. Some of the costs are avoidable; however, many are directly related to the risks involved in contracting for the uncertainties of research and development programs. Many times, the real reasons for poor cost performance are not correctly interpreted. The cost growth may result from contractual defects, pressures from the business environment, economic conditions, as well as poor cost management by the contractor (30). As cost growth occurs in one research and development or production area, dollars must be made available from other areas. This may require reprogramming of funds if dollars exceed thresholds within DOD. This reprogramming action requires the approval of Congress or DOD depending on the dollar amounts involved (66:57-58). The problem of cost growth is less severe for operating and support costs. Anticipated payments are easier to determine; therefore, fixed cost contracts can be developed. This allows for expenses to more closely track contractual obligations.

In summary, the financial allocation and expenditure portion of the financial sector provides the last link between the DOD and the national economy through the payments for goods and services by DOD. The character of this link is established through the contracting and financial policies which exist in DOD. Systems acquisition has a significant effect on this process because approximately ten percent of the total DOD budget applies to Research and Development of new systems alone (68:15). When production costs are considered, the effect is further amplified.

<u>Technology Sector</u>

Technology is one of the basic ingredients in the development of weapon systems. It provides the know-how required to develop hardware and industrial processes required for defense systems production (38:42). The DOD policy towards pursuit, protection, and application of technology impacts the economic activities and national security of the United States.

The causal loop diagram for the technology sector is depicted in Figure 4-7. Although the total technology base continually grows, within DOD the behavior is generally goal seeking. This is due to the technology or performance goals established for defense products and processes. As the gap between the existing technology and the desired technology increases, greater amounts of pressure are placed on the research community to provide the necessary technology. This characteristic was particularly apparent in the space programs of the 1960s which sought to provide state-of-the-art technology.

It is important to recognize that the technology goal is a key policy issue which is currently receiving far more debate than in the past. The United States has traditionally sought to achieve military advantages through the qualitative aspects rather than the quantitative aspects of its forces. This has been accomplished primarily through technological superiority of weapon systems (46:42). Recently, there has been a movement towards developing less technologically risky weapons. The A-10 and the F-16 aircraft are acclaimed to be a step in this direction (60). Several studies have presented evidence that producing less complex systems is more cost effective and provides more reliable results in terms of performance, cost, and schedule plans (17:23-29; 61).

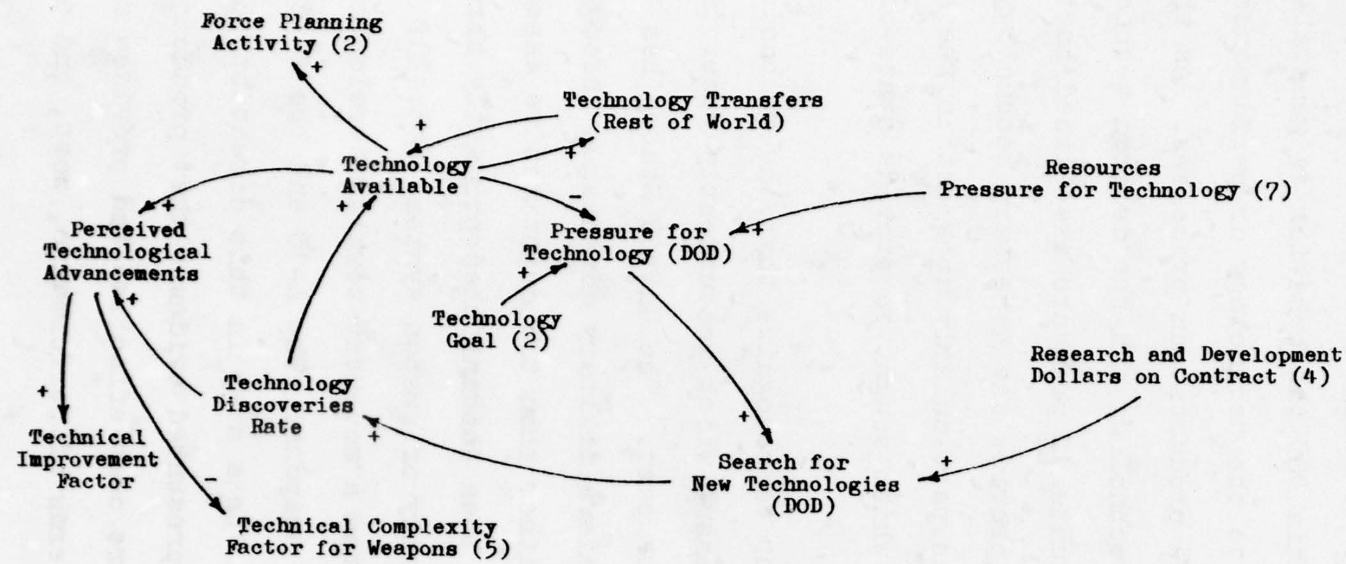


Figure 4-7

Technology Sector

Just as the technology goal is a vital determinant of the pressures for technology, the amount of financial resources applied towards satisfying the technology goal is also important. The search for new technology for DOD is funded through the research and development appropriations. As more funds become available for internal DOD research efforts and contracts in the private sector, the search for new technology heightens. Research for defense systems and processes is conducted along two lines: research aimed at specific weapon system applications and research conducted to maintain the technology base.

Eventually, the research efforts discover technologies applicable to DOD which go towards increasing the total amount of technology available. The result of the discovery and additions to technology relieve much of the pressures established by the original technology goal. This goal seeking feedback loop is the primary loop within the technology sector.

A second important issue in the technology sector is the role of technology transfer between government and commercial industries in the United States, as well as transfers among foreign countries. Although the causal loop displays the technology transfer concept as a positive or growth type loop, transfers are perceived by many as a lopsided arrangement with many underdeveloped countries.

The debate includes the degradation of national security when critical military technologies find their way into Soviet and Warsaw Pact hands (46:42). On the opposite side of the technology transfer issue, transfers of technology to our allies increase their abilities to fight because the qualitative features of their weapons has been enhanced and their industrial base has been improved. In addition to benefits for foreign countries, the export of technologies is a big business for U.S. firms. Limiting trade would have a significant economic effect on many multinational companies (38).

In the past, transfer of new technologies normally went from the DOD to commercial industries; however, more technologies are being developed in commercial industries before they are applied to military applications. These spin-offs are considered a valuable resource for the acquisition process and provide many of the new ideas which subsequently satisfy needs (8). The technology search and discovery cycle is also prompted by the resources scarcity. This will be discussed more fully in the resources sector.

A final concept in the Technology Sector is perceived technological advancement. This is sensed by research and development planners and affects both the goals and the actual technical effectiveness that occurs in the research, development, and production phases of the acquisition process. The perceived advancement is a function of the rate of change in technology relative to the amount of technology that was initially available in the perception time period.

The estimation of the level of technology required for a weapon system is one of the major determinants in the effort or work required to accomplish the various weapon system development phases. In the next section the application of technology to the research and development efforts in DOD are discussed.

Weapons Systems Research and Development Management

One of the more studied aspects of the DOD systems acquisition process is the activity associated with research and development (R&D). R&D is normally divided into three distinct, although similar phases of work: conceptual effort, validation, and full-scale development. These three phases are linked together by the DSARC decision-making network which was addressed in the literature review contained in Chapter 2 and also in the discussion of the Need Sector in this chapter. After weapons development is complete, the production phase begins. The decisional structure for production is quite similar to the structure for research and development, although the product is more tangible. In order to avoid repetition, many of the concepts that are contained in this section will also apply to production; therefore, only the differences between research and development and production will follow in the Production Sector discussion.

Two general categories of actions and decision-making exist in this portion of the model. The first category focuses on the decision structure required to initiate, approve, and fund R&D and production in the DOD. The second part develops the cause and effect relationship which exists within a program once it is approved and funded.

The formal decision structure which existed to review and approve weapon systems has been addressed continually throughout this research. The DSARC process is captured in the model by four separate phases of activity which are activated by the DSARC and funding decisions characteristics of the actual system. One of the issues which is of concern in DOD today is that the DSARC and PPBS systems are not formally linked; therefore, discontinuity and delay may result if these two processes do not remain synchronized as weapons are developed and produced. This lack of coordination may also be very costly due to stretch-outs or work stoppages. Many recent studies have suggested that closer coordination and formal linkage of these decisional processes be instituted in the DOD systems acquisition process (17; 50).

The basic objective of these decisional points is to determine whether the program is perceived to have enough merit or product value to continue development or production. The causal loop diagram contained in Figure 4-8 provides a representation of product value. The basic concept has been adapted from Robert's model concerning R&D management (55).

Two elements are required in the determination of product value: costs and benefits. Benefits are derived from the progress towards the R&D and production goals, as well as the decision-maker's perceptions of the urgency and importance of the mission requirements and political desirability. Costs are measured by the actual and anticipated expenditures resulting from work performance. The weighting of cost and benefits determine the outcome of the decision process. This process can be compared to programming activities addressed in the Financial Sector; however, the product value assessment relates to one specific program rather than trade-offs made between programs.

Product value is increased as a result of increases in progress or decreases in costs. This provides a means to evaluate the performance of the program. To this basis, desirability and urgency of need are added. Although this idea is conceptually supported by discussions with managers in the formal interview process, the actual weighting

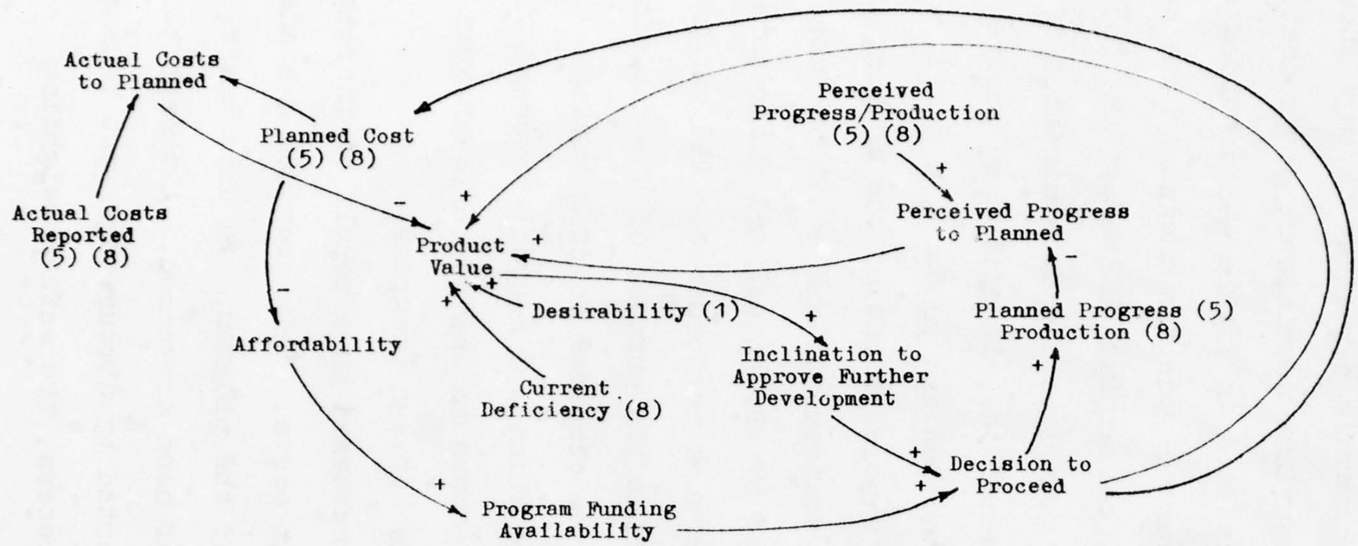


Figure 4–8

Product Value, Weapons Development and Production and measurement devices are vague; therefore, completely consistent or rational cost benefit trade-offs are difficult. Even dollar costs are relatively intangible when evaluated in terms of life-cycle expenses.

Prior to any tangible performance measures, the product value is anticipated based on information about the expected performance of the program. This expectation is captured not only in the planned cost and progress variables, but also by the perceived urgency of need and desirability elements. The interviews revealed that early impressions about a system have a lasting effect on the decision-making environment even if new information conflicts with prior beliefs.

As product value increases, there is an inclination to approve further development or production within the DSARC process. The "go" decisions represent a commitment for increases in both planned progress and planned costs in future periods. The progress loop is characterized by growth--more progress, more product value, approval for more progress. The cost loop provides control. Until recently, this loop was very weak; however, affordability appeared to be a growing issue (33). The discussion includes both current R&D and investment costs as well as life cycle costs incurred well after production completion.

Without funding, a program cannot continue, although it is unrealistic to assume that all activities and expenses cease immediately.

Throughout the interviews, logistics managers noted a heavy bias to ignore the out year effects of R&D decisions. This bias is slowly changing as a result of recent initiatives including Design to Cost, Life Cycle Cost, and Integrated Logistics Support programs.

The final elements which affect the perception of product value are urgency of need and desirability. Urgency is the result of both the size and timing of the deficiencies. The B-1 bomber and cruise missile decisions provide examples of these concepts. The need for the Air Launched Cruise Missile became more critical following the cancellation of the B-1 bomber. This resulted from the lack of desirability for the B-1 bomber by many top government officials, such as the Congress and the President.

Once a R&D or production effort is approved, the program is continually monitored. The focal point individual is the Program Manager who is responsible for the majority of tasks related to R&D and production. In addition, extensive requirements are placed on the Program Manager to interface with elements external to the System Program Office (19).

The key control mechanisms within the management of R&D and production efforts include technical performance, schedule and cost. These three elements are highly correlated in terms of their effect on the program. Technical performance is the driver and considered by some individuals to be the only goal, cost and schedule being constraints.

A simple presentation of these three elements is depicted in Figure 4-9.

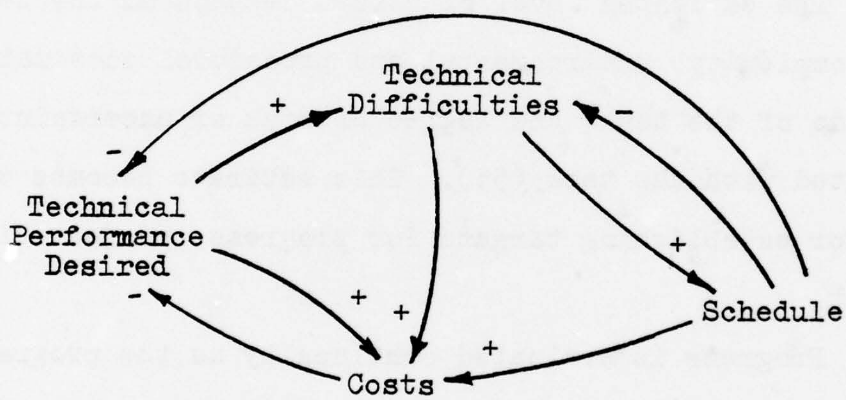


Figure 4-9

Performance, Cost, Schedule

Several studies have supported this cause and effect relationship as well as the discussions with managers (47; 61). Cost and schedule goals may only be reached if technical performance goals are reduced. The remainder of the discussion about R&D and production management will expand this concept of technical performance, cost and schedule into five areas:

1. Planning the level of effort,
2. Evaluation of progress,
3. Evaluation of costs,
4. Adjustments to schedule,
5. Adjustments to costs.

These five areas are displayed graphically in Figure 4-10 for Research and Development and Figure 4-12 for Production.

The estimated level of effort depends on the technical complexity, environmental and procedural constraints, magnitude of the task, and degree of risk or uncertainty associated with the task (55). This estimate becomes the basis for establishing targets for progress, project time, and cost.

Progress is evaluated continually as the program moves towards completion. In R&D, the actual progress is difficult to measure; therefore, perceived progress becomes the measurement device used to compare what has been accomplished to what was planned. A number of formal reports are used to report progress to the program management staff; however, progress is also evaluated more informally through meetings and discussion with the contractor (19). As a deviation from planned progress or production is noticed, actions are taken to adjust the progress rate in order to

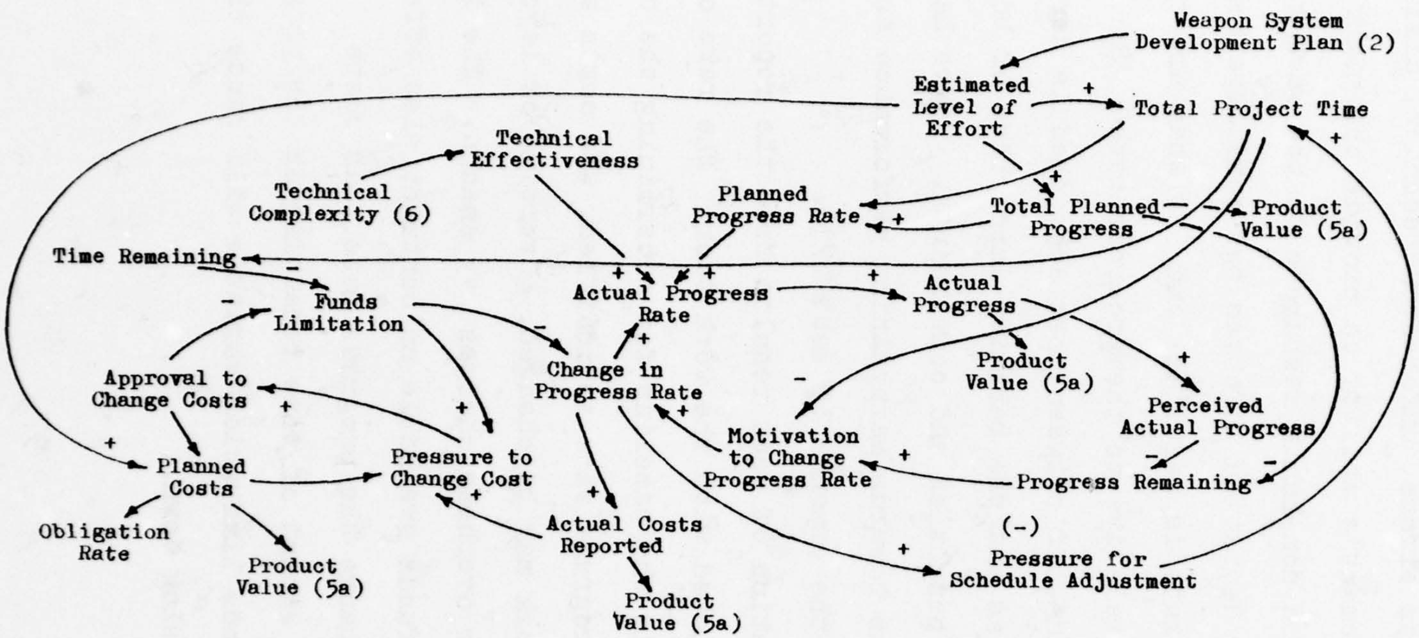


Figure 4-10

Weapon System Development Sector

stay on schedule. Deviations occur due to many factors involving estimation errors, unforeseen technical difficulties, and management's ability to provide the right amounts of human and non-human resources to the work task. The adjustment for deviation involves two considerations: (1) what progress rate is required; and (2) what are the cost implications relative to the progress rate? The result of this trade-off between cost and schedule depends on management's bias and the relative importance of both cost and schedule penalties and constraints. There has been a general bias towards maintaining performance and schedule goals at the expense of cost (71).

The evaluation of cost results from the reporting of expenses associated with the work task. The rate of planned progress is the baseline for determining the cost; however, as the progress rate is modified, the costs associated with the work may be changed. Overtime or layoffs may be required or overhead charges may change. The limit on the amount of funds available on contract also effects the decision to change the progress rate. As costs increase, and the amount of time remaining in the program decreases, the funds limitation variable will cause the progress rate to slow down.

The continual monitoring of the program provides information required for adjusting schedule and cost. As progress falls behind schedule, there is pressure to slip the program, causing an increase in the total project time. If the decision is made to slip the milestone, the pressure to increase the schedule is alleviated. The decision to approve a change in milestone decision is a function of the amount of time required, the current progress and costs, and the urgency associated with system development.

Pressures to change contractual cost occurs when funds are used faster than planned. This can be the result of formal changes in the level of effort, cost estimating errors, or the deviations which result from the changes in the progress rate. The decision to approved funding increases is a function of the funds available from other programs and the current progress performance of the program under consideration. Many managers indicated that there was a reluctance to spend "good money after bad", believing that a program could not recover from past problems. This has led to a number of recent systems being cancelled at the DSARC II and DSARC III decisional points (60).

In addition to the impressions that follow a program through its life, the actual decisions concerning cost and technical performance effect subsequent phases of development production, and operational use. This is particularly evident in the area of technical problems. If a program experiences problems not corrected prior to start of the next development or production phase, technical difficulties will continue. Effort must still be performed in order to meet the technical goals--unless the program goals are changed. Many systems do not live up to their expectations in terms of performance. This is characteristic of many operational systems today. Studies have shown (17; 61) there is a greater risk of technical problems when the schedule is compressed. One of the reasons concurrency was prohibited was to avoid this problem. Technical problems affects more than just performance. Costs to correct problems after production begins severely impact the life cycle cost of the system. These costs are incurred both in modifying the system and also in providing increased support required when a system cannot be maintained at its necessary level of operational readiness.

In summary, the research and development process is characterized by a series of controls. These provide the framework for achieving research objectives and provide the groundwork for the production process.

Resources Sector

The Resources Sector illustrates the process of discovery and use of raw materials required for the production of defense systems. The causal loop diagram (Figure

4-11) depicts five feedback loops which characterize the sector structure. The concept employed is based on Forrester's application in his world model (25).

The resources sector is goal seeking due to the strong influence of limited natural resources. Resources become less available due to increased demands from growing industrial populations. This creates the necessity to search for new resources and increase extraction rates for existing resources. Increased efforts eventually result in new discoveries and increased resources; however, there is a finite limit to this behavior. Today, the limit of the oil reserves available to the U.S. is in sight, barring any substantial discoveries in new oil frontiers. The increased efforts to produce more oil have yielded smaller and smaller volume from existing pumps (62:60).

As the supply of resources is diminished, use is gradually decreased as the full impact of resource shortage is felt. This results from a delayed desire to conserve resources and provisions for resource saving alternatives. These resource saving alternatives are developed as the result of a call for new technology to provide a know-how to develop processes that can use alternate resources or provide for more efficient use of existing resources.

Because resources are limited and may be unavailable to the U.S. except by import, the protection of existing

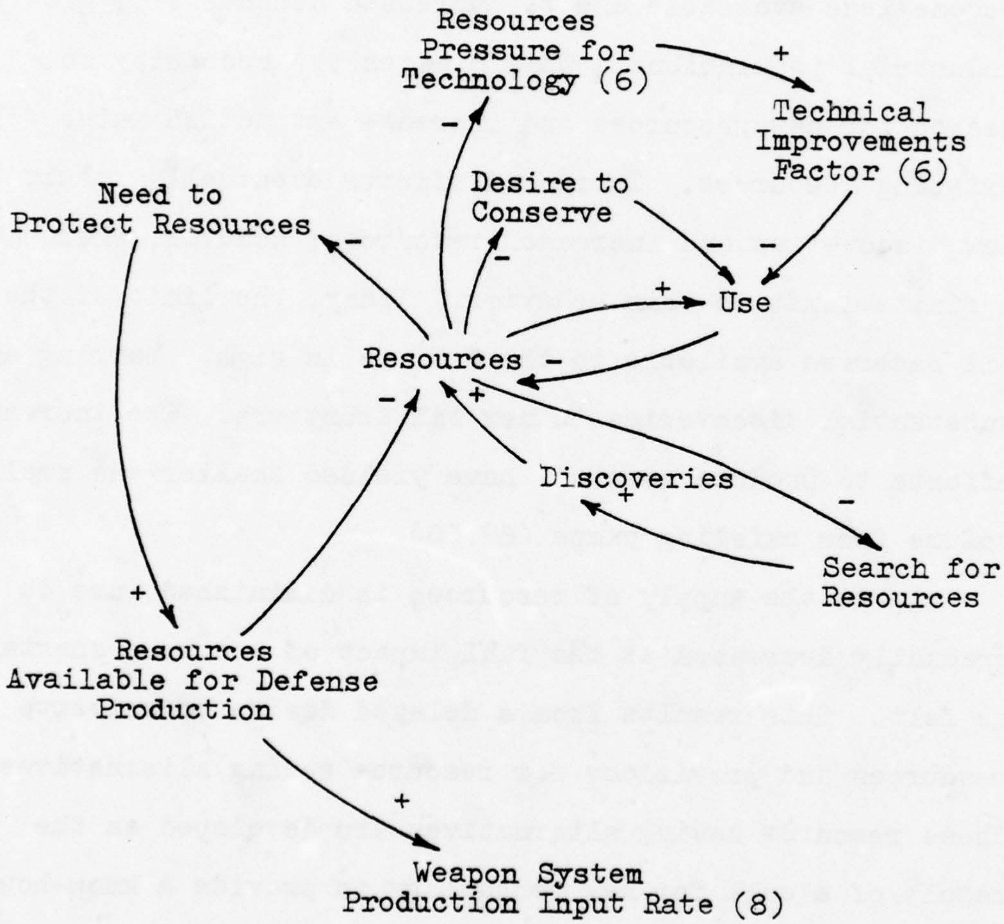


Figure 4–11

Resources Sector

resources and nuturing of political alliances with resource rich countries has become an increasingly important policy issue. Today, the United States is almost completely dependent on other countries for several primary ingredients for our industrial processes. If the supplies were shut off, a significant disruption would occur in our current industrial base. Diplomacy has been the preferred way to develop and maintain supply lines; however, recent events in the Mid East indicate that political alliances are not necessarily the answer to all our resource problems. Alliances change daily.

It is projected that as resources become less available for all users or the political situation degrades resource supplies to the U.S., greater allocations of existing resources will be provided to defense production in order to protect those resources which are available for U.S. use (45:281). Although this is conjecture, the recent events concerning U.S. storage of oil for defense lend support for this hypothesis.

The role of resources in the industrial processes required to produce weapon systems has not played an important role in the decision-making process relative to acquisitions until the last decade. Resource considerations are projected to become increasingly important factors in the U.S. ability to access specific raw materials and to control the economic impact of scarce resources.

Production Sector

As noted in the Research and Development Sector, the system characteristics which exist in production are similar to those addressed for R&D. Only the differences, additional detail, and production issues will be discussed in the section. The purpose of the Production Sector is to combine the technology, raw materials, and financial resources with the output of the research and development effort. This merging of inputs provides the basis for the production process. As noted from Figure 4-12, the process structure is quite similar to the relationships which exist in the R&D phases. One of the differences is the input of significant quantities of material resources. Limited supply of some raw materials can constrain or alter production processes as noted in the discussion of the Resource Sector.

Another difference between the R&D and the production processes is the tangibility of the output production. For production, the assembly and final delivery of weapon systems are much more visible than the achievement of development concepts within the early stages of R&D. Because of this increased tangibility, more top level management review was noted. This is also due to the relative increases in costs as systems are approved for production. The result of senior management attention

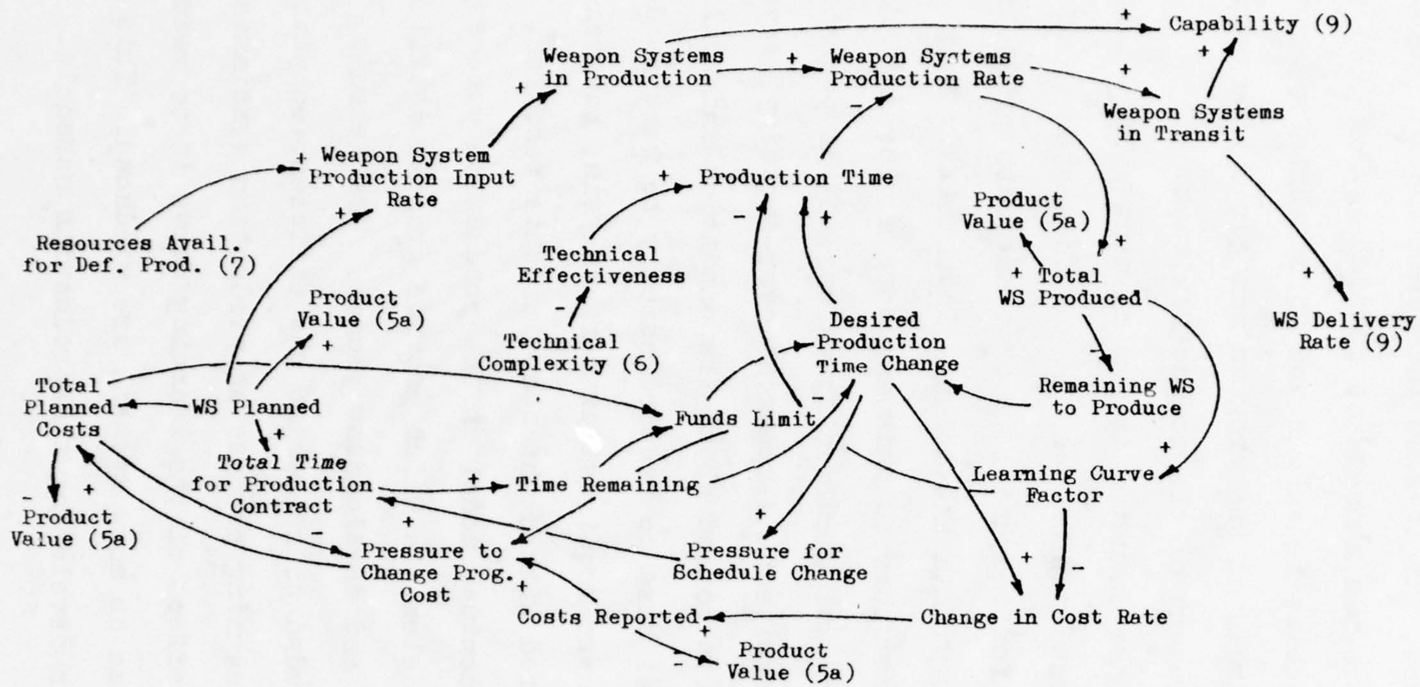


Figure 4–12

Production Sector

appears to create a tighter control network around the production process, but it also increases the information demands on the program management staff. As Fox (26) noted that the public relations and formal briefing process create a large drain on the program manager's time available for actual management of the production task.

The defense industry is the element within this system which actually produces the weapon systems. One of the assumptions for the model is that adequate production facilities exist within the defense industries. Many individuals have supported this assumption (28; 31), noting the over-capacity which currently exists in the peacetime environment. Despite this apparent over-capacity, several concerns have been voiced about the condition and ability of the industrial base to respond quickly to wartime demands (64). This concern requires further analysis; however, it was not considered within the scope of this research.

The conceptual model of the production process does contain several elements which provide greater detail than in the research and development phases. The learning curve concept is included to represent the efficiencies which relate to the learning process as production continues (26:156). The effect of the learning curve is to reduce production flow time as more systems are produced. This must be considered in developing the production schedule.

Production schedules are also different than those in research and development due to the ability to measure actual quantities of systems rather than the achievement of research and development tasks. Many managers noted that the schedule becomes a device used in the programming cycles for adjusting total force requirements to meet financial constraints. Thus, many schedules are lengthened when funds run short, or conversely, schedules are accelerated if urgent threats exist. The schedule, coupled with the abilities of the production process, determines the delivery rate of operational systems to the operating commands. The next section will describe the relationships which exist in the operational environment within DOD.

U.S. Operations Sector

The U.S. operations sector provides one of the basic feedback mechanisms for the systems acquisition process. In this sector, needs for support are generated and capablities are determined by the employment of weapon systems. The sector is divided into two general parts. The first part deals with the inventory flow within the operational system. The second part deals with the capability information that results from the condition of the various inventories. The causal loop diagram contained in Figure 4-13 provides a framework for discussion.

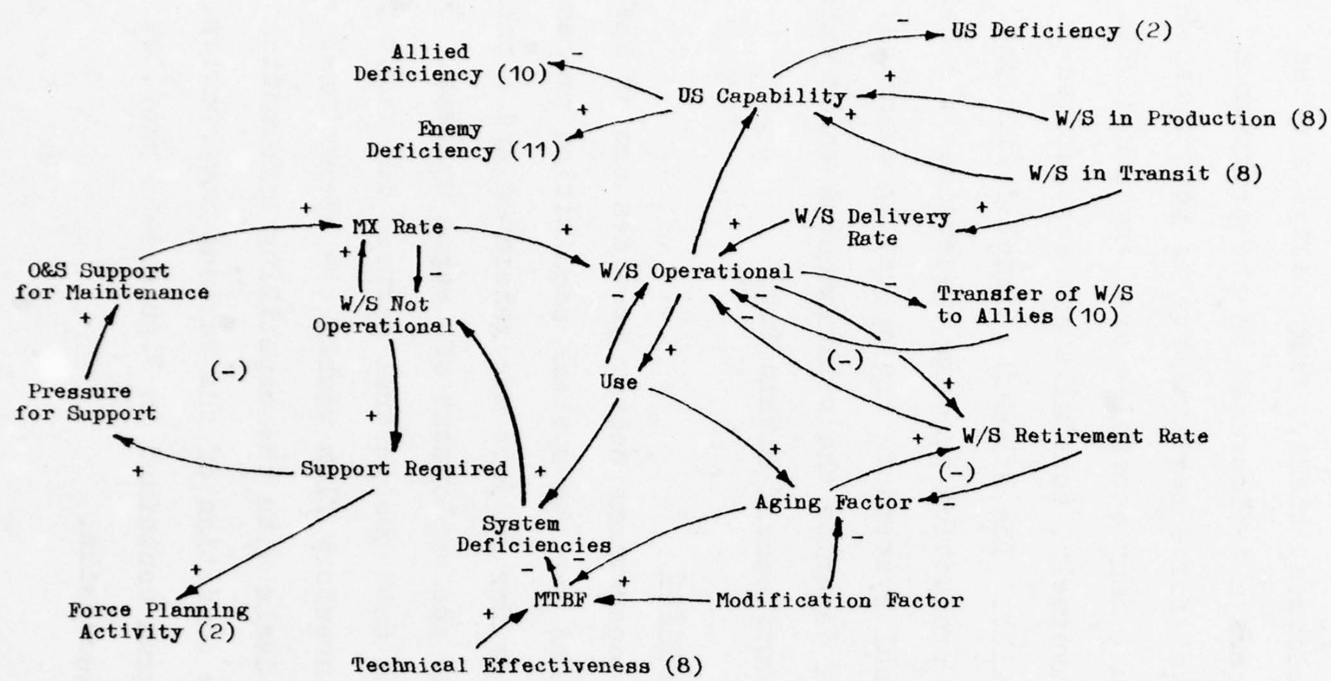


Figure 4-13

Operational Sector

The inventories within this sector include both operational and non-operational systems. The primary goal is to maintain a desired percent of the systems in operational condition. This goal becomes a measurement device or standard for the commands to compare to actual operational experience. The result of this comparison is an adjustment to the relative pressures for support. In addition to command review of operational performance, other organizations involved with reviewing and approving support plans and new acquisition programs use this as a measurement of operational performance.

Systems are delivered to operations from the production sector. Once the systems reach the field, they are used to meet the planned operating program established for each unit. As the weapons are operated, failures and aging of the fleet occurs. The systems deficiency variable is used to capture both the failure and aging characteristics, in addition to the inherent design problems existing in new equipment delivered from the Production Sector. As the systems deficiencies increase, more systems become non-operational, creating a demand on repair and support. This pressure intensifies as more and more systems are incapable of meeting their assigned mission, creating a request for additional support.

In the Air Force, support costs have increased three times since 1964 (67); therefore, costs related to operating and support are becoming more a concern of top decision-makers within all areas of the DOD system (57). In acquisition, the trend to consider the effects of design on the downstream costs is becoming more apparent from both the beliefs and actions within the acquisition systems. Although the actions are sincere, the difficulties involved with estimating and measuring the pertinent costs and benefits are different. This was described in the discussion on product value.

One manager (42) within acquisition expressed a concern for the increasing age of U.S. operational forces. This results from a lengthening of system life cycles, without timely provisions for replacement systems. Many of the operational forces have far exceeded their planned operational life. This results in increased support costs.

A final issue within this sector discussion is the ability of DOD to measure readiness. As noted in earlier discussions, the percent of systems which are operational provides one of the most often used measurement devices of operational capabilities. This measure is rather short-sighted in that it does not address the abilities to meet sustained wartime mission requirements through the use of equipment, spares, and personnel support. Throughout this research, the lack of adequate measures for operational capabilities and readiness were noted. Although these concepts are complex, it is important to know the general ability of the operational system in order to provide useful estimates of needs.

Allied Sector

The role of allied defense in supplementing U.S. military strengths draws on both DOD production and operational systems. In addition, the many allies develop their own internal defense industry.

The acquisition system's role in allied support has expanded significantly in the last two decades. The major growth of U.S. military support to our allies began at the conclusion of World War II when U.S. resources were used to restore political and economic stability (62:41). Today, each contract proposal submitted for a major systems acquisition includes a section describing relevant NATO industries and opportunities for co-production (8). Because of the increasing importance of allied defense to the DOD acquisition process, the policies that apply to this sector must consider the careful balance of military, economic, and foreign affairs.

The structure of the allied sector (Figure 4-14) is believed to be a simplified version of the U.S. system.

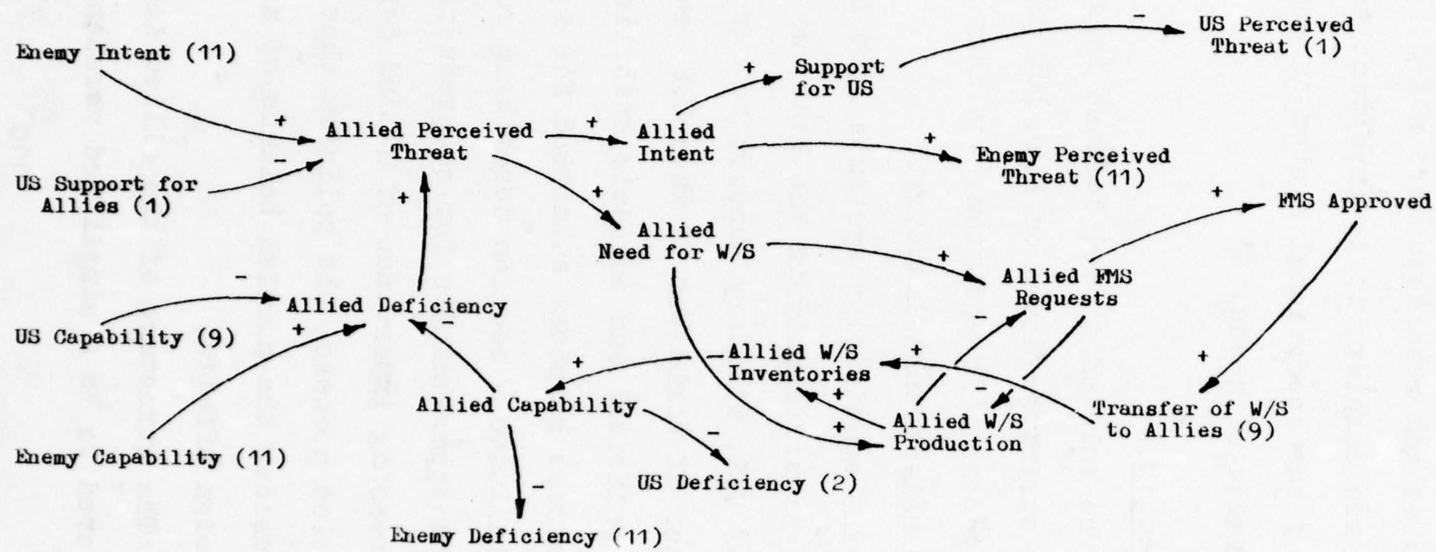


Figure 4-14

Allied Sector

Based on the allied perception of threat, enemy intent, and U.S. support, needs for weapon systems are determined. These needs can be satisfied through in-country production of weapons or through the transfer of arms from the United States. Arms transfers result from the request and approval of Foreign Military Sales (FMS) agreements with allied nations. Normally nations rely on the U.S. for arms when adequate industrial capability is not available within country or when the country's weapons do not satisfy the deficiency. Industrial nations also seek to share or continue development of their capabilities by jointly producing weapons with the U.S. This is called co-production. The F-16 fighter aircraft is the most recent large scale co-production program involving a partnership arrangement between the U.S. and foreign nations. The benefits resulting from co-production arrangements include the sharing of a portion of the acquisition costs, increased standardization of weapon systems and closer economic ties (8). Standardization within NATO is also a separate policy goal currently receiving much attention. Increased use of standard parts enhances U.S. and allied ability to combat the Warsaw Pact threat (64).

The increase in capabilities for U.S. allies lessens the overall threat that both the U.S. and its allies perceive from the enemy. This relieves some of the pressures on the DOD acquisition process to produce weapons. Many reports stated that the role of the U.S. as a world power is declining. This is placing a strain on U.S. alliances, resulting from doubt of true U.S. intentions to provide support to its allies. This lack of assurance of U.S. support may eventually cause a shift in alliances, impacting the relative threats that the U.S. must counter through the production of arms (62:39).

The motivations which cause shifts in political and economic alliances are related to the concept of quality of life discussed in the Political Sector. The needs for both military and economic security appear to play an important role in the policies that effect political alliances and military support for allied nations. As allied demand for U.S. weapons increases, world diplomacy enters into the considerations of DOD acquisition policy.

Enemy Sector

The final sector in the conceptual model is the Enemy Sector depicted in Figure 4-15. Although this sector is the briefest in detail, omission of the concept represented would remove the major stimulus to the acquisition system—enemy threat. This threat affects the activities within both the U.S. and allied defense systems.

Perceived threat is the driving factor in the production of arms. This threat is a function of the relative

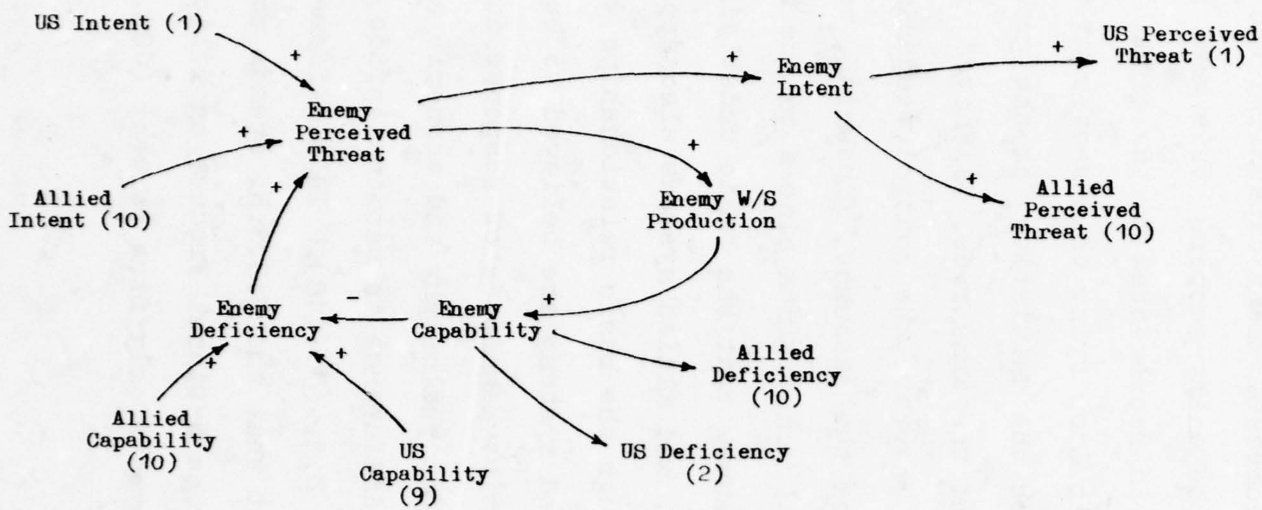


Figure 4-15

Enemy Sector

capabilities and intent factors based on evaluations of the U.S. and allied systems. As the enemy senses threat from these two areas, more weapons are input into production and ultimately provide increased enemy capability and decreased deficiencies within the enemy sector. This goal seeking aspect of the system is represented in the causal loop diagram. The implicit loop tying this sector to the others in the system provides the initiative for the growth behavior characteristic of the arms race. As noted in the introduction to this chapter, the control mechanism on the arms race results from the resource, financial, technological, and political constraints placed on the system.

The model assumes that the basic underlying structure existing in U.S. and allied systems also applies to the enemy system. Although the basic relationships within the enemy, U.S. and allied systems are believed to be similar, the motives and relative magnitude of response differ as a result of the political philosophy and economic systems. Smith noted a large difference in national pride between the U.S.S.R. and the U.S. (58:118). This difference is reflected by the fact that the U.S.S.R. spends more than 11 percent of its Gross National Product on military defense, whereas, the U.S. invests only five percent (10).

The differences between the U.S. and enemy philosophy may lead to slightly different perceptions of the actual intentions and motivations within both the military and political environment. Luttwak noted that the Soviets perceive a military advantage due the sheer numbers of forces and equipment they have in comparison to the United States (44). The concept of perception also plays an important role in interpreting the intent to use force. In times where U.S. intent has been mistaken, the enemy has sought to use force in order to take advantage of a situation, often resulting in military conflicts (39).

Conclusion

In this chapter the first resolution of the weapon systems acquisition process was presented. The key issues and goals of the system and the various sectors within the system were discussed. These discussions were based on information from both the literature review and interviews conducted with key managers within the acquisition process. With this work as the basis of the system dynamics model, the next chapter develops these concepts into the flow diagrams and equations necessary to computerize the system and experiment with changes to structure and policy.

Chapter 5

THE MATHEMATICAL MODEL OF THE DOD SYSTEMS ACQUISITION PROCESS

Introduction

The flow diagrams and mathematical equations for the acquisition policy model are presented in this chapter. Each of the sectors is described by one or a series of diagrams which depict the flows of material, money, or information throughout the system. These diagrams and the equations provide greater detail and structure to the system. The discussion will include the supporting rationale for the equations and functions developed within the model. This discussion is intended to supplement the system concepts, relationships, and issues presented in Chapter 4. The relationships portrayed in the mathematical equations represent the general concepts and beliefs discovered during the research.

The presentation approach will apply the system dynamics symbology introduced in Chapter 3. Each sector will be discussed by flow diagrams and corresponding equation sets. The flow diagram symbols each contain a variable name, symbol, and equation number. The equation numbers are prefixed with a two character alpha code which corresponds to the sector names. For example, FN denotes financial and PO denotes political. The equations are developed in the DYNAMO simulation language notation. Only the level, rate, and auxiliary equations are developed. For interested readers, a complete, documented listing of the model is contained in Appendix C.

The model developed from the flow diagrams is intended to focus on one mission area. No provisions were made to consider the impact or relationships between different mission area requirements in need identification. This represents the real system process in that few tradeoffs are made outside of one mission area except on funding issues. The model does provide visibility of the various funding categories required for research and development, investment, operations and support. Because of the sequential approach to both weapon system development and funding decisions, the three research and development phases and the fiscal funding cycle were explicitly developed. This created a degree of repetition in the model structure which will be avoided in the discussion; however, the repetition was necessary to fully represent the decisional structure which existed.

Political Sector

The informational flows within the political sector provide the basis for the general environment that impacts the systems acquisition process. In the previous chapter the Political Sector was described as the integration process in which the U.S. balanced the demands for military international, and economic considerations in national policy. This section focuses on four distinct parts of the political system: the impact of international relations, economic issues, general support for DOD, and specific support for DOD acquisitions. The political process which determines the nature of the various pressures is defined by the information structure within the political environment. Because of this, the variables developed in the model relate to the rates and levels within other sectors, providing the important linkage of the DOD systems acquisition process with the political environment.

The first portion of the political sector addresses the international environment. The flow diagram which represents the international environment is depicted in Figure 5-1. Two specific areas are involved: enemy threat and alliances. Both concepts are the result of political intent. Spector (59) developed a method of determining political intent by analysis of trends in the day-to-day relations between two nations. Two general categories were used to classify events: the tone of the event and the intensity of the action. This concept was employed to establish the military intentions of the U.S., allied, and

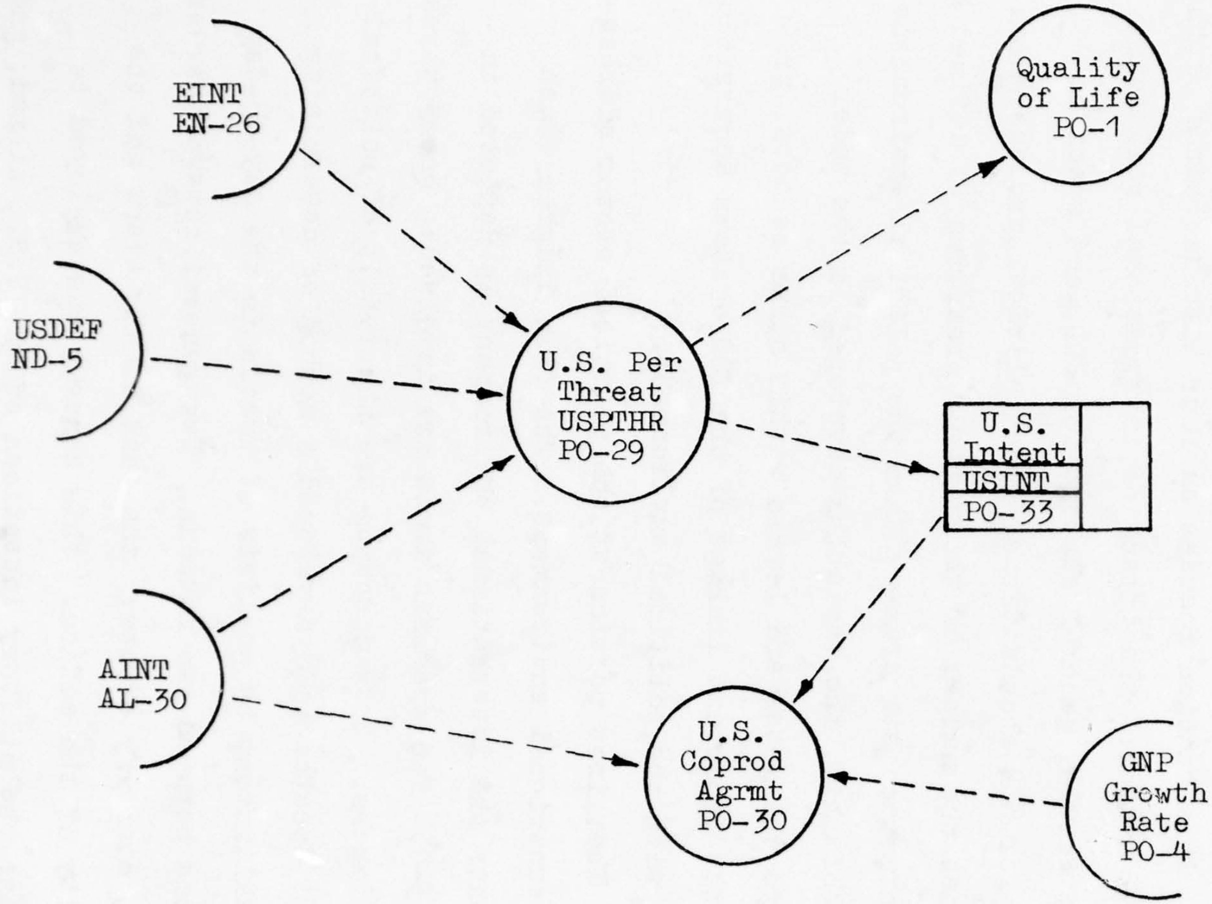
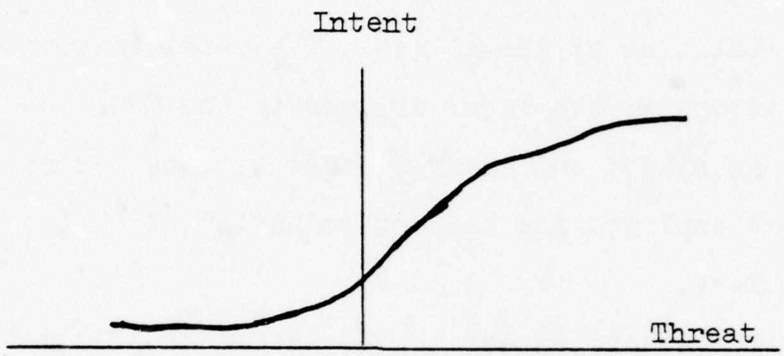


Figure 5-1

Political Sector--International Relations enemy defense systems within the model. The measure of tone is represented by the threat that a nation perceives. The amount of threat determines the intensity of intentions. As threat increases, the intent to use force also increases. The relationship is illustrated in Figure 5-2.



Threat vs. Intent

Figure 5-2

Threat is evaluated through time and is not immediately updated. The trend of events determines the actual political intent that a nation perceives. This is represented in the following equations.

```
A    USINT.K=TABHL(USINTT,SPTHR.K,0,2,.2)
T    USINTT=0/0/0/0/.1/.8/1.25/1.97/2.35/2.5/2.6
A    SPTHR.K=USURCF.K*SUM(USPTHR.K)/120
A    USDWSL.K=USDESW*TABHL(USDWST,SPTHR.K,0,2,.2)
T    USDWST=.2/.2/.2/.35/.55/.8/.92/1/1.05/1.1/1.1
NOTE     USINT    US INTENT
NOTE     SPTHR    SMOOTHED PERCEIVED THREAT
```

```
NOTE     USURGF  US URGENCY FACTOR
NOTE     USDWSL  US DESIRED WEAPON SYSTEMS LEVEL
```

The other portion of the threat equation concerns the relative differences that exist between U.S. capability and capabilities of the allies. The determination of threat is one of the major drivers in the U.S. needs process, as well as allied and enemy defense systems. Similar concepts are employed for the determination of allied and enemy threat.

The second aspect of the international environment concerns the military ties which result from foreign military sales and co-production. These relationships reduce U.S. and allied deficiencies and also strengthen diplomatic relations. The equations which relate to the international aspects of the political environment are:

```
A    USPTHR.K(MO)=(EINT.K-AINT.K)*USDEF.K(MO)
A    USCOPA.K=CLIP(1,Ø,AINT.K*SPTHR.K,.8)
NOTE     USDESW  US DESIRABILITY TO BUILD WEAPONS
NOTE     USPTHR  US PERCEIVED THREAT
NOTE     EINT    ENEMY INTENT
NOTE     AINT    ALLIED INTENT
NOTE     USDEF   US DEFICIENCY
NOTE     USCOPA  US COPRODUCTION AGREEMENT
NOTE     SPTHR   SMOOTHED PERCEIVED THREAT
```

Perceived threat is one of two determinants of the quality of life concept discussed in Chapter 4. The quality of life variable ties the international and economic situations together. The economic system within the political sector is depicted in Figure 5-3. Quality of life is a function of both threat and the general economic conditions in the U.S. In the model, Gross National Product was used to represent the state of the U.S. economy. As economic conditions improve, the quality of life increases. The equations that represent this concept are given below.

```
A   QOL.K=TABHL(QLMT,GNP.K/SPTHR.K,Ø,5,1)
NOTE     QOL     QUALITY OF LIFE
NOTE     GNP     GROSS NATIONAL PRODUCT
NOTE     SPTHR   SMOOTHED PERCEIVED THREAT
L   GNP.K=GNP.J+DT*(GNPGR.JK)
R   GNPGR.KL=.Ø3
A   BUD.K=FBRQMT.K*BRF
NOTE     FBRQMT  FEDERAL BUDGET REQUIREMENTS
NOTE     BUD     FEDERAL BUDGET
A   NDODD.K=BUD.K*PBND.K
A   PBND.K=TABHL(BUDT,NDDMD.K,Ø,1,.1)
A   DODD.K=BUD.K*PBDOD.K
A   PBDOD.K=1-PBND.K
NOTE     NDODD   NON-DOD DDOLLARS APPROPRIATED
NOTE     PBND    PERCENT BUDGET TO NON-DOD
NOTE     NDDMD   NON-DOD DEMAND
NOTE     DODD    DOD DOLLARS APPROPRIATED
NOTE     PBDOD   PERCENT BUDGET TO DOD
A   FBRQMT.K=BRF*(DDMD.K+NDDMD.K)
A   DDMD.K=SUM(FYDP1.K)+SUM(FYDP2.K)+SUM(FYDP3.K)
A   NDDMD.K=GNP.K*GNPGR.JK*TABHL(NDODT,QOL.K,Ø,3,.3)
T   NDODT=2.5/2.1/1.5/1.2/.86/.67/.42/.21/.15/.11
NOTE     BRF     BUDGET REDUCTION FACTOR
NOTE     DDMD    DOD DEMAND FOR DOLLARS
```

In this model, the interaction of the economy with the systems acquisition process was not defined. The focus

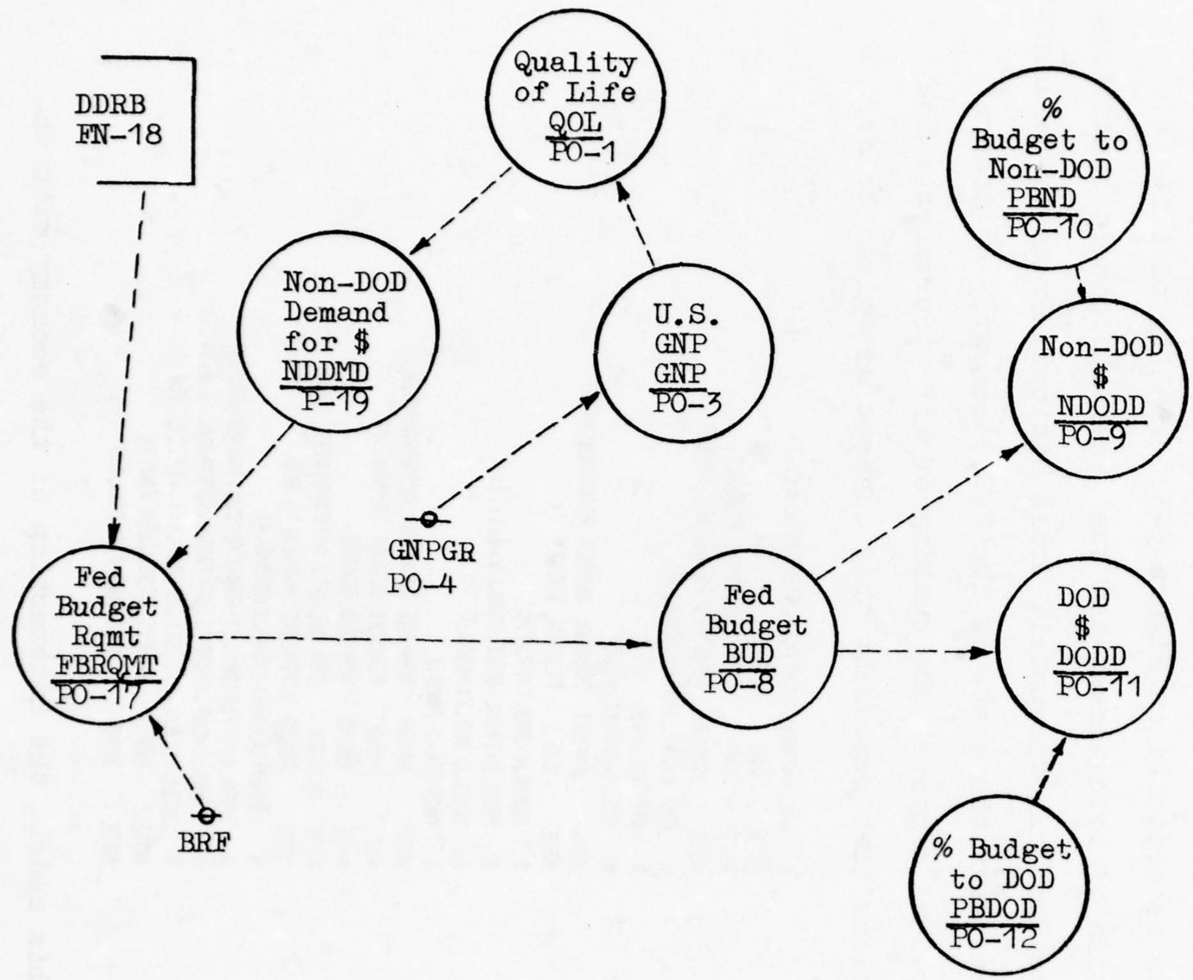


Figure 5-3

Political Sector--Economic Issues

was to show the effect of economic conditions on the acquisition process; not to show the acquisition process' effect on the economy. With this intent, the economic state is assumed to be given in the model.

The third concept within the political sector is the pressures which determine the general funding support for DOD programs. The general mood of the nation towards DOD is partially determined by the perceived threat. If threat is small, there is less desire to build weapon systems. This is related to the quality of life concept discussed previously. Support of DOD is also influenced by the general performance of DOD in terms of cost and performance. If past performance in DOD has been poor, there is a reluctance to support DOD requests for funds. The final consideration which determines the general support for DOD is the specific desires of the top decision-makers within the political system. Presidential and congressional goals for national policy influence the support provided to DOD. The flow diagram which depicts the general support structure for DOD programs is contained in Figure 5-4. The system equations which relate to the diagram are:

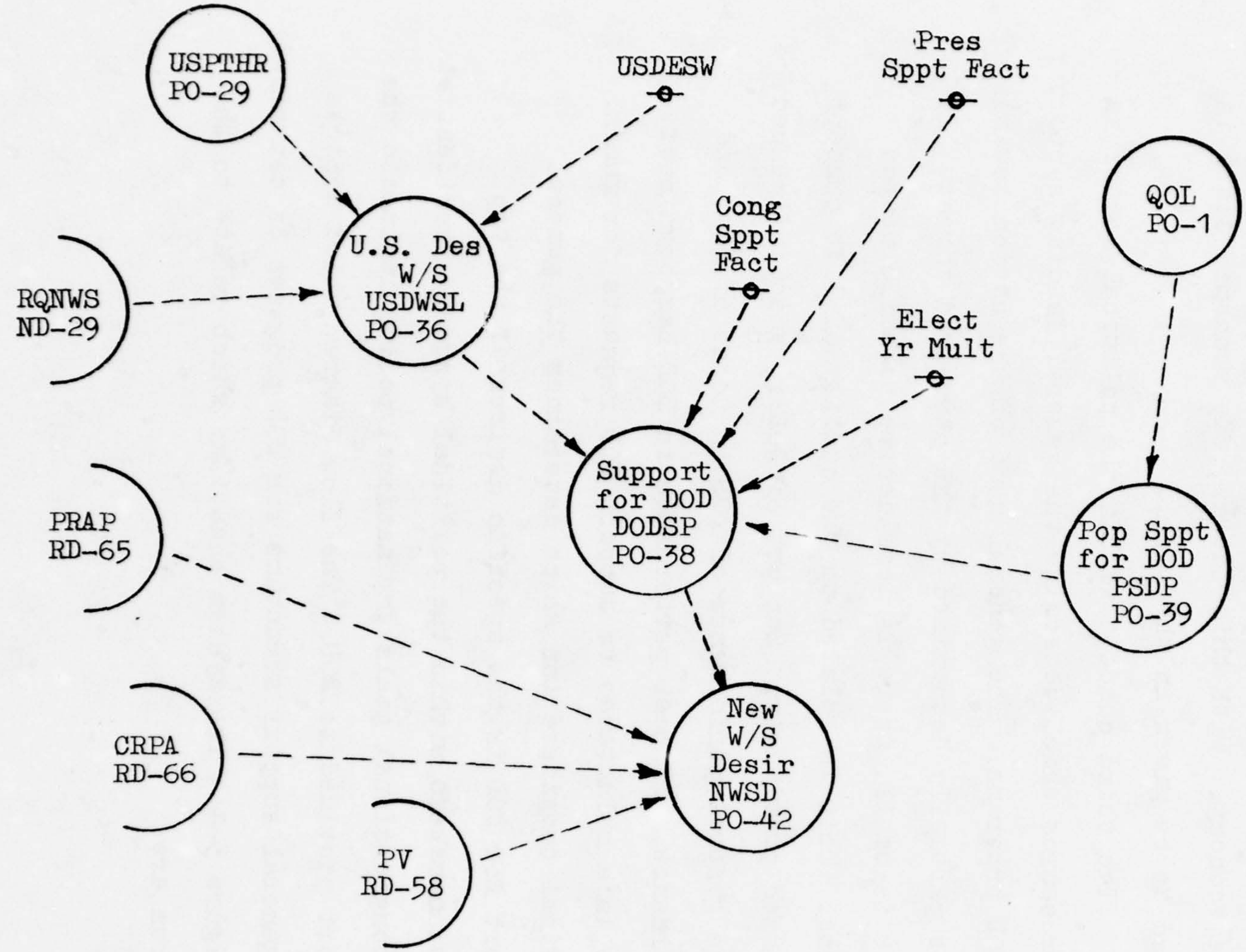


Figure 5-4

Political Sector--General Support for DOD

```
A    DODSP.K=(PRESSF.K+CONGSF.K+PSDD.K)+USDWSL.K*ELYRM.K
A    PSDD.K=TABHL(POPST,QOL.K,0,3,.3)
T    POPST=2.0/1.99/1.98/1.87/1.65/1.4/1.05/.85/.83/.8
NOTE      DODSP    SUPPORT FOR DOD IN GENERAL
NOTE      PSDD     POPULAR SUPPORT FOR DOD
NOTE      PRESSF   PRESIDENTIAL SUPPORT FACTOR
NOTE      CONGSF   CONGRESSIONAL SUPPORT FACTOR
NOTE      USDWSL   US DESIRED WEAPON SYSTEMS LEVEL
NOTE      ELYRM    ELECTION YEAR MULTIPLIER
```

In addition to general support for DOD programs, pressures are amplified for a specific program by the desires and demands of several factions in the U.S. The relationship of the factors which affect specific program support are area benefits, general DOD support, lobbyist pressure, and desirability of the new weapon system. Lobbyist pressure is measured by the state of the economy using Gross National Product and the technical complexity of the new weapon system. Technical complexity is used to capture the desire on the part of industry to reach or maintain a lead role in the defense industry. As more complex weapon systems are requested, the chance to work on new concepts which may lead to extended DOD business and product spinoffs leads to increased support for DOD programs. The equations which relate this concept to the flow diagram contained in Figure 5-5 are given below.

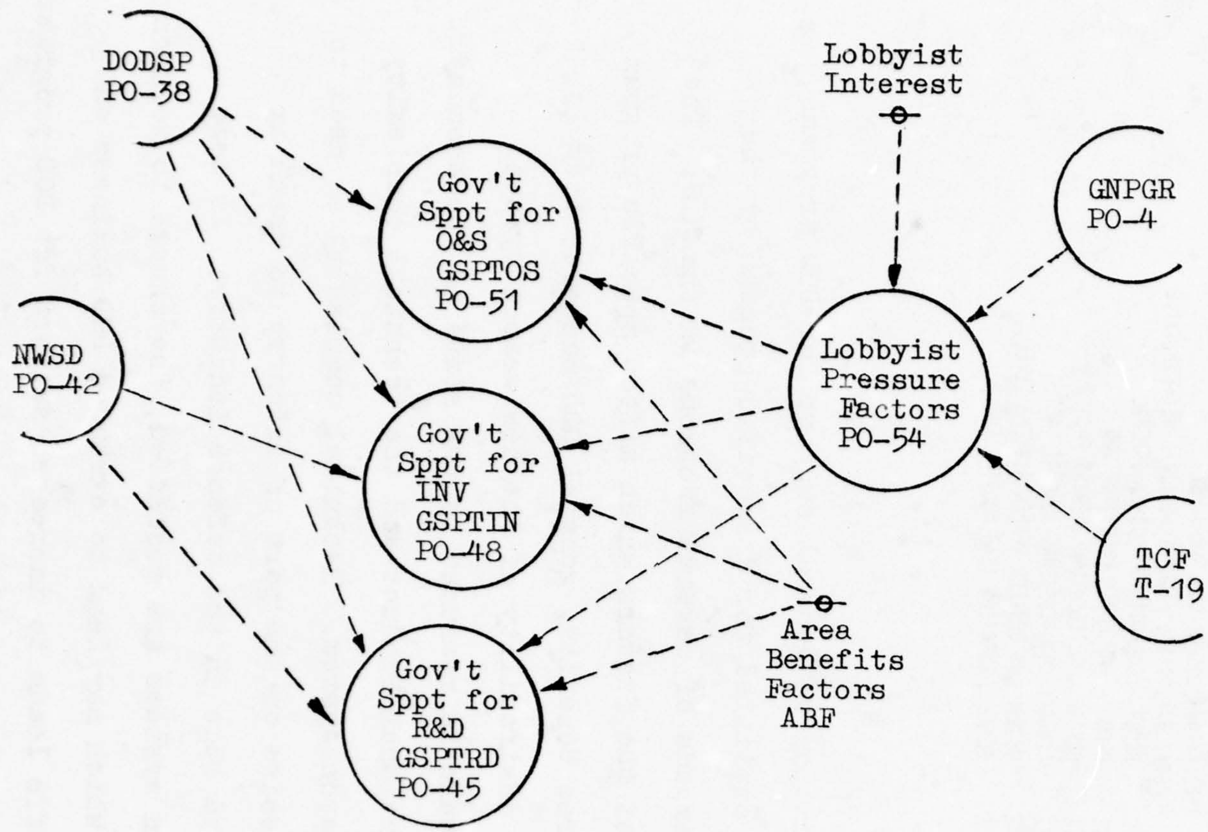


Figure 5-5

Political Sector--Specific Support for DOD Acquisitions

```
A    NWSD.K=TABHL(NWSDT,NWSP.K,0,3,.3)*DODSP.K
T    NWSDT=.2/.2/.2/.33/.5/.72/.85/.94/1/1.05
A    NWSP.K=CWSF*CRPA.K+PWSF*PRPA.K
NOTE      NWSD    NEW WEAPON SYSTEMS DESIRABILITY
NOTE      NWSP    NEW WEAPON SYSTEMS PERFORMANCE FACTOR
NOTE      CWSF    COST WEIGHTED SUPPORT FACTOR
NOTE      PWSF    PERFORMANCE WEIGHTED SUPPORT FACTOR
NOTE      CRPA    COST RATIO PLANNED TO ACTUAL
NOTE      PRPA    PERFORMANCE RATIO PLANNED TO ACTUAL
A    GSPTRD.K(1)=TABHL(GSPTT1,NWSD.K,0,1,.1)
A    GSPTRD.K(2)=TABHL(GSPPT2,SPTHR.K,0,2,.2)
T    GSPTT1=.8/.82/.83/.85/.86/.91/.99/1.1/1.3/1.5/2.0
A    GSPTIN.K(1)=TABHL(GSPTT1,NWSD.K,0,1,.1)
A    GSPTIN.K(2)=TABHL(GSPTT2,SPTHR.K,0,2,.2)
T    GSPTT2=2.0/1.5/1.3/1.1/.99/.91/.86/.85/.83/.82/.81
A    GSPTOS.K(1)=TABHL(GSPTT1,NWSD.K,0,1,.1)
A    GSPTOS.K(2)=TABHL)GSPTT2,SPTHR.K,0,2,.2)
NOTE      GSPTRD  GOVERNMENT SUPPORT FOR R&D PROGRAMS
NOTE      GSPTIN  GOVERNMENT SUPPORT FOR INVESTMENT
NOTE      GSPTOS  COVERNMENT SUPPORT FOR O&S
NOTE      SPTHR   SMOOTHED PERCEIVED THREAT
T    LOBBY=2/1.99/1.9/1.8/1.67/1.5/1.37/1.25/1.16/1.1
A    LPF.K=TABHL(LOBBY,GNPGR.JK/TCF.K,0,2,.2)*ABF
```

In summary, the political sector integrates the four factors of international environment, economic conditions, general support for DOD, and specific support for DOD programs into a consolidated plan to promote national goals. Two of these goals are based on providing adequate economic and military security. The threat that is perceived determines the inclination of the political system to recognize and approve mission needs that are developed by the Services. In the next sections, the process within DOD that identifies and evaluates mission needs that result from the perceived threat is described.

Need Sector

Threat is a function of both intent and capability to employ weapon systems. The need sector consolidates the information that links threat to mission analysis and then to capability. In this sector, the concepts of identifying a deficiency, evaluating alternative methods to meet the deficiency, and planning force structure and budget requirements are defined.

The flow diagram contained in Figure 5-6 portrays the mission area analysis portion of the determination of needs. Three factors influence the system alternatives. The first factor is the deficiency that exists in a given mission area. This process begins with the identification of the total deficiencies which result from a comparison of the relative capabilities of the U.S., its allies, and the enemy. A nation's capability is strongly influenced by the number and quality of current and planned weapon system inventories. The quality factor is a function of the technological advantages; availability of facilities, equipment, and spares support; and the skills and flexibility of the workforce. As the capability comparison occurs for both short-term and long-range planning periods, a portion of

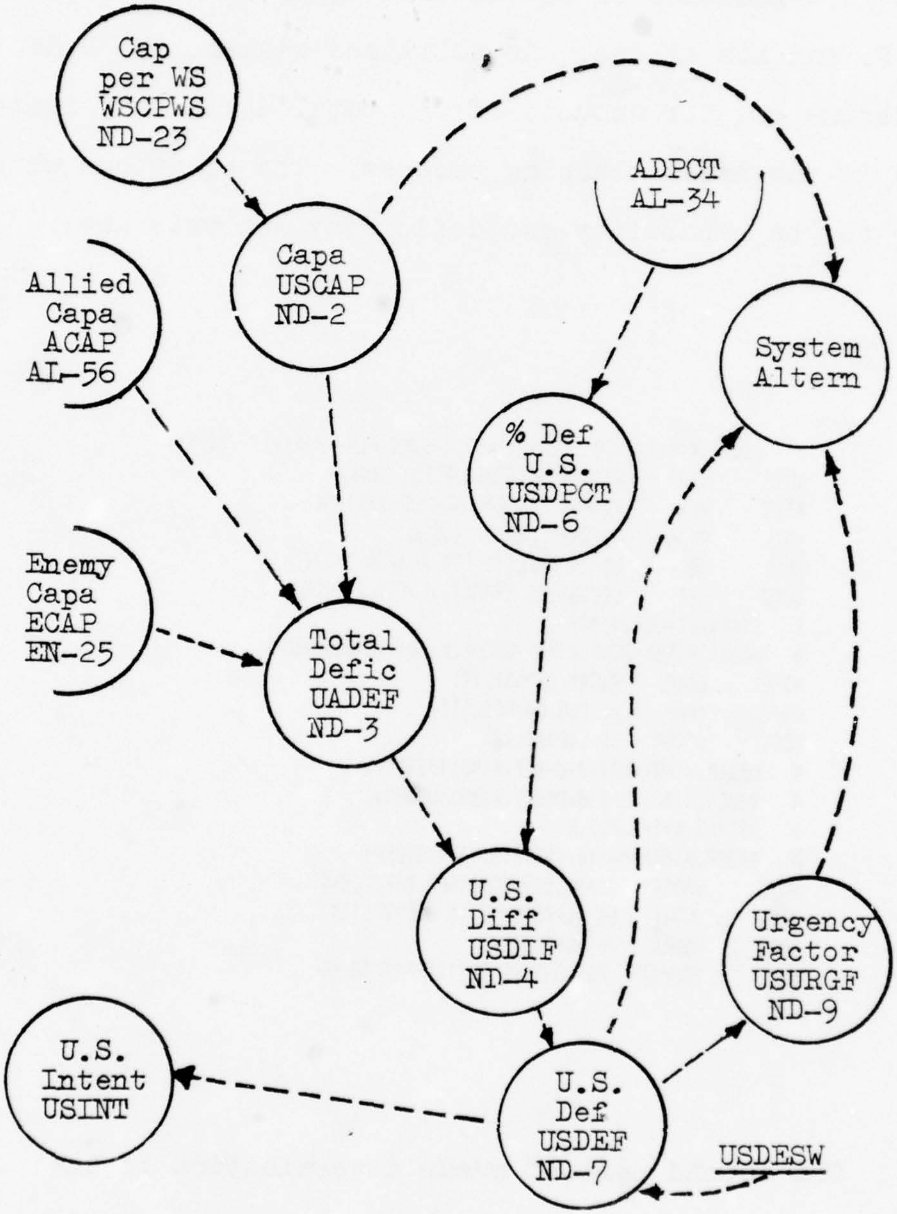


Figure 5-6

Need Sector--Mission Area Analysis

the total deficiency is allocated to the U.S. This allocation is a function of the international relations between the U.S. and its allies. As alliances weaken, the U.S. must assume greater amounts of the total deficiency identified in the needs planning process. The equations which relate to the capability and deficiency analysis are:

```
A   USCAP.K(MO)=(WSO.K+WSN.K+WSP.K+SUMV(PLAN.K(*),1,T(MO)))*
NOTE     WSO     WEAPON SYSTEMS OPERATIONAL
NOTE     WSN     WEAPON SYSTEMS NON-OPERATIONAL
NOTE     PLAN    PLANNED FORCE LEVELS
NOTE     USCPWS  US CAPABILITY PER WEAPON SYSTEM
NOTE     LEF     LOGISTICS EFFECTIVENESS FACTOR
X   USCPWS.K*LEF.K(MO)
A   UADEF.K(MO)=ECAP.K(MO)-USCAP.K(MO)-ACAP.K(MO)
NOTE     ECAP    ENEMY CAPABILITY
NOTE     ACAP    ALLIED CAPABILITY
NOTE     USCAP   US CAPABILITY
A   USDIF.K(MO)=MAX(Ø,UADEF.K(MO)*USDPCT.K)
A   USDEF.K(MO)=MAX(Ø,USDIF.K(MO)*USDESW)
A   USDPCT.K=1-ADPCT.K
A   USDEF.K(MO)=MAX(Ø,USDIF.K(MO)*USDESW)
NOTE     UADEF   US/ALLIED COMBINED DEFICIENCY
NOTE     USDIF   US DIFFERENCE IN CAPABILITY
NOTE     USDEF   US DEFICIENCY
NOTE     USDPCT   PERCENT OF DEFICIENCY TO US
```

The second part of needs determination is the evaluation of urgency relative to each mission requirement. Urgency is a function of the time until the deficiency will exist in the operational forces. If a short-term deficiency exists, the urgency of the requirement increases. The equations which relate to this concept are given below:

```
A    USURG.K=URGENCY(USDEF.K)
A    USURGF.K=TABLE(EWGT,USURG.K,0,120,10)
NOTE      USURG      US URGENCY--TIME IN MONTHS TIL FIRST DEFICIENCY
```

As deficiencies are identified, the process of evaluating system alternatives to resolve the imbalance in military capabilities begins. The decisional process is influenced by the magnitude, urgency, and the current capability which exists or is expected from procurement or development of additional system hardware. Four general categories are considered within the model. They are: increasing support for existing systems, modifying existing inventories, investing in additional weapons in production or development, and developing new weapon systems.

The evaluation considers the cost, schedule, and performance implications of each alternative. The flow diagram contained in Figure 5-7 represents this process, although the specific decisional variables are not explicitly depicted on the diagram. Each of the alternatives will be discussed as it relates to the decision process. The process involves a cost comparison of feasible alternatives. Alternatives are judged feasible if they meet

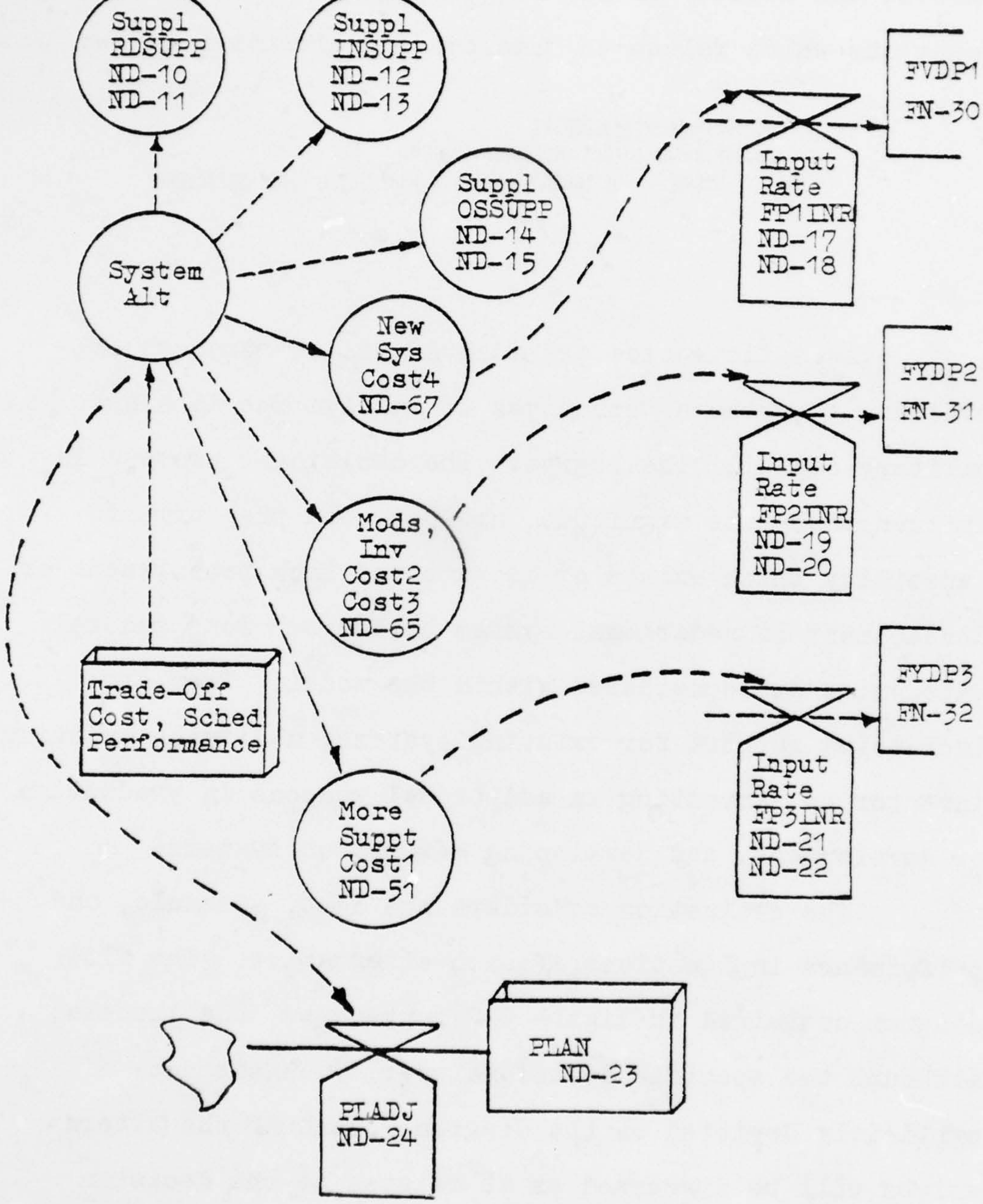


Figure 5-7

Need Sector--Force Planning

the desired performance level required to satisfy the deficiency within the appropriate timeframe. Costs relate to both explicit and implicit values associated with each system alternative. The explicit costs are tangible amounts associated with such elements as procurement or training. The implicit costs are much more difficult to evaluate. They result from the relative values that managers place on specific alternatives regarding risks, pay-off, or personal preference. These implicit costs can be represented by the adjustment of the constants in the model in order to change the relative differences between alternatives.

The alternative to increase support of existing systems considers the costs associated with raising support to achieve the desired capability. Information about current system operations is used as a basis for the decision. As the gap between current and desired capability widens or the capability goal exceeds 100 percent, this alternative becomes infeasible. In the model, the costs of increasing capability grows significantly when capability goals are high or beyond the physical ability of the system. For smaller increases in capability, the support option is considered the least expensive and most responsive means to meet deficiencies. The equations in the model are used to determine the costs associated with increasing the capability from the current rate, expressed as percent of systems operational to that percent required to satisfy the deficiency. The option is rejected if the number of weapons needed to fill the deficiency exceeds the number available. For example, if 100 operational systems were required and only 75 existed, this alternative would be rejected. The equations which relate to this are:

```
A    VALT1.K=SUM(USDEF.K)/(ORDM*USCPWS.K)
A    SCHF1.K=CLIP(Ø,1,SCHED1,USURGF.K)
A    COSTF1.K=CLIP(1,Ø,TFSL.K,COST1.K)
A    COST1.K=TABHL(CST1T,NEWORR.K,8.8,1.,.Ø2)
T    CST1T=1Ø/2Ø/3Ø/6Ø/1ØØ/3ØØ/55Ø/12ØØ/1E4/1.E6
A    NEWORR.K=MIN(1,DORR.K)
A    DORR.K=(VALT1.K+WSO.K)/(WSO.K+WSN.K)
A    DC1.K=COSTF1.K*SCHF1.K
NOTE      VALT1    VALUE OF ALTERNATIVE 1
NOTE      SCHF1    SCHEDULE FACTOR
NOTE      COSTF1   COST FACTOR
NOTE      COST1    COST OF ALTERNATIVE 1
NOTE      TFSL     TOTAL FORCE SYSTEMS LEVEL
NOTE      NEWOR    NEW OPERATIONAL READY(OR) RATE
NOTE      DORR     DESIRED OR RATE
NOTE      DC1      DECISION CONTROL OPTION #1
```

The modification alternative is reviewed in terms of the expected increase in both performance and life of the weapon system. Both of these effects add to the quality aspect of capability. The performance increase is set as a constant value in the model, however, this can be adjusted to show the effects of varying degrees of modification. The expected increase in performance is compared to the system deficiency to determine if the alternative is feasible. If the deficiency cannot be satisfied, the alternative is rejected. The cost and schedule factors for modification are computed for feasible solutions. The decision criterion becomes the costs related to the increased capability. This is used to compare to other alternatives. The equations applicable to the modification alternative are given below.

```
A    VALT2.K=USCPWS.K+MODK
A    SCHF2.K=CLIP(0,1,SCHED2,USURGF.K)
A    COSTF1.K=CLIP(1,0,TFSL.K,COST2.K)
A    MODC.K=TABLE(MODFT,MODK,0,100,10)
A    MODF.K=SWITCH(0,MODK,DC2.K)
A    NSYSM.K=MIN((WSO.K+WSN.K),SUM(USDEF.K)/VALT2.K)
A    COST2.K=TABHL(CST2T,NSYSM.K,0,1000,100)*MODC.K
A    DC2.K=COSTF2.K*SCHF2.K
T    CST2T=100/200/300/400/600/840/1100/1500/1640/1700/1750
T    MODFT=1/1/1/1/1.15/1.35/1.58/1.8/2.05/2.2/2.24
NOTE      VALT2   VALUE OF ALTERNATIVE 2
NOTE      SCHF2    SCHEDULE FACTOR
NOTE      COSTF2  COST FACTOR
NOTE      MODC    MODIFICATION COST FACTOR
NOTE      MODF    MODIFICATION FACTOR
NOTE      NSYSM   NUMBER OF SYSTEMS TO BE MODIFIED
NOTE      COST2   COST OF ALTERNATIVE 2
NOTE      DC2     DECISION CONTROL OPTION #2
NOTE      TFSL    TOTAL FORCE SYSTEMS LEVEL
```

The third alternative evaluates the costs required to produce more of the weapons already in production or in the inventory. Cost associated with this alternative consider the investments cost related to production, including production line preparation. If the production line is still in operation, costs relating to line preparation are minimal. For systems already out of production, costs are higher. The number of years since the last weapon was produced is evaluated to determine this cost. Costs and schedule factors are computed for the desired number of weapons needed to fill the deficiency, and these are compared to the other alternatives. The equations to find the cost of buying more weapon systems are given below.

```
A     SCHF3.K=CLIP(Ø,1,SCHED3,USURGF.K)
A     COSTF3.K=CLIP(1,Ø,TFSL.K,COST3.K)
A     VALT3.K=NEWCAP.K
A     NEWCAP.K=PPV3.K
A     DNOWS.K(MO)=USDEF.K(MO)/VALT3.K
A     D3.K=SCHF3.K*COSTF3.K
A     COST3.K=SUM(DNOWS.K)*USCOST.K*AGEM.K
A     AGEM.K=TABLE(AGFT,PLAGE.K,Ø,12Ø,12)
T     AGFT=1/1/1.1/1.3/1.6/1.8/1.99/2.1/2.18/2.22/2.25
NOTE       SCHF3    SCHEDULE FACTOR
NOTE       COSTF3   COST FACTOR
NOTE       VALT3    VALUE OF ALTERNATIVE 3
NOTE       NEWCAP   CAPABILITY OF NEW WEAPON SYSTEM PRODUCED
NOTE       DNOWS    DESIRED NUMBER OF OLD WEAPON SYSTEMS
NOTE       PPV3     PERCEIVED PRODUCT VALUE FROM PRODUCTION
NOTE       COST3    COST OF ALTERNATIVE 3
NOTE       USCOST   COST OF US WEAPON SYSTEM
NOTE       AGEM     PRODUCTION LINE AGE MULTIPLIER
NOTE       PLAGE    PRODUCTION LINE AGE
```

Finally, the new weapon system alternative considers those costs associated with developing and producing a totally new weapon system. The expected cost of this alternative includes many costs not applicable to the other alternatives. Therefore, the relative costs is considered to be higher to represent research and development expenses. Current policy indicates this alternative should be selected only when no other feasible alternative exists (33). In the research effort, it was noted that this is not always the case. This indicates that management normally places a low implicit cost on alternatives that lead to pursuit of new weapon systems and that the benefits are assumed to be large. The equations which determine the expected costs are given below.

```
A    SCHF4.K=CLIP(Ø,1,SCHED4,USURG.K)
A    COSTF4.K=CLIP(1,Ø,TFSL.K,COST4.K)
A    VALT4.K=1ØØ
A    DNNWS.K(MO)=USDEF.K(MO)/VALT4.K
A    D4.K=SCHF4.K*COSTF4.K
A    COST4.K=SUM(DNNWS.K)*PC1.K
NOTE    SCHF4    SCHEDULE FACTOR
NOTE    COSTF4   COST FACTOR
NOTE    VALT4    VALUE OF ALTERNATIVE 4
NOTE    DNNWS    DESIRED NUMBER OF NEW WEAPON SYSTEMS
NOTE    COST4    COST OF ALTERNATIVE 4
NOTE    PC1      PERCEIVED COST OF NEW WEAPON SYSTEM
NOTE    TFSL     TOTAL FORCE SYSTEMS LEVEL
```

Once the cost, schedule, and performance factors for each alternative are weighed, the alternative(s) required to meet the deficiency are selected. The decision criterion is least cost. Schedule is considered in the force planning part of needs determination. If urgent requirements are identified, supplemental funding requests may be required in order to counter the deficiency more rapidly than if the normal planning cycle were used. The requests for supplemental funds can be noted from the flow diagram contained in Figure 5-7. Other alternatives that are selected become part of the force plan. This plan contains the number of forces and funding amounts required for plan implementation. Inputs to the plan are made in the annual planning cycle. The equations which relate to the force plan are given below.

```
A    TFSL.K=SUM(FYDP3.K)/USCOST.K
R    FP1INR.KL(1)=SWITCH(Ø,CNRD.K,DC4.K)
R    FP1INR.KL(2)+FYDPRDC
R    RP1INR.KL(2)=FYDPC*RDC
R    FP2INR.KL(1)=SWITCH(Ø,COST4.K,WSD3.K)
R    FP2INR.KL(2)=SWITCH(Ø,COST3.K,DC3.K)
R    FP3INR.KL(1)=NWSP.K*COST.K
R    FP3INR.KL(2)=FYDP3.K(2)*OSC+COST1.K+COST2.K
NOTE    TFSL    TOTAL FORCE SYSTEMS LEVEL
NOTE     FP-INR  DOLLAR REQUEST INPUT TO FYDP
NOTE     COST-   COST OF ALTERNATIVE #-
```

```
NOTE     FYDP3   FIVE YEAR DEFENSE PLAN O&S REQUEST
A   RDSUPP.K(1)=SWITCH(0,RSUP1.K,RSUPAF.K(1))
A   RDSUPP.K(2)=SWITCH(0,RSUP2.K,RSUPAF.K(2))
A   INSUPP.K(1)=SWITCH(0,ISUP1.K,ISUPAF.K(1))
A   INSUPP.K(2)=SWITCH(0,ISUP2.K,ISUPAF.K(2))
A   OSSUPP.K(1)=SWITCH(0,OSUP1.K,OSUPAF.K(1))
A   OSSUPP.K(2)=SWITCH(0,OSUP2.K,OSUPAF.K(2))
A   RSUP1.K=CNRD.K*(1-SCHF4.K)*SUPF.K
A   RSUP2.K=0
A   ISUP1.K=COST4.K*(1-SCHF4.K)*SUPF.K
A   ISUP2.K=COST3.K*(1-SCHF3.K)*SUPF.K
A   OSUP1.K=NWSP.K*COST.K*(1-SCHF3.K)*SUPF.K
A   OSUP2.K=(COST1.K+COST2.K)*SUPF.K
A   SUPF.K=SWITCH(1,0,SCHF1.K+SCHF2.K+SCHF3.K+
X   SCHF4.K)
NOTE     RDSUPP   R&D SUPPLEMENTAL REQUEST
NOTE     INSUPP   INVESTMENT SUPLEMENTAL REQUEST
NOTE     OSSUPP   O&S SUPPLEMENTAL REQUEST
NOTE     RSUP     R&D SUPPLEMENTAL AMOUNT REQUESTED
NOTE     ISUP     AMOUNT OF INVESTMENT SUPLLEMENT
NOTE     OSUP     AMOUNT OF O&S SUPPLEMENT
NOTE     SUPF     SUPPLEMENT NECESSITY FACTOR
NOTE     RSUPAF    APPROVAL OF R&D SUPPLEMENT
NOTE     ISUPAF    APPROVAL OF INVESTMENT SUPPLEMENT
NOTE     OSUPAF    APPROVAL OF O&S SUPPLEMENT
```

The result of the system alternatives process establishes the plan used to acquire additional inventory, or maintain the systems already in the U.S. inventory. This is only the first part in the Planning, Programming, and Budgeting System (PPBS). The Financial Sector provides the continuation of this process and shows the transition from mission requirements to dollars required in specific appropriations.

Financial Sector

In this section, the model was developed to show the flow of funds and information which relates to funding decisions. Three categories of funds exist within the model: research and development, investment, and operating and support funding. Although these categories are not completely representative of the budget appropriations, they provide the degree of detail necessary to capture the behavior of the system. Within each funding category, two levels exist. The first level applies to one specific weapon system under review. The second level applies to all other systems which compete for funding within the particular funding category. Equations which are similar to other levels of funding categories will only be discussed once using the Research and Development dollar flow as the example.

The first group of equations correspond to the flow diagram contained in Figure 5-8.

```
L    FYDP1.K(IB)=FYDP1.J(IB)+DT*(FP1INR.JK(IB)-FP1OR.JK(IB))
R    FP1OR.KL(IB)=RDRQT.K(IB)
NOTE      FYDP1    R&D EXPENDITURES PLANNED IN THE FYDP
NOTE      FP1INR   R&D COSTS INPUT TO THE FYDP
NOTE      FP1OR    R&D COSTS FUNDED FROM THE FYDP
NOTE      RDRQT    R&D FUNDS REQUIREMENT
L    RDRB.K(IB)=RDRB.J(IB)+DT*(RDMDR.JK(IB)-RREDR.JK(IB))
R    RDMDR.KL(IB)=RDRQT.K(IB)
R    RREDR.KL(IB)=RDAR.JK(IB)
NOTE      RDRB     R&D DOLLARS REQUESTED IN THE BUDGET
NOTE      RDMDR    R&D DEMAND RATE
NOTE      RREDR    R&D DEMAND REDUCTION RATE
NOTE      RDRQT    R&D FUNDS REQUIREMENT
NOTE      RDAR     R&D ALLOCATION RATE
```

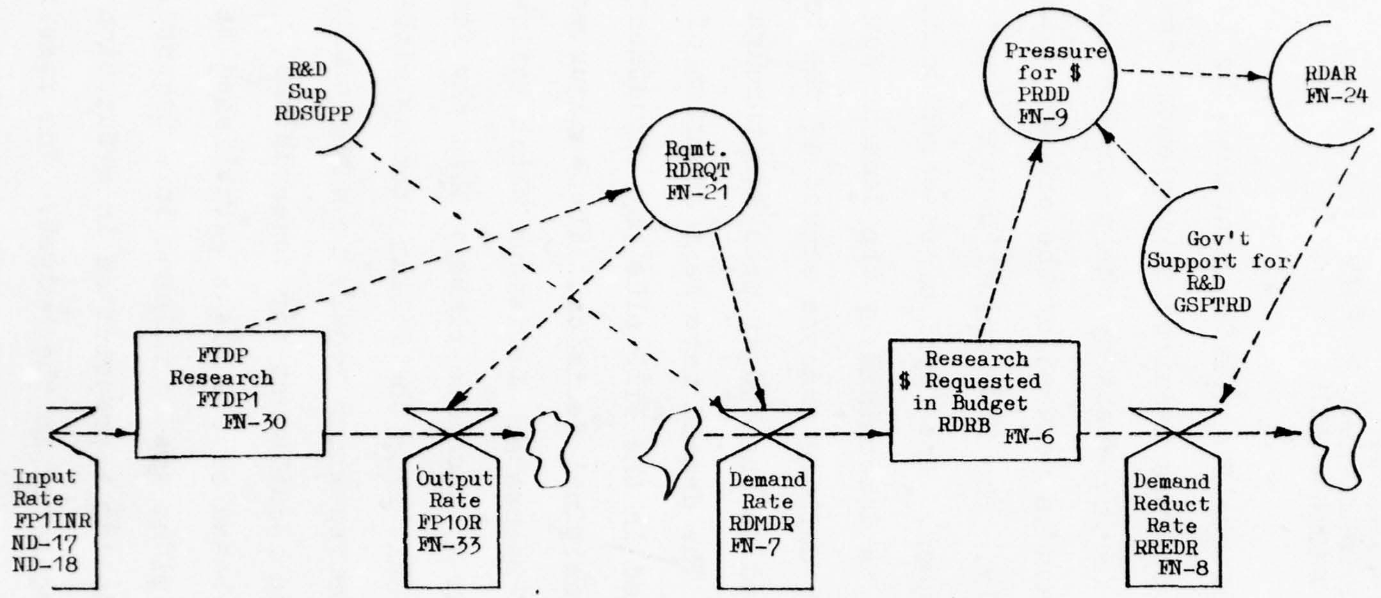


Figure 5-8

Financial Sector--Programming and Budgeting

```
A    RDRQT.K(IB)=FYDP1.K(IB)*PULSE(1,11,12)+RDSUPP.K(IB)
NOTE      RDRQT    R&D FUNDS REQUIREMENT
NOTE      FYDP1    R&D EXPENDITURES PLANNED IN THE FYDP
NOTE      RDSUPP   R&D SUPPLEMENTAL REQUEST
```

The Five Year Defense Plan (FYDP) contains the level of forces and estimated dollars required to implement the force plan. This level is increased by the plans that are created in the process and is reduced by the process which updates the FYDP annually. The FYDP requirements become the input to the budget request. The level of research dollars requested in the budget is determined by the demands for research and development dollars and the amount of the total demand which is satisfied as the budget proceeds through the various review levels. The demand rate is a function of both the amount contained in the FYDP plus any adjustments made to supplement the original decision. These adjustments are called supplemental requests. Decisions which influence the budget request occur at specific times within the fiscal year. The decisions result from the dollar amounts within each level and the pressures which result from the changing system environment. The requirement for research and development dollars is based on the plans established in the FYDP. Annually, these plans are formulated in a request. Similarly, the actual dollar appropriation is a function of the level of funding requested in the budget. For research and development, the equations which determine the amount and result of pressure for a specific appropriation are given below:

```
A    PRDD.K(IB)=GSPTRD.K(IB)+RDRB.K(IB)
NOTE      PRDD     PRESSURE FOR R&D DOLLARS
NOTE      GSPTRD   GOVERNMENT SUPPORT FOR R&D
NOTE      RDRB     R&D DOLLARS REQUESTED IN THE BUDGET
R    RDAR.KL(IB)=PRDD.K(IB)*PULSE(1,10,12)
NOTE      RDAR     R&D APPROPRIATION RATE
NOTE      PRDD     PRESSURE FOR R&D DOLLARS
```

The actual appropriation of dollars contained in the budget depends on the pressure for research and development dollars (PRDD). This pressure results from both the magnitude of the budget request as well as from government support for research and development programs.

The system structures for investment and operating and support funding are identical to the structure for research and development. The flow diagrams and the systems equations which apply to these funding categories are contained in Appendix C.

In addition to the discussion of the separate funding categories, the equations which apply to the total DOD budget (DDRB) follow.

```
L    DDRB.K(IB)=DDRB.J(IB)+DT*(DDMDR.JK(IB)-DREDR.JK(IB))
R    DDMDR.KL(IB)=RDRQT.K(IB)+IRQT.K(IB)+ORQT.K(IB)
R    DREDR.KL(IB)=RDAR.JK(IB)+IDAR.JK(IB)+OSDAR.JK(IB)
NOTE      DDRB     DEFENSE DOLLARS REQUESTED IN THE BUDGET
NOTE      DDMDR    DEFENSE DEMAND RATE
NOTE      DREDR    DEFENSE DEMAND REDUCTION RATE
```

```
NOTE     RDRQT   R&D FUNDS REQUIREMENT
NOTE     ORQT    O&S FUNDS REQUIREMENT
NOTE     IRQT    INVESTMENT FUNDS REQUIREMENT
NOTE     RDAR    R&D APPROPRIATION RATE
NOTE     IDAR    INVESTMENT APPROPRIATION RATE
NOTE     OSDAR   O&S APPROPRIATION RATE
```

The DOD budget (Figure 5-9) is the sum of the dollars requested for the three funding categories. The information about the DOD budget is used in the political sector to determine the characteristics of the Federal budget. Decisions are made annually according to the fiscal year cycles established by law.

The appropriation and expenditure of research dollars is depicted in the flow diagram contained in Figure 5-10. In this section of the financial sector, some of the equations differ between the two levels within the funding categories. Whenever possible, variables which apply to the first level were placed on the upper portion of the flow diagram and equations for the second level were placed on the lower portion of the diagram. The model assumes that transfers between these two levels are possible; however, no provision for transfers between funding categories is developed in the equation system. Transfers of funds between appropriation categories is not a common practice in the real system. The first group of equations are:

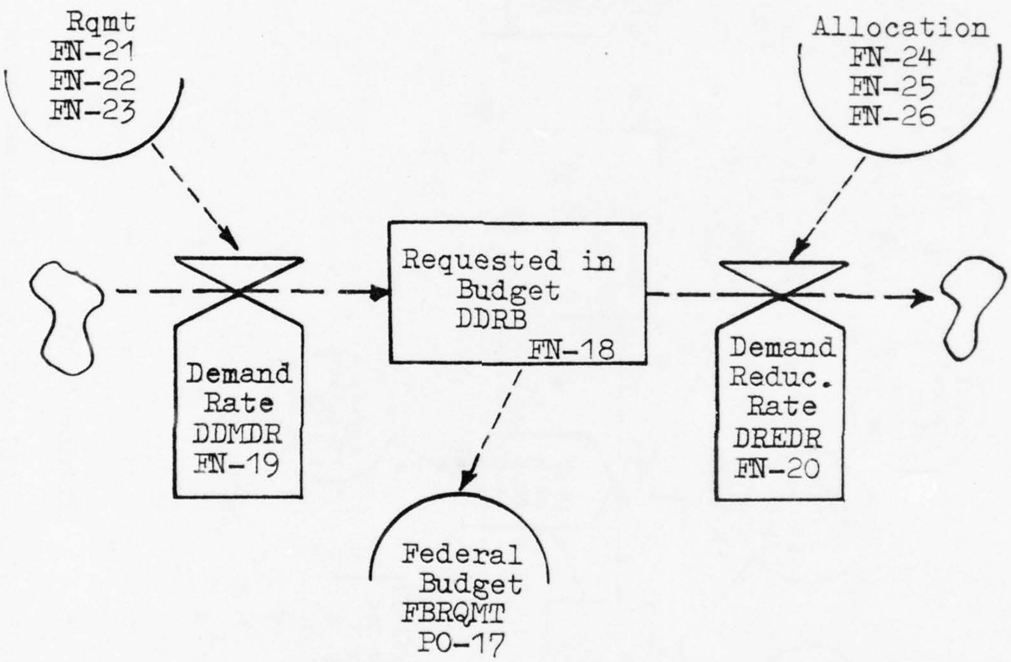


Figure 5-9

Financial Sector--DOD Budget

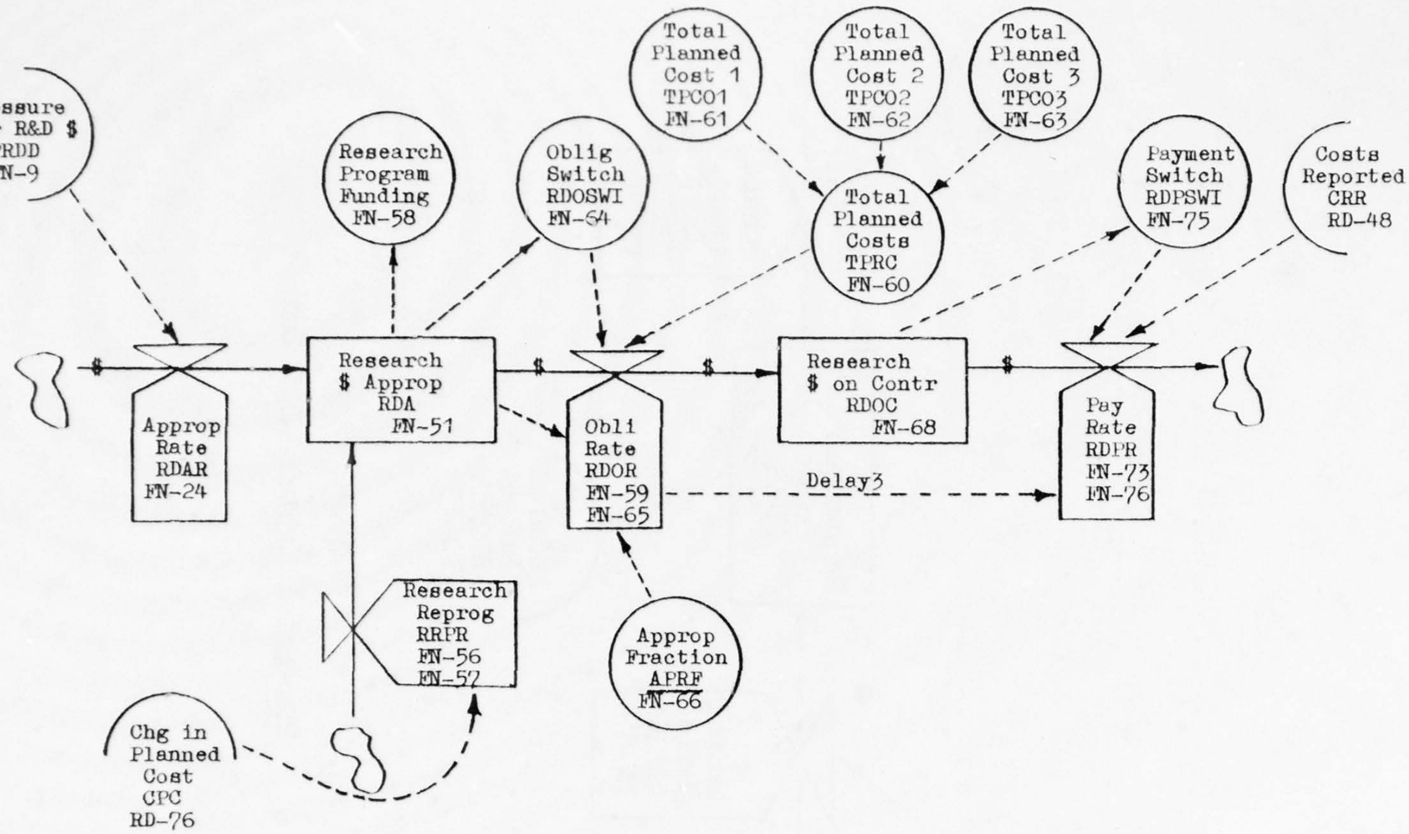


Figure 5-10

Financial Sector--Allocation and Expenditure

```
L    RDA.K(P)=RDA.J(P)+DT*(RDAR.JK(P)-RDOR.JK(P)+RRPR.JK(P))
R    RRPR.KL(1)=CPC1.K+CPC2.K+CPC3.K
R    RRPR.KL(2)=-(CPC1.K+CPC2.K+CPC3.K)
R    RDOR.KL(1)=TPRC.K*RDOSWI.K(1)
R    RDOR.KL(2)=(RDA.K(2)*APRF.K)*RDOSWI.K(2)
NOTE      RDA      RESEARCH DOLLARS APPROPRIATED
NOTE      RDAR     R&D APPROPRIATION RATE
NOTE      RDOR     RESEARCH DOLLARS OBLIGATION RATE
NOTE      RRPR     RESEARCH REPROGRAMMING RATE
NOTE      TPRC     TOTAL PLANNED RESEARCH COSTS
NOTE      CPC      CHANGE IN PLANNED COSTS
NOTE      RDOSWI   RESEARCH DOLLARS OBLIGATION SWITCH
```

The level of research dollars available for DOD spending is based on the amount of research dollars appropriated annually, the rate research dollars are obligated, and the rate that research dollars are reprogrammed from other programs. As weapon system plans are developed, the estimated dollars required to implement the plan are obligated on a contract. These dollars are obligated at the time that the contract is signed. The obligation rate has a switch to ensure that obligations do not exceed the total research dollars appropriated for a given program or level. For the second level, a less detailed approach was used to develop system equations. The obligation rate is based on desires to spread spending throughout the year. An appropriation fraction is used to determine the amount of time remaining in the year in order to provide stable spending patterns as the fiscal year proceeds. Reprogramming of research dollars involves transferring funds from one account to another. In this model, level two dollars are transferred to level one if the decision is made to approve a change in planned costs for one of the research and development phases. Several self-explanatory auxiliary equations apply to the previous equation set. They are:

```
A    RPF.K=SWITCH(Ø,1,RDA.K(1))
A    RDOSWI.K(P)=SWITCH(Ø,1,RDA.K(P))
NOTE      RPF      RESEARCH PROGRAM FUNDING
NOTE      RDA      RESEARCH DOLLARS APPROPRIATED
NOTE      RDOSWI   RESEARCH DOLLARS OBLIGATION SWITCH
A    APRF.K=TABLE(APRFT,FYTIME.K,1,12,1)
T    APRFT=1.Ø/.5/.33/.25/.2/.167/.143/.125/.111/.1/.Ø91/.Ø83
A    TPRC.K=TPCO1.K+TPCO2.K+TPCO3.K
A    TPCO1.K=(TPC1.K*WSD1.K*DSWI1.K)+CPC1.K
A    TPCO2.K=TPC2.K*WSD2.K*DSWI2.K+CPC2.K
A    TPCO3.K=TPC3.K*WSD3.K*DSWI3.K+CPC3.K
NOTE      TPRC     TOTAL PLANNED RESEARCH COSTS
NOTE      TPCO     TOTAL PLANNED COSTS OBLIGATED(BY PHASE)
NOTE      WSD      WEAPON SYSTEM DEVELOPMENT DECISION
NOTE      DSWI     DOLLAR SWITCH(BY PHASE)
NOTE      CPC      CHANGE IN PLANNED COSTS
NOTE      FYTIME   TIME IN FISCAL YEAR
```

Work on research and development programs cannot begin without funding and a signed contract. A switch function is used to note the availability of funds. If funds are exhausted, work must stop until additional funding is obtained or the program is cancelled. To ensure that funds are not over obligated, continual monitoring of funding status occurs. Funds are obligated as total planned costs are determined and placed on research and development contracts. Costs are developed from the original estimates of planned costs and any changes which are approved. The dollar switch and weapon system decision switch ensure that the total planned costs are obligated only once—on the first day of a research and development phase.

The second section of equations focuses on the level of research dollars on contract (RDOC).

```
L    RDOC.K(P)=RDOC.J(P)+DT*(RDOR.JK(P)-RDPR.JK(P))
R    RDPR.KL(1)=RDPSWI.K(1)*(DELAY3(CRR1.JK,RDPRD)+DELAY3(CRR2.JK,
X    RDPRD)+DELAY3(CRR3.JK,RDPRD))
R    RDPR.KL(2)=DELAY3(RDOR.JK(2),RDPRD)
NOTE      RDOC     RESEARCH DOLLARS ON CONTRACT
NOTE      RDOR     RESEARCH DOLLARS OBLIGATION RATE
NOTE      RDPR     RESEARCH DOLLARS PAYMENT RATE
NOTE      RDPSWI   RESEARCH DOLLAR PAYMENT SWITCH
NOTE      CRR      COST REPORTING RATE(BY PHASE)
NOTE      RDPRD    RESEARCH DOLLARS PAYMENT RATE DELAY
A    RDPSWI.K(P)=SWITCH(Ø,1,RDOC.K(P))
NOTE      RDPSWI   RESEARCH DOLLARS PAYMENT SWITCH
NOTE      RDOC     RESEARCH DOLLARS ON CONTRACT
```

The level of dollars on contract is increased by obligations that result from signing or amending contracts. The level is reduced as payments are made for contractual work. These payments are normally made as progress towards the final product is achieved. As costs are reported from the work accomplished in a research and development project, progress payments are paid to the contractor. The payment rate for level-two contracts is simply expressed as a delay function representing the average time necessary to complete work related to a research and development contract. A payment switch ensures that payments do not exceed the amount of dollars on contract. Contract amendments are required if cost expenditures exceed the amount of dollars obligated to the contract.

The flow diagrams and equation set for investment funds is very similar to research and development funding. The difference is that only the production sector provides the input concerning costs. The flow diagram and the system equations are contained in Appendix C.

The operating and support funds structure is also similar to the other funding categories. However, several differences were included in the model because there is less visibility and control over costs in this area. This allows for more flexibility to transfer funds between levels by means of reallocation rather than by reprogramming. Reallocation does not require such extensive a review and approval cycle, therefore, more flexibility exists. Operating and support funds are reallocated based on the decision to transfer monies between two or more programs. This decision is based on the magnitude of the requirement, the dollar availability from other programs, and the mission area importance related to the funding reallocation request. The result of this decisional process determines the percent of dollars that will be reallocated.

Strategic-level managers have little visibility and control over costs directly related to operation and support of specific weapon system programs. Their primary information is presented in aggregate form rather than by system. At this level, the objective is to provide support throughout the year by ensuring that spending is fairly stable. When problems occur in one program, first the monies allocated to that specific program are expended, accelerating demands for funds. After the assigned source of funds is exhausted, reallocation from other programs may occur.

The flow of funds directly affects the activities that DOD can pursue. In the acquisition process one of the first set of costs is related to the search for technology in order to maintain the technology base and meet specific goals resulting from needs.

Technology Sector

The Technology Sector flow diagram depicted in Figure 5-11 shows the flow of technology through the system. The level of technology is measured in terms of the present technology base. Using an index of one hundred as a reference point, the level increases or decreases as the system moves through time. The following equations and discussion describe the system flow of technology.

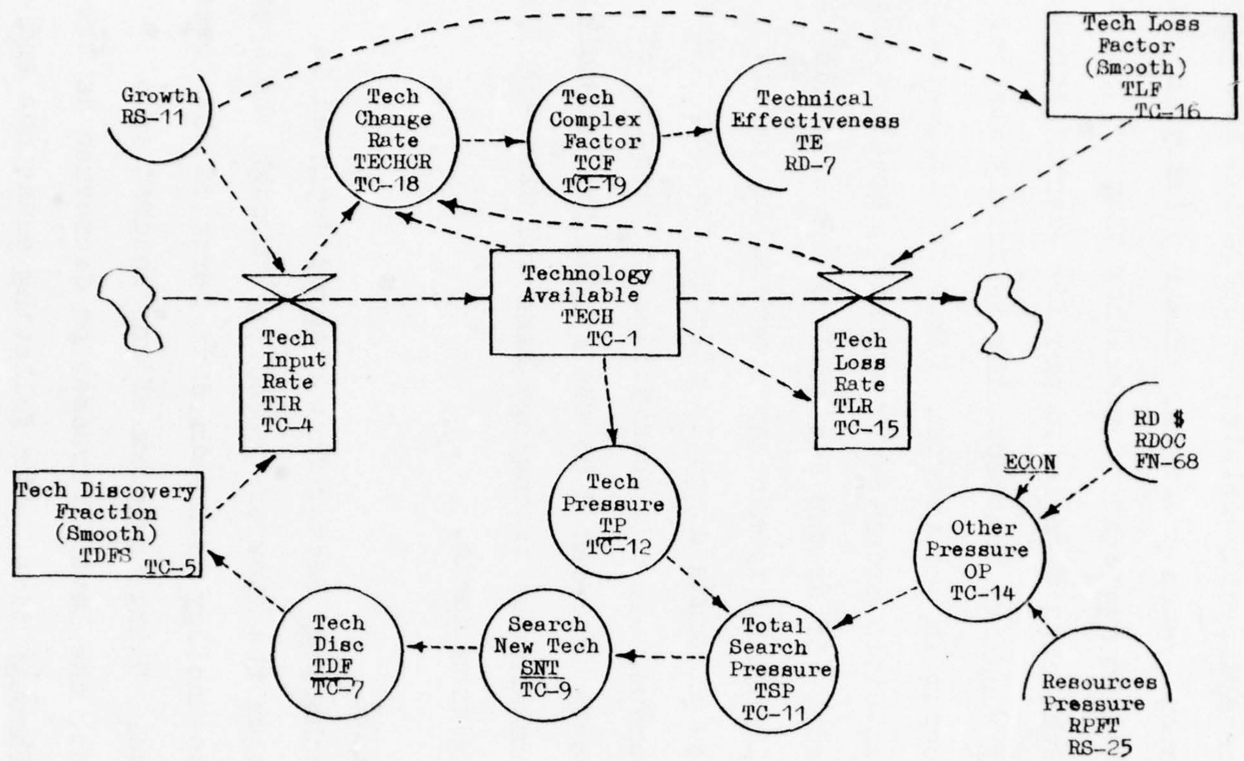


Figure 5-11

Technology Sector

```
L   TECH.K=TECH.J+DT*(TIR.JK-TLR.JK)
R   TIR.KL=TECH.K*(GROWTH.K+TDFS.K)
R   TLR.K=SMOOTH(GROWTH.K,TLFD)
NOTE    TECH    TECHNOLOGY AVAILABLE
NOTE    TIR     TECHNOLOGY INPUT RATE
NOTE    TLR     TECHNOLOGY LOSS RATE
NOTE    GROWTH  GROWTH FACTOR
NOTE    TDFS    TECHNOLOGY DISCOVERY FRACTION(SMOOTHED)
```

The level of available technology (TECH) is increased by the inputs to technology from research and development and industrial growth throughout the world, as well as by specific pressure to meet technology goals set by DOD. Technology is lost as time passes and technology becomes obsolete. As the rate of input to technology increases, the aging process also accelerates. This is due to the accumulation of many new technologies which replace or overshadow previous technological achievements.

The second set of equations pertains to the pressures to increase the rate of new technological discoveries. The equations are:

```
A   TDFS.K=SMOOTH(TDF.K,TDFD)
A   TDF.K=TABHL(TDFT,SNT.K,0,1,.2)/12
T   TDFT=.01/.03/.07/.1/.12/.13
NOTE    TDFS    TECHNOLOGY DISCOVERY FRACTION(SMOOTHED)
NOTE    TDF     TECHNOLOGY DISCOVERY FRACTION
NOTE    SNT     SEARCH FOR NEW TECHNOLOGY
NOTE    TDFD    TECHNOLOGY DISCOVERY FRACTION DELAY
A   SNT.K=TABHL(SNTT,TSP.K,0,.15,.03)
T   SNTT=.1/.15/.32/.52.80/1.0
A   TSP.K=TP.K+OP.K
A   TP.K=TABHL(TPT,TECH.K,0,100,10)
T   TPT=1/1/.8/.5/.27/.1
```

```
A    OP.K=SUM(RDOC.K)/ECON*RPFT.K
NOTE      SNT      SEARCH FOR NEW TECHNOLOGY
NOTE      TSP      TOTAL SEARCH PRESSURE
NOTE      TP       TECHNOLOGY PRESSURE
NOTE      OP       OTHER PRESSURE
NOTE      TECH     TECHNOLOGY AVAILABLE
NOTE      RDOC     RESEARCH DOLLARS ON CONTRACT
NOTE      ECON     ECONOMIC BASELINE FACTOR
NOTE      RPFT     RESOURCES PRESSURE FOR TECHNOLOGY
```

As a result of pressures, new technologies are discovered. These discoveries gradually become apparent to the system as the technology is applied. The percent of increase is based on the pressures to search for new technology. These pressures result from general efforts to maintain or increase technology, based on the existing level of technology. Other pressures for technology result from specific efforts within DOD. The amount of research and development dollars on contract is used to measure the relative pressures by DOD for technology. In addition to this pressure, the level of resources also places a demand for technology as raw materials become scarce. As the pressure to search for new technology increases, the rate of discovery also increases. This increase occurs at a decreasing rate of growth as the limit approaches.

The final equation set for the technology sector includes:

```
A    TECHCR.K=(TIR.JK-TLR.JK)/TECH.K
A    TCF.K=TABHL(TCFT,TECHCR.K,0,.2,.02)
T    TCFT=2.0/1.95/1.85/1.7/1.45/1.0/.67/.5/.35/.3/.25
NOTE     TECHCR  TECHNOLOGY CHANGE RATE
NOTE     TCF     TECHNICAL COMPLEXITY FACTOR
NOTE     TIR     TECHNOLOGY INPUT RATE
NOTE     TLR     TECHNOLOGY LOSS RATE
NOTE     TECH    TECHNOLOGY AVAILABLE
```

The rate and magnitude of the changes in technology indicate the technological advancement which is perceived. Within DOD, the goal to reach out for state-of-the-art technology is affected by this technological advancement. If the rate of change is rapid, the expected technical problems should be lower than if the same technology goals were established and the rate of technological advancement were slower. The technical complexity attributed to DOD acquisitions is a function of the rate of technology change. The technical complexities which exist have a direct impact on the amount of real progress in both research and development and production efforts.

Research and Development Sector

The research and development sector is divided into three similar parts to represent the research and development phases established for major weapon systems acquisitions. These phases include: Conceptual Effort, Validation, and Full-Scale Development. Due to the similarities in model structure, only one phase will be used as an example.

The flow diagrams and equation presentation will discuss the flow of information, progress, and cost reporting through a research and development phase. The first part of this section will focus on the flow of progress and the corresponding information loops applicable to managing a research and development effort. The flow diagram depicted in Figure 5-12 and the following equations provide the basis for starting a research and development phase.

```
L    PP1.K=PP1.J+DT*(PPGM1.JK-PPTX1.JK)
R    PPGM1.KL=TABLE(PGM1T,PSCHD1.K,Ø,1,.Ø833)*WSD1.K*DCP1.K
X    *12/TICP.K
A    PSCHD1.K=TSMSØ.K/TICP.K
NOTE      PP1      PLANNED PROGRESS
NOTE      PPGM1    PLANNED PROGRESS RATE
NOTE      PPTX1    PLANNED PROGRESS TRANSFER RATE
NOTE      WSD      WEAPON SYSTEM DEVELOPMENT DECISION
NOTE      DCP      DECISION COORDINATING POINT
NOTE      TICP     TIME IN CONCEPTUAL PHASE
NOTE      PSCHD1   PLANNED SCHEDULE
NOTE      TSMSØ    TIME SINCE MILESTONE Ø
```

The plan for progress is determined by the estimated work effort required to accomplish research and development. This plan is measured by man months. The total estimated man months required is assumed to be given. The progress rate can then be expressed in terms of the percent of the total project which is completed each month. The progress rate relates to the monthly work schedules which are established. Using a typical program buildup, the graph in Figure 5-13 was used to represent the planned work

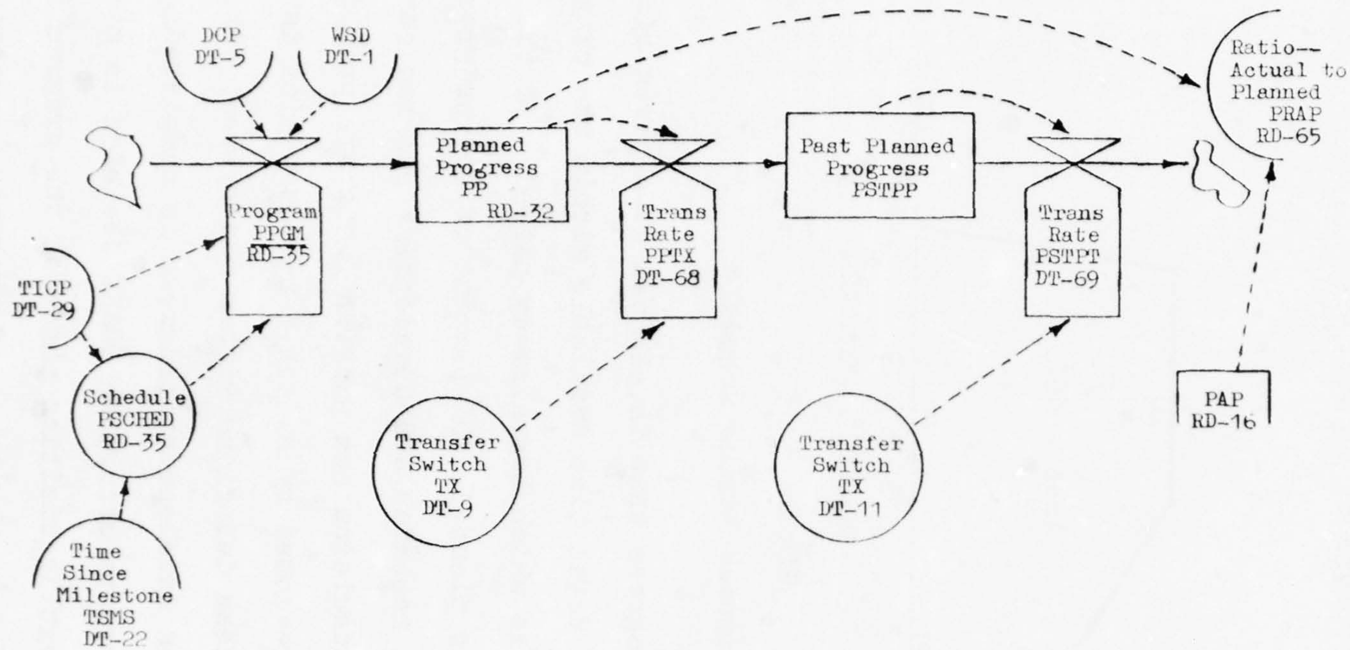


Figure 5-12

Weapon System Development--Planned Progress schedule which was programmed for the various times throughout a research and development effort.

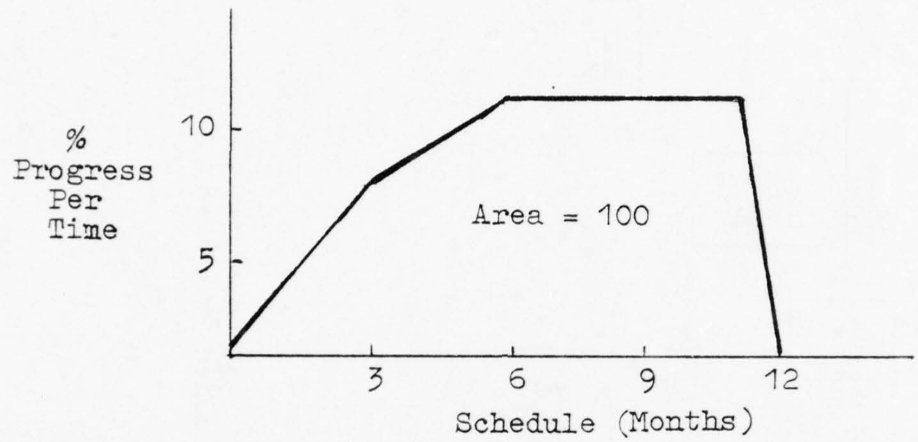


Figure 5-13

Progress Versus Schedule

The percentage of progress that is planned at a given time is a function of the total time available within the program and the amount of time which has already passed. If the program progresses as planned, 100 percent of the progress goal is achieved. A research and development program cannot begin until a DSARC decision and program funds are provided. This concept is represented by switch functions which determine the state of these decisions within the system. The plan for research and development progress is completed when either of two events occur: a DSARC decision is made to proceed to the next acquisition phase or the program is cancelled. At this time, the level of progress is emptied.

In many cases, the actual progress made on a research and development program is not the same as the planned progress. This is due to the uncertainties that characterize the research and development task. The following equations pertain to actual progress:

```
L    AP1.K=AP1.J+DT*(APR1.JK-APTR1.JK)
R    APR1.KL=TE1.K*PGM1.K*CAPRS1.K
A    TE1.K=TCF.K*ME1
NOTE      AP1      ACTUAL PROGRESS
NOTE      APR1     ACTUAL PROGRESS RATE
NOTE      APTR1    ACTUAL PROGRESS TRANSFER RATE
NOTE      TE1      TECHNICAL EFFECTIVENESS
NOTE      PGM1     PROGRAM
NOTE      CAPRS1   CHANGE IN ACTUAL PROGRESS RATE
NOTE      TCF      TECHNICAL COMPLEXITY FACTOR
NOTE      ME1      MANAGEMENT EFFECTIVENESS FACTOR
A    PGM1.K=TABHL(PGM1T,SCHED1.K,Ø,1,.Ø833)*WSD1.K*DCP1.K*
X    12/(TTMS1.K+TSMSØ.K)
T    PGM1T=Ø/3/6/7.5/9/9.67/1Ø.33/11/11/11/11/11
T    PGM1T=Ø/3/6/7.5/9/9.67/1Ø.33/11/11/11/11/11/Ø
A    SCHED1.K=TSMSØ.K/(TSMSØ.K+TTMS1.K)
A    CAPRS1.K=SMOOTH(CAPR1.K,CAPRD)
NOTE      PGM1     PROGRAM
NOTE      SCHED1   SCHEDULE
NOTE      WSD1     WEAPON SYSTEM DEVELOPMENT DECISION
NOTE      DCP1     DECISION COORDINATING POINT
NOTE      TTMS1    TIME TO MILESTONE 1
NOTE      TSMSØ    TIME SINCE MILESTONE Ø
NOTE      CAPRS1   CHANGE IN ACTUAL PROGRESS RATE(SMOOTHED)
NOTE      CAPRD    CHANGE IN ACTUAL PROGRESS SMOOTHING CONSTANT
```

The level of actual progress (Figure 5-14) is determined by the programmed rate of progress, adjusted by the degree of technical effectiveness within the research and development program and the changes which result from evaluations of the work effort. The level of progress is accumulated throughout the research and development phase until a DSARC decision is made to proceed to the next phase or to cancel

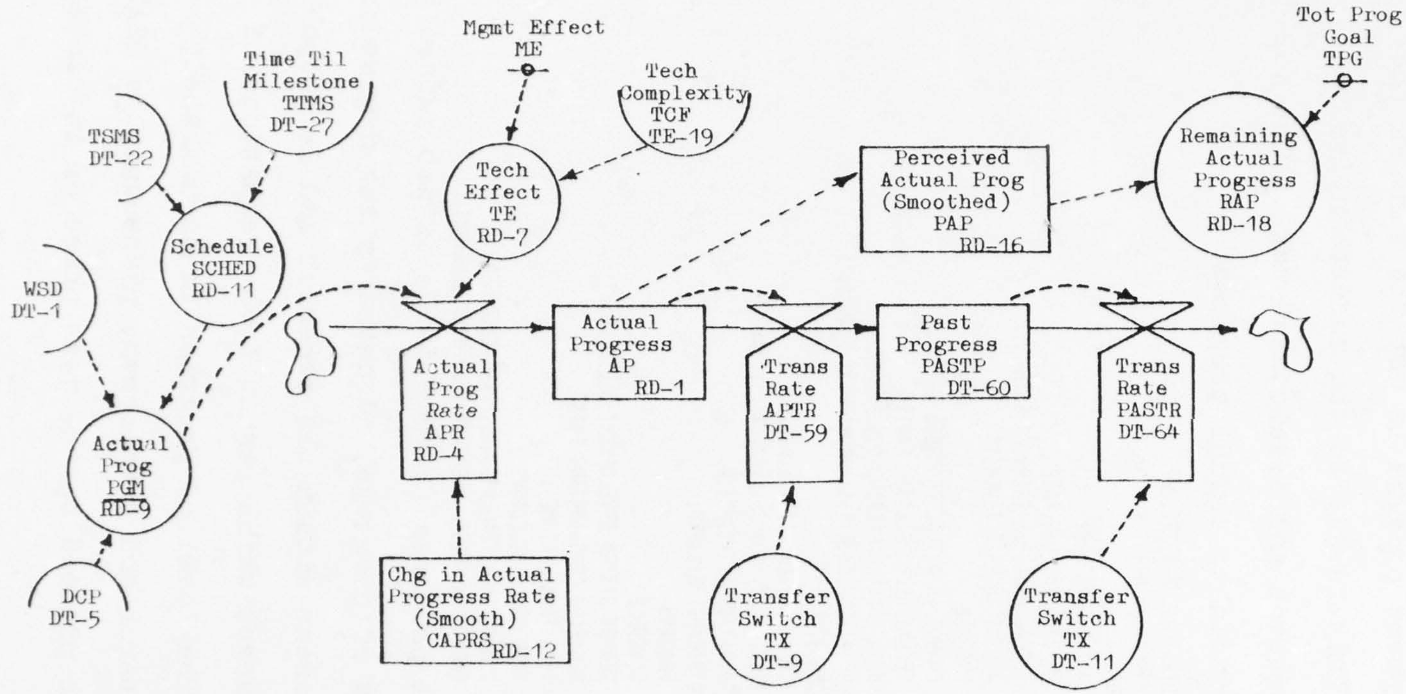


Figure 5-14

Weapon System Development--Actual Progress the program. At this time, the progress is removed from its current level and added to the historical records of research and development programs. This is similar to the activity which occurs for the planning aspects of research and development. The programmed rate of progress is based on the original schedule established in the plan and any adjustments which have been approved to change the schedule. The difference between actual and planned progress is caused by two general factors. First, technical effectiveness measures the degree that the contractor is successful in dealing with the technical challenges which exist in research and development. This is based on the technical complexity associated with the program and the research and development management expertise within the firm. The second determinant of the actual progress rate is the change which results from the evaluation of progress. The change in actual progress is adjusted gradually to avoid wide fluctuations in the progress rate which may cause excessive overtime, hiring, or layoffs of personnel. The evaluation which results in the change in actual progress begins with a determination evaluation of the perceived actual progress. The equations below explain the concept.

```
A    PAP1.K=SMOOTH(AP1.K,APD)
A    RAP1.K=TPG-PAP1.K
NOTE      PAP1     PERCEIVED ACTUAL PROGRESS
NOTE      AP1      ACTUAL PROGRESS
NOTE      APD      ACTUAL PROGRESS DELAY
NOTE      RAP1     REMAINING ACTUAL PROGRESS
NOTE      TPG      TOTAL PROGRESS GOAL
```

The perception of actual progress (PAP) reflects the fact that managers do not have the ability or the information to make instantaneous evaluations of the situation. This results in a delay, causing decisions to be made on the perceived rather than the actual situation. The evaluation begins with a comparison of the perceived actual progress and the total progress goal. This comparison determines the amount of progress that remains. From this information, the manager begins to assess the situation to determine the best way to adjust the work effort to create minimum disruption in both planned progress schedules and planned cost. This decision is represented in the following equations which determine the relative penalties which exist in altering the performance (progress), schedule, and cost aspects of the research and development effort. These equations correspond to the flow diagram contained in Figure 5-15.

```
A    PRR1.K(I)=RAP1.K/RTTMS1.K(I)
A    RTTMS1.K(I)=TTMS1.K+T(I)
A    CP1.K(I)=CF1.K(I)*RTTMS1.K(I)
A    CF1.K(I)=TABHL(CFT,PRR1.K(I),.6,1.6,.1)
T    CFT=1.15/1.Ø6/1.Ø2/1.Ø1/1/1.1/1.25/1.32/1.62/2/3
```

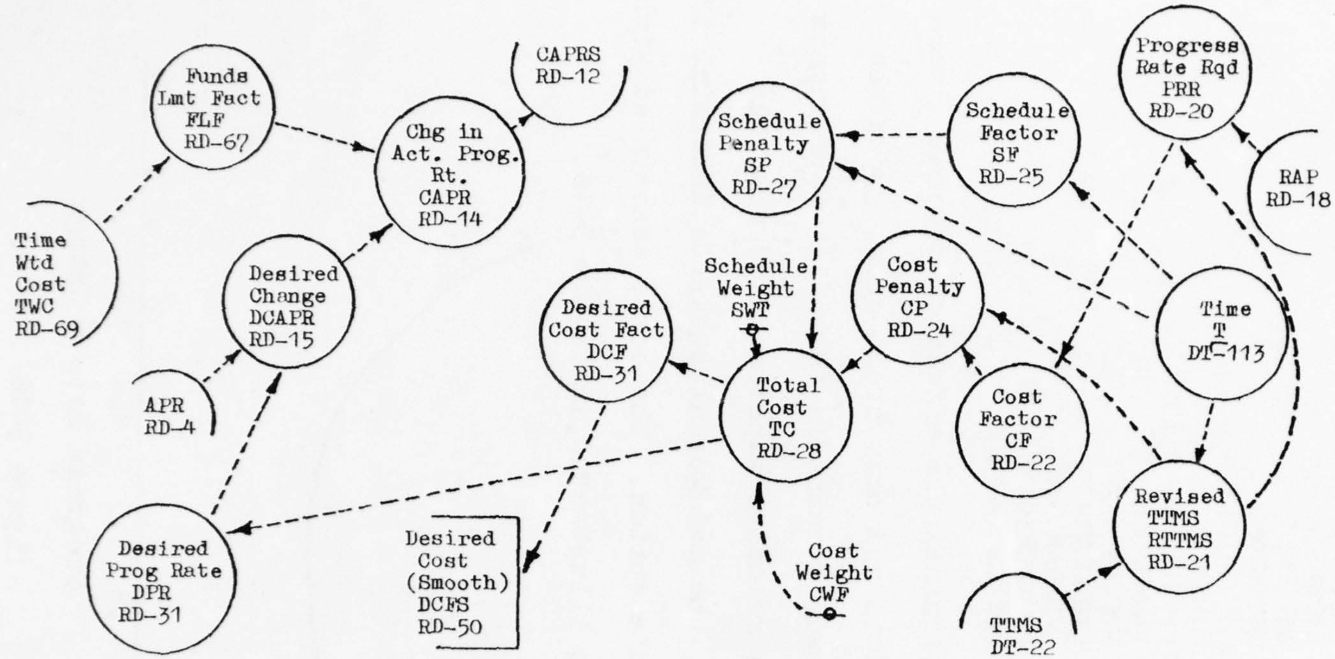


Figure 5-15

Weapon System Development--Cost and Schedule Tradeoff

```
NOTE     PRR1     PROGRESS RATE REQUIRED
NOTE     RAP1     REMAINING ACTUAL PROGRESS
NOTE     RTTMS1   REVISED TIME TO MILESTONE 1
NOTE     TTMS1    TIME TO MILESTONE 1
NOTE     T        TIME LATE
NOTE     CP1      COST PENALTY
NOTE     CF1      COST FACTOR
A    SF1.K(I)=TABHL(SFT,T(I),1,10,1)
A    SP1.K(I)=SF1.K(I)*T(I)
A    TC1.K(I)=(CWF*CP1.K(I))+(SWF*SP1.K(I))
NOTE     SF1      SCHEDULE FACTOR
NOTE     T        TIME LATE
NOTE     SP1      SCHEDULE PENALTY
NOTE     TC1      TOTAL PENALTY COST
NOTE     SWF      SCHEDULE WEIGHTING FACTOR
NOTE     CWF      COST WEIGHTING FACTOR
```

Management first determines the effect of several alternative sets of schedule and cost trade-offs, given the progress rate required to maintain technical performance goals. Based on the relative importance of cost and schedule deviations, the management seeks to determine the best cost and schedule option. The costs associated with these trade-offs are illustrated in Figure 5-16.

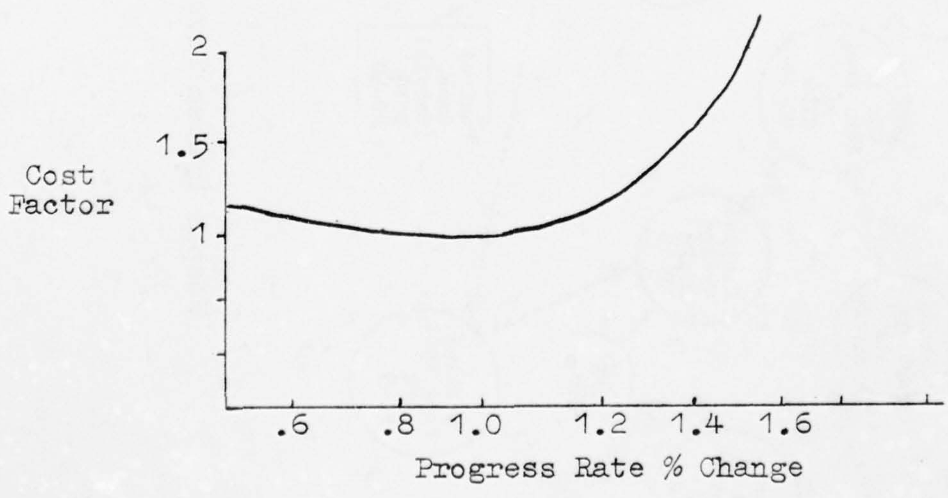


Figure 5-16

Cost Versus Progress Rate

As the progress rate is increased, the costs also increase due to overtime payments and increased hiring. A small increase can be made as the result of increased productivity of the work force. Therefore, the curve is relatively flat closer to the point where the planned progress rate lies. The actual contractual arrangement for each program determines the shape of the curve. Incentives for cost control may influence the weights established for cost and schedule considerations in the decisional process.

The costs associated with being late in contract completion are depicted in Figure 5-17. As the time late

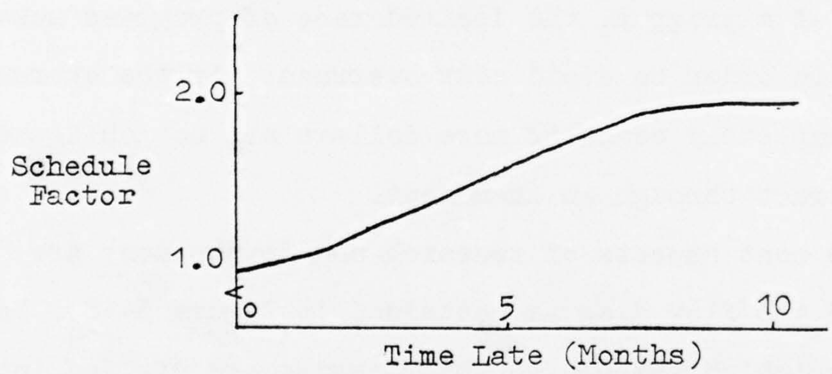


Figure 5-17

Schedule Versus Time Late

becomes very long, the penalties become less meaningful than in the earlier times. The research indicated that there is little motivation to come in ahead of schedule.

The model contains a subroutine which selects the best alternative relative to the implicit and explicit costs associated with changing the desired progress rate. The new progress rate desired is the output of this analysis. The decision which results is implemented gradually within the work effort. This decision is reflected below.

```
A    CAPR1.K=FLF1.K*DCAPR1.K
NOTE      CAPR1   CHANGE IN ACTUAL PROGRESS
NOTE      FLF1    FUNDS LIMIT FACTOR
NOTE      DCAPR1  DESIRED CHANGE IN ACTUAL PROGRESS RATE
```

The desired change in the progress rate is also influenced by the amount of funds available. If funds begin to run out at the end of a program, the desired rate of progress must be reduced in order to avoid cost overruns. At the extreme, work can completely cease if more dollars are not obligated to the contract through an amendment.

The cost aspects of research and development are depicted in the flow diagram contained in Figure 5-18. The equations which correspond to this diagram are divided into two sections. The first equation set is:

```
L    PC1.K=PC1.J+DT*(PCR1.JK-PCTR1.JK)
R    PCR1.KL=PPCM1.JK/PTCR+CPC1.K
A    TPC1.K=TPG/PTCR+CPC1.K
NOTE      PC1     PLANNED COSTS
NOTE      PCR1    PLANNED COST RATE
NOTE      PCTR1   PLANNED COST TRANSFER RATE
NOTE      PPCM1   PLANNED PROGRAM RATE
NOTE      PTCR    PROGRESS TO COST RATIO
```

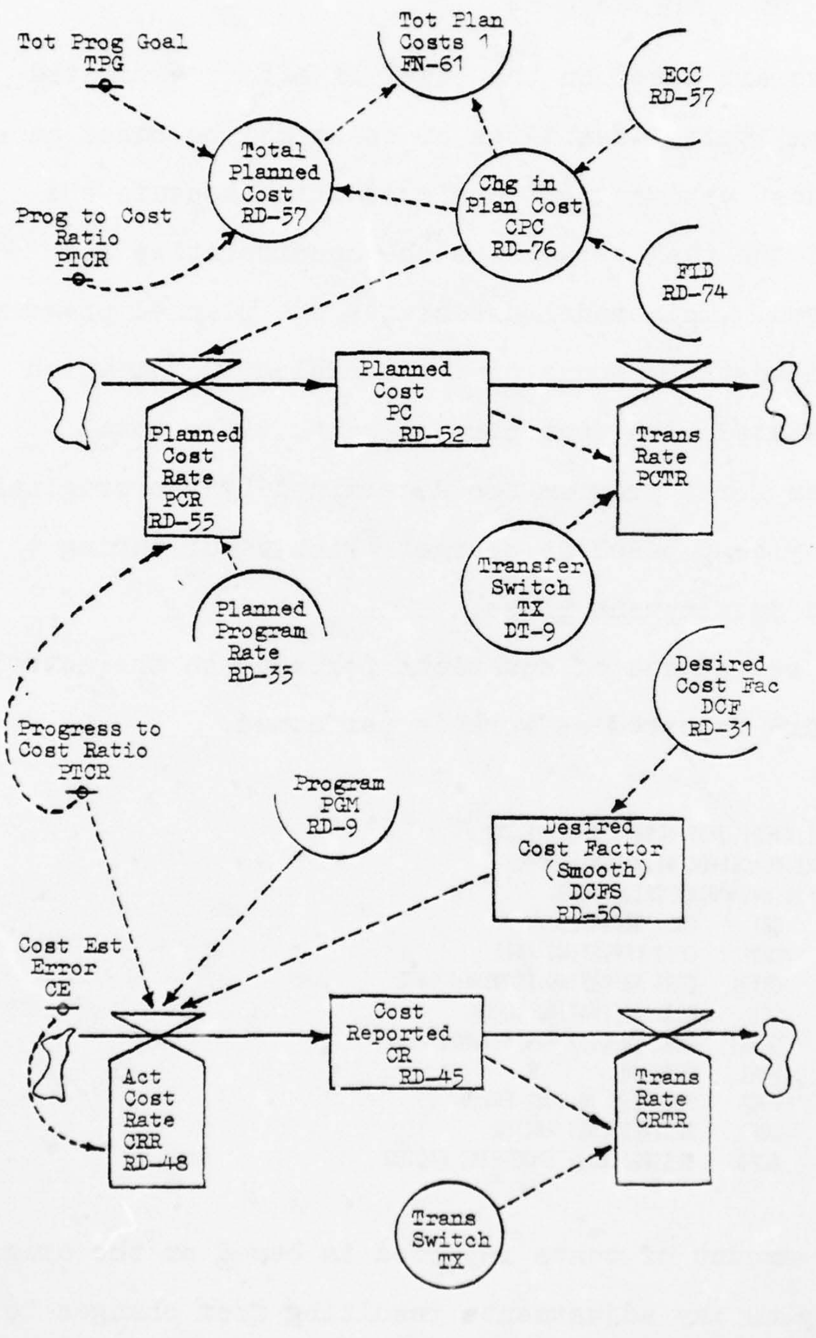


Figure 5-18

Weapon System Development--Planned and Actual Cost

```
NOTE     CPC1    CHANGE IN PLANNED COST
NOTE     TPC1    TOTAL PLANNED COST
NOTE     TPG     TOTAL PROGRESS GOAL
```

Planned costs are based on the level of effort estimated prior to work start. Estimates of costs may be based on a variety of cost estimating techniques which measure the magnitude of the task as well as the uncertainties and risks involved. This model associates the planned program with planned costs by means of a conversion factor which can be associated with cost per man month. The total planned costs for a program are determined by the original plan plus any cost baseline changes which occur during the research and development phase.

The second set of equations pertains to the actual costs that are reported as work is performed.

```
L    CR1.K=CR1.J+DT*(CRR1.JK-CRTR1.JK)
R    CRR1.KL=CE1*DCFS1.K*PGM1.K/PTCR
A    DCFS1.K=SMOOTH(DCF1.K,DCFD)
NOTE     CR1     COST REPORTED
NOTE     CRR1    COST REPORTING RATE
NOTE     CRTR1   COST REPORTING TRANSFER RATE
NOTE     CE1     COST ESTIMATING ERROR
NOTE     DCFS1   DESIRED COST FACTOR(SMOOTHED)
NOTE     PGM1    PROGRAM
NOTE     PTCR    PROGRESS TO COST RATIO
NOTE     DCF1    DESIRED COST FACTOR
NOTE     DCFD    DESIRED COST SMOOTHING FACTOR
```

The amount of costs reported is based on the original cost rates plus any adjustments resulting from changes to the progress rate or unanticipated changes due to cost estimation errors.

As the research and development program continues, the cost and schedule status are monitored closely. Pressures to delay a milestone decision are increased as schedule changes occur in the evaluation process. The equations which represent this process are given below. These equations correspond to the flow diagram contained in Figure 5-19.

```
A    PSE1.K=TABHL(PSE1T,ELF1.K,Ø,1,.2)
T    PSET=Ø.Ø/.15/.35/.58/.88/1.Ø
A    ELF1.K=DTL1.K/TTMS1.K
NOTE      PSE1     PRESSURE FOR SCHEDULE EXTENSION
NOTE      ELF1     ESTIMATED LATE FACTOR
NOTE      DTL1     DESIRED TIME LATE
NOTE      TTMS1    TIME TIL MILESTONE 1
NOTE      USURGF   US URGENCY FACTOR
A    SEA1.K=PSE1.K*CRPA1.K/USURGF.K
A    CRPA1.K=PC1.K/CR1.K
A    SCD1.K=CLIP(SEA1.K,Ø,SEA1.K,.5)
A    SCDM1.K=CLIP(1,SCD1.K,SCD1.K,1)
A    CMS1.K=SCDM1.K*DTL1.K
NOTE      SEA1     SCHEDULE EXTENSION ADJUSTOR
NOTE      CRPA1    COST RATIO(PLANNED TO ACTUAL)
NOTE      PC1      PLANNED COST
NOTE      CR1      COST REPORTED
NOTE      SCD1     SCHEDULE EXTENSION DECISION
NOTE      SCDM1    SCHEDULE MULTIPLIER
NOTE      CMS1     CHANGE IN MILESTONE 1
```

The decision to approve a schedule delay is based upon the intensity of the pressures to extend the schedule, the urgency of the requirement, and the cost performance expressed as the ratio of planned to actual costs. If

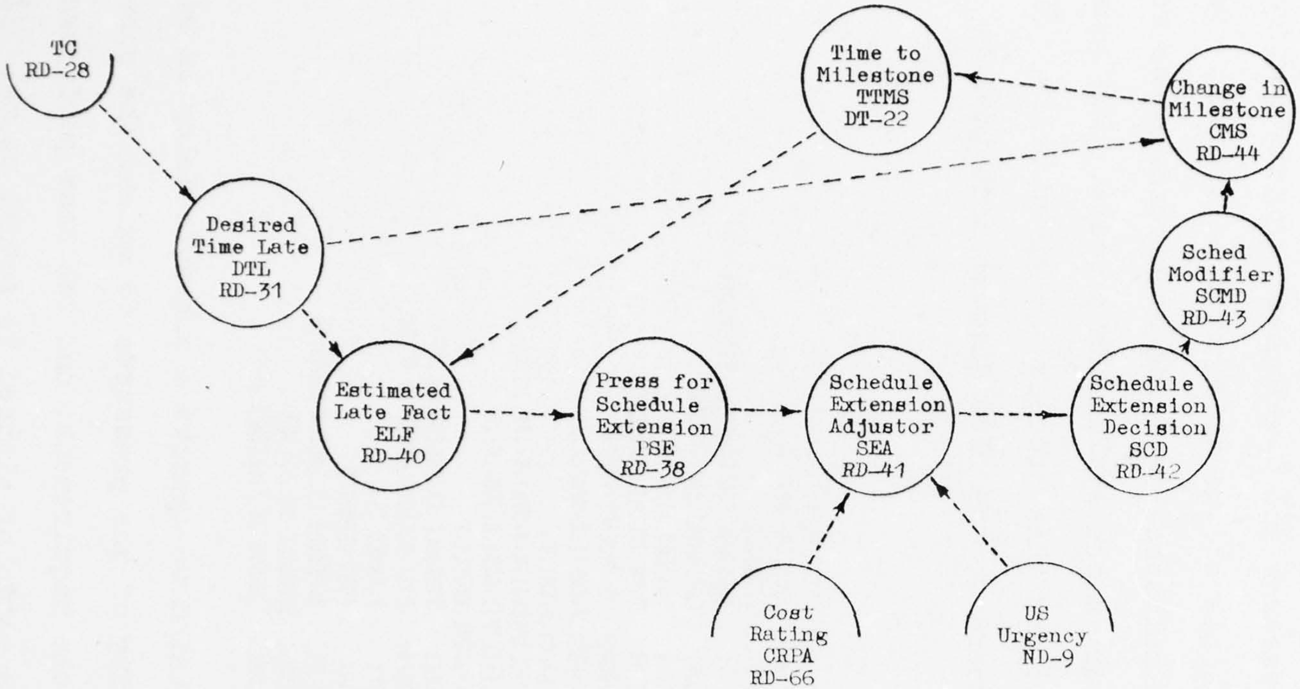


Figure 5-19

Weapon System Development--Schedule Extension either the urgency is great or cost performance is very poor, there is a reluctance to approve schedule changes. Urgent requirements are pushed to meet a schedule, often sacrificing both performance and cost in order to obtain even a limited increase in capability.

Changes in schedule do not necessarily mean that the total contract cost is changed. To illustrate the pressures for funding increases, the following equations are explained, which correspond to the flow diagram in Figure 5-20. The equations are:

```
A    FLF1.K=TABHL(FLFT,3*TWC1.K,Ø,1Ø,1)
T    FLFT=Ø/Ø/.11/.22/.33/.45/.55/.66/.77/.88/1.Ø
NOTE      FLF1    FUNDS LIMIT FACTOR
A    TWC1.K=TTMS1.K*CRPA1.K
NOTE      TWC1    TIME WEIGHTED COST
NOTE      TTMS1   TIME TIL MILESTONE 1
NOTE      CRPA1   COST RATIO, PLANNED TO ACTUAL
A    PIF1.K=TABHL(PIFT,FLF1.K,Ø,1.4,.2)
T    PIFT=1/.72/.57/.45/.38/.32/.28/.26/.25
NOTE      PIF1    PRESSURE FOR INCREASED FUNDS
```

The pressure results from the combined affect of both time and cost constraints on the research and development program. As the DSARC milestone draws near, the pressure increases if spending is ahead of schedule. The decision to increase costs is similar to the schedule change concept. The difference is that cost is the primary decisional criterion and performance/schedule aspects influence the decision. Also considered in the decision

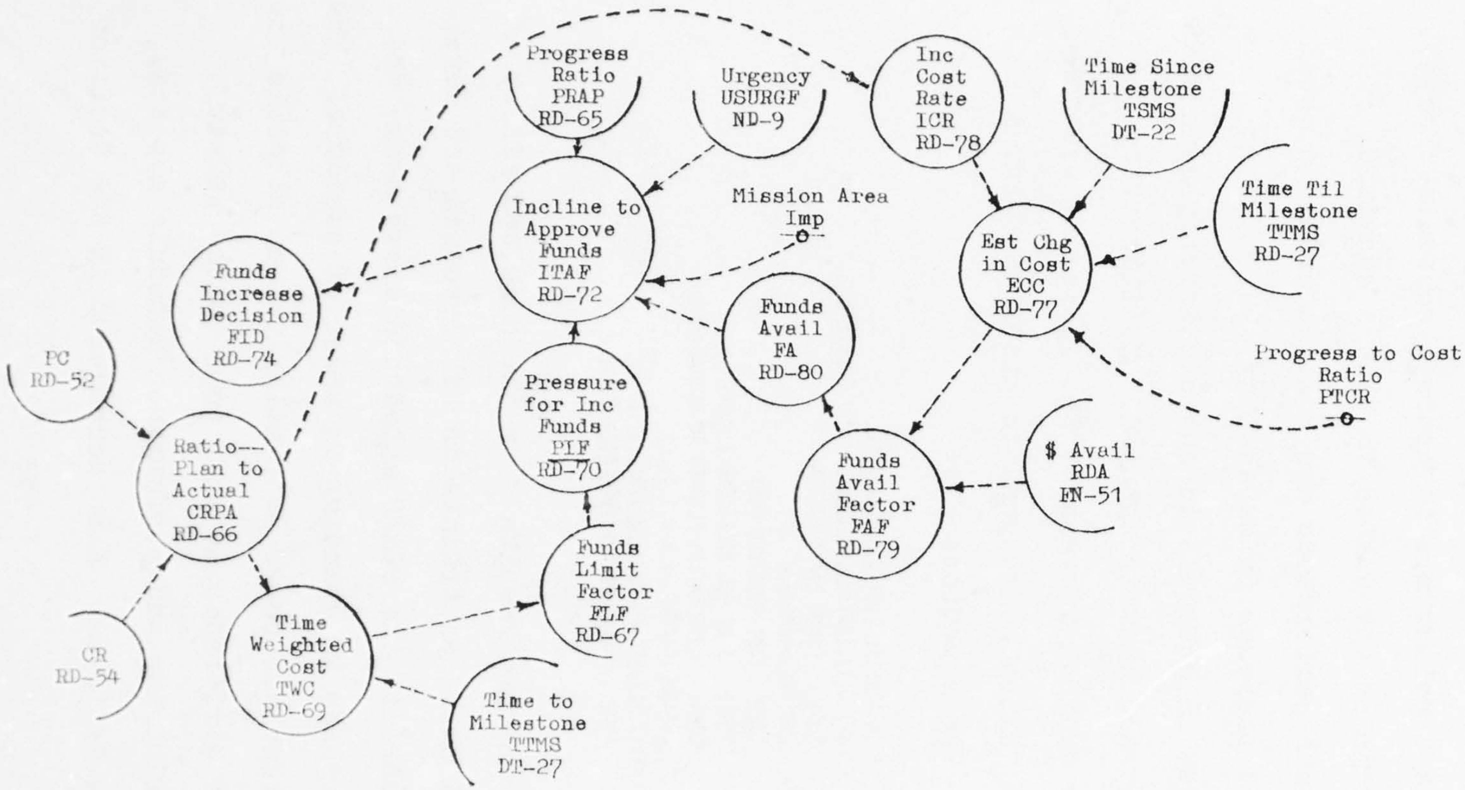


Figure 5-20

Weapon System Development--Funds Increase are the urgency of the requirement for additional funds and the relative importance of the mission area which requires the funds. If a program is important or urgent, money restrictions are relaxed by the desire to continue the program to improve mission area capability. The last consideration is the funds available from other programs. If the contract cost is increased, amendments must be made and the appropriate financial transfers accomplished. The equations for this decision and result are:

```
A   ITAF1.K=FA1.K*PIF1.K*PRAP1.K+USURGF.K*MAIMPF
NOTE     ITAF1   INCLINATION TO APPROVE FUNDS
NOTE     PIF1    PRESSURE FOR INCREASED FUNDS
NOTE     PRAP1   PROGRESS RATIO, ACTUAL TO PLANNED
NOTE     MAIMPF  MISSION AREA IMPORTANCE FACTOR
A   FID1.K=TABHL(FIDT,ITAF1.K,.8,2.0,.2)
T   FIDT=0/.375/.62/.75/.86/.92/.96/.97
NOTE     FID1    FUNDS INCREASE DECISION
A   CPC1.K=FID1.K*ECC1.K
NOTE     CPC1    CHANGE IN PLANNED COST
NOTE     FID1    FUNDS INCREASE DECISION
A   ECC1.K=CLIP(ICR1.K,0,ICR1.K,0)*(TSMS0.K+TTMS1.K)/PTCR
A   ICR1.K=1-1/CRPA1.K
NOTE     ECC1    ESTIMATED CHANGE IN COST
NOTE     CRPA1   COST RATIO, PLANNED TO ACTUAL
NOTE     TSMS0   TIME SINCE MILESTONE 0
NOTE     TTMS1   TIME TIL MILESTONE 1
NOTE     PTCR    PROGRESS TO COST RATIO
NOTE     ICR     INCREASE IN COST RATE
A   FA1.K=TABHL(FAT,FAF1.K,0,.4,.05)
T   FAT=0/.55/.375/.25/.1/.05/.02/.001/.0
NOTE     FA1     FUNDS AVAILABILITY
NOTE     FAF1    FUNDS AVAILABILITY FACTOR
A   FAF1.K=ECC1.K/RDA.K(2)
NOTE     FAF1    FUNDS AVAILABILITY FACTOR
NOTE     RDA(2)  RESEARCH DOLLARS APPROPRIATED
```

The final concept expressed in this discussion of research and development management is product value. The

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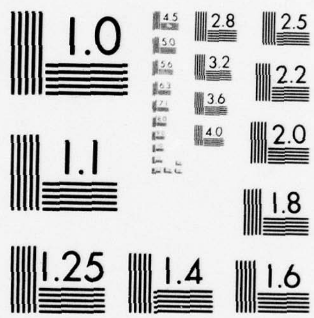

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value associated with a program becomes the decision criteria used in the DSARC process to approve or cancel a program. This measure is also used in the budgetary process to determine DOD funding and follow-on funding for the specified program. The flow diagram portrayed in Figure 5-21 depicts the structural aspects of this decision. This diagram represents the mathematical equations given below.

```
L   PV1.K=PV1.J+DT*(PVR1.JK-PVTR1.JK)
R   PVR1.KL=PPVS1.K*PVA1.K
A   PPVS1.K=SMOOTH(PP1.K,PPD)
NOTE     PV1      PRODUCT VALUE
NOTE     PVR1     PRODUCT VALUE RATE
NOTE     PVTR1    PRODUCT VALUE TRANSFER RATE
R   PVR1.KL=PPVS1.K*PVA1.K
NOTE     PPVS1     PLANNED PRODUCT VALUE (SMOOTHED)
A   PPVS1.K=SMOOTH(PP1.K,PPD)
NOTE     PP1      PLANNED PROGRESS
NOTE     PPD     PLANNED PROGRESS DELAY
A   PVA1.K=PRAP1.K*CRPA1.K
A   PRAP1.K=PAP1.K/PP1.K
NOTE     PVA1     PRODUCT VALUE ADJUSTOR
NOTE     PRAP1    PROGRESS RATIO, ACTUAL TO PLANNED
NOTE     CRPA1    COST RATIO, PLANNED TO ACTUAL
NOTE     PAP1     PERCEIVED ACTUAL PROGRESS
A   CRPA1.K=PC1.K/CR1.K
NOTE     CRPA1    COST RATIO, PLANNED TO ACTUAL
NOTE     PC1      PLANNED COST
NOTE     CR1      COST REPORTED
```

The level of product value is based on the perceived cost and progress performance which result from ongoing research and development efforts. If either costs are greater than planned or actual progress is less than expected, the rate of increase in product value is diminished. When a milestone decision is required, the past performance of the program is evaluated and the decision

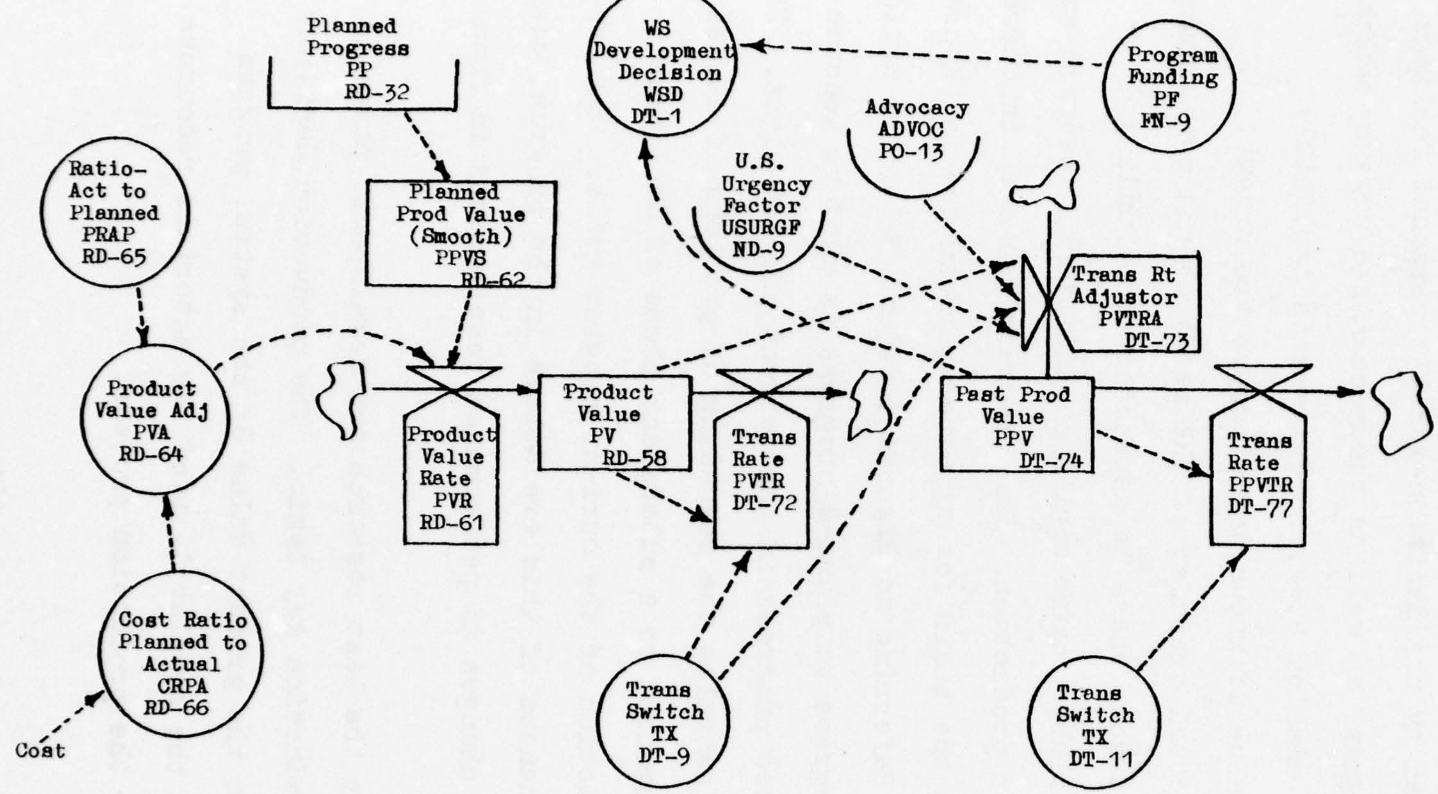

Figure 5-21

Weapon System Development--Product Value is made to cancel or continue the program. This decision is also influenced by the decision-maker's personal feelings about the program, as well as the recognized urgency which exists in the mission area. Requirements implicitly increase in value if known deficiencies are urgent.

The actual transfer of the research and development process to the next phase is dependent upon funding. If funds are available, work begins on additional research and development or production. The progress achieved in current phase becomes the basis for expected performance in future activities. Referring to Figures 5-12 and 5-14, the ratio of actual progress to planned progress is used to measure the anticipated progress in the current project phase. This structure illustrates the cascading of problems if decisions are made to proceed to a subsequent phase of development without completion of the current program goals. The possible consequences of this are delays in the program, cost overruns, or changes in performance requirements in future periods.

After the last research and development phase is complete, production may begin. The production decision must consider the product value of the system, program funding, and the availability of raw materials resources required for the production process.

Resources Sector

The flow of worldwide resources is depicted in the flow diagram contained in Figure 5-22. Worldwide resources are an aggregate measure of all the raw materials available for consumption. In his world policy model, Forrester (25) used the number of years supply remaining, if current per capita consumption continued. Consumption was based on expected growth, represented by changes in the gross national product. Borrowing from this concept, the following system equations were developed for the resources sector.

```
L    TOTRES.K=TOTRES.J+DT*(DISCOV.JK-TRUSE.JK)
R    DISCOV.KL=DISCOF.K*TOTRES.K
R    TRUSE.KL=GROWTH.K*TOTRES.K
NOTE      DISCOV  DISCOVERY RATE
NOTE      TRUSE   TOTAL RESOURCE USE RATE
NOTE      DISCOF  DISCOVERY FRACTION
NOTE      GROWTH  GROWTH RATE
```

The level of total world resources (TOTRES) is increased by discoveries of new resources and increased extraction rates of existing resources. Consumption of resources decreases the level. The discovery and use rates are both expressed as a percent of the total resources available.

The discovery of resources fraction is a function of the amount of pressure to search for new resources or

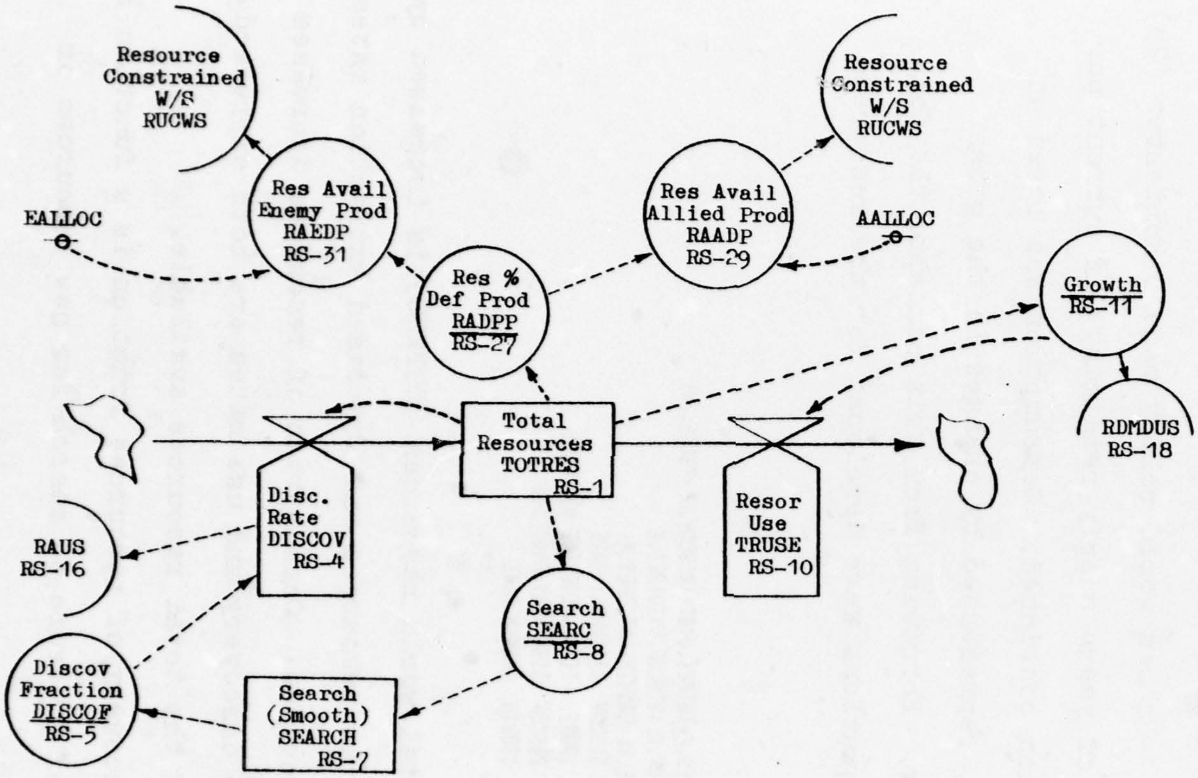

Figure 5-22

Resources Sector--Worldwide

increase extraction of existing resources. This pressure results from declining levels of available resources. As the search for resources increases, the number of resources discovered increases over time. The next group of equations apply to the discovery of resources.

```
A     DISCOF.K=TABHL(DISCOT,SEARCH.K,Ø,.1,.Ø2)
T     DISCOT=Ø/.Ø2/.Ø6/.Ø8/.Ø9/.1
A     SEARCH.K=SMOOTH(SEARC.K,3Ø)
T     SEARCT=1/.9/.8/.55/.3/.15
A     SEARC.K=TABHL(SEARCT,TOTRES.K,Ø,1ØØ,2Ø)
NOTE      DISCOF  DISCOVERY FRACTION
NOTE      SEARCH  SEARCH FOR RESOURCES(SMOOTHED)
NOTE      SEARC   SEARCH FOR RESOURCES
NOTE      TOTRES  TOTAL RESOURCES
```

Further equations apply the resources allocated for defense to the production of weapons for the allies and the enemy. The percentage of resources available for defense production is a function of the total resources available to each country. As noted in Chapter 4, Smith (59) explained the willingness of the Soviet Union to withold resources from its populace in order to further defense production. In the context of this model, therefore, the enemy sector is considered to have no real constraint due to resources on defense production.

```
A     RADPP.K=TABHL(RADPPT,TOTRES.K,Ø,1ØØ,1Ø)
T     RADPPT=Ø/.1/.25/.4/.35/.32/.3/.28/.27/.26/.25
NOTE      RADPP   RESOURCES AVAILABLE % FOR DEFENSE PRODUCTION
NOTE      TOTRES  TOTAL RESOURCES
A     RAADP.K=TOTRES.K*RADPP.K*AALLOC
NOTE      RADPP   RESOURCES AVAILABLE FOR ALLIED DEFENSE PRODUCTION
NOTE      AALLOC  ALLIED ALLOCATION PERCENT
```

```
A   RAEDP.K=TOTRES.K*RADPP.K*EALLOC
NOTE     RAEDP   RESOURCES AVAILABLE FOR ENEMY DEFENSE PRODUCTION
NOTE     EALLOC  ENEMY ALLOCATION PERCENT
```

The percentage of resources available for defense production is a function of the total resources available. As the level of resources declines, a greater percent of total resources is allocated to defense production in order to protect resources that are available. This behavior occurs until resources become so scarce that defense production is infeasible. The resources available for defense production are determined by the relative amounts of total resources which are allocated to the allies and the enemy.

The flow diagram in Figure 5-23 represents the U.S. resource sector. The U.S. is estimated to use approximately one-third of the total world resources (45). The equations which apply to U.S. resources are noted here.

```
L    USRES.K=USRES.J+DT*(RAUS.JK-RDMDUS.JK)
R    RAUS.KL=DISCOV.JK*ALLOCF
R    RDMDUS.KL=(GROWTH.K-(EFFF.K/100))*USRES.K
NOTE     USRES   US RESOURCES
NOTE     RAUS    RESOURCES ALLOCATED TO US
NOTE     RDMDUS  TESOURCES DEMANDED(USEX) BY US
NOTE     DISCOV  DISCOVERY FRACTION
NOTE     GROWTH  GROWTH RATE
NOTE     EFFF    EFFICIENCY FACTOR
NOTE     ALLOCF  US ALLOCATION FACTOR
```

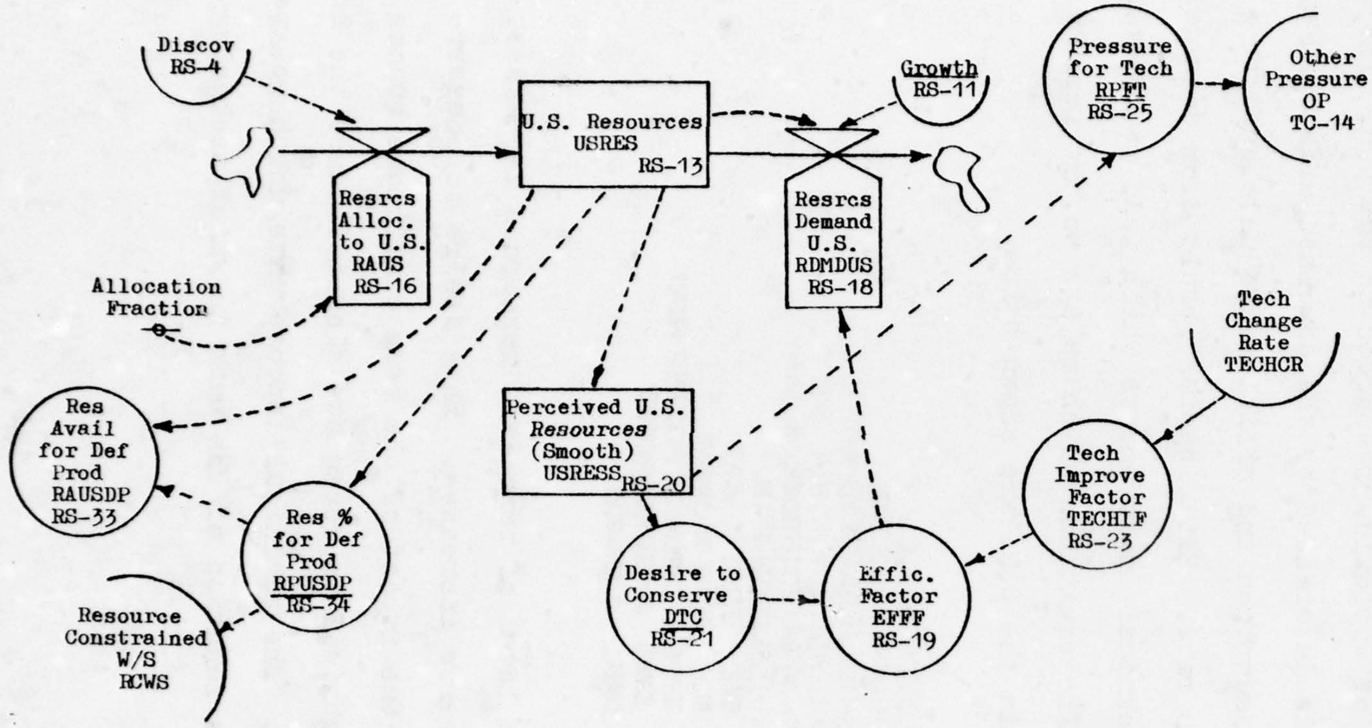

Figure 5-23

Resources Sector--U.S.

This equation set is similar to the levels and rates for total resources. The U.S. resources level is increased by allocations of worldwide resources to the U.S. The demand for resources is determined by the combined effect of growth in resource consumption and efficiencies developed to slow the consumption rate. Efficiencies result from conservation efforts and technical improvements which lead to reduced consumption. The equations which relate to the resource consumption rate in the U.S. are shown below.

```
A    EFFF.K=DTC.K+TECHIF.K
A    USRESS.K=SMOOTH(USRES.K,10)
A    DTC.K=TABHL(DTCT,USRESS.K,0,35,5)
T    DTCT=-2/-.75/-.15/.4/.7/.9/1/1
A    TECHIF.K=TABHL(TECHIT,TECHCR.K,0,.2,.04)
T    TECHIT=1/.5/.25/.15/.07/.04
NOTE     EFFF     EFFICIENCY FACTOR
NOTE     DTC      DESIRE TO CONSERVE
NOTE     TECHIF   TECHNOLOGICAL IMPROVEMENT FACTOR
NOTE     USRESS   US RESOURCES(SMOOTHED)
NOTE     USRES    US RESOURCES
```

As the level of perceived resources decreases, the desire to conserve increases. This desire to conserve is delayed until the impact of the true conditions become apparent. Technical improvements also influence the efficiency factor. The technical improvements which relate to resources is a function of the rate in which technology changes.

In addition to influences within the sector, the state of resources also affects other sectors as shown below. As the perceived U.S. resources decrease, pressure is created for new resource-saving technologies.

In addition to effects of technology demands, the percentage of resources available for U.S. defense production may become a constraint in the production process if the production plan exceeds the resources that are available.

```
A    RPFT.K=TABHL(RPFTT,USRESS.K,0,100,10)
T    RPFTT=1/.8/.7/.6/.6/.45/.4/.37/.35
A    RAUSDP.K=USRES.K*RPUSDP.K
A    RPUSDP.K=TABHL(RPUSDT,USRES.K,0,35,5)
T    RPUSDT=0/.2/.4/.3/.28/.27/.26/.25
NOTE      RPFT    RESOURCE PRESSURE FOR TECHNOLOGY
NOTE      USRESS  US RESOURCES(SMOOTHED)
NOTE      RAUSDP  RESOURCES ALLOWED FOR US DEFENSE PRODUCTION
NOTE      RPUSDP  RESOURCE PERCENT FOR US DEFENSE PRODUCTION
NOTE      USRES   US RESOURCES
```

Production Sector

This sector will address the transformation process which integrates the various production inputs, such as resources, research and development knowledge, production plans, and funding, to produce weapon systems for U.S. operations. Many of the concepts which are included in the model of the production process are similar to those discussed for the research and development process. The flow of weapon systems and the information network which influences flow in the production process are depicted in Figure 5-24. The first set of equations which apply to the production process are given below.

```
L    WSP.K=WSP.J+DT*(WSPIR.JK-WSPR.JK)
R    WSPIR.KL=MIN(PGM4.K,RCWS.K)
R    WSPR.KL=DELAY3(WSPIR.JK,PRODT.K)
A    PGM4.K=TABLE(PGM1T,SCHEDP.K,0,1,.0833)*WSD4.K*12*DCP4.K/
X    (TSMS3.K+TTPCC.K)
NOTE      WSP      WEAPON SYSTEMS IN PRODUCTION
NOTE      WSPIR    WEAPON SYSTEM PRODUCTION INPUT RATE
NOTE      WSPR     WEAPON SYSTEM PRODUCTION RATE
NOTE      PGM4     PROGRAM
NOTE      WSD4     WEAPON SYSTEM DEVELOPMENT DECISION
NOTE      DCP4     DECISION COORDINATING POINT
NOTE      TSMS3    TIME SINCE MILESTONE 3
NOTE      TTPCC    TIME TO PRODUCTION COMPLETION
A    SCHEDP.K=TSMS3.K/(TSMS3.K+TTPCC.K)
A     RCWS.K=RAUSDP.K*WSRCF
A    PRODT.K=APRODT.K+PRODTA.K
NOTE      SCHEDP   PRODUCTION SCHEDULE
NOTE      RCWS     RESOURCE CONSTRAINT ON WEAPON SYSTEMS
NOTE      RAUSDP   RESOURCES AVAILABLE FOR DEFENSE PRODUCTION
NOTE      WSRCF    WEAPON SYSTEM TO RESOURCES CONVERSION FACTOR
NOTE      PRODT    PRODUCTION TIME
```

The level of weapon systems in the production process is determined by two rates. The input to production is determined by the production plan. This plan is similar to plans for research and development except that the measurement is in weapon systems instead of progress. The plan may be adjusted if resource availability requires. The rate of output from production is a function of the input of weapons into the production process and the amount of time required to produce each weapon system. If the production flow time is reduced, the total number of systems in production is decreased. By adjusting the flow time, the

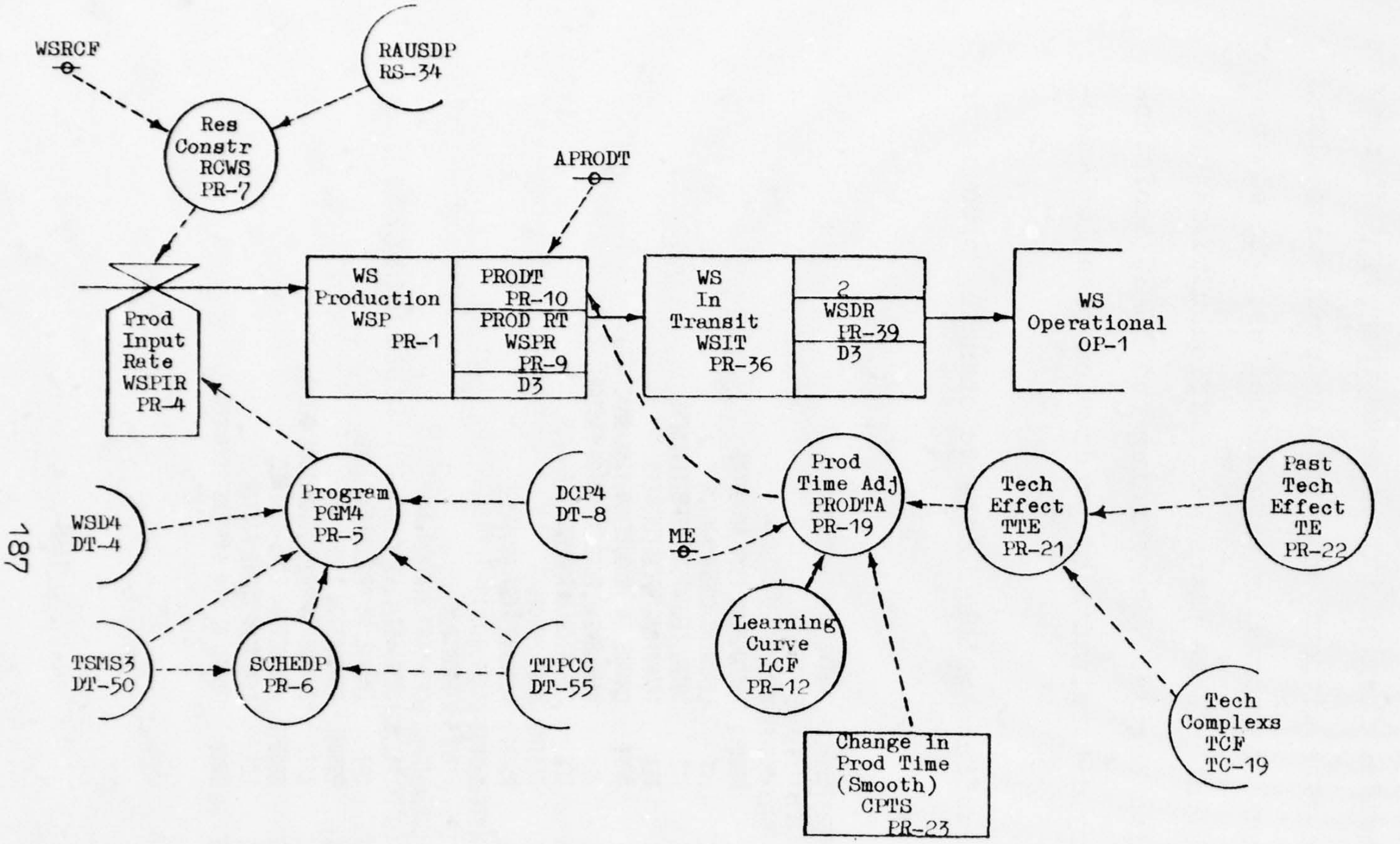

Figure 5-24

Production Sector--Production Process

number of resources contained in the production pipeline is changed. This is useful to management of DOD acquisitions because it provides flexibility to make temporary changes to the production rate without changing the production plan. Production plans are normally established well in advance of actual production. These plans are difficult to adjust after production begins. The funding and DSARC decisions are the primary determinants of production plan implementation.

The equations which relate to changing production flow times are:

```
A    PRODTA.K=LCF.K+(TTE.K*ME4*CPTS.K)
A    TTE.K=TE4.K*ME4/TCF.K
A    TE4.K=PASTP3.K/PSTPP3.K
NOTE      PRODTA  PRODUCTION TIME ADJUSTOR
NOTE      LCF     LEARNING CURVE FACTOR
NOTE      TTE     TOTAL TECHNICAL EFFECTIVENESS
NOTE      TE4     TECHNICAL EFFECTIVENESS
NOTE      CPTS    CHANGE IN PRODUCTION TIME(SMOOTHED)
NOTE      ME4     MANAGEMENT EFFECTIVENESS FACTOR
NOTE      TCF     TECHNICAL COMPLEXITY FACTOR
NOTE      PASTP3  PAST PROGRESS
NOTE      PSTPP3  PLANNED PAST PROGRESS
A    CPTS.K=SMOOTH(CPT.K,CPTD)
A    CPT.K=PRODT.K-PRODTD.K
A    LCF.K=TABHL(LCFT,TWSP.K,Ø,520,40)
T    LCFT=1/1.15/1.35/1.57/1.69/1.78/1.87/1.96/2.02/2.11/2.2/2.2/2.2
NOTE      CPT     CHANGE IN PRODUCTION TIME
NOTE      PRODT   PRODUCTION TIME
NOTE      CPTD    CHANGE IN PRODUCTION TIME DELAY
NOTE      PRODTD  PRODUCTION TIME DESIRED
NOTE      LCF     LEARNING CURVE FACTOR
NOTE      TWSP    TOTAL WEAPON SYSTEMS PRODUCED
```

As noted from the equations, four elements affect the adjustment to flow time. The first three elements are similar to those discussed in research and development. They include: technical effectiveness, managerial effectiveness, and changes in production due to evaluation of production progress. The fourth element which affects the adjustments to production times is the learning curve. As more systems are produced, the production times are decreased due to the efficiencies which result from learning the production process. The flow diagram contained in Figure 5-25 depicts the accumulation of production know-how which determines the relative effect of the learning curve. The following equation set mathematically represents the accumulation of production knowledge.

```
A   RWSP.K=NWSP.K-TWSP.K
A   WSPRR.K(P)=RWSP.K/RTTPCC.K(P)
NOTE     RWSP    REMAINING WEAPON SYSTEMS TO PRODUCE
NOTE     NWSP    NUMBER OF WEAPON SYSTEMS TO PRODUCE
NOTE     WSPRR   WEAPON SYSTEM PRODUCTION RATE REQUIRED
NOTE     RTTPCC  REMAINING TIME TO PRODUCTION COMPLETION
L   TWSP.K=TWSP.J+DT*(WSPR.JK-LCRR.JK)
R   LCRR.KL=TX4.K*TWSP.K
NOTE     TWSP    TOTAL WEAPON SYSTEMS TO PRODUCE
NOTE     WSPR    WEAPON SYSTEM PRODUCTION RATE
NOTE     LCRR    LEARNING CURVE RELEASE RATE
```

The total number of weapon systems produced becomes the comparison device to evaluate production progress. As the actual number of weapon systems produced deviates from

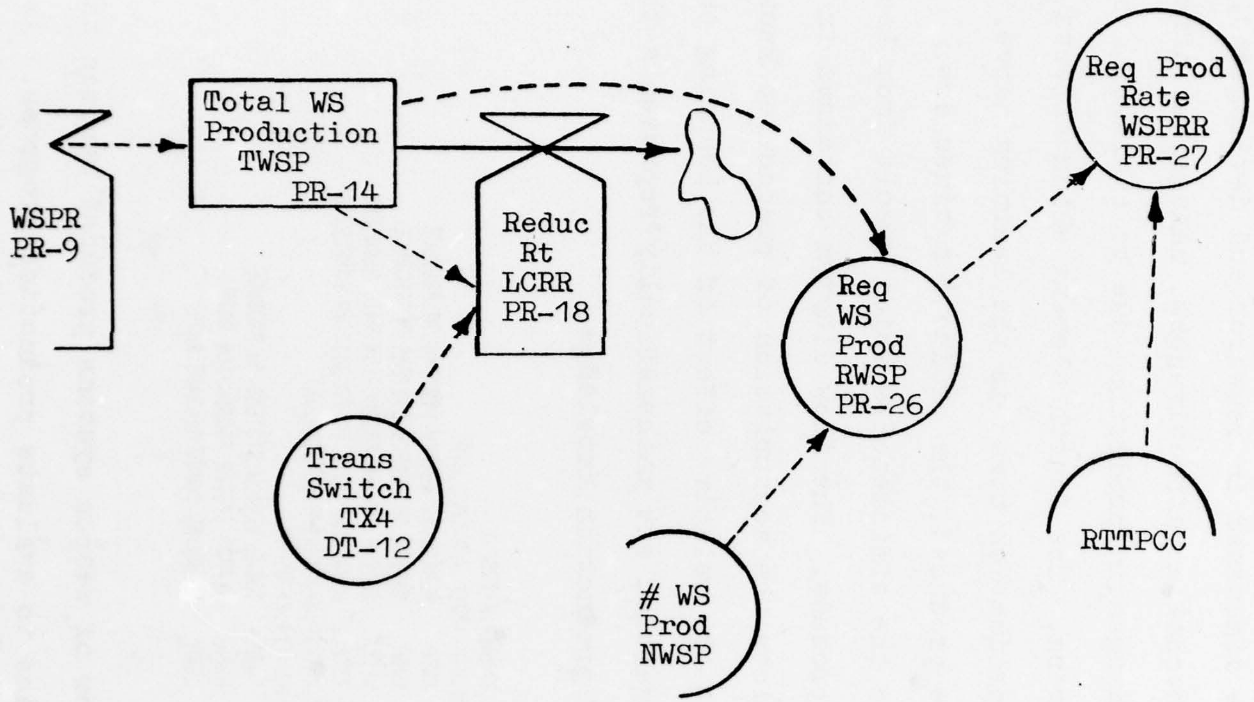

Figure 5-25

Production Sector--Accumulated Production from production plans, management initiates changes to the production process using the same type of decisional phase described in the research and development section. The result of the cost and schedule trade-offs determines the actual changes made to the production process via changes in the flow time.

The remainder of the model of the production process is constructed along the same lines as the research and development phases. The flow diagrams and equations development for cost reporting and cost/schedule changes will not be discussed to avoid repetition. Also, the concept of product value was omitted from this portion of the model since further decisions concerning the program are made by evaluating the actual performance in the operational environment.

As systems are produced, they are shipped to the operational commands. The weapon systems in transit and the subsequent delivery rate is a function of the production rate and the time in transit. This is developed into the following equations.

```
L    WSIT.K=WSIT.J+DT*(WSPR.JK-WSDR.JK)
R    WSDR.KL=DELAY3(WSPR.JK,2)
NOTE      WSIT    WEAPON SYSTEMS IN TRANSIT
NOTE      WSPR    WEAPON SYSTEMS PRODUCTION RATE
NOTE      WSDR    WEAPON SYSTEMS DELIVERY RATE
```

The flow of weapons to the operational commands provides increased capability which, in turn, relieves the pressure for weapon system production. The next section of this chapter will discuss the effects of weapon system inventories as they are used in the operational environment.

U.S. Operations

The flow of inventory into the operational environment is depicted in the diagram contained in Figure 5-26. As new systems are delivered to the operational commands, the inventory is used to accomplish the mission requirements established by the operating plans for each base. Two system states are represented in the model. Operational weapon systems are able to accomplish their assigned missions. Non-operational weapon systems cannot accomplish their missions due to system failures, scheduled maintenance, supply problems, or personnel support problems. The final inventory state is implied by the retirement rate. The retired inventory encompasses weapons delivered to storage and those systems lost through attrition. The following equations provide the basis for discussion about the state of U.S. forces.

```
L   WSO.K=WSO.J+DT*(WSMR.JK+WSDR.JK-WSSDR.JK-WSRR.JK)
L   WSN.K=WSN.J+DT*(WSSDR.JK-WSMR.JK)
R   WSSDR.KL=USE.K/MTBF.K
R   WSMR.KL=WSORP.K*OSF.K
```

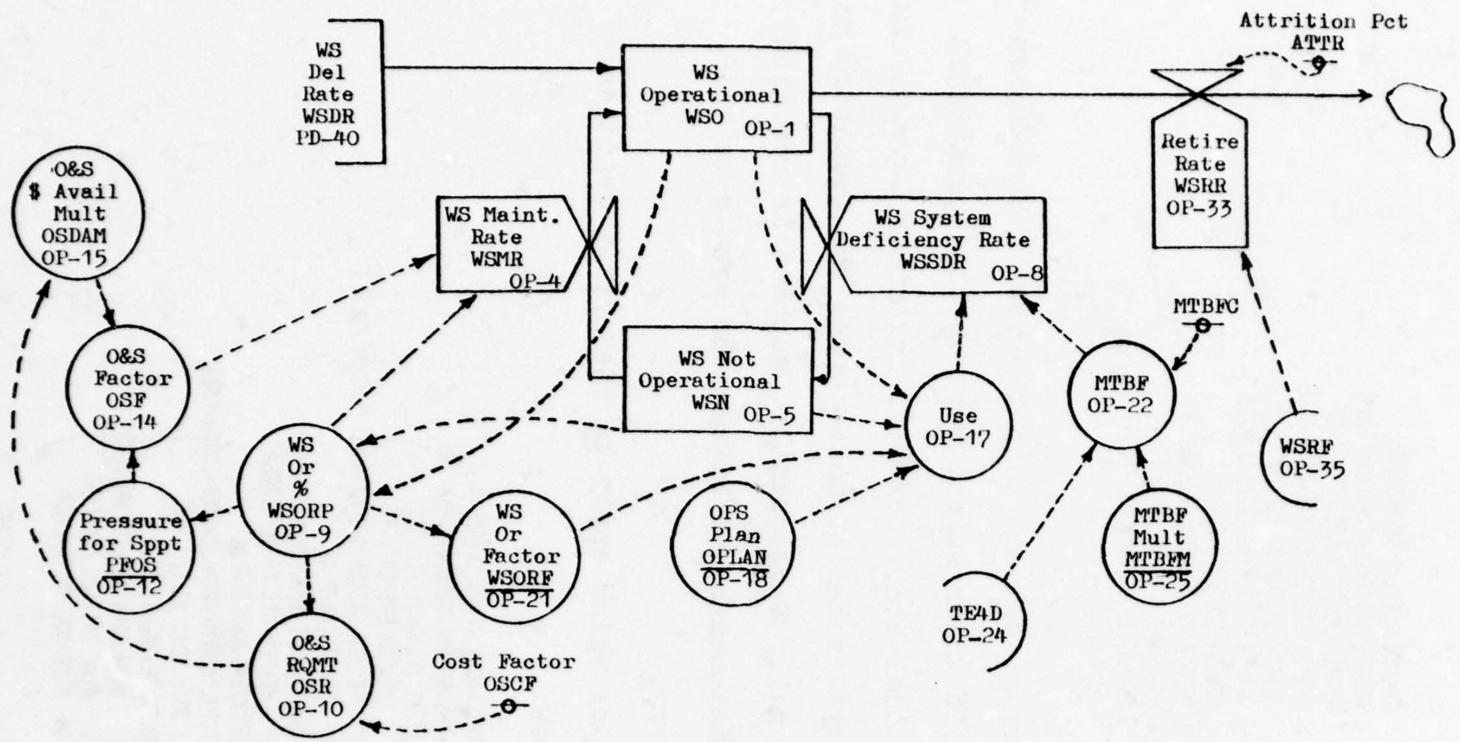

Figure 5-26

U.S. Operations Sector--Inventory

```
NOTE    WSO     WEAPON SYSTEMS OPERATIONAL
NOTE    WSN     WEAPON SYSTEMS NON-OPERATIONAL
NOTE    WSDR    WEAPION SYSTEM DELIVERY RATE
NOTE    WSMR    WEAPON SYSTEM MAINTENANCE RATE
NOTE    WSSDR   WEAPON SYSTEM DEFICIENCY RATE
NOTE    WSRR    WEAPON SYSTEM RETIREMENT RATE
NOTE    USE     WEAPON SYSTEM USE
NOTE    MTBF    MEAN TIME BETWEEN FAILURES
NOTE    WSORP   WEAPON SYSTEM OR PERCENT
NOTE    OSF     OPERATING ND SUPPORT FACTOR
```

The delivery of weapons into the operational inventory begins the cycle which exists between the operational and the non-operational states of U.S. inventory levels. As weapons are used, system deficiencies cause the inventory to become non-operational. Subsequently, support is required to correct the deficiencies and return the system to the operational inventory.

The equations which apply to the system deficiency rate are given below.

```
A    USE.K=WSORF.K*(WSO.K+WSN.K)*OPLAN.K
A    OPLAN.K=TABHL(OPLANT,TIME.K,0,240,20)
T    OPLANT=1/1/1/1/1/1.2/1/1/1/.9/1
NOTE    USE     WEAPON SYSTEM USE
NOTE    WSORF   WEAPON SYSTEM OPERATIONALLY READY FACTOR
NOTE    OPLAN   OPERATING PLAN
A    WSORF.K=TABHL(WSORFT,WSORP.K,0,50,10)
NOTE    WSORP   WEAPON SYSTEM OR PERCENT
A    MTBF.K=MTBFC*TE4D.K*MTBFAM.K
A    MTBFAM.K=TABHL(MTBFMT,WSAA.K,5000,15000,2000)
T    MTBFMT=1/1.05/1.13/1.25/1.6/1.9
A    TE4D.K=SMOOTH(TE4.K,18)
NOTE    MTBF    MEAN TIME BETWEEN FAILURES
NOTE    MTBFC   MTBF INITIAL CONSTANT
NOTE    MTBFAM  MTBF AGE MULTIPLIER
```

```
NOTE    TE4D    TECHNICAL EFFECTIVENESS DESIGNED(SMOOTHED)
NOTE    TE4     TECHNICAL EFFECTIVENESS DESIGNED
NOTE    WSAA    WEAPON SYSTEM AVERAGE AGE
```

As use increases, the number of system deficiencies also increases. The actual use rate is determined by the flying hours or mission programs and the constraints that exist from the current inventory. As more and more weapons become non-operational, the operating plan cannot be fully accomplished. The other determinant of system deficiencies is the inherent system reliability. This is expressed in terms of mean time between failures (MTBF). In this model, an aggregate measure is used to show the ratio of weapon system failures to the operating program period. The failure rate is influenced by the technical effectiveness achieved in the production process, equipment aging, and equipment enhancements due to modification of existing systems.

The activities and decisions affecting the maintenance rate are represented by the equations:

```
A    WSORP.K=WSO.K/(WSN.K+WSO.K)
NOTE    WSORP   WEAPON SYSTEMS OPERATIONAL READY PERCENT
NOTE    WSO     WEAPON SYSTEMS OPERATIONAL
NOTE    WSN     WEAOPN SYSTEM NON-OPERATIONAL
A    OSR.K=WSORP.K*OSCF
NOTE    OSR     O&S REQUIRED
NOTE    OSCF    O&S COST FACTOR
A    PFOS.K=TABHL(PFOST,WSORP.K,0,1,.2)
T    PFOST=1/1/1/1.15/1.82/2.68
NOTE    PFOS    PRESSURE FOR O&S
```

```
A    OSF.K=OSDAM.K*PFOS.K
NOTE      OSF      O&S FACTOR
NOTE      OSDAM    O&S DOLLAR AVAILABILITY MULTIPLIER
NOTE      OSA      O&S AVAILABLE
A    OSDAM.K=TABLE(OSDAMT,OSR.K/OSA.K(1),0,2,.2)
T    OSDAMT=1/.98/.9/.82/.7/.52/.38/.29/.26/.24/.22
```

The percent of the total weapon systems operational is used to determine the relative degree of pressure that is placed on the logistics system to provide support. As more systems become non-operational, pressure is increased. This pressure acts to increase the maintenance rate; however, funds may limit the degree to which maintenance can support the increased demands.

The rate that weapons are removed from the inventory is determined by the number of weapon system attritions and the planned rate of retirement. The equations which represent the decision process which supports the actions to remove weapon systems from the U.S. inventory as depicted in Figure 5-27 are shown below:

```
L    AWSA.K=AWSA.J+DT*(WSAR.JK-WSARR.JK)
R    WSAR.KL=USE.K
R    WSARR.KL=(MODF.K*AWSA.K)+WSAA.K*WSRR.JK
NOTE      AWSA     ACCUMULATED WEAPON SYSTEM AGE
NOTE      WSAR     WEAPON SYSTEM AGE RATE
NOTE      WSARR    WEAPON SYSTEM AGE RESTORATION & RETIREMENT RATE
NOTE      USE      WEAPON SYSTEM USE
NOTE      MODF     MODIFICATION FACTOR
```

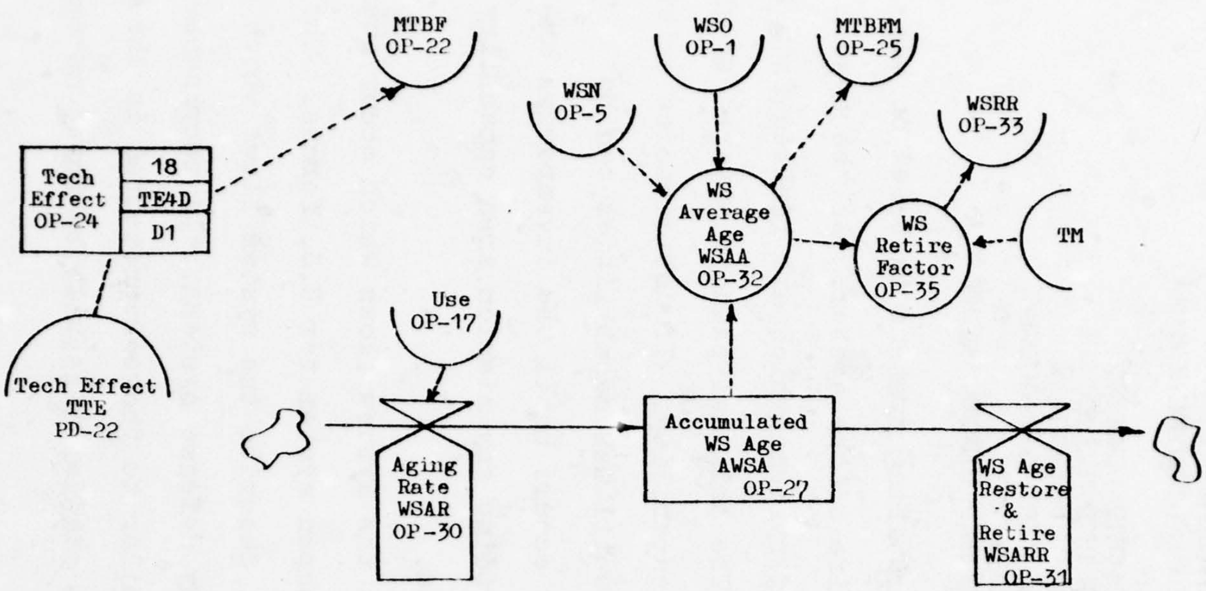

Figure 5-27

U.S. Operations Sector--Reliability and Aging

```
A    WSAA.K=AWSA.K/(WSO.K+WSN.K)
R    WSRR.KL=MIN(1,WSO.K*(ATTR+WSRF.K))
A    WSRF.K=TABHL(WSRFT,WSAA.K,2500,10000,2500)*TM.K
T    WSRFT=0/.33/.66/1.00
NOTE     WSAA     WEAPON SYSTEM AVERAGE AGE
NOTE     WSRR     WEAPON SYSTEM RETIREMENT RATE
NOTE     WSO      WEAPON SYSTEMS OPERATIONAL
NOTE     WSN      WEAPON SYSTEMS NON-OPERATIONAL
NOTE     ATTR     ATTRITION FACTOR
NOTE     WSRF     WEAPON SYSTEM RETIREMENT FRACTION
```

The original plan for retiring systems is based on the expected operational life of the system. As the system ages, the percentage of systems which are retired from the inventory increases. The original plan is altered by the actual needs for U.S. capability. If deficiencies exist, retirement is delayed until new capabilities can be developed. This delay occurs until the inventories are no longer capable of providing any mission area capability or all systems are retired.

This completes the system flows which occur over the life cycle of a weapon system for U.S. forces. The next two sections will describe the system flows which apply to the allied and enemy defense systems. In many cases the model concepts are similar to those represented in the U.S. defense system. These similarities will be noted as appropriate.

Allied Sector

The Allied Sector contains the flow of weapons and information associated with weapon system decisions. The basic structure of the inventory flow is similar to the U.S. Operations Sector. In addition to this structure, the force aging, capability and threat assessment, are also similar. The unique portions of this sector involve allied evaluations of productive capacity and desires to produce or purchase weapons. This decision, in part, affects the political, military, and economic ties with the U.S. and determines the allied demands for acquisition in the U.S.

The flow diagram contained in Figure 5-28 depicts the flow of inventory through the allied defense system. As noted, the structure is very similar to the U.S. operations. The only difference is that purchase of inventory from the U.S. is also represented in the allied defense system. The equations which apply to this structure are:

```
L    AWSP.K=AWSP.J+(DT)(AWSPR.JK-AWSDR.JK)
R    AWSPR.KL=FSHIFT(APLAN.K)
A    ADELR.K=24/AURGF.K
R    AWSDR.KL=DELAY3(AWSPR.JK,ADELR.K)
NOTE      AWSP     ALLIED WEAPON SYSTEMS IN PRODUCTION
NOTE      AWSPR    ALLIED WEAPON SYSTEMS PRODUCTION RATE
NOTE      APLAN    ALLIED PLANNED PRODUCTION
NOTE      ADELR    ALLIED DELAY RATE IN PRODUCTION
NOTE      AURGF    ALLIED URGENCY FACTOR
L    AWSO.K=AWSO.J+DT*(AWSDR.JK+AWSMR.JK-AWSUR.JK+AFMSDR.JK)
NOTE      AWSO     ALLIED WEAPON SYSTEMS OPERATIONAL
NOTE      AWSDR    ALLIED WEAPON SYSTEMS DELIVERY RATE
NOTE      AWSMR    ALLIED WEAPON SYSTEMS MAINTENANCE RATE
NOTE      AWSUR    ALLIED WEAPON SYSTEMS USE RATE
NOTE      AFMSDR   ALLIED FOREIGN MILITARY SALES DELIVERY RATE
```

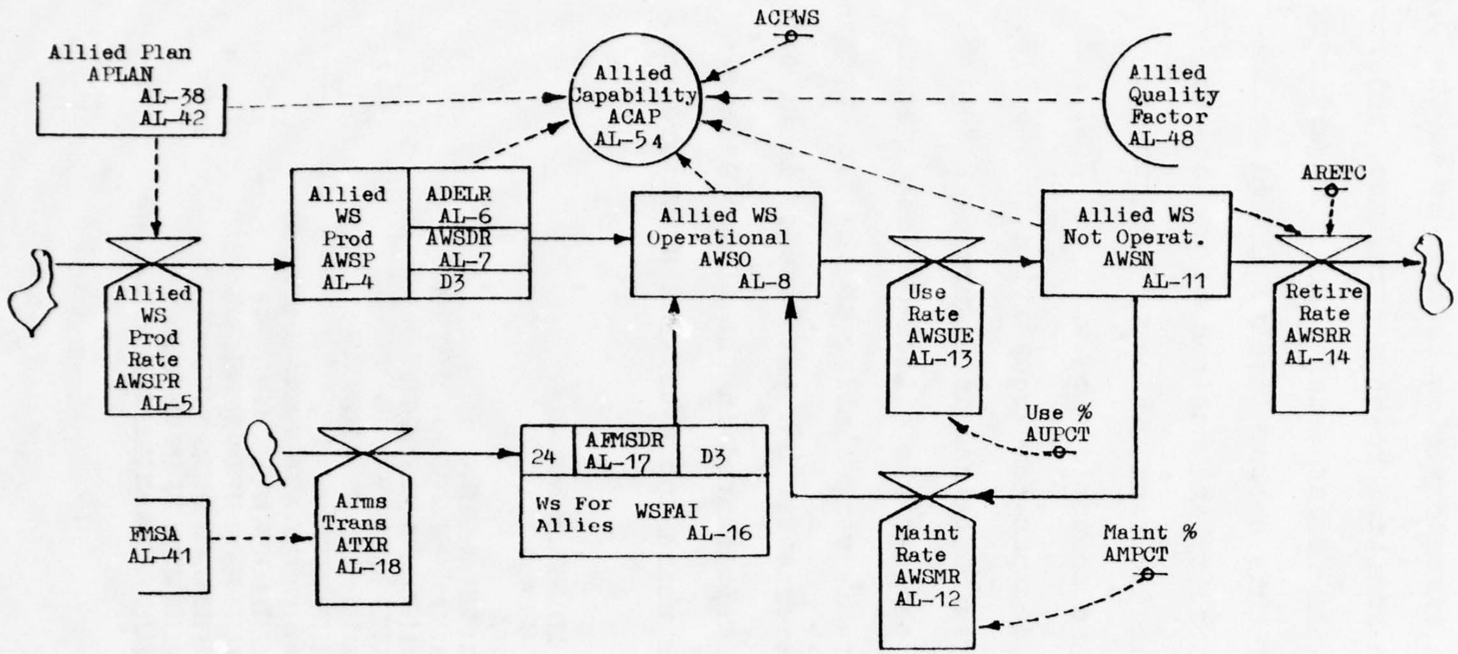

Figure 5-28

Allied Sector--Inventory

```
L    AWSN.K=AWSN.J+(DT)(AWSUR.JK-AWSMR.JK-AWSRR.JK)
R    AWSMR.KL=AWSN.K*AMPCT
R    AWSUR.KL=AWSO.K*AUPCT
R    AWSRR.KL=ARETC*AWSN.K
NOTE      AWSN     ALLIED WEAPON SYSTEMS NON-OPERATIONAL
NOTE      AWSRR    ALLIED WEAPON SYSTEMS RETIREMENT RATE
NOTE      AMPCT    ALLIED PERCENTAGE OF WEAPONS REPAIRED
NOTE      AUPCT    ALLIED PERCENTAGE OF WEAPONS USED
NOTE      ARETC    ALLIED RETIREMENT CONSTANT
L    WSFAI.K=WSFAI.J+DT*(ATXR.JK-AFMSDR.JK)
R    AFMSDR.KL=DELAY3(ATXR.JK,24)
R    ATXR.KL=FMSIFT(FMSA.K)
NOTE      WSFAI    WEAPON SYSTEMS FOR ALLIED INVENTORIES
NOTE      ATXR     ALLIED TRANSFER RATE
NOTE      FMSA     FOREIGN MILITARY SALES AGREEMENTS
NOTE      ARETC    ALLIED RETIREMENT CONSTANT
```

U.S. transfer of arms to allied nations is determined by the level of approved foreign military sales agreements. Systems are scheduled for delivery to the allies after a delay to facilitate administrative and procurement activities which must occur to prepare the weapon systems order. The combined effect of allied inventories leads to capability. This capability includes both quantitative and qualitative features as noted in the Need Sector for U.S. defense.

In the model, the qualitative features which relate to allied inventories are represented as a function of the degree of standardization between U.S. and allied inventory and the average age of the allied force. The flow diagram contained in Figure 5-29 depicts the determination of aging and standardization. The following equations correspond to the standardization aspect of inventory quality:

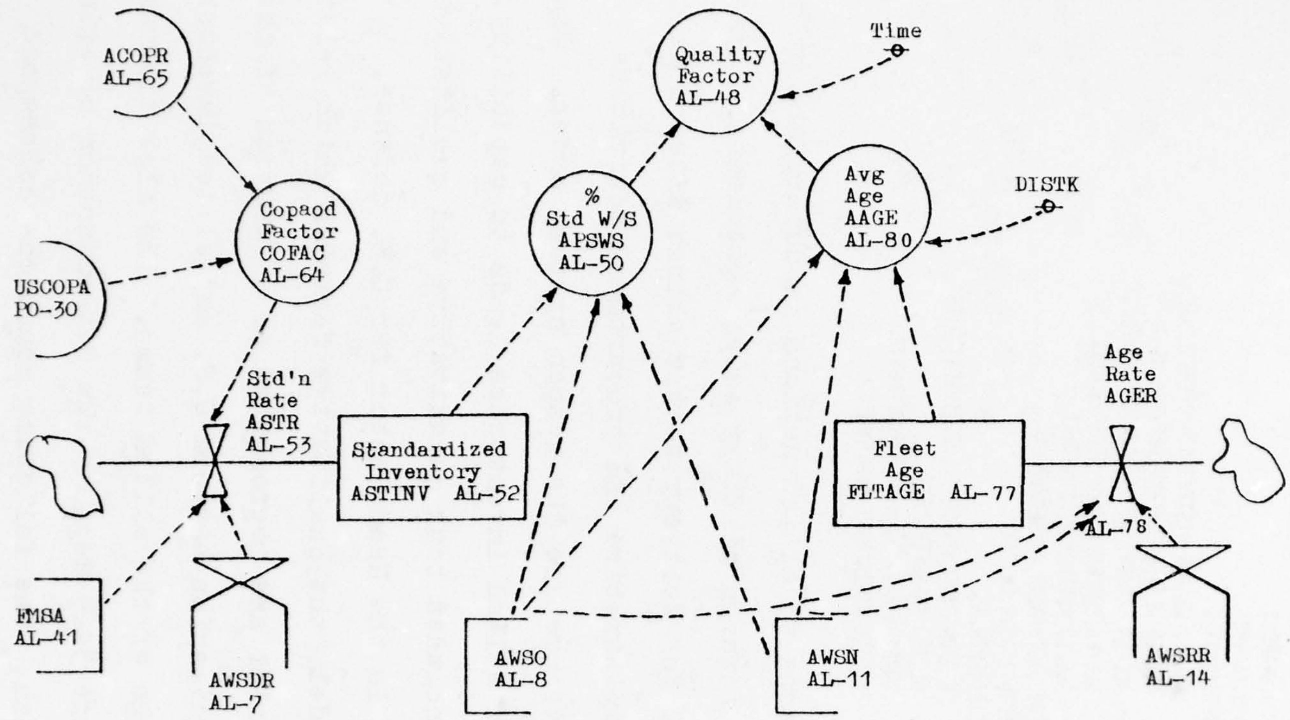

Figure 5-29

Allied Sector--Aging and Standardization

```
A    AGEF.K=TABHL(AGFT,AAGE.K/12,0,10,1)
T    AGFT=1/1/1/1/1/1.25/1.75/2.5/3.25/4.15/6.0
NOTE      AGEF     AGE FACTOR
NOTE      AAGE     AVERAGE AGE
NOTE
A    STDF.K=TABHL(STDFT,APSWS.K,0,1,.1)
T    STDFT=2/1.75/1/.85/.65/.43/.30/.23/.17/.12/.05
NOTE      STDF     STANDARDIZATION FACTOR
A    AQF.K(MO)=TABHL(AQUAL,T(MO)*AGEF.K/STDF.K,0,120,12)
T    AQUAL=1.0/.99/.99/.98/.95/.85/.7/.55/.35/.25/.1
NOTE      AQF      ALLIED QUALITY FACTOR
NOTE      T        TIME
A    APSWS.K=ASTINV.K/(AWSO.K+AWSN.K)
L    ASTINV.K=ASTINV.J+DT*(ASTR.JK)
R    ASTR.KL=FMSA.K(1)+SWITCH(0,AWSDR.JK,COFAC.K)
A    COFAC.K=ACOPR.K*USCOPA.K
NOTE      APSWS    ALLIED PERCENTAGE OF STANDARDIZED WEAPON SYSTEMS
NOTE      ASTINV   ALLIED STANDARDIZED INVENTORY
NOTE      AWSO     ALLIED WEAPON SYSTEMS OPERATIONAL
NOTE      AWSN     ALLIED WEAPON SYSTEMS NON-OPERATIONAL
NOTE      ASTR     ALLIED STANDARDIZATION TRANSFER RATE
NOTE      FMSA     FOREIGN MILITARY SALES AGREEMENTS
NOTE      AWSDR    ALLIED WEAPON SYSTEMS DELIVERY RATE
NOTE      COFAC    COPRODUCTION FACTOR
NOTE      ACOPR    ALLIED COPRODUCTION REQUEST
NOTE      USCOPA   US COPRODUCTION AGREEMENT
```

Standardization results from both foreign military sales and co-production agreements. As the number of allied systems common to U.S. forces increases, the overall quality factor is increased. This concept assumes that capability is enhanced as support increases. Standardized equipment enhances the logistics system's ability to respond to demands for equipment, supplies, and personnel to support mission requirement for both U.S. and allied forces. This is particularly important in wartime.

The age of the force also impacts the quality aspect of the allied inventory. The equations for this concept are:

```
N   FLTAGE=AAGE*WSO
L   FLTAGE.K=FLTAGE.J+DT*(AGER.JK)
R   AGER.KL=AWSO.K+AWSN.K-AWSRR.JK*AAGE.K*DISTK
NOTE     FLTAGE  COMBINED AGE OF ALLIED FLEET
NOTE     AWSO    ALLIED WEAPON SYSTEMS OPERATIONAL
NOTE     AGER    ALLIED AGE RATE
NOTE     AWSN    ALLIED WEAPON SYSTEMS NON-OPERATIONAL
NOTE     AWSRR   ALLIED WEAPON SYSTEMS RETIREMENT RATE
NOTE     DISTK   DISTRIBUTION CONSTANT
A   AAGE.K=FLTAGE.K/(AWSO.K+AWSN.K)
NOTE     AAGE    AVERAGE AGE OF ALLIED WEAPONS
```

The product of weapon system quantities and the related quality is the basis for determining allied capability. Capability is used to compare to threats in order to determine weapon system plans. The same concept as applied in the U.S. needs sector is used. In Figure 5-30 the threat assessment and planning activity are shown. The following equations correspond to the portion of the flow diagram which depicts deficiency identification.

```
A   ACAP.K(MO)=(AWSO.K+AWSN.K+AWSP.K+SUMV(APLAN.K(*),1,
X   T(MO)))*ACPWS*AQF.K(MO)
A   ADEF.K(MO)=MAX(ADIF.K(MO),Ø)*ADPCT.K
A   ADIF.K(MO)=ECAP.K(MO)-ACAP.K(MO)-USCAP.K(MO)
NOTE     ADEF    ALLIED DEFICIENCY
NOTE     ADIF    ALLIED DIFFERENCE IN CAPABILITY
NOTE     ADPCT   ALLIED PERCENTAGE OF DEFICIENCY
NOTE     ECAP    ENEMY CAPABILITY
NOTE     ACAP    ALLIED CAPABILITY
NOTE     USCAP   US CAPABILITY
A   AURGF.K=TABLE(EWGT,AURG.K/12,Ø,1Ø,1)
A   AURG.K=URGENCY(ADEF.K)
NOTE     AURGF   ALLIED URGENCY FACTOR
NOTE     EWGT    URGENCY WEIGHTING TABLE
NOTE     AURG    ALLIED URGENCY--TIME TO FIRST DEFICIENCY
```

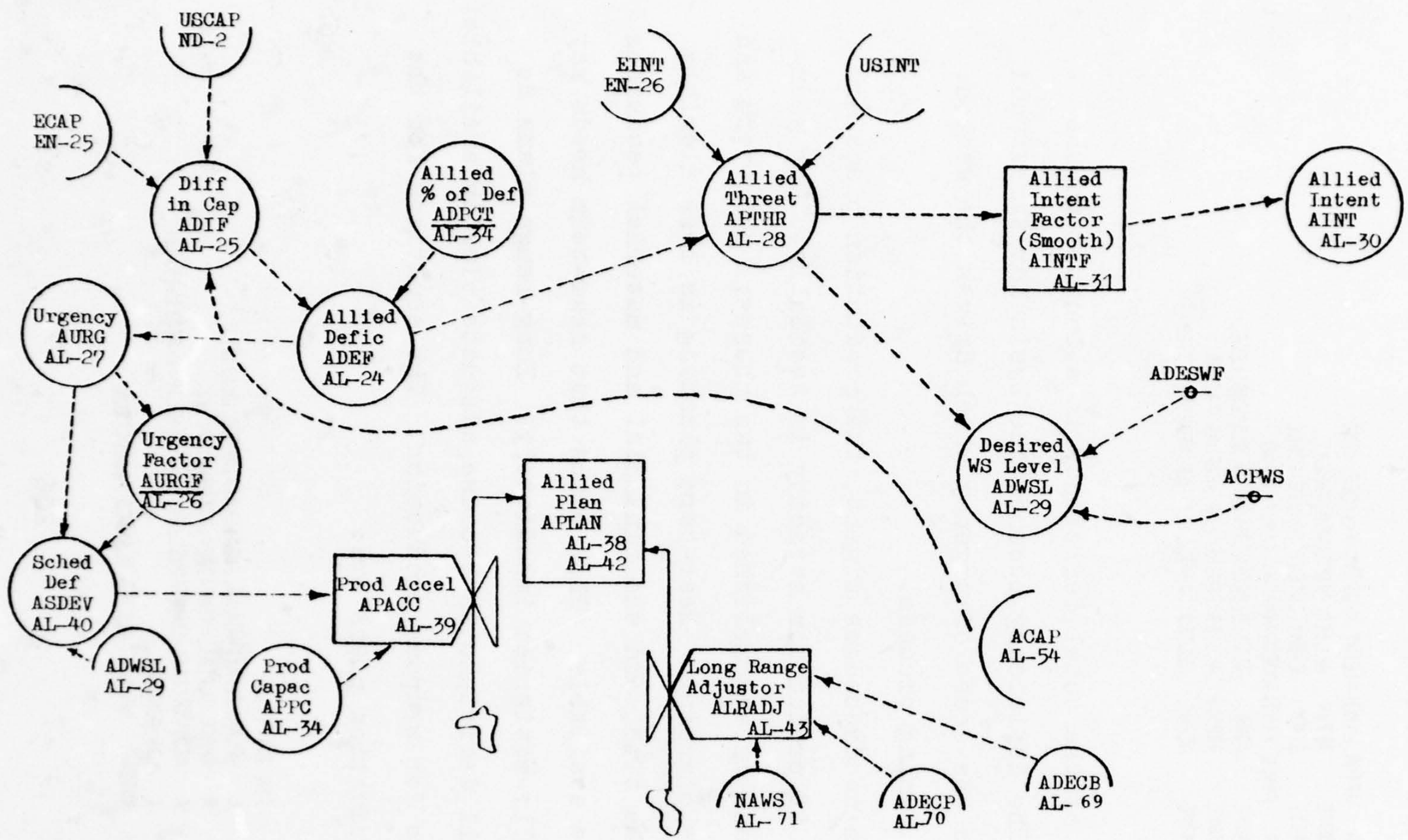

Figure 5-30

Allied Sector--Threat Assessment and Planning

```
A    APTHR.K(MO)=(EINT.K-USINT.K)*ADEF.K(MO)
NOTE      APTHR    ALLIED PERCEIVED THREAT
NOTE      EINT     ENEMY INTENT TO USE FORCE
A    ADWSL.K(MO)=ADESWF*APTHR.K(MO)/ACPWS
NOTE      ADWSL    ALLIED DESIRED WEAPON SYSTEMS LEVEL
NOTE      ADESWF   ALLIED DESIRE FOR WEAPONS FACTOR
NOTE      ACPWS    ALLIED CAPABILITY PER WEAPON SYSTEM
```

A portion of the total deficiency is allocated to the allies. The deficiency becomes the basis for threat and determines the sense of urgency which drives the weapon systems planning process.

As needs become urgent, the production plans are increased if production capacity is available. The planning process is accomplished in two phases: near-term and long-range planning. Near-term planning is less flexible because the time, and the financial and material resources may not be available. This means that near-term needs may not be fully satisfied immediately. Long-range plans do reflect all deficiencies because adequate time is available to prepare for weapons production. The equations for the allied production plans are:

```
FOR IA1=1,36
L    APLAN.K(IA1)=APLAN.J(IA1)+DT*(APACC.JK(IA1))
R    APACC.KL(IA1)=MIN(ASDEV.K(IA1),APPC.K)
A    ASDEV.K(IA1)=SUMV(ADWSL.K(*),1,36)*CLIP(1,Ø,T(IA1),12)/
X    (36-AURG.K)
NOTE      APLAN    ALLIED PLANNED PRODUCTION
```

```
NOTE     APACC   ALLIED PRODUCTION ACCELERATOR
NOTE     ASDEV   ALLIED SCHEDULE DEVIATION
NOTE     APPC    ALLIED PROJECTED PRODUCTION CAPACITY
NOTE     ADWSL   ALLIED DESIRED WEAPON SYSTEMS LEVEL
NOTE     AURG    ALLIED URGENCY--TIME TO FIRST DEFICIENCY
NOTE     T       TIME
FOR IA2=37,120
L   APLAN.K(IA2)=APLAN.J(IA2)+DT*(ALRADJ.JK(IA2-36))
R   ALRADJ.KL(IA2-36)=CLIP(NAWS.K(IA2),0,ADECP.K,ADECB.K)
NOTE     ALRADJ  ALLIED LONG-RANGE ADJUSTMENT RATE
NOTE     NAWS    NUMBER OF ALLIED WEAPON SYSTEMS
NOTE     ADECP   ALLIED DECISION TO PRODUCE
NOTE     ADECB   ALLIED DECISION TO BUY
```

The allied intent to use force is a function of the threat perceived. As threat increases, the allies may seek other alliances if the U.S. is not able or willing to provide support. This action changes the allied intent towards the U.S. causing a change in the deficiency equation: the allies become friendly towards the enemy, thus reducing their perceived threat. The equations which represent this concept are:

```
A   AINT.K=TABHL(AWGT,AINTF.K,-1,1,.2)
A   AINTF.K=SMOOTH(SUM(APTHR.K)/120,3)
T   AWGT=0/0/0/.05/.10/.25/.45/.85/.99/-.60/-1.00
NOTE     AINT    ALLIED INTENT TO USE FORCE
NOTE     AINTF   ALLIED INTENT FACTOR
NOTE     APTHR   ALLIED PERCEIVED THREAT
A   ADPCT.K=TABLE(APFT,AINT.K,-1,1,.2)
T   APFT=-1.0/-.86/-.25/-.15/-.05/0/.05/.15/.25/.60/.65
NOTE     ADPCT   ALLIED PERCENTAGE OF DEFICIENCY
```

The allied decision concerning production or purchase of weapons is influenced by the ability of their industrial base to produce weapons. The flow diagram contained in Figure 5-31 depicts the decision structure which exists to determine make or buy decisions. The following equations correspond to the diagram.

```
A    ARUCWS.K=RAADP.K*RESCF.K
A    RESCF.K=TABXT(RSCFT,RAADP.K,0,100,10)
T    RESCFT=1.E6/1.E4/1000/650/400/280/200/140/80/40/10
NOTE      ARUCWS  ALLIED RESOURCE UNIT CONSTRAINT PER WEAPON SYSTEM
NOTE      RAADP   RESOURCES ALLOWED FOR ALLIED DEFENSE PRODUCTION
NOTE      RESCF   RESOURCE COST FACTOR
A    ACAPDP.K=MIN(ARUCWS.K,AGNP.K*APGNPD)
NOTE      ACAPDP  ALLIED CAPACITY FOR DEFENSE PRODUCTION
NOTE      ARUCWS  ALLIED RESOURCE UNIT CONSTRAINT PER WEAPON SYSTEM
NOTE      AGNP    ALLIED GROSS NATIONAL PRODUCT
NOTE      APGNPD  ALLIED PERCENT OF GNP TO DEFENSE
C    APGNPD=.003
N    AGNP=1E10
L    AGNP.K=AGNP.J+DT*(AGNPGR.JK)
R    AGNPGR.KL=AGNP.K*AGNPGF
C    AGNPGF=.002
NOTE      APGNPD  ALLIED PERCENT OF GNP TO DEFENSE
NOTE      AGNP    ALLIED GROSS NATIONAL PRODUCT(GNP)
NOTE      AGNPGR  ALLIED GNP GROWTH RATE
NOTE      AGNPGF  ALLIED GNP GROWTH FACTOR
NOTE      ACAPDP  ALLIED CAPACITY FOR DEFENSE PRODUCTION
NOTE      ADECP   ALLIED DECISION TO PRODUCE
```

Productive capacity is determined by the constraints from resources and the economy. If more capacity exists than is planned for defense, the allied desire to co-produce increases. If the productive capacity is not sufficient to meet all needs for defense production, the allied nation must consider foreign military sales with the U.S.

The allied decision process relative to foreign military sales is depicted in the flow diagram contained in Figure 5-32. The equations for this diagram follow:

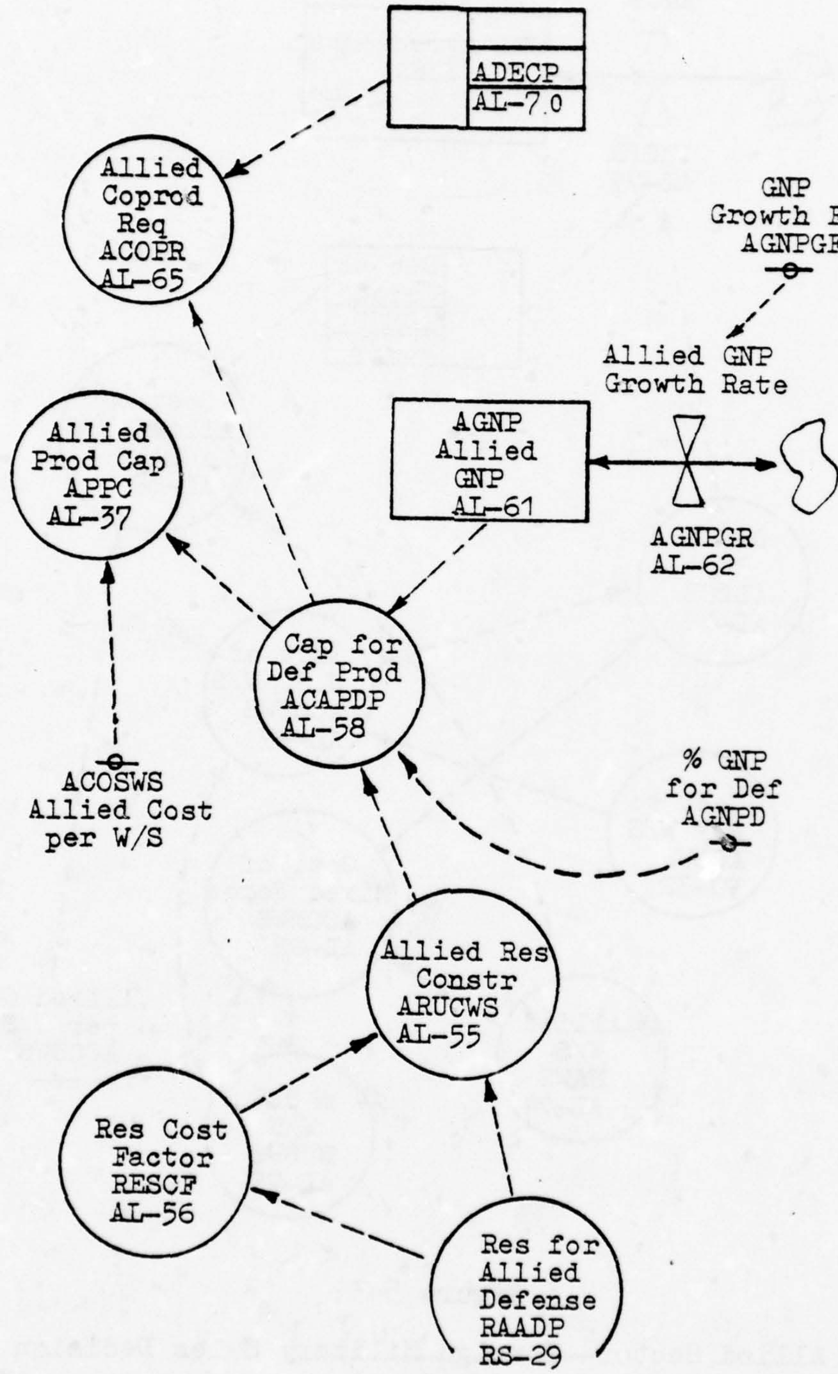

Figure 5-31

Allied Sector--Production Capacity

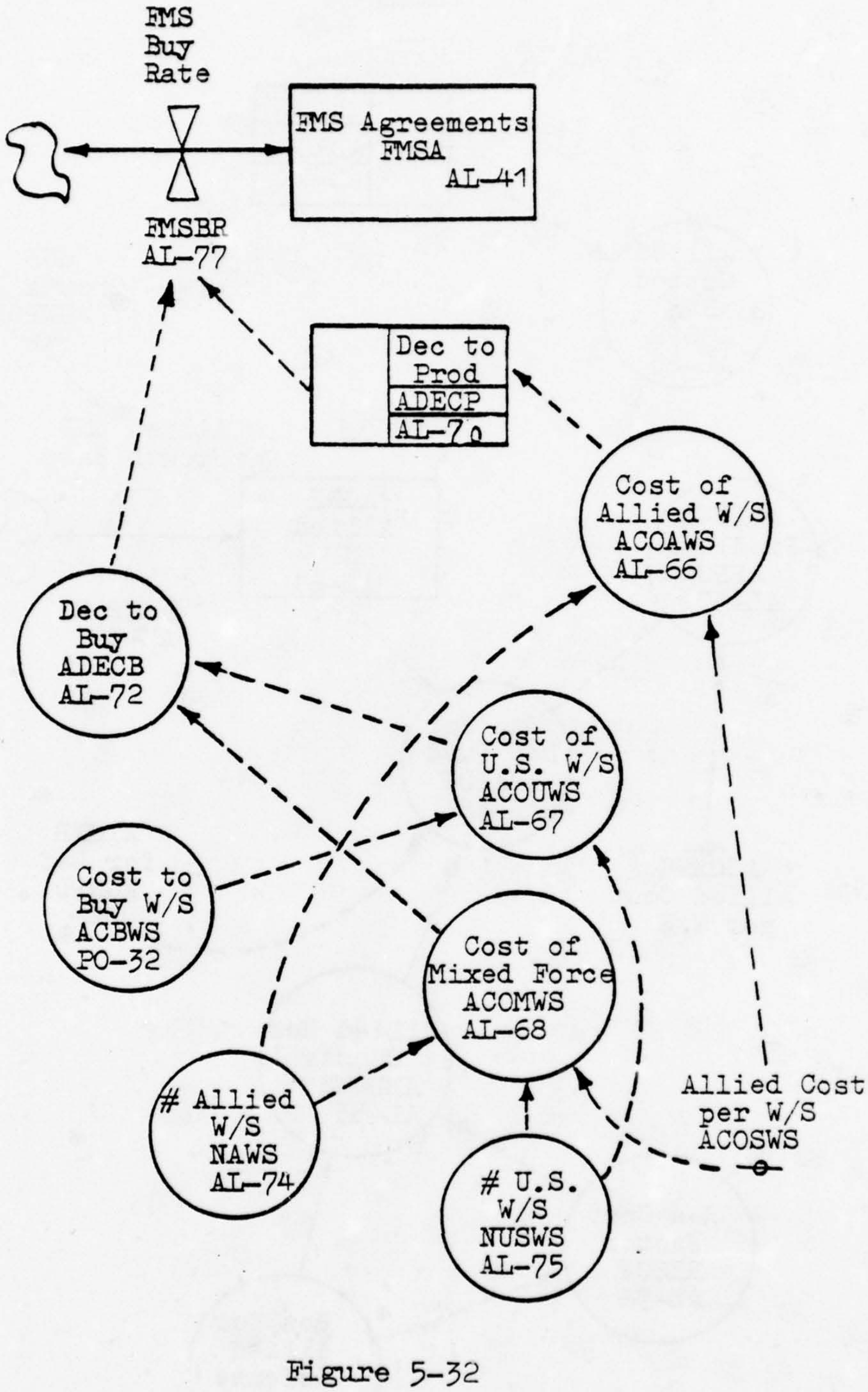

Figure 5-32

Allied Sector--Foreign Military Sales Decision

```
A    NAWS.K(MO)=CLIP(APTHR.K(MO)-USCPWS.K*COMP.K(MO),ADWSL.K(MO),
X    ADECP.K,ACOAWS.K)
NOTE      NAWS    NUMBER OF ALLIED WEAPON SYSTEMS PLANNED
NOTE      COMP    COMPUTED TRADEOFF FACTOR
NOTE      ADECP   ALLIED DECISION TO PRODUCE
NOTE      ACOAWS  ALLIED COST FOR ALLIED WEAPON SYSTEMS
A    NUSWS.K(MO)=CLIP(ACPWS*COMP.K(MO),APTHR.K(MO)/USCPWS.K,
X    ADECP.K,ACOUWS.K)
NOTE      NUSWS   NUMBER OF US WEAPON SYSTEMS PLANNED
NOTE      ACPWS   ALLIED CAPABILITY PER WEAPON SYSTEM
NOTE      COMP    COMPUTED TRADEOFF FACTOR
NOTE      ADECP   ALLIED DECISION TO PRODUCE
NOTE      ACOUWS  ALLIED COST FOR US WEAPON SYSTEMS
A    COMP.K(MO)=(ACOSWS*APTHR.K(MO)-ACAPDP.K))/(USCPWS.K*ACOSWS
X    -ACPWS*ACBWS.K)
NOTE      ACAPDP  ALLIED CAPACITY FOR DEFENSE PRODUCTION
NOTE      ACBWS   ALLIED COST TO BUY WEAPON SYSTEMS
```

The decision process involves a trade-off of cost and threat considerations of three alternatives: total self-sufficiency, a mix of U.S. and allied inventory, or foreign military sales. The goal in this trade-off is assumed to be cost oriented as long as the deficiency is satisfied. The evaluation which precedes this decision involves an analysis of cost, desire for weapon systems, threat, current plans, and capability. The decision which results from this analysis and the inventory mix determination establishes the basis for foreign military sales desires. The equations which represent the inventory mix are:

```
L    FMSA.K(MO)=FMSA.J(MO)+DT*(FMSBR.JK(MO))
R    FMSBR.KL(MO)=CLIP(NUSWS.K(MO),Ø,ADECP.K,ADECB.K)
NOTE      FMSA    FOREIGN MILITARY SALES AGREEMENT
NOTE      FMSBR   FOREIGN MILITARY SALES BUY RATE
NOTE      NUSWS   NUMBER OF US WEAPON SYSTEMS PLANNED
NOTE      ADECP   ALLIED DECISION TO PRODUCE
NOTE      ADECB   ALLIED DECISION TO BUY
```

```
A    ACOAWS.K=SUM(ADWSL.K)*ACOSWS
A    ACOUWS.K=SUM(APTHR.K)*ACBWS.K/USCPWS.K
A    ACOMWS.K=SUM(NAWS.K)*ACOSWS+SUM(NUSWS.K)*ACBWS.K
NOTE      ACOAWS  ALLIED COST FOR ALLIED WEAPON SYSTEMS
NOTE      ACOSWS  ALLIED COST PER WEAPON SYSTEM
NOTE      ACOUWS  ALLIED COST FOR US WEAPON SYSTEMS
NOTE      ACBWS   ALLIED COST TO BUY WEAPON SYSTEMS
NOTE      USCPWS  US CAPABILITY PER WEAPON SYSTEM
NOTE      NAWS    NUMBER OF ALLIED WEAPON SYSTEMS PLANNED
NOTE      NUSWS   NUMBER OF US WEAPON SYSTEMS PLANNED
A    ADECB.K=MIN(ACOUWS.K,ACOMWS.K)
A    ADECP.K=SMOOTH(MIN(ADECB.K,ACOAWS.K),1)
NOTE      ADECB   ALLIED DECISION TO BUY
NOTE      ACOUWS  ALLIED COST FOR US WEAPON SYSTEMS
NOTE      ACOMWS  ALLIED COST FOR MIXED WEAPON SYSTEMS INVENTOR
NOTE      ADECP   ALLIED DECISION TO PRODUCE
```

The role of allied defense in the worldwide military environment is important. As allies seek to protect themselves from enemy threat, the total U.S./allied capability increases and presents a threat to the enemy.

Enemy Sector

The final sector depicts the flow of weapon systems and the related information network applicable to enemy defense. This sector depicts two primary structures. The first is the actual flow of inventory in the enemy defense system. The second depicts the threat analysis, political intentions, and defense planning activities. The enemy sector flow diagrams are provided in Figure 5-33 and 5-34. The similarities to the allied structures contained in Figure 5-28 and 5-30 should be noted. The equations which

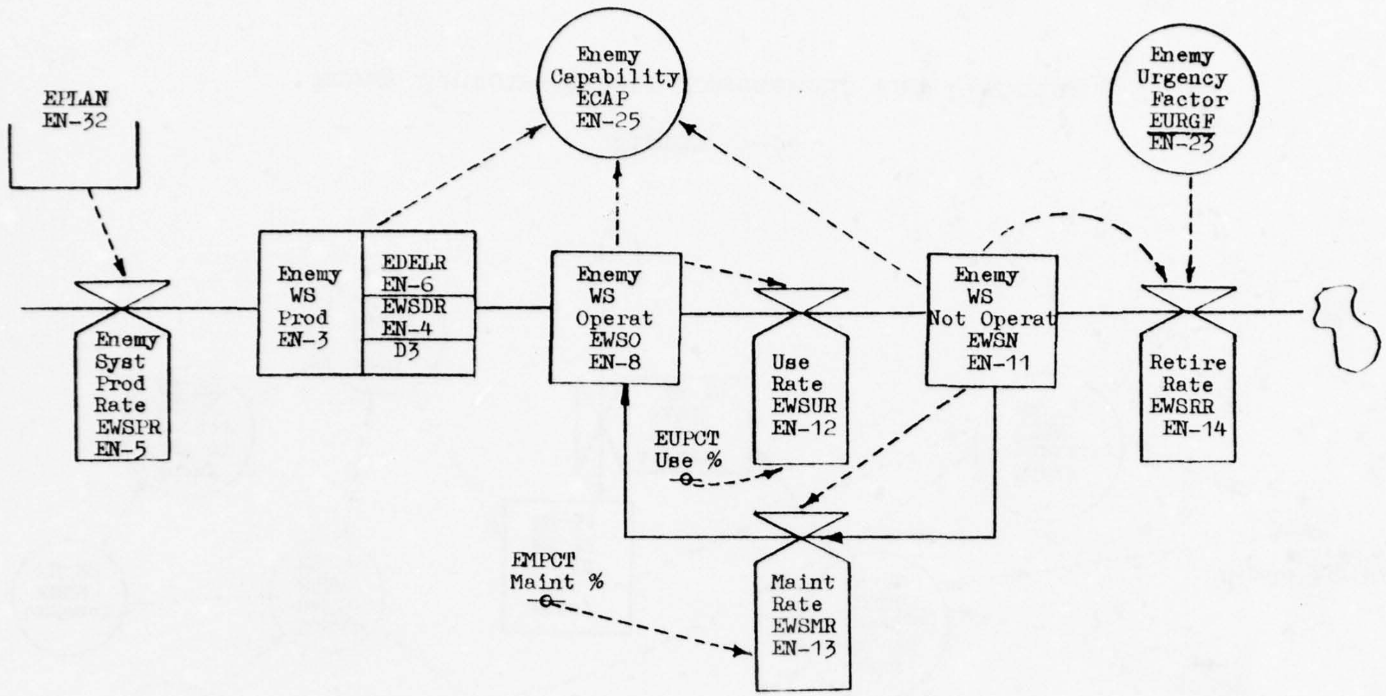

Figure 5-33

Enemy Sector--Inventory

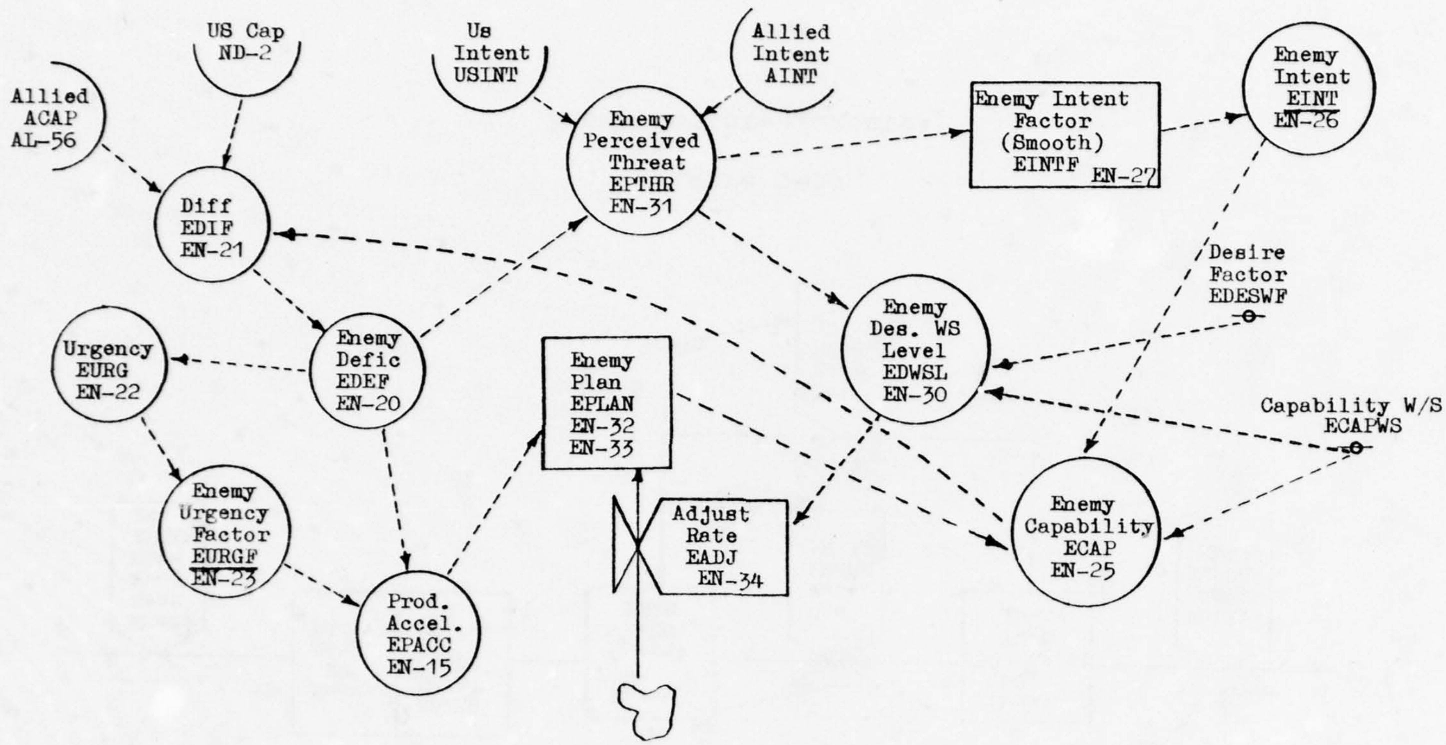

Figure 5-34

Enemy Sector--Threat Assessment and Planning represent the flows of inventory in the enemy system are given below:

```
L    EWSP.K=EWSP.J+(DT)(EWSPR.JK-EWSDR.JK)
R    EWSDR.KL=DELAY3(EWSPR.JK,EDELR.K)
R    EWSPR.KL=FSHIFT(EPLAN.K)
NOTE      EPLAN    ENEMY PLANNED PRODUCTION
NOTE      EWSP     ENEMY WEAPON SYSTEMS PRODUCTION
NOTE      EWSPR    ENEMY WEAPON SYSTEMS PRODUCTION INPUT RATE
NOTE      EWSDR    ENEMY WEAPON SYSTEMS DELIVERY RATE
A    EDELR.K=24/EURGF.K
NOTE      EDELR    ENEMY PRODUCTION DELAY FACTOR
NOTE      EURGF    ENEMY URGENCY FACTOR
L    EWSO.K=EWSO.J+(DT)(EWSDR.JK+EWSMR.JK-EWSUR.JK)
NOTE      EWSO     ENEMY WEAPON SYSTEMS OPERATIONAL
L    EWSN.K=EWSN.J+(DT)(EWSUR.JK-EWSMR.JK-EWSRR.JK)
NOTE      EWSN     ENEMY WEAPON SYSTEMS NON-OPERATIONAL
NOTE      EWSRR    ENEMY WEAPON SYSTEMS RETIREMENT RATE
R    EWSUR.KL=EUPCT*EWSO.K
NOTE      EUPCT    ENEMY PERCENTAGE OF WEAPON SYSTEMS USED
R    EWSMR.KL=EMPCT*EWSN.K
NOTE      EMPCT    ENEMY PERCENTAGE OF WEAPONS REPAIRED
R    EWSRR.KL=EWSN.K*.002/EURGF.K
A    ECAP.K(MO)=(EWSP.K+EWSO.K+EWSN.K+SUMV(EPLAN.K(*),
X    1,T(MO)))*ECAPWS
NOTE      ECAP     ENEMY CAPABILITY
NOTE      EPLAN    ENEMY PLAN FOR WEAPON SYSTEMS PRODUCTION
NOTE      ECAPWS   ENEMY CAPABILITY PER WEAPON SYSTEM
```

The only real differences in the allied and enemy sectors are the exclusion of arms transfers in the enemy sector and the values of goals established by the enemy. In many cases, the enemy was assumed to establish higher goals concerning weapon system inventory and desired capability. These desires influence the worldwide threat situation.

The equations which apply to the enemy evaluation of threat are similar to the concepts presented in both the U.S. and allied defense systems. Threat is a function of the relative difference in capability and the intent of others to use force. This threat, in turn, determines the intent of the enemy towards others. The equations which apply to enemy threat are:

```
A    EINT.K=TABHL(EINTT,SUM(EPTHR)/12Ø,-1,1,.2)
NOTE      EINT     ENEMY INTENT
NOTE      EPTHR    ENEMY PERCEIVED THREAT
T    EINTT=1.99/1.7/1.3/1.15/1.Ø5/1/1.Ø5/1.15/1.3/1.7/1.99
A    EINTF.K=SMOOTH(SUM(EPTHR)/12Ø,3)
NOTE      EINTF    ENEMT INTENT FACTOR
A    EDWSL.K(MO)=EDESWF*EPTHR.K(MO)/ECAPWS
NOTE      EDWSL    ENEMY DESIRED WEAPON SYSTEMS LEVEL
NOTE      EDESWF   ENEMY DESIRE FOR WEAPONS FACTOR
NOTE      ECAPWS   ENEMY CAPABILITY PER WEAPON SYSTEM
A    EPTHR.K(MO)=(USINT.K+AINT.K)*EDEF.K(MO)
NOTE      USINT    US INTENT
NOTE      AINT     ALLIED INTENT
NOTE      EDEF     ENEMY DEFICIENCY
```

The deficiency is determined by the evaluation of U.S., allied, and enemy capabilities. The difference between the capability is considered the deficiency which will be included in the enemy production plan. The equations are:

```
A    EDEF.K(MO)=MAX(EDIF.K(MO),Ø.Ø)
NOTE      EDEF     ENEMY DEFICIENCY
NOTE      EDIF     ENEMY DIFFERENCE IN CAPABILITY
A    EDIF.K(MO)=USCAP.K(MO)+ACAP.K(MO)-ECAP.K(MO)
NOTE      USCAP    US CAPABILITY
NOTE      ACAP     ALLIED CAPABILITY
NOTE      ECAP     ENEMY CAPABILITY
A    EURG.K=URGENCY(EDEF.K)
NOTE      EURG     ENEMY URGENCY--TIME TO FIRST DEFICIENCY
T    EWGT=2.Ø/1.75/1.35/1.15/1.Ø5/1./.99/.98/.97/.97/.96
A    EURGF.K=TABLE(EWGT,EURG.K,Ø,12Ø,12)
NOTE      EURGF    ENEMY URGENCY FACTOR
```

The final concept within the enemy sector is the development of the production plan. The plan is similar to the concept described for the allied sector; however, no resource constraints are considered. Near-term plans are considered less flexible than long-range plans because of the planning cycle required to develop and evaluate industrial capability and provide financial and material resources to defense production. The equations that represent enemy production planning are:

```
FOR ME=1,36
L    EPLAN.K(ME)=EPLAN.J(ME)+(DT)(EPACC.JK)
NOTE     EPLAN   ENEMY PLAN FOR WEAPON SYSTEMS PRODUCTION
NOTE     EPACC   ENEMY PRODUCTION ACCELERATOR
FOR MEE=37,120
L    EPLAN.K(MEE)=EPLAN.J(MEE)+DT*(EADJ.JK(MEE-36))
R    EADJ.KL(MEE-36)=EDWSL.K(MEE)
NOTE     EADJ    ENEMY ADJUSTMENT RATE
```

In summary, the enemy sector is developed in less detail because less information is available to managers in the U.S. acquisition system about the decision process. The conclusions made about enemy decisions result from evaluation of hardware inventories, plans, and the political environment which affects the goals and desires of the enemy defense system. Enemy goals provide the basis for the positive feedback loop which is characterized by the arms race. This becomes the stimulus for DOD mission requirements and subsequent acquisitions of weapon systems and military equipment.

Summary

In this chapter the decision structure which affects actions in the DOD acquisition process was developed. The system dynamics methodology provided a meaningful way to display the important states, flows, and decisions which exist. These concepts were further enriched by mathematical equations which provide greater detail to the concepts which have been developed throughout this thesis. The analysis of the descriptive information contained in Chapter 4 and the structural information contained in this chapter provide great insight into the reasons for much of the behavior in the systems acquisition process. This insight increases management's understanding of the system processes and provides a basis to determine the impact of policy decisions prior to implementation.

In the next chapter, the conclusions of the research will provide a basis for recommendations to improve the system and address the managerial applications of policy modeling of complex and dynamic systems.

Chapter 6

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

The primary goal of this research was to develop a policy model of the DOD systems acquisition process. The model was developed to assist management in understanding the complex and dynamic nature of the system and to provide a tool for policy development and analysis. As noted in Chapter 1, eight specific objectives were established in order to achieve this goal. The objectives were:

1. identify the structure of the systems acquisition process;

2. isolate the interactions and influence of the components and variables within the system;

3. describe the decision structure that determines the information, money, and material flows within the system;

4. construct a mathematical model which represents the components, relationships, information flows, and decisional policies of the system;

5. develop a computerized model which can be used for policy analysis and development;

6. verify and validate that the model represents the structure and decision-making process within the systems acquisition process;

7. identify areas of sensitivity or critical issues in acquisition policy; and

8. suggest changes, if required, in the management structure of the systems acquisition process.

The purpose of this chapter is to summarize the research effort by review of the research methodology and findings relative to each objective. In addition, conclusions and recommendations for management application of the policy model will be addressed. Finally, suggestions for further research will be proposed in order to extend the theory and application of policy modeling of the systems acquisitions process within DOD.

Summary of Research

The first objective of this research was to identify the structure of the systems acquisition process. This involved identification of the major components within the system as well as defining the system boundary. The structure was extended beyond the traditional processes that are associated with acquisition. The purpose of extending the boundaries was to capture the political process which affects the goals and policies established for DOD and the acquisition of major weapon systems. The political process involves internal U.S. and international relationships. The system was divided into ten sectors in order to assist in analysis and model construction. These sectors are explained in greater detail in the conceptual model presented in Chapter 4. The sectors included were:

Political, Need, Financial, Technology, Weapon Systems Research and Development, Resources, Production, U.S. Operations, Allied Defense, and Enemy Defense. The elements within each sector and relationships between sectors provided a means to achieve the second objective.

The isolation of interactions and influences between variables within the system was accomplished through a two-part approach. The first resolution of the model was developed as a result of knowledge obtained from a formal literature review, experience, and observations about the system. The second part of the research involved verifying and validating the relationships by discussions with key managers within the acquisition system. The results of this effort are presented in the description and diagrams contained in Chapter 4. The research revealed that several key variables within the system influence many of the decisions and processes. These variables determine the nature of the major feedback loops. Threat and capability appeared to be the driving factors in the identification of needs. Approval of needs was influenced by the political environment which included international intentions and specific desires for DOD weapon systems. The satisfaction of needs was determined by both the financial process and the research, development, production, and deployment of weapons. The dollars provided to DOD for system acquisitions represent the implicit policy concerning the relative importance of DOD in the achievement of national goals and objectives. The weapon system program characteristics determine the ultimate capability and cost of the system.

The third objective of the research was to describe the decisional structure that determined the informational, money and material flows within the system. The flow diagrams and discussion in Chapter 5 document the results of this effort. Four specific decisional structures were studied in relationship to the system. The first was the mission-area planning structure that exists to identify and evaluate needs. This structure was difficult to capture because of the vagueness of threat and capability assessments. Recently, a new technique has been applied which aims to institutionalize a procedure which may lead to improvements in the process. The second process which was analyzed was the Defense Systems Acquisition Review Council decisons. This group is responsible for making the decisions which relate to approving mission area needs. In this decision, the trade-offs between various alternatives to satisfy a specific need were addressed. The new policies implementing OMB Circular A-109 have somewhat altered the decisional process; therefore, the relative weights of the decisional variables appear to be changing. The third decisional process which was developed in the model is the programming and budgeting process which determines the amount of dollars available for DOD acquisitions. This process seeks to evaluate the various funding alternatives to be pursued within DOD. All three of these decisional structures require a large amount of data in order to evaluate alternatives. The research revealed that although much data were provided to the decision-makers, few alternatives were actually evaluated. The major reasons given for this were the volume and the timing of information. The fourth decisional structure in the model was the program management evaluations required to achieve cost, schedule, and performance goals. The research indicated that there was a general bias to forego cost aspects of a program in order to meet schedule and performance goals; however, cost was becoming more important to the decisional process. In summary, the decisional processes relative to systems acquisitions are similar. Research revealed that managers use similar information to make decisions; however, the amount, timing, and format of information partially determined the number of trade-offs that are made between and among alternatives.

The fourth research objective was to develop a mathematical model which represented the components, relationships, information flows, and decisional policies of the system. This was accomplished by developing the structural model contained in the flow diagrams into mathematical relationships believed to represent the system. The specific measurement and dimensions of the variables resulted from the functional relationships noted in the literature review and the interview process. Parametric techniques were not used; however, the relationships provide meaningful representations of the real system. The measurement criteria for several concepts was very difficult to develop. These concepts include variables such as threat, capability, technology, and political desires. Consideration of these variables was accomplished by developing comparative measures to portray the relationships which existed between variables that were not well measured in the actual acquisition system. The system equations are presented in Chapter 5.

The mathematical equations were developed using the DYNAMO simulation notation in order to accomplish the fifth research objective. Experiments with the simulation model are recommended for policy analysis and development; however, this was beyond the scope of this research. At the close of the research effort, the model was tested and initial results indicated there were no major defects with the system logic, although additional testing was required to fully verify and validate the model operation. It may now be used for policy analysis.

Although the model was not exercised fully, the sixth research objective was accomplished by verifying and validating the model concept and structure. This task was accomplished throughout the research to ensure internal validity and to verify that the model was consistent with development intentions. This repetitive approach led to model integrity even though the behavior of the system was not observed through model operation. The confirmation of concepts and system structure addressed in the interview process provided credence to the model validity and usefulness in policy analysis.

The seventh research objective was to identify areas sensitive to the system behavior. The issues and discussions in Chapter 4 identify areas of current concern. Specific attention was given to the political goals and desires of the system. The power and inclinations of the political process make it important to understand the role of the systems acquisition in national policy development. The impact of this process normally is expressed in dollars which are provided for DOD research, development, production, and operations. The system was noted to be very stable. Analysis of past performance and results of policy changes indicated that the long delays within the system create much of the stability, despite the cyclical actions of the DSARC and funding processes. The complexity of the system appears to make it difficult to institute changes in system behavior when only several variables are changed. Forrester stated that this is characteristic of multi-looped systems of complex systems. The important areas which appear to affect the system are in the major feedback loops. The evaluation of threat and capability is essential to determining the requirements which must be satisfied by systems acquisition and support. The political environment is also essential to the behavior of the system. Finally, the goals that are established within DOD for specific weapon system performance characteristics impacts the down-stream cost, schedule, and operational performance of the system.

The eighth research objective will be addressed in the following sections of this chapter. The suggestions and recommendations to management illustrate the power which results from careful analysis of system relationships and decisional structures within large, complex systems.

Conclusions

The presentation of this research has indicated that the systems acquisition process is indeed complex. The development of a policy model provided a valuable tool for both policy analysis and development. The models presented in Chapters 4 and 5 are the basis for the following conclusions, recommendation for improvements, and the implication of policy-model use in analysis and development of DOD acquisition policy. These conclusions represent the preliminary analysis of the policy structure within the system; however, it is recommended that the full impact of the policy decisions which result from analysis be evaluated through exercising the simulation model developed in this research.

The first general research conclusion concerns the system decision structure. The structure which supports policy decisions in the DOD systems acquisition process does not appear to be well integrated. This was noted throughout the system processes which support decisions concerning planning, programming, budgeting, and approving needs. Key decisions relative to acquisition are difficult to make due to the multiple goals in the system, vagueness and inconsistencies within performance measures, and the nature of the information flow. Because decisions are difficult, the integrative process is essential to balance the requirements for military support. The problem appears to result from a lack of both horizontal and vertical integration of requirements and information. Horizontal integration is required in order to make the necessary trade-offs between mission areas and funding appropriations. Vertical integration is required to provide consolidated information to strategic level managers, rather than details which exist at the operating levels of the acquisition hierarchy. It is believed that the executive and legislative branches of government should serve in this integrative capacity; leaving the details of specific acquisition management problems to the Services. The strategic levels in the acquisition hierarcy must make the broad trade-offs and establish long-term goals. Implementation of the decisions and goals should be the responsibility of the lower levels of the organization as long as the intent and purpose of the policy is consistently implemented.

The second general research conclusion concerns the goal structure within the DOD systems acquisition process. There is a variety of goals established for the various sub-parts of the system. Many times these goals are in conflict or are not consistent within the levels of the organization hierarchy. These goals relate to the missions and performance measures established within each process and level within the system. As noted in Chapter 4, there are many goal seeking loops within the system. Goal disparity was apparent, particularly in the needs process. This disparity results from the performance, cost, and schedule aspects of DOD weapon systems. In addition, the goals of the political process often conflict with the established goals within DOD.

The research also revealed that there was little integration of the various sub-goals in the system. Many of the differing sub-goals resulted from the relative position of the decision-maker or organization within the acquisition hierarchy. The focus on hardware and performance goals at the operational level has not been integrated with the funding and political goals which affect the strategic level management decisional structure. The goal disparity has led to much confusion, specifically noticed in the implementation of OMB Circular A-109 policy regarding mission needs.

In addition to goal disparity resulting from mission or position in the acquisition process, the impact of short-term goals on the decision process was observed. The goals established in acquisition favor achieving near-term goals without full realization of the long-term behavioral effect. This point is illustrated by the general disregard for downstream life cycle costs associated with weapons system operations and support. Although recent trends look more promising than past actions, current research and development goals often preempt the consideration of long-term effects on logistics support.

The third general research conclusion concerns the performance measures used in system acquisition. As noted in the preceding paragraph, the measures may not be consistent within the various levels and processes within acquisition. In addition to this, research revealed that many performance measures were not well developed, leading to vagueness and confusion within the system. Several areas are specifically noted because they are considered the primary factors within the system. They include: threat, capability, research and development progress, technology, and political desires and intentions. The acquisition process can be improved if a clear understanding and meaningful measurement devices can be developed to assist in evaluating system performance. It is believed that measures can be developed for variables. Management attention should focus on developing and implementing consistent performance measures for the variables mentioned above. Of particular concern are measures for threat and capability. These measures are considered to be the primary determinants of acquisition needs. Better measures in these areas should assist in evaluating system requirements and provide a means to develop consistent plans. In addition to this, the behavior of the system may become more apparent if the vagueness of the system's performance measures is removed.

The fourth general research conclusion is intended to draw the first three conclusions together and provide the basis for a recommendation to improve the system. The flow of information throughout the system determines the decisional environment. The research revealed that the information flow within the systems acquisition process does not always support the decisions which must be made. This leads to inappropriate policies. As noted in Chapter 1, managers that operate with mental models of the processes within their responsibility often make inconsistent and incorrect decisions due to the complex and dynamic nature of the decision-making environment. The establishment of an appropriate information system to assist managers within all levels in the acquisition process is required. The system should focus on providing timely, appropriate information which is aggregated to the extent necessary for each level of management and decision-making situation. The result of this management information system should assist in making better decisions and appropriate trade-offs. In addition, the information system should address the needs to develop specific performance measures. The policy model should be used to identify the specific areas of sensitivity which can be improved through better measurement and understanding of the system process.

In addition to exercising the model to determine the areas of sensitivity, managers within the acquisition should operate the model in conjunction with policy analysis and development. Two specific uses are foreseen. The model provides an excellent tool to evaluate the effects of structural changes to the system. For example, the DSARC and PPBS systems could be linked together to determine whether the system behavior improves as a result of this policy decision. The second use for policy analysis is to evaluate the response of the system to changes in various system states. This could be used to determine the effect elements such as increasing worldwide threat or economic conditions within the country. These examples are but a few of the potential issues and problems which can be studied using the policy model. In addition to this, the model provides a powerful tool for evaluating the impact of proposed policy decisions before they are implemented in the real system.

Recommendations for Further Study

Further study is recommended in order to realize the full benefits of the policy model developed in this research. The scope of this research did not include the actual operation and analysis of the policy model in a dynamic environment. The operation of the model is recommended in order to analyze the behavior of the system over time. In addition, policy experiments should be developed to assist managers in developing effective policy for the acquisition system.

Validation of the system behavior through comparison of simulated behavior with actual historical trends is also recommended. This process should seek to refine variables and concepts as necessary to ensure an accurate representation of the real system. This research began the validation process; however, comparison with a real system environment was beyond the research scope.

The results of model operations are two-fold, each leading to further study. First, the model operation may identify areas which are highly sensitive to policy decisions or environmental situations. These areas should be the focus of specific efforts to develop precise relationships between variables using empirical analysis. Second, the search for information to develop these relationships should also consider the needs for performance measures and the information system discussed in the previous section.

Several specific areas in the model require further study in order to fully represent the system. The first area is to develop the flow of manpower within the system. Several simplifying assumptions were required in the current model. The visibility over skills, motivation, and experience could provide additional insight and meaning to the model. A second area concerns the precise relationship of the political and economic conditions on the systems acquisition process. The general linkages are portrayed; however, specific relationships were not explicitly developed. Of specific concern is the motivations of the defense industry and the increasing importance of the military alliances which affect the systems acquisition process. The final area for model expansion is the inclusion of capital equipment and production facility constraints. The research revealed conflicting information about this essential part of the system, more in-depth analysis is required.

In summary, the use of a policy models can increase the understanding of the dynamic and complex processes which relate to the systems acquisition process. The impact of policy decisions can be analyzed through policy experiments in a simulation environment. This feature is, perhaps, the most valuable to management because expectations and response of the system to changes guide strategic management's policy decisions and determine the ultimate behavior of the system. It is the authors sincere hopes that this research will be continued and contribute to the policy-making capabilities of management within the DOD systems acquisition process.

APPENDIX A

INTERVIEW GUIDE

1. <u>Goals and Objectives</u>

What are the major objectives or products relative to your organization's role in the acquisition process?

2. <u>Decision Situation</u>

a. In your area, what is one of the most critical decisions you have made concerning the acquisition process in the last month?

b. Is this decision representative of the types of decision situations in which you are involved?

c. If not, could you give me an example of recurring type of decision which you are required to address?

3. <u>Information Channels--Input</u>

a. How did you become aware of the problem or issue that required a decision?

Who?
Organization--chain of command?
External to organization?
Formal document?
Informal communication?

b. Did you seek assistance or ask for further information before making the decision?

Who did you go to?
What kind of help did you request?
How did you request assistance (formal, informal)?

4. <u>Decision Making Process and Refinement of Attributes</u>

a. Did you consider any alternatives before making the final decision?

What were the alternatives?

b. What do you consider the major pros and cons to the alternatives?

c. Why do you consider the decision you made to be superior to the other alternatives?

5. Performance Measurement

a. How will the implementation of your decision be monitored?

Who will be responsible?
What is their relationship to you?

b. How will the results be measured? Is there a predetermined set of standards or performance measured established?

c. Could you give me an example of an acquisition program that you consider to be well managed? What specific characteristics of the program highlight the strengths of the program?

6. Output and Feedback

a. What do you expect the impact of this decision to be in your area and also on others in your organization, other organizations, and the environment?

b. Who would benefit or lose by this decision?

7. Delays

In your estimation, how long will it take before the results of this decision will have an effect? Do you consider this to be complete implementation, or will there be a gradual response to your decision?

8. Timing and Dynamics of Situation

a. At the time you made the decision, would you have followed a different problem solving procedure if there had been more/less time available? Explain.

b. Knowing what you know now, would you have made a different decision than you did before?

9. General Information About Key Issues

a. In your opinion, what are some of the continuing problems or issues in the system acquisition process that the DOD has not suceeded (or has ignored) in correcting?

b. Do you feel these problems can be corrected or the issues resolved? If so, how would you propose to do it?

c. What are some of the major trends or changes you see in the future?

APPENDIX B

PERSONAL INTERVIEWS

—Colonel Kyle D. Barnes, USAF, Director of Mission and Functional Planning, Air Force Systems Command.

—Lt. Col. Juan Benjamin, USAF, Aeronautical Systems Division, Air Force Systems Command.

—Lt. Col. Lynn T. Berringer, USAF, Integration Branch Action Officer, Foreign Technology Division.

—Colonel R. E. Brence, USAF, Deputy Director of Contracting and Acquisition, HQ USAF (RDC).

—Major General James L. Brown, Assistant Chief of Staff for Intelligence, HQ USAF.

—Lt. Col. Walter T. Bryan, USAF, Chief, Operational Requirements Management Group, HQ USAF, Deputy Chief of Staff for Research and Development.

—Budget Examiner Allan V. Burman, National Security Division, Office of Management and Budget.

—Mrs. Deborah P. Christie, Director, Mobility Forces Division, DCS, Program Analysis and Evaluation, Office of the Secretary of Defense.

—David Chu, Assistant Director for National Security and International Affairs, Congressional Budget Office.

—Major General Gerald E. Cooke, Commandant, Air Force Institute of Technology.

—John Cove, Budget Committee, U.S. House of Representatives.

—Ronald Davidson, Program and Budget Division, Office of the Secretary of Defense (Comptroller).

—H. L. Everett, Associate Director of Maintenance and Supply, HQ USAF (LEY).

—Major Bruce Ewing, USAF, Engineering and Support Division, HQ USAF (LEYE).

—Donald Gessaman, Chief, Navy Branch, National Security Division, Office of Management and Budget.

—Harvey J. Gordon, Deputy for Acquisition, Office of the Secretary of the Air Force.

—Lt. Col. Robert H. Hale, Directorate of Development and Programming Branch, HQ USAF.

—Gary D. Hooper, Budget Examiner, National Security Division, Office of Management and Budget.

—Glen R. Hoover, F-15 Systems Program Office, Aeronautical Systems Division, Air Force Systems Command.

—Terry L. Jenkins, Mission Area Analysis, Air Force Acquisitions Logistics Division, Air Force Logistics Command.

—Lt. Col. Frank N. Koval, USAF, Acting Chief, Operational Test and Evaluation Division, HQ USAF, Directorate of Operational Readiness.

—Major Robert E. Linhard, USAF, Planning and Programming Officer, HQ USAF, Force Capabilities Integration Division.

—Dr. Andrew J. Marshall, Director of Net Assessment, Offices of the Secretary of Defense.

—Lloyd Moseman, Deputy Assistant Secretary of the Air Force (Logistics), SAF.

—Colonel B. J. Ratledge, USAF, Deputy Director, Investment Appropriations Division, HQ USAF (ACBI).

—Herman A. Shipley, Office of Federal Procurement Policy.

—Russell Shorey, Directorate of Manpower, Reserve Affairs and Logistics, Office of the Secretary of Defense

—Colonel Robert Sigethy, USAF, Deputy Director, Office of Scientific Research.

—John E. Smith, Deputy Director, Major Systems Acquisition, DCS Research and Evaluation, Office of the Secretary of Defense.

--Colonel R. C. Smith, USAF, Management Policy Division, Chief, Directorate of Development and Programming Policy, HQ USAF (RDP).

--Perry Stewart, Director of Concepts and Analysis, Air Force Acquisition Logistics Division (XRS).

--Richard A. Stubbing, Deputy Chief of the National Security Division, Office of Management and Budget.

--Edward Trusella, Principle Assistant, DCS Contracting and Manufacturing, Air Force Systems Command.

--Peter Van Scheik, Air Force Propulsion Laboratory.

--Colonel Karl R. Wiegard and Mr. Ed Bando, Director of Policy and Programs, Air Force Systems Command.

--Colonel Bernard Weiss, USAF, Director of Procurement and Manufacturing, Aeronautical Systems Division.

APPENDIX C

COMPUTER LISTING AND FLOW DIAGRAMS

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NOTE     ******* POLITICAL SECTOR  *******
NOTE
A   QOL.K=TABHL(QLMT,GNP.K/SPTHR.K,Ø,5,1)                       PO-  1
T   QLMT=.2/1/1.7/2.3/2.7/2.9                                   PO-  2
NOTE
NOTE      QOL     QUALITY OF LIFE
NOTE      GNP     GROSS NATIONAL PRODUCT
NOTE      SPTHR   SMOOTHED PERCEIVED THREAT
NOTE
L   GNP.K=GNP.J+DT*(GNPGR.JK)                                   PO-  3
R   GNPGR.KL=.Ø3                                                PO-  4
A   FREV.K=GNP.K*PGNPG                                          PO-  5
C   PGNPG=.23                                                   PO-  6
A   DEF.K=FREV.K-FBRQMT.K                                       PO-  7
A   BUD.K=FBRQMT.K*BRF                                          PO-  8
NOTE
NOTE      GNP     GROSS NATIONAL PRODUCT
NOTE      GNPGR   GNP GROWTH RATE
NOTE      FREV    FEDERAL REVENUES
NOTE      PGNPG   PERCENT GNP TO THE GOVERNMENT
NOTE      DEF     FEDERAL DEFICIT
NOTE      FBRQMT  FEDERAL BUDGET REQUIREMENTS
NOTE      BUD     FEDERAL BUDGET
NOTE
A   NDODD.K=BUD.K*PBND.K                                        PO-  9
A   PBND.K=TABHL(BUDT,NDDMD.K,Ø,1,.1)                           PO- 1Ø
A   DODD.K=BUD.K*PBDOD.K                                        PO- 11
A   PBDOD.K=1-PBND.K                                            PO- 12
NOTE
NOTE      NDODD   NON-DOD DDOLLARS APPROPRIATED
NOTE      PBND    PERCENT BUDGET TO NON-DOD
NOTE      NDDMD   NON-DOD DEMAND
NOTE      DODD    DOD DOLLARS APPROPRIATED
NOTE      PBDOD   PERCENT BUDGET TO DOD
NOTE      BUD     BUDGET
NOTE
A   ADVOC.K=CLIP(1,Ø,DDRB.K,DODD.K)                             PO- 13
NOTE
NOTE      ADVOC   ADVOCACY FOR DOD DOLLARS
NOTE      DDRB    DOD DOLLARS REQUESTED IN THE BUDGET
NOTE      DODD    DOD DOLLARS APPROPRIATED
NOTE
T   BUDT=.6Ø/.61/.62/.63/.64/.65/.69/.72/.74/.75/.76            PO- 14
C   ABF=1                                                       PO- 15
C   BRF=.95                                                     PO- 16
A   FBRQMT.K=BRF*(DDMD.K+NDDMD.K)                               PO- 17
A   DDMD.K=SUM(FYDP1.K)+SUM(FYDP2.K)+SUM(FYDP3.K)               PO- 18
A   NDDMD.K=GNP.K*GNPGR.JK*TABHL(NDODT,QOL.K,Ø,3,.3)            PO- 19
T   NDODT=2.5/2.1/1.5/1.2/.86/.67/.42/.21/.15/.11               PO- 2Ø
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NOTE
NOTE     BRF     BUDGET REDUCTION FACTOR
NOTE     FBRQMT  FEDERAL BUDGET REQUIREMENT
NOTE     DDMD    DOD DEMAND FOR DOLLARS
NOTE     NDDMD   NON-DOD DEMAND FOR DOLLARS
NOTE     FYDP    FIVE YEARD DEFENSE PLANS FOR FUNDS
NOTE     GNP     GROSS NATIONAL PRODUCT
NOTE     QOL     QUALITY OF LIFE
NOTE
A   PRESSF.K=PRESSC*PRPA.K*LPF.K                                 PO-  21
C   PRESSC=.5                                                    PO-  22
A   CONGSF.K=CONGSC*CRPA.K*LPF.K                                 PO-  23
C   CONGSC=.4                                                    PO-  24
A   ELYRM.K=RAMP(.02,EYM.K)+SPPTC                                PO-  25
A   EYM.K=TIME.K*(1-PULSE(1,1,48))                               PO-  26
C   SPPTC=.5                                                     PO-  27
NOTE
NOTE     PRESSF  PRESIDENTIAL SUPPORT FACTOR
NOTE     PRESSC   PRESIDENTIAL SUPPORT CONSTANT
NOTE     CONGSF  CONGRESSIONAL SUPPORT FACTOR
NOTE     CONGSC  CONGRESSIONAL SUPPORT CONSTANT
NOTE     ELYRM   ELECTION YEAR MULTIPLIER
C   USDESW=1                                                     PO-  28
A   USPTHR.K(MO)=(EINT.K-AINT.K)*USDEF.K(MO)                     PO-  29
A   USCOPA.K=CLIP(1,0,AINT.K*SPTHR.K,.8)                         PO-  30
NOTE
NOTE     USDESW  US DESIRABILITY TO BUILD WEAPONS
NOTE     USPTHR  US PERCEIVED THREAT
NOTE     EINT    ENEMY INTENT
NOTE     AINT    ALLIED INTENT
NOTE     USDEF   US DEFICIENCY
NOTE     USCOPA  US COPRODUCTION AGREEMENT
NOTE     SPTHR   SMOOTHED PERCEIVED THREAT
NOTE
A   EQUATION NOT USED                                            PO-  31
A   EQUATION NOT USED                                            PO-  32
A   USINT.K=TABHL(USINTT,SPTHR.K,0,2,.2)                         PO-  33
T   USINTT=0/0/0/0/.1/.8/1.25/1.97/2.35/2.5/2.6                  PO-  34
A   SPTHR.K=USURGF.K*SUM(USPTHR.K)/120                           PO-  35
A   USDWSL.K=USDESW*TABHL(USDWST,SPTHR.K,0,2,.2)                 PO-  36
T   USDWST=.2/.2/.2/.35/.55/.8/.92/1/1.05/1.1/1.1                PO-  37
NOTE
NOTE     USINT   US INTENT
NOTE     SPTHR   SMOOTHED PERCEIVED THREAT
NOTE     USURGF  US URGENCY FACTOR
NOTE     USDWSL  US DESIRED WEAPON SYSTEMS LEVEL
NOTE
A   DODSP.K=(PRESSF.K+CONGSF.K+PSDD.K)*USDWSL.K*ELYRM.K          PO-  38
A   PSDD.K=TABHL(POPST,QOL.K,0,3,.3)                             PO-  39
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T   POPST=2.Ø/1.99/1.98/1.87/1.65/1.4/1.Ø5/.85/.83/.8          PO- 4Ø
C   POPSC=.1                                                    PO- 41
NOTE
NOTE      DODSP   SUPPORT FOR DOD IN GENERAL
NOTE      PSDD    POPULAR SUPPORT FOR DOD
NOTE      PRESSF  PRESIDENTIAL SUPPORT FACTOR
NOTE      CONGSF  CONGRESSIONAL SUPPORT FACTOR
NOTE      USDWSL  US DESIRED WEAPON SYSTEMS LEVEL
NOTE      ELYRM   ELECTION YEAR MULTIPLIER
NOTE
A   NWSD.K=TABHL(NWSDT,NWSP.K,Ø,3,.3)*DODSP.K                   PO- 42
T   NWSDT=.2/.2/.2/.33/.5/.72/.85/.94/1/1.Ø5                    PO- 43
A   NWSP.K=CWSF*CRPA.K+PWSF*PRPA.K                              PO- 44
NOTE
NOTE      NWSD    NEW WEAPON SYSTEMS DESIRABILITY
NOTE      NWSP    NEW WEAPON SYSTEMS PERFORMANCE FACTOR
NOTE      CWSF    COST WEIGHTED SUPPORT FACTOR
NOTE      PWSF    PERFORMANCE WEIGHTED SUPPORT FACTOR
NOTE      CRPA    COST RATIO PLANNED TO ACTUAL
NOTE      PRPA    PERFORMANCE RATIO PLANNED TO ACTUAL
NOTE
A   GSPTRD.K(1)=TABHL(GSPTT1,NWSD.K,Ø,1,.1)                     PO- 45
A   GSPTRD.K(2)=TABHL(GSPPT2,SPTHR.K,Ø,2,.2)                    PO- 46
T   GSPTT1=.8/.82/.83/.85/.86/.91/.99/1.1/1.3/1.5/2.Ø           PO- 47
A   GSPTIN.K(1)=TABHL(GSPTT1,NWSD.K,Ø,1,.1)                     PO- 48
A   GSPTIN.K(2)=TABHL(GSPTT2,SPTHR.K,Ø,2,.2)                    PO- 49
T   GSPTT2=2.Ø/1.5/1.3/1.1/.99/.91/.86/.85/.83/.82/.81          PO- 5Ø
A   GSPTOS.K(1)=TABHL(GSPTT1,NWSD.K,Ø,1,.1)                     PO- 51
A   GSPTOS.K(2)=TABHL)GSPTT2,SPTHR.K,Ø,2,.2)                    PO- 52
NOTE
NOTE      GSPTRD  GOVERNMENT SUPPORT FOR R&D PROGRAMS
NOTE      GSPTIN  GOVERNMENT SUPPORT FOR INVESTMENT
NOTE      GSPTOS  GOVERNMENT SUPPORT FOR O&S
NOTE      SPTHR   SMOOTHED PERCEIVED THREAT
NOTE      NWSD    NEW WEAPON SYSTEMS DESIRABILITY
NOTE
T   LOBBY=2/1.99/1.9/1.8/1.67/1.5/1.37/1.25/1.16/1.1            PO- 53
A   LPF.K=TABHL(LOBBY,GNPGR.JK/TCF.K,Ø,2,.2)*ABF                PO- 54
NOTE
NOTE      LPF     LOBBYIST PRESSURE FACTOR
NOTE      GNPGR   GNP GROWTH RATE
NOTE      TCF     TECHNICAL COMPLEXITY FACTOR
NOTE      ABF     AREA BENEFITS FACTOR
NOTE
C   CWSF=.7                                                     PO- 55
C   PWSF=.3                                                     PO- 56
NOTE
NOTE      CWSF    COST WEIGHTED SUPPORT FACTOR
NOTE      PWSF    PERFORMANCE WEIGHTED SUPPORT FACTOR
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NOTE     NEED SECTOR     **********
NOTE
FOR IN=1,12Ø
N   PLAN(IN)=Ø                                                  ND-  1
NOTE
A   USCAP.K(MO)=(WSO.K+WSN.K+WSP.K+SUMV(PLAN.K(*),1,T(MO)))*    ND-  2
X   USCPWS.K*LEF.K(MO)
A   UADEF.K(MO)=ECAP.K(MO)-USCAP.K(MO)-ACAP.K(MO)               ND-  3
A   USDIF.K(MO)=MAX(Ø,UADEF.K(MO)*USDPCT.K)                     ND-  4
A   USDEF.K(MO)=MAX(Ø,USDIF.K(MO)*USDESW)                       ND-  5
A   USDPCT.K=1-ADPCT.K                                          ND-  6
A   USDEF.K(MO)=MAX(Ø,USDIF.K(MO)*USDESW)                       ND-  7
NOTE
NOTE     USCAP   US CAPABILITY
NOTE     UADEF   US/ALLIED COMBINED DEFICIENCY
NOTE     USDIF   US DIFFERENCE IN CAPABILITY
NOTE     USDEF   US DEFICIENCY
NOTE     USDPCT   PERCENT OF DEFICIENCY TO US
NOTE
A   USURG.K=URGENCY(USDEF.K)                                    ND-  8
A   USURGF.K=TABLE(EWGT,USURG.K,Ø,12Ø,1Ø)                       ND-  9
NOTE
NOTE     USURG     US URGENCY--TIME IN MONTHS TIL FIRST DEFICIENCY
NOTE     USURGF    US URGENCY FACTOR
A   RDSUPP.K(1)=SWITCH(Ø,RSUP1.K,RSUPAF.K(1))                   ND- 1Ø
A   RDSUPP.K(2)=SWITCH(Ø,RSUP2.K,RSUPAF.K(2))                   ND- 11
A   INSUPP.K(1)=SWITCH(Ø,ISUP1.K,ISUPAF.K(1))                   ND- 12
A   INSUPP.K(2)=SWITCH(Ø,ISUP2.K,ISUPAF.K(2)))                  ND- 13
A   OSSUPP.K(1)=SWITCH(Ø,OSUP1.K,OSUPAF.K(1))                   ND- 14
A   OSSUPP.K(2)=SWITCH(Ø,OSUP2.K,OSUPAF.K(2))                   ND- 15
NOTE
NOTE     RDSUPP  R&D SUPPLEMENTAL REQUEST
NOTE     INSUPP   INVESTMENT SUPPLEMENTAL REQUEST
NOTE     OSSUPP  O&S SUPPLEMENTAL REQUEST
NOTE     RSUP    AMOUNT OF SUPPLEMENT FOR R&D
NOTE     ISUP     AMOUNT OF SUPPLEMENT FOR INVESTMENT
NOTE     OSUP    AMOUNT OF SUPPLEMENT FOR O&S
NOTE
R   FP1INR.KL(1)=SWITCH(Ø,CNRD.K,DC4.K)                         ND- 16
R   FP1INR.KL(2)=FYDPC*RDC                                      ND- 17
R   FP2INR.KL(1)=SWITCH(Ø,COST4.K,WSD3.K)                       ND- 18
R   FP2INR.KL(2)=SWITCH(Ø,COST3.K+COST2.K,DC3.K+DC2.K)          ND- 19
R   FP3INR.KL(1)=NWSP.K*NCOST.K                                 ND- 2Ø
R   FP3INR.KL(3)=FYDP3.K(2)*OSC                                 ND- 21
NOTE
NOTE     FP-INR  INPUT RATES TO FIVE YEAR DEFENSE PLAN
NOTE     CNRD    COST FOR R&D ON NEW WEAPON SYSTEM
NOTE     COST-   COST FOR OPTION #-
NOTE     DC-     DECISION CONTROL FOR OPTION #-
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NOTE     FYDP3   O&S FUNDS REQUESTED IN THE FYDP
C   FYDPC=1.E6                                                  ND- 22
C   USDESW=1.0                                                  ND- 23
L   PLAN.K(MO)=PLAN.J(MO)+DT*(PLADJ.JK(MO))                     ND- 24
R   PLADJ.KL(MO)=DNNWS.K+TABHL(SCHT,T(MO),0,120,12)*LTF.K(MO)   ND- 25
A   LTF.K(MO)=CLIP(1,0,T(MO),18)                                ND- 26
T   SCHT=.03/.04/.08/.09/.11/.11/.11/.11/.11/.11/.11            ND- 27
NOTE
NOTE     PLAN     PLANNED PFORCE LEVEL
NOTE     PLADJ    PLAN ADJUSTMENT RATE
NOTE     LTF      LEAD TIME FACTOR
NOTE     T        TIME TABLE
NOTE
NOTE
A   NWSP.K=CLIP(SUM(DNOWS.K),SUM(DNNWS.K),D4.K,D3.K)            ND- 28
A   RQNWS.K=SUM(DNNWS.K)                                        ND- 29
A   VALT1.K=SUM(USDEF.K)/(ORDM*USCPWS.K)                        ND- 30
A   VALT2.K=MODF.K                                              ND- 31
A   VALT3.K=NCPWS.K                                             ND- 32
A   VALT4.K=100                                                 ND- 33
NOTE
NOTE     VALT-   VALUE OF ALTERNATIVE #-
NOTE     MODF    MODIFICATION FACTOR
NOTE     NCPWS   NEW CAPABILITY PER WEAPON SYSTEM
NOTE
A   SCHF1.K=CLIP(0,1,SCHED1,USURG.K)                            ND- 34
C   SCHED1=24                                                   ND- 35
A   SCHF2.K=CLIP(0,1,SCHED2,USURG.K)                            ND- 36
C   SCHED2=48                                                   ND- 37
A   SCHF3.K=CLIP(0,1,SCHED3,USURG.K)                            ND- 38
C   SCHED3=48                                                   ND- 39
A   SCHF4.K=CLIP(0,1,SCHED4,USURG.K)                            ND- 40
C   SCHED4=08                                                 ND- 41
NOTE
NOTE     SCHF-   SCHEDULE DECISION FACTOR FOR ALTERNATIVE #-
NOTE              THIS VARIABLE DETERMINES IF TIME SS TOO SHORT
NOTE     USURG    US URGENCY
NOTE
A   TFSL.K=(FYDP3.K(1)+FYDP3.K(2))/USCOST.K                     ND- 42
A   COSTF1.K=CLIP(1,0,TFSL.K,COST1.K)                           ND- 43
A   COSTF2.K=CLIP(1,0,TFSL.K,COST2.K)                           ND- 44
A   COSTF3.K=CLIP(1,0,TFSL.K,COST3.K)                           ND- 45
A   COSTF4.K=CLIP(1,0,TFSL.K,COST4.K)                           ND- 46
NOTE
NOTE     COSTF-   COST FACTOR FOR ALTERNATIVE #-
NOTE     THIS VARIABLE DETERMINES IF COST IS WITHIN TOTAL FORCE LIMI
NOTE     IF NOT, PRESSURE MUST BE PUT ON TO RAISE FORCE LEVEL
NOTE
A   DORR.K=(VALT1.K+WSO.K)/(WSO.K+WSN.K)                        ND- 47
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A   NEWORR.K=MIN(1,DORR.K)                                       ND- 48
A   COST1.K=TABLE(CST1T,NEWORR.K,80,100,2)                       ND- 49
A   D1.K=SCHF1.K*COSTF1.K                                        ND- 50
C   ORDM=.1                                                      ND- 51
NOTE
NOTE     DORR     DESIRED OR RATE
NOTE     NEWORR   NEW OR RATE
NOTE     COST1    COST OF ALTERNATIVE 1
NOTE     D1       DECISION FOR ALTERNATIVE 1
NOTE
C   MODK=5                                                       ND- 52
A   MODC.K=TABLE(MODFT,MODK,0,100,10)                            ND- 53
A   MODF.K=SWITCH(0,MODC.K,D2.K)                                 ND- 54
A   NSYSM.K=MIN((WSO.K+WSN.K),SUM(USPTHR.K/VALT2.K)              ND- 55
A   COST2.K=TABLE(CST2T,NSYSM.K,0,100,10)                        ND- 56
T   CST2T=0/100/200/300/400/500/600/700/800/900/1000             ND- 57
NOTE
NOTE     MODK     MODIFICATION CONSTANT INCREASE IN CAPABILITY
NOTE     MODC     MODIFICATION COST
NOTE     MODF     MODIFICATION FACTOR
NOTE     COST2    COST OF ALTERNATIVE 2
NOTE     D2       DECISION FOR ALTERNATIVE 2
NOTE
A   D2.K=SCHF2.K*COSTF2.K                                        ND- 58
A   DNOWS.K(MO)=USDEF.K(MO)/VALT3.K                              ND- 59
A   DNNWS.K(MO)=USDEF.K(MO)/VALT4.K                              ND- 60
A   D3.K=SCHF3.K*COSTF3.K                                        ND- 61
A   D4.K=SCHF3.K*COSTF3.K                                        ND- 62
NOTE
NOTE     DNOWS     DESIRED NUMBER OF OLD WEAPONS SYSTEMS
NOTE     DNNWS     DESIRED NUMBER OF NEW WEAPON SYSTEMS
NOTE     D3        DECISION FOR ALTERNATIVE 3
NOTE     D4       DECISION FOR ALTERNATIVE 4
NOTE
A   COST3.K=SUM(DNOWS.K)*USCOST.K*AGEM.K                         ND- 63
A   AGEM.K=TABLE(AGFT,TIME.K,0,20,10)                          ND- 64
A   COST4.K=DNNWS.K*PC1.K                                        ND- 65
NOTE
NOTE     AGEM     AGE MULTIPLIER
NOTE     COST3     COST OF ALTERNATIVE 3
NOTE     COST4     COST OF ALTERNATIVE 4
NOTE
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NOTE     NEED SECTOR      **********
NOTE
FOR IN=1,12Ø
N   PLAN(IN)=Ø                                                     ND-   1
NOTE
A   USCAP.K(MO)=(WSO.K+WSN.K+WSP.K+SUMV(PLAN.K(*),1,T(MO)))+        ND-   2
X   USCPWS.K*LEF.K(MO)
A   UADEF.K(MO)=ECAP.K(MO)-USCAP.K(MO)-ACAP.K(MO)                  ND-   3
A   USDIF.K(MO)=MAX(Ø,UADEF.K(MO)*USDPCT.K)                        ND-   4
A   USDEF.K(MO)=MAX(Ø,USDIF.K(MO)*USDESW)                          ND-   5
A   USDPCT.K=1-ADPCT.K                                             ND-   6
A   USDEF.K(MO)=MAX(Ø,USDIF.K(MO)*USDESW)                          ND-   7
NOTE
NOTE     USCAP   US CAPABILITY
NOTE     UADEF   US/ALLIED COMBINED DEFICIENCY
NOTE     USDIF   US DIFFERENCE IN CAPABILITY
NOTE     USDEF   US DEFICIENCY
NOTE     USDPCT   PERCENT OF DEFICIENCY TO US
NOTE
A   USURG.K=URGENCY(USDEF.K)                                       ND-   8
A   USURGF.K=TABLE(EWGT,USURG.K,Ø,12Ø,1Ø)                          ND-   9
NOTE
NOTE     USURG     US URGENCY--TIME IN MONTHS TIL FIRST DEFICIENCY
NOTE     USURGF    US URGENCY FACTOR
A   RDSUPP.K(1)=SWITCH(Ø,RSUP1.K,RSUPAF.K(1))                      ND-  1Ø
A   RDSUPP.K(2)=SWITCH(Ø,RSUP2.K,RSUPAF.K(2))                      ND-  11
A   INSUPP.K(1)=SWITCH(Ø,ISUP1.K,ISUPAF.K(1))                      ND-  12
A   INSUPP.K(2)=SWITCH(Ø,ISUP2.K,ISUPAF.K(2)))                     ND-  13
A   OSSUPP.K(1)=SWITCH(Ø,OSUP1.K,OSUPAF.K(1))                      ND-  14
A   OSSUPP.K(2)=SWITCH(Ø,OSUP2.K,OSUPAF.K(2))                      ND-  15
NOTE
NOTE     RDSUPP  R&D SUPPLEMENTAL REQUEST
NOTE     INSUPP   INVESTMENT SUPPLEMENTAL REQUEST
NOTE     OSSUPP  O&S SUPPLEMENTAL REQUEST
NOTE     RSUP    AMOUNT OF SUPPLEMENT FOR R&D
NOTE     ISUP     AMOUNT OF SUPPLEMENT FOR INVESTMENT
NOTE     OSUP    AMOUNT OF SUPPLEMENT FOR O&S
NOTE
R   FP1INR.KL(1)=SWITCH(Ø,CNRD.K,DC4.K)                            ND-  16
R   FP1INR.KL(2)=FYDPC*RDC                                         ND-  17
R   FP2INR.KL(1)=SWITCH(Ø,COST4.K,WSD3.K)                          ND-  18
R   FP2INR.KL(2)=SWITCH(Ø,COST3.K+COST2.K,DC3.K+DC2.K)             ND-  19
R   FP3INR.KL(1)=NWSP.K*NCOST.K                                    ND-  2Ø
R   FP3INR.KL(3)=FYDP3.K(2)*OSC                                    ND-  21
NOTE
NOTE     FP-INR  INPUT RATES TO FIVE YEAR DEFENSE PLAN
NOTE     CNRD    COST FOR R&D ON NEW WEAPON SYSTEM
NOTE     COST-   COST FOR OPTION #-
NOTE     DC-     DECISION CONTROL FOR OPTION #-
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NOTE     FYDP3   O&S FUNDS REQUESTED IN THE FYDP
C   FYDPC=1.E6                                                  ND-  22
C   USDESW=1.0                                                  ND-  23
L   PLAN.K(MO)=PLAN.J(MO)+DT*(PLADJ.JK(MO))                     ND-  24
R   PLADJ.KL(MO)=DNNWS.K*TABHL(SCHT,T(MO),0,120,12)*LTF.K(MO)   ND-  25
A   LTF.K(MO)=CLIP(1,0,T(MO),18)                                ND-  26
T   SCHT=.03/.04/.08/.09/.11/.11/.11/.11/.11/.11/.11            ND-  27
NOTE
NOTE     PLAN     PLANNED PFORCE LEVEL
NOTE     PLADJ    PLAN ADJUSTMENT RATE
NOTE     LTF      LEAD TIME FACTOR
NOTE     T        TIME TABLE
NOTE
NOTE
A   NWSP.K=CLIP(SUM(DNOWS.K),SUM(DNNWS.K),D4.K,D3.K)            ND-  28
A   RQNWS.K=SUM(DNNWS.K)                                        ND-  29
A   VALT1.K=SUM(USDEF.K)/(ORDM*USCPWS.K)                        ND-  30
A   VALT2.K=MODF.K                                              ND-  31
A   VALT3.K=NCPWS.K                                             ND-  32
A   VALT4.K=100                                                 ND-  33
NOTE
NOTE     VALT-   VALUE OF ALTERNATIVE #-
NOTE     MODF    MODIFICATION FACTOR
NOTE     NCPWS   NEW CAPABILITY PER WEAPON SYSTEM
NOTE
A   SCHF1.K=CLIP(0,1,SCHED1,USURG.K)                            ND-  34
C   SCHED1=24                                                   ND-  35
A   SCHF2.K=CLIP(0,1,SCHED2,USURG.K)                            ND-  36
C   SCHED2=48                                                   ND-  37
A   SCHF3.K=CLIP(0,1,SCHED3,USURG.K)                            ND-  38
C   SCHED3=48                                                   ND-  39
A   SCHF4.K=CLIP(0,1,SCHED4,USURG.K)                            ND-  40
C   SCHED4=08                                                 ND-  41
NOTE
NOTE     SCHF-   SCHEDULE DECISION FACTOR FOR ALTERNATIVE #-
NOTE              THIS VARIABLE DETERMINES IF TIME SS TOO SHORT
NOTE     USURG     US URGENCY
NOTE
A   TFSL.K=(FYDP3.K(1)+FYDP3.K(2))/USCOST.K                     ND-  42
A   COSTF1.K=CLIP(1,0,TFSL.K,COST1.K)                           ND-  43
A   COSTF2.K=CLIP(1,0,TFSL.K,COST2.K)                           ND-  44
A   COSTF3.K=CLIP(1,0,TFSL.K,COST3.K)                           ND-  45
A   COSTF4.K=CLIP(1,0,TFSL.K,COST4.K)                           ND-  46
NOTE
NOTE     COSTF-   COST FACTOR FOR ALTERNATIVE #-
NOTE     THIS VARIABLE DETERMINES IF COST IS WITHIN TOTAL FORCE LIMI
NOTE     IF NOT, PRESSURE MUST BE PUT ON TO RAISE FORCE LEVEL
NOTE
A   DORR.K=(VALT1.K+WSO.K)/(WSO.K+WSN.K)                        ND-  47
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A    NEWORR.K=MIN(1,DORR.K)                                        ND-  48
A    COST1.K=TABLE(CST1T,NEWORR.K,80,100,2)                        ND-  49
A    D1.K=SCHF1.K*COSTF1.K                                         ND-  50
C    ORDM=.1                                                       ND-  51
NOTE
NOTE      DORR     DESIRED OR RATE
NOTE      NEWORR   NEW OR RATE
NOTE      COST1    COST OF ALTERNATIVE 1
NOTE      D1       DECISION FOR ALTERNATIVE 1
NOTE
C    MODK=5                                                        ND-  52
A    MODC.K=TABLE(MODFT,MODK,0,100,10)                             ND-  53
A    MODF.K=SWITCH(0,MODC.K,D2.K)                                  ND-  54
A    NSYSM.K=MIN((WSO.K+WSN.K),SUM(USPTHR.K/VALT2.K)               ND-  55
A    COST2.K=TABLE(CST2T,NSYSM.K,0,100,10)                         ND-  56
T    CST2T=0/100/200/300/400/500/600/700/800/900/1000              ND-  57
NOTE
NOTE      MODK     MODIFICATION CONSTANT INCREASE IN CAPABILITY
NOTE      MODC     MODIFICATION COST
NOTE      MODF     MODIFICATION FACTOR
NOTE      COST2    COST OF ALTERNATIVE 2
NOTE      D2       DECISION FOR ALTERNATIVE 2
NOTE
A    D2.K=SCHF2.K*COSTF2.K                                         ND-  58
A    DNOWS.K(MO)=USDEF.K(MO)/VALT3.K                               ND-  59
A    DNNWS.K(MO)=USDEF.K(MO)/VALT4.K                               ND-  60
A    D3.K=SCHF3.K*COSTF3.K                                         ND-  61
A    D4.K=SCHF3.K*COSTF3.K                                         ND-  62
NOTE
NOTE      DNOWS     DESIRED NUMBER OF OLD WEAPONS SYSTEMS
NOTE      DNNWS     DESIRED NUMBER OF NEW WEAPON SYSTEMS
NOTE      D3        DECISION FOR ALTERNATIVE 3
NOTE      D4       DECISION FOR ALTERNATIVE 4
NOTE
A    COST3.K=SUM(DNOWS.K)*USCOST.K*AGEM.K                          ND-  63
A    AGEM.K=TABLE(AGFT,TIME.K,0,20,10)                           ND-  64
A    COST4.K=DNNWS.K*PC1.K                                         ND-  65
NOTE
NOTE      AGEM     AGE MULTIPLIER
NOTE      COST3     COST OF ALTERNATIVE 3
NOTE      COST4     COST OF ALTERNATIVE 4
NOTE
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NOTE                FINANCIAL SECTOR
NOTE
NOTE     *******   BUDGET SECTION   *******
NOTE
FOR IB=1,2
N   RDRB(IB)=0                                                   FN-   1
N   IDRB(IB)=0                                                   FN-   2
N   ODRB(IB)=0                                                   FN-   3
N   DDRB(IB)=0                                                   FN-   4
C   FYDPC=1.E6                                                   FN-   5
NOTE
L   RDRB.K(IB)=RDRB.J(IB)+DT*(RDMDR.JK(IB)-RREDR.JK(IB))         FN-   6
R   RDMDR.KL(IB)=RDRQT.K(IB)+RDSUPP.K(IB)                        FN-   7
R   RREDR.KL(IB)=RDAR.JK(IB)                                     FN-   8
NOTE
NOTE     RDRB    R&D DOLLARS REQUESTED IN THE BUDGET
NOTE     RDMDR   R&D DEMAND RATE
NOTE     RREDR   R&D DEMAND REDUCTION RATE
NOTE     RDRQT   R&D FUNDS REQUIREMENT
NOTE     RDAR    R&D ALLOCATION RATE
NOTE     RDSUPP  R&D SUPPLEMENTAL REQUEST
NOTE
A   PRDD.K(IB)=GSPTRD.K(IB)*RDRB.K(IB)                           FN-   9
NOTE
NOTE     PRDD    PRESSURE FOR R&D DOLLARS
NOTE     GSPTRD  GOVERNMENT SUPPORT FOR R&D
NOTE     RDRB    R&D DOLLARS REQUESTED IN THE BUDGET
NOTE
L   IDRB.K(IB)=IDRB.J(IB)+DT*(IDMDR.JK(IB)-IREDR.JK(IB))         FN-  10
R   IDMDR.KL(IB)=IRQT.K(IB)+INSUPP.K(IB)                         FN-  11
R   IREDR.KL(IB)=IDAR.JK(IB)                                     FN-  12
NOTE
NOTE     IDRB    INVESTMENT DOLLARS REQUESTED IN THE BUDGET
NOTE     IDMDR   INVESTMENT DEMAND RATE
NOTE     IREDR   INVESTMENT DEMAND REDUCTION RATE
NOTE     IRQT    INVESTMENT FUNDS REQUIREMENT
NOTE     IDAR    INVESTMENT ALLOCATION RATE
NOTE     INSUPP  INVESTMENT SUPPLEMENTAL REQUEST
NOTE
A   PID.K(IB)=GSPTIN.K(IB)*IDRB.K(IB)                            FN-  13
NOTE
NOTE     PID     PRESSURE FOR INVESTMENT DOLLARS
NOTE     GSPTIN  GOVERNMENT SUPPORT FOR INVESTMENT
NOTE     IDRB    INVESTMENT DOLLARS REQUESTED IN THE BUDGET
NOTE
L   ODRB.K(IB)=ODRB.J(IB)+DT*(ODMDR.JK(IB)-OREDR.JK(IB))         FN-  14
R   ODMDR.KL(IB)=ORQT.K(IB)+OSSUPP.K(IB)                         FN-  15
R   OREDR.KL(IB)=OSDAR.JK(IB)                                    FN-  16
NOTE
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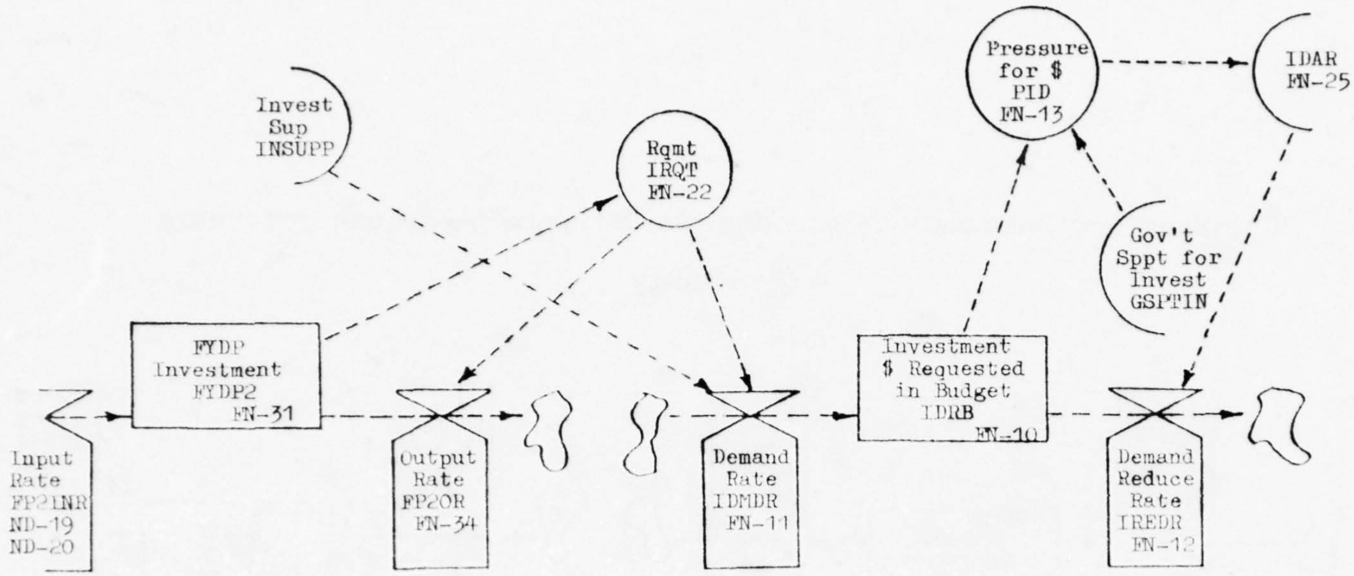

Figure C-1

Financial Sector--Investment Programming and Budgeting

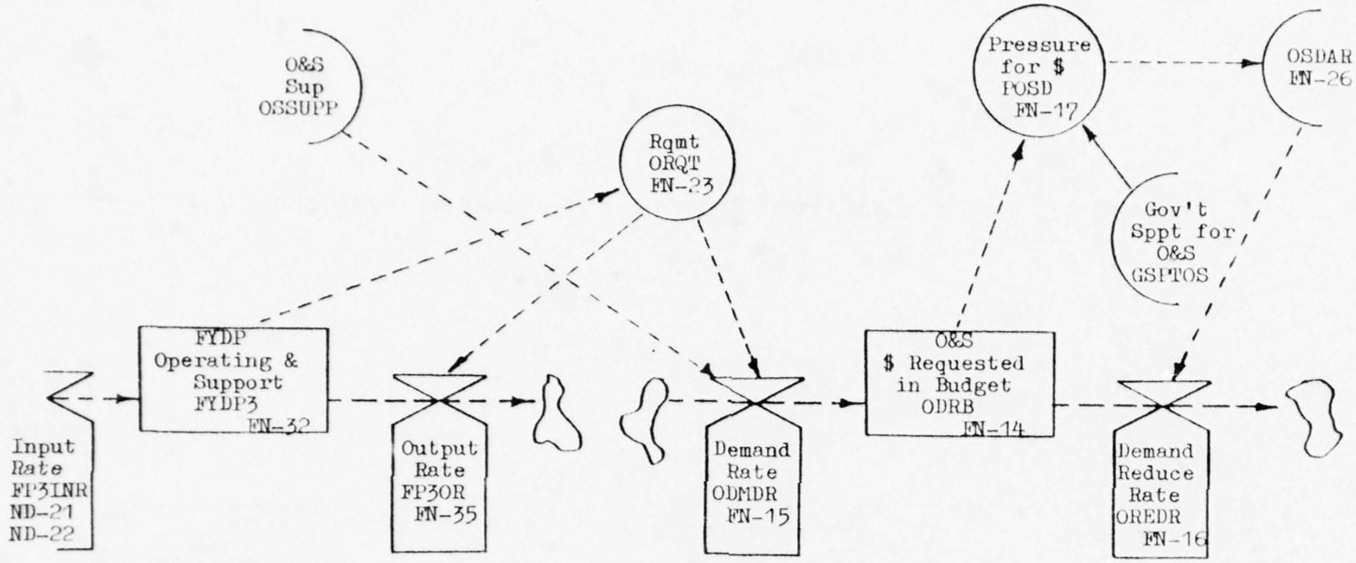

Figure C-2

Financial Sector--Operating and Support Programming and Budgeting

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NOTE     ODRB    O&S DOLLARS REQUESTED IN THE BUDGET
NOTE     ODMDR   O&S DEMAND RATE
NOTE     OREDR   O&S DEMAND REDUCTION RATE
NOTE     ORQT    O&S FUNDS REQUIREMENT
NOTE     OSDAR   O&S ALLOCATION RATE
NOTE     OSSUPP  O&S SUPPLEMENTAL REQUEST
NOTE
A  POSD.K(IB)=GSPTOS.K(IB)*ODRB.K(IB)                         FN- 17
NOTE
NOTE     POSD    PRESSURE FOR O&S DOLLARS
NOTE     GSPTOS  GOVERNMENT SUPPORT FOR O&S
NOTE     ODRB    O&S DOLLARS REQUESTED IN THE BUDGET
NOTE
L  DDRB.K(IB)=DDRB.J(IB)+DT*(DDMDR.JK(IB)-DREDR.JK(IB))       FN- 18
R  DDMDR.KL(IB)=RDRQT.K(IB)+IRQT.K(IB)+ORQT.K(IB)            FN- 19
R  DREDR.KL(IB)=RDAR.JK(IB)+IDAR.JK(IB)+OSDAR.JK(IB)          FN- 20
NOTE
NOTE     DDRB    DEFENSE DOLLARS REQUESTED IN THE BUDGET
NOTE     DDMDR   DEFENSE DEMAND RATE
NOTE     DREDR   DEFENSE DEMAND REDUCTION RATE
NOTE     RDRQT   R&D FUNDS REQUIREMENT
NOTE     IRQT    INVESTMENT FUNDS REQUIREMENT
NOTE     ORQT    O&S FUNDS REQUIREMENT
NOTE     RDAR    R&D ALLOCATION RATE
NOTE     IDAR    INVESTMENT ALLOCATION RATE
NOTE     OSDAR   O&S ALLOCATION RATE
NOTE
A  RDRQT.K(IB)=FYDP1.K(IB)*PULSE(1,11,12)                     FN- 21
NOTE
NOTE     RDRQT   R&D FUNDS REQUIREMENT
NOTE     FYDP1   R&D EXPENDITURES PLANNED IN THE FYDP
NOTE
A  IRQT.K(IB)=FYDP2.K(IB)*PULSE(1,11,12)                      FN- 22
NOTE
NOTE     IRQT    INVESTMENT FUNDS REQUIREMENT
NOTE     FYDP2   INVESTMENT EXPENDITURES PLANNED IN THE FYDP
NOTE
A  ORQT.K(IB)=FYDP3.K(IB)*PULSE(1,11,12)                      FN- 23
NOTE
NOTE     ORQT    O&S FUNDS REQUIREMENT
NOTE     FYDP3   O&S EXPENDITURES PLANNED IN THE FYDP
NOTE
R  RDAR.KL(IB)=PRDD.K(IB)*PULSE(1,10,12)                      FN- 24
NOTE
NOTE     RDAR    R&D APPROPRIATION RATE
NOTE     PRDD    PRESSURE FOR R&D DOLLARS
NOTE
R  IDAR.KL(IB)=PID.K(IB)*PULSE(1,10,12)                       FN- 25
NOTE
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NOTE     IDAR    INVESTMENT APPROPRIATION RATE
NOTE     PID     PRESSURE FOR INVESTMENT DOLLARS
NOTE
R   OSDAR.KL(IB)=POSD.K(IB)*PULSE(1,10,12)                        FN-  26
NOTE
NOTE     OSDAR   O&S APPROPRIATION RATE
NOTE     POSD    PRESSURE FOR O&S DOLLARS
NOTE
N   FYDP1(IB)=0                                                   FN-  27
N   FYDP2(IB)=0                                                   FN-  28
N   FYDP3(IB)=0                                                   FN-  29
NOTE
NOTE     FYDP    FIVE YEAR DEFENSE PLAN
NOTE
L   FYDP1.K(IB)=FYDP1.J(IB)+DT*(FP1INR.JK(IB)-FP1OR.JK(IB))       FN-  30
R   FP1OR.KL(IB)=RDRQT.K(IB)                                      FN-  31
NOTE
NOTE     FYDP1   R&D EXPENDITURES PLANNED IN THE FYDP
NOTE     FP1INR  R&D COSTS INPUT TO THE FYDP
NOTE     FP1OR   R&D COSTS FUNDED FROM THE FYDP
NOTE     RDRQT   R&D FUNDS REQUIREMENT
NOTE
L   FYDP2.K(IB)=FYDP2.J(IB)+DT*(FP2INR.JK(IB)-FP2OR.JK(IB))       FN-  32
R   FP2OR.KL(IB)=IRQT.K(IB)                                       FN-  33
NOTE
NOTE     FYDP2   INVESTMENT EXPENDITURES PLANNED IN THE FYDP
NOTE     FP2INR  INVESTMENT COSTS INPUT TO THE FYDP
NOTE     FP2OR   INVESTMENT COSTS FUNDED FROM THE FYDP
NOTE     IRQT    INVESTMENT FUNDS REQUIREMENT
NOTE
L   FYDP3.K(IB)=FYDP3.J(IB)+DT*(FP3INR.JK(IB)-FP3OR.JK(IB))       FN-  34
R   FP3OR.KL(IB)=ORQT.K(IB)                                       FN-  35
NOTE
NOTE     FYDP3   O&S EXPENDITURES PLANNED IN THE FYDP
NOTE     FP3INR  O&S COSTS INPUT TO THE FYDP
NOTE     FP3OR   O&S COSTS FUNDED FROM THE FYDP
NOTE     ORQT    O&S FUNDS REQUIREMENT
NOTE
NOTE     FINANCIAL ALLOCATION AND EXPENSES
NOTE
FOR PROJ=1,2
L   RDA.K(PROJ)=RDA.J(PROJ)+DT*(RDAR.JK(PROJ)-RDOR.JK(PROJ)       FN-  36
X   +RRPR.JK(PROJ))
N   RDA(1)=RDA1C                                                  FN-  37
C   RDA1C=0                                                       FN-  38
N   RDA(2)=RDA2C                                                  FN-  39
N   RDA2C=0                                                       FN-  40
NOTE     RDA     RESEARCH DOLLARS APPROPRIATED
NOTE     RDAR    RESEARCH DOLLAR APPROPRIATION RATE
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R    RDPR.KL(2)=DELAY3(RDOR.JK(2),RDPR2D)                        FN- 60
C    RDPR2D=48                                                   FN- 61
NOTE      RDPR    RESEARCH DOLLARS PAYMENT RATE
NOTE      RDOR    RESEARCH DOLLAR OBLIGATION RATE
NOTE      RDPR2D  RESEARCH DOLLAR PAYMENT RATE DELAY
NOTE
NOTE
NOTE      INVESTMENT COSTS
NOTE
NOTE
L    IDA.K(PROJ)=IDA.J(PROJ)+DT*(IDAR.JK(PROJ)-IDOR.JK(PROJ)     FN- 62
X    +IRPR.JK(PROJ))
N    IDA(1)=IDA1C                                                FN- 63
C    IDA1C=0                                                     FN- 64
N    IDA(2)=IDA2C                                                FN- 65
C    IDA2C=0                                                     FN- 66
NOTE      IDA     INVESTMENT DOLLARS APPROPRIATED
NOTE      IDAR    INVESTMENT DOLLARS APPROPRIATION RATE
NOTE      IDOR    INVESTMENT DOLLARS OBLIGATION RATE
NOTE      IRPR    INVESTMENT REPROGRAMMING RATE
R    IRPR.KL(1)=CPC4.K                                           FN- 67
R    IRPR.KL(2)=-CPC4.K                                          FN- 68
NOTE      IRPR   INVESTMENT REPROGRAMMING RATE
NOTE      CPC4   CHANGE IN PLANNED COSTS
A    IPF.K=SWITCH(0,1,IDA.K(1))                                  FN- 69
NOTE      IPF     INVESTMENT PROGRAM FUNDING
NOTE      IDA     INVESTMENT DOLLARS APPROPRIATED
NOTE
R    IDOR.KL(1)=TPIC.K*IDOSWI.K                                  FN- 70
NOTE      IDOR    INVESTMENT DOLLARS OBLIGATION RATE
NOTE      TPIC    TOTAL PLANNED COSTS
NOTE      IDOSWI  INVESTMENT DOLLARS OBLIGATION SWITCH
A    TPIC.K=TPC4.K*WSD4.K*DSWI4.K+CPC4.K                         FN- 71
NOTE      TPIC    TOTAL PLANNED INVESTMENT COSTS
NOTE      TPC4    TOTAL PLANNED COSTS
NOTE      WSD     WEAPON SYSTEM DEVELOPMENT DECISION
NOTE      DSWI4   DOLLAR SWITCH 4
NOTE      CPC     CHANGE IN PLANNED COSTS
A    IDOSWI.K(PROJ)=SWITCH(0,1,IDA.K(PROJ))                      FN- 72
NOTE      IDOSWI  INVESTMENT DOLLARS OBLIGATION SWITCH
NOTE      IDA     INVESTMENT DOLLARS APPROPRIATED
R    IDOR.KL(2)=IDA.K(2)*APRF.K*IDOSWI.K(2)                      FN- 73
NOTE      IDOR    INVESTMENT DOLLARS OBLIGATED FOR OTHER
NOTE      IDA     INVESTMENT DOLLARS APPROPRIATED FOR OTHER
NOTE      APRF    APPROPRIATATION RATE FRACTION
NOTE      IDOSWI  INVESTMENT DOLLARS OBLIGATION SWITCH
L    IDOC.K(PROJ)=IDOC.J(PROJ)+DT*(IDOR.JK(PROJ)-IDPR.JK(PROJ))  FN- 74
N    IDOC(1)=IDOC1C                                              FN- 75
C    IDOC1C=0                                                    FN- 76
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NOTE     RDOR    RESEARCH DOLLARS OBLIGATION RATE
NOTE     RRPR    RESEARCH REPROGRAMMING RATE
R   RRPR.KL(1)=CPC1.K+CPC2.K+CPC3.K                                FN-  41
R   RRPR.KL(2)=-(CPC1.K+CPC2.K+CPC3.K)                             FN-  42
NOTE     RRPR    RESEARCH REPROGRAMMING RATE
NOTE     CPC     CHANGE IN PLANNED COSTS
A   RPF.K=SWITCH(Ø,1,RDA.K(1))                                     FN-  43
NOTE     RPF     RESEARCH PROGRAM FUNDING
NOTE     RDA     RESEARCH DOLLAR APPROPRIATED
R   RDOR.KL(1)=TPRC.K*RDOSWI.K(1)                                  FN-  44
NOTE     RDOR    RESEARCH DOLLARS OBLIGATION RATE
NOTE     TPRC    TOTAL PLANNED RESEARCH COSTS
NOTE     RDOSWI  RESEARCH DOLLARS OBLIGATION SWITCH
A   TPRC.K=TPCO1.K+TPCO2.K+TPCO3.K                                 FN-  45
A   TPCO1.K=(TPC1.K*WSD1.K*DSWI1.K)+CPC1.K                         FN-  46
A   TPCO2.K=TPC2.K*WSD2.K*DSWI2.K+CPC2.K                           FN-  47
A   TPCO3.K=TPC3.K*WSD3.K*DSWI3.K+CPC3.K                           FN-  48
NOTE     TPRC    TOTAL PLANNED RESEARCH COSTS
NOTE     TPCO    TOTAL PLANNED COST OBLIGATED
NOTE     WSD     WEAPON SYSTEM DEVELOPMENT DECISION
NOTE     DSWI    DOLLAR SWITCH
NOTE     CPC     CHANGE IN PLANNED COSTS
A   RDOSWI.K(PROJ)=SWITCH(Ø,1,RDA.K(PROJ))                         FN-  49
NOTE     RDOSWI  RESEARCH DOLLARS OBLIGATION SWITCH
NOTE     RDA     RESEARCH DOLLAR APPROPRIATED
R   RDOR.KL(2)=(RDA.K(2)*APRF.K)*RDOSWI.K(2)                       FN-  5Ø
NOTE     RDOR    RESEARCH DOLLARS OBLIGATION RATE
NOTE     RDOSWI  RESEARCH DOLLARS OBLIGATION SWITCH
A   APRF.K=TABLE(APRFT,FYTIME.K,1,12,1)                            FN-  51
T   APRFT=1.Ø/.5/.33/.25/.2/.167/.143/.125/.111/.1/.Ø9/.Ø83        FN-  52
NOTE     APRF    APPROPRIATION RATE FRACTION
NOTE     FYTIME  FISCAL YEAR TIME
N   RDOC(1)=RDOC1C                                                 FN-  53
C   RDOC1C=Ø                                                       FN-  54
N   RDOC(2)=RDOC2C                                                 FN-  55
C   RDOC2C=Ø                                                       FN-  56
NOTE     RDOC    RESEARCH DOLLARS ON CONTRACT
NOTE     RDOR    RESEARCH DOLLARS OBLIGATION RATE
NOTE     RDPR    RESEARCH DOLLAR PAYMENT RATE
R   RDPR.KL(1)=RDPSWI.K(1)*(DELAY3(CRR1.JK,RDPRD)+DELAY3(CRR2.JKFN-  57
X   ,RDPRD)+DELAY3(CRR3.JK,RDPRD))
C   RDPRD=3                                                        FN-  58
NOTE     RDPR    RESEARCH DOLLARS PAYMENT RATE
NOTE     RDPSWI  RESEARCH DOLLARS PAYMENT SWITCH
NOTE     CRR     COST REPORTING RATE
NOTE     RDPRD   RESEARCH DOLLARS PAYMENT RATE DELAY
A   RDPSWI.K(PROJ)=SWITCH(Ø,1,RDOC.K(PROJ))                        FN-  59
NOTE     RDPSWI  RESEARCH DOLLARS PAYMENT SWITCH
NOTE     RDOC    RESEARCH DOLLARS ON CONTRACT
```

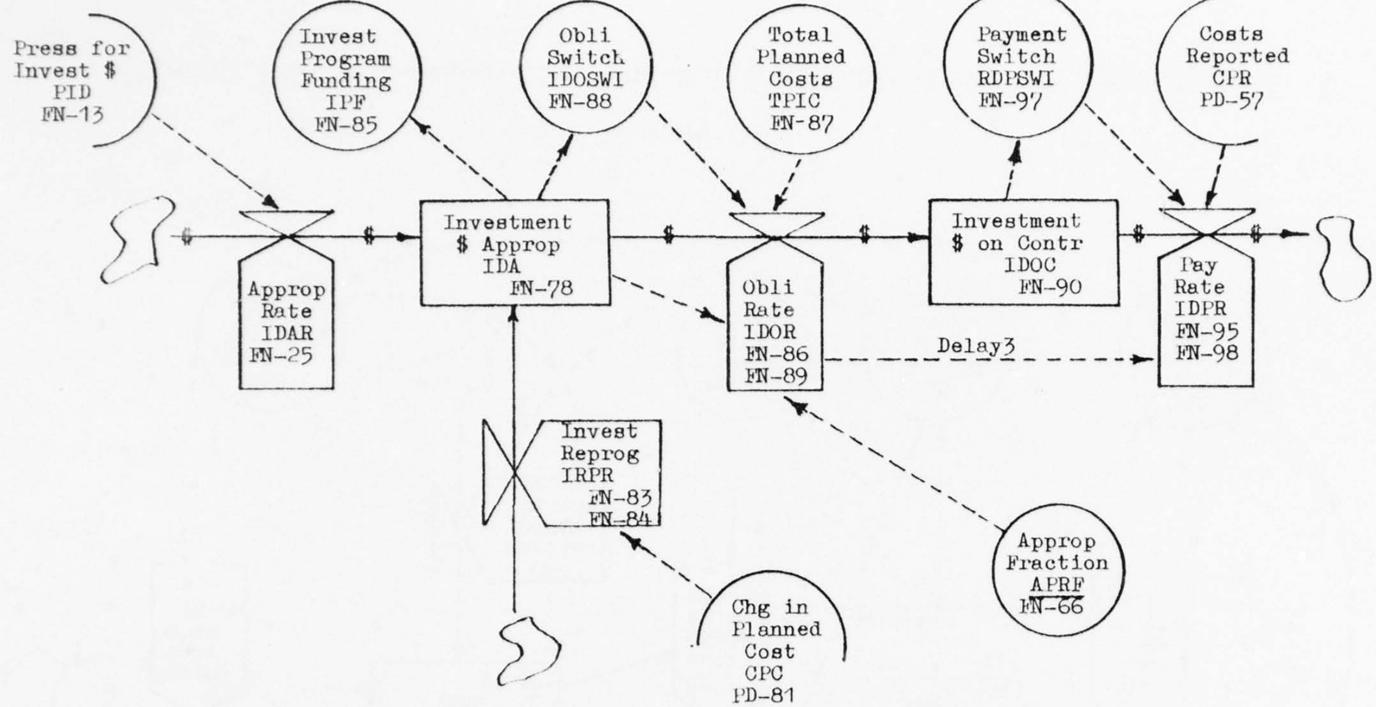

Figure C-3

Financial Sector--Investment Allocation and Expenditure

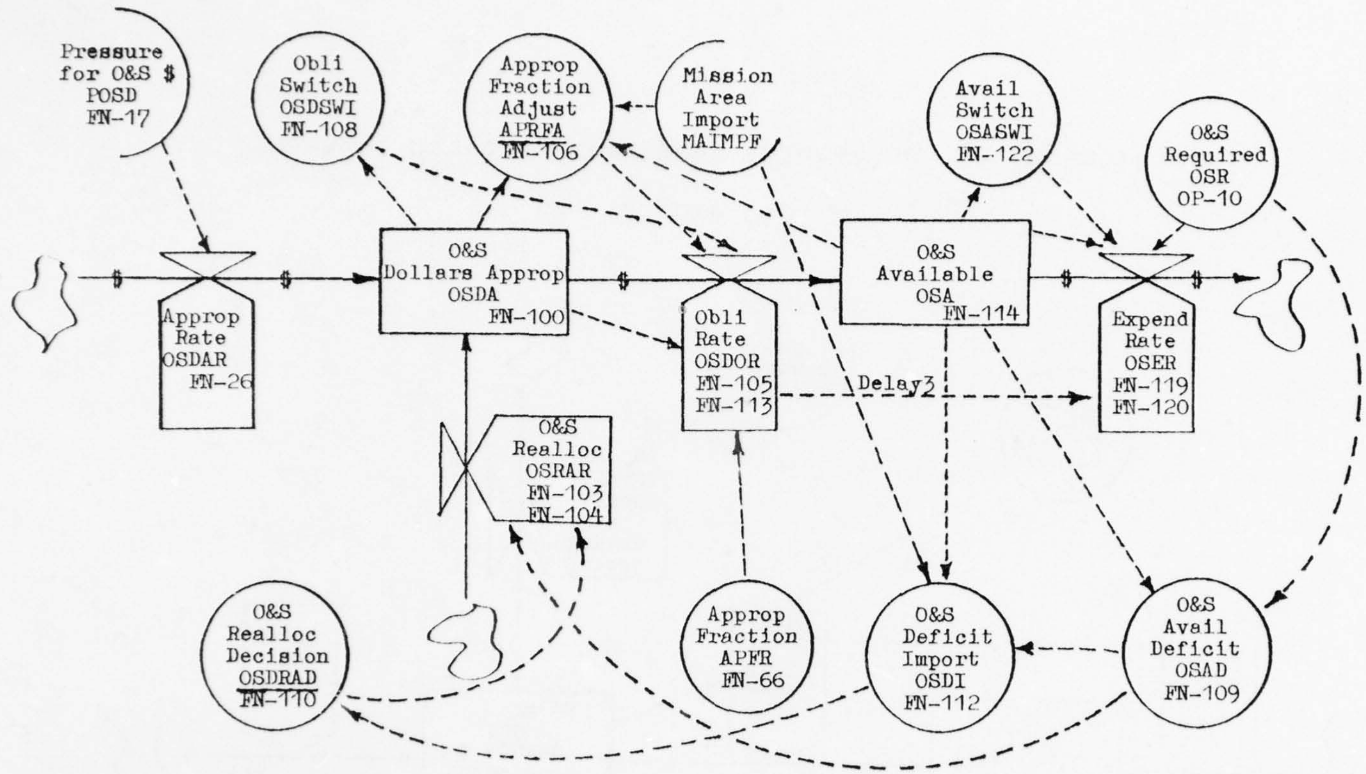

Figure C-4

Financial Sector--Operating and Support Allocation and Expenditure

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A   OSAD.K=MAX(OSR.K-OSA.K(1),0)                                     FN-  93
NOTE      OSAD    O&S AVAILABLE DEFICIT
NOTE      OSR     O&S REQUESTED
NOTE      OSA     O&S AVAILABLE
A   OSDRAD.K=TABHL(0SDRAT,OSDI.K,0,10,1)                             FN-  94
T   OSDRAT=1.0/1.0/.9/.66/.42/.2/.3/.01/0.0/0.0/0.0                   FN-  95
NOTE      OSDRAD  O&S DOLLARS REALLOCATION DECISION
NOTE      OSDI    O&S DEFICIT IMPORTANCE
A   OSDI.K=OSAD.K/OSA.K(2)+1/MAIMPF                                  FN-  96
NOTE      OSDI    O&S DEFICIT IMPORTANCE
NOTE      OSAD    O&S AVAILABLE DEFICIT
NOTE      OSA     O&S AVAILABLE
NOTE      MAIMPF  MISSION AREA IMPORTANCE FACTOR
R   OSDOR.KL(2)=OSDA.K(2)*APRF.K*OSDSWI.K(2)                         FN-  97
NOTE      OSDOR   O&S DOLLAR OBLIGATION RATE
NOTE      OSDA    O&S DOLLARS APPROPRIATED
NOTE      APRF    APPROPRIATION FRACTION
NOTE      OSDSWI  O&S DOLLARS SWITCH
L   OSA.K(PROJ)=OSA.J(PROJ)+DT*(OSDOR.JK(PROJ)-OSER.JK(PROJ))        FN-  98
N   OSA(1)=OSA1C                                                     FN-  99
C   OSA1C=0                                                          FN- 100
N   OSA(2)=OSA2C                                                     FN- 101
C   OSA2C=0                                                          FN- 102
NOTE      OSA     O&S AVAILABLE
NOTE      OSDOR   O&S DOLLARS OBLIGATION RATE
NOTE      OSER    O&S EXPENSE RATE
R   OSER.KL(1)=MIN(OSR.K,OSA.K(1))*OSASWI.K(1)                       FN- 103
NOTE      OSER    O&S EXPENSE RATE
NOTE      OSR     O&S REQUESTED
NOTE      OSA     O&S AVAILABLE
NOTE      OSASWI   O&S AVAILABLE SWITCH
R   OSER.K(2)=DELAY3(OSDOR.KL(2),OSERD)                              FN- 104
C   OSERD=1                                                          FN- 105
NOTE      OSER    O&S EXPENSE RATE
NOTE      OSDOR   O&S DOLLAR OBLIGATION RATE
NOTE      OSERD   O&S EXPENSE REPORTING DELAY
A   OSASWI.K(PROJ)=SWITCH(0,1,OSA.K(PROJ))                           FN- 106
NOTE      OSASWI  O&S AVAILABLE SWITCH
NOTE      OSA     O&S AVAILABLE
NOTE      APRF    APPROPRIATION FRACTION
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N    IDOC(2)=IDOC2C                                            FN-  77
C    IDOC2C=Ø                                                  FN-  78
NOTE      IDOC    INVESTMENT DOLLARS ON CONTRACT
NOTE      IDOR    INVESTMENT DOLLARS OBLIGATION RATE
NOTE      IDPR    INVESTMENT DOLLARS PAYMENT RATE
R    IDPR.KL(1)=IDPSWI.K(1)*DELAY3(CRR4.JK,IDPRD)              FN-  79
C    IDPRD=3                                                   FN-  8Ø
NOTE      IDPR    INVESTMENT DOLLAR PAYMENT RATE FOR PROJECT
NOTE      IDPSWI  INVESTMENT DOLLARS PAYMENT SWITCH
NOTE      CRR4    COST REPORTING RATE 4
NOTE      IDPRD   INVESTMENT DOLLARS PAYMENT RATE DELAY
A    IDPSWI.K(PROJ)=SWITCH(Ø,1,IDOC.K(PROJ))                   FN-  81
NOTE      IDPSWI  INVESTMENT DOLLAR PAYMENT SWITCH
NOTE      IDOC    INVESTMENT DOLLARS ON CONTRACT
R    IDPR.KL(2)=DELAY3(IDOR.JK(2),IDPR2D)                      FN-  82
C    IDPR2D=24                                                 FN-  83
NOTE      IDPR    INVESTMENT DOLLAR PAYMENT RATE FOR OTHER
NOTE      IDOR    INVESTMENT DOLLARS OBLIGATION RATE
NOTE      IDPR2D  INVESTMENT DOLLAR PAYMENT RATE DELAY
NOTE
NOTE
NOTE      OPERATING AND SUPPORT COSTS
NOTE
L    OSDA.K(PROJ)=OSDA.J(PROJ)=DT*(OSDAR.JK(PROJ)-OSDOR.JK(PROJ) FN-  84
X    +OSRAR.JK(PROJ)
N    OSDA=OSDAC                                                FN-  85
C    OSDAC=Ø                                                   FN-  86
NOTE      OSDA    O&S DOLLARS APPROPRIATED
NOTE      OSDAR   O&S DOLLARS APPROPRIATION RATE
NOTE      OSDOR   O&S DOLLARS OBLIGATION RATE
NOTE      OSRAR   O&S REALLOCATION RATE
R    OSRAR.KL(1)=OSAD.K*OSDRAD.K                               FN-  87
R    OSRAR.KL(2)=-(OSAD.K*OSDRAD.K)                            FN-  88
NOTE      OSRAR   O&S REALLOCATION RATE
NOTE      OSAD    O&S AVAILABLE DEFICIT
NOTE      OSDRAD  O&S DOLLARS REALLOCATION DECISION
R    OSDOR.KL(1)=OSDA.K(1)*APRF.K*APRFA.K*OSDSWI.K(1)          FN-  89
NOTE      OSDOR   O&S DOLLARS OBLIGATED RATE
NOTE      OSDA     O&S DOLLARS APPROPRIATED
NOTE      APRF    APPROPRIATION FRACTION
NOTE      APRFA   APPROPRIATION FRACTION ADJUSTOR
NOTE      OSDSWI  O&S DOLLARS SWITCH
A    APRFA.K=TABHL(APRFAT,(OSA.K(1)/OSDA.K(1)+1/MAIMPF),Ø,5,1)  FN-  9Ø
T    APRAT=1.3/1.3/1.22/1.1/1.Ø3/1.Ø                           FN-  91
NOTE      APRFA   APPROPRIATION FRACTION ADJUSTOR
NOTE      OSA     O&S AVAILABLE
A    OSDSWI.K(PROJ)=SWITCH(Ø,1,OSDA.K(PROJ))                   FN-  92
NOTE      OSDWSI  O&S DOLLAR SWITCH
NOTE      OSDA    O&S DOLLARS APPROPRIATED
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NOTE     WEAPON SYSTEM DEVELOPMENT SECTOR
NOTE
NOTE
NOTE     ACTUAL PROGRESS SECTION
NOTE
NOTE
L   AP1.K=AP1.J + DT*(APR1.JK-APTR1.JK)                              RD-  1
N   AP1=AP1C                                                         RD-  2
C   AP1C=Ø                                                           RD-  3
NOTE     AP1     ACTUAL PROGRESS
NOTE     APR1    ACTUAL PROGRESS RATE (PROGRESS/TIME)
NOTE     APTR1   ACTUAL PROGRESS TRANSFER RATE (PROGRESS/TIME)
R   APR1.KL=TE1.K*PGM1.K*CAPRS1.K                                    RD-  4
N   APR1=Ø                                                           RD-  5
N   TE1=.5                                                           RD-  6
A   TE1.K=1/TCF.K*ME1                                                RD-  7
C   ME1=1                                                            RD-  8
NOTE     APR1    ACTUAL PROGRESS RATE
NOTE     TE1.K     TECHNICAL EFFECTIVENESS
NOTE     PGM1    PROGRAM
NOTE     CAPRS1  CHANGE IN ACTUAL PROGRESS RATE (SMOOTHED)  (FRACTIO
NOTE     ME1     MANAGEMENT EFFECTIVENESS
A   PGM1.K=TABHL(PGM1T,SCHED1.K,Ø,1,.Ø83)*WSD1.K*DCP1.K*12/          RD-  9
X   (TTMS1.K+TSMSØ.K)
T   PGM1T=Ø/3/6/7.5/9/9.67/1Ø.33/11/11/11/11/11/Ø                    RD- 1Ø
NOTE-    PGM1    PROGRAM
NOTE     SCHED   SCHEDULE
NOTE     TSMSØ   TIME SINCE MILESTONE Ø
NOTE     TTMS1   TIME TIL MILESTONE 1
NOTE     WSD1    WEAPONS SYSTEM DEVELOPMENT PHASE 1
NOTE     DCP1    DECISION COORD PAPER 1
A   SCHED1.K=TSMSØ.K/(TSMSØ.K+TTMS1.K)                               RD- 11
A   CAPRS1.K=SMOOTH(CAPR1.K,CAPRD)                                   RD- 12
C   CAPRD=1                                                          RD- 13
A   CAPR1.K=FLF1.K*DCAPR1.K                                          RD- 14
NOTE     CAPRS1  CHANGE IN ACTUAL PROGRESS RATE (SMOOTHED)
NOTE     CAPR1   CHANGE IN ACTUAL PROGRESS RATE
NOTE     CAPRD  CHANGE IN ACTUAL RATE DELAY
NOTE     FLF1    FUNDS LIMIT FACTOR
NOTE     DCAPR1  DESIRED CHANGE IN ACTUAL PROGRESS RATE
A   DCAPR1.K=APR1.JK-DPR1.K                                          RD- 15
NOTE     DCAPR1  DESIRED CHANGE IN ACTUAL PROGRESS RATE
NOTE     APR1    ACTUAL PROGRESS RATE
NOTE     DPR1    DESIRED PROGRESS RATE
NOTE
A   PAP1.K=SMOOTH(AP1.K,APD)                                         RD- 16
C   APD=1                                                            RD- 17
NOTE     PAP1    PERCEIVED ACTUAL PROGRESS
NOTE     AP1      ACTUAL PROGRESS
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NOTE     APD     ACTUAL PROGRESS DELAY
A    RAP1.K=TPG-PAP1.K                                               RD-  18
C    TPG=1ØØ                                                         RD-  19
NOTE     RAP1    REMAINING ACTUAL PROGRESS
NOTE     TPG     TOTAL PROGRESS GOAL
NOTE     PAP1    PERCEIVED ACTUAL PROGRESS
FOR I=1,1Ø
A    PRR1.K(I)=RAP1.K/RTTMS1.K(I)                                    RD-  2Ø
NOTE     PRR1    PROGRESS RATE REQUIRED
NOTE     RAP1    REMAINING ACTUAL PROGRESS
NOTE     RTTMS1  REVISED TIME TIL MILESTONE 1
A    RTTMS1.K(I)=TTMS1.K+TL1.K(I)                                    RD-  21
T    TL1(I)=1/2/3/4/5/6/7/8/9/1Ø                                     RD-  22
NOTE     RTTMS1  REVISED TIME TIL MILESTONE 1
NOTE     TTMS1   TIME TIL MILESTONE 1
NOTE     TL1     TIME LATE
A    CF1.K(I)=TABHL(CFT,PRR1.K(I),.6,1.6,.1)                         RD-  23
T    CFT=1.15/1.Ø6/1.Ø2,1.Ø1,1.Ø/1.1/1.25/1.38/1.62/2.Ø/3.Ø           RD-  24
NOTE     CF1     COST FACTOR
NOTE     PRR1    PROGRESS RATE REQUIRED
A    CP1.K(I)=CF1.K(I)*RTTMS1.K(I)                                   RD-  25
NOTE     CP1     COST PENALTY
NOTE     CF1     COST FACTOR
NOTE     RTTMS1  REVISED TIME TIL MILESTONE 1
A    SF1.K(I)=TABHL(SFT,TL1.K(I),1,1Ø,1)                             RD-  26
T    SFT=1.Ø/1.Ø1,1.1/1.25/1.4/1.58/1.75/1.87/1.95/2.Ø/2.Ø            RD-  27
NOTE     SF1     SCHEDULE FACTOR
NOTE     TL1     TIME LATE
A    SP1.K(I)=SF1.K(I)*TL1.K(I)                                      RD-  28
NOTE     SP1     SCHEDULE PENALTY
NOTE     SF1     SCHEDULE FACTOR
NOTE     TL1     TIME LATE
A    TC1.K(I)=(CWF*CP1.K(I))+(SWF*SP1.K(I))                          RD-  29
C    CWF=.5                                                          RD-  3Ø
C    SWF=.5                                                          RD-  31
NOTE     TC1     TOTAL COST
NOTE     CWF     COST WEIGHT FACTOR
NOTE     CP1     COST PENALTY
NOTE     SWF     SCHEDULE WEIGHT FACTOR
NOTE     SP1     SCHEDULE PENALTY
FNCTN DPR1(6,2,ØØ1111)                                               RD-  32
NOTE
A    DATA.K=DPR1(DTL1.K,DCF.K,TC1.K,PRR1.K,CF1.K,TL1.K)              RD-  33
NOTE     PLANNED PROGRESS
NOTE
L    PP1.K=PP1.J+DT*(PPGM1.JK-PPTX1.JK)                              RD-  34
N    PP1=PP1C                                                        RD-  35
C    PP1C=Ø                                                          RD-  36
NOTE     PP1      PLANNED PROGRESS
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NOTE     PPGM1   PLANNED PROGRAM RATE
NOTE     PPTX1   PLANNED PROGRESS TRANSFER RATE
R   PPGM1.KL=TABLE(PGM1T,PSCHD1.K,Ø,1,.Ø83)*WSD1.K*DCP1.K*         RD- 37
X   12/TICP.K
A   PSCHD1.K=TSMSO.K/TICP.K                                         RD- 38
NOTE     PPGM1   PLANNED PROGRAM RATE
NOTE     WSD     WEAPON SYSTEM DEVELOPMENT DECISION
NOTE     DCP     DECISION COORD POINT
NOTE     TICP    TIME IN CONCEPTUAL PHASE
NOTE     PSCHD1  PLANNED SCHEDULE
NOTE     TSMS    TIME SINCE MILESTONE
NOTE
NOTE
NOTE     PRESSURE FOR SCHEDULE EXTENSION
NOTE
A   PSE1.K=TABHL(PSE1T,ELF1.K,Ø,1,.2)                               RD- 39
T   PSET=Ø.Ø/.15/.35/.58/.88/1.Ø                                    RD- 4Ø
NOTE     PSE1    PRESSURE FOR SCHEDULE EXTENSION
NOTE     ELF1    ESTIMATED LATE FACTOR
A   ELF1.K=DTL1.K/TTMS1.K                                           RD- 41
NOTE     ELF     ESTIMATED LATE FACTOR
NOTE     DTL1    DESIRED TIME LATE
NOTE     TTMS1   TIME TIL MILESTONE 1
A   SEA1.K=(PSE1.K+CRPA1.K/USURGF.K                                 RD- 42
NOTE     SEA1    SCHEDULE EXTENSION ADJUSTOR
NOTE     CRPA1   COST RATIO, PLANNED TO ACTUAL
A   CRPA1.K=PC1.K/CR1.K                                             RD- 43
NOTE     CRPA1   COST RATIO, PLANNED TO ACTUAL
NOTE     PC1     PLANNED COST
NOTE     CR1     COST REPORTED
A   SCD1.K=CLIP(SEA1.K,Ø,SEA1.K,.5)                                 RD- 44
NOTE     SCD1    SCHEDULE EXTENSION DECISION
NOTE     SEA1    SCHEDULE EXTENSION ADJUSTOR
A   SCDM1.K=CLIP(1,SCD1.K,SCD1.K,1)                                 RD- 45
NOTE     SCDM1   SCHEDULE MULTIPLIER
A   CMS1.K=SCDM.K*DTL1.K                                            RD- 46
NOTE     CMS1    CHANGE IN MILESTONE 1
NOTE     SCD1    SCHEDULE EXTENSION DECISION
NOTE     DTL1    DESIRED TIME LATE
NOTE
NOTE     COST REPORTING
NOTE
L   CR1.K=CR1.J+DT*(CRR1.JK-CRTR1.JK)                               RD- 47
N   CR1=CR1C                                                        RD- 48
C   CR1C=Ø                                                          RD- 49
NOTE     CR1     COST REPORTED
NOTE     CRR1    COST REPORTING RATE
NOTE     CRTR1   COST REPORTING TRANSFER RATE
R   CRR1.KL=CE1*DCFS1.K*PGM1.K/PTCR                                 RD- 5Ø
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C   CE1=1                                                    RD-  51
NOTE      CRR1    COST REPORTED RATE
NOTE      CE1     COST ESTIMATING ERROR
NOTE      DCFS1   DESIRED COST FACTOR (SMOOTHED)
A   DCFS1.K=SMOOTH(DCF1.K,DCFD)                              RD-  52
C   DCFD=1                                                   RD-  53
NOTE      DCFS1   DESIRED COST FACTOR (SMOOTHED)
NOTE      DCF1    DESIRED COST FACTOR
NOTE      DCFD   DESIRED COST FACTOR DELAY
NOTE
NOTE      PLANNED COSTS
NOTE
L   PC1.K=PC1.J+DT*(PCR1.JK-PCTR1.JK)                        RD-  54
N   PC1=PC1C                                                 RD-  55
C   PC1C=0                                                   RD-  56
NOTE      PC1     PLANNED COSTS
NOTE      PCR1    PLANNED COST RATE
NOTE      PCTR1   PLANNED COST TRANSFER RATE
R   PCR1.KL=PPGM1.JK/PTCR+CPC1.K                             RD-  57
C   PTCR=100                                                 RD-  58
NOTE      PCR1    PLANNED COST RATE
NOTE      PPGM1   PROGRAM
NOTE      PTCR    PROGRESS TO COST RATIO
A   TPC1.K=TPG/PTCR+CPC1.K                                   RD-  59
NOTE      TPC1    TOTAL PLANNED COST
NOTE      TPG1    TOTAL PROGRESS GOAL
NOTE      PTCR    PROGRESS TO COST RATIO
NOTE      CPC1    CHANGE IN PLANNED COST
NOTE
NOTE      PRODUCT VALUE
NOTE
L   PV1.K=PV1.J+DT*(PVR1.JK-PVTR1.JK)                        RD-  60
N   PV1=PV1C                                                 RD-  61
C   PV1C=0                                                   RD-  62
NOTE      PV1     PRODUCT VALUE
NOTE      PVR1    PRODUCT VALUE RATE
NOTE      PVTR1   PRODUCT VALUE TRANSFER RATE
R   PVR1.KL=PPVS1.K*PVA1.K                                   RD-  63
NOTE      PVR1    PRODUCT VALUE RATE
NOTE      PPVS1    PLANNED PRODUCT VALUE (SMOOTHED)
NOTE      PVA1    PRODUCT VALUE ADJUSTOR
A   PPVS1.K=SMOOTH(PP1.K,PPD)                                RD-  64
C   PPD=1                                                    RD-  65
NOTE      PPVS1    PLANNED PRODUCT VALUE (SMOOTHED)
NOTE      PP1     PLANNED PROGRESS
NOTE      PPD   PLANNED PROGRESS DELAY
A   PVA1.K=PRAP1.K*CRPA1.K                                   RD-  66
NOTE      PVA1    PRODUCT VALUE ADJUSTOR
NOTE      PRAP1   PROGRESS RATIO, ACTUAL TO PLANNED
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NOTE      CRPA1   COST RATIO, PLANNED TO ACTUAL
A   PRAP1.K=PAP1.K/PP1.K                                      RD-  67
NOTE      PRAP1   PROGRESS RATIO, ACTUAL TO PLANNED
NOTE      PAP1    PERCEIVED ACTUAL PROGRESS
NOTE      PP1     PLANNED PROGRESS
A   CRPA1.K=PC1.K/CR1.K                                       RD-  68
NOTE      CRPA1   COST RATIO, PLANNED TO ACTUAL
NOTE      PC1     PLANNED COST
NOTE      CR1     COST REPORTED
NOTE
NOTE      FUNDS LIMIT AND PRESSURE FOR ADDITIONAL FUNDS
NOTE
A   FLF1.K=TABHL(FLFT,3*TWC1.K,Ø,1Ø,1)                        RD-  69
T   FLFT=Ø/Ø/.11/.22/.33/.45/.55/.66/.77/.88/1.Ø              RD-  7Ø
NOTE      FLF1    FUNDS LIMIT FACTOR
NOTE      TWC1    TIME WEIGHTED COST
A   TWC1.K=TTMS1.K*CRPA1.K                                    RD-  71
NOTE      TWC1    TIME WEIGHTED COST
NOTE      TTMS1   TIME TIL MILESTONE 1
NOTE      CRPA1   COST RATIO, PLANNED TO ACTUAL
A   PIF1.K=TABHL(PIFT,FLF1.K,Ø,1.4,.2)                        RD-  72
T   PIFT=1/.72/.57/.45/.38/.32/.28/.26/.25                    RD-  73
NOTE      PIF1    PRESSURE FOR INCREASED FUNDS
NOTE      FLF1    FUNDS LIMIT FACTOR
A   ITAF1.K=FA1.K*PIF1.K*PRAP1.K+USURGF.K*MAIMPF)             RD-  74
NOTE      ITAF1   INCLINATION TO APPROVE FUNDS
NOTE      FA1     FUNDS AVAILIABILITY
NOTE      PIF1    PRESSURE FOR INCREASED FUNDS
NOTE      PRAP1   PROGRESS RATIO, ACTUAL TO PLANNED
NOTE      MAIMPF  MISSION AREA IMPORTANCE FACTOR
A   FID1.K=TABHL(FIDT,ITAF1.K,.8,2.Ø,.2)                      RD-  75
T   FIDT=Ø/.375/.62/.75/.86/.92/.96/.97                       RD-  76
NOTE      FID1    FUNDS INCREASE DECISION
NOTE      ITAF1   INCLINATION TO APPROVE FUNDS
A   CPC1.K=FID1.K*ECC1.K                                      RD-  77
NOTE      CPC1    CHANGE IN PLANNED COST
NOTE      FID1    FUNDS INCREASE DECISION
NOTE      ECC1    ESTIMATED CHANGE IN COST
A   ECC1.K=CLIP(ICR1.K,Ø,ICR1.K,Ø)*(TSMSO.K+TTMS1.K)/PTCR      RD-  78
A   ICR1.K=1-1/CRPA1.K                                        RD-  79
NOTE      ECC1    ESTIMATED CHANGE IN COST
NOTE      CRPA1   COST RATIO, PLANNED TO ACTUAL
NOTE      TSMSØ   TIME SINCE MILESTONE Ø
NOTE      TTMS1   TIME TIL MILESTONE 1
NOTE      PTCR    PROGRESS TO COST RATIO
NOTE      ICR     INCREASE IN COST RATE
A   FA1.K=TABHL(FAT,FAF1.K,Ø,.4,.Ø5)                          RD-  8Ø
T   FAT=Ø/.55/.375/.25/.1/.Ø5/.Ø2/.ØØ1/.Ø                     RD-  81
NOTE      FA1     FUNDS AVAILABILITY
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NOTE     FAF1    FUNDS AVAILABILITY FACTOR
A   FAF1.K=ECC1.K/RDA.K(2)                                      RD-  82
NOTE     FAF     FUNDS AVAILABILITY FACTOR
NOTE     ECC1    ESTIMATED CHANGE IN COST
NOTE     RDA(2)  RESEARCH DOLLARS APPROPRIATED
NOTE     WEAPON SYSTEM DELEPOPMENT-VALIDATION
NOTE
NOTE     ACTUAL PROGRESS SECTION
NOTE
L   AP2.K=AP2.J + DT*(APR2.JK-APTR2.JK)                         RD-  83
N   AP2=AP2C                                                    RD-  84
C   AP2C=Ø                                                      RD-  85
NOTE     AP2     ACTUAL PROGRESS
NOTE     APR2    ACTUAL PROGRESS RATE (PROGRESS/TIME)
NOTE     APTR2   ACTUAL PROGRESS TRANSFER RATE (PROGRESS/TIME)
R   APR2.KL=TE2.K*PGM2.K*CAPRS2.K                               RD-  86
A   TE2.K=1/TCF.K*ME2*PAST1.K/PSTPP1.K                          RD-  87
C   ME2=1                                                       RD-  88
NOTE     APR2    ACTUAL PROGRESS RATE
NOTE     TE2.K     TECHNICAL EFFECTIVENESS
NOTE     PGM2    PROGRAM
NOTE     CAPRS2  CHANGE IN ACTUAL PROGRESS RATE(SMOOTHED)
NOTE     ME2     MANAGEMENT EFFECTIVENESS
A   PGM2.K=TABLE(PGM1T,SCHED2.K,Ø,1,.Ø833)*WSD2.K*DCP2.K*12/    RD-  89
X   (TTMS2.K+TSMS1.K)
NOTE-    PGM2  PROGRAM
NOTE     TTMS2   TIME TIL MILESTONE 2
NOTE     WSD2    WEAPONS SYSTEM DEVELOPMENT PHASE 2
NOTE     DCP2    DECISION COORD PAPER 2
A   SCHED2.K=TSMS1.K/(TSMS1.K+TTMS2.K)                          RD-  9Ø
A   CAPRS2.K=SMOOTH(CAPR2.K,CAPRD)                              RD-  91
A   CAPR2.K=FLF2.K*DCAPR2.K                                     RD-  92
NOTE     CAPRS2  CHANGE IN ACTUAL PROGRESS RATE (SMOOTHED)
NOTE     CAPR2   CHANGE IN ACTUAL PROGRESS RATE
NOTE     CAPRD2  CHANGE IN ACTUAL RATE DELAY
NOTE     FLF2    FUNDS LIMIT FACTOR
NOTE     DCAPR2  DESIRED CHANGE IN ACTUAL PROGRESS RATE
A   DCAPR2.K=APR2.JK-DPR2.K                                     RD-  93
NOTE     DCAPR2  DESIRED CHANGE IN ACTUAL PROGRESS RATE
NOTE     APR2    ACTUAL PROGRESS RATE
NOTE     DPR2    DESIRED PROGRESS RATE
NOTE
A   PAP2.K=SMOOTH(AP2.K,APD)                                    RD-  94
NOTE     PAP2    PERCEIVED ACTUAL PROGRESS
NOTE     AP2      ACTUAL PROGRESS
NOTE     APD     ACTUAL PROGRESS DELAY
A   RAP2.K=TPG-PAP2.K                                           RD-  95
NOTE     RAP!    REMAINING ACTUAL PROGRESS
NOTE     TPG     TOTAL PROGRESS GOAL
NOTE     PAP2    PERCEIVED ACTUAL PROGRESS
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A   PRR2.K(I)=RAP2.K/RTTMS2.K(I)                                  RD- 96
NOTE     PRR2    PROGRESS RATE REQUIRED
NOTE     RAP2    REMAINING ACTUAL PROGRESS
NOTE     RTTMS2  REVISED TIME TIL MILESTONE 2
A   RTTMS1.K(I)=TTMS2.K+T(I)                                      RD- 97
NOTE     RTTMS2  REVISED TIME TIL MILESTONE 2
NOTE     TTMS2   TIME TIL MILESTONE 2
NOTE     T       TIME
A   CF2.K(I)=TABHL(CFT2,PRR2.K(I),.6,2,.2)                        RD- 98
NOTE     CF2     COST FACTOR
NOTE     PRR2    PROGRESS RATE REQUIRED
A   CP2.K(I)=CF2.K(I)*RTTMS2.K(I)                                 RD- 99
NOTE     CP2     COST PENALTY
NOTE     CF2     COST FACTOR
NOTE     RTTMS2  REVISED TIME TIL MILESTONE 2
A   SF2.K(I)=TABHL(SFT,T(I),1,10,1                                RD- 100
NOTE     SF2     SCHEDULE FACTOR
NOTE     T       TIME
A   SP2.K(I)=SF2.K(I)*T(I)                                        RD- 101
NOTE     SP2     SCHEDULE PENALTY
NOTE     SF2     SCHEDULE FACTOR
NOTE     T       TIME
A   TC2.K(I)=(CWF*CP2.K(I))+(SWF*SP2.K(I))                        RD- 102
C   SWF=.5                                                        RD- 103
NOTE     TC2     TOTAL COST
NOTE     CWF     COST WEIGHT FACTOR
NOTE     CP2     COST PENALTY
NOTE     SWF     SCHEDULE WEIGHT FACTOR
NOTE     SP2     SCHEDULE PENALTY
A   DATA2.K=DPR2(DTL2.K,DCF2.K,TC2.K,PRR2.K,CF2.K,TL1.K)          RD- 104
NOTE     PLANNED PROGRESS
NOTE
L   PP2.K=PP2.J+DT*(PPGM2.JK-PPTX2.JK)                            RD- 105
N   PP2=PP2C                                                      RD- 106
C   PP2C=0                                                        RD- 107
NOTE     PP2      PLANNED PROGRESS
NOTE     PPR2    PLANNED PROGRESS RATE
NOTE     PPTX2    PLANNED PROGRESS TRANSFER RATE
R   PPGM2.KL=TABLE(PGM1T,PSCHD2.K,0,1,.083)*WSD2.K*DCP2.K         RD- 108
X   *12/TIVP.K
A   PSCHD2.K=TSMS1.K/TIVP.K                                       RD- 109
NOTE
NOTE     PRESSURE FOR SCHEDULE EXTENSION
NOTE
A   PSE2.K=TABHL(PSET,ELF2.K,0,1,.2)                              RD- 110
NOTE     PSE2    PRESSURE FOR SCHEDULE EXTENSION
NOTE     ELF2    ESTIMATED LATE FACTOR
A   ELF2.K=DTL2.K/TTMS2.K                                         RD- 111
NOTE     ELF     ESTIMATED LATE FACTOR
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NOTE     DTL2    DESIRED TIME LATE
NOTE     TTMS2   TIME TIL MILESTONE 2
A   SEA2.K=PSE2.K*USURGF.K*CRPA2.K                                  RD- 112
NOTE     SEA2    SCHEDULE EXTENSION ADJUSTOR
NOTE     CRPA2   COST RATIO, PLANNED TO ACTUAL
A   CRPA2.K=PC2.K/CR2.K                                             RD- 113
NOTE     CRPA2   COST RATIO, PLANNED TO ACTUAL
NOTE     PC2     PLANNED COST
NOTE     CR2     COST REPORTED
A   SCD2.K=CLIP(2,0,SEA2.K,.6)                                      RD- 114
NOTE     SCD2    SCHEDULE EXTENSION DECISION
NOTE     SEA2    SCHEDULE EXTENSION ADJUSTOR
A   CMS2.K=SCDM2.K*DTL2.K                                           RD- 115
A   SCHM2.K=CLIP(1,SCH2.K,SCH2.K,1)                                 RD- 116
NOTE     CMS2    CHANGE IN MILESTONE 2
NOTE     SCD2    SCHEDULE EXTENSION DECISION
NOTE     DTL2    DESIRED TIME LATE
NOTE
NOTE     COST REPORTING
NOTE
L   CR2.K=CR2.J+DT*(CRR2.JK-CRTR2.JK)                               RD- 117
N   CR2=CR2C                                                        RD- 118
C   CR2C=0                                                          RD- 119
NOTE     CR2     COST REPORTED
NOTE     CRR2    COST REPORTING RATE
NOTE     CRTR2   COST REPORTING TRANSFER RATE
R   CRR2.KL=CE2*DCFS2.K*PGM2.K/PTCR                                 RD- 120
C   CE2=2                                                           RD- 121
NOTE     CRR2    COST REPORTED RATE
NOTE     CE2     COST ESTIMATING ERROR
NOTE     DCFS2   DESIRED COST FACTOR (SMOOTHED)
NOTE     PGM2    PROGRAM
A   DCFS2.K=SMOOTH(DCF2.K,DCFD)                                     RD- 122
C   DCFD=1                                                          RD- 123
NOTE     DCFS2   DESIRED COST FACTOR (SMOOTHED)
NOTE     DCF2    DESIRED COST FACTOR
NOTE     DCFD    DESIRED COST FACTOR DELAY
NOTE
NOTE     PLANNED COSTS
NOTE
L   PC2.K=PC2.J+DT*(PCR2.JK-PCTR2.JK)                               RD- 124
N   PC2=PC2C                                                        RD- 125
C   PC2C=0                                                          RD- 126
NOTE     PC2     PLANNED COSTS
NOTE     PCR2    PLANNED COST RATE
NOTE     PCTR2   PLANNED COST TRANSFER RATE
R   PCR2.KL=PPGM2.JK/PTCR+CPC2.K                                    RD- 127
NOTE     PCR2    PLANNED COST RATE
NOTE     PGM2    PROGRAM
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AD-A072 618 AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL--ETC F/G 5/1
A DYNAMIC POLICY MODEL OF THE DEPARTMENT OF DEFENSE SYSTEMS ACQ--ETC(U)
JUN 79 S A KAFFENBERGER, D P MARTIN
UNCLASSIFIED AFIT-LSSR-1-79A NL

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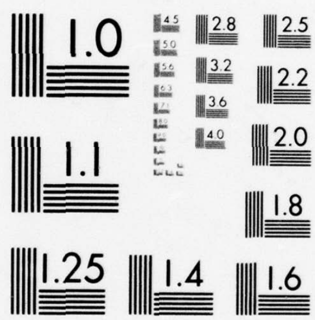

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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NOTE     PTCR    PROGRESS TO COST RATIO
A   TPC2.K=TPG/PTCR+CPC2.K                                    RD- 128
NOTE     TPC2    TOTAL PLANNED COST
NOTE     TPG2    TOTAL PROGRESS GOAL
NOTE     PTCR    PROGRESS TO COST RATIO
NOTE     CPC2    CHANGE IN PLANNED COST
NOTE
NOTE     PRODUCT VALUE
NOTE
L   PV2.K=PV2.J+DT*(PVR2.JK-PVTR2.JK)                         RD- 129
N   PV2=PV2C                                                  RD- 130
C   PV2C=0                                                    RD- 131
NOTE     PV2     PRODUCT VALUE
NOTE     PVR2    PRODUCT VALUE RATE
NOTE     PVTR2   PRODUCT VALUE TRANSFER RATE
R   PVR2.KL=PPVS2.K*PVA2.K                                    RD- 132
NOTE     PVR2    PRODUCT VALUE RATE
NOTE     PPVS2    PLANNED PRODUCT VALUE (SMOOTHED)
NOTE     PVA2    PRODUCT VALUE ADJUSTOR
A   PPVS2.K=SMOOTH(PP2.K,PPD)                                 RD- 133
NOTE     PPVS2    PLANNED PRODUCT VALUE (SMOOTHED)
NOTE     PP2     PLANNED PROGRESS
NOTE     PP2D    PLANNED PROGRESS DELAY
A   PVA2.K=PRAP2.K*CRPA2.K                                    RD- 134
NOTE     PVA2    PRODUCT VALUE ADJUSTOR
NOTE     PRAP2   PROGRESS RATIO, ACTUAL TO PLANNED
NOTE     CRPA2   COST RATIO, PLANNED TO ACTUAL
A   PRAP2.K=PAP2.K/PP2.K                                      RD- 135
NOTE     PRAP2   PROGRESS RATIO, ACTUAL TO PLANNED
NOTE     PAP2    PERCEIVED ACTUAL PROGRESS
NOTE     PP2     PLANNED PROGRESS
A   CRPA2.K=PC2.K/CR2.K                                       RD- 136
NOTE     CRPA2   COST RATIO, PLANNED TO ACTUAL
NOTE     PC2     PLANNED COST
NOTE     CR2     COST REPORTED
NOTE
NOTE     FUNDS LIMIT AND PRESSURE FOR ADDITIONAL FUNDS
NOTE
A   FLF2.K=TABHL(FLFT,2*TWC2.K,0,10,1)                        RD- 137
NOTE     FLF2    FUNDS LIMIT FACTOR
NOTE     TWC2    TIME WEIGHTED COST
A   TWC2.K=TTMS2.K*CRPA2.K                                    RD- 138
NOTE     TWC2   TIME WEIGHTED COST
NOTE     TTMS2   TIME TIL MILESTONE 2
NOTE     CRPA2   COST RATIO, PLANNED TO ACTUAL
A   PIF2.K=TABHL(PIFT,FLF2.K,0,1.4,.2)                        RD- 139
NOTE     PIF2    PRESSURE FOR INCREASED FUNDS
NOTE     FLF2    FUNDS LIMIT FACTOR
A   ITAF2.K=FA2.K*PIF2.K*PRAP2.K+USURGF.K+MAIMPF)             RD- 140
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NOTE     ITAF2   INCLINATION TO APPROVE FUNDS
NOTE     FA2     FUNDS AVAILIBILITY
NOTE     PIF2    PRESSURE FOR INCREASED FUNDS
NOTE     PRAP2   PROGRESS RATIO, ACTUAL TO PLANNED
NOTE     MAIMPF  MISSION AREA IMPORTANCE FACTOR
A   FID2.K=TABHL(FIDT,ITAF2.K,.8,2.Ø,.2)                      RD- 141
NOTE     FID2    FUNDS INCREASE DECISION
NOTE     ITAF2   INCLINATION TO APPROVE FUNDS
A   CPC2.K=FID2.K*ECC2.K                                      RD- 142
NOTE     CPC2    CHANGE IN PLANNED COST
NOTE     FID2    FUNDS INCREASE DECISION
NOTE     ECC2    ESTIMATED CHANGE IN COST
A   ECC2.K=(TSMSØ.K+TTMS2.K)/(PTCR*CRPA2.K)                   RD- 143
NOTE     ECC2    ESTIMATED CHANGE IN COST
NOTE     CRPA2   COST RATIO, PLANNED TO ACTUAL
NOTE     TSMSØ   TIME SINCE MILESTONE Ø
NOTE   - TTMS2   TIME TIL MILESTONE 2
NOTE     PTCR    PROGRESS TO COST RATIO
NOTE
A   FA2.K=TABHL(FAT,FAF2.K,Ø,.4,.Ø5)                          RD- 144
NOTE     FA2     FUNDS AVAILABILITY
NOTE     FAF2    FUNDS AVAILABILITY FACTOR
A   FAF2.K=ECC2.K/RDA.K(2)                                    RD- 145
NOTE     FAF     FUNDS AVAILABILITY FACTOR
NOTE     ECC2    ESTIMATED CHANGE IN COST
NOTE     RDA(2)  RESEARCH DOLLARS APPROPRIATED
NOTE
NOTE     WEAPON SYSTEM DEVELOPMENT-FULL SCALE DEVELOPMENT
NOTE     ACTUAL PROGRESS SECTION
NOTE
L   AP3.K=AP3.J + DT*(APR3.JK-APTR3.JK)                       RD- 146
N   AP3=AP3C                                                  RD- 147
C   AP3C=Ø                                                    RD- 148
NOTE     AP3     ACTUAL PROGRESS
NOTE     APR3    ACTUAL PROGRESS RATE (PROGRESS/TIME)
NOTE     APTR3   ACTUAL PROGRESS TRANSFER RATE (PROGRESS/TIME)
R   APR3.KL=TE3.K*PGM3.K*CAPRS3.K                             RD- 149
A   TE3.K=1/TCF.K*ME3*PASTP2.K/PSTPP2.K                       RD- 15Ø
C   ME3=1                                                     RD- 151
NOTE     APR3    ACTUAL PROGRESS RATE
NOTE     TE3.K     TECHNICAL EFFECTIVENESS
NOTE     PGM3    PROGRAM
NOTE     CAPRS3  CHANGE IN ACTUAL PROGRESS RATE (SMOOTHED)  (FRACTIO
NOTE     ME3     MANAGEMENT EFFECTIVENESS
A   PGM3.K=TABHL(PGM3T,SCHED3.K,Ø,3,.Ø83)*WSD3.K*DCP3.K*12/   RD- 152
X   (TTMS3.K+TSMS2.K)
NOTE-    PGM3   PROGRAM
NOTE     TTMS3   TIME TIL MILESTONE 3
NOTE     WSD3    WEAPONS SYSTEM DEVELOPMENT PHASE 3
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NOTE     DCP3    DECISION COORD PAPER 3
A   SCHED3.K=TSMS2.K/(TSMS2.K+TTMS3.K)                          RD- 153
A   CAPRS3.K=SMOOTH(CAPR3.K,CAPRD)                              RD- 154
A   CAPR3.K=FLF3.K*DCAPR3.K                                     RD- 155
NOTE     CAPRS3  CHANGE IN ACTUAL PROGRESS RATE (SMOOTHED)
NOTE     CAPR3 ' CHANGE IN ACTUAL PROGRESS RATE
NOTE     CAPRD  CHANGE IN ACTUAL RATE DELAY
NOTE     FLF3    FUNDS LIMIT FACTOR
NOTE     DCAPR3  DESIRED CHANGE IN ACTUAL PROGRESS RATE
A   DCAPR3.K=APR3.JK-DPR3.K                                     RD- 156
NOTE     DCAPR3  DESIRED CHANGE IN ACTUAL PROGRESS RATE
NOTE     APR3    ACTUAL PROGRESS RATE
NOTE     DPR3    DESIRED PROGRESS RATE
NOTE
A   PAP3.K=SMOOTH(AP3.K,APD3)                                   RD- 157
C   APD3=1                                                      RD- 158
NOTE     PAP3    PERCEIVED ACTUAL PROGRESS
NOTE     AP3      ACTUAL PROGRESS
NOTE     APD3     ACTUAL PROGRESS DELAY
A   RAP3.K=TPG-PAP3.K                                           RD- 159
NOTE     RAP!    REMAINING ACTUAL PROGRESS
NOTE     TPG    TOTAL PROGRESS GOAL
NOTE     PAP3    PERCEIVED ACTUAL PROGRESS
A   PRR3.K(I)=RAP3.K/RTTMS3.K(I)                                RD- 160
NOTE     PRR3    PROGRESS RATE REQUIRED
NOTE     RAP3    REMAINING ACTUAL PROGRESS
NOTE     RTTMS3  REVISED TIME TIL MILESTONE 3
A   RTTMS1.K(I)=TTMS3.K(I)+T(I)                                 RD- 161
NOTE     RTTMS3  REVISED TIME TIL MILESTONE 3
NOTE     TTMS3   TIME TIL MILESTONE 3
NOTE     T       TIME
A   CF3.K(I)=TABHL(CFT3,PRR3.K(I),.6,2,.2)                      RD- 162
NOTE     CF3     COST FACTOR
NOTE     PRR3    PROGRESS RATE REQUIRED
A   CP3.K(I)=CF3.K(I)*RTTMS3.K(I)                               RD- 163
NOTE     CP3     COST PENALTY
NOTE     CF3     COST FACTOR
NOTE     RTTMS3  REVISED TIME TIL MILESTONE 3
A   SF3.K(I)=TABHL(SFT1,T(I),1,10,1)                            RD- 164
NOTE     SF3     SCHEDULE FACTOR
NOTE     T       TIME
A   SP3.K(I)=SF3.K(I)*T(I)                                      RD- 165
NOTE     SP3     SCHEDULE PENALTY
NOTE     SF3     SCHEDULE FACTOR
NOTE     T       TIME
A   TC3.K(I)=(CWF*CP3.K(I))+(SWF*SP3.K(I))                      RD- 166
NOTE     TC3     TOTAL COST
NOTE     CWF     COST WEIGHT FACTOR
NOTE     CP3     COST PENALTY
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NOTE     SWF     SCHEDULE WEIGHT FACTOR
NOTE     SP3     SCHEDULE PENALTY
NOTE
A   DATA3.K=DPR1(DCF3.K,DTL3.K,TC3.K,PRR3.K,CF3.K,T)            RD- 167
NOTE     PLANNED PROGRESS
NOTE
L   PP3.K=PP3.J+DT*(PPGM3.JK-PPTX3.JK)                          RD- 168
N   PP3=PP3C                                                    RD- 169
C   PP3C=Ø                                                      RD- 170
NOTE     PP3      PLANNED PROGRESS
NOTE     PPGM3    PLANNED PROGRESS RATE
NOTE     PPTX3    PLANNED PROGRESS TRANSFER RATE
A   PSCHD3.K=TSMS3.K/TIFSD.K                                    RD- 171
R   PPGM3.KL=TABLE(PGM1T,PSCHD3.K,Ø,1,.Ø83)*WSD3.K              RD- 172
X   *DCP3.K*12/TIFSD.K
NOTE
NOTE     PSCHD   PLANNED SCHEDULE
NOTE     TSMS3   TIME SINCE MILESTONE 3
NOTE     TIFSD   TIME IN FULL-SCALE DEVELOPMENT
NOTE     PPGM3   PLANNED PROGRESS RATE
NOTE     WSD3    WEAPON SYSTEM DECISION
NOTE     DCP3    DECISION COORDINATING POINT
NOTE
NOTE
NOTE     PRESSURE FOR SCHEDULE EXTENSION
NOTE
A   PSE3.K=TABHL(PSE3T,ELF3.K,Ø,3,.2)                           RD- 173
A   ELF3.K=DTL3.K/TTMS3.K                                       RD- 174
NOTE
NOTE     PSE3    PRESSURE FOR SCHEDULE EXTENSION
NOTE     ELF3    ESTIMATED LATE FACTOR
NOTE     DTL3    DESIRED TIME LATE
NOTE     TTMS3   TIME TIL MILESTONE 3
NOTE
A   SEA3.K=PSE3.K*USURGF.K*CRPA3.K                              RD- 175
NOTE
NOTE     SEA3    SCHEDULE EXTENSION ADJUSTOR
NOTE     CRPA3   COST RATIO, PLANNED TO ACTUAL
NOTE
A   SCD3.K=CLIP(3,Ø,SEA3.K,.6)                                  RD- 176
A   CMS3.K=SCD3.K*DTL3.K                                        RD- 177
NOTE
NOTE     SCD3    SCHEDULE EXTENSION DECISION
NOTE     SEA3    SCHEDULE EXTENSION ADJUSTOR
NOTE     CMS3    CHANGE IN MILESTONE 3
NOTE     DTL3    DESIRED TIME LATE
NOTE
NOTE     COST REPORTING
NOTE
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L    CR3.K=CR3.J+DT*(CRR3.JK-CRTR3.JK)                              RD- 178
N    CR3=CR3C                                                       RD- 179
C    CR3C=Ø                                                         RD- 180
R    CRR3.KL=CE3*DCFS3.K*PGM3.K/PTCR                                RD- 181
C    CE3=1                                                          RD- 182
A    DCFS3.K=SMOOTH(DCF3.K,DCF3D)                                   RD- 183
C    DCF3D=1                                                        RD- 184
NOTE
NOTE      CR3      COST REPORTED
NOTE      CRR3     COST REPORTING RATE
NOTE      CRTR3    COST REPORTING TRANSFER RATE
NOTE      CE3      COST ESTIMATING ERROR
NOTE      PGM3     PROGRAM
NOTE      DCFS3    DESIRED COST FACTOR (SMOOTHED)
NOTE      DCF3     DESIRED COST FACTOR
NOTE      DCF3D    DESIRED COST FACTOR DELAY
NOTE
NOTE      PLANNED COSTS
NOTE
L    PC3.K=PC3.J+DT*(PCR3.JK-PCTR3.JK)                              RD- 185
N    PC3=PC3C                                                       RD- 186
C    PC3C=Ø                                                         RD- 187
R    PCR3.KL=PPGM3.JK/PTCR+CPC3.K                                   RD- 188
NOTE
NOTE      PC3      PLANNED COSTS
NOTE      PCR3     PLANNED COST RATE
NOTE      PCTR3    PLANNED COST TRANSFER RATE
NOTE      PGM3     PROGRAM
NOTE      PTCR     PROGRESS TO COST RATIO
NOTE
A    TPC3.K=TPG/PTCR+CPC3.K                                         RD- 189
NOTE
NOTE      TPC3     TOTAL PLANNED COST
NOTE      TPG3     TOTAL PROGRESS GOAL
NOTE      PTCR     PROGRESS TO COST RATIO
NOTE      CPC3     CHANGE IN PLANNED COST
NOTE
NOTE      PRODUCT VALUE
NOTE
L    PV3.K=PV3.J+DT*(PVR3.JK-PVTR3.JK)                              RD- 190
N    PV3=PV3C                                                       RD- 191
C    PV3C=Ø                                                         RD- 192
R    PVR3.KL=PPVS3.K*PVA3.K                                         RD- 193
A    PPVS3.K=SMOOTH(PP3.K,PPD)                                      RD- 194
NOTE
NOTE      PV3      PRODUCT VALUE
NOTE      PVR3     PRODUCT VALUE RATE
NOTE      PVTR3    PRODUCT VALUE TRANSFER RATE
NOTE      PPVS3     PLANNED PRODUCT VALUE (SMOOTHED)
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NOTE      PVA3    PRODUCT VALUE ADJUSTOR
NOTE      PP3     PLANNED PROGRESS
NOTE      PPD     PLANNED PROGRESS DELAY
NOTE
A    PVA3.K=PRAP3.K*CRPA3.K                                  RD- 195
NOTE
NOTE      PVA3    PRODUCT VALUE ADJUSTOR
NOTE      PRAP3   PROGRESS RATIO, ACTUAL TO PLANNED
NOTE      CRPA3   COST RATIO, PLANNED TO ACTUAL
NOTE
A    PRAP3.K=PAP3.K/PP3.K                                    RD- 196
NOTE
NOTE      PRAP3   PROGRESS RATIO, ACTUAL TO PLANNED
NOTE      PAP3    PERCEIVED ACTUAL PROGRESS
NOTE      PP3     PLANNED PROGRESS
NOTE
A    CRPA3.K=PC3.K/CR3.K                                     RD- 197
NOTE
NOTE      CRPA3   COST RATIO, PLANNED TO ACTUAL
NOTE      PC3     PLANNED COST
NOTE      CR3     COST REPORTED
NOTE
NOTE
NOTE      FUNDS LIMIT AND PRESSURE FOR ADDITIONAL FUNDS
NOTE
A    FLF3.K=TABHL(FLFT,TWC3.K,0,10,1)                        RD- 198
NOTE
NOTE      FLF3    FUNDS LIMIT FACTOR
NOTE      TWC3    TIME WEIGHTED COST
NOTE
A    TWC3.K=TTMS3.K*CRPA3.K                                  RD- 199
NOTE
NOTE      TWC3  TIME WEIGHTED COST
NOTE      TTMS3   TIME TIL MILESTONE 3
NOTE      CRPA3   COST RATIO, PLANNED TO ACTUAL
NOTE
A    PIF3.K=TABHL(PIFT,FLF3.K,0,1.4,.2)                      RD- 200
NOTE
NOTE      PIF3    PRESSURE FOR INCREASED FUNDS
NOTE      FLF3    FUNDS LIMIT FACTOR
NOTE
A    ITAF3.K=FAI.K*PIF3.K*PRAP3.K*USURGF.K*MAIMPF            RD- 201
NOTE
NOTE      ITAF3   INCLINATION TO APPROVE FUNDS
NOTE      FA3     FUNDS AVAILIABILITY
NOTE      PIF3    PRESSURE FOR INCREASED FUNDS
NOTE      PRAP3   PROGRESS RATIO, ACTUAL TO PLANNED
NOTE      MAIMPF  MISSION AREA IMPORTANCE FACTOR
NOTE
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A   FID3.K=TABHL(FIDT,ITAF3.K,.8,2.,.2)                          RD- 202
NOTE
NOTE     FID3    FUNDS INCREASE DECISION
NOTE     ITAF3   INCLINATION TO APPROVE FUNDS
NOTE
A   CPC3.K=FID3.K*ECC3.K                                         RD- 203
NOTE
NOTE     CPC3    CHANGE IN PLANNED COST
NOTE     FID3    FUNDS INCREASE DECISION
NOTE     ECC3    ESTIMATED CHANGE IN COST
NOTE
A   ECC3.KL=(TSMS0.K+TTMS3.K)/PTCR*CLIP(ICR3.K,0,ICR3.K,0)       RD- 204
NOTE
NOTE     ECC3    ESTIMATED CHANGE IN COST
NOTE     CRPA3   COST RATIO, PLANNED TO ACTUAL
NOTE     TSMS0   TIME SINCE MILESTONE 0
NOTE     TTMS3   TIME TIL MILESTONE 3
NOTE     PTCR    PROGRESS TO COST RATIO
NOTE
A   FA3.K=TABHL(FAT,FAF3.K,0,.4,.05)                             RD- 205
NOTE
NOTE     FA3     FUNDS AVAILABILITY
NOTE     FAF3    FUNDS AVAILABILITY FACTOR
NOTE
A   FAF3.K=ECC3.K/RDA.K(2)                                       RD- 206
NOTE
NOTE     FAF     FUNDS AVAILABILITY FACTOR
NOTE     ECC3    ESTIMATED CHANGE IN COST
NOTE     RDA(2)  RESEARCH DOLLARS APPROPRIATED
NOTE
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NOTE     WEAPON SYSTEM DEVELOPMENT SECTOR
NOTE
NOTE
A   WSD1.K=SWITCH(1,Ø,RQNWS.K)                                  DT-   1
A   WSD2.K=CLIP(1,Ø,PPV1.K,.8)*RPF.K                            DT-   2
A   WSD3.K=CLIP(1.Ø,PPV2.K,.8)*RPF.K                            DT-   3
A   WSD4.K=CLIP(1,Ø,PPV3.K,.8)*IPF.K                            DT-   4
NOTE
NOTE     WSD AUTHORIZES THE VARIOUS PHASES OF WEAPONS DEVELOPMENT
NOTE     THE SWITCH IS TURNED ON IF THE PRODUCT VALUE WEIGHTED BY
NOTE     URGENCY IS HIGH ENOUGH TO WARRANT CONTINUED DEVELOPMENT.
NOTE     THE SWITCH STAYS ON DURING THE ENTIRE PHASE, BUT IS
NOTE     TURNED OFF AT THE CANCELLATION OR TRANSFER OF DEVELOPMENT.
NOTE     RPF     RESEARCH PROGRAM FUNDING
NOTE     IPF     INVESTMENT PROGRAM FUNDING
NOTE
A   DCP1.K=SWITCH(Ø,1,TTMS1.K)                                  DT-   5
A   DCP2.K=SWITCH(Ø,1,TTMS2.K)                                  DT-   6
A   DCP3.K=SWITCH(Ø,1,TTMS3.K)                                  DT-   7
A   DCP4.K=SWITCH(1,Ø,TTPCC.K)                                  DT-   8
NOTE
NOTE     DCP IS THE POINT IN TIME WHERE THE DSARC DECISIONS ARE MADE
NOTE     PROGRAMS CAN EITHER BE CANCELLED OR AUTHORIZED FOR FURTHER
NOTE     DEVELOPMENT WHEN THE DSARC DCP ARE REVIEWED
NOTE
A   TX1.K=SWITCH(1,Ø,DCP1.K)                                    DT-   9
A   TX2.K=SWITCH(1,Ø,DCP2.K)                                    DT-  1Ø
A   TX3.K=SWITCH(1,Ø,DCP3.K)                                    DT-  11
A   TX4.K=SWITCH(1,Ø,DCP4.K)                                    DT-  12
NOTE
NOTE     TX IS THE TRANSFER SWITCH WHICH IS TURNED ON WHEN THE
NOTE     DSARC DCP DECISION IS MADE.  IT ALLOWS THE PROGRAM LEVELS
NOTE     TO BE EMPTIED.
NOTE
A   DSWI1.K=CLIP(Ø,1,TSMSØ.K,2)                                 DT-  13
A   DSWI2.K=CLIP(Ø,1,TSMS1.K,2)                                 DT-  14
A   DSWI3.K=CLIP(Ø,1,TSMS2.K,2)                                 DT-  15
A   DSWI4.K=CLIP(Ø,1,TSMS3.K,2)                                 DT-  16
NOTE
NOTE     DSWI IS THE DOLLAR SWITCH WHICH TURNS ON THE DAY THAT
NOTE     MILESTONE DECISION IS MADE TO RELEASE DOLLARS FOR CONTRACTS
NOTE     AND OTHER EXPENDITURES THAT OCCUR AFTER APPROVAL.
NOTE     TIME CONTROL
NOTE
L   FYTIME.K=FYTIME.J+DT*(FYTIN.JK-FYTOUT.JK)                   DT-  17
N   FYTIME=1                                                    DT-  18
NOTE
NOTE     FYTIME  FICSAL YEAR TIME CLOCK(GEARED TO MONTHS)
NOTE     FYTIN   FISCAL TIME IN
```

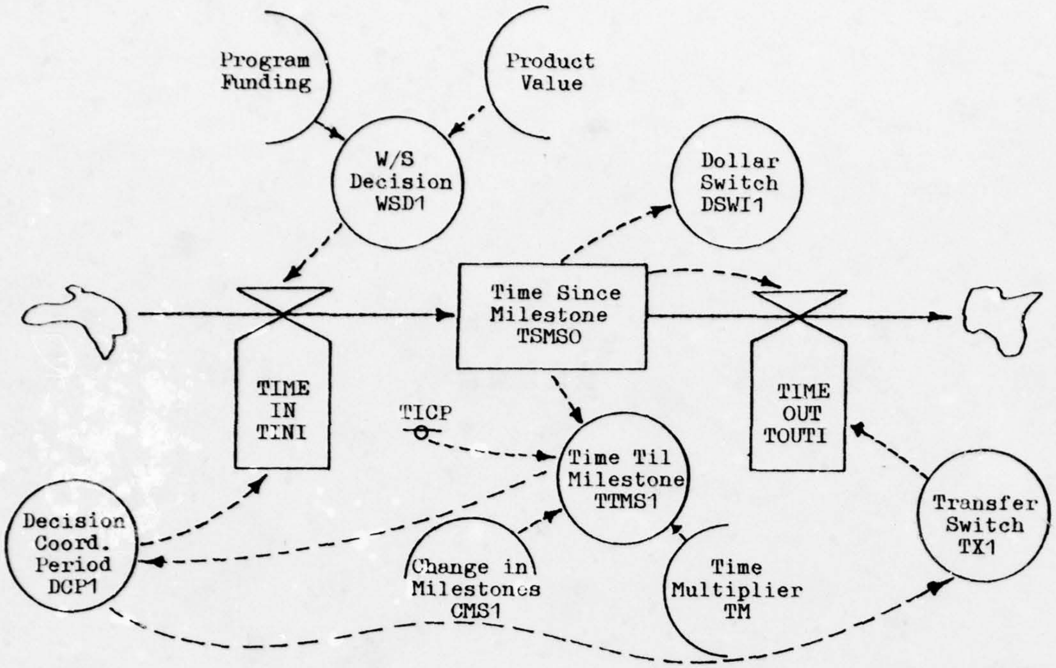

<u>NOTE</u>: This flow diagram structure is similar for the three development phases and for weapon system production. The documentation in the Decision and Time Control Section in the computer model explains the use of the variables.

Figure C-5

Decision and Time Control

```
NOTE      FYTOUT  FISCAL YEAR TIME OUT
R   FYTIN.KL=1                                                DT-  19
NOTE      FYTIN   FISCAL YEAR TIME IN (MONTHS)
R   FYTOUT.KL=FYTIME.K*FYTX.K                                 DT-  20
NOTE      FYTOUT  FISCAL YEAR TIME OUT (MONTHS)
A   FYTX.K=CLIP(1,0,FYTIME.K,12)                              DT-  21
NOTE      FYTX    FISCAL YEAR TRANSFER
NOTE
L   TSMS0.K=TSMS0.J+DT*(TIN1.JK-TOUT1.JK)                     DT-  22
N   TSMS0=TSMS0C                                              DT-  23
C   TSMS0C=0                                                  DT-  24
NOTE
NOTE      TSMS0   TIME SINCE MILESTONE 0
NOTE      TIN1    TIME IN PHASE 1
NOTE      TOUT1   TIME OUT OF PHASE 1
NOTE
R   TIN1.KL=WSD1.K*DCP1.K                                     DT-  25
R   TOUT1.KL=TSMS0.K=TX1.K                                    DT-  26
NOTE
NOTE      TIN1    TIME IN PHASE 1
NOTE      WSD1     WEAPON SYSTEM DEVELOPMENT 1
NOTE      DCP1    DECISION COORD POINT 1
NOTE      TOUT1   TIME OUT OF PHASE 1
NOTE      TSMS0   TIME SINCE MILESTONE 0
NOTE      TX1     TRANSFER SWITCH 1
NOTE
A   TTMS1.K=TICP.K-TSMS0.K+CMS1.K                             DT-  27
A   TICP.K=TICPC*TM.K                                         DT-  28
C   TICPC=12                                                  DT-  29
N   TTMS1=1                                                   DT-  30
A   TM.K=SMOOTH(1/USURGF.K,12)                                DT-  31
NOTE      TM      TIME MULTIPLIER
NOTE      TTMS1   TIME TIL MILESTONE 1
NOTE      TICP    TIME IN CONCEPTUAL PHASE
NOTE      TSMS0   TIME SINCE MILESTONE 0
NOTE      CMS1    CHANGE IN MILESTONE 1
NOTE
L   TSMS1.K=TSMS1.J+DT*(TIN2.JK-TOUT2.JK)                     DT-  32
N   TSMS1=TSMS1C                                              DT-  33
C   TSMS1C=0                                                  DT-  34
NOTE      TSMS1   TIME SINCE MILESTONE 1
NOTE      TIN2    TIME IN PHASE 2
NOTE      TOUT2   TIME OUT OF PHASE 2
R   TIN2.KL=WSD2.K*DCP2.K                                     DT-  35
R   TOUT2.KL=TSMS1.K*TX2.K                                    DT-  36
NOTE
NOTE      TSMS1   TIME SINCE MILESTONE 1
NOTE      TIN2    TIME IN PHASE 2
NOTE      WSD2    WEAPON SYSTEM DEVELOPMENT 2
```

```
NOTE     DCP2    DECISION COORDINATING POINT 2
NOTE     TOUT2   TIME OUT OF PHASE 2
NOTE     TSMS1   TIME SINCE MILESTONE 1
NOTE     TX2     TRANSFER SWITCH 2
A   TTMS2.K=TIVP.K-TSMS1.K+CMS2.K                            DT- 37
N   TTMS2=1                                                  DT- 38
A   TIVP.K=TIVPC*TM.K                                        DT- 39
C   TIVPC=24                                                 DT- 40
NOTE
NOTE     TTMS2   TIME TIL MILESTONE 2
NOTE     TIVP    TIME IN DEVELOPMENT PHASE
NOTE     TSMS1   TIME SINCE MILESTONE 1
NOTE     CMS2    CHANGE IN MILESTONE 2
NOTE     TM      TIME MULTIPLIER
NOTE
L   TSMS2.K=TSMS2.J+DT*(TIN3.JK-TOUT3.JK)                    DT- 41
N   TSMS2=TSMS2C                                             DT- 42
C   TSMS2C=0                                                 DT- 43
NOTE     TSMS2   TIME SINCE MILESTONE 2
NOTE     TIN3   TIME IN PHASE 3
NOTE     TOUT3   TIME OUT OF PHASE 3
R   TIN3.KL=WSD3.K*DCP3.K                                    DT- 44
R   TOUT3.KL=TSMS2.K*TX3.K                                   DT- 45
NOTE     TSMS2   TIME SINCE MILESTONE 2
NOTE     TIN3    TIME IN PHASE 3
NOTE     WSD3    WEAPON SYSTEM DEVELOPMENT 3
NOTE     DCP3    DECISION COORDINATING POINT 3
NOTE     TOUT3   TIME OUT OF PHASE 3
NOTE     TX3     TRANSFER SWITCH 3
NOTE
A   TTMS3.K=TIFSD.K-TSMS2.K+CMS3.K                           DT- 46
N   TTMS3=0                                                  DT- 47
A   TIFSD.K=TIFSDC*TM.K                                      DT- 48
C   TIFSDC=36                                                DT- 49
NOTE
NOTE     TTMS3   TIME TIL MILESTONE 3
NOTE     TIFSD   TIME IN FULL SCALE DEVELOPMENT
NOTE     TSMS2   TIME SINCE MILESTONE 2
NOTE     CMS3    CHANGE IN MILESTONE 3
NOTE     TM      TIME MULTIPLIER
NOTE
L   TSMS3.K=TSMS3.J+DT*(TIN4.JK-TOUT4.JK)                    DT- 50
N   TSMS3=TSMS3C                                             DT- 51
C   TSMS3C=0                                                 DT- 52
R   TIN4.KL=WSD4.K*DCP4.K                                    DT- 53
R   TOUT4.KL=TSMS3.K*TX4.K                                   DT- 54
NOTE
NOTE     TSMS3   TIME SINCE MILESTONE 3
NOTE     TIN4    TIME IN PRODUCTION
```

```
NOTE     WSD     WEAPON SYSTEM PRODUCTION DECISION
NOTE     DCP     DECISION TO CONTINUE PRODUCTION
NOTE     TOUT3   TIME PRODUCTION COMPLETE
NOTE     TSMS3   TIME SINCE MILESTONE 3
NOTE     TX4     TRANSFER RATE (AT PRODUCTION COMPLETION)
A   TTPCC.K=TIP.K-TSMS3.K+CMS4.K                              DT-  55
NOTE     TTPCC   TIME TIL PRODUCTION CONTRACT COMPLETE
NOTE     TIP     TIME IN PRODUCTION
NOTE     TSMS3   TIME SINCE MILESTONE 3
NOTE     CMS4   CHANGE IN SCHEDULE
NOTE
A   TIP.K=TIPC*TM.K                                           DT-  56
C   TIPC=24                                                   DT-  57
NOTE
NOTE     TIP     TIME IN PRODUCTION
NOTE     TM      TIME MULTIPLIER
NOTE
NOTE
NOTE     TRANSFERS AND CANCELLATIONS
NOTE
R   APTR1.KL=AP1.K*TX1.K                                      DT-  58
NOTE
NOTE     APTR1   ACTUAL PROGRESS TRANSFER RATE
NOTE     AP1     ACTUAL PROGRESS
NOTE     TX1     TRANSFER SWITCH 1
NOTE
L   PASTP1.K=PASTP1.J+DT*(APTR1.JK-PASTR1.JK)                 DT-  59
N   PASTP1=PASTC                                              DT-  6Ø
C   PASTC=Ø                                                   DT-  61
R   PASTR1.KL=PASTP1.K*TX2.K                                  DT-  62
NOTE
NOTE     PASTP1  PAST PROGRESS 1
NOTE     APTR1   ACTUAL PROGRESS TRANSFER RATE
NOTE     TX2     TRANSFER RATE2
NOTE     PASTR1  PAST PROGRESS TRANSFER RATE
NOTE
L   PSTPP1.K=PSTPP1.J+DT*(PPTX1.JK-PSTPT1.JK)                 DT-  63
N   PSTPP1=PSTP1C                                             DT-  64
C   PSTP1C=Ø                                                  DT-  65
R   PPTX1.KL=PP1.K*TX1.K                                      DT-  66
NOTE
NOTE     PSTPP   PAST PLANNED PROGRESS
NOTE     PPTX1   PLANNED PROGRESS TRANSFER RATE
NOTE     PP1     PLANNED PROGRESS
NOTE     TX1     TRANSFER RATE
NOTE
R   PSTPT1.KL=PSTPP1.K*TX2.K                                  DT-  67
NOTE
NOTE     PSTPT1   PAST PLANNED PROGRASS TRANSFER RATE
```

```
NOTE     PSTPP1  PAST PLANNED PROGRESS
NOTE     TX2     TRANSFER RATE 2
NOTE
R   CRTR1.KL=CR1.K*TX1.K                                   DT-  68
NOTE
NOTE     CRTR1   COST REPORTED TRANSFER RATE
NOTE     CR1     COST REPORTED
NOTE     TX1     TRANSFER RATE
NOTE
R   PCTR1.KL=PC1.K*TX1.K                                   DT-  69
NOTE
NOTE     PCTR1   PLANNED COST TRANSFER RATE
NOTE     PV1     PRODUCT VALUE
NOTE     TX1     TRANSFER RATE
NOTE
L   PPV1.K=PPV1.J+DT*(PVTRA1.JK-PPVTR1.JK)                 DT-  70
N   PPV1=PPV1C                                             DT-  71
C   PPV1C=0                                                DT-  72
R   PVTRA1.KL=PPV1.K*TX1.K*ADVOC.K*USURGF.K                DT-  73
R   PPVTR1.KL=PPV1.K*TX2.K                                 DT-  74
NOTE
NOTE     PPV1    PAST PRODUCT VALUE
NOTE     PVTRA1  PRODUCT VALUE TRANSFER RATE
NOTE     PPVTR1  PAST PRODUCT VALUE TRANSFER RATE
NOTE     PPV1    PAST PRODUCT VALUE
NOTE     TX2     TRANSFER RATE
NOTE
R   APTR2.KL=AP2.K*TX2.K                                   DT-  75
NOTE
NOTE     APTR2   ACTUAL PROGRESS TRANSFER RATE
NOTE     AP2     ACTUAL PROGRESS
NOTE     TX2     TRANSFER SWITCH 2
NOTE
L   PASTP2.K=PASTP2.J+DT*(APTR2.JK-PASTR2.JK)              DT-  76
N   PASTP2=PASTC                                           DT-  77
C   PASTC=0                                                DT-  78
R   PASTR2.KL=PASTP2.K*TX3.K                               DT-  79
 NOTE                                                      DT-  80
NOTE     PASTP2  PAST PROGRESS 2
NOTE     APTR2   ACTUAL PROGRESS TRANSFER RATE
NOTE     TX3     TRANSFER RATE3
NOTE     PASTR2  PAST PROGRESS TRANSFER RATE
NOTE
L   PSTPP2.K=PSTPP2.J+DT*(PPTX2.JK-PSTPT2.JK)              DT-  81
N   PSTPP2=PSTP2C                                          DT-  82
C   PSTP2C=0                                               DT-  83
R   PPTX2.KL=PP2.K*TX2.K                                   DT-  84
NOTE
NOTE     PSTPP   PAST PLANNED PROGRESS
```

```
NOTE     PPTX2   PLANNED PROGRESS TRANSFER RATE
NOTE     PP2     PLANNED PROGRESS
NOTE     TX2     TRANSFER RATE
NOTE
R   PSTPT2.KL=PSTPP2.K*TX3.K                                    DT- 85
NOTE
NOTE     PSTPT2   PAST PLANNED PROGRASS TRANSFER RATE
NOTE     PSTPP2  PAST PLANNED PROGRESS
NOTE     TX3     TRANSFER RATE 3
NOTE
R   CRTR2.KL=CR2.K*TX2.K                                        DT- 86
R    PCTR2.KL=PC2.K*TX2.K                                       DT- 87
NOTE     CRTR2   COST REPORTED TRANSFER RATE
NOTE     CR2     COST REPORTED
NOTE     TX2     TRANSFER RATE
NOTE     PCTR2   PLANNED COST TRANSFER RATE
NOTE
L   PPV2.K=PPV2.J+DT*(PVTR2.JK-PPVTR2.JK)                       DT- 88
N   PPV2=PPV2C                                                  DT- 89
C   PPV2C=Ø                                                     DT- 9Ø
R   PVTRA2.KL=PPV2.K*TX2.K*ADVOC.K*USURGF.K                     DT- 91
R   PPVTR2.KL=PPV2.K*TX3.K                                      DT- 92
NOTE     PPV2    PAST PRODUCT VALUE
NOTE     PVTRA2   PRODUCT VALUE TRANSFER RATE
NOTE     PPVTR2  PAST PRODUCT VALUE TRANSFER RATE
NOTE     TX3     TRANSFER RATE
NOTE     ADVOC   ADVOCACY FACTOR
NOTE     USURGF  US URGENCY FACTOR
NOTE
R   APTR3.KL=AP3.K*TX3.K                                        DT- 93
NOTE
NOTE     APTR3   ACTUAL PROGRESS TRANSFER RATE
NOTE     AP3     ACTUAL PROGRESS
NOTE     TX3     TRANSFER SWITCH 3
NOTE
L   PASTP3.K=PASTP3.J+DT*(APTR3.JK-PASTR3.JK)                   DT- 94
N   PASTP3=PASTC                                                DT- 95
C   PASTC=Ø                                                     DT- 96
R   PASTR3.KL=PASTP3.K*TX4.K                                    DT- 97
NOTE
NOTE     PASTP3  PAST PROGRESS 3
NOTE     APTR3   ACTUAL PROGRESS TRANSFER RATE
NOTE     TX4     TRANSFER RATE4
NOTE     PASTR3  PAST PROGRESS TRANSFER RATE
NOTE
L   PSTPP3.K=PSTPP3.J+DT*(PPTX3.JK-PSTPT3.JK)                   DT- 98
N   PSTPP3=PSTP3C                                               DT- 99
C   PSTP3C=Ø                                                    DT- 1ØØ
R   PPTX3.KL=PP3.K*TX3.K                                        DT- 1Ø1
```

```
NOTE
NOTE     PSTPP3   PAST PLANNED PROGRESS
NOTE     PPTX3    PLANNED PROGRESS TRANSFER RATE
NOTE     PP3      PLANNED PROGRESS
NOTE     TX3      TRANSFER RATE
NOTE
R   PSTPT3.KL=PSTPP3.K*TX4.K                                  DT- 102
NOTE
NOTE     PSTPT3   PAST PLANNED PROGRASS TRANSFER RATE
NOTE     PSTPP3   PAST PLANNED PROGRESS
NOTE     TX4      TRANSFER RATE 4
NOTE
R   CRTR3.KL=CR3.K*TX3.K                                      DT- 103
NOTE
NOTE     CRTR3    COST REPORTED TRANSFER RATE
NOTE     CR3      COST REPORTED
NOTE     TX3      TRANSFER RATE
NOTE
R   PCTR3.KL=PC3.K*TX3.K                                      DT- 104
R   PVTR3.KL=PV3.K*TX3.K*ADVOC.K*USURGF.K                     DT- 105
NOTE
NOTE     PCTR     PLANNED COST TRANSFER RATE
NOTE     PVTR3    PRODUCT VALUE TRANSFER RATE
NOTE     PV3      PRODUCT VALUE
NOTE     TX3      TRANSFER RATE
NOTE
L   PPV3.K=PPV3.J+DT*(PVTR3.JK-PPVTR3.JK)                     DT- 106
N   PPV3=PPV3C                                                DT- 107
C   PPV3C=0                                                   DT- 108
NOTE
NOTE     PPV3     PAST PRODUCT VALUE
NOTE     PVTR3    PRODUCT VALUE TRANSFER RATE
NOTE     PPVTR3   PAST PRODUCT VALUE TRANSFER RATE
NOTE
R   PPVTR3.KL=PPV3.K*TX4.K                                    DT- 109
NOTE
NOTE     PPVTR3   PAST PRODUCT VALUE TRANSFER RATE
NOTE     PPV3     PAST PRODUCT VALUE
NOTE     TX4      TRANSFER RATE
NOTE
```

```
NOTE     WEAPON SYSTEM OPERATION SECTOR
NOTE
L   WSO.K=WSO.J+DT*(WSMR.JK+WSDR.JK-WSSDR.JK-WSRR.JK)              OP-  1
N   WSO=WSOC                                                         OP-  2
NOTE
C   WSOC=90                                                          OP-  3
NOTE
NOTE     WSO     WEAPON SYSTEM OPERATIONAL
NOTE     WSDR    WEAPON SYSTEM DELIVERY RATE
NOTE     WSMR    WEAPON SYSTEM MAINTENANCE RATE
NOTE     WSSDR   WEAPON SYSTEMS SYSTEM DEFICIENCY RATE
NOTE     WSRR    WEAPON SYSTEMS RETIREMENT RATE
NOTE
R   WSMR.KL=WSORP.K*OSF.K                                            OP-  4
NOTE
NOTE     WSMR   WEAPON SYSTEM MAINTENANCE RATE
NOTE     WSN     WEAPON SYSTEMS NOT OPERATIONAL
NOTE     OSF     OPERATING AND SUPPORT FACTOR
NOTE
L   WSN.K=WSN.J+DT*(WSSDR.JK-WSMR.JK)                                OP-  5
N   WSN=WSNC                                                         OP-  6
C   WSNC=10                                                          OP-  7
NOTE
NOTE     WSN     WEAPON SYSTEMS NOT OPERATIONAL
NOTE     WSSDR   WEAPON SYSTEM SYSTEM DEFICIENCY RATE
NOTE     WSMR    WEAPON SYSTEM MAINTENACE RATE
NOTE
R   WSSDR.KL=USE.K/MTBF.K                                            OP-  8
NOTE
NOTE     WSSDR   SYSTEM DEFICIENCY RATE
NOTE     WSO     WEAPON SYSTEMS OPERATIONAL
NOTE     USE     USE
NOTE     MTBF    MEAN TIME BETWEEN FAILURES
NOTE     OPERATING AND SUPPORT SECTION
NOTE
A   WSORP.K=WSO.K/(WSN.K+WSO.K)                                      OP-  9
NOTE     WSORP   WEAPON SYSTEM OR PERCENT
NOTE     WSO     WEAPON SYSTEM OPERATIONAL
NOTE     WSN     WEAPON SYSTEM NOT OPERATIONAL
NOTE
A   OSR.K=WSORP.K*OSCF                                               OP- 10
C   OSCF=.1                                                          OP- 11
NOTE
NOTE     OSR      O&S REQUIRED
NOTE     WSORP   WEAPON SYSTEM OR PERCENT
NOTE     OSCF    O&S COST FACTOR
NOTE
A   PFOS.K=TABHL(PFOST,WSORP.K,0,50,10)                              OP- 12
T   PFOST=1/1/1/1.15/1.82/2.68                                       OP- 13
```

```
NOTE
NOTE      PFOS    PRESSURE FOR O&S
NOTE      WSORP   WEAPON SYSTEM OR PERSCENT
NOTE
A    OSF.K=OSDAM.K*PFOS.K                                          OP- 14
NOTE      OSF     O&S FACTOR
NOTE      OSDAM   O&S DOLLAR AVAILABLE MULTIPLIER
NOTE      PFOS    PRESSURE FOR O&S
NOTE
A    OSDAM.K=TABLE=TABXT(OSDAMT,OSR.K/OSA.K(1),0,2,.2)             OP- 15
T    OSDAMT=1.0/.98/.9/.82/.7/.52/.38/.29/.26/.24/.22              OP- 16
NOTE
NOTE      OSDAM   O&S DOLLAR AVAILABILITY MULTIPLIER
NOTE      OSA     O&S AVAILABLE
NOTE
A    USE.K=WSORF.K*(WSO.K+WSN.K)*OPLAN.K                           OP- 17
NOTE
NOTE      USE     USE
NOTE      OPLAN   OERATATIONAL PLAN
NOTE      WSORF   WEAPON SYSTEM OR FACTOR
NOTE
A    OPLAN.K=TABHL(OPLANT,TIME.K,0,240,20)                         OP- 18
T    OPLANT=1/1/1/1/1/1.2/1/1/1/.9/1                               OP- 19
NOTE
NOTE      OPLAN   OPERATING PLAN
NOTE
NOTE
T    WSORFT=1/1/.85/.75/.68/.62                                    OP- 20
A    WSORF.K=TABHL(WSORFT,WSORP.K,0,50,10)                         OP- 21
NOTE
NOTE      WSORF   WEAPON SYSTEM OR FACTOR
NOTE      WSORP   WEAPON SYSTEM OR PERCENT
NOTE
A    MTBF.K=MTBFC*TE4D.K*MTBFM.K                                   OP- 22
C    MTBFC=4                                                       OP- 23
NOTE
NOTE      MTBF    MEAN TIME BETWEEN FAILURE
NOTE      MTBFC   MTBF INITIAL CONSTANT
NOTE      TE4D    TECHNICAL EFFECTIVENESS DESIGNED(SMOOTHED)
NOTE      MTBFM   MTBF AGE MULTIPLIER
NOTE
A    TE4D.K=SMOOTH(TE4.K,18)                                       OP- 24
NOTE      TE4D    TECHNICAL EFFECTIVENESS DESIGNED (SMOOTHED)
NOTE      TE4     TECHNICAL EFFECTIVENESS DESIGNED
NOTE
A    MTBFM.K=TABHL(MTBFMT,WSAA.K,5000,15000,2000)                  OP- 25
T    MTBFMT=1/1.05/1.13/1.25/1.6/1.9                               OP- 26
NOTE
NOTE      MTBFM   MTBF AGE MULTIPLIER
```

```
NOTE     AWSA    ACCUMULATED WEAPON SYSTEM AGE
NOTE
L   AWSA.K=AWSA.J+DT*(WSAR.JK-WSARR.JK)                        OP-  27
N   AWSA=AWSAC                                                 OP-  28
C   AWSAC=Ø                                                    OP-  29
NOTE
NOTE     AWSA    ACCUMULATED WEAPON SYSTEM AGE
NOTE     WSAR    WEAPON SYSTEM AGE RATE
NOTE     WSARR   WEAPON SYSTEM AGE RESTORATION AND RETIREMENT RATE
NOTE
R   WSAR.KL=USE.K                                              OP-  3Ø
NOTE
NOTE     WSAR    WEAPON SYSTEM AGING RATE
NOTE     USE     USE
NOTE
R   WSARR.KL=(MODF.K*AWSA.K)+(WSAA.K*WSRR.JK)                  OP-  31
NOTE
NOTE     WSARR   WEAPON SYSTEM AGE RESTORATION AND RETIREMENT RATE
NOTE     MODF    MODICATION FACTOR
NOTE     AWSA    ACCUMULATED WEAPON SYSTEM AGE
NOTE     WSAA    WEAPON SYSTEM AVERAGE AGE
NOTE     WSRR    WEAPON SYSTEM RETIREMENT RATE
NOTE
A   WSAA.K=AWSA.K/(WSO.K+WSN.K)                                OP-  32
NOTE
NOTE     WSAA    WEAPON SYSTEM AVERAGE AGE
NOTE     WSO     WEAPON SYSTEMS OPERATIONAL
NOTE     WSN     WEAPON SYSTEM NOT OPERATIONAL
NOTE
R   WSRR.KL=MIN(1,WSO.K*(ATTR+WSRF.K))                         OP-  33
C   ATTR=.ØØ16                                                 OP-  34
NOTE
NOTE     WSRR    WEAPON SYSTEM RETIREMENT RATE
NOTE
A   WSRF.K=TABHL(WSRFT,WSAA.K,25ØØ.1ØØØØ,25ØØ)*TM.K            OP-  35
T   WSRFT=Ø/.33/.66/1.Ø                                        OP-  36
NOTE
NOTE     WSRF    WEAPON SYSTEMS RETIREMENT FRACTION
NOTE     WSAA    WEAPON SYSTEM AVERAGE AGE
NOTE     TM      TIME MULTIPLIER
```

```
NOTE
NOTE     RESOURCES SECTOR
NOTE
NOTE
L   TOTRES.K=TOTRES.J + DT*(DISCOV.JK-TRUSE.JK)                RS-  1
N   TOTRES=TOTRSC                                              RS-  2
C   TOTRSC=100                                                 RS-  3
NOTE
NOTE     TOTRES  TOTAL RESOURCES
NOTE     DISCOV  DISCOVERY RATE
NOTE     TRUSE   TOTAL RESOURCE USE
NOTE
R   DISCOV.KL=DISCOF.K*TOTRES.K                                RS-  4
NOTE
NOTE     DISCOV  DISCOVERY RATE
NOTE     DISCOF  DISCOVERY FRACTION
NOTE     TOTRES  TOTAL RESOURCES
NOTE
A   DISCOF.K=TABHL(DISCOT,SEARCH.K,0,.1,.02)/12                RS-  5
T   DISCOT=.0/.02/.06/.08/.09/.1                               RS-  6
NOTE
NOTE     DISCOF  DISCOVERY FRACTION
NOTE     SEARCH  SEARCH FOR RESOURCES (SMOOTHED)
NOTE
A   SEARCH.K=SMOOTH(SEARC.K,30)                                RS-  7
A   SEARC.K=TABHL(SEARCT,TOTRES.K,0,100,20)                    RS-  8
T   SEARCT=1/.9/.8/.55/.3/.15                                  RS-  9
NOTE
NOTE     SEARCH  SEARCH FOR RESOURCES (SMOOTHED)
NOTE     SEARC   SEARCH FOR RESOURCES
NOTE     TOTRES  TOTAL RESOURCES
NOTE
R   TRUSE.KL=GROWTH.K*TOTRES.K                                 RS- 10
NOTE
NOTE     TRUSE   TOTAL RESOURCES USE
NOTE     GROWTH  GROWTH FACTOR
NOTE     TOTRES  TOTAL RESOURCES
NOTE
A   GROWTH.K=TABHL(GROWTT,TOTRES.K,0,100,10)/12                RS- 11
T   GROWTT=-50/-30/-15/-5/0/.007/.018/.025/.03/.03             RS- 12
NOTE
NOTE     GROWTH  GROWTH FACTOR
NOTE     TOTRES  TOTAL RESOURCES
NOTE
L   USRES.K=USRES.J + DT*(RAUS.JK-RDMDUS.JK)                   RS- 13
N   USRES=USRESC                                               RS- 14
C   USRESC=33                                                  RS- 15
NOTE
NOTE     USRES   US RESOURCES
```

```
NOTE     RAUS    RESOURCES ALLOCATION FOR THE US
NOTE     RDMDUS  RESOURCE DEMAND IN US
NOTE
R   RAUS.KL=DISCOV.JK*ALLOCF                                RS-  16
C   ALLOCF=.33                                              RS-  17
NOTE
NOTE     RAUS     RESOURCES ALLOCATION FOR THE US
NOTE     DISCOV  DISCOVERY FRACTION
NOTE     TRUSE   TOTAL RESOURCE USE
NOTE     ALLOCF  ALLOCATION FRACTION
NOTE
R   RDMDUS.KL=(GROWTH.K-(EFFF.K/100))*USRES.K               RS-  18
NOTE
NOTE     RDMDUS  RESOURCE DEMAND IN THE US
NOTE     GROWTH  GROWTH FACTOR
NOTE     USRES   US RESOURCES
NOTE     EFFF   EFFICIENCY FACTOR
NOTE
A   EFFF.K=DTC.K+TECHIF.K                                   RS-  19
NOTE
NOTE     EFFF    EFFICIENCY FACTOR
NOTE     DTC     DESIRE TO CONSERVE
NOTE     TECHIF  TECHNICAL IMPROVEMENT FACTOR
NOTE
A   USRESS.K=SMOOTH(USRES.K,10)                             RS-  20
NOTE
NOTE     USRESS  US RESOURCES (SMOOTHED)
NOTE     USRES   US RESOURCES
NOTE
A   DTC.K=TABHL(DTCT,USRESS.K,0,35,5)                       RS-  21
T   DTCT=-2./-.75/-.15/.4/.7/.9/1./1.0                      RS-  22
NOTE
NOTE     DTC     DESIRE TO CONSERVE
NOTE     USRESS  US RESOURCES (SMOOTHED)
NOTE
A   TECHIF.K=TABHL(TECHIT,TECHCR.K,0,.2,.04)                RS-  23
T   TECHIT=1/.5/.25/.15/.07/.04                             RS-  24
NOTE
NOTE     TECHIF  TECHNICAL IMPROVEMENT FACTOR
NOTE     TECHCR  TECHNOLOGY CHANGE RATE
NOTE
A   RPFT.K=TABHL(RPFFT,USRESS.K,0,100,10)                   RS-  25
T   RPFTT=1./.8/.7/.6/.5/.45/.4/.37/.35                     RS-  26
NOTE
NOTE     RPFT    RESOURCES PRESSURE FOR TECHNOLOGY
NOTE     USRESS  US RESOURCES (SMOOTHED)
NOTE
A   RADPP.K=TABHL(RADPPT,TOTRES.K,0,100,10)                 RS-  27
T   RADPPT=0/.1/.25/.4/.35/.32/.3/.28/.27/.26/.25           RS-  28
```

```
NOTE
NOTE     RADPP   RESOURCES AVAILABLE % FOR DEFENSE PRODUCTION
NOTE     TOTRES  TOTAL RESOURCES
NOTE
A   RAADP.K=TOTRES.K*RADPP.K*AALLOC                              RS- 29
C   AALLOC=.35                                                   RS- 3Ø
NOTE
NOTE     RAADP   RESOURCES AVAILABLE FOR ALLIED DEFENSE PRODUCTION
NOTE     TOTRES  TOTAL RESOURCES
NOTE     RADPP   RESOURCES AVAILABLE % FOR DEFENSE PRODUCTION
NOTE     AALLOC  ALLIED ALLOCATION PERCENT
NOTE
A   RAEDP.K=TOTRES.K*RADPP.K*EALLOC                              RS- 31
C   EALLOC=.32                                                   RS- 32
NOTE
NOTE     RAEDP   RESOURCES AVAILABLE FOR ENEMY DEFENSE PRODUCTION
NOTE     TOTRES  TOTAL RESOURCES
NOTE     RADPP   RESOURCES AVAILABLE % FOR DEFENSE PRODUCTION
NOTE     EALLOC  ENEMY ALLOCATION
NOTE
A   RAUSDP.K=USRES.K*RPUSDP.K                                    RS- 33
NOTE     RAUSDP  RESOURCES AVAILABLE FOR US DEFENSE PRODUCTION
NOTE     USRES   US RESOURCES
NOTE     RPUSDP  RESOURCES % FOR US DEFENSE PRODUCTION
NOTE
A   RPUSDP.K=TABHL(RPUSDT,USRES.K,Ø,35,5)                        RS- 34
T   RPUSDT=Ø/.2/.4/.3/.28/.27/.26/.25                            RS- 35
NOTE     RPUSDP  RESOURCES % FOR US DEFENSE PRODUCTION
NOTE     USRES   US RESOURCES
NOTE
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```
NOTE     TECHNOLOGY SECTOR
NOTE
L   TECH.K=TECH.J + DT*(TIR.JK-TLR.JK)                        TC-  1
N   TECH=TECHC                                                TC-  2
C   TECHC=100                                                 TC-  3
NOTE     TECH     TECHNOLOGY AVAILABLE
NOTE     TIR      TECHNOLOGY INPUT RATE
NOTE     TLR      TECHNOLOGY LOSS RATE
NOTE
R   TIR.KL=TECH.K*(GROWTH.K+TDFS.K)                           TC-  4
NOTE
NOTE     TIR      TECHNOLOGY INPUT RATE
NOTE     GROWTH    GROWTH FACTOR
NOTE     TDFS     TECHNOLOGY DISCOVERY FRACTION (SMOOTHED)
NOTE
A   TDFS.K=SMOOTH(TDF.K,TDFD)                                 TC-  5
C   TDFD=6                                                    TC-  6
NOTE
NOTE     TDFS     TECHNOLOGY DISCOVERY FRACTION SMOOTHED
NOTE     TDF      TECHNOLOGY DISCOVERY FRACTION
NOTE     TDFD     TECHNOLOGY DISCOVERY FRACTION DELAY
NOTE
A   TDF.K=TABHL(SNT.K,0,1,.2)/12                              TC-  7
T   TDFT=.01/.03/.07/.1/.12/.13                               TC-  8
NOTE
NOTE     TDF      TECHNOLOGY DISCOVERY FRACTION
NOTE
A   SNT.K=TABHL(SNTT,TSP.K,0,.15,.03)                         TC-  9
T    SNTT=.1/.15/.32/.52/.8/1.0                               TC- 10
NOTE
NOTE     SNT      SEARCH FOR NEW TECHNOLOGY
NOTE
A   TSP.K=TP.K+OP.K                                           TC- 11
NOTE
NOTE     TSP      TOTAL SEARCH PRESSURE
NOTE     TP       TECHNOLOGY PRESSURE
NOTE     OP       OTHER PRESSURE
NOTE
A   TP.K=TABHL(TPT,TECH.K,0,100,10)                           TC- 12
NOTE
NOTE     TP       TECHNOLOGY PRESSURE
NOTE     TECH     TECHNOLOGY AVAILABLE
NOTE
T   TPT=1/1/.8/.5/.27/.1                                      TC- 13
A   OP.K=SUMV(RDOC.K)/ECON*RPFT.K                             TC- 14
C   ECON=1000                                                 TC- 15
NOTE
NOTE     OP       OTHER PRESSURE
NOTE     RDOC     RESEARCH DOLLARS ON CONTRACT
```

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NOTE     ECON     ECONOMIC BASELINE
NOTE     RPFT     RESOURCES PRESSURE FOR TECHNOLOGY
NOTE     TSP      TOTAL SEARCH PRESSURE
NOTE
R   TLR.KL=TECH.K*TLF.K                                            TC- 16
R   TLF.K=SMOOTH(GROWTH.K,TLFD)                                    TC- 17
C   TLFD=60                                                        TC- 18
NOTE
NOTE     TECHCR   TECHNOLOGY CHANGE RATE
NOTE     TIR      TECHNOLOGY INPUT RATE
NOTE     TLF      TECHNICAL LOSS FACTOR
NOTE     TLR      TECHNOLOGY LOSS RATE
NOTE     TECH     TECHNOLOGY AVAILABLE
NOTE
A   TCF.K=TABHL(TCFT,TECHCR.K,0,.2,.02)                            TC- 19
T   TCFT=2.0/1.95/1.85/1.7/1.45/1.0/.67/.5/.35/.3/.25              TC- 20
A   TECHCR.K=(TIR.JK-TLR.JK)/TECH.K                                TC- 21
NOTE
NOTE     TCF      TECHNICAL COMPLEXITY FACTOR
NOTE     TECHCR   TECHNOLOGY CHANGE RATE
NOTE
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```
NOTE     PRODUCTION SECTOR
NOTE
NOTE
NOTE     ACTUAL PRODUCTION SECTION
NOTE
NOTE
L   WSP.K=WSP.J+DT*(WSPIR.JK-WSPR.JK)                          PR-   1
N   WSP=WSPC                                                   PR-   2
C   WSPC=0                                                     PR-   3
NOTE
NOTE     WSP     WEAPON SYSTEM PRODUCTION
NOTE     WSPIR   WEAPON SYSTEM PRODUCTION INPUT RATE
NOTE     WSPR    WEAPON SYSTEM PRODUCTION RATE
NOTE
R   WSPIR.KL=MIN(PGM4.K,RCWS.K)                                PR-   4
NOTE
NOTE     WSPIR   WEAPON SYSTEM PRODUCTION INPUT RATE
NOTE     PGM4    PROGRAM
NOTE     RCWS    RESOURCE CONSTRAINED WEAPON SYSTEMS
NOTE
A   PGM4.K=TABLE(PGM1T,SCHEDP.K,0,1,.0833)*WSD4.K*DCP4.K*12/   PR-   5
X   (TSMS3.K+TTPCC.K)
A   SCHEDP.K=TSMS3.K/(TSMS3.K+TTPCC.K)                         PR-   6
NOTE
NOTE     PGM4    PROGRAM
NOTE     SCHEDP  SCHEDULED PRODUCTION
NOTE     WSD4    WEAPON SYSTEM DEVELOPMENT DECISION
NOTE     TSMS3   TIME SINCE MILESTONE 3
NOTE     TTPCC   TIME TIL PRODUCTION CONTRACT COMPLETE
NOTE
A   RCWS.K=RAUSDP.K*WSRCF                                      PR-   7
C   WSRCF=.1                                                   PR-   8
NOTE
NOTE     RCWS    RESOURCE CONSTRAINED WEAPON SYSTEMS
NOTE     RAUSDP  RESOURCES AVAILABLE FOR DEFENSE PRODUCTION
NOTE     WSRCF   WEAPON SYSTEM TO RESOURCES CONVERSION FACTOR
NOTE
R   WSPR.KL=DELAY3(WSPIR.JK,PRODT.K)                           PR-   9
NOTE
NOTE     WSPR    WEAPON SYSTEM PRODUCTION RATE
NOTE     WSPIR   WEAPON SYSTEM PRODUCTION INPUT RATE
NOTE     PRODT   PRODUCTION TIME
NOTE
A   PRODT.K=APRODT+PRODTA.K                                    PR-  10
C   APRODT=24                                                  PR-  11
NOTE
NOTE     PRODT   PRODUCTION TIME
NOTE     APRODT  AVERAGE PRODUCTION TIME
NOTE     PRODTA   PRODUCTION TIME ADJUSTOR
```

```
NOTE
A   LCF.K=TABHL(LCFT,TWSP.K,0,500,40)                                PR-  12
T   LCFT=1/1.15/1.35/1.57/1.69/1.78/1.87/1.96/2.02/2.11/2.20/        PR-  13
NOTE
NOTE      LCF     LEARNING CURVE FACTOR
NOTE      TWSP    TOTAL WEAPON SYSTEM PRODUCED
NOTE
L   TWSP.K=TWSP.J+DT*(WSPR.JK-LCRR.JK)                               PR-  14
R   LCRR.KL=TX4.K*TWSP.K                                             PR-  15
N   TWSP=TWSPC                                                       PR-  16
C   TWSPC=0                                                          PR-  17
NOTE
NOTE      TWSP    TOTAL WEAPON SYSTEM PRODUCED
NOTE      WSPR    WEAPON SYSTEM PRODUCTION RATE
NOTE      LCRR    LEARNING CURVE RELEASE RATE
NOTE
NOTE
N   PRODT=24                                                         PR-  18
A   PRODTA.K=TTE.K*ME4*CPTS.K-LCF.K                                  PR-  19
C   ME4=1                                                            PR-  20
A   TTE.K=TE4.K*TCF.K                                                PR-  21
A   TE4.K=PASTP3.K/PSTPP3.K                                          PR-  22
NOTE
NOTE      PRODTA  PRODUCTION TIME ADJUSTOR
NOTE      LCF     LEARNING CURVE FACTOR
NOTE      TTE     TOTAL TECHNICAL EFFECTIVENESS
NOTE      ME4     MANAGEMENT EFFECTIVENESS CONSTANT
NOTE      TE4     TECHNICAL EFFECTIVENESS
NOTE      PASTP3  PAST PROCRESS
NOTE      PSTPP   PLANNED PAST PROGRESS TRANSFER RATE
A   CPTS.K=SMOOTH(CPT.K,CPTD)                                        PR-  23
C   CPTD=1                                                           PR-  24
A   CPT.K=PRODT.K-PRODTD.K                                           PR-  25
NOTE
NOTE      CPTS    CHANGE IN PRODUCTION TIME(SMOOTHED)
NOTE      CPT     CHANGE IN PRODUCTION TIME
NOTE      PRODT   PRODUCTION TIME
NOTE      CPTD    CHANGE IN PRODUCTION DELAY
NOTE      DCAPR4  DESIRED CHANGE IN ACTUAL PRODUCTION RATE
NOTE      APR4    ACTUAL PRODUCTION RATE
NOTE      PRODTD  PRODUCTION TIME DESIRED
NOTE
NOTE      MARGINAL ANALYSIS TO DETERMINE DESIRED PRODUCTION TIME,
NOTE      DESIRED TIME LATE, AND DESIRED COST FACTOR
NOTE
FOR P=1,10
A   RWSP.K=NWSP.K-TWSP.K                                             PR-  26
NOTE
NOTE      RWSP    REMAINING WEAPON SYSTEMS TO PRODUCE
```

```
NOTE     NWSP    NUMBER OF WEAPON SYSTEMS TO PRODUCE
NOTE
A   WSPRR.K(P)=RWSP.K/RTTPCC.K(P)                                PR-  27
NOTE
NOTE     WSPRR   WEAPON SYSTEM PRODUCTION RATE REQUIRED
NOTE     RWSP    REMAINING WEAPON SYSTEMS TO PRODUCE
NOTE     TTPCC   TIME TIL PRODUCTION CONTRACT COMPLETE
NOTE     WSPRR   WEAPON SYSTEM PRODUCTION RATE REQUIRED
NOTE
A   RTTPCC.K(P)=TTPCC.K+T(P)                                     PR-  28
NOTE
NOTE     RTTPCC  REVISED TIME TIL PRODUCTION CONTRACT COMPLETE
NOTE     TTPCC   TIME TIL PRODUCTION CONTRACT COMPLETE
NOTE     T       TIME LATE
NOTE
A   CF4.K(P)=TABHL(CFT4,WSPRR.K(P),.6,2,.2)                      PR-  29
NOTE
NOTE     CF4     COST FACTOR
NOTE     WSPRR   WEAPON SYSTEM PRODUCTION RATE REQUIRED
NOTE
A   CP4.K(P)=CF4.K(P)*RTTPCC.K(P)                                PR-  30
NOTE
NOTE     CP4     COST PENALTY
NOTE     CF4     COST FACTOR
NOTE     RTTPCC  REVISED TIME TIL PRODUCTION CONTRACT COMPLETE
NOTE
A   SF4.K(P)=TABHL(SFT4,T(PP),1,10,1)                            PR-  31
NOTE
NOTE     SF4     SCHEDULE FACTOR
NOTE     T       TIME LATE
NOTE
A   SP4.K(P)=SF4.K(P)*T(P)                                       PR-  32
NOTE
NOTE     SP4     SCHEDULE PENALTY
NOTE     SF4     SCHEDULE FACTOR
NOTE     T       TIME LATE
NOTE
A   TC4.K(P)=(CWF*CP4.K(P))+(SWF*SP4.K(P))                       PR-  33
NOTE
NOTE     TC4     TOTAL COST
NOTE     CWF     COST WEIGHT FACTOR
NOTE     CP4     COST PENALTY
NOTE     SWF     SCHEDULE WEIGHT FACTOR
NOTE     SP4     SCHEDULE PENALTY
NOTE
A   DATA4.K=DPR1(DCF4.K,DTL4.K,TC4.K,WSPRR.K,CP4.K,SP4.K)        PR-  34
NOTE     DPR1 IS A FORTRAN FUNCTION TO FIND THE DESIRED
NOTE     TIME LATE(DTL) AND DESIRED COST FACTOR(DCF)
NOTE
```

```
A    PRODTD.K=WSP.K/DWSPR.K                                  PR-  35
NOTE
NOTE      PRODTD  PRODUCTION TIME DESIRED
NOTE      WSP     WEAPON SYSTEM PRODUCTION
NOTE      DWSPR   DESIRED WEAPON SYSTEM PRODUCTION RATE
NOTE
L    WSIT.K=WSIT.J+DT*(WSPR.JK-WSDR.JK)                      PR-  36
N    WSIT=WSITC                                              PR-  37
C    WSITC=0                                                 PR-  38
R    WSDR.KL=DELAY3(WSPR.JK,2)                               PR-  39
NOTE
NOTE      WSIT    WEAPON SYSTEMS IN TRANSIT
NOTE      WSPR    WEAPON SYSTEM PRODUCTION RATE
NOTE      WSDR    WEAPON SYSTEMS DELIVERY RATE
NOTE
L    PP4.K=PP4.J+DT*(PPGM4.JK-PPTX4.JK)                      PR-  40
N    PP4=PP4C                                                PR-  41
C    PPIC=0                                                  PR-  42
NOTE
NOTE      PP4      PLANNED PRODUCTION
NOTE      PPR4    PLANNED PRODUCTION RATE
NOTE      PPTX4    PLANNED PRODUCTION TRANSFER RATE
NOTE
R    PPGM4.KL=TABLE(PGM1T,PSCHD4.K,0,1,.003)*WSD4.K*12/TIP.K     PR-  43
X    *100/NWSP.K
A    PSCHD4.K=TSMS3.K/TIP.K                                  PR-  44
NOTE
A    PSE4.K=SWF*TABHL(PSET,ELF4.K,0,1,.2)+FLF4.K*CWF         PR-  45
NOTE      PSE4    PRESSURE FOR SCHEDULE EXTENSION
NOTE      ELF4    ESTIMATED LATE FACTOR
NOTE      FLF     FUNDS LIMIT FACTOR
NOTE      SWF     SCHEDULE WEIGHTING FACTOR
NOTE      CWF     COST WEIGHTING FACTOR
A    ELF4.K=DTL4.K/TTPCC.K                                   PR-  46
NOTE      ELF     ESTIMATED LATE FACTOR
NOTE      DTL4    DESIRED TIME LATE
NOTE      TTPCC   TIME TIL PRODUCTION CONTRACT COMPLETE
A    SEA4.K=CRPA4.K+PSE4.K/USURGF.K                          PR-  47
A    SCD4.K=CLIP(SEA4.K,0,SEA4.K,.5)                         PR-  48
NOTE
NOTE      PSE4    PRESSURE FOR SCHEDULE EXTENSION
NOTE      CRPA    COST REPORTED PLANNED TO ACTUAL
NOTE      USURGF  US URGENCY FACTOR
NOTE      SCD4    SCHEDULE EXTENSION DECISION
NOTE      SEA4    SCHEDULE EXTENSION ADJUSTOR
NOTE
A    SCDM4.K=CLIP(1,SCD4.K,SCD4.K,1)                         PR-  49
A    SCHC.K=SCDM4.K+DTL4.K                                   PR-  50
A    CPCC.K=CLIP(SCHC.K,FC.K,SCHC.K,FC.K)                    PR-  51
```

```
NOTE
NOTE     SCD4    SCHEDULE EXTENSION DECISION
NOTE     DTL4    DESIRED TIME LATE
NOTE
A   FC.K=MAX(Ø,TTPCC.K/FLF4.K-TTPCC.K)                              PR-  52
NOTE
L   CR4.K=CR4.J+DT*(CRR4.JK-CRTR4.JK)                               PR-  53
N   CR4=CR4C                                                        PR-  54
C   CR4C=Ø                                                          PR-  55
NOTE
NOTE     CR4     COST REPORTED
NOTE     CRR4    COST REPORTING RATE
NOTE     CRTR4   COST REPORTING TRANSFER RATE
NOTE
R   CRR4.KL=CE4*DCFS4.K*PPGM4.JK*LCF.K                              PR-  56
C   CE4=1                                                           PR-  57
NOTE
NOTE     CRR4    COST REPORTED RATE
NOTE     CE4     COST ESTIMATING ERROR
NOTE     PPGM4   PLANNED PROGRAM
NOTE     DCFS4   DESIRED COST FACTOR (SMOOTHED)
NOTE
 NOTE                                                               PR-  58
A   DCFS4.K=SMOOTH(DCF4.K,DCF4D)                                    PR-  59
NOTE
NOTE     DCFS4   DESIRED COST FACTOR (SMOOTHED)
NOTE     DCF4    DESIRED COST FACTOR
NOTE     DCF4D   DESIRED COST FACTOR DELAY
NOTE
L   PC4.K=PC4.J+DT*(PCR4.JK-PCTR4.JK)                               PR-  6Ø
NOTE
NOTE     PC4     PLANNED COSTS
NOTE     PCR4    PLANNED COST RATE
NOTE     PCTR4   PLANNED COST TRANSFER RATE
NOTE
R   PCR4.KL=PGM4.K/PTCR+CPC4.K                                      PR-  61
NOTE
NOTE     PCR4    PLANNED COST RATE
NOTE     PGM4    PROGRAM
NOTE     PTCR    PRODUCTION TO COST RATIO
NOTE
A   TPC4.K=NWSP.K/PTCR+CPC4.K                                       PR-  62
NOTE
NOTE     TPC4    TOTAL PLANNED COST
NOTE     TPG4    TOTAL PRODUCTION GOAL
NOTE     PTCR    PRODUCTION TO COST RATIO
NOTE     CPC4    CHANGE IN PLANNED COST
NOTE
NOTE
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A   FLF4.K=TABHL(FLFT,TWC4.K,Ø,1Ø,1)                          PR- 63
NOTE     FLF4    FUNDS LIMIT FACTOR
NOTE     TWC4    TIME WEIGHTED COST
A   TWC4.K=TTPCC.K*CRPA4.K                                    PR- 64
NOTE     TWC4   TIME WEIGHTED COST
NOTE     TTPCC   TIME TIL PRODUCTION CONTRACT COMPLETE
NOTE     CRPA4   COST RATIO, PLANNED TO ACTUAL
A   PIF4.K=TABHL(PIFT,FLF4.K,Ø,1.4,.2)                        PR- 65
NOTE     PIF4    PRESSURE FOR INCREASED FUNDS
NOTE     FLF4    FUNDS LIMIT FACTOR
A   ITAF4.K=FA4.K*PIF4.K*PRAP4.K*USURGF.K*MAIMPF              PR- 66
NOTE     ITAF4   INCLINATION TO APPROVE FUNDS
NOTE     FA4     FUNDS AVAILIABILITY
NOTE     PIF4    PRESSURE FOR INCREASED FUNDS
NOTE     PRAP    PROGRESS RATIO,ACTUAL TO PLANNED
NOTE     USURGF  US URGENCY FACTOR
NOTE     MAIMPF  MISSION AREA IMPORTANCE FACTOR
A   FID4.K=TABHL(FIDT,ITAF4.K,.8,2.Ø,.2)                      PR- 67
NOTE     FID4    FUNDS INCREASE DECISION
NOTE     ITAF4   INCLINATION TO APPROVE FUNDS
A   CPC4.K=FID4.K*ECC4.K                                      PR- 68
NOTE     CPC4    CHANGE IN PLANNED COST
NOTE     FID4    FUNDS INCREASE DECISION
NOTE     ECC4    ESTIMATED CHANGE IN COST
A   ECC4.K=CLIP(ICR4.K,Ø,ICR4.K,Ø)*(TSMS3.K+TTPCC.K)/PTCR     PR- 69
NOTE     ECC4    ESTIMATED CHANGE IN COST
NOTE     CRPA4   COST RATIO, PLANNED TO ACTUAL
NOTE     TSMSØ   TIME SINCE MILESTONE Ø
NOTE     TTPCC   TIME TIL PRODUCTION CONTRACT COMPLETE
NOTE     PTCR    PROGRESS TO COST RATIO
A   ICR4.K=1-1/CRPA4.K                                        PR- 7Ø
A   FA4.K=TABHL(FAT,FAF4.K,Ø,.4,.Ø5)                          PR- 71
NOTE
NOTE     FA4     FUNDS AVAILABILITY
NOTE     FAF4    FUNDS AVAILABILITY FACTOR
A   FAF4.K=ECC4.K/IDA.K(2)                                    PR- 72
NOTE     FAF     FUNDS AVAILABILITY FACTOR
NOTE     ECC4    ESTIMATED CHANGE IN COST
NOTE     RDA(2)  RESEARCH DOLLARS APPROPRIATED
```

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NOTE     ALLIED SECTOR     **********
NOTE
FOR IAA=1,120
N   APLAN(IAA)=0                                                 AL-   1
NOTE     APLAN   ALLIED PLANNED PRODUCTION
N   FMSA(IAA)=0                                                  AL-   2
NOTE     FMSA    FOREIGN MILITARY SALES AGREEMENTS
NOTE
N   AWSP=0                                                       AL-   3
L   AWSP.K=AWSP.J+(DT)(AWSPR.JK-AWSDR.JK)                        AL-   4
R   AWSPR.KL=FSHIFT(APLAN.K)                                     AL-   5
A   ADELR.K=24/AURGF.K                                           AL-   6
R   AWSDR.KL=DELAY3(AWSPR.JK,ADELR.K)                            AL-   7
NOTE
NOTE     AWSP    ALLIED WEAPON SYSTEMS IN PRODUCTION
NOTE     AWSPR   ALLIED WEAPON SYSTEMS PRODUCTION RATE
NOTE     AWSDR   ALLIED WEAPON SYSTEMS DELIVERY RATE
NOTE     APLAN   ALLIED PLANNED PRODUCTION
NOTE     ADELR   ALLIED DELAY RATE IN PRODUCTION
NOTE     AURGF   ALLIED URGENCY FACTOR
NOTE
L   AWSO.K=AWSO.J+DT*(AWSDR.JK+AWSMR.JK-AWSUR.JK+AFMSDR.JK)      AL-   8
N   AWSO=5                                                       AL-   9
NOTE
NOTE     AWSO    ALLIED WEAPON SYSTEMS OPERATIONAL
NOTE     AWSDR   ALLIED WEAPON SYSTEMS DELIVERY RATE
NOTE     AWSMR   ALLIED WEAPON SYSTEMS MAINTENANCE RATE
NOTE     AWSUR   ALLIED WEAPON SYSTEMS USE RATE
NOTE     AFMSDR  ALLIED FOREIGN MILITARY SALES DELIVERY RATE
NOTE
N   AWSN=1                                                       AL-  10
L   AWSN.K=AWSN.J+(DT)(AWSUR.JK-AWSMR.JK-AWSRR.JK)               AL-  11
R   AWSMR.KL=AWSN.K*AMPCT                                        AL-  12
R   AWSUR.KL=AWSO.K*AUPCT                                        AL-  13
R   AWSRR.KL=ARETC*AWSN.K                                        AL-  14
NOTE
NOTE     AWSN    ALLIED WEAPON SYSTEMS NON-OPERATIONAL
NOTE     AWSUR   ALLIED WEAPON SYSTEMS USE RATE
NOTE     AWSMR   ALLIED WEAPON SYSTEMS MAINTENANCE RATE
NOTE     AWSRR   ALLIED WEAPON SYSTEMS RETIREMENT RATE
NOTE     AMPCT   ALLIED PERCENTAGE OF WEAPONS REPAIRED
NOTE     AUPCT   ALLIED PERCENTAGE OF WEAPONS USED
NOTE     ARETC   ALLIED RETIREMENT CONSTANT
NOTE
N   WSFAI=0                                                      AL-  15
L   WSFAI.K=WSFAI.J+DT*(ATXR.JK-AFMSDR.JK)                       AL-  16
R   AFMSDR.KL=DELAY3(ATXR.JK,24)                                 AL-  17
R   ATXR.KL=FHSIFT(FMSA.K)                                       AL-  18
NOTE
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NOTE      WSFAI    WEAPON SYSTEMS FOR ALLIED INVENTORIES
NOTE      ATXR     ALLIED TRANSFER RATE
NOTE      AFMSDR   ALLIED FOREIGN MILITARY SALES DELIVERY RATE
NOTE      FMSA     FOREIGN MILITARY SALES AGREEMENTS
NOTE
C   AMPCT=.85                                                 AL-  19
NOTE      AMPCT    ALLIED PERCENTAGE OF WEAPONS REPAIRED
C   AUPCT=.20                                                 AL-  20
NOTE      AUPCT    ALLIED PERCENTAGE OF WEAPONS USED
C   ARETC=.002                                                AL-  21
NOTE      ARETC    ALLIED RETIREMENT CONSTANT
C   ADESWF=1.0                                                AL-  22
NOTE      ADESWF   ALLIED DESIRE FOR WEAPON SYSTEMS
C   ACPWS=75                                                  AL-  23
NOTE      ACPWS    ALLIED CAPABILITY PER WEAPON SYSTEM
NOTE
A   ADEF.K(MO)=MAX(ADIF.K(MO),0)*ADPCT.K                      AL-  24
A   ADIF.K(MO)=ECAP.K(MO)-ACAP.K(MO)-USCAP.K(MO)              AL-  25
NOTE
NOTE      ADEF     ALLIED DEFICIENCY
NOTE      ADIF     ALLIED DIFFERENCE IN CAPABILITY
NOTE      ADPCT    ALLIED PERCENTAGE OF DEFICIENCY
NOTE      ECAP     ENEMY CAPABILITY
NOTE      ACAP     ALLIED CAPABILITY
NOTE      USCAP    US CAPABILITY
NOTE
A   AURGF.K=TABLE(EWGT,AURG.K/12,0,10,1)                      AL-  26
A   AURG.K=URGENCY(ADEF.K)                                    AL-  27
NOTE
NOTE      AURGF    ALLIED URGENCY FACTOR
NOTE      EWGT     URGENCY WEIGHTING TABLE
NOTE      AURG     ALLIED URGENCY--TIME TO FIRST DEFICIENCY
NOTE
A   APTHR.K(MO)=(EINT.K-USINT.K)*ADEF.K(MO)                   AL-  28
NOTE
NOTE      APTHR    ALLIED PERCEIVED THREAT
NOTE      EINT     ENEMY INTENT TO USE FORCE
NOTE      ADEF     ALLIED DEFICIENCY
A   ADWSL.K(MO)=ADESWF*APTHR.K(MO)/ACPWS                      AL-  29
NOTE
NOTE      ADWSL    ALLIED DESIRED WEAPON SYSTEMS LEVEL
NOTE      ADESWF   ALLIED DESIRE FOR WEAPONS FACTOR
NOTE      APTHR    ALLIED PERCEIVED THREAT
NOTE      ACPWS    ALLIED CAPABILITY PER WEAPON SYSTEM
NOTE
A   AINT.K=TABHL(AWGT,AINTF.K,-1,1,.2)                        AL-  30
A   AINTF.K=SMOOTH(SUM(APTHR.K)/120,3)                        AL-  31
N   AINTF=.85                                                 AL-  32
T   AWGT=0/0/0/.05/.10/.25/.45/.85/.99/-.60/-1.00             AL-  33
```

```
NOTE
NOTE     AINT    ALLIED INTENT TO USE FORCE
NOTE     AINTF   ALLIED INTENT FACTOR
NOTE     APTHR   ALLIED PERCEIVED THREAT
NOTE
A   ADPCT.K=TABLE(APFT,AINT.K,-1,1,.2)                               AL-  34
T   APFT=-1.0/-.86/-.25/-.15/-.05/0/.05/.15/.25/.60/.65              AL-  35
NOTE
NOTE     ADPCT   ALLIED PERCENTAGE OF DEFICIENCY
NOTE     AINT    ALLIED INTENT
NOTE
C   ACOSWS=5.5E6                                                     AL-  36
A   APPC.K=ACAPDP.K/ACOSWS                                           AL-  37
NOTE
NOTE     ACOSWS   ALLIED COST PER WEAPON SYSTEM
NOTE     APPC     ALLIED PROJECTED PRODUCTION CAPACITY
NOTE     ACAPDP   ALLIED CAPACITY FOR DEFENSE PRODUCTION
NOTE
FOR IA1=1,36
L   APLAN.K(IA1)=APLAN.J(IA1)+DT*(APACC.JK(IA1))                     AL-  38
R   APACC.KL(IA1)=MIN(ASDEV.K(IA1),APPC.K)                           AL-  39
A   ASDEV.K(IA1)=SUMV(ADWSL.K(*),1,36)*CLIP(1,0,T(IA1),12)/          AL-  40
X   (36-AURG.K)
NOTE
NOTE     APLAN   ALLIED PLANNED PRODUCTION
NOTE     APACC   ALLIED PRODUCTION ACCELERATOR
NOTE     ASDEV   ALLIED SCHEDULE DEVIATION
NOTE     APPC    ALLIED PROJECTED PRODUCTION CAPACITY
NOTE     ADWSL   ALLIED DESIRED WEAPON SYSTEMS LEVEL
NOTE     AURG    ALLIED URGENCY--TIME TO FIRST DEFICIENCY
NOTE     T       TIME
NOTE
L   FMSA.K(MO)=FMSA.J(MO)+DT*(FMSBR.JK(MO))                          AL-  41
NOTE
NOTE     FMSA    FOREIGN MILITARY SALES AGREEMENT
NOTE     FMSBR   FOREIGN MILITARY SALES BUY RATE
NOTE
FOR IA2=37,120
L   APLAN.K(IA2)=APLAN.J(IA2)+DT*(ALRADJ.JK(IA2-36))                 AL-  42
R   ALRADJ.KL(IA2-36)=CLIP(NAWS.K(IA2),0,ADECP.K,ADECB.K)            AL-  43
NOTE
NOTE     APLAN    ALLIED PLANNED PRODUCTION
NOTE     ALRADJ   ALLIED LONG-RANGE ADJUSTMENT RATE
NOTE     NAWS     NUMBER OF ALLIED WEAPON SYSTEMS
NOTE     ADECP    ALLIED DECISION TO PRODUCE
NOTE     ADECB    ALLIED DECISION TO BUY
NOTE
A   AGEF.K=TABHL(AGFT,AAGE.K/12,0,10,1)                              AL-  44
T   AGFT=1/1/1/1/1/1.25/1.75/2.5/3.25/4.15/6.0                       AL-  45
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NOTE
NOTE     AGEF    AGE FACTOR
NOTE     AAGE    AVERAGE AGE
NOTE
A   STDF.K=TABHL(STDFT,APSWS.K,0,1,.1)                          AL- 46
T   STDFT=2/1.75/1/.85/.65/.43/.30/.23/.17/.12/.05              AL- 47
NOTE
NOTE     STDF    STANDARDIZATION FACTOR
NOTE     APSWS   ALLIED PERCENTAGE OF STANDARIDIZED WEAPON SYSTEMS
NOTE
A   AQF.K(MO)=TABHL(AQUAL,T(MO)*AGEF.K/STDF.K,0,120,12)         AL- 48
T   AQUAL=1.0/.99/.99/.98/.95/.85/.7/.55/.35/.25/.1             AL- 49
NOTE
NOTE     AQF     ALLIED QUALITY FACTOR
NOTE     T       TIME
NOTE     AGEF    AGE FACTOR
NOTE     STDF    STANDARDIZATION FACTOR
NOTE
A   APSWS.K=ASTINV.K/(AWSO.K+AWSN.K)                            AL- 50
N   ASTINV=0                                                    AL- 51
L   ASTINV.K=ASTINV.J+DT*(ASTR.JK)                              AL- 52
R   ASTR.KL=FMSA.K(1)+SWITCH(0,AWSDR.JK,COFAC.K)                AL- 53
NOTE
NOTE     APSWS   ALLIED PERCENTAGE OF STANDARDIZED WEAPON SYSTEMS
NOTE     ASTINV  ALLIED STANDARDIZED INVENTORY
NOTE     AWSO    ALLIED WEAPON SYSTEMS OPERATIONAL
NOE     AWSN    ALLIED WEAPON SYSTEMS NON-OPERATIONAL           AL- 54
NOTE     ASTR    ALLIED STANDARDIZATION TRANSFER RATE
NOTE     FMSA    FOREIGN MILITARY SALES AGREEMENTS
NOTE     AWSDR   ALLIED WEAPON SYSTEMS DELIVERY RATE
NOTE     COFAC   COPRODUCTION FACTOR
NOTE
A   ACAP.K(MO)=(AWSO.K+AWSN.K+AWSP.K+SUMV(APLAN.K(*),1,         AL- 55
X   T(MO)))*ACPWS*AQF.K(MO)
NOTE
NOTE     ACAP    ALLIED CAPABILITY
NOTE     AWSO    ALLIED WEAPON SYSTEMS OPERATIONAL
NOTE     AWSN    ALLIED WEAPON SYSTEMS NON-OPERATIONAL
NOTE     AWSP    ALLIED WEAPON SYSTEMS IN PRODUCTION
NOTE     APLAN   ALLIED PLANNED PRODUCTION
NOTE     ACPWS   ALLIED CAPABILITY PER WEAPON SYSTEM
NOTE     AQF     ALLIED QUALITY FACTOR
NOTE
A   ARUCWS.K=RAADP.K*RESCF.K                                    AL- 56
A   RESCF.K=TABXT(RSCFT,RAADP.K,0,100,10)                       AL- 57
T   RESCFT=1.E6/1.E4/1000/650/400/280/200/140/80/40/10          AL- 58
NOTE
NOTE     ARUCWS  ALLIED RESOURCE UNIT CONSTRAINT PER WEAPON SYSTEM
NOTE     RAADP   RESOURCES ALLOWED FOR ALLIED DEFENSE PRODUCTION
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NOTE     RESCF   RESOURCE COST FACTOR
NOTE
A   ACAPDP.K=MIN(ARUCWS.K,AGNP.K*APGNPD)                      AL-  59
NOTE
NOTE     ACAPDP  ALLIED CAPACITY FOR DEFENSE PRODUCTION
NOTE     ARUCWS  ALLIED RESOURCE UNIT CONSTRAINT PER WEAPON SYSTEM
NOTE     AGNP    ALLIED GROSS NATIONAL PRODUCT
NOTE     APGNPD  ALLIED PERCENT OF GNP TO DEFENSE
NOTE
C   APGNPD=.ØØ3                                               AL-  6Ø
N   AGNP=1E1Ø                                                 AL-  61
L   AGNP.K=AGNP.J+DT*(AGNPGR.JK)                              AL-  62
R   AGNPGR.KL=AGNP.K*AGNPGF                                   AL-  63
C   AGNPGF=.ØØ2                                               AL-  64
NOTE
NOTE     APGNPD  ALLIED PERCENT OF GNP TO DEFENSE
NOTE     AGNP    ALLIED GROSS NATIONAL PRODUCT(GNP)
NOTE     AGNPGR  ALLIED GNP GROWTH RATE
NOTE     AGNPGF  ALLIED GNP GROWTH FACTOR
NOTE
NOTE
A   COFAC.K=ACOPR.K*USCOPA.K                                  AL-  65
A   ACOPR.K=CLIP(1,Ø,ACAPDP.K,ADECP.K)                        AL-  66
NOTE
NOTE     COFAC   COPRODUCTION FACTOR
NOTE     ACOPR   ALLIED COPRODUCTION REQUEST
NOTE     USCOPA  US COPRODUCTION AGREEMENT
NOTE     ACAPDP  ALLIED CAPACITY FOR DEFENSE PRODUCTION
NOTE     ADECP   ALLIED DECISION TO PRODUCE
NOTE
A   ACOAWS.K=SUM(ADWSL.K)*ACOSWS                              AL-  67
A   ACOUWS.K=SUM(APTHR.K)*ACBWS.K/USCPWS.K                    AL-  68
A   ACOMWS.K=SUM(NAWS.K)*ACOSWS+SUM(NUSWS.K)*ACBWS.K          AL-  69
NOTE
NOTE     ACOAWS  ALLIED COST FOR ALLIED WEAPON SYSTEMS
NOTE     ADWSL   ALLIED DESIRED WEAPON SYSTEMS LEVEL
NOTE     ACOSWS  ALLIED COST PER WEAPON SYSTEM
NOTE     ACOUWS  ALLIED COST FOR US WEAPON SYSTEMS
NOTE     APTHR   ALLIED PERCEIVED THREAT
NOTE     ACBWS   ALLIED COST TO BUY WEAPON SYSTEMS
NOTE     USCPWS  US CAPABILITY PER WEAPON SYSTEM
NOTE     NAWS    NUMBER OF ALLIED WEAPON SYSTEMS PLANNED
NOTE     NUSWS   NUMBER OF US WEAPON SYSTEMS PLANNED
NOTE
A   ADECB.K=MIN(ACOUWS.K,ACOMWS.K)                            AL-  7Ø
A   ADECP.K=SMOOTH(MIN(ADECB.K,ACOAWS.K),1)                   AL-  71
NOTE
NOTE     ADECB   ALLIED DECISION TO BUY
NOTE     ACOUWS  ALLIED COST FOR US WEAPON SYSTEMS
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NOTE     ACOMWS  ALLIED COST FOR MIXED WEAPON SYSTEMS INVENTORY
NOTE     ADECP   ALLIED DECISION TO PRODUCE
NOTE     ACOAWS  ALLIED COST FOR ALLIED WEAPON SYSTEMS
NOTE
A   NAWS.K(MO)=CLIP(APTHR.K(MO)-USCPWS.K*COMP.K(MO),ADWSL.K(MO),AL-  72
X   ADECP.K,ACOAWS.K)
NOTE
NOTE     NAWS    NUMBER OF ALLIED WEAPON SYSTEMS PLANNED
NOTE     APTHR   ALLIED PERCEIVED THREAT
NOTE     USCPWS  US CAPABILITY PER WEAPON SYSTEM
NOTE     COMP    COMPUTED TRADEOFF FACTOR
NOTE     ADWSL   ALLIED DESIRED WEAPON SYSTEMS LEVEL
NOTE     ADECP   ALLIED DECISION TO PRODUCE
NOTE     ACOAWS  ALLIED COST FOR ALLIED WEAPON SYSTEMS
NOTE
A   NUSWS.K(MO)=CLIP(ACPWS*COMP.K(MO),APTHR.K(MO)/USCPWS.K,      AL-  73
X   ADECP.K,ACOUWS.K)
NOTE
NOTE     NUSWS   NUMBER OF US WEAPON SYSTEMS PLANNED
NOTE     ACPWS   ALLIED CAPABILITY PER WEAPON SYSTEM
NOTE     COMP    COMPUTED TRADEOFF FACTOR
NOTE     APTHR   ALLIED PERCEIVED THREAT
NOTE     USCPWS  US CAPABILITY PER WEAPON SYSTEM
NOTE     ADECP   ALLIED DECISION TO PRODUCE
NOTE     ACOUWS  ALLIED COST FOR US WEAPON SYSTEMS
NOTE
A   COMP.K(MO)=(ACOSWS*APTHR.K(MO)-ACAPDP.K))/(USCPWS.K*ACOSWS  AL-  74
X   -ACPWS*ACBWS.K)
NOTE
NOTE     COMP    COMPUTED TRADEOFF FACTOR
NOTE     ACOSWS  ALLIED COST PER WEAPON SYSTEM
NOTE     APTHR   ALLIED PERCEIVED THREAT
NOTE     ACAPDP  ALLIED CAPACITY FOR DEFENSE PRODUCTION
NOTE     USCPWS  US CAPABILITY PER WEAPON SYSTEM
NOTE     ACPWS   ALLIED CAPABILITY PER WEAPON SYSTEM
NOTE     ACBWS   ALLIED COST TO BUY WEAPON SYSTEMS
NOTE
R   FMSBR.KL(MO)=CLIP(NUSWS.K(MO),0,ADECP.K,ADECB.K)            AL-  75
NOTE
NOTE     FMSBR   FOREIGN MILITARY SALES BUY RATE
NOTE     NUSWS   NUMBER OF US WEAPON SYSTEMS PLANNED
NOTE     ADECP   ALLIED DECISION TO PRODUCE
NOTE     ADECB   ALLIED DECISION TO BUY
NOTE
N   AAGE=60                                                     AL-  76
N   FLTAGE=AAGE*WSO                                             AL-  77
L   FLTAGE.K=FLTAGE.J+DT*(AGER.JK)                              AL-  78
R   AGER.KL=AWSO.K+AWSN.K-AWSRR.JK*AAGE.K*DISTK                 AL-  79
C   DISTK=2                                                     AL-  80
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NOTE
NOTE    AAGE    AVERAGE AGE OF ALLIED WEAPONS
NOTE    FLTAGE  COMBINED AGE OF ALLIED FLEET
NOTE    AWSO    ALLIED WEAPON SYSTEMS OPERATIONAL
NOTE    AGER    ALLIED AGE RATE
NOTE    AWSN    ALLIED WEAPON SYSTEMS NON-OPERATIONAL
NOTE    AWSRR   ALLIED WEAPON SYSTEMS RETIREMENT RATE
NOTE    DISTK   DISTRIBUTION CONSTANT
NOTE
A   AAGE.K=FLTAGE.K/(AWSO.K+AWSN.K)                         AL-  81
NOTE
NOTE    AAGE    AVERAGE AGE OF ALLIED WEAPONS
NOTE    FLTAGE  COMBINED AGE OF ALLIED FLEET
NOTE    AWSO    ALLIED WEAPON SYSTEMS OPERATIONAL
NOTE    AWSN    ALLIED WEAPON SYSTEMS NON-OPERATIONAL
NOTE
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NOTE     *****   ENEMY SECTOR    *****
FOR IE=1,120
N   EPLAN(IE)=0                                                   EN-   1
NOTE
N   EWSP=20                                                       EN-   2
L   EWSP.K=EWSP.J+(DT)(EWSPR.JK-EWSDR.JK)                         EN-   3
R   EWSDR.KL=DELAY3(EWSPR.JK,EDELR.K)                             EN-   4
R   EWSPR.KL=FSHIFT(EPLAN.K)                                      EN-   5
NOTE
NOTE     EPLAN   ENEMY PLANNED PRODUCTION
NOTE     EWSP    ENEMY WEAPON SYSTEMS PRODUCTION
NOTE     EWSPR   ENEMY WEAPON SYSTEMS PRODUCTION INPUT RATE
NOTE     EWSDR   ENEMY WEAPON SYSTEMS DELIVERY RATE
NOTE
A   EDELR.K=24/EURGF.K                                            EN-   6
NOTE
NOTE     EDELR   ENEMY PRODUCTION DELAY FACTOR
NOTE     EURGF   ENEMY URGENCY FACTOR
NOTE
N   EWSO= 100                                                     EN-   7
L   EWSO.K=EWSO.J+(DT)(EWSDR.JK+EWSMR.JK-EWSUR.JK)                EN-   8
NOTE
NOTE     EWSO    ENEMY WEAPON SYSTEMS OPERATIONAL
NOTE     EWSDR   ENEMY WEAPON SYSTEMS DELIVERY RATE
NOTE     EWSMR   ENEMY WEAPON SYSTEMS MAINTENANCE RATE
NOTE     EWSUR   ENEMY WEAPON SYSTEMS USE RATE
NOTE
N   EWSN=10                                                       EN-   9
L   EWSN.K=EWSN.J+(DT)(EWSUR.JK-EWSMR.JK-EWSRR.JK)                EN-  10
NOTE
NOTE     EWSN    ENEMY WEAPON SYSTEMS NON-OPERATIONAL
NOTE     EWSUR   ENEMY WEAPON SYSTEMS USE RATE
NOTE     EWSMR   ENEMY WEAPON SYSTEMS MAINTENANCE RATE
NOTE     EWSRR   ENEMY WEAPON SYSTEMS RETIREMENT RATE
NOTE
R   EWSUR.KL=EUPCT*EWSO.K                                         EN-  11
NOTE
NOTE     EUPCT   ENEMY PERCENTAGE OF WEAPON SYSTEMS USED
NOTE     EWSO    ENEMY WEAPON SYSTEMS OPERATIONAL
NOTE
R   EWSMR.KL=EMPCT*EWSN.K                                         EN-  12
NOTE
NOTE     EMPCT   ENEMY PERCENTAGE OF WEAPONS REPAIRED
NOTE
R   EWSRR.KL=EWSN.K*.002/EURGF.K                                  EN-  13
NOTE
NOTE     EWSRR   ENEMY WEAPON SYSTEMS RETIREMENT RATE
NOTE     EURGF   ENEMY URGENCY FACTOR
NOTE     EWSN    ENEMY WEAPON SYSTEMS NON-OPERATIONAL
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R   EPACC.KL=EURGF.K*SUMV(EDEF.K(*),1,36)/((36-EURG.K)*ECAPWS)  EN-  14
NOTE
NOTE     EPACC   ENEMY PRODUCTION ACCELERATOR
NOTE     EURGF   ENEMY URGENCY FACTOR
NOTE     EDEF    ENEMY DEFICIENCY
NOTE     EURG    ENEMY URGENCY--TIME TO FIRST DEFICIENCY
NOTE     ECAPWS  ENEMY CAPABILITY PER WEAPON SYSTEM
NOTE
C   ECAPWS=75                                                    EN-  15
NOTE     ECAPWS  ENEMY CAPABILITY PER WEAPON SYSTEM
C   EDESWF=1.15                                                  EN-  16
NOTE     EDESWF  ENEMY DESIRE FOR WEAPONS FACTOR
C   EUPCT=.20                                                    EN-  17
NOTE     EUPCT   ENEMY PERCENTAGE OF WEAPON SYSTEMS USED
C   EMPCT=.90                                                    EN-  18
NOTE     EMPCT   ENEMY PERCENTAGE OF WEAPON SYSTEMS REPAIRED
NOTE
FOR MO=1,120
A   EDEF.K(MO)=MAX(EDIF.K(MO),0.0)                               EN-  19
NOTE
NOTE     EDEF    ENEMY DEFICIENCY
NOTE     EDIF    ENEMY DIFFERENCE IN CAPABILITY
NOTE
A   EDIF.K(MO)=USCAP.K(MO)+ACAP.K(MO)-ECAP.K(MO)                 EN-  20
NOTE
NOTE     EDIF    ENEMY DIFFERENCE IN CAPABILITY
NOTE     USCAP   US CAPABILITY
NOTE     ACAP    ALLIED CAPABILITY
NOTE     ECAP    ENEMY CAPABILITY
NOTE
A   EURG.K=URGENCY(EDEF.K)                                       EN-  21
NOTE
NOTE     EURG    ENEMY URGENCY--TIME TO FIRST DEFICIENCY
NOTE     EDEF    ENEMY DEFICIENCY
NOTE
T   EWGT=2.0/1.75/1.35/1.15/1.05/1./.99/.98/.97/.97/.96          EN-  22
A   EURGF.K=TABLE(EWGT,EURG.K,0,120,12)                          EN-  23
NOTE
NOTE     EURGF   ENEMY URGENCY FACTOR
NOTE     EURG    ENEMY URGENCY--TIME TO FIRST DEFICIENCY
NOTE
NOTE
A   ECAP.K(MO)=(EWSP.K+EWSO.K+EWSN.K+SUMV(EPLAN.K(*),             EN-  24
X   1,T(MO)))*ECAPWS
NOTE
NOTE     ECAP    ENEMY CAPABILITY
NOTE     EWSP    ENEMY WEAPON SYSTEMS IN PRODUCTION
NOTE     EWSO    ENEMY WEAPON SYSTEMS OPERATIONAL
NOTE     EWSN    ENEMY WEAPON SYSTEMS NON-OPERATIONAL
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NOTE     EPLAN   ENEMY PLAN FOR WEAPON SYSTEMS PRODUCTION
NOTE     T       TIME TABLE
NOTE     ECAPWS  ENEMY CAPABILITY PER WEAPON SYSTEM
NOTE
A   EINT.K=TABHL(EINTT,SUM(EPTHR)/120,-1,1,.2)                  EN- 25
NOTE
NOTE     EINT    ENEMY INTENT
NOTE     EPTHR   ENEMY PERCEIVED THREAT
NOTE
T   EINTT=1.99/1.7/1.3/1.15/1.05/1/1.05/1.15/1.3/1.7/1.99       EN- 26
A   EINTF.K=SMOOTH(SUM(EPTHR)/120,3)                            EN- 27
N   EINTF=1                                                     EN- 28
NOTE
NOTE     EINTF   ENEMT INTENT FACTOR
NOTE     EPTHR   ENEMY PERCEIVED THREAT
NOTE
A   EDWSL.K(MO)=EDESWF*EPTHR.K(MO)/ECAPWS                       EN- 29
NOTE
NOTE     EDWSL   ENEMY DESIRED WEAPON SYSTEMS LEVEL
NOTE     EDESWF  ENEMY DESIRE FOR WEAPONS FACTOR
NOTE     EPTHR   ENEMY PERCEIVED THREAT
NOTE     ECAPWS  ENEMY CAPABILITY PER WEAPON SYSTEM
NOTE
A   EPTHR.K(MO)=(USINT.K+AINT.K)*EDEF.K(MO)                     EN- 30
NOTE
NOTE     EPTHR   ENEMY PERCEIVED THREAT
NOTE     USINT   US INTENT
NOTE     AINT    ALLIED INTENT
NOTE     EDEF    ENEMY DEFICIENCY
FOR ME=1,36
L   EPLAN.K(ME)=EPLAN.J(ME)+(DT)(EPACC.JK)                      EN- 31
NOTE
NOTE     EPLAN   ENEMY PLAN FOR WEAPON SYSTEMS PRODUCTION
NOTE     EPACC   ENEMY PRODUCTION ACCELERATOR
NOTE
FOR MEE=37,120
L   EPLAN.K(MEE)=EPLAN.J(MEE)+DT*(EADJ.JK(MEE-36))              EN- 32
R   EADJ.KL(MEE-36)=EDWSL.K(MEE)                                EN- 33
NOTE
NOTE     EADJ    ENEMY ADJUSTMENT RATE
NOTE
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NOTE     *******   FORTRAN SUBROUTINES   *******
NOTE
NOTE
X      REAL FUNCTION URGENCY(ARRAY)
       COMMON X(109),T(120),X1(196),X2(167),PRR1(10),X3(10)
       COMMON CF1(10),X4(30),TC2(10),PRR3(10),X5(10),CF3(10)
       COMMON X6(30),TC3(10),EPLAN(120),X7(684),APLAN(120)
       COMMON FMSA(120),X8(600),X9(601),WSPRR(10),Y(20)
       COMMON CP4(10),Y1(10),SP4(10),TC4(10),X12(2)
       DIMENSION ARRAY(120)
NOTE
NOTE     FUNCTION URGENCY FINDS THE FIRST NONZERO ENTRY IN THE ARRAY
NOTE     THIS IS USED TO FIND THE TIME OF THE FIRST DEFICIENCY
NOTE
       DO 10 J=1,120
       IF(ARRAY(J).EQ.0.0) GO TO 10
       URGENCY=J
       RETURN
    10 CONTINUE
       URGENCY=120.
       RETURN
       END
NOTE
NOTE
X      REAL FUNCTIONFSHIFT(ARRAY)
       COMMON X(109),T(120),X1(196),X2(167),PRR1(10),X3(10)
       COMMON CF1(10),X4(30),TC2(10),PRR3(10),X5(10),CF3(10)
       COMMON X6(30),TC3(10),EPLAN(120),X7(684),APLAN(120)
       COMMON FMSA(120),X8(600),X9(601),WSPRR(10),Y(20)
       COMMON CP4(10),Y1(10),SP4(10),TC4(10),X12(2)
       DIMENSION ARRAY(120)
NOTE
NOTE     FUNCTION FSHIFT MOVES EACH VALUE IN THE ARRAY FORWARD BY ON
NOTE     THIS IS USED WITH THE COMPUTED PLANS TO INPUT THE PLANNED
NOTE     SALES OR PRODUCTION AS THE TIME OF THE EVENT ARRIVES.
NOTE
       DO 10 I=1,119
    10 ARRAY(I)=ARRAY(I+1)
       ARRAY(120)=0.0
       FSHIFT=ARRAY(1)
       RETURN
       END
NOTE
NOTE
X      REAL FUNCTION DPR1(A,B,C,TC,PRR,CF,TL)
       COMMON X(109),T(120),X1(196),X2(167),PRR1(10),X3(10)
       COMMON CF1(10),X4(30),TC2(10),PRR3(10),X5(10),CF3(10)
       COMMON X6(30),TC3(10),EPLAN(120),X7(684),APLAN(120)
       COMMON FMSA(120),X8(600),X9(601),WSPRR(10),Y(20)
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      COMMON CP4(10),Y1(10),SP4(10),TC4(10),X12(2)
      DIMENSION TC(10),PRR(10),CF(10),TL(120)
NOTE
NOTE    FUNCTION DPR1 IS DESIGNED TO COMPUTE THE LEAST COST TRADEOF
NOTE    BETWEEN LEVEL OF EFFORT AND SCHEDULE DELAYS.
NOTE
      MTC=TC(1)
      DO 10 I=2,10
      IF(TC(I).GE.MTC) GO TO 10
      MTC=TC(I)
      DPR1=PRR(I)
      DCF(N)=CF(I)
      DTL(N)=TL(I)
   10 CONTINUE
      RETURN
      END
```

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