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A SYSTEM DYNAMICS ANALYSIS OF THE FACTORS AFFECTING COMBAT READINESS

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The term "Combat Readiness" is used in the United States Air Force as the basis for managing resources. There is no clear understanding of what factors affect combat readiness or how the factors that do affect it interact to determine a unit's level of readiness. Due to this lack of understanding, no analytical vehicle has been developed which will enable a commander to determine how a change in policy will affect combat readiness prior to the policy's implementation. To aid in the understanding of the elements which interact to determine a unit's level of readiness, a system dynamics analysis of the factors affecting readiness was accomplished. Key managers within the United States Air Force combat readiness system were interviewed and the information acquired in these interviews was used to develop a large scale policy model for the management of combat readiness. The combat readiness model is comprised of ten sectors which address the interactions of personnel and equipment readiness. The generation of pressures to improve readiness and its affect on combat readiness is also addressed. Further development and use of this model to manage combat readiness will enable commanders to determine in advance the effect of policy changes.

LSSR 48-80

A SYSTEM DYNAMICS ANALYSIS OF THE FACTORS AFFECTING COMBAT READINESS

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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INTRODUCTION

Overview

Over the past two years "combat readiness" has become the basis for the management of the United States' military resources (34:7). General David C. Jones emphasized its importance in his 25 January 1979 presentation to the Senate Armed Services Committee when he stated, "I have long espoused the philosophy that 'Readiness Now' is the best insurance for the security of our country. . . [25:28]." The fact that combat readiness is critical to our national security and is utilized in the management of our military resources makes the understanding of what combat readiness is and how it is achieved of utmost importance to military managers. The Fiscal Year 1978 Department of Defense Report defines combat readiness as:

> 'Readiness' refers to the capability to respond adequately to diverse situations and to sustain that response as long as necessary. The 'readiness' of Defense combat forces depends on a myriad of diverse and often interrelated factors [29:2].

This definition primarily addresses what combat forces are capable of doing, but does not discuss what factors contribute to combat readiness or how it is derived. Brigadier General Patrick J. Halloran, the Strategic Air Command

Inspector General, discussed some of the factors which comprise readiness in the August 1978 issue of TIG Brief. He stated that readiness ". . . encompasses all facets of any unit operation. It is the equipment, people, leadership knowledge, maturity, teamwork, and discipline that combine to keep us prepared [32:3]." The necessity of being prepared is the reason for the importance of combat readiness. The Soviet's development and deployment of highly sophisticated and destructive weapons leaves us "little or no time for preparation should any hostile action be initiated [15:3]." Readiness is needed not only for survival should we come under attack but also to deter attacks. It has become the most important element in the operability of current national security plans (32:3).

As important as combat readiness is, it is elusive when attempts are made to measure it. Combat readiness is a dynamic concept, but we can measure it only in terms of static evaluations of the elements which comprise it. This disparity presents a major challenge to military managers (24:6A-35 to 6A-48).

Problem Analysis

An accurate system to measure combat readiness is essential to determine the Air Force's contribution to national power (33:7). Assessing the current system's ability to do this has been the topic of many studies in recent years (29:27). Although improvements have been made in this area, the management of combat readiness requires more than the ability to determine a unit's level of readiness. The use of this information to determine where deficiencies exist and what actions can be taken to best correct them is required to effectively manage combat readiness. Current understanding of the elements which comprise combat readiness and how they interact does not allow accomplishment of this task (29:3).

Problem Statement

The term "Combat Readiness" is used in the United States Air Force (USAF) as the basis for managing our resources (34:7). There is no clear understanding of exactly what factors affect combat readiness or how the factors that do affect it interact dynamically to determine a unit's level of combat readiness. Due to this lack of understanding, no analytical vehicle has been developed which will enable a commander to determine how a change in policy will affect combat readiness prior to the policy's implementation.

Justification for Research

In 1976, the US Navy justified a request for additional training funds based on the need to improve readiness. Their request was refused because Congress indicated they could not determine the existence of a readiness deficiency from the Navy's readiness reporting system (37:3). In 1977, the Senate Armed Services Committee reported that it was "often impossible for the services to relate proposed expenditures to specific, planned changes in readiness [29:4]." The committee went on to direct the services to link proposed expenditures to the established readiness requirements (29:5). These two occurrences emphasize the importance of the capability to measure readiness and justify expenditures in terms of readiness.

General Michael Rogers, former commander of the Air Force Logistics Command, stated that one of the vital issues in readiness planning is the need for the "development of credible capability assessment systems that measure output activity versus resource input in terms of readiness [17:40]." This ability to measure output versus input is more critical today due to resource limitations which do not allow the implementation of all desired programs (34:39). The ability to understand how the elements of readiness combine to determine our level of combat readiness is the first step in this process. Once we understand how readiness is derived, we will then be able to project how policy changes affect combat readiness and evaluate the relative worth of different programs. This evaluation ability will insure the most effective utilization of resources in terms of improved readiness and enable the Air Force to justify to Congress the proposed expenditure of funds.

Research Objectives

The general objective of this research project is to provide a vehicle to enable commanders to project the effects of their policy decisions in terms of improvements to combat readiness, prior to the policy's implementation. The specific objectives are:

1. identify the factors affecting combat readiness;
2. capture the interaction of these factors in their relationship to combat readiness;
3. construct a dynamic systems and mathematical model of the combat readiness system;
4. develop a computerized model which can be used for policy development and analysis;
5. verify and validate that the model represents this system; and
6. identify critical areas of concern for policy makers.

Scope

This research will develop a model of the tactical forces of the USAF. It will deal with the primary elements which interact to determine the level of readiness of a Tactical Fighter Wing (TFW). A macro approach is required for the model to be useful as a management tool. If the scope was narrowed to model a particular situation, then the model would only represent that situation and only be useful in its management. The macro approach will allow the model to be of value in aiding commanders with combat readiness decisions in the variety of situations that they presently face (7:5-8).

Plan of Presentation

The research will be presented in a format which follows the basic outline presented by the Research Objectives. Chapter 2 will include a general discussion of the areas which impact combat readiness and the system dynamics approach to research. The actual processes involved in modeling will be presented in Chapter 3 to aid those readers who are unfamiliar with system dynamics in following the research. In Chapter 4, causal loop diagrams will be utilized to capture the interactions of the various factors which affect combat readiness. The interactions of these factors will be quantified utilizing flow diagrams and system equations in Chapter 5. Chapter 6 will discuss the combat readiness model validation and the areas of concern to management which were identified through experimentation with the model. The final chapter will summarize the research findings and present recommendations.

CHAPTER 2

LITERATURE REVIEW

History of Readiness

For many years the military has used the term combat readiness to define a unit's or person's ability to perform an operational task (40:360). During the first half of this century, concern in this area was limited to times of war. When the United States was not at war, readiness levels would drastically decrease. This is evidenced by the excessive time that was required to field combat units after the initiation of hostilities. It took eight months from the time the United States entered World War II until the Eighth Air Force flew its first bombing mission from England (23:160). The nature of combat during this period allowed for preparation after the war had started (25:27). As weapon systems became more complex and far more destructive, the need for a constant state of high combat readiness became more important.

Increased Emphasis on Combat Readiness

As weapon systems have become more complex, the lead time for their development and production has become longer. Today it takes approximately seven years from the time the design process starts on an aircraft until it becomes operational (4:4). During World War II, the B-29, the most complex aircraft of the war, was designed and entered combat in a period of three years (23:127). This increased lead time applies not only to the development and production of the weapon systems but also to the acquisition of spare parts and the training of personnel to operate and maintain these systems.

While the lead time required to field weapon systems becomes longer, the time available to field them is becoming shorter. The destructive capability of weapon systems has vastly increased over the past thirty years. Today fighter aircraft can carry far larger conventional bomb loads than the B-17 could in World War II (23:161). The advent of air refueling has given the Air Force a world wide striking capability. The fielding of intercontinental ballistic missiles has brought with it the ability to directly expend ordnance anywhere in the world (32:9). All this increased destructive capability converts to a shorter time available to prepare for a war once it starts (32:3).

The increased lead time required to develop and produce weapon systems for combat in combination with a decrease in the time available to field effective fighting units calls for an increased combat readiness. For the past several years, General Jones has stressed the need for increased readiness with his philosophy "Ready Now." He stated in his March 1979 presentation to the Senate Armed

Services Committee that, "In the past, we have never been ready when a war came, relying on a large acceleration lane to build up after an attack. In modern warfare, we do not have that luxury [25:27]." He also went on to stress the importance of ". . . maximizing our capacity to fight with what we have today [25:28]." Combat readiness will continue to be the main aim in the Air Force in the foreseeable future. Brigadier General Patrick J. Halloran, Strategic Air Command Inspector General (SAC IG), stated, "Readiness will continue to receive emphasis because it is the single most important element in the workability of our national security posture [32:3]." The discussion thus far has dealt with the importance of readiness, although its importance is clear, the measurement of readiness is not.

Readiness Measurement

One of the difficult factors faced in the management of combat readiness is the lack of agreement of how readiness is achieved. The February 1979 issue of TIG Brief stated,

> Readiness is the end result of a series of conscious and dedicated efforts. It does not happen, but must be purposefully achieved through individual and collective action--a total system [10:5].

Although the article does not discuss what "dedicated efforts" are required to achieve combat readiness, it does make an important point. That point is that readiness is a system and must be managed as a system. Unfortunately the current measurement system only measures static factors such as the percentage of aircraft mission ready (24:6A-35 to 6A-48). Lieutenant Colonel Thomas A. Musson, in his Air War College research report titled Readiness Measurement and Reporting Systems, found that,

> . . . the existing systems are directed at measures which can be described as similar to the engineering theorem "availability." In fact some people equate readiness with availability [29:29].

The Unit Capability Measurement System (UCMS) was implemented in 1975, and represented a vast improvement over previous reporting systems (29:16-21). It takes into account all of a weapon system's capabilities and concentrates on the wartime missions which a particular unit is expected to perform, in our various planning documents. Each unit is rated separately in each mission it is capable of performing. For example, the F-4 is capable of air-to-air combat, conventional ground attack, nuclear weapons delivery, and to differing degrees, guided weapons delivery. Each unit which flies F-4s is assigned one of the missions as its primary designated operational capabilities (DOC) and one or more as a secondary DOC. Units then report readiness in each DOC separately, through the chain of command, to give the Joint Chiefs of Staff (JCS) a clearer idea of the Air Force's actual ability to perform its wartime tasking (29:47).

The UCMS looks at a unit's total readiness by measuring its materiel, equipment, logistics, and personnel readiness (29:19). These separate factors are used to give the JCS a "snapshot" of the present level of readiness and enable them to project the readiness needs of the future. Because readiness is a system, an increase in one area, such as equipment, does not necessarily mean an increase in total readiness. All the elements and their interrelations must be considered to determine a unit's readiness. To aid in the understanding of this process it will be helpful to look at the elements which comprise combat readiness.

Combat Readiness Elements

The list of factors which contribute to combat readiness is endless. Virtually everything that is accomplished in the Air Force contributes either directly or indirectly to combat readiness (37:40). In keeping with the scope of this thesis, looking at combat readiness on the macro level, consideration will only be given to those factors which contribute directly to combat readiness. These factors will be referred to as "elements," and divided into the areas of personnel, equipment, and materiel.

Personnel

No matter how good a weapon system is, it cannot be effective without personnel to operate and maintain it. Not only are the proper number of personnel needed, but they must have the right training and experience (35:9). A recent article in TIG Brief stated that "our deterrent credibility hinges on our level of combat readiness, and relies on training programs to develop that readiness [35:9]." Better training is often referred to as more realistic training. The article went on to say that "the single most important ingredient of training for combat is realism [35:9]." Upon initial investigation of this comment it seems to be directed to the weapon systems operators, but it is equally important for maintenance, logistics, and support personnel. The personnel in each of these areas must be prepared for combat if combat readiness is to be achieved. Security police must be trained to battle saboteurs and guerrilla groups; firemen must be trained to deal with large scale damage from airfield attacks. The best way to achieve the desired training levels is through frequent and realistic training exercises. The more realistic our training scenarios, the better prepared personnel will be for combat (35:10).

Equipment

In assessing the contribution of the equipment possessed by a unit to its combat readiness, there are many elements which must be considered. They include:

1. Equipment capability
2. Equipment maintainability
3. Equipment reliability

Each of these elements makes a distinctive contribution to combat readiness (29:18-20). The net effect of that contribution cannot be viewed in a void. If a new aircraft is introduced with a vast improvement in capability, an increase in combat readiness would be expected. This would hold true only if that aircraft had reasonable reliability and maintainability. If the aircraft was extremely difficult to maintain the net effect of its introduction may be a decrease in capability. The key to managing combat readiness is the ability to understand these relationships. Just as the elements of equipment readiness are interrelated, so are the areas we are discussing. Equipment readiness and personnel readiness must be considered in conjunction with materiel readiness to assess total readiness (29:18-20).

Materiel

General Rogers, a past commander of AFLC, stated,

> Our contribution to force readiness is an essential one, and without a responsive logistical support capability, our first line weapon systems would become little more than static displays [37:37].

Parts and supplies are needed not only to maintain weapon systems, but also for the equipment that is used to service and repair these weapon systems. A multimillion dollar aircraft can be grounded for the lack of a small value replacement part or the availability of its servicing equipment (37:36-41). Currently DOD uses the operational ready rate of weapon systems to measure levels of materiel readiness

(17:ii). DOD is required to submit to Congress an annual materiel readiness report. The objective of this report is to provide Congress with projected materiel readiness levels based on possible Congressional funding alternatives. An October 1979 General Accounting Office (GAO) report found that the current DOD materiel readiness report did not adequately meet this objective (17:iii). The primary shortfall was DOD's inability to ". . . make reliable quantitative projections of the effect of appropriations requested on materiel readiness requirements [17:10]." The GAO also discussed the problems associated with using a materiel readiness report in isolation. The other factors which contribute to combat readiness could provide better funding alternatives or could render improvement in the materiel area ineffective in improving the overall level of combat readiness (17:10). Analytical tools are needed which are capable of determining the contribution of different Congressional funding alternatives to improving combat readiness (23:9). Such a tool must consider all the elements which contribute to combat readiness and their interactions to adequately link resource expenditures to readiness improvement.

System Dynamics

The management of our vast and complex military and social systems is a task which has become increasingly difficult. Our systems today are characterized by the enormity of their scale and the interrelatedness of their elements (13:vii). This increase in complexity has greatly complicated the task of managing these systems. With less complex systems, managers are able to predict system reactions to different policy decisions. This cause-and-effect reasoning process works well if the interrelations of the system elements are properly understood and analyzed. As systems become more complex it becomes more difficult for the human mind to cope with all the elements involved and accurately predict what a system's reaction to a change will be (13:viii). The difficulty of accurately predicting how complex systems will react to policy changes has prompted a search for new analytical techniques to be used in their management (13:vii). One such technique which was developed and is considered the most powerful such tool presently available is computer simulation (22:15).

Simulation of a system involves the construction of a model which represents the real world system.

> A simulation of a system or an organism is the operation of a model or simulator which is a representation of the system or organism. The model is amenable to manipulations which would be impossible, too expensive or impractical to perform in the entity it portrays. The operation of the model can be studied and, from it, properties concerning the behavior of the actual system or its subsystems can be inferred [30:2].

The development of the computer in the early 1950's brought with it the ability to experiment using mathematical models of complex systems to simulate the system's reaction to various inputs (30:1). Since its development, computer simulation has been utilized in the management of many complex systems. The art of analyzing systems by developing mathematical models which simulate their interactions over time is called "system dynamics." Some areas of successful application include: transportation, economic, environmental, military, and agricultural systems (22:192-193). The successful application of the system dynamics approach to complex systems and its increased importance in their management has led to a search for new areas of application. The military currently uses system dynamics in aerodynamic design, combat scenario development, and determining manpower requirements (30:3). Further application of this management tool to areas such as the combat readiness system will greatly improve our understanding of such systems and improve our ability to efficiently manage them.

The system dynamics approach is predicated on the movement of a model, which represents the system of interest, through time (14:13). By performing experiments on this model we can determine how policy changes will effect the system. The system dynamics approach is based on several premises. These premises are:

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

2. Our intuitive judgment is unreliable about how these systems will change with time, even when we have good knowledge of the individual parts of the system.

3. Model experimentation is now possible to fill the gap where our 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. Our industrial 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 [6:13-14].

Research into the behavior of military systems was one of the primary motivating factors in the development of the system dynamics approach (14:14). This research led to the following four concepts which are considered the foundations of system dynamics.

1. The theory of information-feedback systems.

2. A knowledge of the decision-making process.

3. The experimental model approach to complex systems.

4. The digital computer as a means to simulate realistic mathematical models [14:14].

Although each of these foundations play an important role in the use of system dynamics, the information-feedback system is the most important. "An information-feedback system exists whenever the environment leads to a decision that results in action which affects the environment and thereby influences future decisions [14:44]." "Management decisions are made in the framework of an information-feedback system. . . [14:61]." Figure 2-1 represents this system and when used in the system dynamics approach, it represents the "control system structure" of an organization. Decisions are made based on the comparison of apparent achievements to desired achievements. These decisions are transformed by delays and noise which exist in the system and by the structure of the system itself. The transformed decisions cause changes to the system which are represented in the diagram as real accomplishments. Delays, noise, and bias affect the way real accomplishments are perceived by managers and the apparent achievements are again compared to desired achievements to make future decisions (38:416-417). Information-feedback systems are present in all levels of organizations. Their effectiveness in bringing about desired achievements in an orderly fashion determines a system's stability and growth (14:61).

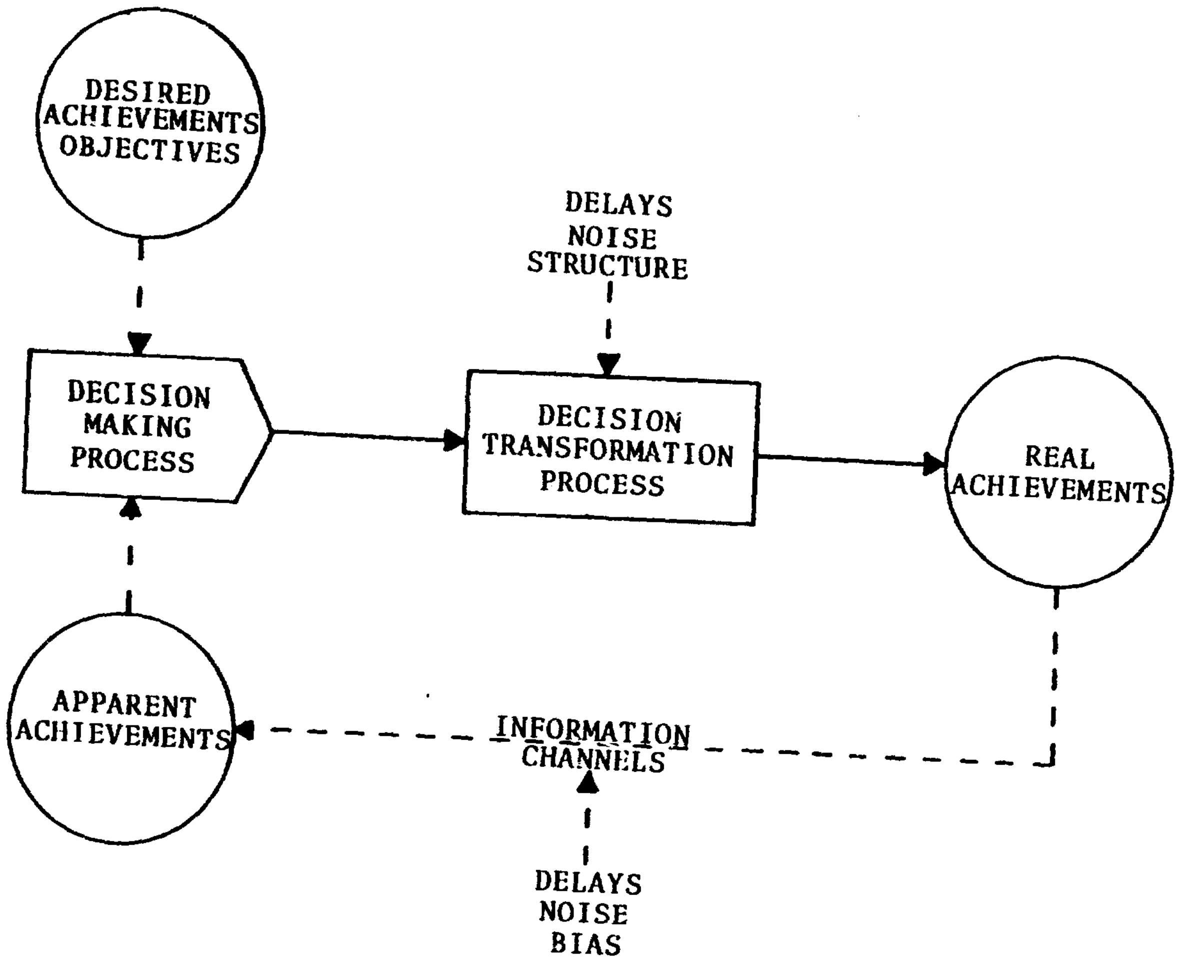

Fig. 2-1. Information Feedback System

Information-feedback systems are concerned with the flow of information. The decision-making process which occurs within these systems is the second foundation of system dynamics. Decisions are not "free will" but are strongly influenced by the information-feedback system in which they are made (14:17). By increasing understanding of this decision-making process and the influence of the information-feedback system on it, problems such as bias in the system can be identified. Once problem areas have been identified, policies to correct them can be investigated.

When the information-feedback and decision-making processes of a system are understood they can be captured in a model to simulate the operation of the real system. By moving this model through time we can study the effects of possible policy changes on the operation of the system and introduce policy changes which produce a more effective system (14:13). This experimental model approach to improving systems is the third foundation of system dynamics. The last foundation is the use of the digital computer to conduct the simulation. Prior to the development of digital computers, such simulation was not possible due to the large number of interactions which exist within a complex system (14:18). When the computer became available, the computational barrier was removed and system dynamics methodology was vastly enhanced.

Summary

The importance of maintaining combat ready forces has increased as weapon systems have become more complex and destructive. This need for increased readiness places on Air Force managers the requirement to accurately assess current readiness levels and to continually improve them. This task can best be accomplished by understanding the elements of readiness and how they interact to form the combat readiness system. Due to the nature and complexity of the combat readiness system, the system dynamics approach is the best tool currently available to aid in the management of this system.

CHAPTER 3

RESEARCH METHODOLOGY

Introduction

The need for an analytical tool which will enable commanders to determine how a change in policy will effect combat readiness is a major DOD problem (28). Currently there is no clear understanding of how the factors that effect combat readiness interact to determine a unit's level of readiness. The understanding of these interactions is the key to the development of an analytical tool which will improve combat readiness management. The system dynamics modeling technique was developed to aid in the management of complex systems. This technique involves the capturing of the interactions which occur within a system and the development of a computer model which simulates that system (18:9-11). This chapter will discuss the system dynamics modeling technique and how it will be used in the development of a tool for managing combat readiness.

Causal Loop Diagrams

Once a problem has been identified, the next step in the system dynamics approach is to isolate the factors which appear to bear on the problem (14:13). In Chapter 2, factors which affect combat readiness were addressed under the broad heading of personnel, equipment, and materiel.

The interactions which occur between both the factors and the areas determine levels of combat readiness. The factors which effect combat readiness combine to form ". . . information-feedback loops that link decisions to action to resulting information changes and to new decisions . . . [14:13]."

Causal loop diagrams are utilized to describe feedback relationships (18:7). They play two important roles in the system dynamics process.

> First, during model development, they serve as preliminary sketches of causal hypothesis. Second, causal loop diagrams can simplify illustrations of a model. In both capacities, causal loops allow the analyst to quickly communicate the structural assumptions underlying his model [18:5].

To aid in the development of causal loops, pairwise relationships as shown in Figure 3-1 are developed.

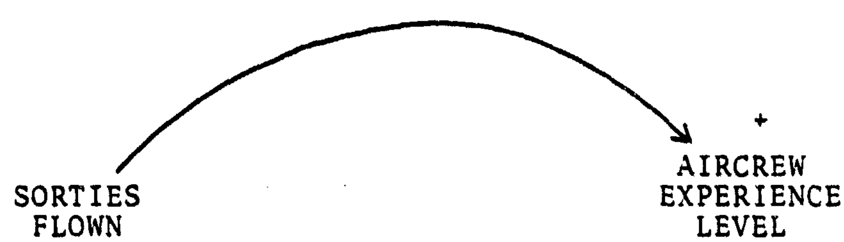

Fig. 3-1. Positive Pairwise Relationship

This pairwise relationship represents the interaction between the number of sorties flown and aircrew experience levels. The arrow indicates the direction of flow and the plus sign indicates the relationship is positive. A relationship is positive when ". . . all other things being equal, a change in one variable generates a change in the same direction in the second variable relative to its prior value [18:7]." In this case an increase in sorties flown results in an increase in aircrew experience level. "A negative relationship denoted by a minus sign occurs when a change in one variable produces a change in the opposite direction in the second variable [18:7]." Figure 3-2 is an example of a negative pairwise relationship.

Fig. 3-2. Negative Pairwise Relationship

In this case an increase in aircrew experience level causes a decrease in the number of sorties required.

Pairwise relationships are combined to develop causal loops. They are primarily used to visualize real world systems in terms of feedback loops (18:5). Causal loops are most helpful during the early stages of model development. "When a feedback loop response to a variable change opposes the original perturbation, the loop is negative or goal seeking [18:9]." Figure 3-3 illustrates a negative loop.

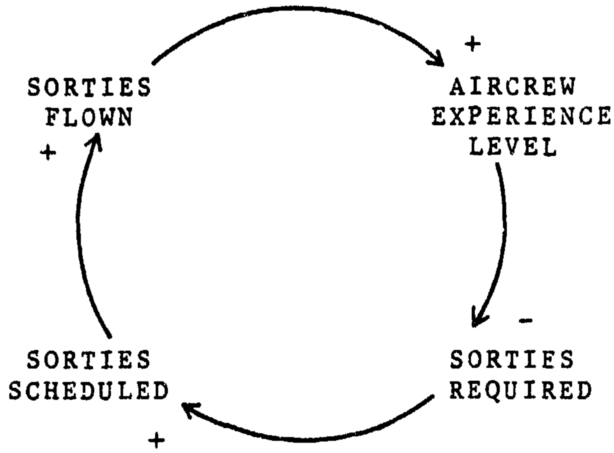

Fig. 3-3. Negative Causal Loop

In this loop, an increase in sorties flown causes an increase in aircrew experience level which causes a decrease in sorties required. This decrease in sorties required causes a decrease in sorties scheduled which results in a decrease in sorties flown. The original increase in sorties flown has a net effect of reducing sorties flown. "When a loop response reinforces the original perturbation, the loop is positive [18:9]." Figure 3-4 illustrates a positive loop.

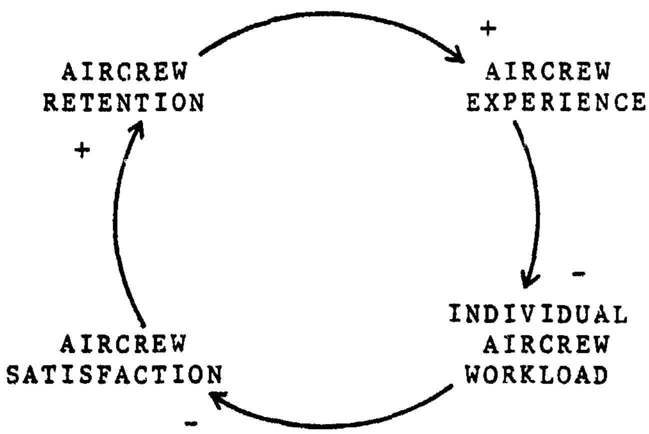

Fig. 3-4. Positive Causal Loop

In this loop an increase in aircrew retention causes an increase in aircrew experience which in turn causes a decrease in individual aircrew member's workload. This decrease in workload causes an increase in aircrew satisfaction which results in increased aircrew retention. The initial increase in aircrew retention resulted in even greater retention. The causal loop diagrams developed to represent the combat readiness system are hypotheses of the interaction which exist within the system. As with any hypotheses, they must be verified. The verification was accomplished through an interview process.

Interview Process

Interviews were conducted with key managers at different levels of the combat readiness system. The levels of management ranged from the Tactical Fighter Wing to the Office of the Secretary of Defense. A listing of the persons interviewed is contained in Appendix C.

The interviews were conducted utilizing the consistent but unstructured interview guide shown in Appendix B and the causal loop diagrams discussed in the previous section and shown in Appendix A. The causal loop diagrams were introduced at the beginning of each interview and questions were directed towards verifying the relationships depicted and determining what decisions, if any, were made in the management of these relationships. When conscious management decisions were made which affected the causal loop diagram relationships, questions concerning the information flows, decision criteria, implementation, and the feedback process were asked. This information was used to further structure the initial model; amend it as necessary; and to determine the levels, flow, delays, bias, and structure of the combat readiness system. The levels, flows, delays, and bias were utilized in the development of detailed flow diagrams and system equations. This process is discussed in the following two sections.

Flow Diagrams

Flow diagrams are developed in conjunction with system equations and represent the interaction within a system. The flow diagrams are pictorial descriptions of these interactions. The use of visual images lends clarity to the interactions and serves to link the verbal descriptions of the system to the rate equations (14:81). Flow diagrams will be developed using the information gained about the system and will display relationships in terms of levels and rates. Levels are accumulations within a system (14:68). An example of a level in the combat readiness system is aircrew experience. Levels are determined by the difference between the inflows and the outflows. These flows are called rates (14:68). Rates represent the instantaneous flow between two levels in a system and are

LEVELS--present values of those variables that have resulted from the accumulated differences

DECISION FUNCTION (RATE)--policies that control the flows between levels

FLOWS--the movement of: information

material

personnel

SOURCE/SINK--represents source or destination outside the system

AUXILIARY VARIABLE--provides independent meaning to decision function

PARAMETERS--characteristics of a system considered constant

DELAYS--represents the process of time delays

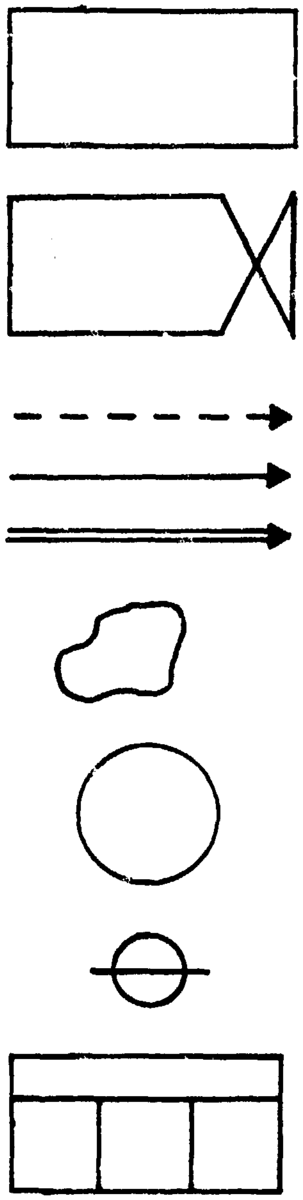

Fig. 3-5.

Flow Diagramming Symbols (6:82-84)

determined by the levels they connect (14:69). For example, if the aircrew experience level was below a desired standard, management would attempt to increase the aircrew retention rate. "The decision functions are the relationships that describe how the levels control the flow rates [14:13]." The test to determine if a factor is a level or a rate is accomplished by bringing a system to rest (14:68). Levels will continue to exist if the system is at rest while rates will cease.

To enhance the ability of flow diagrams to depict the actual decision functions which are active within a system; flow sources, auxiliary variables, parameters, and delays are added. The symbols which are used to depict each of these and a definition of what they represent in the system is given in Figure 3-5. These symbols are combined in a flow diagram which represents the actual decision structure in the system. They depict how information flows, where delays are encountered, where and how decisions are made, and how they effect rates. Figure 3-6 is a simple example of a flow diagram. It shows how the symbology is utilized in depicting the decision structure. In this example a delay in information exists between the level and the auxiliary. Information about the level, after reaching the auxiliary, is compared with the goal to determine rate. In this decision structure the delay in information would

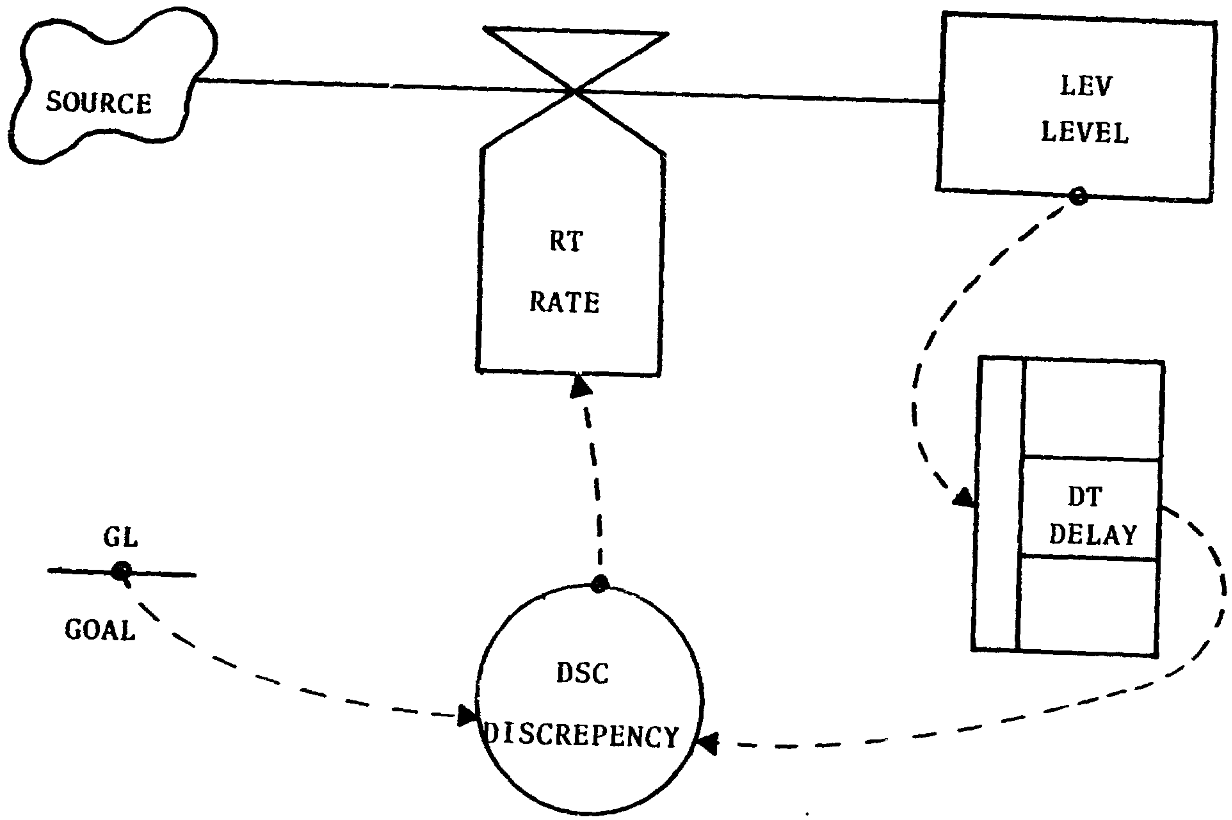

Fig. 3-6. Flow Diagram

cause the rate to lag the actual level. Simultaneous to the development of flow diagrams, system equations are generated (14:81).

System Equations

Like flow diagrams, system equations define the rates of flow which occur between the levels of a system (14:77). Their depiction of the decision process is mathematical. Each equation is developed independently and the equations are compiled to represent the system. "It should be stressed that equations are not 'right' in any intrinsic or mathematical way. They merely describe what we have chosen as the most significant relationships [14:140-141]." They are correct if the way the system is perceived is correct, and incorrect to the extent that the system is misinterpreted (14:77).

Levels are assigned initial values in the model and then as the model progresses through time, the rate equations determine changes in levels and the level equations determine changes in the rates. A simple example of this computational procedure follows:

1. Compute the first rate using the initial value of the level.

2. Multiply the rate by the time interval used in the simulation to determine the level change.

3. Add the change in level computed in Step 2 to the initial value of the level to determine the new level.

4. Repeat the process to progress the model through time (8:19).

Time is denoted in system equations by the use of letters. J represents the past, K the present, and L the future. In this way past information can be used to determine rates which are applied to present values to determine future values. By adding delays, bias, and noise to this process, the operation of the actual system can be depicted. System equations are divided into six categories: level (L), rate (R), auxiliary (A), initial value (N), constant (C), and supplementary (S). The time dimensions are utilized when dealing with level, rate, and auxiliary equations only. An example of a rate equation is:

```
R    RT.KL=DELAY 3(CONST*LEV.K, DT)
C    CONST=.1
C    DT=.5
```

RT - RATE (units/month)

CONST - CONSTANT (fraction/month)

LEV - LEVEL (units)

DT - DELAY TIME (fraction of a month)

This equation determines the rate which will be used for the level computation in the KL time period. It is computed by multiplying the constant (.1) by the level in time period K.

DT=.5 represents a delay of two weeks. When all the rate equations have been developed, they are combined to form the model of the system.

Model Verification and Validation

Model validation is defined as ". . . the process by which we establish sufficient confidence in a model to be prepared to use it for a particular purpose [7:18]." Validation tests are, in effect, attempts to prove that a model is incorrect. As tests are applied and fail to prove the model incorrect, confidence in the model grows. Although this process will never allow complete validation, it will raise confidence to a level where utilization of a model for its intended purpose is possible (7:181).

R. C. Coyle, in his book Management Systems Dynamics, presents a five step process for model validation. It is this validation process which will be used to validate the combat readiness model. The first step in Coyle's validation process is to view the entire model, as it fits into its environment, to determine if the system boundaries are correct. Of critical importance in this area of model validation is the consideration of the model's objectives. The model's objectives determine what factors from the system's environment must be included. If the model fails to capture factors from the environment which impact system behavior, then the model's use to improve system behavior would be limited or totally ineffective. After the system boundaries have been validated, the model should then be viewed for gross errors (7:182).

The actual computer model must be checked to determine occurrences, such as negative personnel or product flows, do not exist. This portion of the validation process primarily insures that events which occur in the model are possible in the real world. It is a check to insure that the model's equations are computing values which are consistent with what the modelers had intended. The process is accomplished by obtaining a listing of the factor values from each model sector and checking that they are reasonable. After the model has been checked for gross errors, the model's structure must then be reviewed (7:183).

The model is studied to insure that its structure corresponds with that of the actual system. This process focuses on the variables which exist in a model and insures that they are properly interconnected. The study and validation of the system's structure is a difficult task and is primarily a confidence building process. As more information flows or decision functions are determined to be correct, more confidence is gained in the model. When sufficient confidence is gained in the model's structure, the parameter values can then be viewed for correctness (7:183).

The parameter values that are used in the model vary in importance. The vast majority of the model's parameter values are robust in nature. Values which are within the approximate range of the actual system values are sufficient for proper model operation. In each model there are several parameter values which are critical. It is these parameter values that the model attempts to identify and when manipulated result in the discovery of ways to improve a system's performance (7:183).

The last step in the validation process is to view the model's behavior as it relates to the actual system's. Although the model's performance generally does not correspond identically with that of the system's, its stability and response to shocks from the environment should be consistent with the actual system's (7:183).

When the validation process has provided sufficient confidence in the model, experiments with the model's structure can be made in an attempt to determine changes which will improve system performance. These experiments fall under the broad area of sensitivity analysis.

Sensitivity Analysis

"The final judgment of industrial dynamics models rest on the extent to which they are helpful to the manager in designing better industrial systems [14:133]." Mathematical techniques are not yet powerful enough to disclose solutions for problems which are encountered in complex systems (14:17). An experimental approach is used in which models are manipulated to determine areas of sensitivity. This process is called sensitivity analysis. Areas in a system which are sensitive to change require increased management attention (14:276). New policies and management structures are developed and tested on the model in an attempt to determine ways to improve the system. A sensitivity analysis on the combat readiness system will yield two benefits. Areas of sensitivity within the system will be identified and studied to determine policy changes that will improve the system. Proposed resource expenditures in areas such as maintenance or materiel can be studied to determine their effects on the system and therefore, their relative worth in improving combat readiness.

Summary

The system dynamics methodology is the most powerful tool presently available for the study of the combat readiness system. Utilizing this methodology, the factors which effect the combat readiness system will be studied and a computer simulation model will be developed. After the model has been verified and validated, a sensitivity analysis will be conducted to determine ways of improving combat readiness.

The first step in this process was the development of the causal loop diagrams which were utilized in the interview process. The amended causal loop diagrams, as they appeared after the interview process, are shown and discussed in the next chapter.

CHAPTER 4

COMBAT READINESS MODEL CAUSAL LOOP DIAGRAMS

Introduction

Presented in this chapter is a conceptual model of the combat readiness system. Due to the size of the system, and the large number of factors involved in determining the USAF's readiness posture, the model has been divided into ten sector diagrams. The first sector diagram provides an overview of how pressure to improve combat readiness is generated and the other nine sectors give a description of how pressure to improve combat readiness interacts within the system in achieving readiness goals. The relationships, which are hypothesized in the sector diagrams, were developed from the literature review and the interview process. The primary purpose of this chapter is to provide a general understanding of the relationships which exist in the USAF combat readiness system. A detailed discussion of the structural elements which exist in each of the sectors will be given in Chapter 5.

Combat Readiness Overview

The USAF combat readiness system is characteristic of all large scale system. It is a goal oriented system which is connected by the flow of personnel, materiel,

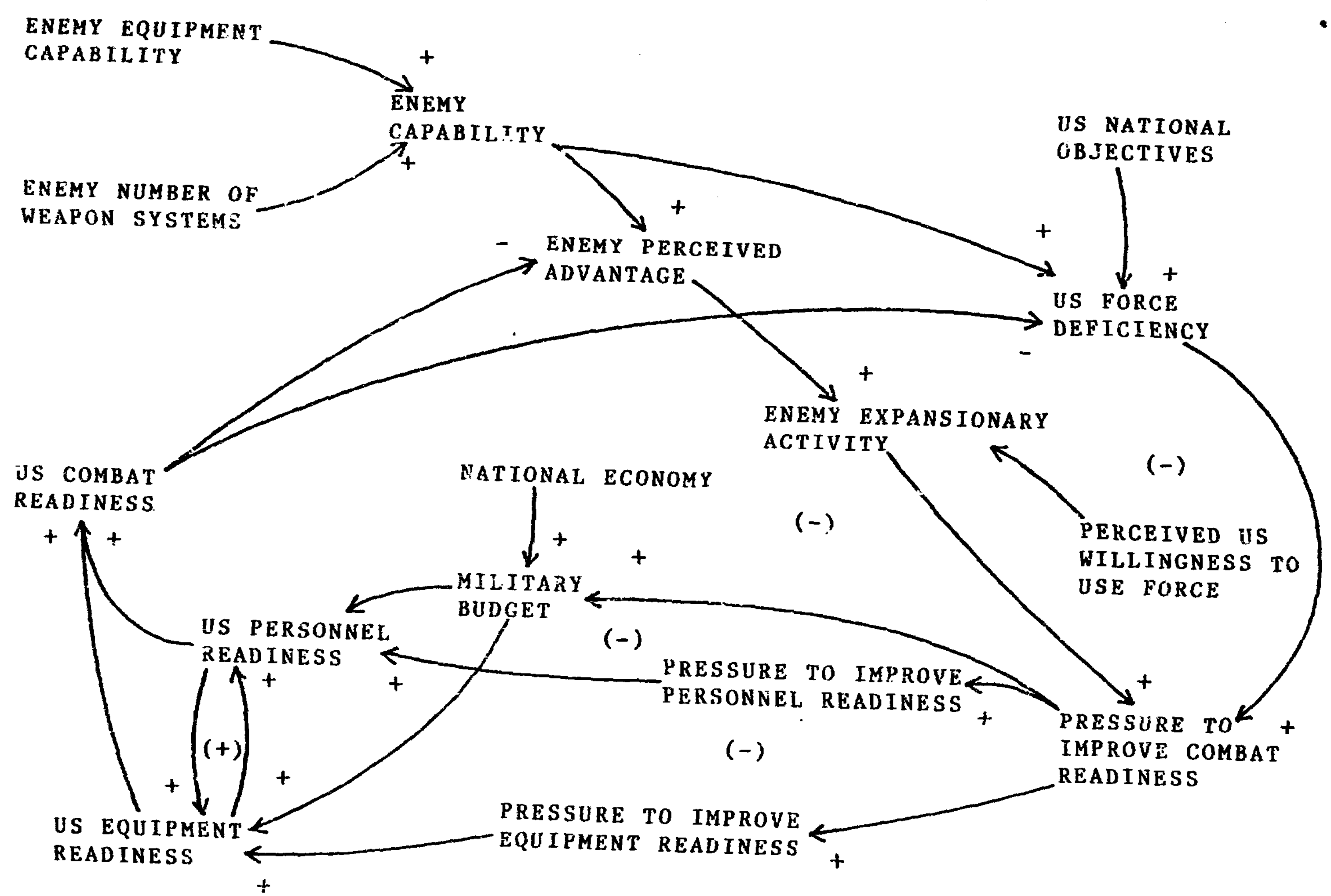

Fig. 4-1. Combat Readiness Overview--Causal Loop

money, and information. The interactions of these flows combine to determine the Air Force's readiness posture. Figure 4-1 provides an overview of the combat readiness system. It is a causal loop diagram which addresses the many factors that drive the system and determine levels of combat readiness.

Prior to discussing the relationships which are depicted in Figure 4-1, it is important to discuss the role of the USAF combat readiness system as it relates to the national security objective. "Our basic national security objective is to preserve the United States as a free nation with its fundamental institutions and values intact [44:1]." The USAF combat readiness system can be viewed as an instrument of national power which, if necessary, is available to the National Command Authority to insure this objective is met. The fact that the national security objective is to preserve the United States indicates that there is a threat to American society. It is this threat from enemies of the United States which requires the USAF be ready to enter combat if the National Command Authority deems it necessary. The combat readiness requirements of the USAF are, therefore, determined by the national objective and the enemy threat.

Figure 4-1 depicts enemy capability as a factor which is determined by the number of weapon systems it possesses and the capability of these weapon systems.

If either of these factors increase, then the enemy capability increases. Unfortunately enemy capability is not easily determined. United States intelligence agencies provide information as to approximately what it is, but the United States' view of enemy capability is only a perception of actual enemy capability (5). The United States' perception of an enemy's capability is compared to the perception of our capability to determine if a force deficiency exists. The United States' force deficiency as depicted in Figure 4-1 can be either positive (a disadvantage) or negative (an advantage). It is also impacted by national objectives (5). If the United States' national objectives called on the USAF to be a stronger instrument of national power, the force deficiency would increase without any change in either the United States or enemy force capabilities.

The United States' force deficiency is not the only factor which impacts the pressure to improve combat readiness. Enemy expansionary activity, which is contrary to national objectives, also generates pressure to improve combat readiness (5). Enemy expansionary activity, or a threat, does not occur in a vacuum. It occurs due to a combination of two factors. These factors are the enemy perceived advantage and the perceived willingness of the United States to use force. As is shown in Figure 4-1, the enemy perceived advantage is generated in the same way as the United States' force deficiency. It is a comparison of enemy capability to their perception of the United States' military capability. As enemies of the United States perceive a larger advantgae, or smaller disadvantage, their willingness to partake in expansionary activities, which are contrary to national objectives would increase.

The second factor mentioned, the enemy's perception of the United States' willingness to use force also has a major impact on enemy expansionary activities (45). As an enemy's perception of the United States' willingness to use force decreases, it is more likely to engage in expansionary activities. How an enemy perceives the United States' willingness to use force is not determined by the United States' military capability but is a result of the resolve which is projected by the political leaders of the nation. If political leaders show strong resolve and a willingness to use the military elements of national power, then enemy expansionary activity will decrease.

Once a pressure to improve readiness is generated, it is channeled into several different areas. They include the military budget, personnel readiness, and equipment readiness. The military budget, which is a result of the pressure to improve readiness and the national economy, in combination with the pressure to improve personnel and equipment readiness result in improvements in these areas and increases in combat readiness. The resulting increase in combat readiness will decrease the enemy perceived advantage and the United States' force deficiency resulting in an eventual decrease in the pressure to improve readiness.

The combat readiness system as modeled here represents a closed-loop, negative feedback system. As discussed in Chapter 3, negative feedback systems are goal seeking. In this case the goal of the system is to insure the USAF, as an instrument of national power, is capable of insuring the national objectives are met. The following nine sectors of the model deal with the activities which occur between the generation of pressure to improve combat readiness and the resulting increase in combat readiness. The first sector which will be discussed is that of aircrew manning.

AIRCREW MANNING

In the area of personnel readiness the model has been divided into six sectors. The first to be presented is aircrew manning. Insuring that a sufficient number of aircrews are available to pilot the USAF weapon systems in war is the goal of this sector of the system. This goal is shown in Figure 4-2 as desired aircrew manning. It is determined by the number of weapon systems which the USAF possesses and the aircrew manning factor. If either the number of weapon systems possessed or the aircrew manning

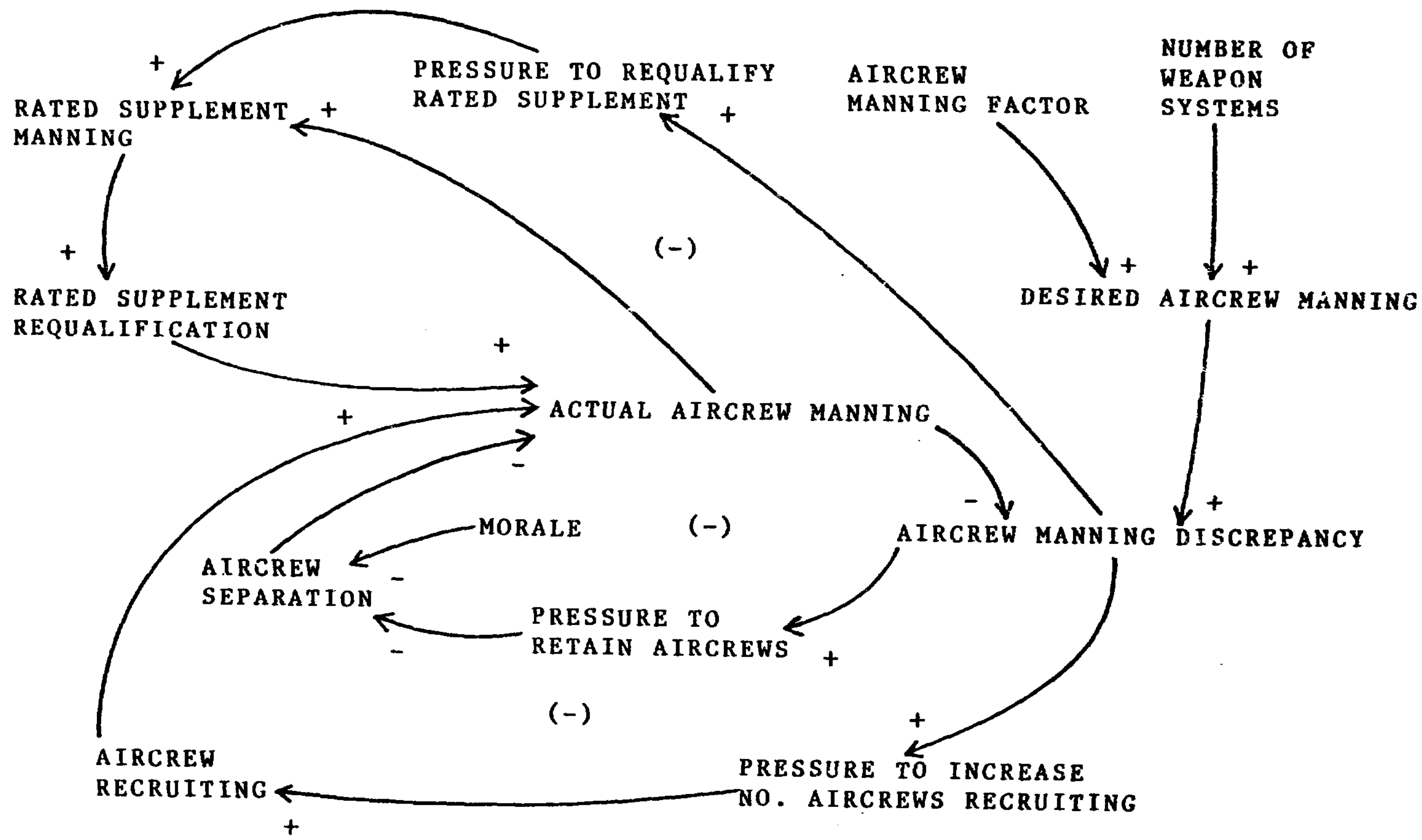

Fig. 4-2. Aircrew Manning--Causal Loop

factor increases then there will be a corresponding increase in the desired aircrew manning.

Management actions within the aircrew manning sector are taken based on the aircrew manning discrepancy. The aircrew manning discrepancy is determined by comparing the desired level of aircrew manning to the actual level of aircrew manning. The result of this comparison is the generation of pressure to decrease the existing discrepancy. The pressure to correct an aircrew manning discrepancy is channelled into several areas. These areas include, the pressure to improve aircrew retention, the pressure to requalify aircrew members currently in the rated supplement, and the pressure to increase aircrew recruiting (19). As can be seen in Figure 4-2, each of these pressures will result in an increase in the aircrew manning level and reduce the aircrew manning discrepancy.

The aircrew manning sector is of critical interest in the USAF today. In the last four years aircrew losses due to aircrew separations have increased from 25 percent to 49 percent of those pilots in the 6 - 11 years group (15:9). The pressures generated from this increased loss rate can be seen in the changes which are being generated in pilot training capacity, rated supplement and rated staff personnel levels, and programs to improve aircrew retention. In a goal seeking system such as this the aircrew manning discrepancy will be corrected but the

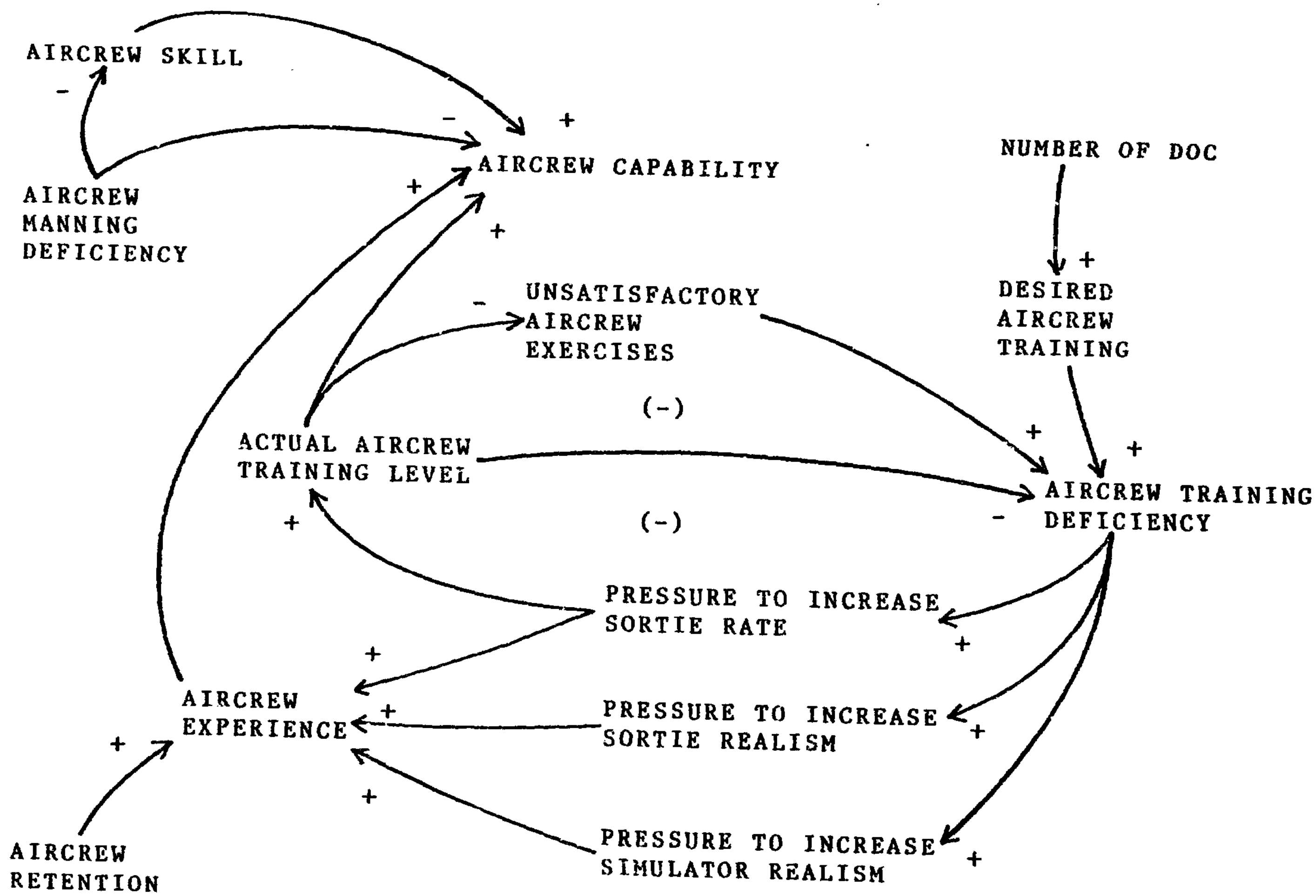

Fig. 4-3. Aircrew Capability--Causal Loop

decrease in aircrew retention will affect the USAF combat readiness in other areas. One area which is greatly affected is the aircrew capability, which will be discussed next.

AIRCREW CAPABILITY

Having a sufficient number of aircrews to pilot the USAF weapon systems is only one of the aircrew factors which impacts combat readiness. The aircrew must also possess sufficient training and experience in the use of assigned weapon system to insure its effective utilization. These factors are combined and called aircrew capability. Aircrew capability is difficult to measure without actual employment in a combat situation. It is currently measured with the UNITREP reporting system. This system looks at the number of aircrews a unit possesses and the training level of these aircrews (42:5-5). This process compares the number of aircrews that have trained to a combat ready level to a unit's total authorized aircrews. The determination of the combat readiness level is made with the guideline presented in the 51-series regulations (43:72). The UNITREP system also requires that information on the number of aircrews qualified in unique missions or capabilities or weapon systems be reported. Although this system gives MAJCOM and Air Force commanders a picture of aircrew training levels and availability, it does not directly address aircrew capability (21).

Figure 4-3 is the causal loop diagram which represents the aircrew capability sector of the model. The goal of the system is to achieve the desired aircrew training level which is determined by the number of Designated Operational Capabilities (DOCs) which a unit is assigned. The desired aircrew training level is compared with the actual aircrew training level. If a deficiency exists, pressure is generated to increase the unit's sortie rate and, therefore, increase the actual training level. Aircrew training deficiencies are also identified through the use of realistic training exercises (27). These exercises, such as ORIs and TAC's Red Flag, introduce a measurement of a unit's ability to actually perform its wartime mission. As deficiencies are identified, pressures to improve sortie realism and aircraft simulator realism are introduced into the system. It is a combination of the training sortie rate, sortie realism, and aircraft simulator realism which combine to determine, over time, the aircrew experience level (20).

Aircrew experience is a major factor in determining aircrew capability. It is impacted, not only by sortie rate, sortie realism, and simulator realism, but also by aircrew retention. Although Tactical Air Command (TAC) has a desired aircrew experience level for each unit, the system measures experience in terms of flying hours, which equates to the amount of time an aircrew member has flown an aircraft. This system of measurement lacks the ability to assign a quantifiable value on an aircrew member's actual experience, and is therefore ineffective in measuring aircrew capability (21).

Aircrew experience, aircrew training level, and aircrew skill are the factors which combine to determine a unit's actual aircrew capability. Aircrew experience and training levels have been addressed, but aircrew skill is a new concept which is not measured in the UNITREP reporting system. In every squadron there are aircrew members of different skill levels (27). Although an aircrew member's capability can be improved with increased sorties or experience, the skill factor will still cause a different capability level between aircrews of equal experience and training level. This factor is seen in all units and is one that changes very little with time. The aircrew skill factor of combat capability is primarily determined by the elimination process which exists in pilot training units. This process eliminates those potential aircrews with less flying aptitude or flying skill and under normal training conditions the process is effective in insuring that the minimum levels of aircrew skill are maintained. However, as aircrew manning deficiencies increase, the pressure to increase aircrew recruiting has a tendency to increase the number of lower skill pilots who enter the aircrew manning force. This has a long-term negative effect on on aircrew capability.

The ability of the aircrews to fly the aircraft is no more important than the ability of the maintenance system to insure they are in flyable condition. Maintenance manning is discussed in the next section.

Maintenance Manning

The maintenance manning sector, like the aircrew manning sector, is a goal-oriented, negative feedback system. The goal of this sector is to achieve a desired level of maintenance manning. The number of personnel required to maintain the USAF's weapon systems is determined by the number of weapon systems possessed and the number of people required to maintain a weapon system. If either of these factors should increase, the desired level of maintenance manning would also increase. As with all goal-oriented systems, the desired level of maintenance manning is compared to the actual level of maintenance manning to determine if a maintenance manning discrepancy exists.

If a maintenance manning discrepancy does exist, management action is initiated to correct the discrepancy (19). Management action is generally channeled in two directions. The first is to increase maintenance manning retention. Pressure to increase maintenance retention will, to varying degrees of success, tend to increase retention which, when all other factors remain constant, will increase

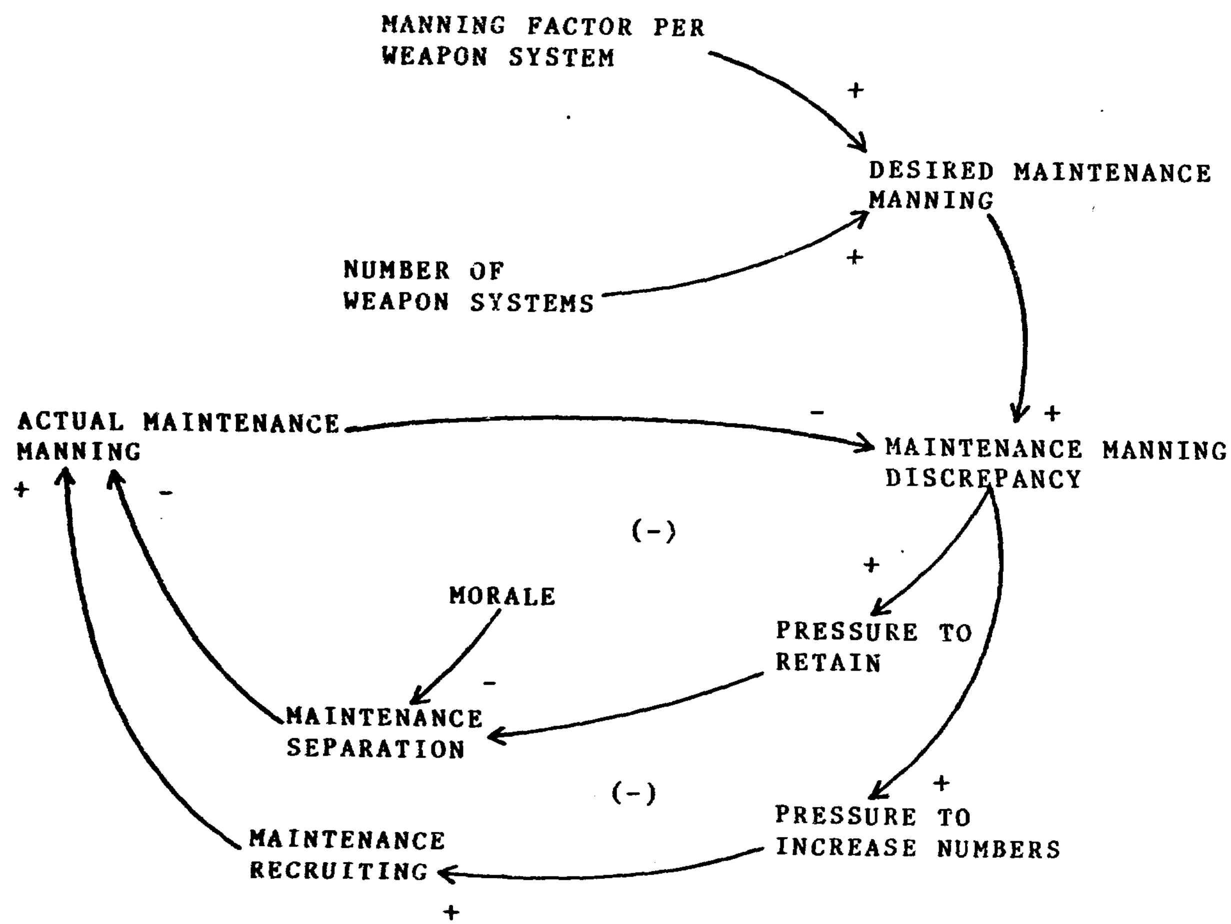

Fig. 4-4. Maintenance Manning--Causal Loop

maintenance manning. A second management action, which can be taken to increase maintenance manning, would be to increase the maintenance recruiting rate. An increase in recruiting will increase actual maintenance manning, and like an increase in retention, reduce a maintenance manning discrepancy.

Having a sufficient number of personnel to satisfactorily maintain the USAF's weapon systems does not in itself insure that an acceptable operationally ready (OR) rate will be met. The maintenance personnel as aircrews must meet desired skill and training criteria.

Maintenance Capability

The ability of maintenance personnel to keep aircraft flying in a wartime environment is difficult to measure during normal peacetime operations. The USAF presently measures maintenance availability through the UNITREP reporting system. Maintenance personnel and munitions personnel (both included in the maintenance sector of the model) are designated as critical personnel in this reporting system and are reported daily (42:143). This report addresses the percent of authorized manning which is currently possessed by the unit and in actuality is more closely related to the maintenance manning discrepancy discussed in the maintenance manning sector than it is to maintenance capability.

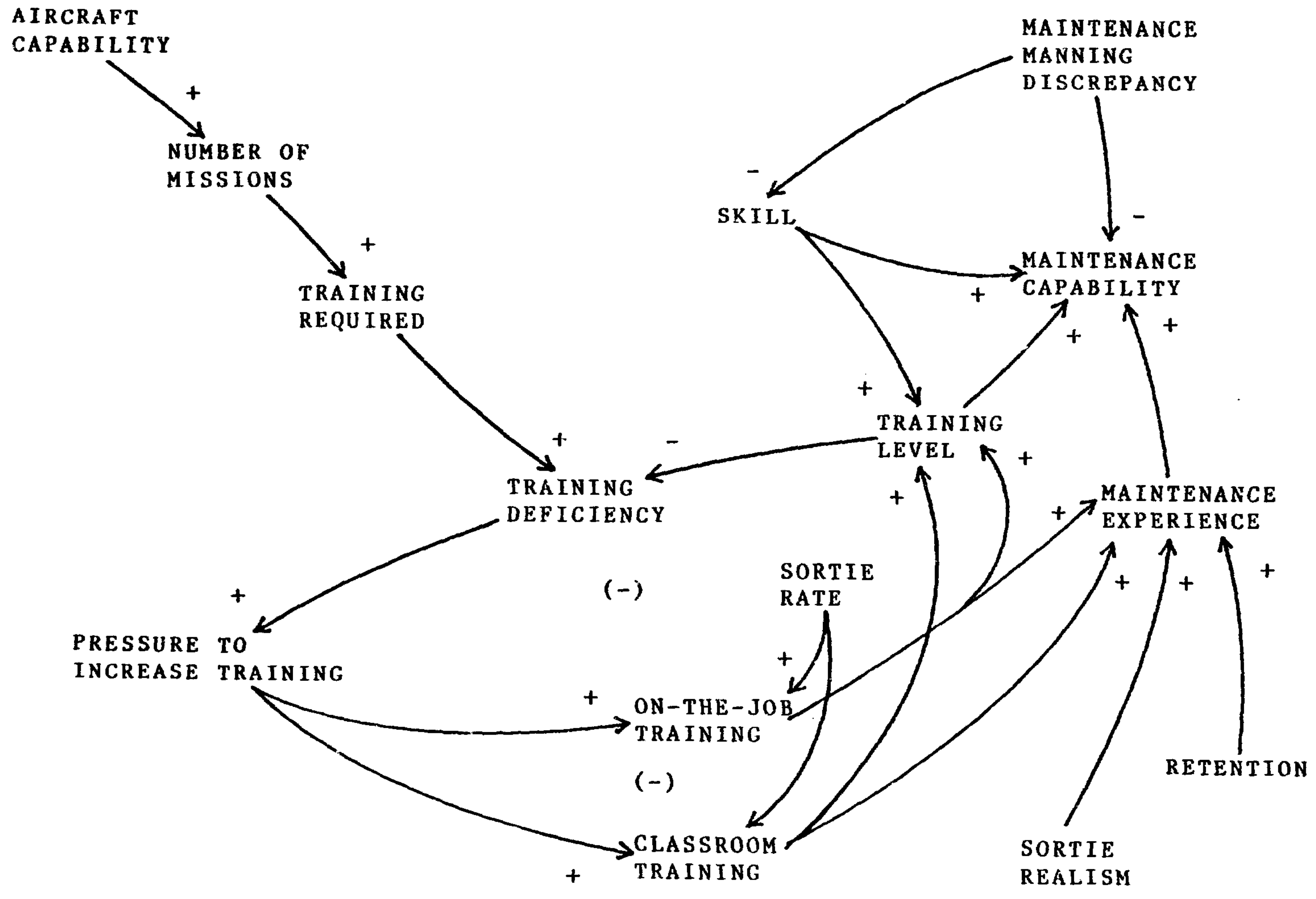

Fig. 4-5. Maintenance Capability--Causal Loop

Maintenance capability is a somewhat subjective concept which is determined by a combination of inter-related factors (20). Maintenance capability, as depicted in Figure 4-5, is determined by the maintenance manning discrepancy, the training level of those maintenance personnel possessed, the maintenance force's experience level, and the overall skill level. Each of these factors has an individual impact on maintenance capability, and in combination they determine the overall level of capability.

Maintenance experience is a factor which is primarily determined by maintenance retention (27). As retention rates increase, the overall experience level of the maintenance force increases. The maintenance experience level is also impacted by the amount of training that the experienced personnel have received over their career and the amount of realism that they see in training operations.

The training level of the maintenance force is more short-term than their experience level. Training is a continuous process and occurs in both a classroom type environment and in the form of on-the-job training. The amount of training required is dependent on the number of missions which a unit is assigned. The number of missions a unit is assigned is normally based on the capabilities of the assigned aircraft. As the number of different missions assigned increases, the amount of equipment which must be maintained increases and, as a result, the amount of training which is required increases. The current training levels of the maintenance personnel possessed is compared to the desired training levels to determine if a training deficiency exists. If a deficiency does exist, pressure to increase the training levels of maintenance personnel is generated. This pressure generally results in an increase of both on-the-job and classroom type training. These two types of training are affected by the training sortie rate which is being flown. If the sortie rate is increased, on-the-job training is increased, and the time available for classroom type training would be decreased. The sortie rate, therefore, plays an important role in the maintenance training levels (9).

The last factor which impacts maintenance capability is the skill of the maintenance force. This skill factor is closely related to the skill factor discussed in the aircrew capability sector. Standards are maintained for recruit acceptance into the USAF. As the maintenance manning discrepancy is increased, due to a manning deficiency, the standards will often have to be lowered in order to recruit the required number of personnel (15:36A). The recruiting of lower skill personnel, due to a large manning discrepancy, will impact the maintenance capability. Closely related to maintenance manning and capability are the support manning and capability sectors of the model.

Support Manning

To operate a combat wing in the USAF, personnel are required to fly the aircraft, maintain the aircraft, and also to provide support for all the other base activities. These other activities include the protection of base facilities, supply, finance, personnel, and many others. The manning of these support activities is critical to the operation of a base. Several of these activities, such as security police, are considered critical manning areas under the UNITREP reporting system (42:11). Because of the importance of the support area, two sectors of the model have been included which address this area. The support manning sector addresses the process of acquiring sufficient numbers of support personnel and the support capability sector addresses the personnel's ability to accomplish their mission.

The support manning sector of the model is depicted in Figure 4-6. When viewed in relation to Figure 4-4 (maintenance manning) it can be seen that there is very little difference. As in the maintenance manning sector, the support manning sector is a goal seeking, negative feedback structure which is driven by the support manning discrepancies. If manning deficiencies exist, pressures are generaged to correct the situation (11). These pressures, as with the maintenance manning sector, are

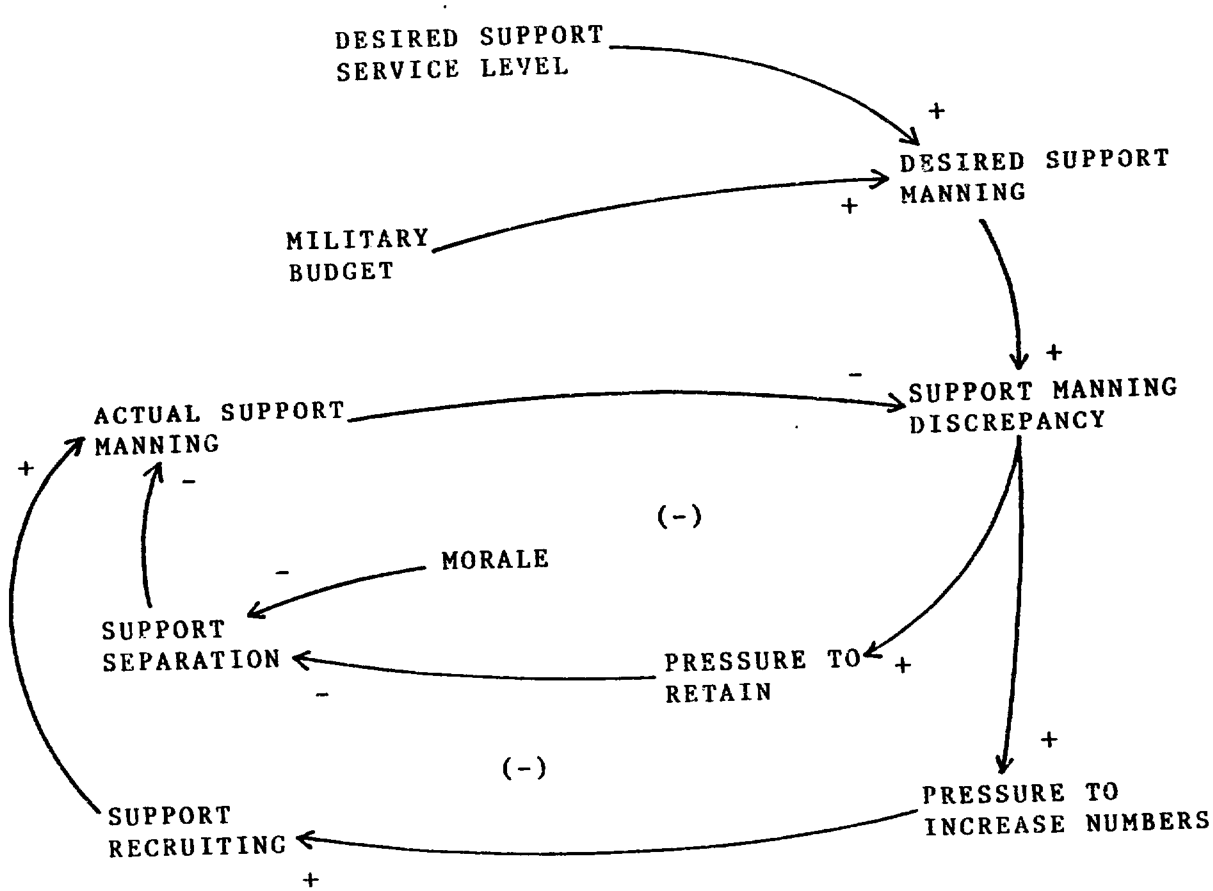

Fig. 4-6. Support Manning--Causal Loop

channeled into the areas of the pressures to increase retention and recruiting. The operation and results of these pressures are the same as in the maintenance mannings sector and will not be discussed again. The one difference, which is important, is the determination of desired support manning.

The desired support manning is determined by consideration of the number of people required to provide a given level of service. If the desired support service level is increased, then the desired support manning level will also increase. A second factor which impacts the desired support manning is the military budget. When limits are placed on the number of military personnel, through the budget process, the support manning area is impacted. This could lower desired manning below the level that is required to meet the desired service requirements. Such a change in the desired support manning level will have an impact on the support capability. This sector is the second of those dealing with support manning.

Support Capability

Support capability is determined by four primary factors. They are the number of support personnel available, the training of these personnel, their experience level, and their skill level (15:36A). The determination and general effects of skill level, manning deficiencies,

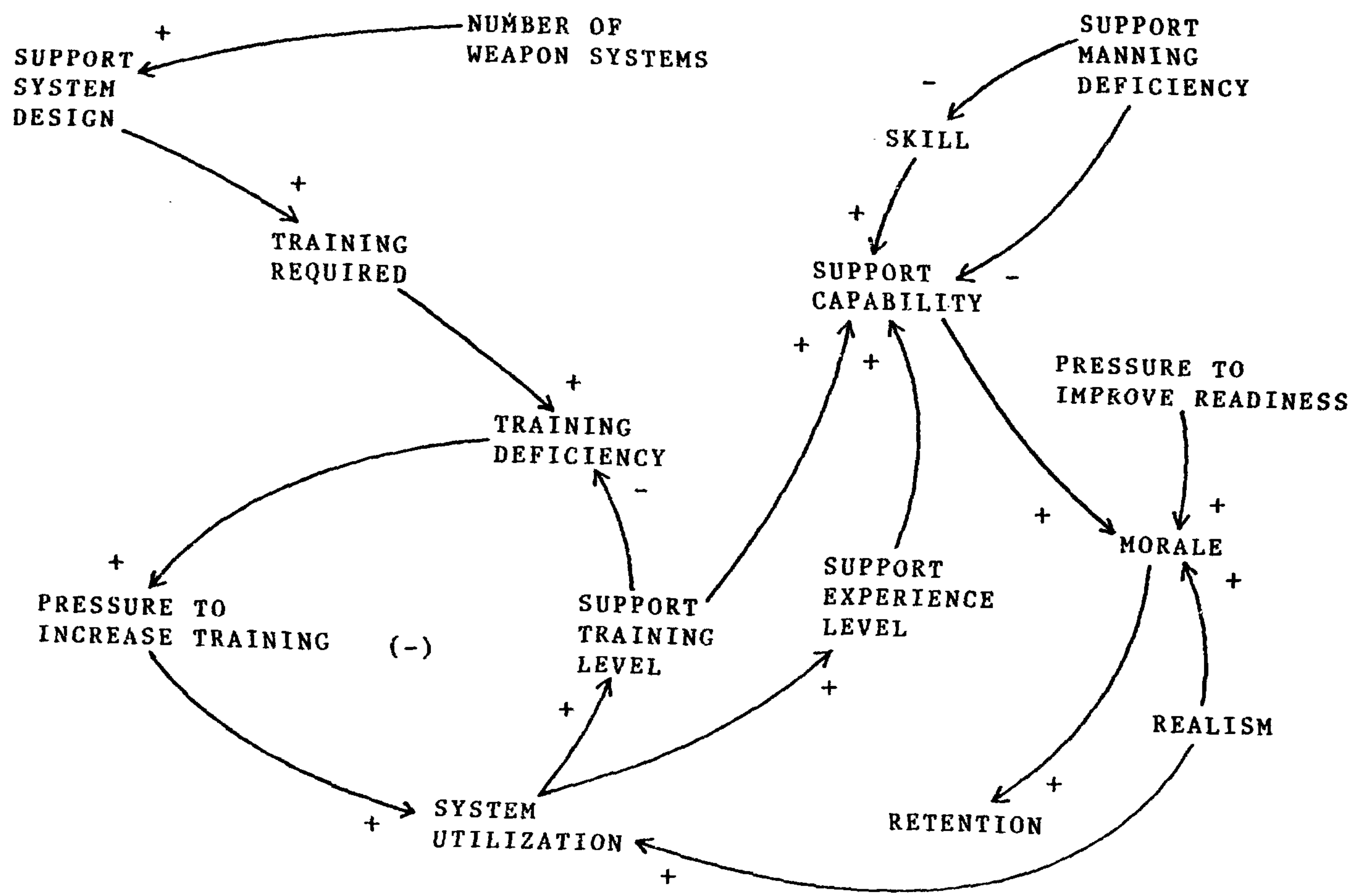

Fig. 4-7. Support Capability--Causal Loop

and experience have on capability were discussed in the maintenance and aircrew manning sector and will not be discussed again. The two factors which differ in this sector are the determination of support training levels and the morale factor.

The determination of support training levels is a negative feedback system which utilized training deficiencies as its primary driving factor. Training required as compared to training levels determine the training deficiency. Since the role of many support activities is greatly changed under wartime conditions, mush of the training required and the evaluation of training levels is primarily accomplished during exercises (26). These exercises, or system utilization, are determined by the level of realistic training which is accomplished by a unit. The amount of training required is determined by the support system design and to some degree by the weapon systems being utilized. The support system design impacts training requirements based on the difficulty of operating the system. The weapon system being utilized impacts the support system design based on the weapon systems individual support requirements. As a weapon systems' capabilities or the weapon systems themselves change, the support requirements and possibly the support system design will change.

The last portion of this sector to be discussed is the morale factor. This sector was chosen because the support capability is a major factor in the determination of personnel morale. The service individuals receive at base facilities (support capability) during peacetime will affect greatly morale, which in turn impacts personnel retention (27). Two other factors which impact morale are the pressure to improve readiness and the realism factor. Both of these factors impact morale from the standpoint of the individual perception of the value in their present position. Pressure to improve readiness and training realism both increase an individual's judgment of their value to the system and, therefore their morale (26).

This concludes discussion of those sectors which deal with personnel readiness. The remaining three sectors address equipment readiness with the first area to be discussed that of weapon systems capability.

Weapon Systems Capability

The capability of weapon systems to perform their wartime mission is most important to combat readiness. Since aircraft must be utilized to perform a wartime mission against an enemy force, it is that enemy force which determines the desired total weapon systems capability. Figure 4-8 is a depiction of the weapon systems capability sector of the model. The determination of the

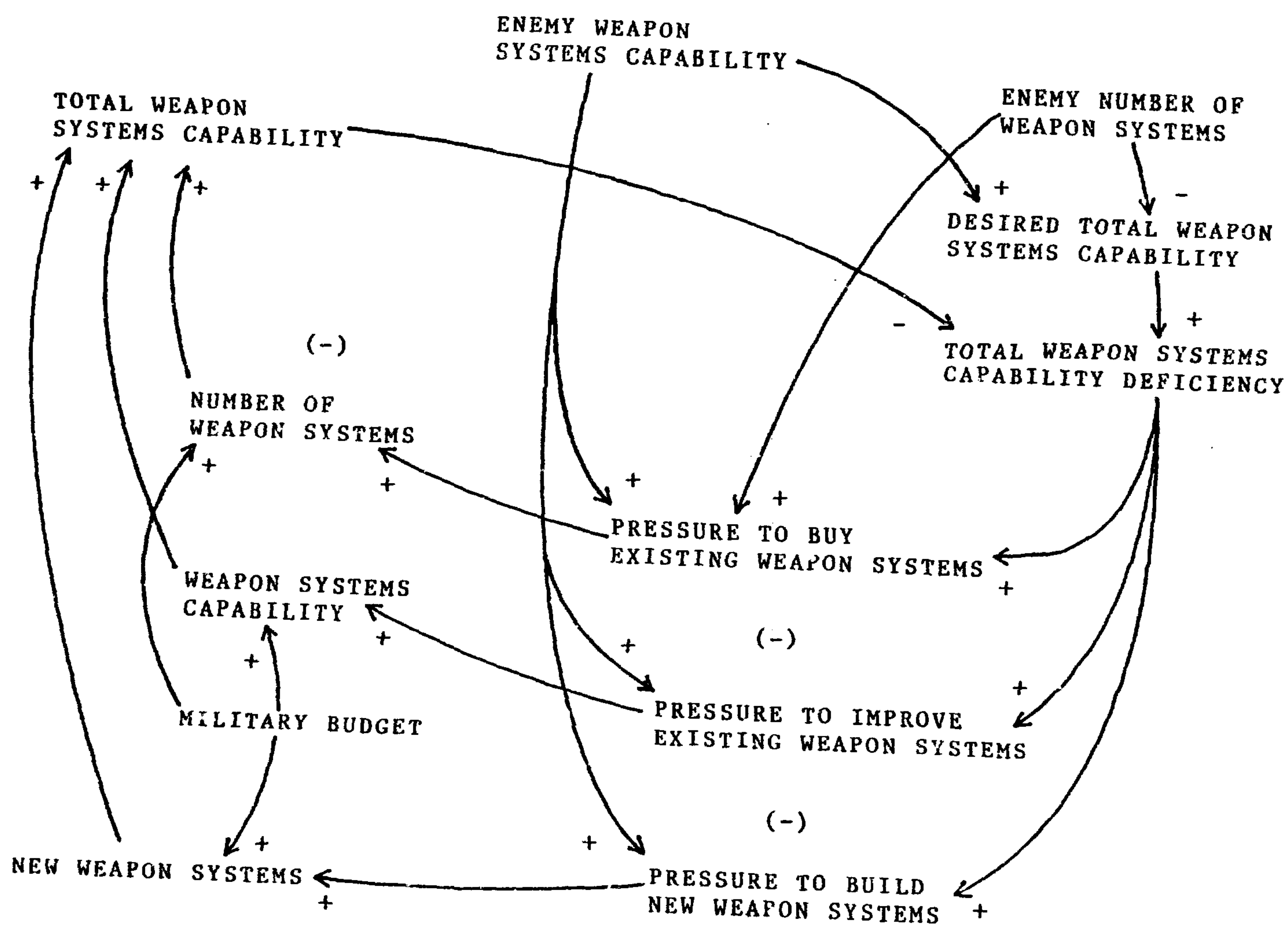

Fig. 4-8. Weapon Systems Capability--Causal Loop

desired total weapon systems capability is shown as a factor determined by the enemy weapon systems capability and the number of weapon systems they possess. The desired total weapon systems capability is compared to the existing United States' total weapon systems capability to determine if a total weapon systems capability deficiency exists. If such a deficiency exists, pressures are generated to improve the total weapon systems capability.

These pressures to improve total weapon systems capability will be channeled into pressure to buy more existing weapon systems, to improve existing weapon systems capabilities, or to build new weapon systems depending on the nature of the total deficiency (1). If the deficiency is caused strictly by the number of enemy systems and the United States' existing weapon systems have a satisfactory capability advantage, then the primary pressure will be to buy more existing weapon systems. If the capability of individual weapon systems does not represent a satisfactory advantage, then pressure to improve existing or to build new weapon systems is generated. The actual changes in the number, capability, or building of new weapon systems is dependent on the pressures which are generated and on the military budget. Because of the large expense of any of these improvements, the military budget is often the primary factor in the determination of which course of action is taken. Whatever action is taken, its results will generally be the improvement of the total weapon systems capability which will result in a decrease in the total weapon systems capability deficiency. A second factor which must be considered in the equipment readiness area is weapon systems availability. The following sector will discuss this aspect of combat readiness.

Aircraft Availability

As weapon systems become more sophisticated, the percent of those possessed which are capable of flying combat missions at any given point of time, has decreased (20). The percent of aircraft which are mission capable is reported daily through the UNITREP reporting system (42:14). Availability is an important aspect of the combat readiness system because it is the prime determinate of the number of combat missions a unit will be able to fly in a given short-run period of time. Aircraft availability is impacted by several other factors included in the combat readiness model. These sectors include the level of spares available, maintenance capability, training sortie rate, weapon systems reliability, and weapon systems availability. All of these factors can have a positive or negative affect on aircraft availability.

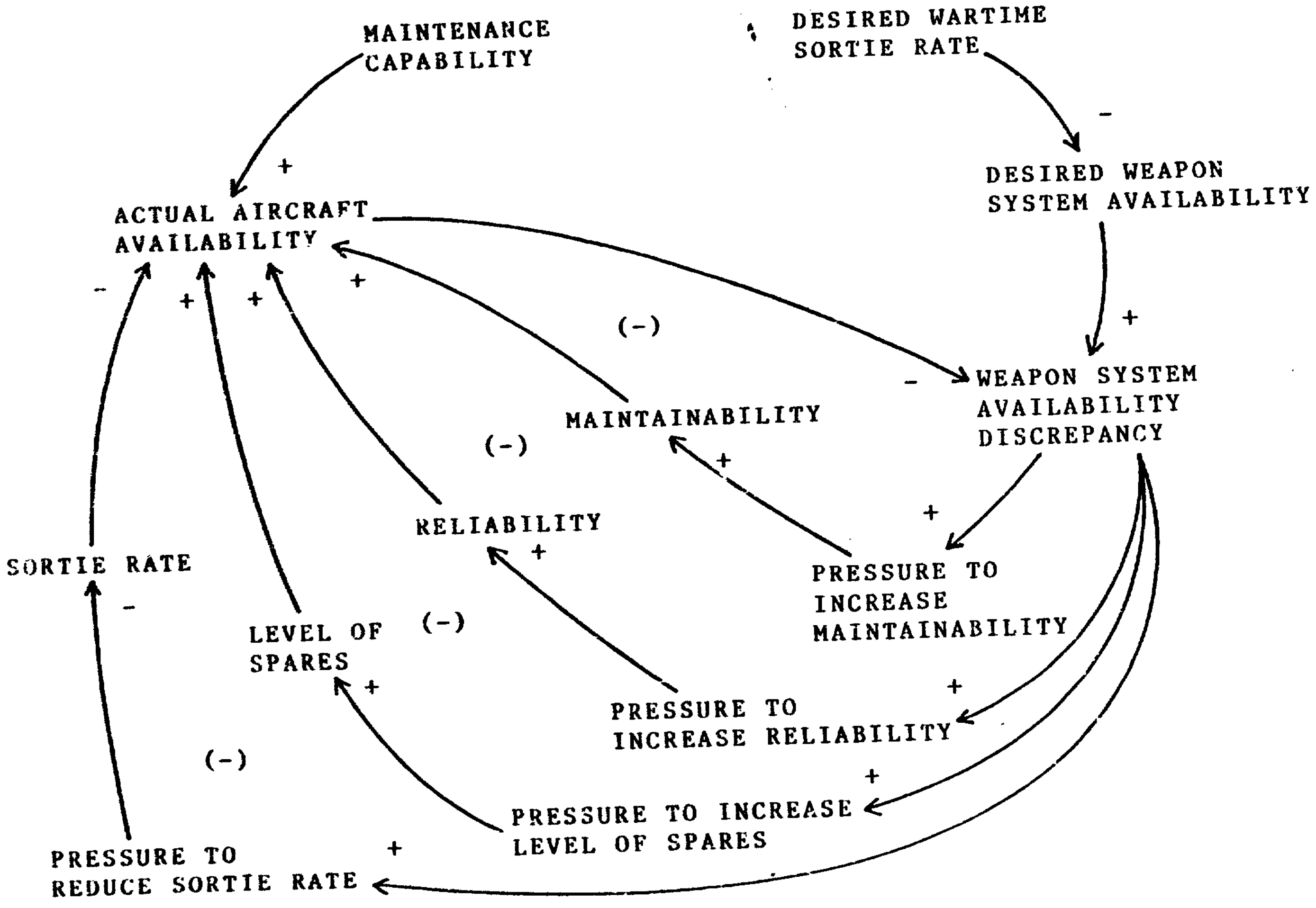

Fig. 4-9. Aircraft Availability--Causal Loop

The level of spares available was discussed at length in several of the interviews and is felt by many to be the prime determinate of aircraft availability. As the aircraft become more complex, the purchase and maintenance of spare parts has become an increasingly difficult task. Because aircraft can be grounded due to the lack of a single part, the logistics system becomes a major determinate of availability. A separate sector is devoted to this topic and will be discussed next.

The ability of the maintenance personnel to perform their required duties has an impact on weapon systems availability (20). If a maintenance training deficiency exists, the effect will be in the form of a lower aircraft availability. The pressures generated and the action taken to correct such a situation were addressed in sector five. Another factor which is related to maintenance capability is that of sortie rate. One of the determinants of the weapon systems sortie rate was discussed in sector three; aircrew capability. The weapon systems sortie rate has the opposite impact on aircraft availability. To improve aircraft availability through the sortie rate factor, the sortie rate must be reduced. Such an action would decrease aircrew capability, so these two sectors of the model are in conflict. There are other means of improving weapon systems availability without impacting aircrew capability.

The two primary areas are through maintainability and reliability improvements.

Maintainability refers to the ease with which weapon systems can be worked on or repaired, while reliability refers to the mean time between failures. These two factors represent a means of improving weapon systems availability and are long term in nature (39). They cannot be changed as easily as factors such sortie rate or maintenance capability levels. Improvement in either one will result in improved aircraft availability. The last sector which will be discussed, is the materiel readiness or level of spares sector.

Materiel Readiness

Materiel readiness and its importance was discussed in Chapter 2. It is primarily considered a factor of the level of spares that are possessed. Spares are the replacement parts which are necessary to keep weapon systems flying. As parts fail, they are removed from the weapon systems and delivered to a facility where they are repaired. They are then returned to operational units for reuse. Depending on the break rate and the repair time, the number of spares that are required to assure an acceptable number of spare part requisitions can be filled, is determined.

The number of required spares can vary with several factors which have been previously discussed. These

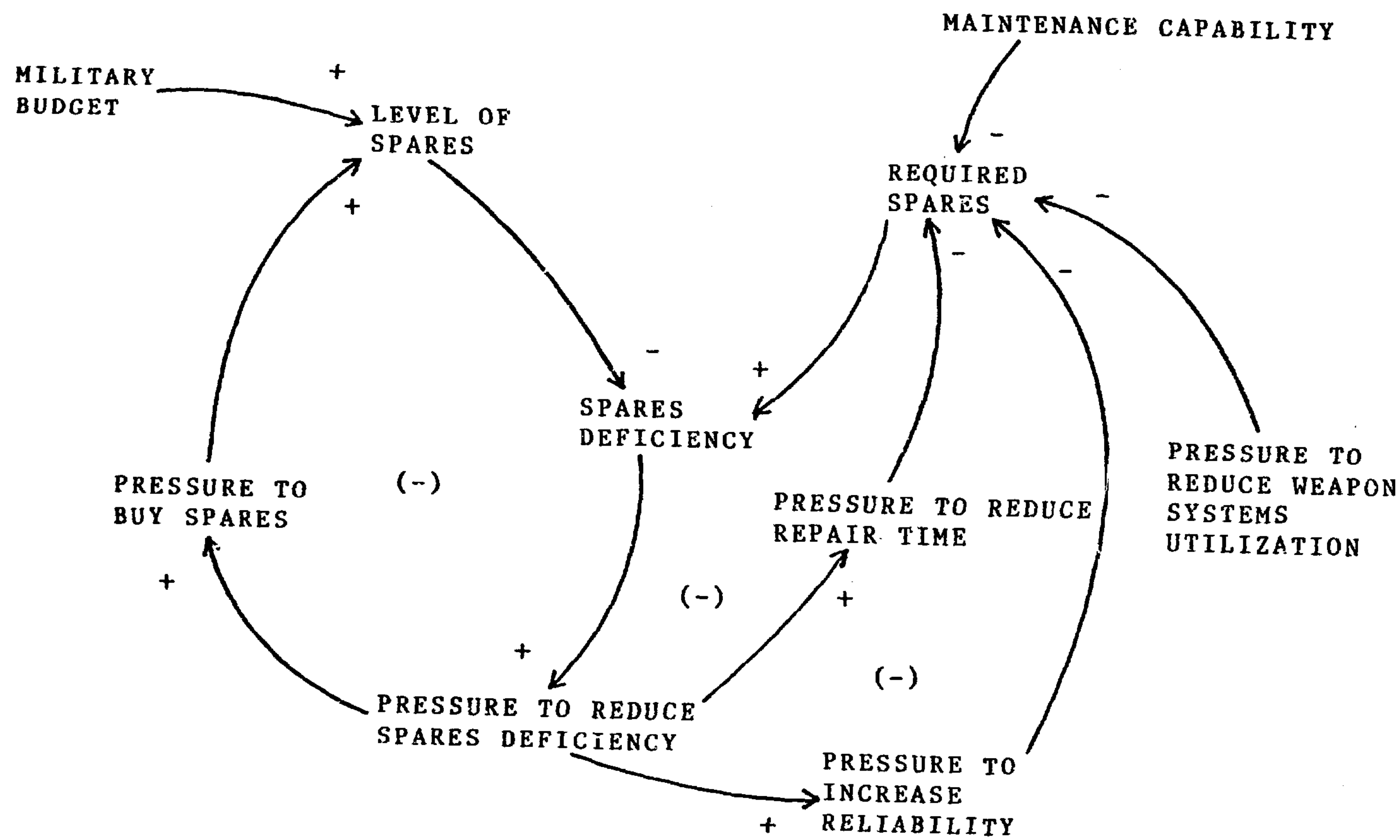

Fig. 4-10. Materiel Readiness--Causal Loop

factors include maintenance capability, weapon systems utilization, and weapon systems reliability. As the weapon systems reliability or the maintenance capability increases, the number of spares will decrease. If these factors decrease, the required number of spares will increase. Weapon systems utilization works in the opposite manner. Pressure to reduce a spares deficiency can cause pressure to reduce weapon systems utilization (39). If systems utilization is decreased, then the required number of spares will also decrease. One other method of reducing a spares deficiency would be to decrease the repair time of the spares. In this case, a smaller number of spares would be required to repair the weapon systems due to the reduced repair cycle time.

The one remaining factor to be discussed is the level of spares. A spares deficiency can be reduced by increasing the number of spares available. The purchase of spares as an alternative means of reducing a spares deficiency, is affected by the military budget. As the budget is increased, more funds will normally be available to purchase additional spares if they are needed to reduce a spares deficiency.

Summary

This chapter contains the initial conceptualization of the combat readiness model. The model was discussed in the ten sectors covering the major areas of personnel and equipment readiness. The relationships which were discussed in these sectors represent hypotheses about the interrelationships which exist in the combat readiness system as they were discovered through the literature review and the interview process. In the next chapter the structure of the system will be presented in the form of flow diagrams and model equations.

CHAPTER 5

FLOW DIAGRAMS AND MATHEMATICAL EQUATIONS FOR THE COMBAT READINESS MODEL

Introduction

In this chapter, the flow diagrams and system equations, as described in Chapter 3, will be presented. The model will be discussed in ten sections which cover the causal loop diagrams sectors presented in Chapter 4. Each sector will be presented individually and the supporting rationale for its development will be discussed. To aid the reader, flow diagrams of the sector structure will be presented at the beginning of each section. The corresponding system equations are located in Appendix E for those readers who are interested. The same variable labels used in the flow diagrams are used in the system equations so the reader will be able to relate the structure presented in the flow diagrams to the system equations.

The model equations, as presented in this chapter, were developed with parameters which correspond to combat readiness as it relates to TAC. Although the basic structure of the model should hold true in any command, many of the values used pertain specifically to TAC. Tac was selected due to the role of combat readiness in the successful accomplishment of its missions. Tactical forces, as an instrument of national power, must be ready to enter combat and fight effectively with little or no prior notice (25:28). TAC, in addition to Pacific Air Force (PACAF) and United States Air Forces Europe (USAFE), are the commands where the authors have gained their flight experience and have the most familiarity. As stated in Chapter 1, this model represents the combat readiness of tactical forces at the macro level. It therefore is concerned with the readiness level of the overall force and not the readiness level of an individual unit. The first sector presented is where the combat readiness levels are measured and the pressure to improve readiness is generated.

Combat Readiness Overview

As presented in Chapter 4, the need for combat readiness does not just happen. It is developed to meet the threat of an enemy. It is this threat or enemy capability which causes the need for the tactical forces of this country to be ready to enter combat. Figure 5-1 shows the flow diagram which was developed to represent this sector of the model. It includes the generation of an enemy capability and a measurement of United States capability, and then uses these two factors to generate pressures to improve readiness.

The enemy capability (EC) is developed from two factors. These factors are the number of weapon systems that an enemy possesses (ELOW) and the capability of these

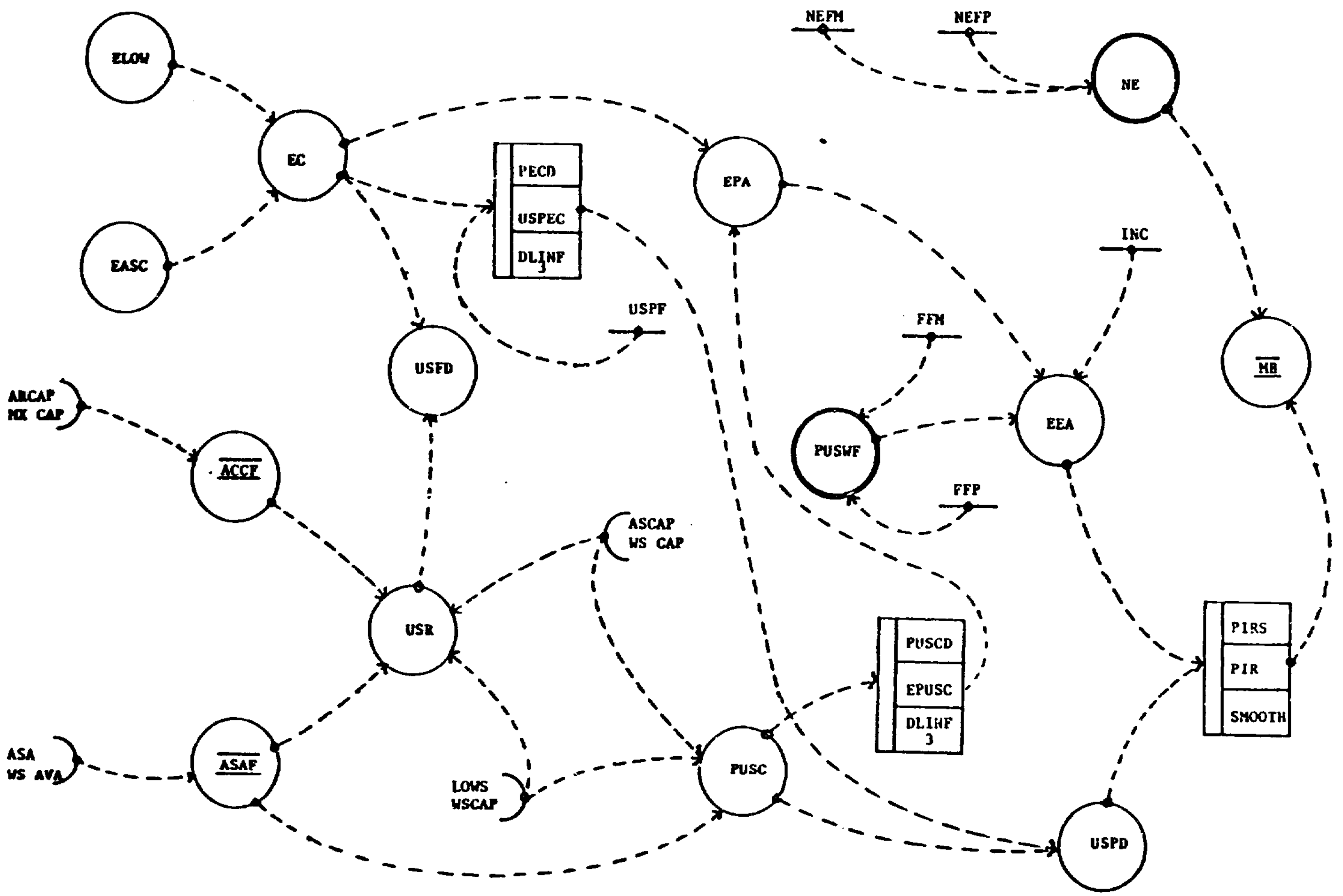

Fig. 5-1. Combat Readiness Overview--Flow Diagram

weapon systems (EASC).

Enemy capability is the product of the number of weapon systems possessed and the capability of these weapon systems. The number of weapon systems possessed is initialized at 2000 and then increased at a rate of five aircraft a month. The capability of the enemy's weapon systems is initialized at an arbitrary value of three and increases at a rate of .02 units a month. This way of developing enemy capability was used mainly as a means of introducing a capability element and the growth rates. The use of different growth rates will allow the combat readiness system to be studied under different conditions to determine the system's response.

When changes in enemy capability do occur, the United States is not always immediately aware of it and does not always perceive what an enemy's capability actually is (5). To include these facts into the model an information delay was added. The enemy's capability is fed into an information delay and held for a period of twelve months. The value in the delay is then multiplied by a perception factor (USPF) which allows for incorrect information. Both the length of the delay and the perception factor can be varied to study their effects on the combat readiness system. Similar equations were developed for the capability of the United States.

The United States capability and readiness equations were developed to show both the United States capability, as measured by the UNITREP (PUSC) reporting system, and an actual level of combat readiness (USR). The United States readiness factor was developed to provide information on the actual readiness of the tactical forces. It is a numerical value generated by multiplying the current level of weapon systems (LOWS) by the capability of those weapon systems (ASCAP) and then modifying this value by an aircrew capability factor (ACCF) and weapon systems availability factor (ASAF). The level of weapon systems and the weapon systems capability values are generated in the weapon systems capability sector of the model and are actual computed values.

The aircrew capability factor is a table function which uses information from the aircrew capability sector of the model. This information is in the form of a capability value which ranges from one to four and is transformed in the table to an improvement or detraction from the capability value generated by the level of weapon systems and the weapon systems reliability. As the aircrew capability factor decreases, the United States readiness is also decreased. The values used represent a summation of the opinions of several persons who were interviewed. The change in capability can be decreased as much as fifteen percent or improved as much as thirty percent due to the aircrew capability factor. The generation of the aircrew capability value will be discussed in the aircrew capability section of this chapter.

The second factor which influences the United States readiness value is the aircraft systems availability. This factor, like the aircrew capability factor, is computed in a table function. The information which feeds into the table comes from the aircraft availability sector where it is generated utilizing information from the two support sectors, the two maintenance sectors, and the materiel readiness sector. The influence of the availability factor on combat readiness is large (27). The aircraft systems total availability ranges from twenty percent to ninty percent of the fleet; the readiness value is decreased as much as forty-five percent and increased as much as thirty percent. The computation of the aircraft systems total availability will be discussed in the aircraft availability section of this chapter.

Although a United States readiness value is computed, it is not used in the model. The value which is used is the perceived United States capability. This value was computed to represent the information which is received by commanders through the UNITREP reporting system. It is computed in a similar manner to the United States readiness value but does not include an aircrew capability factor. Although aircrew training levels are reported in the

UNITREP reporting system, these values do not represent actual capability. Training funds and sorties have decreased fifteen percent in the last four years while the training levels reported have increased five to ten percent (26). This fact shows that the Air Force changes its reporting system to reflect training accomplishments based on the training resources available and not the training required to have aircrews ready to enter combat. Like the distortion of the United States view of enemy capability, an enemy has a somewhat distroted view of the United States capability.

The enemy perceived United States capability is generated is the same manner as the United States perceived enemy capability. The equation used to accomplish this is the enemy perceived United States capability (EPUSC). In the case of the enemy perceived United States capability an information delay (PUSCP) of three months was used. The distortion factor (EPF) was set five percent above actual capability. These values can be varied to study the effects of different United States security programs on the combat readiness system. Once the model generates capabilities and perceptions of capabilities, it then compares these values.

Three equations are used to develop a comparison of force capabilities. One equation represents the United States force deficiency (USFD) and utilizes the actual capabilities of both the enemy and United States forces. The second equation computes the enemy perceived advantage (EPA) and uses the values generated in the enemy perceived United States capability equation and the enemy capability equation. The last equation generates the United States perceived deficiency (USPD) and uses the values from the United States perceived enemy capability and the perceived United States capability equation. The values computed in the enemy perceived advantage and the United States perceived disadvantage are used to generate enemy expansionary activity and pressure to improve readiness.

Enemy expansionary activity (EEA) is a value which is computed to represent an action which is taken by an enemy that is contrary to the United States national objectives. The amount of enemy expansionary activity is dependent on the perceived advantage and the perceived United States willingness to use force. The perceived United States willingness to use force (PUSWF) as discussed in Chapter 4 is dependent on the attitudes projected by our nation's leaders. It is this enemy perception in combination with their estimate of force advantage which drives expansionary activity. Because the perceived United States willingness to use force is a factor independent of the combat readiness system, it is generated as a sine wave which fluctuates over time. A period (FFP) of eight years or ninty-six months was selected for this sine wave to represent the average period of time between new national leaders. The period and values of willingness to use force are not extremely important to the model but the influence of its change on enemy expansionary activity is. This value is computed by dividing the enemy perceived advantage by the perceived willingness to use force. As the willingness to use force increases, enemy expansionary activity will decrease. The values generated in this equation are multiplied by one hundred to give the enemy expansionary activity a value between zero and ten. This value is then utilized to generate pressure to improve readiness.

Pressure to improve readiness (PIR) is the driving factor in the remaining sectors of the model. It affects time delays, the military budget, and the levels of activity in the system. It is computed using the perceived United States deficiency and enemy expansionary activity. The pressure to improve readiness equation muiltplies the United States perceived deficiency by the enemy expansionary activity and then smoothes this value over a six month period. The value is generated in this manner to insure that little pressure to improve readiness is initiated when an enemy expansionary activity occurs and the United States has a clear advantage. As the advantage decreases, the pressure to improve readiness will increase only if enemy expansionary activity exists. This equation attempts to represent the phenomenon where little or no effort to improve readiness is taken, regardless of force capability levels, until a threat to the United States national objectives is felt through enemy expansionary activity.

The last equation in this sector is the representation of the change in the military budget (MB) as it is affected by the pressure to improve readiness and the national economy (NE). The primary factor which influences the military budget is the pressure to improve readiness. This value stands at what would be considered a normal military budget when pressure to improve readiness is low. As pressure to improve readiness increases, so does the military budget at a rate equal to the amount of pressure. The national economy is generated through a sine wave representing growth and depression periods and has an influence of up to a fifteen percent increase or a ten percent decrease in the change of the military budget. These equations then represent the increases which can be expected in the military budget as the pressure to improve readiness changes. The scale of this value does not equate to dollars but to the change in the level of equipment and spares which could be expected as a result of the change in budget. One of the first factors which was discussed in the overview was the aircrew capability factor. The generation of this value will be discussed in the next section.

Aircrew Manning

The Aircrew Manning sector was structured to capture the influence of both aircrew experience and aircrew skill for the aircrew capability sector of the model. To accomplish this, an array was developed and the aircrews were divided into four year groups (YG) and three skill levels (SL). The flow diagram of this structure is shown in Figure 5-2. At the center of this figure is the aircrew manning level (ACML).

The aircrew manning levels are determined by rates of flow into and from each of the twelve levels. The rates which enter the aircrew manning levels include the aircrew recruiting completion rate (ACRCR), the rated supplement requalification rate (RSRCR), and the aircrew year group exit rate (YGER). The rates which reduce the aircrew manning levels are the aircrew exit rate (ACER), the rated supplement entrance rate (RSER), and the aircrew year group exit rate. Each of the equations for these rates are influenced by deviations from desired aircrew manning levels, pressures from the external environment, and the pressure to improve readiness.

The rated supplement requalification completion rate is a third order delay of the rated supplement requalification rate (RSRR). This delay represents the time period which is required to retrain an aircrew member after he leaves the rated supplement. The length of this

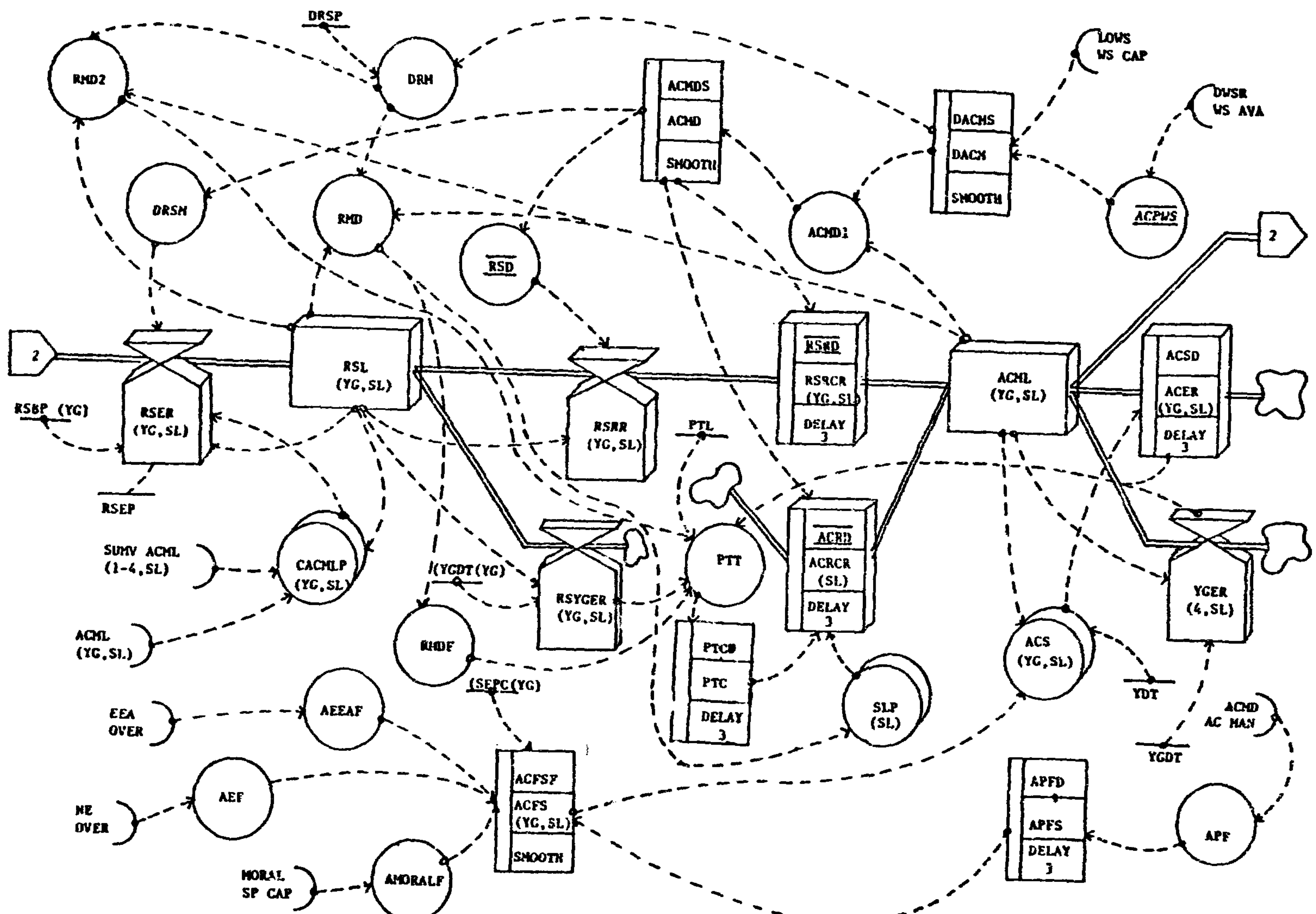

Fig. 5-2. Aircrew Manning--Flow Diagram

delay (RSRD) is a variable which has a range of values from three to seven months depending on the aircrew manning discrepency (ACMD). Like the rated supplement requalification completion rate, the rated supplement requalification rate represents a delay in the system. This equation determines the time an aircrew member will spend in the rated supplement. The equation divides each of the twelve rated supplement levels by the average length of a rated supplement tour. The length of a rated supplement tour is not constant. In the rated supplement delay equation (RSD) it varies from eighteen to forty-eight months, again depending on the aircrew manning discrepency. The aircrew manning and rated manning discrepencies are important factors in the structure of the aircrew manning sectors. Their values are determined by a comparison of desired levels to actual levels.

The aircrew manning discrepency is a smoothed value. The value is smoothed over a period of six months (ACMDS) to better represent the management philosophy of viewing the aircrew manning discrepency over a time period rather than making decisions based on a single month's discrepency (19). The discrepency itself is generated by dividing the total aircrew manning (TACM) by the desired aircrew manning. Total aircrew manning is a summation of the twelve aircrew manning levels, while desired aircrew manning (DACM) is dependent on several variables. Desired aircrew manning is determined by multiplying the level of weapon systems (LOWS) by the desired number of aircrews per weapons system (ACPWS). Like the aircrew manning discrepency, this value is smoothed (DACMS) to represent current management philosophies. The determination of the desired aircrews per weapon system is currently made by a computer simulation model named TACFLYER (6). This model simulates wartime sortie rates and combat conditions to determine the aircrew requirements per aircraft. The aircrews per weapon system equation simulates this process by the use of a table function which varies the number of aircrews per weapon system depending on the desired wartime sortie rate.

Aircrews hold positions other than those which require flying. Because of this, the management of the rated force must consider both the aircrews filling flying positions and those who are in rated staff and nonrated positions (19). To accomplish this in the model, a desired rated manning (DRM) and two rated manning discrepency values are generated. The desired rated manning value is generated by adding to the desired aircrew manning a percentage of desired aircrew manning which represents the aircrews in rated staff and nonrated positions. This value is then used to determine rated manning discrepencies. Rated manning discrepencies are computed both in number of aircrews (RMD2) and the discrepency percentage (RMD). These discrepencies are then used to determine the number of aircrews who will be introduced into the system.

The aircrew recruiting completion rate (ACRCR) is a delay of pilot training capacity. This delay was included to represent the time required for a potential aircrew member to complete pilot training and upgrade into a weapon system. The time delay is varied from sixteen to twenty-four months using the variable aircrew recruiting delay (ACRD). This variable is computed in a table function and is dependent on the aircrew manning discrepency. This equation is also used to determine skill levels of the pilots entering the rated force. This is accomplished by multiplying the total number of aircrew members entering the force by a skill level percentage (SLP). The skill level percentages vary with the rated manning discrepency, as described in Chapter 4, through the use of table functions. These equations represent the variations of the pilot training output which are seen when the pressure to reduce the aircrew manning discrepency increases.

The use of pilot training capacity to determine the rate of flow into the system models the current situations where recruiting of aircrew members is limited only by the capacity to train them. This capacity to train aircrew members will vary with time but the change is not instantaneous (15). To include this fact in the model, the pilot training capacity equation delays the change in the desired pilot training capacity (PTT) by the pilot training capacity delay (PTCO). The length of the pilot training capacity delay varies from eight to twelve months and is dependent on the rated manning discrepency. This capacity varies depending on the desired pilot training capacity. The desired pilot training capacity is determined by the flow contained in the rates. These rates represent exits from the rated force multiplied by a rated manning discrepency factor (RMDF). The rated manning discrepency factor will increase or decrease this value by as much as forty percent. The use of this type of equation allows the system to make required increases or reductions to the rated force.

The aircrew exit rate (ACER) determines the number of aircrew members which will separate from the service. It is a delay of those aircrew members who wish to leave the service (ACS) by a period of six months. The six month delay (ACSD) represents the period involved in the separation process. Individual separation rates are developed for each of the twelve aircrew manning levels. These equations multiply each of the aircrew manning levels by the percentage of aircrews which desire separation (ACSF1). For those aircrew members in year group one, one to six years of service, the separation rate is zero. Although there are some separations in these time frames, their effect on the system is not significant so that factor was not modeled. The actual percentage of aircrews which desire to leave the service (ACSF1) while in year groups two and three is computed by taking an average loss factor reflected by past experience and modifying it by the present conditions (41). This process is accomplished by smoothing the effects of military pay (APFS), the national economy (AEF), the morale factor (AMORLF), and the enemy expansionary activity factor (AEEF). Each of these factors is computed in a table function which serves to increase or decrease the separation rate by the approximate amount determined through the interview process (21; 27). Although other factors which may affect aircrew separations were discussed in the interviews, these four seemed to have the largest impact. The aircrew economic factor is based on the national economy and represents the job availability factor to include airline hirings. As the national economy improves, separations increase as much as ten percent. The aircrew pay factor (APFS) is a delay of the change in aircrew pay (APF) based on the aircrew manning discrepency. This factor captures the change in aircrew pay that could be expected when aircrew manning discrepencies exist. The factor is not in dollars but relates aircrew pay to civilian pay and determines the relative value of the two as driven by the discrepency. The aircrew pay factor can increase or decrease aircrew separations by as much as twenty percent.

The aircrew morale factor is determined by the use of the morale variable developed in the support capability sector and discussed in Chapter 4. The basic function of this equation is to increase or decrease aircrew separations as the unit's morale varies. This concept will be further explained when the morale equation is discussed.

The last factor affecting aircrew separations is the enemy expansionary activity factor. This factor is developed based on the enemy expansionary activity and attempts to capture the influence of this factor on the aircrew's perceptions of their individual importance in the system. When enemy expansionary activity is present and the pressure to improve readiness increases, aircrews see their value to the system as much greater and separations will decrease. This factor can increase aircrew separations as much as ten percent during times of little enemy expansionary activity and decrease separations as much as fifty percent when enemy expansionary activity is extremely high.

To account for the movement of aircrews between year groups equations were added to both the rated supplement and aircrew manning levels. These equations move aircrews between year groups at specified periods. The movement from year group four represents retirement from the rated force at the twenty year point.

The rated supplement levels, like the aircrew manning levels, are in twelve levels which account for aircrews by both year group and skill. The entry into the rated supplement is controlled by the rated supplement entrance rate. This equation removes aircrews from the aircrew manning levels at the rate required to meet the desired rated supplement manning (DRSM). This is accomplished by multiplying the desired rated supplement manning by the rated supplement year group percentage (RSBP) to determine the number of aircrews from each year group in the desired rated supplement. This value is then multiplied by the skill level percentages of the year groups (CALCOMP) to further define the desired rated supplement manning by year group and skill levels. These values are then compared to the actual number in the rated supplement by year group and skill level. This result is then multiplied by the rated supplement entrance percentage (RSEP) to determine the number of aircrew members which will enter the rated supplement during a one month time period. This process of determining the number of aircrews entering the rated supplement was used to keep the percentages of skill levels equal between the aircrew manning levels and the rated supplement levels. The necessity to do this was generated because in the actual management of rated personnel no skill factor is considered when assignments are made. If an unbalanced condition existed, the overall capability of the rated force could be misjudged in the aircrew capability sector of the model.

The last factor from the aircrew manning sector is the desired rated supplement manning (DRSM). This value is computed based on the aircrew's manning discrepency. A table function is used to determine the percent of the rated force which will be in the rated supplement based on the aircrew manning discrepency. As the aircrew manning discrepency increases, the percentage of the rated force in the rated supplement decreases to represent the reduction in the number of staff and nonrated positions filled by aircrews. This method of reducing aircrew manning discrepencies is currently being used in the Air Force (19). As the aircrew manning discrepency has increased, the rated staff positions are being reduced and aircrew entrance into the rated supplement has been curtailed. The manning and skill levels generated in the aircrew manning sector of the model serves as an input into the aircrew capability sector. The process of determining aircrew capability will be discussed in the next sector.

Aircrew Capability

The aircrew capability sector of the model developes the measure of aircrew capability which is used in the determination of United States readiness. This measure is produced by combining the factors which determine an individual aircrew member's capability and then modifying this value based on the aircrew manning discrepency.

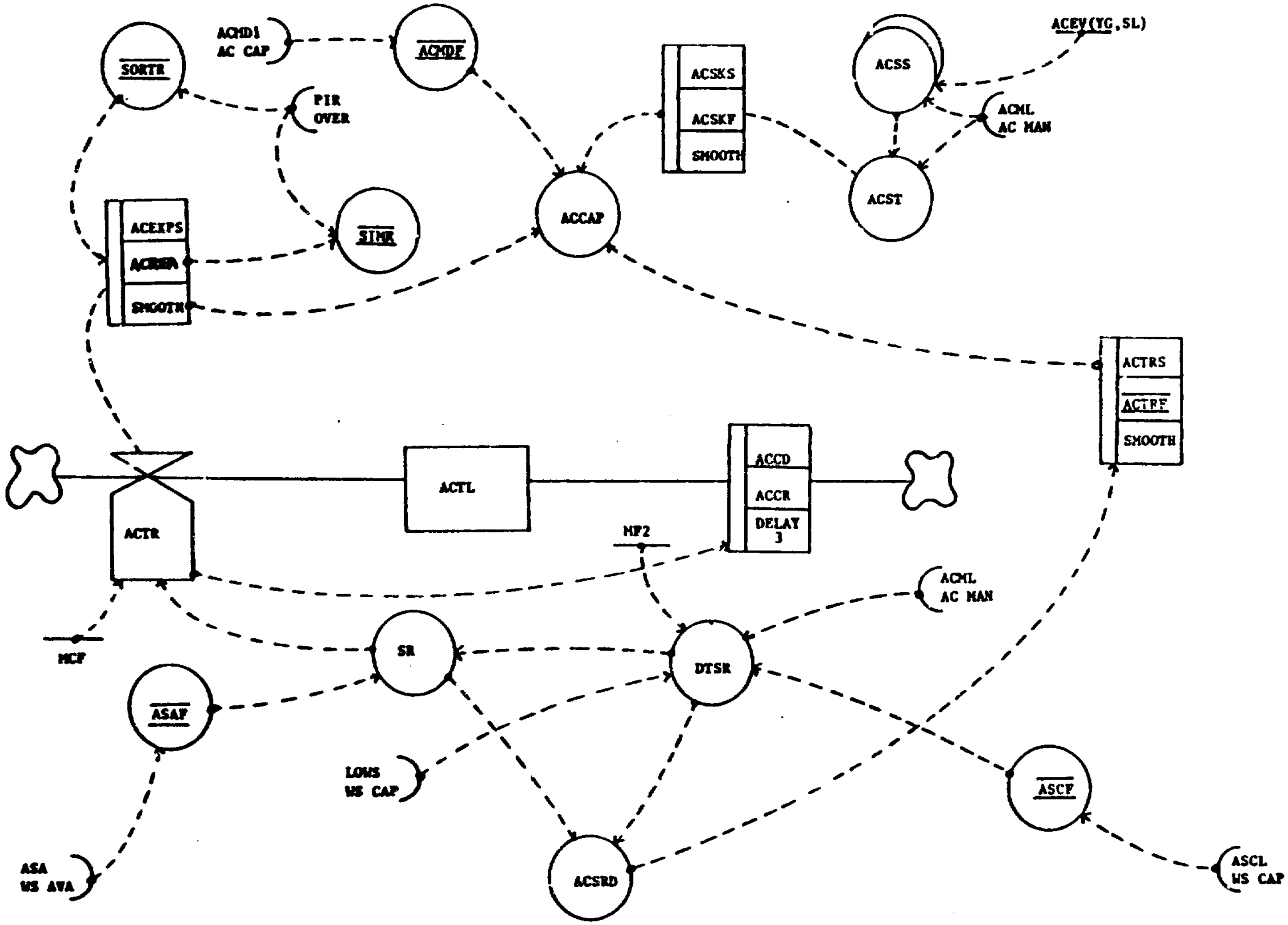

Fig. 5-3. Aircrew Capability--Flow Diagram

A flow diagram of the method used to measure this factor is shown in Figure 5-3. The first factor affecting an individual aircrew member's capability is the aircrew training level (ACTL).

The aircrew training level is determined by the aircrew training rate (ACTR) and the aircrew currency rate (ACCR). The aircrew training rate is based on the current sortie rate modified by a mission completion factor (MCF). While the aircrew training rate adds to the aircrew training level, the aircrew currency rate reduces it. The aircrew currency rate is a delay of the aircrew training rate. This delay lasts for three months and represents the time value of a sortie as it relates to current training levels (21). The generation of the sorite rate is based on two factors. These factors are the desired training sortie rate and the aircraft system availability factor (ASAF). The sortie rate equation selects the smallest of the two values to determine what the aircrew training rate input will be. The aircraft system availability factor is generated in a table function which considers aircraft system availability as it relates to possible training sortie rates. Although the military budget impacts the sorite rate, from the interview process it was found that this affect is felt more through aircraft system availability than it is in actual dollars for flying. Many units have a hard time flying the sorties allocated based on their aircraft availability (26). For these reasons the military budget factor was not directly included in this section of the model.

Determination of the desired training sortie rate was accomplished by multiplying the aircraft system capability factor (ASCF) by the number of aircrews and dividing this value by the level of weapon systems (26). This total value was then multiplied by a second mission completion factor (MCF2) to determine the desired training sortie rate. The aircraft system capability factor is computed in a table function which relates the aircraft capability to the aircraft sortie rates required to satisfactorily train the aircrews. As the aircraft capability is increased, the desired training sortie rate is also increased. This factor models the concept that as an aircraft's capability increases so does its complexity and the amount of training required to master its operation.

With values for both an aircraft sortie and a desired aircrew training rate developed, a comparison can be made to determine the aircrew training rate discrepency (ACTRD). This value is computed by dividing the actual training sortie rate by the desired sortie rate to determine the percent of desired training which is accomplished. As the number of training missions flown is important to aircrew capability, so is the quality of the missions which are flown.

The aircrew realism factor (ACREA) accounts for the affects of training realism in the model. It is a smoothed value of the desired training realism (DREA) as modified by the sortie realism factor (SORTR) and the simulator realism factor (SIMR). The desired training realism value is set at a constant value of two. This value changes as the sortie and simulator realism values change. The simulator and sortie realism factors are both developed in table function based on the pressure to improve readiness. The pressure to improve readiness was selected to drive the realism factors for two reasons. Aircraft losses which accompany increased sorite realism are only acceptable when pressure to improve readiness is present (26). The second reason deals with the aircrew member's attitude toward training. When pressure to improve readiness exists, aircrews place more effort into both their flight and simulator missions. This increased effort results in better training. The affects of these two factors on the desired realism factor can increase it as much as forty-five percent during periods of high pressure to improve readiness, and decreases it as much as thirty percent during periods of low pressure to improve readiness. Although the interview process placed values approximately twice this great on the affects of sortie and simulator realism, these higher values were modified to reflect that not all flights or simulators can be conducted with realistic combat scenarios (21).

Missions will always be required to maintain aircrew proficiency in basic flight and instrument procedures, so that they can safely operate aircraft on the more realistic training missions. The last factor which impacts aircrew capability is the aircrew experience factor.

Aircrew experience levels (ACSKF) are considered by many commanders the most important determinate of aircrew capability (21). In the combat readiness model, the impact of aircrew experience was captured through the use of the year groups and the skill levels generated in the aircrew manning sector of the model. In two interviews, the value of one experienced Captain was placed at more than two times that of an inexperienced aircrew member (27). Based on these interviews a series of experience and skill values (ACEV) were assigned to each of the twelve aircrew manning levels (21; 27). These values were then multiplied by the number of aircrews in each of the manning levels and divided by the total number of aircrews. The result of this process was an average experience value for an aircrew member. This value was then used with the factors previously discussed to determine the aircrew capability factor (ACCAP).

The aircrew capability factor was computed by multiplying the aircrew realism, training rate, experience, and manning discrepancy factors. The value of aircrew capability ranges between one and four and, as discussed in the overview section of this chapter, impacts the

United States readiness value. The affects of the training rate, manning discrepency, and experience factors were computed in table functions with each based on the values of the respective variables computed in this sector. The range of their affect varies to reflect the information acquired in several of the interviews. The affect of aircrew experience has the largest impact on aircrew capability with the ability to increase or decrease it by as much as fifty percent (21). Aircrew manning discrepencies has the second largest impact with a range of a fifty percent decrease to a five percent increase for a large over-manning situation (19). The increase for an aircrew over-manning was limited because aircraft will limit the number of sorties which can be flown, regardless of how many extra aircrews are possessed. Training rate, the last factor, is computed in a table and can increase aircrew capability by as much as twenty percent and decrease it by as much as thirty percent. Based on the combination of these values, the aircrew capability factor can have a relatively wide range of values. The wide range was required to show the effects of training policies, aircrew retention, and the pressure to improve readiness on aircrew capability.

This sector of the combat readiness model provided a measure of aircrew capability to be used in the determination of United States readiness. The maintenance manning and capability sectors of the model were developed in a manner similar to those for aircrew manning and capability. The maintenance manning sector will be discussed next.

Maintenance Manning

As discussed in Chapter 4, the maintenance manning sector represents a goal oriented negative feedback system. Figure 5-4 presents the flow diagram which was developed to capture this concept. The structure of this flow diagram is similar to the aircrew manning sector. Central to the flow diagram is the maintenance manning level (MYML). This level represents the personnel which are in the maintenance work force. It was divided into four year groups to capture the structure of the maintenance force, by the member's length of service. The maintenance manning levels have rates which flow in and out of them to determine the number of personnel in each level.

The rates which flow into the maintenance manning levels are the maintenance recruiting completion rate (MXRXR) and the maintenance year group exit rate (MXYGER). The maintenance recruiting completion rate only influences the first maintenance manning level. It represents new recruits entering the work force. This rate is a delay of the maintenance recruiting rate (MXRR). The length of the delay (MXRD), is dependent on the maintenance manning discrepency (MXDMS) and varies between five and seven months (9). After entering maintenance manning level one, the

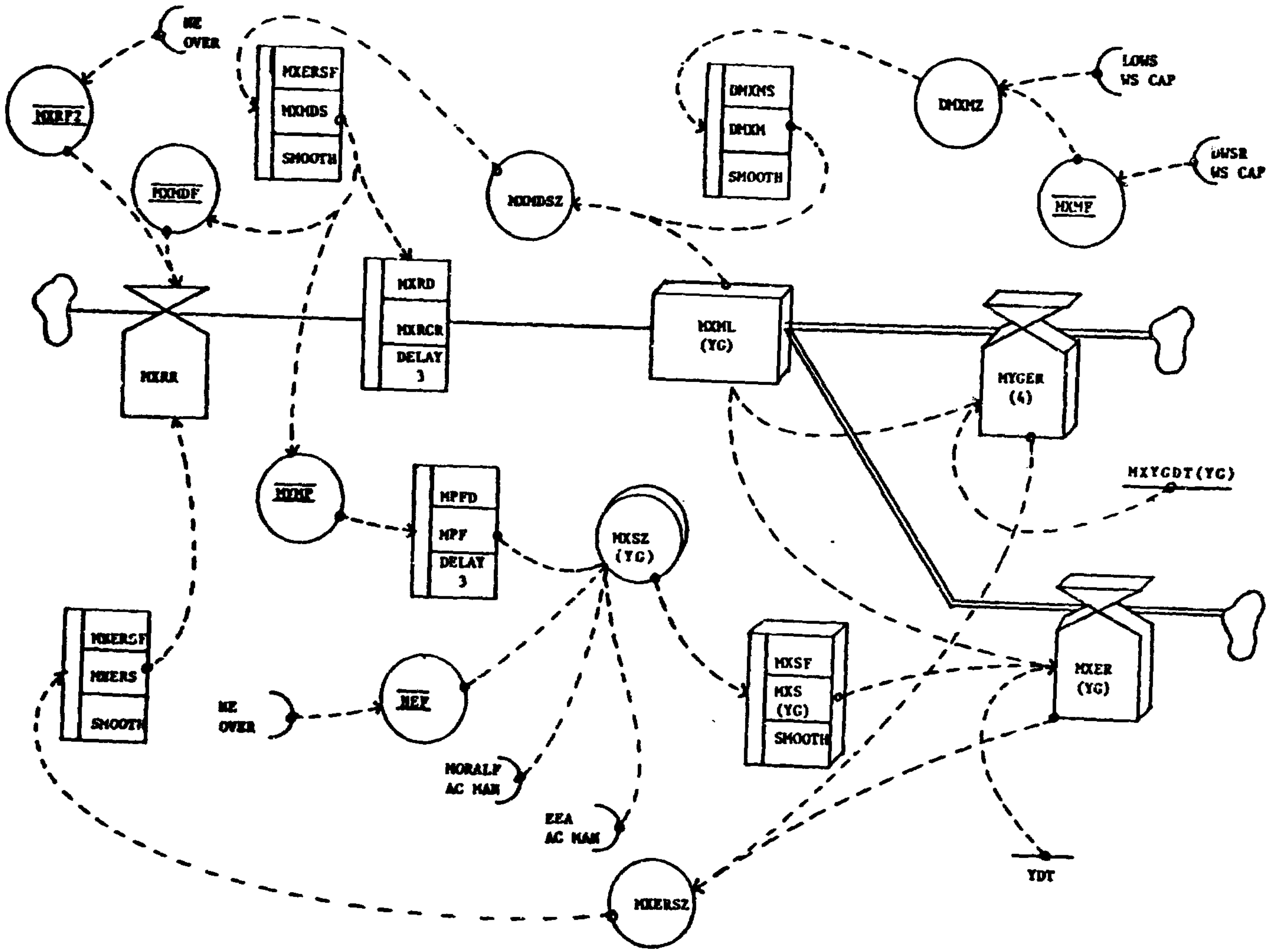

Fig. 5-4. Maintenance Manning--Flow Diagram

recruits remain for a period of four years. This length is designed to represent their first enlistment. At the end of this period they exit year group one and enter year group two. This process is accomplished with the maintenance year group exit rate (MYGOR). This equation withdraws maintenance personnel from their present year group and adds them to the next. The length of time personnel stay in a year group is determined by the maintenance year group delay time (MYGOT). These times represent periods of four, six, five, and six years respectively. The first period represents first term enlistees and the remainder of the year groups represent the career force, divided at the ten and fifteen year points. Year group four is six years long to keep personnel in the system until the average retirement point of 21 years (11). The number of personnel in the maintenance manning levels, when compared to the desired maintenance manning, determines the maintenance recruiting rate.

The maintenance recruiting rate is determined by three variables. These variables are the total maintenance exit rate (MXERS), the maintenance manning discrepency factor (MXMDS), and the national economy recruiting factor (MXRF2). The equation multiplies these three factors to compute the maintenance recruiting rate. Total maintenance exit rate provides as basic recruiting rate value. This value is then varied by the manning discrepency factor and the national economy factor to determine the actual recruiting rate.

The total maintenance exit rate smoothed is computed by summing all the rates which represent exits from the maintenance manning sector (MXERS), and smoothing their values over a six month period (MXORSF). The value is smoothed to represent current management information (11). To enable the maintenance recruiting rate to correct to a goal, the maintenance manning discrepency was included in the equation.

The maintenance manning discrepency has as an input, the summed maintenance manning levels divided by the desired maintenance manning (MXMDZ). This value is smoothed over a six month period. It represents the percentage of the desired maintenance manning levels. The use of this variable in the maintenance manning discrepency table corrects manning discrepencies by varying the relationship of recruiting to personnel exiting the system. The last factor which influences the maintenance recruiting rate is the national economy factor. This factor was modeled to capture the affect of the economy on civilian job opportunities and, therefore, military enlistment.

Also, during periods of economic growth, military pay tends to lag the civilian pay for comparable positions. These trends impact the ability of military recruiters to enlist the desired number of personnel. For the Air Force the impact has been small and only recently has it affected actual recruiting. For this reason the affect of the national economy factor was made a maximum of only four percent during the most adverse conditions and has no affect during normal conditions (11).

The maintenance manning discrepency had as its inputs the actual maintenance manning level and the desired maintenance manning level (DMXM). This value is computed by multiplying the level of weapon systems and the maintenance manning factors and smoothed this value for a period of six months. The maintenance manning factor, like the aircrew manning factor, was determined based on the desired wartime sortie rate. By computing the desired maintenance manning in this way the number of maintenance personnel will vary with both the number of aircraft and the planned usage of those aircraft (6). The last rate to be discussed is the maintenance exit rate.

The maintenance exit rate is computed for each year group. The computation of the percentage which will exit the system is computed by smoothing the combined effects of the national economy, military pay, morale and enemy expansionary activities by the desired separation toal. These factors are computed in the same manner as those affecting aircrew separations. The tables for the national economy factor and the military pay factor were given different variables to reflect their effects on a force composed of primarily enlisted personnel. The national economy factor was given a slightly larger impact due to the nature of the jobs which separated maintenance personnel would most likely seek. Similarily, the military pay factor was given a larger value to reflect the relative importance of a pay increase to the lower income maintenance force as compared to the aircrews. Once the separation factors for each manning level are computed they are multiplied by the number of personnel in that level to determine the number of separations.

This concludes the discussion of maintenance manning. This sector has an impact on the maintenance capability sector which will be discussed next.

Maintenance Capability

The maintenance capability sector was developed to provide inputs into the aircraft availability and the materiel readiness sectors of the model. The structure of this sector is presented in Figure 5-5. As can be seen, the actual maintenance capability (MXCAP) and the perceived maintenance capability (PMXCAP) are determined by many factors. The maintenance capability levels are given a desired maintenance capability value of ten and the factors which impact capability are then multiplied by this value to determine the actual and perceived maintenance capability. Each of these factors and their impacts will

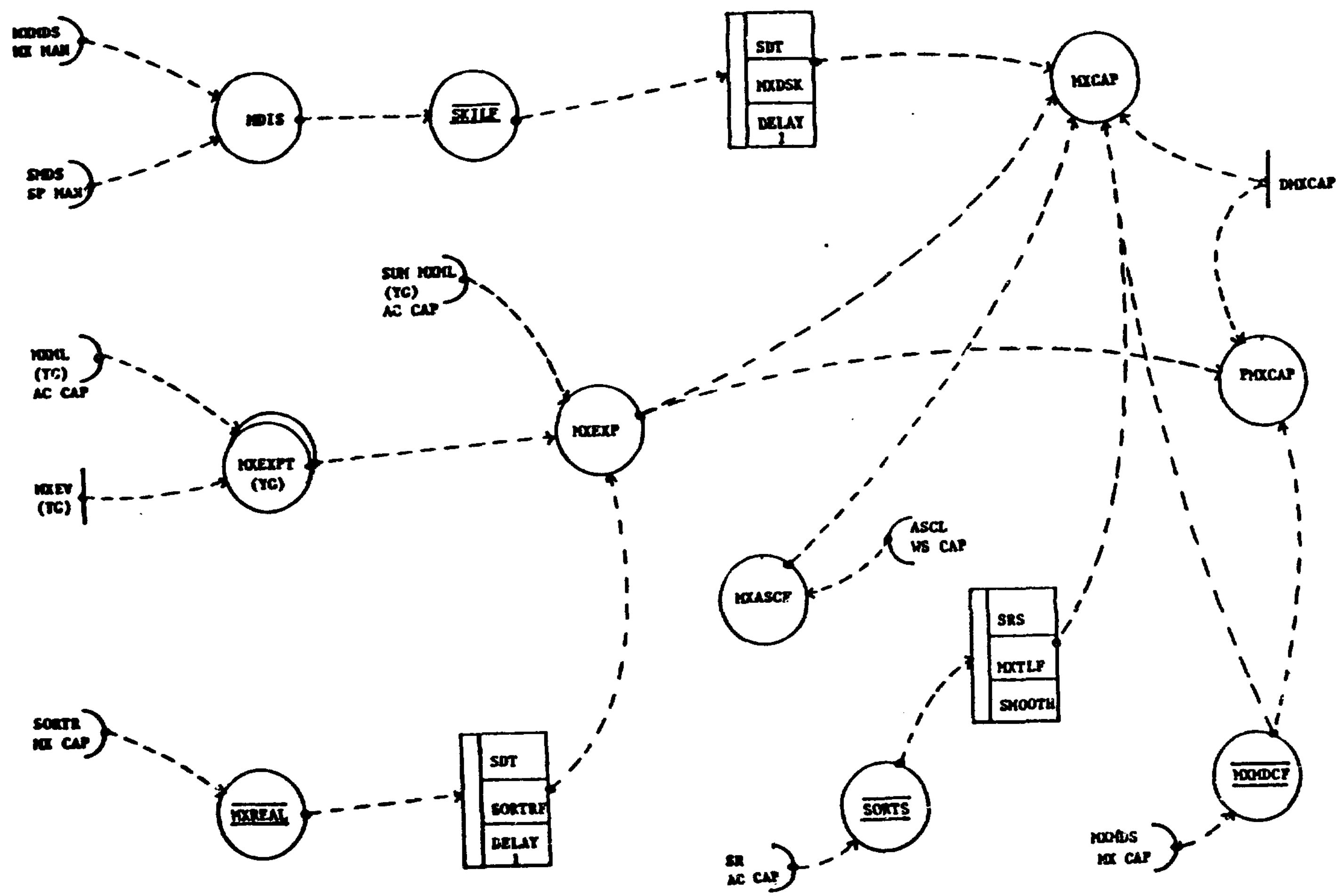

Fig. 5-5. Maintenance Capability--Flow Diagram

be discussed in this section.

The first factor which will be discussed is the skill factor (MXDSK). As presented in Chapter 4, the skill level of the enlisted force is primarily impacted by the manning discrepencies (15). As manning discrepencies increase, less skilled personnel have to be recruited to meet manning requirements. This value is computed by adding the maintenance and support manning discrepencies (MDIS) and using this value in a table function (SKILF) to determine the impact of the skill level. The value range of this table represents as much as a twenty-five percent reduction of maintenance capability for very low skill levels and as much as a fifteen percent increase in capability for very high skill levels. The values from this table are then put into a first order delay lasting twenty-one years. The shape of the curve for a first order delay very closely resembles desired maintenance manning by year group and therefore will provide an average skill factor which closely approximates the skill levels which would exist.

As in the aircrew capability sector, the maintenance capability sector has an input from aircrew experience. The maintenance experience factor is computed by multiplying each maintenance year group by its appropriate experience value (MXEXPT). The maintenance experience values were based on information gained through the interview process (20). This total maintenance experience value is then divided by the sum of all the maintenance manning levels to determine an average experience value for each individual in the maintenance force. The average experience value is modified by the sortie realism factor (SORTRF) to determine maintenance experience. Sortie realism impacts maintenance capability as in the aircrew capability sector. The overall effect is less than in the aircrew sector but it is still important. Realistic training for maintenance personnel provides training in wartime activities which are not part of normal training (9). These activities include tasks such as loading live ordnance, quick-turning aircraft, and repairing battle damage. Adequate training in these areas can improve maintenance as much as fifteen percent and inadequate training can reduce it as much as twenty percent (9).

Aircraft system capability also will affect maintenance capability. As aircraft are given more capabilities, the task of repairing and maintaining them becomes more difficult. To reflect this in the model a table function was developed (MYASCF) to decrease maintenance capability as aircraft became very complex. It therefore models the need for more experience, skill, training, or manning to acquire the same maintenance capability for a complex aircraft than for one which is less complex.

The effect of the training sortie rate on maintenance capability differs from its effect on aircrew capability. As discussed in Chapter 3, maintenance training is a combination of on-the-job and classroom-type training (9). As training sortie rate varies, the time available for each of these types of training will vary. If too low a sortie rate is flown, there will not be enough on-the-job training, and if too high a sorite rate is flown, there will be too little time for classroom-type training. To reflect this in the model, a table function (SORTS) was used with sortie rate as the input. The ideal training sortie rate was set at .75 sorties per aircraft per day. As sortie rate increased or decreased, the training rate factor decreased (20).

The last factor which affects maintenance capability is the maintenance manning discrepency. The structure of this factor is the same as the one used in the aircrew capability sector. Its affect on maintenance capability is large. As the maintenance manning discrepency increases, the maintenance capability drops off. Maintenance capability decreases rapidly when the discrepency exceeds a twenty percent under-manned situation. The effect of all the factors discussed, results in an overall maintenance capability value. Under normal conditions, this value ranges from thirty to fifty. Under extremely adverse or good conditions, it will exceed this range. The difference between the maintenance capability and the perceived maintenance capability stems from the effects of realism, aircraft capability, and the maintenance training levels. These were not included in perceived maintenance capability because they are not reflected in the UNITREP reporting system and, therefore, are not considered when judging maintenance capability (42:3-7). The perceived maintenance capability factor is not used in the model and is only computed so as to allow the comparison of actual and perceived capability. This concludes the two sectors of the chapter which address the maintenance sectors of the model. The next sector will address support manning.

Support Manning

The support manning sector of the model is presented in Figure 5-6. The basic structure of this sector is the same as that for maintenance manning. In the final model many of the equations for the maintenance manning sector are also used in the support manning sector. Rather than repeat the development of these equations, the discussion will be limited to those factors which differ from the ones found in the maintenance manning sector.

Two factors that differ from those found in the maintenance manning sector are the support manning recruiting delay time and the support manning discrepency factor. Although the structure is the same in both sectors, the values in the table functions are different. The length of time that support personnel are delayed prior

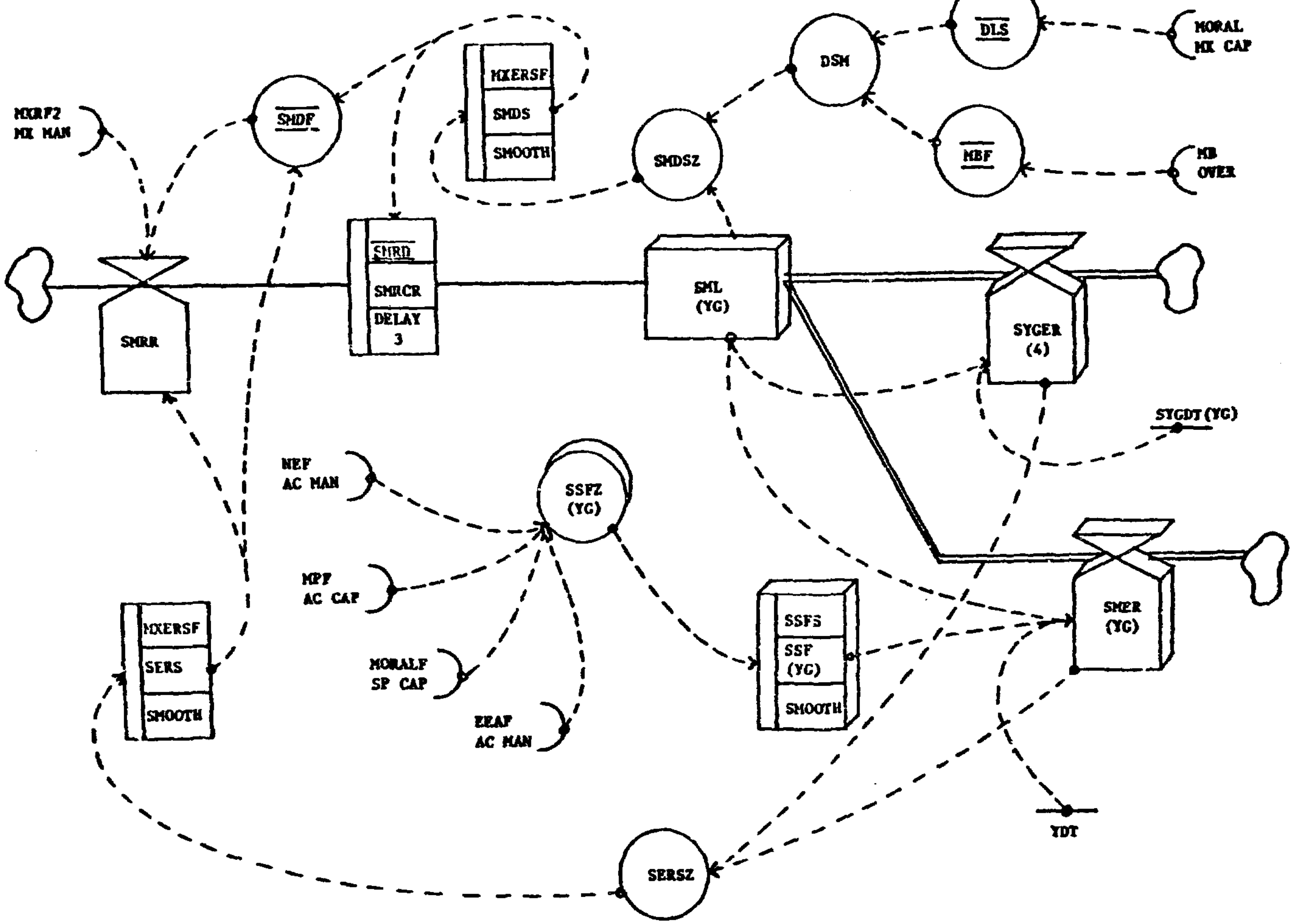

Fig. 5-6. Support Manning--Flow Diagram

to entering the work force is reduced to between three and six months depending on the support manning discrepency (11). The support manning discrepency factor used in the determining of support recruiting rate also has different values than those used in the maintenance sector. The values reflect a slower response to an under-manning situation. This was modeled to show the relative emphasis in correcting discrepencies between the two sectors.

The determination of the desired support manning (DSM) also differs from the maintenance sector. Two factors were selected as having the largest impact on support manning. The first of these factors is the military budget. This factor is computed in a table function which relates the military budget to the percentage of the desired level of support value which will equal the desired support manning. The military budget (MBF) was selected because during periods of low funding the support areas normally are the first to feel the effects. The reduced funds result in a lower desired support manning value, while large military budgets result in higher desired support manning levels. The desired level of support equations provide the number of personnel for input into the desired support manning equations. This equation is a table function which varies the number of personnel based on the morale value. This equation is designed to reflect the emphasis which is placed on adequate support manning based on unit morale. As morale declines, the desired support manning will increase and conversely as the morale increases, less emphasis is placed on support manning, and the desired manning level will decrease. The support manning level will impact the support capability sector which will be discussed next.

Support Capability

As with the structures of the maintenance manning and support manning sectors of the model, the support capability structure is very close to that of maintenance capability. The flow diagrams for this structure are presented in Figure 5-7. As with maintenance capability, both a perceived (PSCAP) and actual (SCAP) support capability are computed. The structure of these equations and the factors which affect them are the same as in the maintenance capability equation. The only change is to the amount of effect the factors have. Since the maintenance skill factor was computed using both the maintenance and support manning discrepencies, its value was used directly in the support capability equation. The experience factor (SECP) was computed the same way as in the maintenance sector but the effect of sorite realism was greatly reduced. The same holds true for the aircraft capability factor (SASCF). It does affect support capability through the supply system, but not as much as in

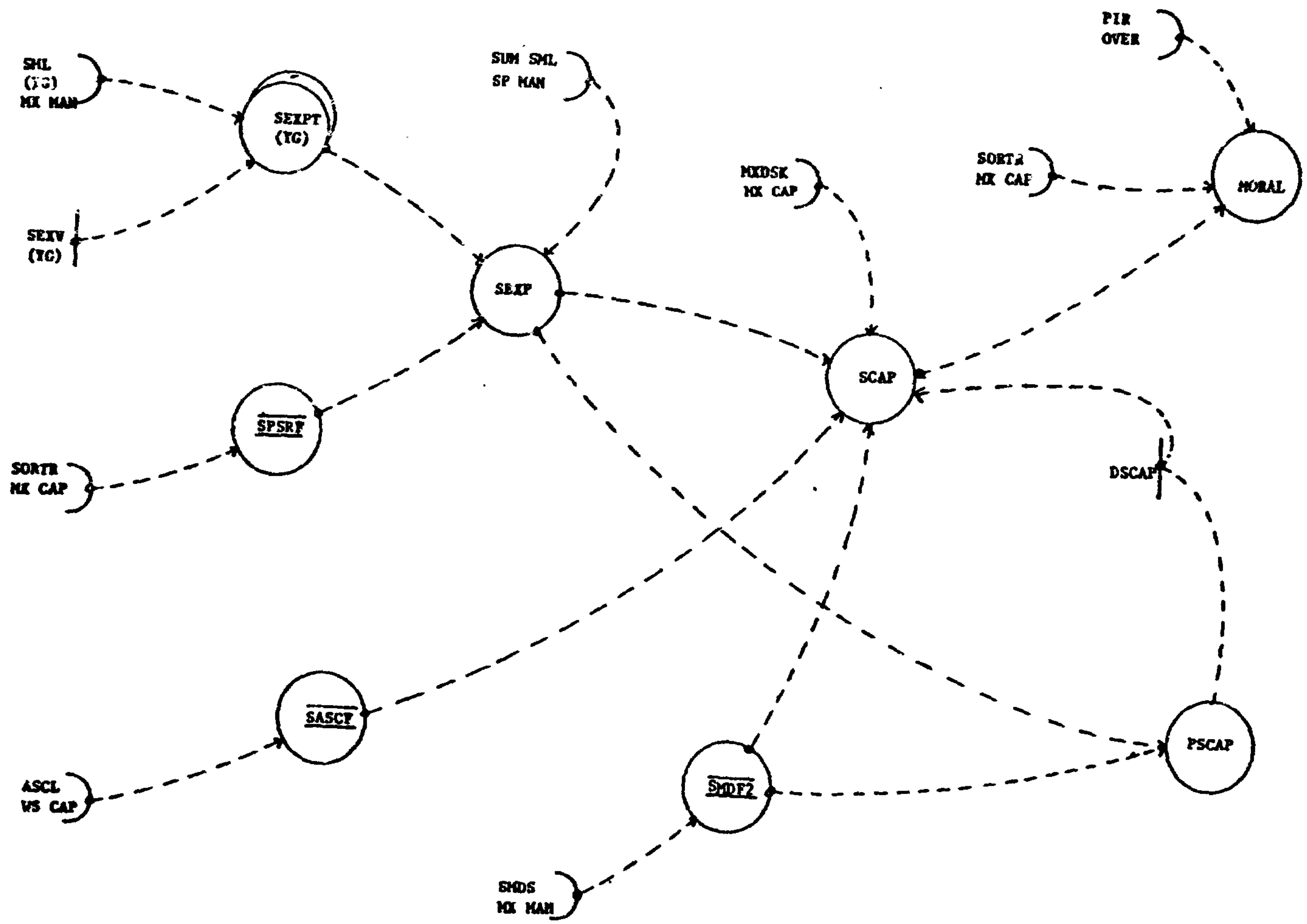

Fig. 5-7. Support Capability--Flow Diagram

the maintenance capability sector. The last factor, the support manning discrepency factor (SMDF2), also was modeled with a reduced affect on support capability. This reflects the opinions that support manning can be reduced with less affect on the combat readiness system than any other manning area (27).

One factor which is computed in the support capability sector which was not included in the maintenance capability sector is the morale factor. This factor is computed by multiplying the support capability factor by the pressure to improve readiness and the sortie realism factor. Although the interview process revealed many factors which affect morale, these three factors were selected as having the most consistent and definable impact on readiness.

All three of these factors affect an individual's view of his worth to the system. In each case the factors added to this perceived worth. The realism factor does this by demonstrating the importance of an individual's job in the combat readiness system. Pressure to improve readiness accomplishes this by showing the importance of combat readiness to national security, and support capability improves morale by reflecting a unit's capability to respond to individual needs. This discussion concludes the six sectors of the combat readiness model which are dedicated to personnel readiness. The next three sectors will address equipment readiness. The first sector, which will be presented, is aircraft systems capability.

Weapon Systems Capability

The ability of Air Force weapon systems to accomplish their wartime missions is an important aspect of combat readiness. Weapon systems capabilities are constantly improved to meet changing "mission area" needs (1). These improvements can be accomplished by improving existing weapons systems capabilities or building new weapon systems. The process used to determine which of the above alternatives, or combination of alternatives is selected, is complex and involves long delays. Many books, articles, regulations, and even previous theses have addressed this topic. In the combat readiness model, the concept of weapon systems capability is addressed at a very macro level. The structure of this sector, as shown in Figure 5-9, was developed to model only the response of the process and not the process itself.

Changes to weapon systems capability are made in response to the capability of enemy weapon systems. It was determined through the interview process that the United States desires to possess weapon systems which are more capable than their enemies (1). To model this concept, the desired aircraft systems capability equation (DASC) was developed. This equation multiplies the enemy weapon

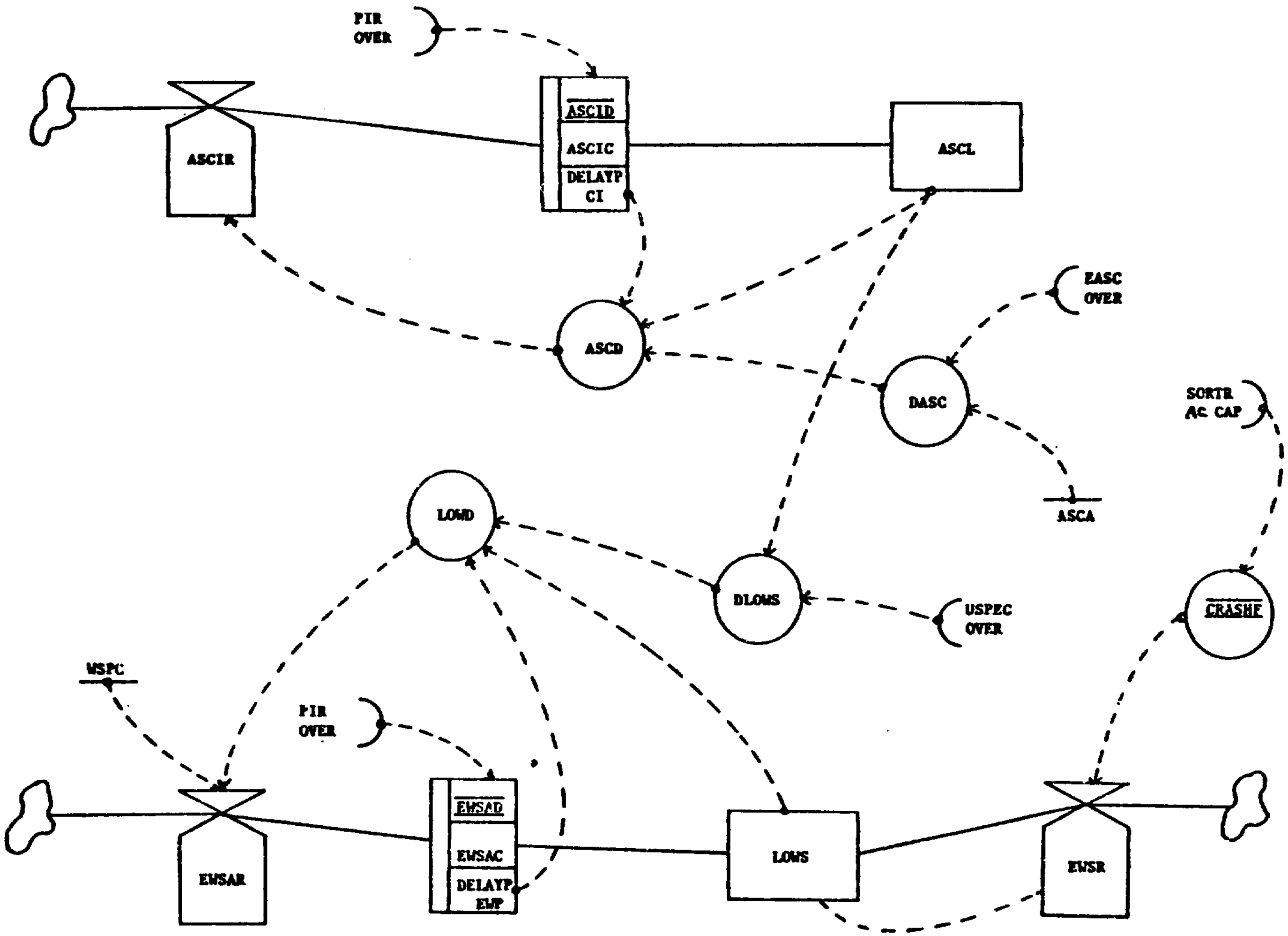

Fig. 5-8. Weapon Systems Capability--Flow Diagram

system capability (EASC) by the United States desired aircraft system advantage (ASCA). The value of this advantage was set at thirty percent. This value represents an estimate of the United States desired advantage based on comments received during the interviews (45). With information on the desired aircraft system capability, a comparison can be made to determine if a capability deficiency exists. The aircraft system capability deficiency (ASCD) is computed by subtracting the existing aircraft system capability (ASC) and the capabilities improvement in progress (CI) from the desired capability. This deficiency is then used to determine the capability improvement rate (CIR).

The capability improvement rate is equal to the capability discrepency. Although this may seem unrealistic at first, desired improvements to capability are normally made. The true impact on the system is the length of time required to complete these improvements. This delay in the system represents many factors which exist in the actual system (1). It is included in the aircraft system capability improvement complete rate (ASCIC) and is determined by the pressure to improve readiness. The pressure to improve readiness is used in a table function, aircraft capability improvement delay (ASCID), to represent the congressional approval process and the time required to accomplish the capability improvement. This delay can be as long as ten years during periods of low pressure to improve readiness and as short as two years during periods of high pressure. Due to the long delay time, the United States aircraft system capability may lag behind enemy aircraft system capability. Even when pressure to improve readiness is very high, it will take years to achieve the desired weapon system capability level. The aircraft system capability is only one aspect of the overall capability concept. Aircraft system capability could be equal to the desired aircraft system capability; but a deficiency still exists due to the number of weapon systems possessed.

The level of weapon systems (LOWS) equation is used to measure how many weapon systems the United States currently possesses. It is determined by the existing weapon systems acquisition rate (EWSAR) and the existing weapon systems retirement. Prior to the acquisition of weapon systems, a weapon system discrepency must exist. The level of weapon systems discrepency (LOWD) is computed by subtracting the actual level of weapon systems and those weapon systems acquired but not yet in the inventory (EWP) from the desired level of weapon systems. To determine the desired level of weapon systems, the United States perceived enemy capability (USPEC) is divided by the existing United States aircraft system's capability. This method of determining the desired level of weapon systems was used to capture the concept of force sufficiency (44:4-13).

It produces a total United States capability which is equal to the strongest enemy capability. Information about discrepencies is fed into the existing weapon systems acquisition rate where it is compared to production capacity to determine the number of weapon systems which will enter the acquisition rate. This acquisition rate is then delayed by the pressure to improve readiness in the same manner and for the same reasons as the capability improvement rate.

The last factor affecting the level of weapon systems is the existing weapon systems retirement rate (EWSR). This rate reduces the level of weapon systems based on the crash factor (CRASHF). The crash factor computes aircraft losses based on the amount of realistic training being accomplished. As realism increases, more losses occur due to the more demanding nature of the mission (26). A table function was used to capture this concept and it determines the percent of aircraft which will be lost as sortie realism varies. This percentage is then multiplied by the level of weapon systems to determine the existing weapon systems retirement rate. The aircraft system capability sector provides information to the aircraft availability sector of the model. This sector will be discussed next.

Aircraft Availability

Modern complex aircraft require a large number of spare parts and a great deal of maintenance. For these reasons they are not always available to fly. As weapon systems availability varies, so does combat readiness (39). The aircraft availability sector of the model as presented in Figure 5-9 provides this input into the model. Aircraft availability is computed as the percentage of aircraft available to fly and is impacted by their reliability, their maintainability, the level of spares factor and the maintenance capability factor.

Aircraft reliability and maintainability play an important role in aircraft availability. They determine how often an aircraft breaks and how long it will take to repair it. When new weapon systems enter the inventory, they have certain reliability and maintainability levels. These levels improve during the aircraft's life span due to improvement modifications and better maintenance techniques, and finally reach desired levels of reliability and maintainability after five to ten years of service (20). The structures for determining availability and maintainability are identical and only their impact on availability varies. For this reason only the reliability structure will be discussed.

To capture the concept of aircraft reliability, a reliability level (ASRL) was included in the model. This

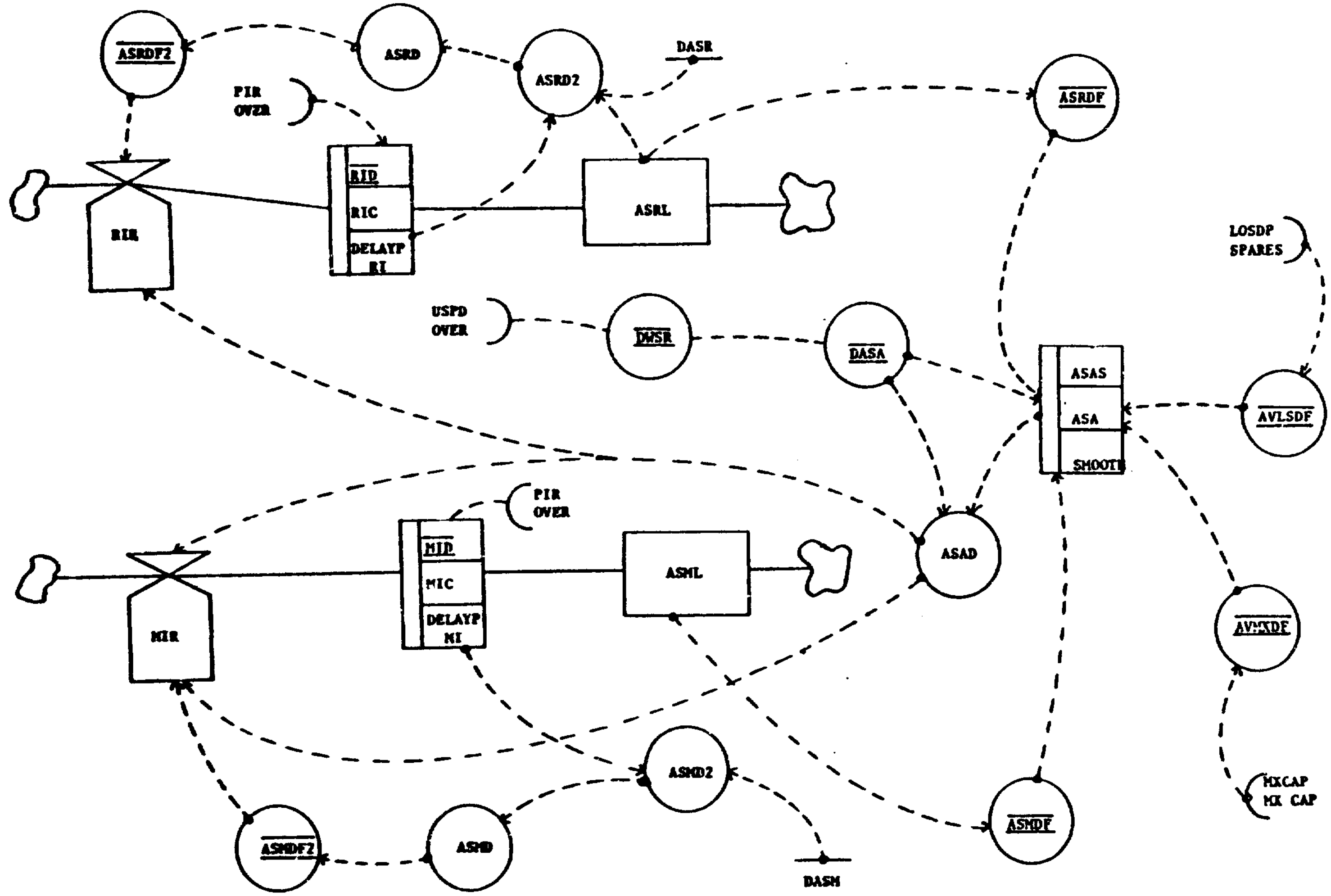

Fig. 5-9. Aircraft Availability--Flow Diagram

level was initialized at an arbitrary value of five and given a desired goal of ten. As this level increases towards its goal, aircraft availability is improved accordingly. The improvement rate (ARD1) is dependent on two factors. These factors are the aircraft availability discrepency (ASAD) and the reliability discrepency (ASAD2). These discrepencies are both computed by subtracting actual availability and reliability, plus any improvement in process, from the desired levels. The reliability discrepency is then used in a table to determine a reliability improvement rate, with no consideration of aircraft availability (ASRDF2). This value is multiplied by the availability discrepency to compute the reliability improvement rate. The availability discrepency will decrease the improvement rate when low availability discrepencies exist and increase it as the discrepancy grows. The values in these tables were developed to vary the time to reach the desired reliability level between five and ten years and have no real meaning in regard to actual improvement. The reliability improvement completion rate (RIC) provides a delay before the reliability level is increased. This delay (RID) is determined by the pressure to improve readiness. As in the aircraft capability sector, pressure to improve readiness was used to generate delay times to represent approval and funding plus the actual improvement delay.

In the aircraft system availability equation, the levels of reliability and maintainability along with the spares and maintenance capability factors determine actual availability as it relates to desired availability. The desired aircraft availability is determined in a table function which compares the desired wartime sortie rates (DWSR) to the availability percentages required to meet these sortie rates. The desired wartime sortie rate is computed based on the United States perceived capability discrepencies (USPD) discussed in the Combat Readiness Overview section. As this perceived discrepency increases, the desired wartime sortie rate also increases (1). The maximum desired wartime sorties rate is 3.5 and the minimum desired rate is 1.6. Once the desired availability is determined, the affects of the influencing factors can be introduced.

The influences of the factors which impact the desired aircraft availability are each computed in a table function. Both the reliability and maintainability factors will reduce availability when they are below their desired levels. Although there are differing opinions on which of these factors has the largest impact on availability, it is clear that the impact of both is great. In the interview process it was established that maintenance personnel believe, regardless of reliability levels, aircraft are going to break, so the most important factor influencing aircraft availability is maintainability. For this reason, maintainability is given a slightly larger impact than reliability. The impacts of the spares and maintenance capability factors can reduce availability in a manner similar to reliability but can also improve aircraft availability. Better maintenance capability and a more adequate supply of spare parts can cause improvements in aircraft availability which exceed the desired availability (20). Although this seems unlikely when viewing current funding levels and maintenance retention rates, if long periods of high pressure to improve readiness are experienced, aircraft availability could exceed the desired level. The cause of this increased availability would primarily be attributed to the level of spares and the maintenance capability. The materiel readiness sector is the last which remains to be discussed and will be covered next.

Materiel Readiness

The importance of having an adequate supply of spare parts was discussed in the previous section. The materiel readiness sector of the model attempts to capture the process of acquiring and maintaining this supply. Figure 5-10 presents the flow diagram developed to capture the structure of this sector of the model. It contains a level of spare parts (LOS) and several rates which serve to increase and decrease this level. The rates which

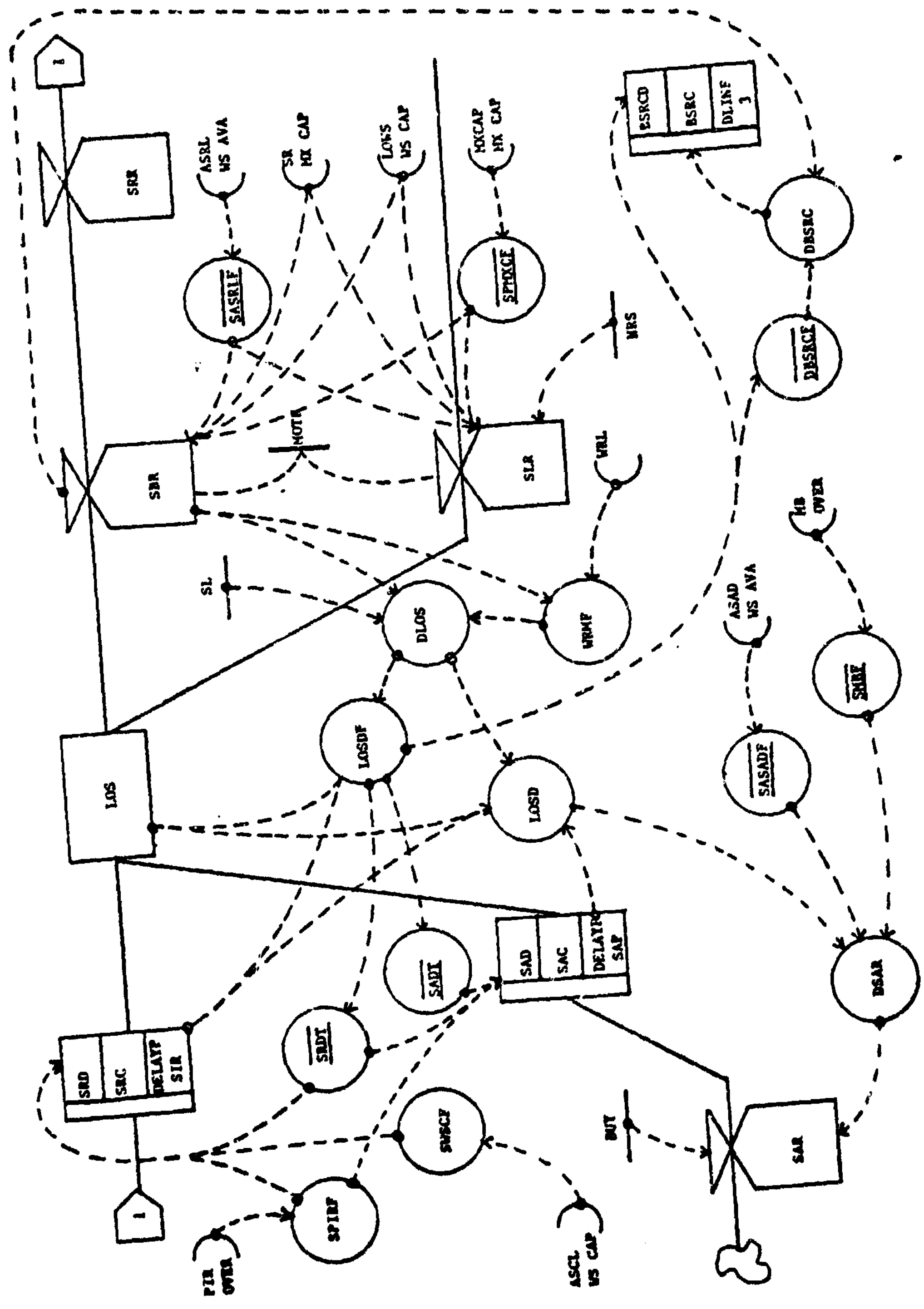

Fig. 5-10. Materiel Readiness--Flow Diagram

increase the level of spares are the spare acquisition complete rate (SAC) and the spare repair complete rate (SRC).

The spare acquisition complete rate is a delay of the spare acquisition rate. The length of the delay (SAD) is dependent on pressure to improve readiness (SPIRF), the complexity of the weapons systems (SWSCF), and the level of spares discrepency percentage (LOSDP). Each of these factors can increase or decrease the acquisition delay (SAD). The effects of the pressure to improve readiness and the size of the discrepency on delay times has been discussed several times in this chapter. Their affect on the spare acquisition delay is the same. The affect of weapon systems complexity was modeled using the aircraft capability factor. This factor was included to reflect the impact that weapon systems complexity, based on aircraft capability, has on the time required to manufacture spares.

The spare acquisition rate is computed by comparing the desired spare acquisition rate to a minimum purchase order. The desired spare acquisition rate (DSAR) is computed by multiplying the level of spares discrepency (LOSD) by a military budget (SMBF) and an aircraft system availability (SASAF) factor (39). The spares military budget factor has a major impact on the number of spares purchased. When the military budget is at the lowest possible value, spare purchases are reduced fifty percent.

As the budget increases to higher values, spare purchases increase, reaching a maximum value of 1.2 or an overbuy situation. The aircraft system availability discrepency factor impacts the purchase of spares by bringing attention to the impact of reduced spares. If no availability discrepency exists then little attention is focused on the spares situation and less are purchased.

The delay in repairing broken spares is included in the spare repair complete rate (SRCR). The length of this delay (SRD) was set at an average time of six months and varied using the same factors which impacted the spares acquisition delay. The input to the spare repair complete rate is the maximum of the spare break rate or the spare repair capacity. To include the fact that spare repair capacity changes, factors to determine the desired spare repair capacity (DBSRC) and the time delay required to make a change in repair capacity (BSRCD) were included. The desired broken spare repair capacity is computed by multiplying the spare break rate by a factor. This factor, broken spare repair capacity (BSACF), increases the desired repair capacity as the levels of spares discrepency increases. The maximum broken spare repair capacity was set at two times the break rate to allow for surges in the system. This factor, in combination with a reduced repair time, will allow a larger percentage of possessed spares to be available for use and reduce the impact of a spares discrepency.

The spare break rate (SBR) and the spare loss rate are the two factors which reduce the level of spares. The spare break rate is determined by multiplying the current sortie rate by the level of weapon systems and two factors which reflect the aircraft reliability (SACRF) and maintenance capability (SPMXCF). From this value the number of nonreparable spares is subtracted to compute the total number of spares which will be entering repair. The maintenance capability factor was included in the equation to reflect the major impact is has on the number of spares which are sent to depot for repair. As maintenance capability decreases and less qualified personnel are working on aircraft, good parts are often replaced in an attempt to correct problems which were not correctly diagnosed (39). This practice increases the spare break rate and both the desired repair capacity and the desired level of spares. The spare loss rate is computed in the same manner as the spare break rate with the addition of a nonreparable spares percentage (NRS). The percentage is set at two and remains constant.

The last two factors in this section are the desired level of spares and the level of spares discrepency. The desired level of spares is computed by multiplying the spare break rate by the pipeline length and adding a safety level and a war reserve materiel factor. The pipeline length was defined as six months and the safety level was set at twenty percent. The war reserve materiel factor was computed by multiplying the desired wartime sortie rate by the aircraft reliability factor and the desired length of supply which was set at two months. With a desired level of spares computed, a comparison can be made with the actual level of spares and the level of spares discrepency determined. This discrepency was computed in both a number of spares (LOSD) and a percentage of desired spares (LOSDP). The equation for the level of spares discrepency takes the desired level of spares and subtracts the level of spares, the number of spares in the repair pipeline (SIR), and the number of spares in the acquisition pipeline (SAP). The percentage discrepency is computed by adding the same three factors and then dividing by the desired level of spares. Information about the level of spares discrepency percentage is then used in the aircraft availability sector of the combat readiness model.

Summary

This chapter has presented the flow diagrams and system equations as they were developed to model the combat readiness system. The model sectors are driven by the pressure to improve readiness and the discrepencies which exist in each respectively. These system equations were then run as sectors to validate the model. The procedure used to accomplish this is discussed in Chapter 6.

CHAPTER 6

VALIDATION AND VERIFICATION OF THE COMBAT READINESS MODEL

The validation procedure described in Chapter 3 was used in validating the combat readiness model. This process involves a series of steps which, when satisfactorily accomplished, will allow the modeler to gain sufficient confidence in his model so that he will be able to use it for its intended purpose (7:181). This chapter will describe the validation efforts which were accomplished for each of the ten sectors of the combat readiness model. Although the sectors were combined and run as a single model, time constraints did not allow for validation of the combined sectors. The first step which was accomplished in the validation process was a review of the system boundaries

In viewing the boundaries of the combat readiness system, two approaches were used. The first was to view the entire system as it relates to its environment and determine if all the factors which impact its behavior were modeled. After this was accomplished, each sector of the model was viewed to insure that the factors affecting their behavior, both internal and external to the combat readiness system, were included. In both cases, the problem statement and research objectives presented in Chapter 1 were used to guide the examination. As discussed in Chapter 4, the USAF combat readiness system is an instrument of national power. Its ultimate goal is to insure that the national objective is met. That objective is to insure the preservation of the United States with its fundamental institutions and values intact (44:1-1). Viewing the combat readiness system from this standpoint highlights the importance of including factors which were contrary to the United States national objectives and factors from the national command structure in the models. In examining the combat readiness model boundaries, no omissions were discovered. The evaluation of the sector boundaries was accomplished next.

In viewing the boundaries of the model's sectors, the goal of each sector and its impact on the combined readiness model was studied. Each sector was examined to determine if omissions were made which could affect the operation of the system. Although no omissions were made, two areas were identified where further structure could better define the relationships which exist. The areas are the aircraft capability and the materiel readiness sectors. Although the effect of systems capability improvement was included in the materiel readiness structure, the simple structure of the aircraft capability sector did not allow for specific reactions from occurrences such as the introduction of a new weapon system. Although such a relationship was planned in the combat readiness model, time constraints prevented its inclusion. After viewing the boundaries of the combat readiness model, the computer programs were run and checked for gross errors.

After the computer programs were "debugged," each program was run, listing a sufficient number of variable values to determine if the equations were performing their operations as the modelers had intended. The accomplishment of this step of the validation process was long and complex. The result was increased confidence in the model's sectors. Figure 6-1 gives an example of the graph which resulted from a gross error check made on the combat readiness overview sector. After the error check was completed, each sector was viewed to determine if its structure adequately represented that of the system it was modeling.

The process of reviewing the structure of the system is primarily concerned with insuring that the variables in the model are properly interconnected (7:183). This process was accomplished by compiling the notes from the interview process and the literature review by sector and then comparing them to the sector flow diagrams. In this step of the validation process there were several instances where conflicting information was evident. In each such occurrence, the knowledge of the persons interviewed and their familiarity with the relationship in conflict was viewed. Information from the persons who seemed the most

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         0.    T         10.000T        20.000T        30.000T        40.000T 12
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         0.              0.050          0.100          0.150          0.200  4
         0.              5.000         10.000         15.000         20.000  5
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         .     64       5 1  2         .               .               . 23
         .     64       5  1 2         .               .               . 23
    144.0. - - - 4 - - -.5 1 2 - - - - . - - - - - - - -.- - - - - - - - . 23,46
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         .      64      .    12        .               .               . 23,15
         .       4      .    1235      .               .               . 46
    156.0. - - - -4- - -.- -123- -5- - . - - - - - - - -.- - - - - - - - . 46
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         .            4.6    2 1      3.              5                .
    180.0. - - - - - - -4-6- 2 1 - - - 3 - - - - - - - -5- - - - - - - - .
         .              .4 6 2  1      . 3            5                .
         .              . 4 62  1      .   3        5 .                .
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         .              .    246 1     .     5   3    .                .
         .              .    2  4 1    . 5         3  .                . 46
         .              .    2   41   5.             3.                . 46
    204.0. - - - - - - -.- - 2 - -51 - . - - - - - - - -.3 - - - - - - . 14,56
         .              .    2 5   14  .                . 3            . 16
         .              .   52     14 .                 .  3           . 16
         .              . 5  2     1  4                 .  3           . 16
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         .              5    2       16. 4              .  3           .
         .              .5   2       1. 4              . 3             . 16
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         .              .    2  5      164           3.                .
         .              .    2     5   1 4          3 .                . 46
    240.0. - - - - - - -.- - 2 - - - - 514 - - - - 3 -.- - - - - - - - . 46
         .              .    2         .145        3  .                . 46
         .              .    2         .41    5  3    .                . 16
         .              .    2         .416     35    .                .
```

Fig. 6-1. Combat Readiness Overview--Computer Plot familiar and closest to that section of the system was used. Conflicts also arose in the checking of the parameter values used in several relations of the model. The checking of the parameters was the next step of the validation process.

As discussed in Chapter 3, the parameter values used in a model vary in importance (7:183). Because most of the parameter values are robust in nature, if they are within the approximate range of the actual system values, they will be sufficient to provide for adequate operation of the model. At this point of the validation process the combined notes from the interviews were again reviewed. Where conflicts existed, the same selection criteria as described in the structural analysis stage was used. In several cases compromise values were developed based on the inputs from several different interviews. One set of values which was determined in this manner was the selection as to the relative importance of reliability and maintainability as they impact aircraft availability. Personnel who were associated with the maintenance side of availability felt that maintainability was unquestionably the most important aspect of availability while those associated with the materiel side felt reliability unquestionably had the largest affect. In cases such as these, the modelers attempted to weigh the amount of bias which was evident in the interview before selecting the criteria to be used.

During this stage of the validation process, a search was made for parameters which were extremely sensitive to change. This process was limited because the sectors were run individually. One parameter did surface as having a major impact on the pressure to improve readiness. That parameter is the United States perception factor (USPF). When this perception factor was varied, the change in the pressure to improve readiness under similar conditions of enemy expansionary activity was large. This response points out how misconceptions of enemy capability can cause an over or under reaction to an enemy's expansionary activities. The last step of the validation process was to view each sector's behavior as it relates to that of the actual system.

To evaluate the system sector behavior, each sector of the model was run until it reached an equilibrium condition. The relationship of the sector variables were then studied to determine if they corresponded with the actual system. An example of this process was the evaluation of the personnel manning levels. These levels were plotted on the graph shown in Figure 6-2; their individual percent of the total force was computed. These figures were then compared to the system manning goals to determine if they were compatible (9). After this process was completed, the variables which represented inputs from another sector of the model were varied and the sector

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MXML(1)=1  MXML(2)=2  MXML(3)=3  MXML(4)=4

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    .          34 .     2       .              .            1.
    .          34 .    2        .              .            1.
    .          34 .    2        .              .            1.
    .          34 .    2        .              .           1 .
    .          34 .    2        .              .           1 .
    .          34 .    2        .              .           1 .
    .          3 4.    2        .              .           1 .
    .          3 4.   2         .              .           1 .
    .          3 4.   2         .              .          1  .
30.0.----------3 4.---2---------.--------------.----------1--.
    .          3 4.   2         .              .          1  .
    .          3 4.   2         .              .          1  .
    .          3 4.   2         .              .          1  .
    .          3 4.   2         .              .          1  .
    .          3 4.   2         .              .          1  .
    .          3 4.   2         .              .          1  .
   ..          3 4.   2         .              .          1  .
    .          3 4.   2         .              .          1  .
    .          3 4.   2         .              .         1   .
60.0.---------3--4.---2---------.--------------.---------1---.
    .         3  4.   2         .              .         1   .
    .         3  4.   2         .              .         1   .
    .         3  4.  2          .              .         1   .
    .         3  4.  2          .              .         1   .
    .         3  4.  2          .              .         1   .
    .         3  4.  2          .              .         1   .
    .         3  4.  2          .              .         1   .
    .         3  4.  2          .              .         1   .
    .         3  4.  2          .              .         1   .
90.0.---------3--4.--2----------.--------------.---------1---.
    .         3  4.  2          .              .         1   .
    .         3  4.  2          .              .         1   .
    .         3. 4.  2          .              .         1   .
```

Fig. 6-2. Maintenance Manning Level--Computer Plot response studied. This process added further confidence in the relationships which were developed as well as comparing the sector's behavior to the portions of the combat readiness system it was modeled to represent.

The validation process was accomplished to gain confidence in the model's sectors so that they could be used for their intended purpose. It was not accomplished to prove the sectors were valid; it was intended to show that the validation procedures used did not prove them incorrect. It also added confidence to the combined combat readiness model. The accomplishment of the validating process on each portion of a model has the same effect as validating the entire model (14:177). The successful accomplishment of the sector validation has provided enough confidence in the model to allow some general conclusions about the combat readiness system to be made. This will be accomplished in Chapter 7.

CHAPTER 7

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

The general objective of this research project was to provide a vehicle to enable commanders to project the effects of their policy decisions in terms of improvements to combat readiness. The specific objectives, as presented in Chapter 1 were to:

1. identify the factors affecting combat readiness;

2. capture the interaction of these factors in their relationship to combat readiness;

3. construct a dynamic systems and mathematical model of the combat readiness system;

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

5. verify and validate that the model represents this system; and

6. identify critical areas of concern for policy makers.

This chapter will summarize the research effort as it relates to each of the objectives. Following the summary, some conclusions about the combat readiness system will be presented. The last section of the chapter will contain recommendations concerning the continued development of the combat readiness model.

Summary

The first objective of this research effort was to identify the factors affecting combat readiness. This was accomplished through the development of the sectors which exist in the combat readiness system. The system was divided into ten sectors, which included the areas: combat readiness overview, aircrew manning, aircrew capability, maintenance manning, maintenance capability, support manning, support capability, aircraft capability, aircraft availability and materiel readiness. Within each of these sectors, relationships were identified which influenced not only the sector that contained them but also other sectors of the model. This identification process led to the accomplishment of the second objective.

The second objective of this research was to capture the interaction between the factors which affect combat readiness. The process used to accomplish this objective was a combination of interviews and literature review. The interaction between the factors which affect combat readiness as identified to meet this objective were presented in Chapter 4. The pressure to improve readiness was identified as the primary influencing factor in the combat readiness system. This factor was determined by the level of enemy expansionary activity and the United States perceived deficiency. It had a major impact on the other sectors of the model. With this understanding of the relationships which exist in the combat readiness system, the third objective could be accomplished.

The construction of a dynamic systems and mathematical model of the combat readiness system was the third objective of this research. This process was accomplished through the development of flow diagrams. Models were developed for each sector of the combat readiness system and presented in Chapter 5 along with a discussion of the computerized model equations that were developed to meet the fourth research objective. With a computerized model developed, the process of verifying and validating it, research objective number five, was initiated.

The validation and verification of the combat readiness model was presented in Chapter 6. It included a five step process of reviewing the system boundaries, checking the models for gross errors, viewing the structure of the model as it compared to the structure of the system, checking the parameter values, and lastly, comparing the model's behavior to that of the system. Through this process, sufficient confidence in the model was established to make generalized conclusions about the combat readiness system. The presentation of these conclusions will be accomplished in the next section.

Conclusions

The combat readiness system as presented in this research is a goal oriented, negative-feedback system. Its goal is to provide an adequate air arm to the national command authority. Although time did not permit experimentation with the combined sectors of the combat readiness model, conclusions were reached through the interview process, the literature review and the study of the combat readiness sectors. These conclusions will be presented in this section of the chapter.

The first conclusion concerning the combat readiness system is that it truly lacks a valid measurement device. The UNITREP reporting system provides a measure of availability, but availability and readiness are not equal. Due to the lack of a valid readiness measure, misconceptions about a combat unit's ability to perform its wartime mission exist. "Readiness" is not a static concept, but is a product of the combined effects of the rates and levels which exist within the combat readiness sytem. Because of this, any reporting system which measures only levels or rates and not the combined effect of their interactions will result in distortion of actual "readiness." This distortion will have a serious impact of the readiness system's ability to respond to readiness deficiencies. The system dynamics approach to modeling appears to present a solution to this problem.

This research effort has shown that the measurement of combat readiness is possible. By determining the factors which affect combat readiness and modeling their interactions within the structure of the combat readiness system, a methodology for the measurement and study of combat readiness was provided. Although the research effort was not extended to include actual validation and experimentation with the combined sectors of the combat readiness model, it did demonstrate that such a methodology for combat readiness study is possible. Based on these conclusions the research recommendations were developed.

Recommendations

In order to achieve the full benefit of this study, it is recommended that the study of combat readiness, as a system, be continued. This further study should be conducted at two levels. The first is the continuation of the large scale policy model as presented in this research.

The combat readiness model which was produced by combining the ten model sectors presented in this chapter should be operated further and fully validated. This policy model will aid in determining the sensitive parameters which exist in the combat readiness system and will highlight areas of contrary intuitive behavior. The value of such a model lies in its ability to aid commanders in making policy decisions which affect the combat readiness system. Its power lies in its ability to simultaneously consider the multitude of variables which affect combat readiness. While such a model will aid in improving the management of combat readiness, the combat readiness system still lacks a valid measure of a unit's readiness.

The ability to accurately measure a unit's readiness level brings with it the ability to demonstrate the impact of different funding levels on individual combat units. It further enables commanders to more effectively distribute resources and to select the units which are best suited for a particular mission during a time of national emergency. The development of a system dynamics model to measure readiness at the unit level would provide this capability. The Air Force is currently attempting to develop such a model (3). It is recommended that this program receive the highest priority due to the major benefits which could be obtained from its successful completion.

APPENDICES

APPENDIX A

INTERVIEW GUIDE

1. Readiness Factors

a. What are your organization's primary contributions to combat readiness; or, what do you consider the primary factors which contribute to combat readiness?

b. Are there any factors which effect the results of your efforts to improve combat readiness or combat readiness factors?

c. If so, who controls these factors?

2. Decisions

a. What is the most critical decision you made in the last month concerning combat readiness or combat readiness factors?

b. How often do you have to make this type of decision?

c. Is this decision typical of the decisions which you make?

d. If it is not, what would you consider a typical decision you are required to make?

e. Was there a time factor involved in making this decision?

f. Did you receive any information after making this decision which would have altered your choice?

3. Decision Structure

a. How do you make a decision regarding the readiness factors?

b. What limits the alternatives available to you?

c. Are there better solutions to the problems which were not possible due to these limitations?

d. Why did you make the choice you did?

4. <u>Information for Decisions</u>

a. How did you find out about this problem?

b. Did you have to gather information to find a solution to this problem?

c. Where did you get this information?

d. What other information sources are important to you?

5. <u>Decision Implementation</u>

a. How did you implement your decision?

b. How long will it be before it is fully implemented?

c. Who is actually responsible for carrying out your decision?

d. What is his relationship to you?

e. How will your decision impact you, your organization, and other organizations?

6. <u>Feedback</u>

a. How will you know when your decision is fully implemented?

b. How long will this take?

c. How long will it take before your decision affects the system?

7. <u>Combat Readiness System Problems</u>

a. In your opinion, what is the weakest link in the combat readiness system?

b. Is this problem widely known?

c. Is anyone trying to solve it?

d. Are there any other major problems which need attention?

e. What areas do you consider best suited for readiness improvement efforts?

APPENDIX B

PERSONAL INTERVIEWS

Adams, Colonel Jimmy V., USAF. Assistant Deputy Chief of Staff for Requirements, Tactical Air Command.

Barrows, Colonel Ralph E., USAF. Assistant Deputy Chief of Staff for Intelligence, Tactical Air Command.

Bishop, Major Gerald K., USAF. Mission Area Analysis, HQ USAF.

Clark, Lieutenant Colonel Ronald, USAF. Logistics Plans Division, Tactical Air Command.

Czeluizmak, Lieutenant Colonel Donald R., USAF. Tactical Air Division, Programs Analysis and Evaluation, Office of the Secretary of Defense.

Demuith, Major Steven H., USAF. Chief, Maintenance Training Branch, 1st Tactical Fighter Wing.

Dixon, Major Howard L., USAF. Readiness Analysis Division, HQ USAF.

Duerbig, Major Alfred H., USAF. Manpower and Personnel Division, HQ USAF.

Fritz, Lieutenant Colonel Nicholas H., USAF. Mission Area Analysis, HQ USAF.

Frostic, Lieutenant Colonel Fredrick L., USAF. Studies and Analysis, HQ USAF.

Gasner, Lieutenant Colonel Robert R., USAF. Operations and Readiness Assessment Division, HQ USAF.

Greenwood, Major George R., USAF. Manpower and Personnel Division, HQ USAF.

Hammack, Major Larry C., USAF. Operations and Readiness Analysis Division, HQ USAF.

Hatch, Lieutenant Colonel Ronald N., USAF. Assistant Deputy Commander for Maintenance, 1st Tactical Fighter Wing.

Hawley, Colonel Robert E., USAF. Deputy Commander for Operations, 1st Tactical Fighter Wing.

McCarthy, Lieutenant Colonel Michael E., USAF. Tactics and Training Division, HQ USAF.

Miller, Colonel Donald L., USAF. Commander, 1st Tactical Fighter Wing.

Minter, Lieutenant General B. M., USAF. Deputy Chief of Staff for Logistics and Engineering, HQ USAF.

Olson, Major Douglas, USAF. Operations Plans Division, HQ USAF.

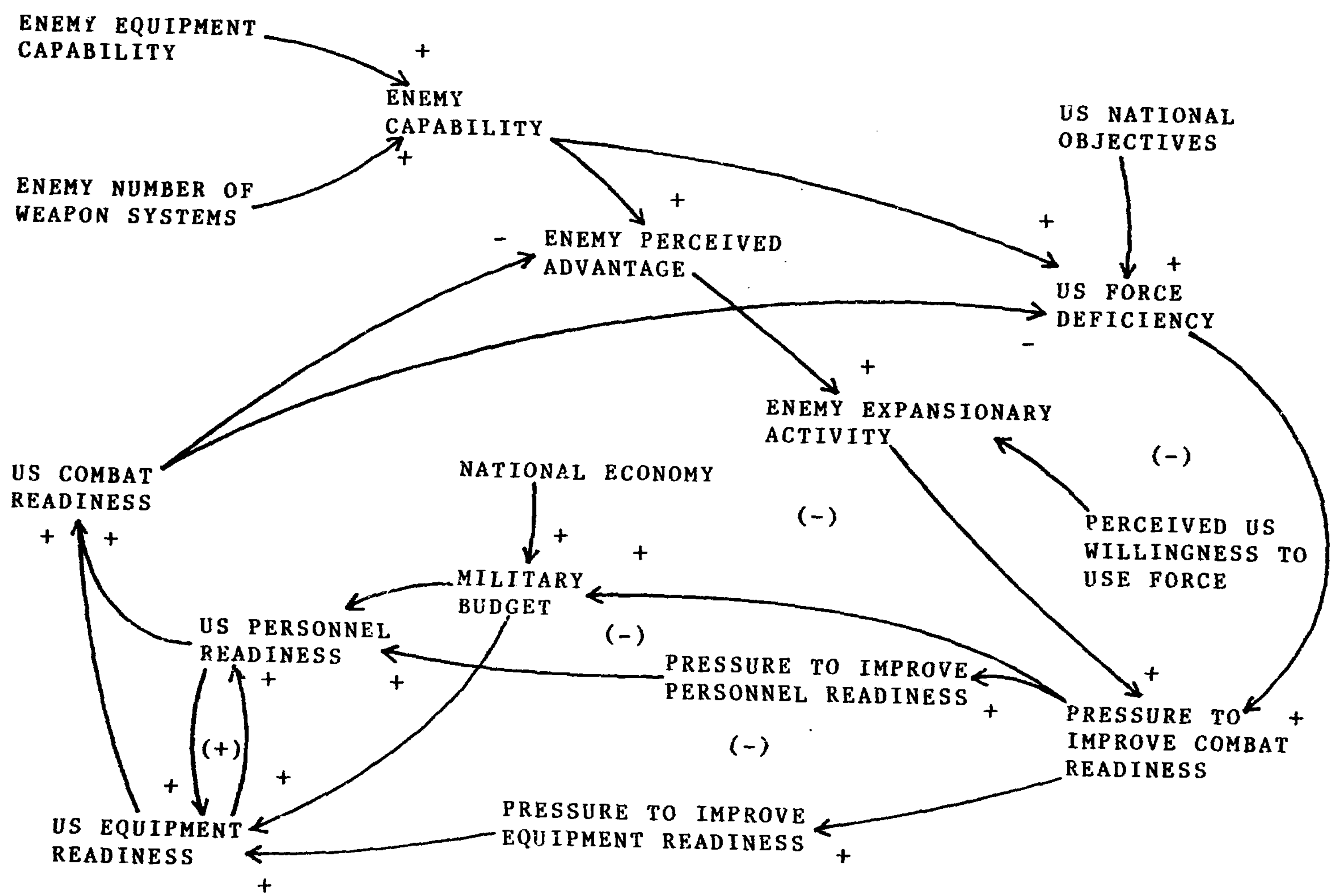
Pickett, Brigadier General John L., USAF. Deputy Chief of Staff for Plans, Tactical Air Command.

Uher, Colonel Edward L., USAF. Deputy Director of Logistics Plans and Programs, HQ USAF.

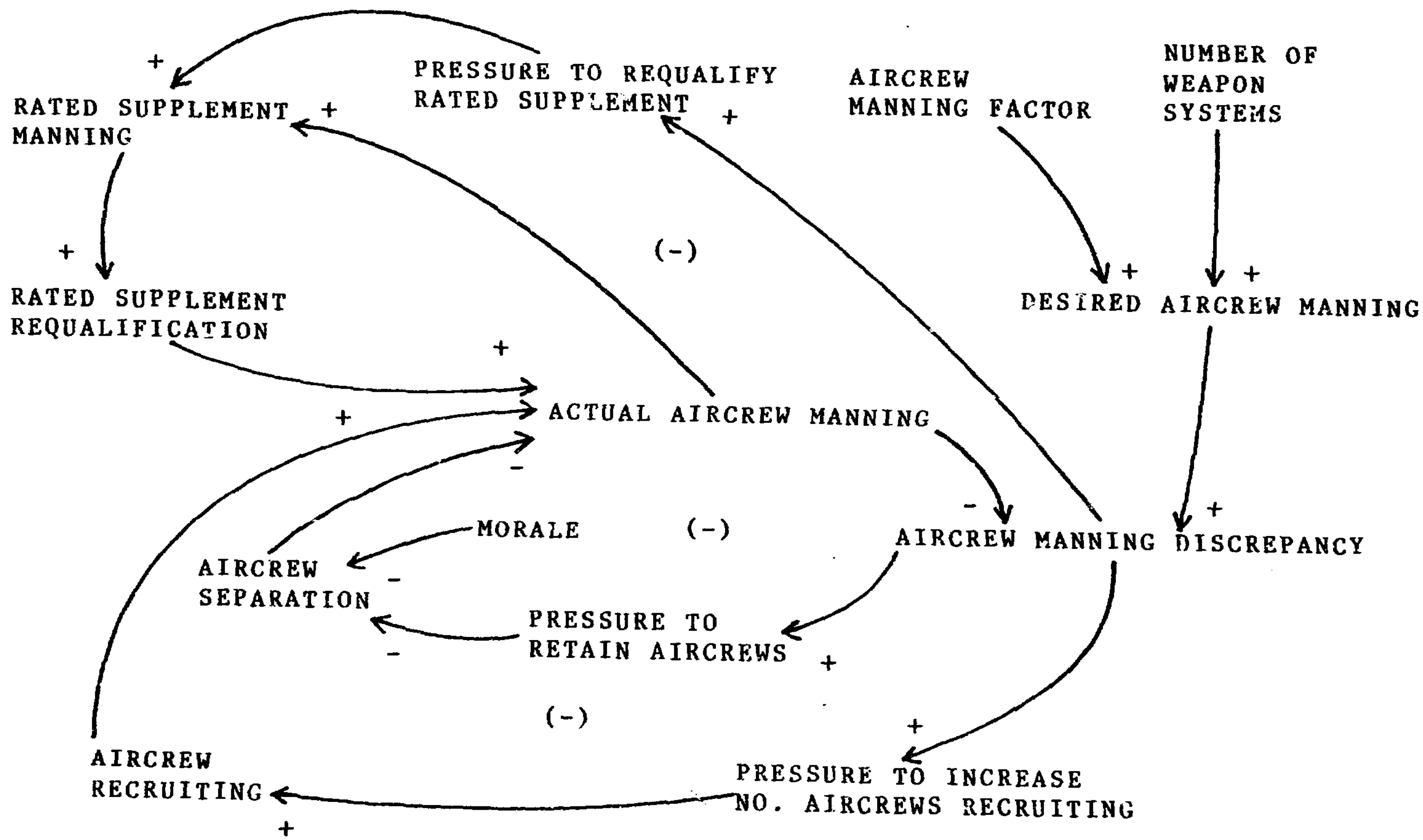
Welch, Major General Larry D., USAF. Deputy Chief of Staff for Operations, Tactical Air Command.

APPENDIX C

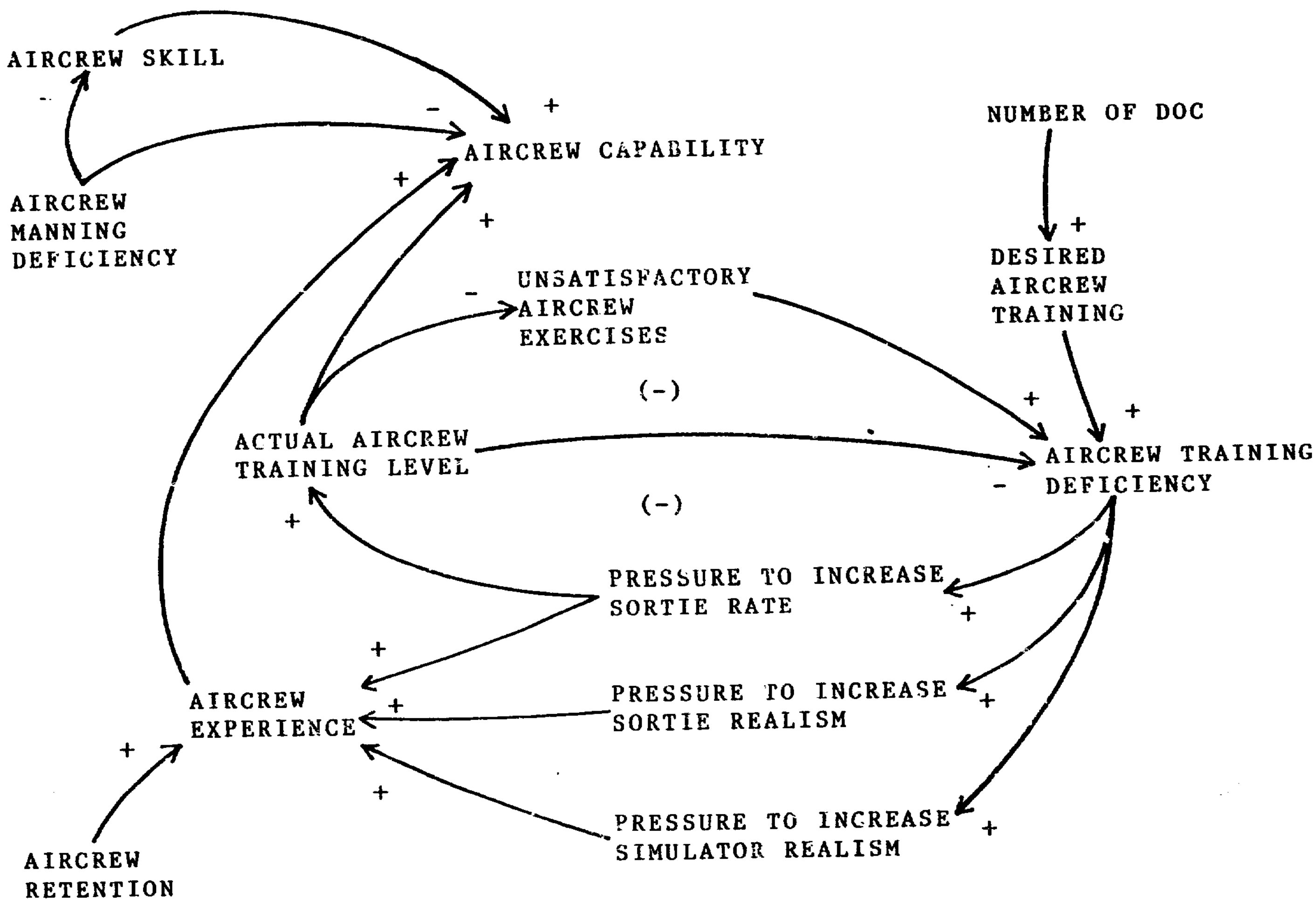
CAUSAL LOOP DIAGRAMS



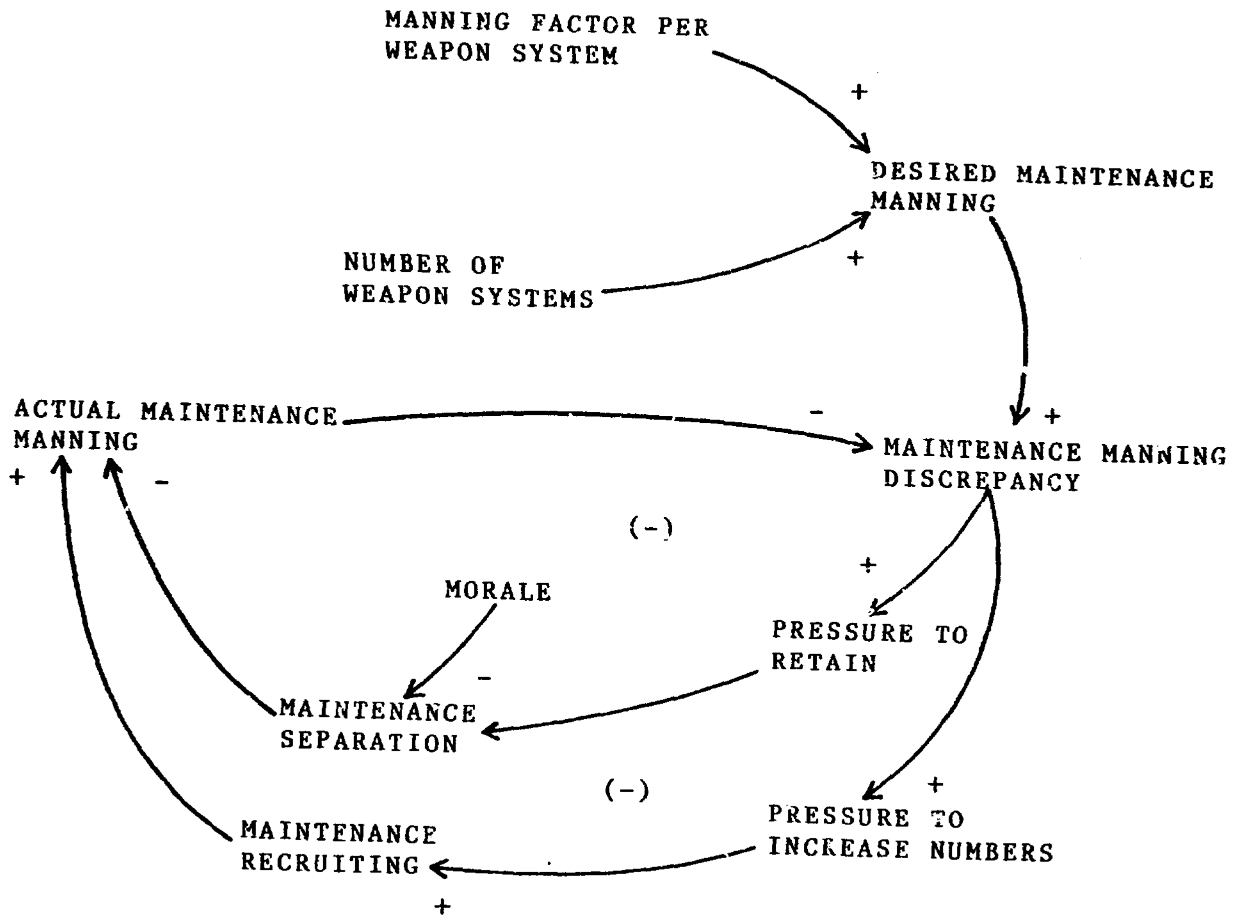
Combat Readiness Overview



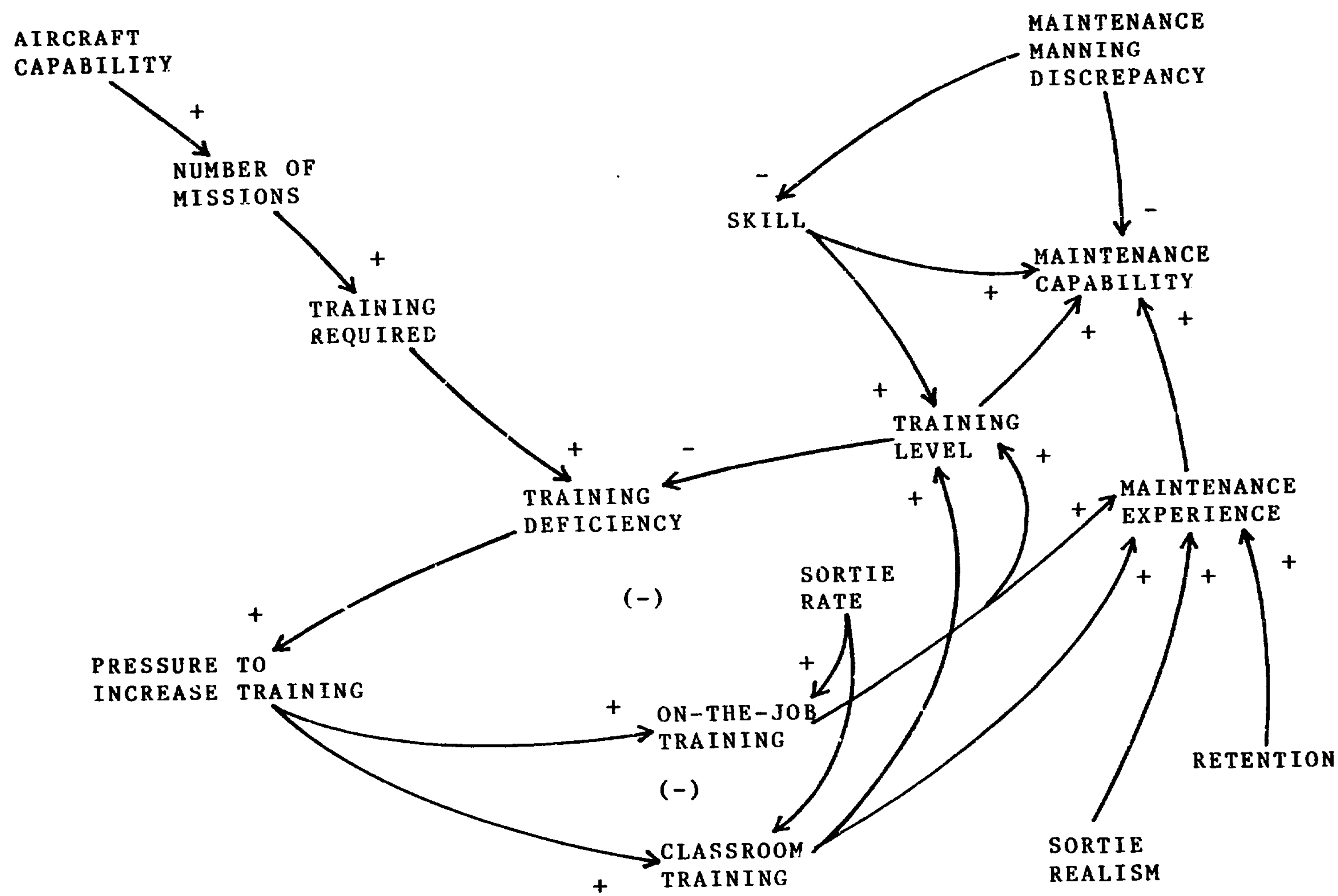
Aircrew Manning



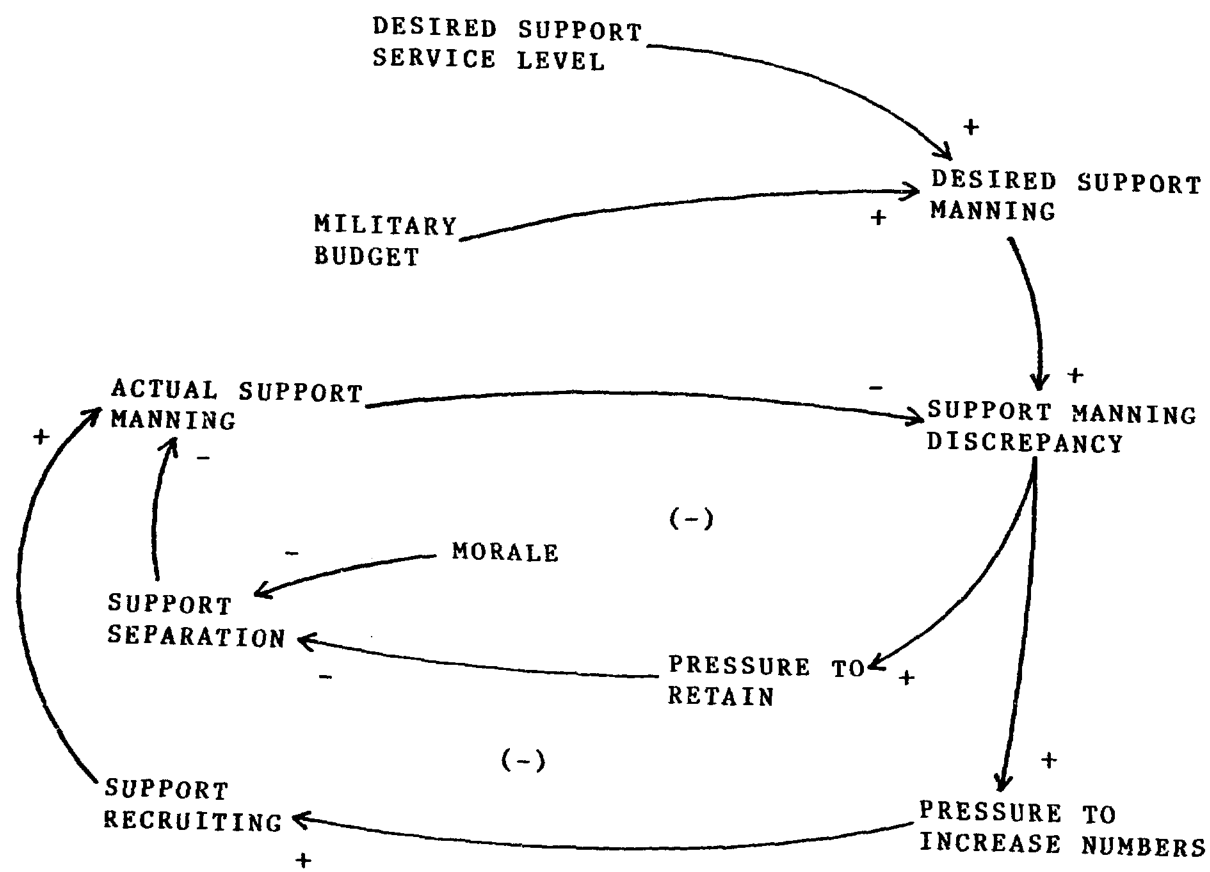
Aircrew Capability



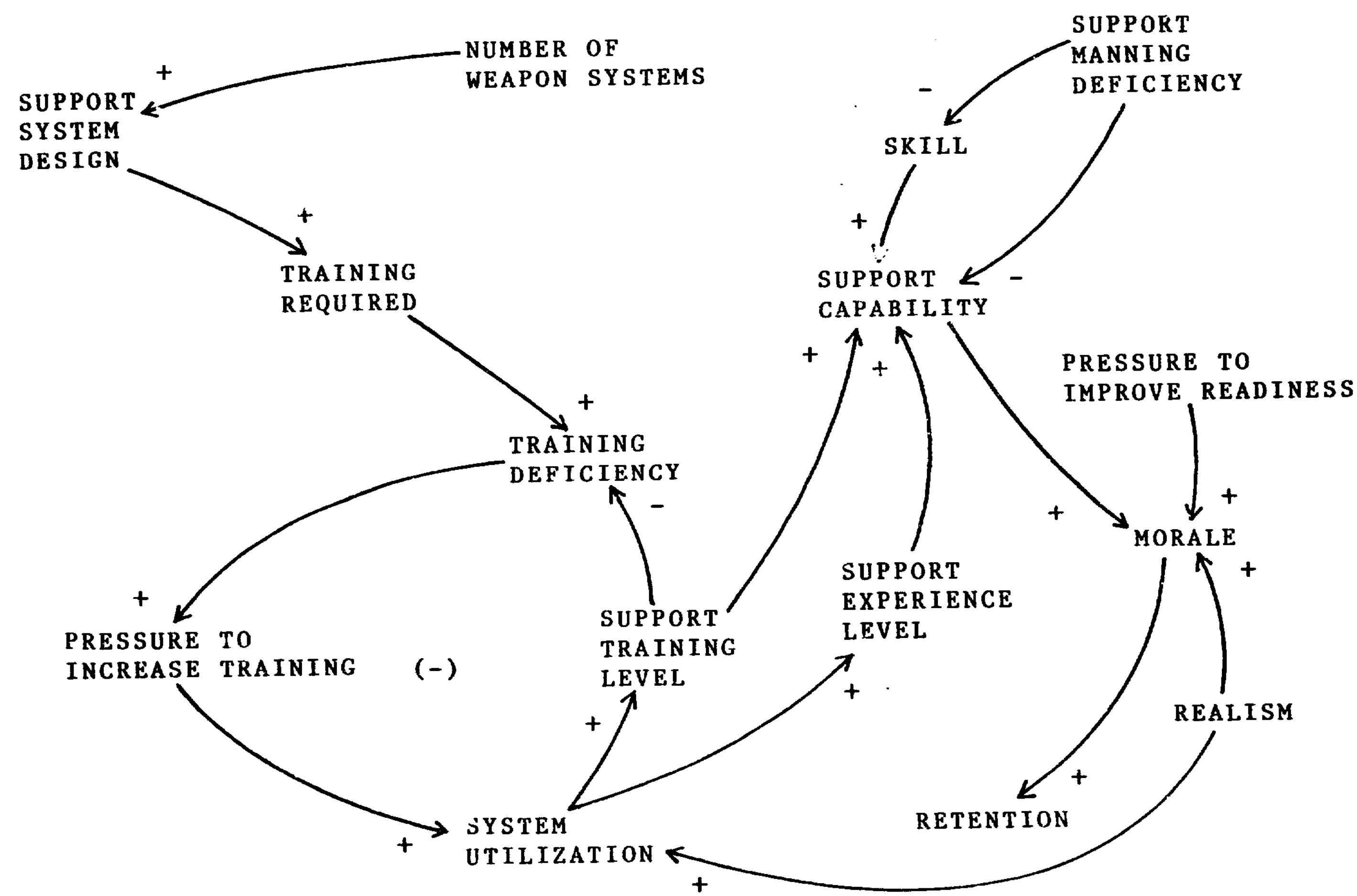
Maintenance Manning



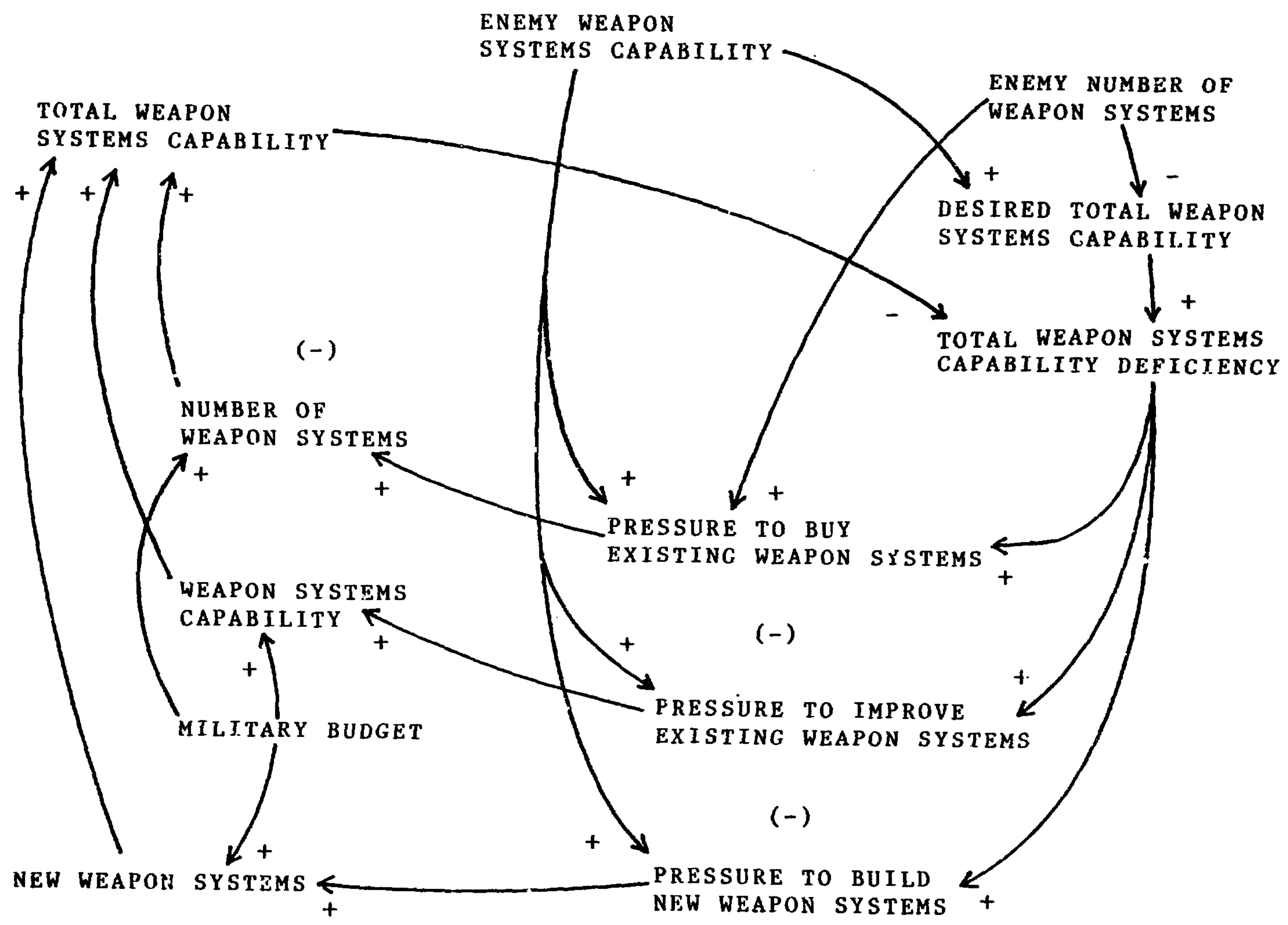
Maintenance Capability



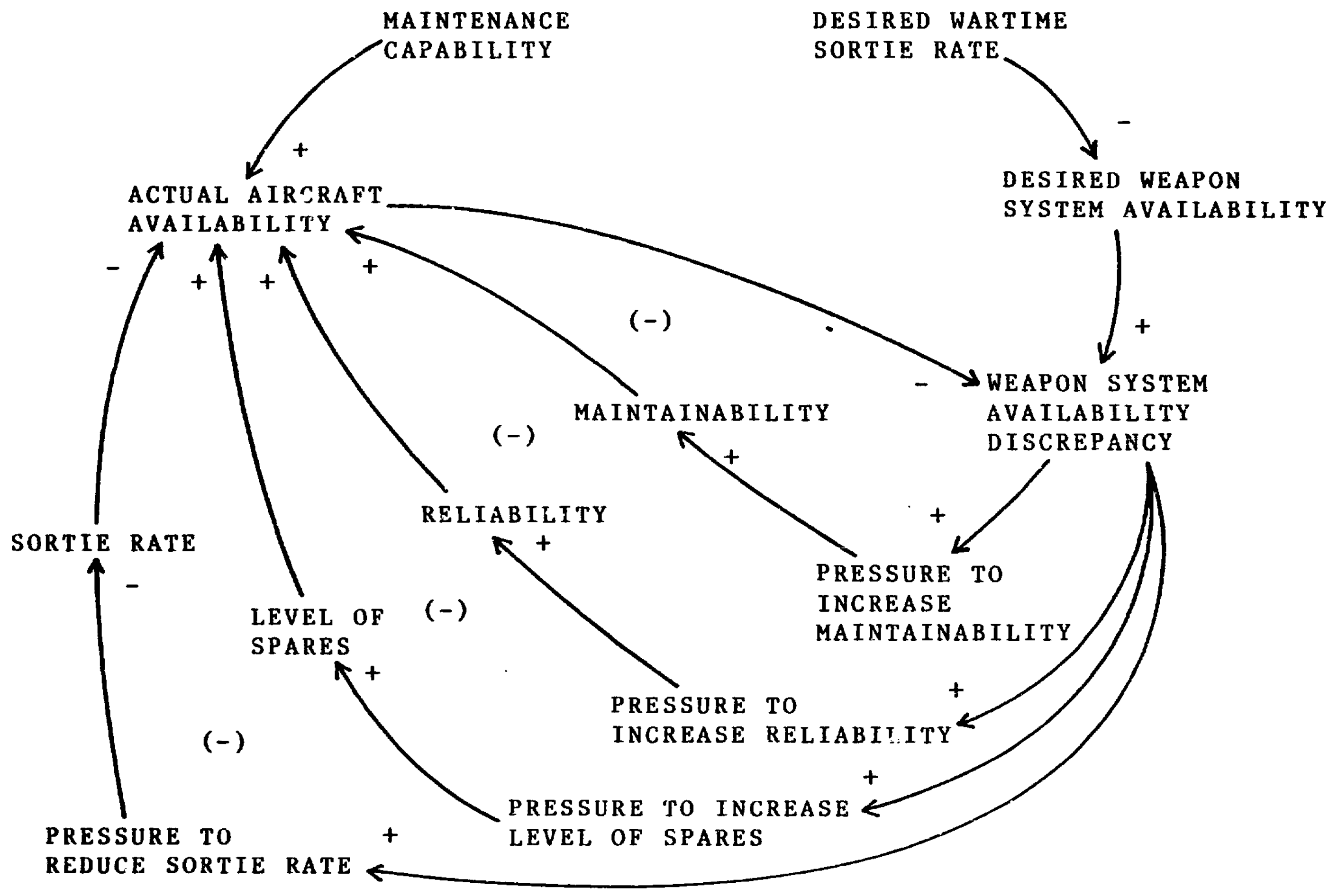
Support Manning



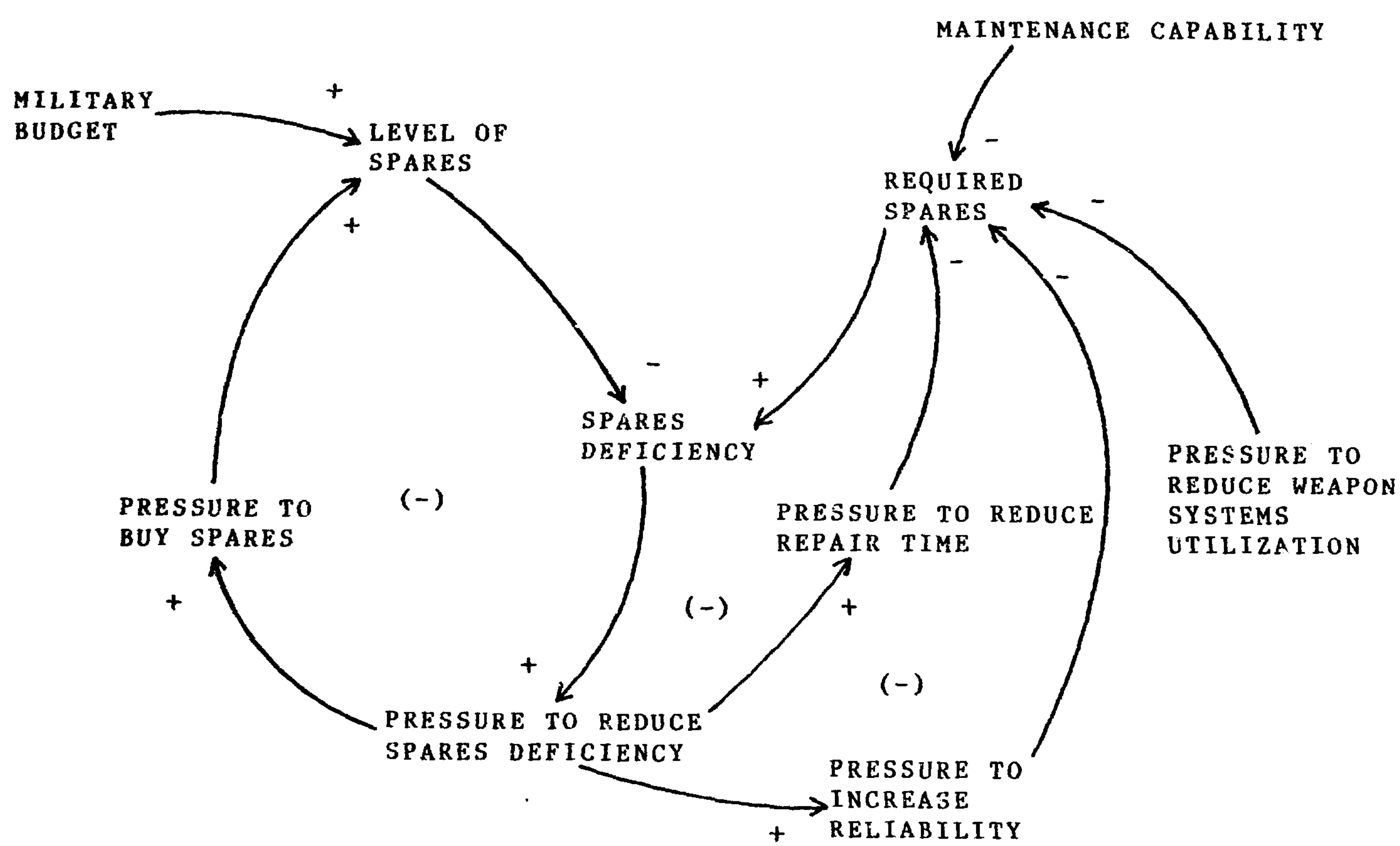
Support Capability



Weapon Systems Capability



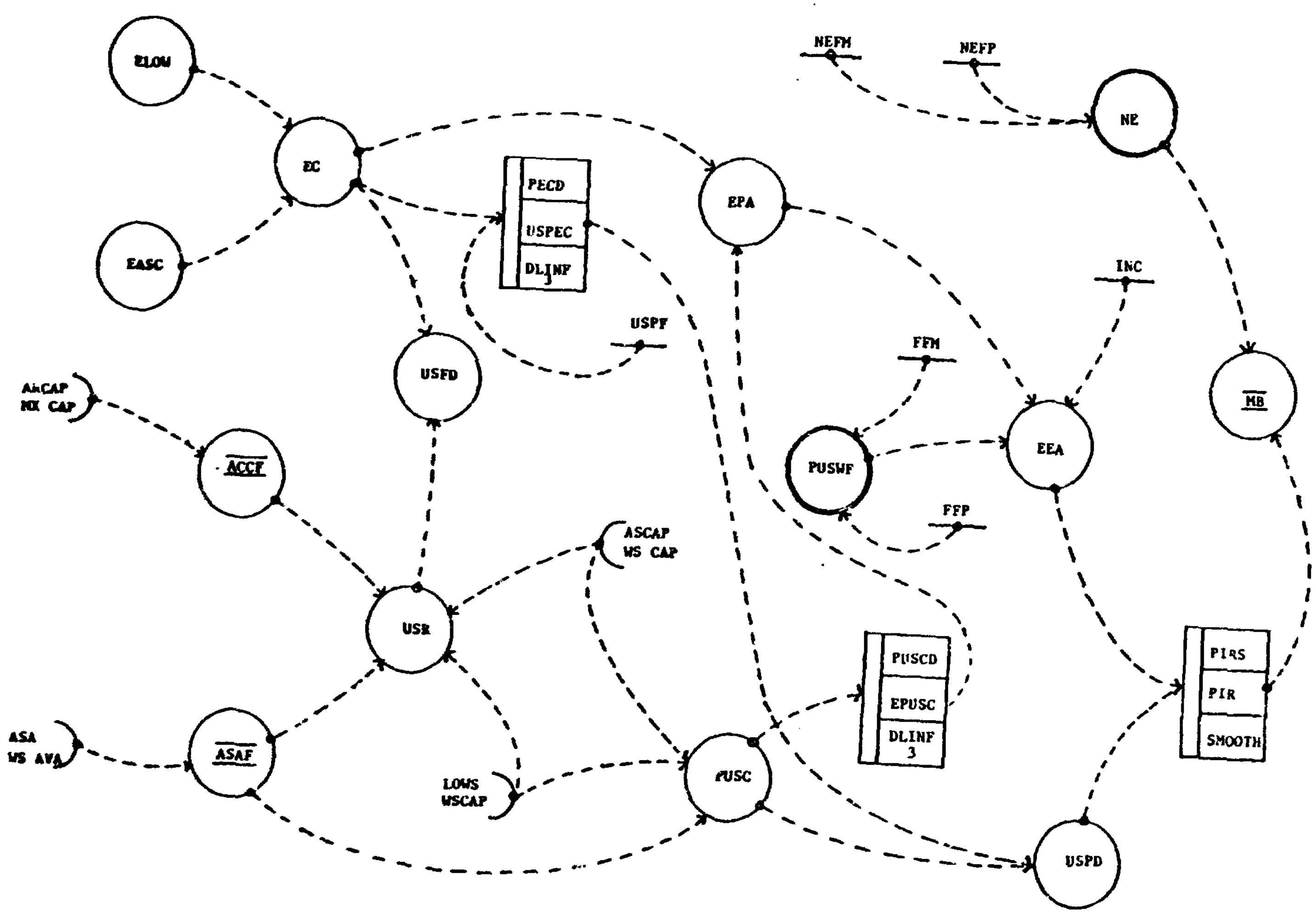
Aircraft Availability



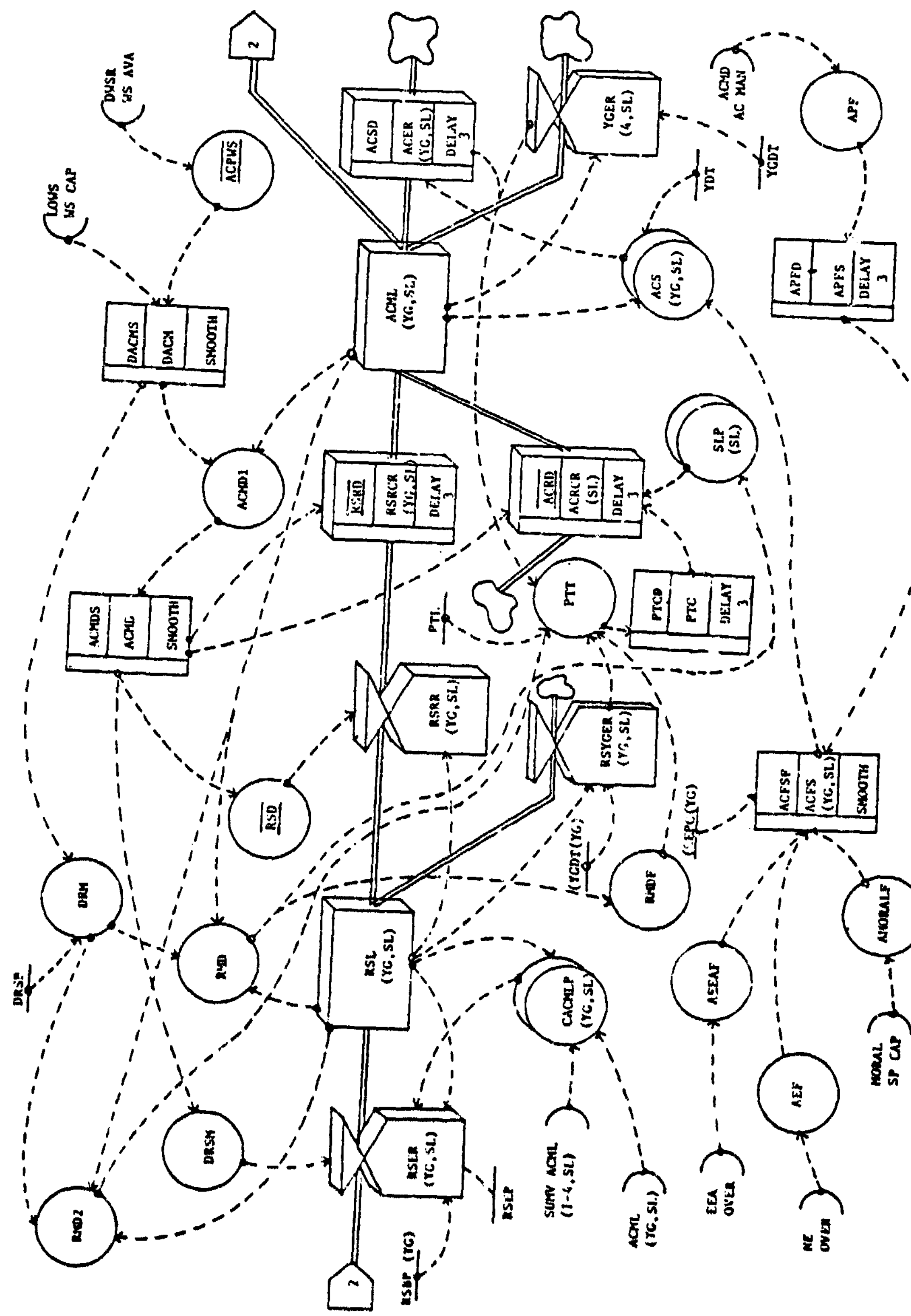
Materiel Readiness

APPENDIX D

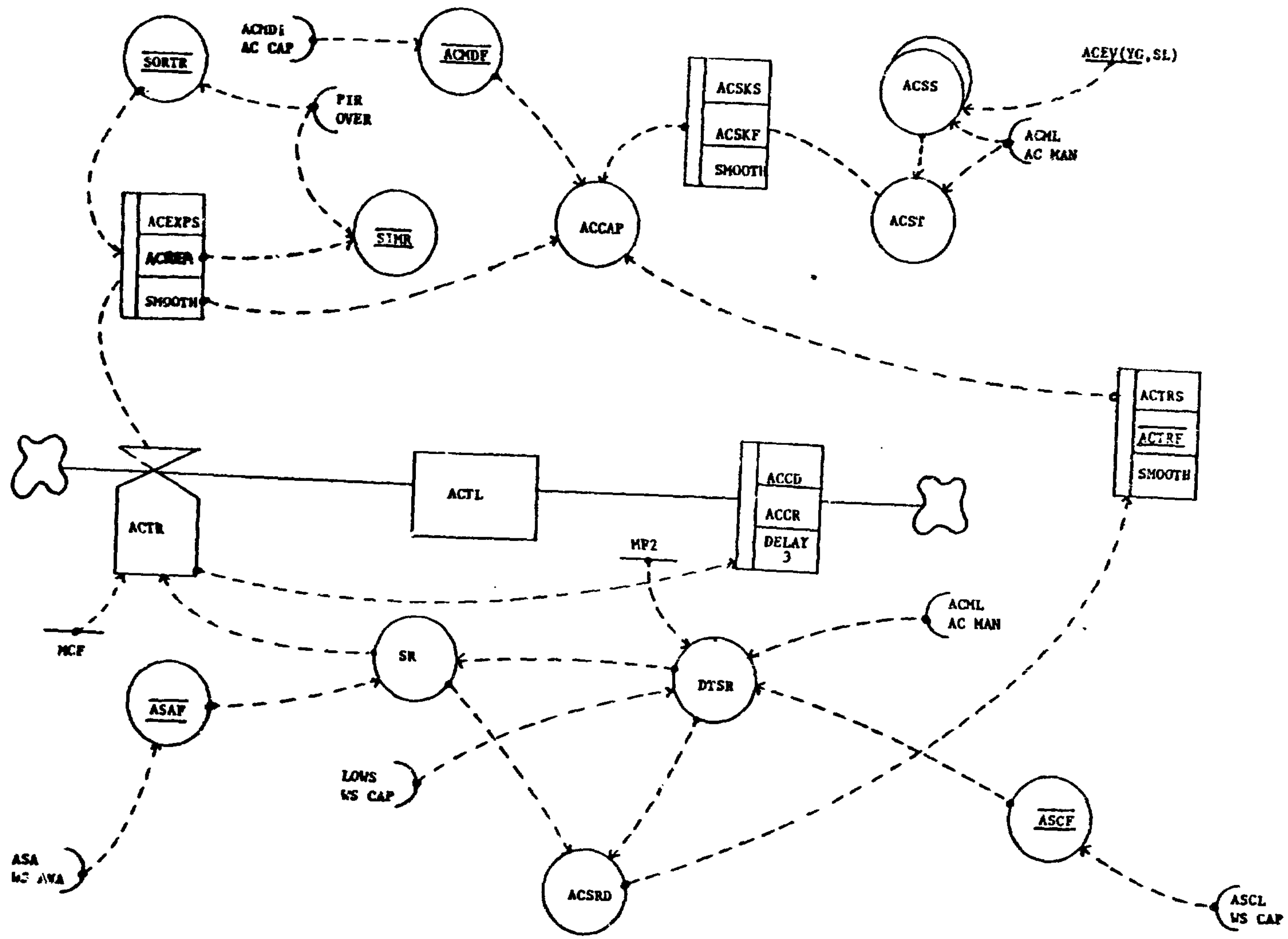
FLOW DIAGRAMS



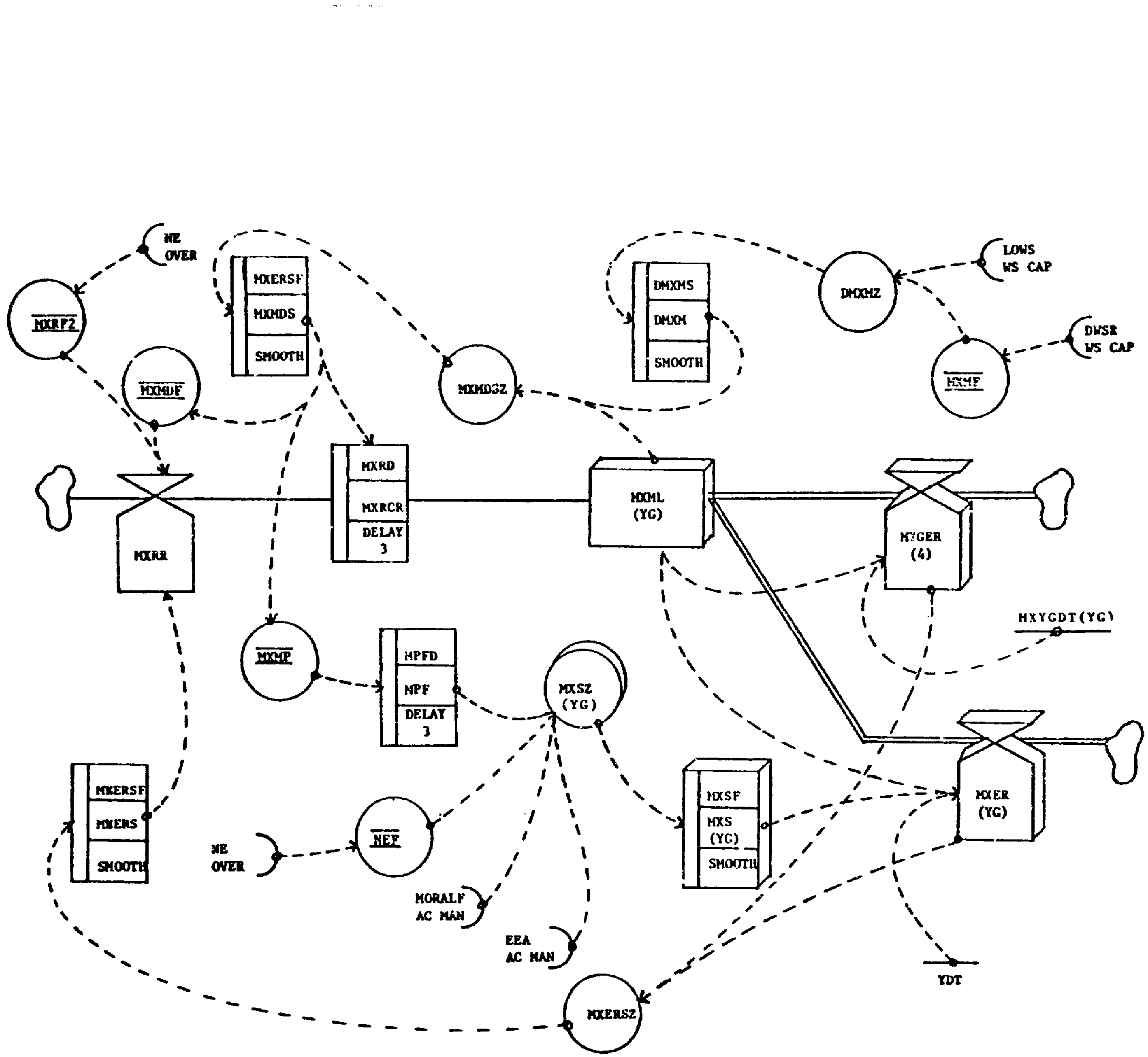
Combat Readiness Overview



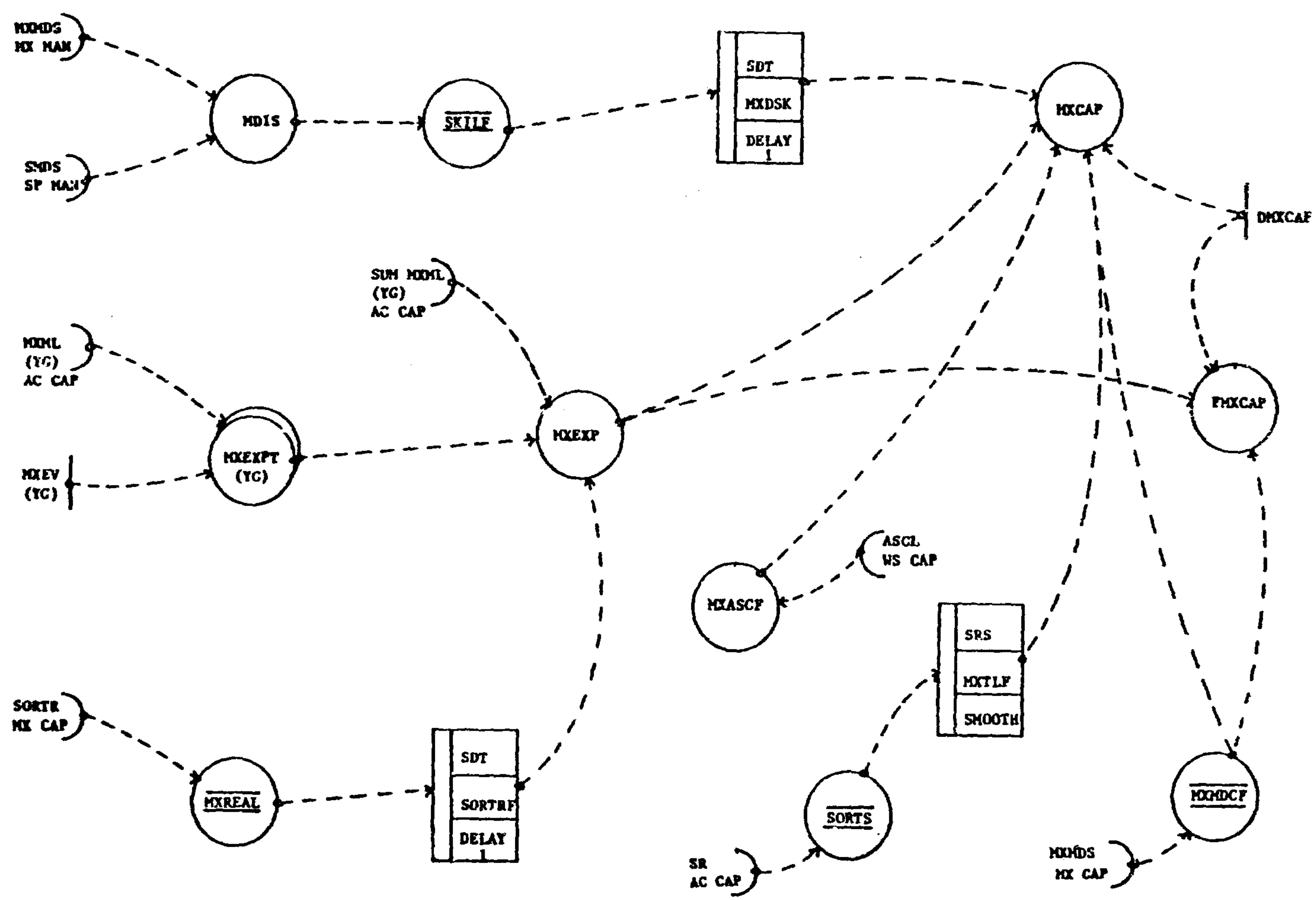
Aircrew Manning



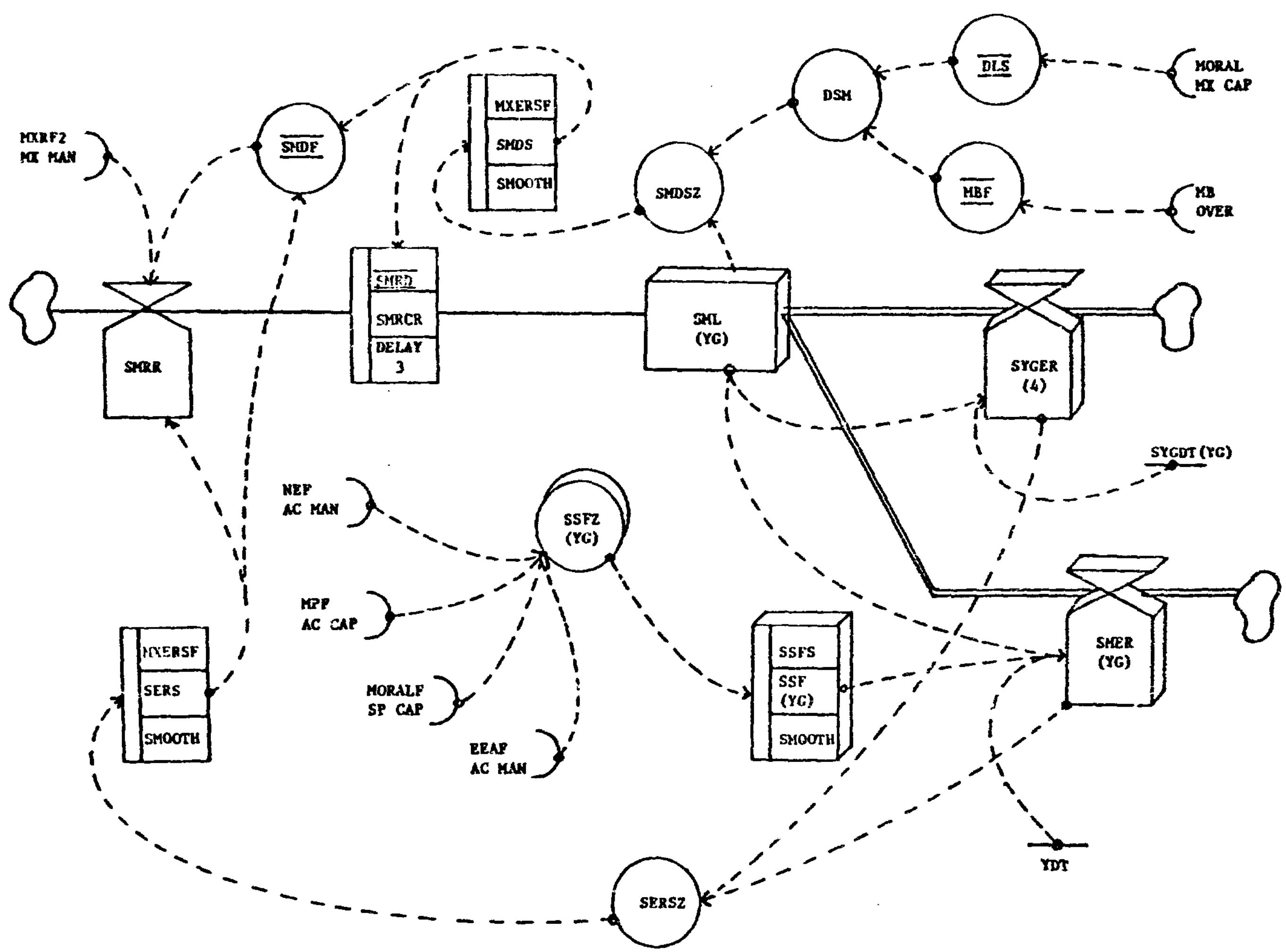
Aircrew Capability



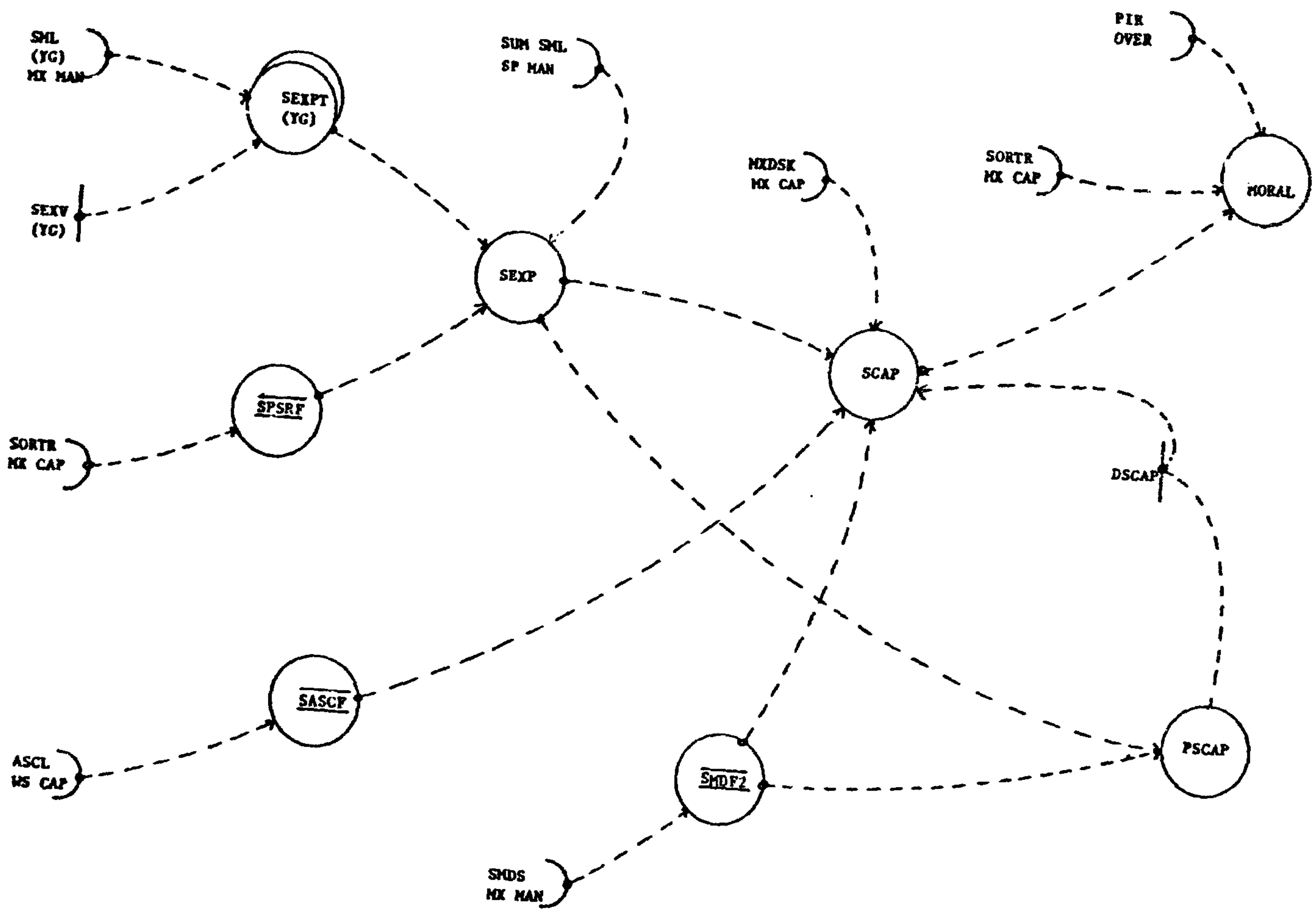
Maintenance Manning



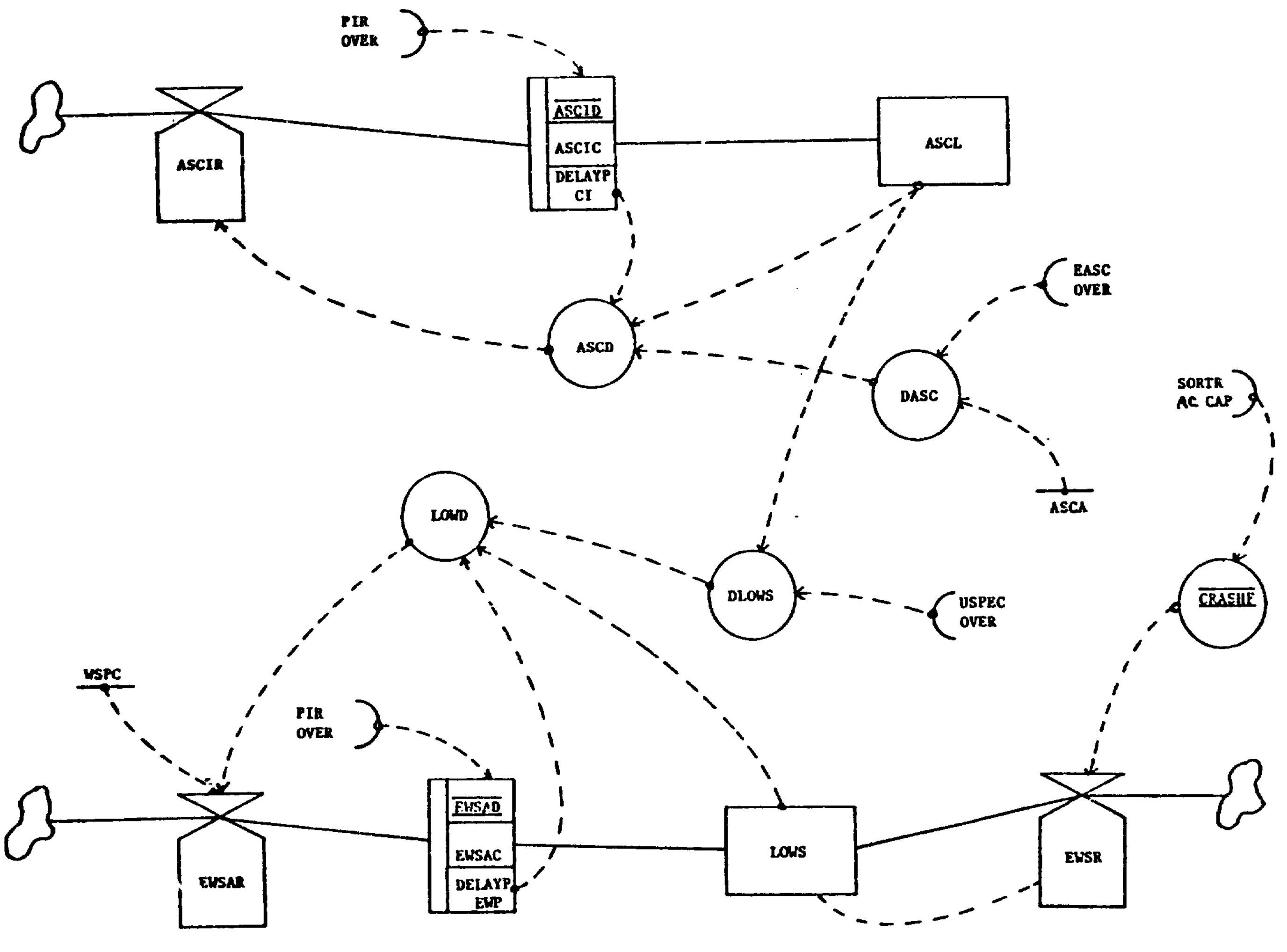
Maintenance Capability



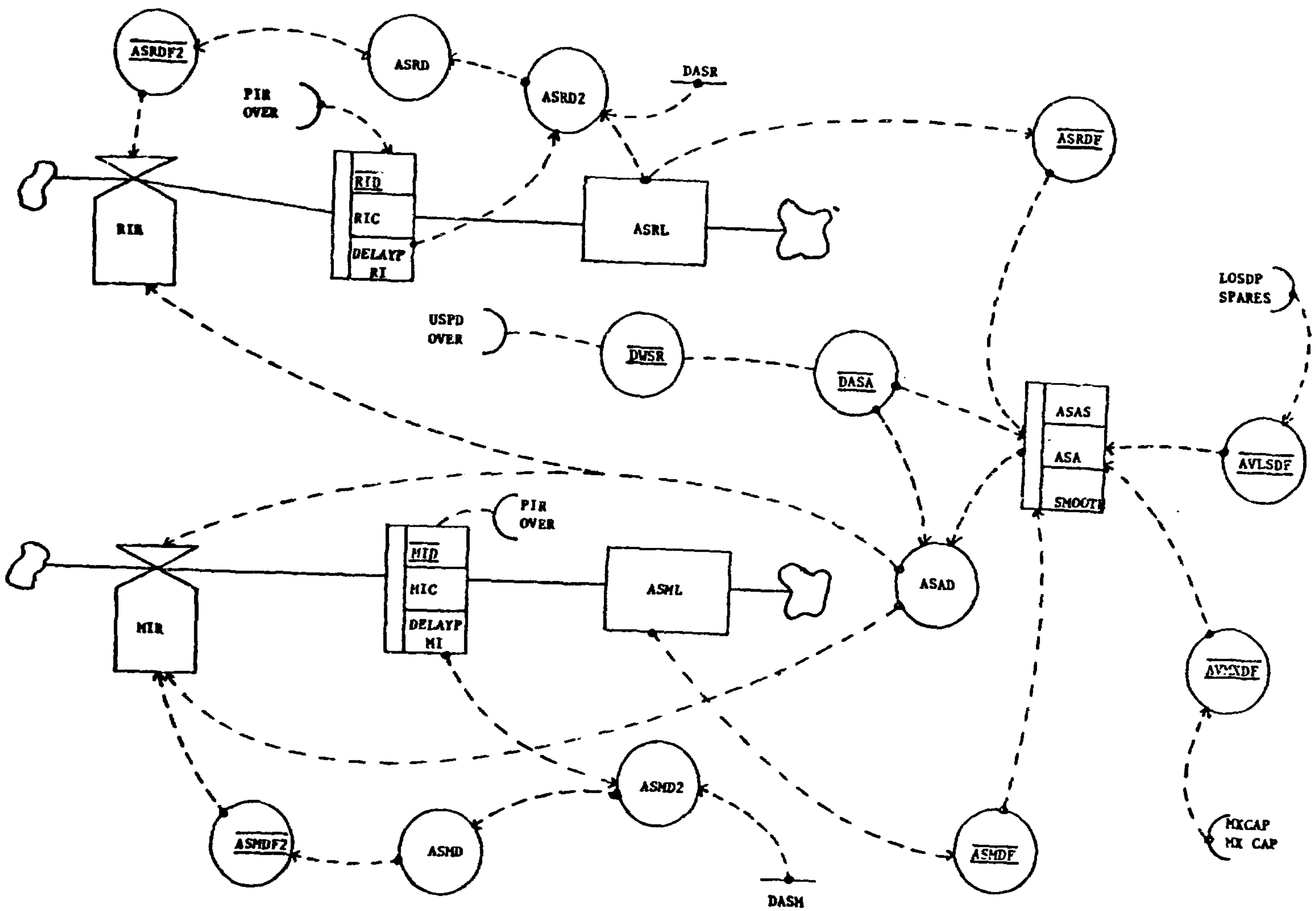
Support Manning



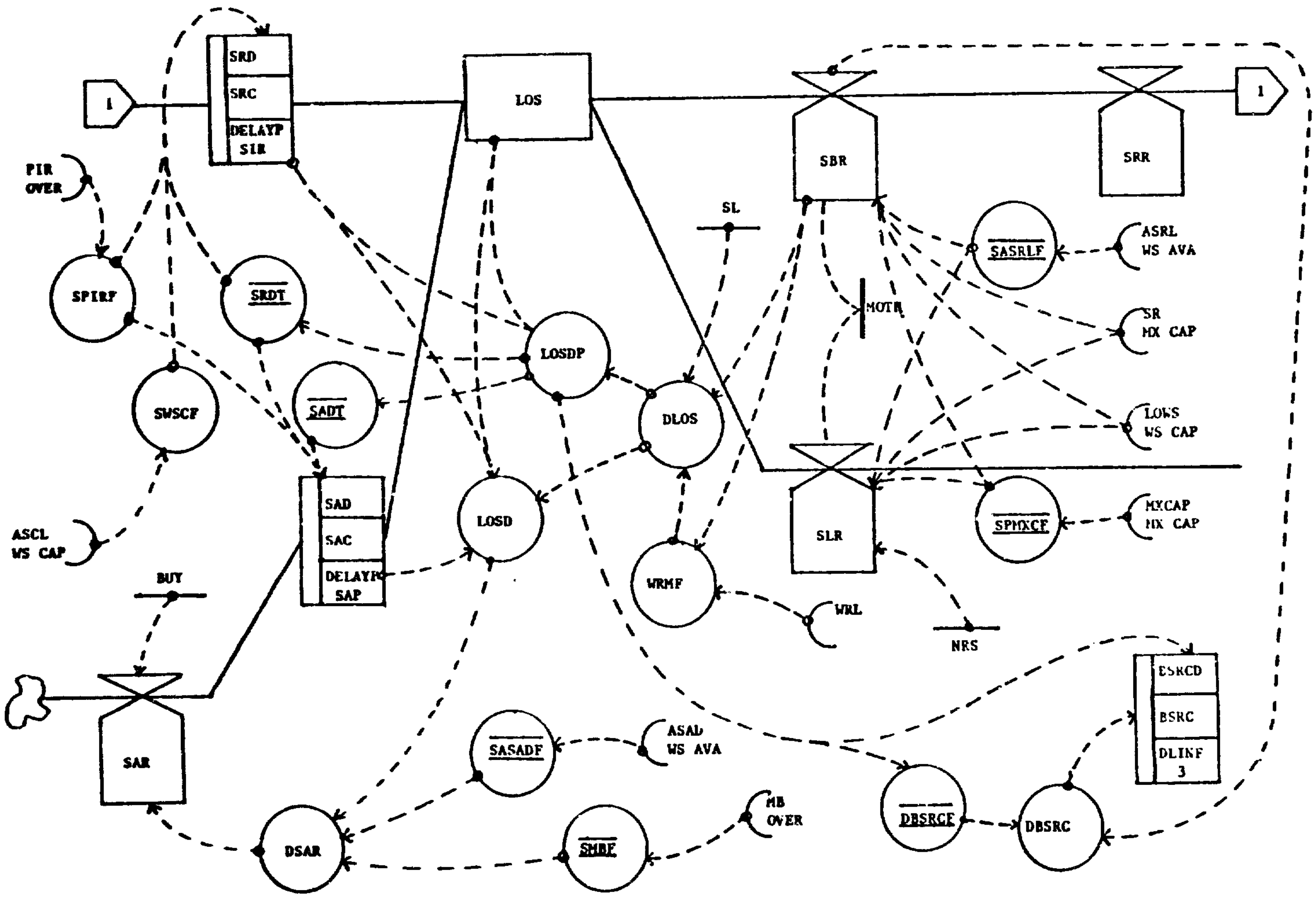
Support Capability



Weapon Systems Capability



Aircraft Availability



Materiel Readiness

APPENDIX E

SYSTEM EQUATIONS

```
*        COMBAT READINESS OVERVIEW

A     EC.K=ELOW.K*EASC.K
A     ELOW.K=2000+RAMP(5,40)
A     EASC.K=3+RAMP(.02,60)

          NOTE      EC = ENEMY CAPABILITY
          NOTE    ELOW = ENEMY LEVEL OF WEAPON SYSTEMS
          NOTE    EASC = ENEMY AIRCRAFT SYSTEMS CAPABILITY

A     USPEC.K=DLINF3(EC.K,PECD)*USPF
C     PECD=12
C     USPF=1.1

          NOTE   USPEC = UNITED STATES PERCEIVED ENEMY CAPABILITY
          NOTE    PECD = PERCEIVED ENEMY CAPABILITY DELAY
          NOTE    USPF = U.S. PERCEPTION FACTOR

S     USR.K=ACCF.K*ASCAP.K*LOWS.K*ASAF.K
A     ACCF.K=TABLE(ACCFT,ARCAP.K,1,4,.5)
T     ACCFT=.85/.9/.95/1.0/1.1/1.1/1.3
A     ASAF.K=TABLE(ASAFT,ASA.K,.2,.9,.1)
T     ASAFT=.6/.65/.7/.85/1/1.05/1.15/1.3
A     PUSC.K=ASCAP.K*LOWS.K*ASAF.K

          NOTE     USR = UNITED STATES READINESS
          NOTE    ACCF = AIRCREW CAPABILITY FACTOR
          NOTE   ASCAP = AIRCRAFT SYSTEMS CAPABILITY
          NOTE    LOWS = LEVEL OF WEAPON SYSTEMS
          NOTE    ASAF = AIRCRAFT SYSTEM AVAILABILITY FACTOR
          NOTE   ACCAP = AIRCREW CAPABILITY
          NOTE    ASTA = AIRCRAFT SYSTEM TOTAL AVAILABILITY
          NOTE    PUSC = PERCEIVED UNITED STATES CAPABILITY

A     EPUSC.K=DLINF3(PUSC.K,PUSCD)*EPF
C     PUSCD=3
C     EPF=1.05

          NOTE   EPUSC = ENEMY PERCEIVED U.S. CAPABILITY
          NOTE   PUSCD = PERCEIVED U.S. CAPABILITY DELAY
          NOTE     EPF = ENEMY PERCEPTION FACTOR

S     USFD.K=USR.K/EC.K
A     EPA.K=EC.K/EPUSC.K
A     USPD.K=USPEC.K/PUSC.K

          NOTE    USFD = UNITED STATES FORCE DEFICIENCY
          NOTE     EPA = ENEMY PERCEIVED ADVANTAGE
          NOTE    USPD = UNITED STATES PERCEIVED DISADVANTAGE
```

```
A     PUSWF.K=20+(FFM)(SIN((6.28*TIME.K)/FFP))
A     EEA.K=EPA.K/PUSWF.K*INC
N     INC=100
C     FFM=5
C     FFP=96

         NOTE  PUSWF = PERCEIVED U.S. WILLINGNESS TO USE FORCE
         NOTE    EEA = ENEMY EXPANSIONARY ACTIVITY
         NOTE    FFM = FORCE FREQUENCY MODULATION
         NOTE    FFP = FORCE FREQUENCY PERIOD

A     PIR.K=SMOOTH(MAX(USPD.K*EEA.K,MX),PIRS)
C     MX=0
C     PIRS=6
A     MB.K=PIR.K*TABHL(MBT,NE.K,5,15,2)
T     MBT=.9/.95/1.0/1.0/1.05/1.15
A     NE.K=10+(NEFM)(SIN((6.28*TIME.K)/NEFP))
C     NEFM=5
C     NEFP=80

         NOTE    PIR = PRESSURE TO IMPROVE READINESS
         NOTE   PIRS = PRESSURE TO IMPROVE READINESS SMOOTHING CONSTANT
         NOTE     MB = MILITARY BUDGET
         NOTE     NE = NATIONAL ECONOMY
         NOTE   NEFM = NATIONAL ECONOMY FREQUENCY MODULATION
         NOTE   NEFP = NATIONAL ECONOMY FREQUENCY PERIOD
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*    AIRCREW MANNING/CAPABILITY

FOR  YG=1,4/SL=1,3
L    ACML.K(1,SL)=ACML.J(1,SL)+(DT)(ACRCR.JK(SL)+RSRCR.JK(1,SL)
X    -ACER.JK(1,SL)-ACYGER.JK(1,SL)-RSER.JK(1,SL))
L    ACML.K(2,SL)=ACML.J(2,SL)+(DT)(ACYGER.JK(1,SL)+RSRCR.JK(2,SL)
X    -ACER.JK(2,SL)-ACYGER.JK(2,SL)-RSER.JK(2,SL))
L    ACML.K(3,SL)=ACML.J(3,SL)+(DT)(ACYGER.JK(2,SL)+RSRCR.JK(3,SL)
X    -ACER.JK(3,SL)-ACYGER.JK(3,SL)-RSER.JK(3,SL))
L    ACML.K(4,SL)=ACML.J(4,SL)+(DT)(ACYGER.JK(3,SL)+RSRCR.JK(4,SL)
X    -ACER.JK(4,SL)-ACYGER.JK(4,SL)-RSER.JK(4,SL))

        NOTE     YG = YEAR GROUP
        NOTE     SL = SKILL LEVEL
        NOTE   ACML = AIRCREW MANNING LEVEL
        NOTE  ACRCR = AIRCREW RECRUITING COMPLETION RATE
        NOTE  RSRCR = RATED SUPP REQUAL COMPLETION RATE
        NOTE   ACER = AIRCREW EXIT RATE
        NOTE   RSER = RATED SUPP ENTRANCE RATE

N    ACML(YG,SL)=IACML(YG,SL)
T    IACML(*,1)=325/70/90/15
T    IACML(*,2)=3140/680/860/126
T    IACML(*,3)=727/156/78/26

        NOTE  IACML = INITIAL AIRCREW MANNING LEVEL

R    RSRCR.KL(YG,SL)=DELAY3(RSRR.JK(YG,SL),RSRD.K)
R    RSRR.KL(YG,SL)=RSL.K(YG,SL)/RSD.K
A    RSRD.K=TABLE(RSRDT,ACMD.K,.5,1.5,.25)
T    RSRDT=3/3/4/5/7
A    RSD.K=TABLE(RSDT,ACMD.K,.5,1.5,.25)
T    RSDT=18/24/36/40/48

        NOTE  RSRCR = RATED SUPP REQUAL COMPLETION RATE
        NOTE   RSRR = RATED SUPP REQUAL RATE
        NOTE   RSRD = RATED SUPP REQUAL DELAY
        NOTE    RSD = RATED SUPP DELAY

A    ACMD.K=SMOOTH(ACMD1.K,ACMDS)
A    ACMD1.K=SUM(ACML.K)/DACM.K
C    ACMDS=6
A    DACM.K=SMOOTH(LOWS.K*ACPWS.K,DACMS)
C    DACMS=12
A    DRM.K=DACM.K+(DACM.K*DRSP)
C    DRSP=.5
A    RMD.K=(SUM(ACML.K(YG,SL))+SUM(RSL.K(YG,SL)))/DRM.K
A    RMD2.K=MAX(DRM.K-SUM(ACML.K(YG,SL))-SUM(RSL.K(YG,SL)),.001)
A    ACPWS.K=TABLE(ACPWST,DWSR.K,1.0,4.0,.5)
T    ACPWST=1.3/1.5/1.6/1.8/2.0/2.3/2.6
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      NOTE   ACMD = AIRCREW MANNING DEFICIENCY
      NOTE  ACMDS = AIRECREW MANNING SMOOTHING CONSTANT
      NOTE   DACM = DESIRED AIRCREW MANNING
      NOTE  DACMS = DESIRED AIRCREW MANNING SMOOTHING CONSTANT
      NOTE    DRM = DESIRED RATED MANNING
      NOTE    RMD = RATED MANNING DISCREPANCY
      NOTE   RMD2 = RATED MANNING DISCREPANCY 2

R   ACRCR.KL(1)=DELAY3(PTC.K,ACRD.K)*SLP1.K
R   ACRCR.KL(2)=DELAY3(PTC.K,ACRD.K)*SLP2.K
R   ACRCR.KL(3)=DELAY3(PTC.K,ACRD.K)*SLP3.K
A   ACRD.K=TABLE(ACRDT,ACMD.K,.5,1.5,.25)
T   ACRDT=16/18/20/22/24
A   PTC.K=DELAY3(PTT.K,PTCD.K)
A   PTT.K=(SUMV(ACYGER.JK(4,*K),1,3)+SUM(ACER.JK(YG,SL))
X   +(RMD2.K/PTL)+SUMV(RSYGER.JK(4,*),1,3))*RMDF.K
A   RMDF.K=TABLE(RMDFT,RMD.K,.5,1.5,.25)
T   RMDFT=1.4/1.2/1/.8/.6
C   PTL=12
A   PTCD.K=TABLE(PTCDT,RMD.K,.5,1.5,.25)
T   PTCDT=12/16/18/12/8
A   SLP1.K=TABLE(SLP1T,RMD.K,.5,1.5,.5)
T   SLP1T=.15/.10/.07
A   SLP2.K=TABLE(SLP2T,RMD.K,.5,1.5,.5)
T   SLP2T=.70/.75/.75
A   SLP3.K=TABLE(SLP3T,RMD.K,.5,1.5,.5)
T   SLP3T=.15/.15/.18

      NOTE  ACRCR = AIRCREW RECRUITING COMPLETION RATE
      NOTE   ACRD = AIRCREW RECRUITING DELAY
      NOTE    PTC = PILOT TRAINING CAPACITY
      NOTE    PTT = PILOT TRAINING TOTAL
      NOTE   RMDF = RATED MANNING DISCREPANCY FACTOR
      NOTE    PTL = PILOT TRAINING LENGTH
      NOTE   PTLD = PILOT TRAINING CAPACITY DELAY

R   ACER.KL(YG,SL)=DELAY3(ACS.K(YG,SL),ACSD)
C   ACSD=6
R   ACYGER.KL(YG,SL)=ACML(YG,SL)/YGDT(YG)
T   YGDT=72/60/48/60

      NOTE   ACER = AIRCREW EXIT RATE
      NOTE    ACS = AIRCREW SEPERATION
      NOTE ACYGER = AIRCREW YEAR GROUP EXIT RATE

A   ACS.K(1,SL)=.001
A   ACS.K(2,1)=ACML.K(2,1)*(ACSF1.K/YDT)
A   ACS.K(2,2)=ACML.K(2,2)*(ACSF1.K/YDT)
A   ACS.K(2,3)=ACML.K(2,3)*(ACSF1.K/YDT)
A   ACS.K(3,1)=ACML.K(3,1)*(ACSF2.K/YDT)
A   ACS.K(3,2)=ACML.K(3,2)*(ACSF2.K/YDT)
A   ACS.K(3,3)=ACML.K(3,3)*(ACSF2.K/YDT)
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A     ACS.K(4,SL)=.001
C     YDT=12
A     ACSF1.K=SMOOTH(((AEF.K*APFS.K*AMORLF.K*AEEAF.K)* 49),ACSFS)
A     ACSF2.K=SMOOTH(((AEF.K*APFS.K*AMORLF.K*AEEAF.K)*.05),ACSFS)
C     ACSFS=6

          NOTE    YGDT = YEAR GROUP DELAY TIME
          NOTE   ACSF1 = AIRCREW SEPARATION FACTOR
          NOTE   ACSFS = AIRCREW SEPARATION FACTOR SMOOTHING CONSTANT

A     AEF.K=TABLE(AEFT,NE.K,5,15,2.5)
T     AEFT=.9/.95/1.0/1.05/1.1
A     APFS.K=DELAY3(AFP.K,APFD)
C     APFD=12
A     APF.K=TABLE(APFT,ACMD.K,.5,1.5,.25)
T     APFT=1.1/1.1/1.0/.95/.90
A     AMORLF.K=TABLE(AMORLT,MORAL.K,400,600,50)
T     AMORLT=1.2/1.1/1.8/.90/.80
A     AEEAF.K=TABLE(AEEAT,EEA.K,0,6,1)
T     AEEAT=1.1/1.0/.9/.9/.9/.7/.5

          NOTE     AEF = AIRCREW ECONOMY FACTOR
          NOTE     APF = AIRCREW PAY FACTOR
          NOTE  AMORLF = AIRCREW MORAL FACTOR
          NOTE   AEEAF = AIRCREW ENEMY EXPANSIONARY ACTIVITY FACTOR

L     RSL.K(1,SL)=RSL.J(1,SL)+(DT)(RSER.JK(1,SL)-RSRR.JK(1,SL)
X     -RSYGER.JK(1,SL))
L     RSL.K(2,SL)=RSL.J(2,SL)+(DT)(RSER.JK(2,SL)-RSRR.JK(2,SL)
X     -RSYGER.JK(2,SL))
L     RSL.K(3,SL)=RSL.J(3,SL)+(DT)(RSER.JK(3,SL)-RSRR.JK(3,SL)
X     -RSYGER.JK(3,SL))
L     RSL.K(4,SL)=RSL.J(4,SL)+(DT)(RSER.JK(4,SL)-RSRR.JK(4,SL)
X     -RSYGER.JK(4,SL))
N     RSL(YG,SL)=IRSL(YG,SL)
T     IRSL(*,1)=25/200/75/200
T     IRSL(*,2)=100/1000/300/1000
T     IRSL(*,3)=45/300/100/200
R     RSYGER.KL(YG,SL)=RSL.K(YG,SL)/YGDT(YG)

          NOTE     RSL = RATED SUPP LEVEL
          NOTE    RSEP = RATED SUPP ENTRANCE RATE
          NOTE    RSRR = RATED SUPP REQUALIFICATION RATE
          NOTE  RSYGER = RATED SUPP YEAR GROUP EXIT RATE
          NOTE    IRSL = INITIAL RATED SUPP LEVEL

A     DRSM.K=TABHL(DRSPT,ACMD.K,.5,1.5,.25)*DRM.K
T     DRSPT=.2/.25/.33/.4/.45
R     RSER.KL(YG,SL)=MAX((DRSM.K*RSBP.K(YG)*CACMLP.K(YG,SL)
X     -RSL.K(YG,SL))*RSEP,.001)
C     RSEP=.16
N     RSBP(YG)=IRSBP(YG)
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T     IRSBP(*)=.1/.4/.15/.35

          NOTE   DRSM = DESIRED RATED SUPP MANNING
          NOTE   RSBF = RATED SUPP BASE PERCENTAGE

A     CACMLP.K(1,SL)=ACML.K(1,SL)/SUMV(ACML.K(1,*),1,3)
A     CACMLP.K(2,SL)=ACML.K(2,SL)/SUMV(ACML.K(2,*),1,3)
A     CACMLP.K(3,SL)=ACML.K(3,SL)/SUMV(ACML.K(3,*),1,3)
A     CACMLP.K(4,SL)=ACML.K(4,SL)/SUMV(ACML.K(4,*),1,3)
A     TACM.K=SUM(ACML.K(YG,SL))
S     TRSL.K=SUM(RSL.K(YG,SL))
S     TRSER.K=SUM(RSER.JK(YG,SL))
S     TRSRR.K=SUM(RSRR.JK(YG,SL))
S     TACER.K=SUM(ACER.JK(YG,SL))
S     TACRCR.K=SUM(ACRCR.JK(SL))

          NOTE CACMLP = CALCULATED AIRCREW MANNING LEVEL PERCENTAGE
          NOTE   TACM = TOTAL AIRCREW MANNING
          NOTE   TRSL = TOTAL RATED SUPP LEVEL
          NOTE  TRSER = TOTAL RATED SUPP ENTRANCE RATE
          NOTE  TRSRR = TOTAL RATED SUPP RECRUITING RATE
          NOTE  TACER = TOTAL AIRCREW EXIT RATE
          NOTE TACRCR = TOTAL AIRCREW RECRUITING COMPLETION RATE

L     ACTL.K=ACTL.J+(DT)(ACTR.JK-ACCR.JK)

          NOTE   ACTL = AIRCREW TRAINING LEVEL
          NOTE   ACTR = AIRCREW TRAINING RATE
          NOTE   ACCR = AIRCREW CURRENCY RATE

R     ACTR.KL=SR.K*MCF
C     MCF=.8
A     SR.K=MIN(ASAF.K,DTSR.K)
A     ASAF.K=TABLE(ASAFT,ASA.K,0,1,.2)
T     ASAFT=0/.3/.5/.65/.9/1.2

          NOTE     SR = SORTIE RATE
          NOTE    MCF = MISSION COMPLETION FACTOR
          NOTE   ASAF = AIRCRAFT SYSTEM AVAILABILITY FACTOR
          NOTE   DTSR = DESIRED TRAINING SORTIE RATE

R     ACCR.KL=DELAY3(ACTR.JK,ACCD)
C     ACCD=3
A     DTSR.K=(ASCF.K*SUM(ACML.K(YG,SL))/LOWS.K)*MCF2
C     MCF2=1.2
A     ACSRD.K=SR.K/DTSR.K
A     ASCF.K=TABLE(ASCFT,ASCL,5,20,2.5)
T     ASCFT=.5/.56/.6/.65/.68/.75/.85

          NOTE   ACCR = AIRCREW CURRENCY RATE
          NOTE   ACCD = AIRCREW CURRENCY DELAY
          NOTE   DTSR = DESIRED TRAINING SORTIE RATE
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        NOTE   MCF2 = MISSION COMPLETION FACTOR 2
        NOTE  ACSRD = AIRCREW SORTIE RATE DISCREPANCY
        NOTE   ASCF = AIRCRAFT SYSTEM CAPABILITY FACTOR

A    ACREA.K=SMOOTH((DREA*SORTR.K*SIMR.K),ACEXPS)
C    DREA=2
C    ACEXPS=60
A    SORTR.K=TABLE(SORTRT,PIR.K,0,10,2)
T    SORTRT=.8/.9/1.0/1.1/1.2/1.3
A    SIMR.K=TABLE(SIMRT,PIR,K,0,10,2)
T    SIMRT=.9/.95/1.95/1/1.05/1.1/1.1

        NOTE  ACREA = AIRCREW REALISM FACTOR
        NOTE SORTRT = SORTIE REALISM
        NOTE  SIMRT = SIMULATOR REALISM
        NOTE ACEXPS = AIRCREW REALISM SMOOTHING CONSTANT

A    ACCAP.K=ACREA.K*ACTRF.K*ACSKF.K*ACMDF.K
A    ACTRF.K=SMOOTH(TABLE(ACTRT,ACSRD.K,.5,1.5,.25),ACTRS)
N    ACTRS=3
A    ACMDF.K=TABLE(ACMDT,ACMD1.K,.5,1.5,.25)
T    ACMDT=.5/.8/1.0/1.05/1.05
T    ACTRT=.7/.8/1/1.1/1.2
A    ACSKF.K=SMOOTH(TABLE(ACSKT,ACST.K,1,3.5,.5),ACSKS)
N    ACSKS=6
T    ACSKT=.5/.6/.7/.9/1/1.2
A    ACST.K=SUM(ACSS.K)/SUM(ACML.K)
A    ACSS.K(YG,SL)=ACML.K(YG,SL)*ACEV(YG,SL)
T    ACEV(*,1)=1.6/3.2/5.1/5.1
T    ACEV(*,2)=2/4/5/5
T    ACEV(*,3)=2.5/5/6.1/6.1

        NOTE AIRCAP = AIRCREW CAPABILITY
        NOTE  ACTRF = AIRCREW TRAINING RATE FACTOR
        NOTE  ACSKF = AIRCREW SKILL FACTOR
        NOTE  ACMDF = AIRCREW MANNING DISCREPANCY FACTOR
        NOTE   ACST = AIRCREW SKILL TOTAL
        NOTE   ACEV = AIRCREW EXPERIENCE VALUE
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*   MAINTENANCE MANNING/CAPABILITY

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L    MXML.K(1)=MXML.J(1)+(DT)(MXRCR.JK-MXER.JK(1)-MYGER.JK(1))
L    MXML.K(2)=MXML.J(2)+(DT)(MYGER.JK(1)-MXER.JK(2)-MYGER.JK(2))
L    MXML.K(3)=MXML.J(3)+(DT)(MYGER.JK(2)-MXER.JK(3)-MYGER.JK(3))
L    MXML.K(4)=MXML.J(4)+(DT)(MYGER.JK(3)-MXER.JK(4)-MYGER.JK(4))

        NOTE   MXML = MAINTENANCE MANNING LEVEL
        NOTE  MXRCR = MAINTENANCE MANNING RECRUITING COMPLETION RATE
        NOTE   MXER = MAINTENANCE MANNING EXIT RATE
        NOTE  MYGER = MAINTENANCE YEAR GROUP EXIT RATE

N    MXML(YG)=IMXML(YG)
T    IMXML=10000/3500/2000/2200
R    MXRCR.KL=DELAY3(MXRR.JK,MXRD.K)

        NOTE  IMXML = INITIAL MAINTENANCE MANNING LEVEL
        NOTE   MXRR = MAINTENANCE MANNING RECRUITING RATE
        NOTE   MXRD = MAINTENANCE MANNING RECRUITING DELAY

A    MXRD.K=TABLE(MXRDT,MXMDS.K,.5,1.5,.25)
T    MXRDT=3/5/6/6/7
R    MXRR.KL=MXERS.K*MXMDF.K*MXRF2.K
A    MXMDF.K=TABLE(MXMDFT,MXMDS.K,.5,1.5,.25)
T    MXMDFT=1.4/1.2/1.0/.80/.60
A    MXRF2.K=TABLE(MXRF2T,NE.K,5,15,2.5)
T    MXRF2T=1/1/1/1/.96
A    MXMDS.K=SMOOTH(MXMDSZ.K,MXERSF)
A    MXMDSZ.K=SUM(MXML.K)/DMXM.K
A    MXERS.K=SMOOTH(MXERSZ.K,MXERSF)
A    MXERSZ.K=SUM(MXER.JK)+MYGER.JK(4)
C    MXERSF=6

        NOTE  MXERS = MAINTENANCE MANNING EXIT RATE (SMOOTHED)
        NOTE  MXMDF = MAINTENANCE MANNING DISCREPANCY FACTOR
        NOTE  MXRF2 = MAINTENANCE MANNING RECRUITING FACTOR 2
        NOTE  MXMDS = MAINTENANCE MANNING DISCREPANCY (SMOOTHED)
        NOTE MXMDSZ = MAINTENANCE MANNING DISCREPANCY
        NOTE MXERSZ = MAINTENANCE EXIT RATE
        NOTE MXERSF = MAINTENANCE MANNING EXIT RATE SMOOTHING FACTOR
        NOTE   DMXM = DESIRED MAINTENANCE MANNING
        NOTE MXMDSF = MAINTENANCE MANNING DISCREPANCY SMOOTHING FACTOR

A    DMXM.K=SMOOTH(DMXMZ.K,DMXMS)
A    DMXMZ.K=LOWS*MXMF.K
A    MXMF.K=TABLE(MXMFT,DWSR.K,1,4,1)
T    MXMFT=5/5.5/6/6
C    DMXMS=12

        NOTE   DMXM = DESIRED MAINTENANCE MANNING
        NOTE   LOWS = LEVEL OF WEAPON SYSTEMS
        NOTE   MXMF = MAINTENANCE MANNING FACTOR
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        NOTE   DWSR = DESIRED WARTIME SORTIE RATE
        NOTE  PMXMS = DESIRED MAINTENANCE MANNING SMOOTHING FACTOR

R    MYGER.KL(YG)=MXML.K(YG)/MXYGDT(YG)
T    MXYGDT=48/72/60/72
R    MXER.KL(1)=MXML.K(1)*(MXS1.K/YDT)
R    MXER.KL(2)=MXML.K(2)*(MXS2.K/YDT)
R    MXER.KL(3)=MXML.K(3)*(MXS3.K/YDT)
R    MXER.KL(4)=NONE
C    YDT=12

        NOTE  MYGER = MAINTENANCE YEAR GROUP EXIT RATE
        NOTE MXYGDT = MAINTENANCE YEAR GROUP DELAY TIME
        NOTE   MXER = MAINTENANCE EXIT RATE
        NOTE    MXS = MAINTENANCE SEPARATION FACTOR (SMOOTHED)

A    MXS1.K=SMOOTH(MXS1Z.K,MXSF)
A    MXS1Z.K=NEF.K*MPF.K*MORALF.K*EEAF.K*.653
A    MXS2.K=SMOOTH(MXS2Z.K,MXSF)
A    MXS2Z.K=NEF.K*MPF.K*MORALF.K*EEAF.K*.600
A    MXS3.K=SMOOTH(MXS3Z.K,MXSF)
A    MXS3Z.K=NEF.K*MPF.K*MORALF.K*EEAF.K*.082
C    MXSF=6

        NOTE   MXSZ = MAINTENANCE SEPARATION FACTOR
        NOTE    NEF = NATIONAL ECONOMY FACTOR
        NOTE    MPF = MILITARY PAY FACTOR
        NOTE MORALF = MORAL FACTOR
        NOTE   EEAF = ENEMY EXPANSIONARY ACTIVITY FACTOR
        NOTE   MXSF = MAINTENANCE SEPARATION SMOOTHING FACTOR

A    NEF.K=TABLE(NEFT,NE.K,5,15,5)
T    NEFT=.9/1.0/1.1
A    MPF.K=DELAY3(MXMP.K,MPFD)
C    MPFD=24
A    MXMP.K=TABLE(MPFT,MXMDS.K,.5,1.5,.25)
T    MPFT=1.2/1.05/1.0/1.0/1.0
A    TMXML.K=SUM(MXML.K)
S    TMXER.K=SUM(MXER.JK(YG))

        NOTE  TMXML = TOTAL MAINTENANCE MANNING LEVEL
        NOTE  TMXER = TOTAL MAINTENANCE EXIT RATE

A    MXDSK.K=DELAY1(SKILF.K,SDT)
C    SDT=252
A    SKILF.K=TABLE(SKILFT,MDIS.K,1,3,.5)
T    SKILFT=.75/.85/1.0/1.05/1.15
A    MDIS.K=MXMDS.K+SMDS.K

        NOTE  MXDSK = MAINTENANCE DESIRED SKILL
        NOTE    SDT = SKILL DELAY TIME
        NOTE  SKILF = SKILL FACTOR
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        NOTE   MDIS = MANNING DISCREPANCY INCLUDING SUPPORT
        NOTE   SMDS = SUPPORT MANNING DISCREPANCY SMOOTHED

A    MXEXP.K=(SUM(MXEXPT.K)/SUM(MXML.K))*SORTRF.K
A    MXEXPT.K(YG)=MXML.K(YG)*MXEV(YG)
T    MXEV=3.5/5.0/6.0/6.0
A    SORTRF.K=DELAY1(MXREAL.K,SDT)
A    MXREAL.K=TABLE(MXREAT,SORTR.K,.8,1.3,1)
T    MXREAT=.8/.9/1/1/1.05/1.15

        NOTE  MXEXP = MAINTENANCE EXPERIENCE
        NOTE   MXEV = MAINTENANCE EXPERIENCE VALUE
        NOTE SORTRF = SORTIE REALISM FACTOR
        NOTE MXREAL = MAINTENANCE REALISM
        NOTE  SORTR = SORTIE REALISM

A    MXASCF.K=TABLE(MXASCT,ASCL.K,5,20,5)
T    MXASCT=1.1/1/.95/.95
A    MXTLF.K=SMOOTH(SORTS.K,SRS)
C    SRS=6
A    SORTS.K=TABLE(SORTST,SR.K,.25,1.25,.25)
T    SORTST=.7/.85/1/.9/.75
A    MXMDCF.K=TABLE(MXMDCT,MXMDS.K,.5,1.5,.25)
T    MXMDCT=.6/.8/1/1.1/1.2

        NOTE MXASCF = MAINTENANCE AIRCRAFT SYSTEM CAPABILITY FACTOR
        NOTE   ASCL = AIRCRAFT SYSTEM CAPABILITY LEVEL
        NOTE  MXTLF = MAINTENANCE TRAINING LEVEL FACTOR
        NOTE  SORTS = SORTIES SMOOTHED
        NOTE    SRS = SORTIES SMOOTHED SMOOTHING FACTOR
        NOTE     SR = SORTIE RATE
        NOTE MXMDCF = MAINTENANCE MANNING DEFICIENCY CAPABILITY FACTOR

A    PMXCAP.K=DMXCAP*MXMDCF.K*MXEXP.K
A    MXCAP.K=DMXCAP*MXMDCF.K*MXEXP.K*MXASCF.K*MXTLF.K*MXDSK.K
C    DMXCAP=10

        NOTE PMXCAP = PERCEIVED MAINTENANCE CAPABILITY
        NOTE DMXCAP = DESIRED MAINTENANCE CAPABILITY
        NOTE  MXCAP = MAINTENANCE CAPABILITY
```

```
*       SUPPORT MANNING/CAPABILITY

L    SML.K(1)=SML.J(1)+(DT)(SMRCR.JK-SMER.JK(1)-SYGER.JK(1))
L    SML.K(2)=SML.J(2)+(DT)(SYGER.JK(1)-SMER.JK(2)-SYGER.JK(2))
L    SML.K(3)=SML.J(3)+(DT)(SYGER.JK(2)-SMER.JK(3)-SYGER.JK(3))
L    SML.K(4)=SML.J(4)+(DT)(SYGER.JK(3)-SMER.JK(4)-SYGER.JK(4))

         NOTE     SML = SUPPORT MANNING LEVEL
         NOTE   SMRCR = SUPPORT MANNING RECRUITING COMPLETION RATE
         NOTE    SMER = SUPPORT MANNING EXIT RATE
         NOTE   SYGER = SUPPORT YEAR GROUP EXIT RATE

N    SML(YG)=ISML(YG)
T    ISML=5000/3000/2000/1000
R    SMRCR.KL=DELAY3(SMRR.JK,SMRD.K)

         NOTE    ISML = INITIAL SUPPORT MANNING LEVEL
         NOTE    SMRR = SUPPORT MANNING RECRUITING RATE
         NOTE    SMRD = SUPPORT MANNING RECRUITING DELAY

A    SMRD.K=TABLE(SMRDT,SMDS.K,.5,1.5,.25)
T    SMRDT=3/4/5/5/6
R    SMRR.KL=SERS.K*SMDF.K*MXRF2.K
A    SMDF.K=TABLE(SMDFT,SMDS.K,.5,1.5,.25)
T    SMDFT=1.4/1.2/1.0/.85/.70
A    SMDS.K=SMOOTH(SMDSZ.K,MXERSF)
A    SMDSZ.K=SUM(SML.K)/DSM.K
A    SERS.K=SMOOTH(SERSZ.K,MXERSF)
A    SERSZ.K=SUM(SMER.JK)+SYGER.JK(4)

         NOTE    SERS = SUPPORT MANNING EXIT RATE SMOOTHED
         NOTE    SMDF = SUPPORT MANNING DISCREPANCY FACTOR
         NOTE    MXRF = MAINTENANCE MANNING RECRUITING FACTOR 2
         NOTE    SMDS = SUPPORT MANNING DISCREPANCY SMOOTHED
         NOTE   SMDSZ = SUPPORT MANNING DISCREPANCY
         NOTE   SERSZ = SUPPORT EXIT RATE

A    DSM.K=DLS.K*MBF.K
A    DLS.K=TABHL(DLST,MORAL.K,400,600,50)
T    DLST=9000/10000/11000/12000/13000
A    MBF.K=TABHL(MBFT,MB.K,1,9,2)
T    MBFT=.8/.9/1/1.1/1.2

         NOTE     DSM = DESIRED SUPPORT MANNING
         NOTE     DLS = DESIRED LEVEL OF SUPPORT
         NOTE     MBF = MILITARY BUDGET FACTOR

R    SYGER.KL(YG)=SML.K(YG)/SYGDT(YG)
T    SYGDT=48/72/60/72
R    SMER.KL(1)=SML.K(1)*(SSF1.K/YDT)
R    SMER.KL(2)=SML.K(2)(SSF2.K/YDT)
```

```
R     SMER.KL(3)=SML.K(3)(SSF3.K/YDT)
C     YDT=12
R     SMER.KL(4)=NONE

          NOTE  SYGER = SUPPORT YEAR GROUP EXIT RATE
          NOTE   SMER = SUPPORT EXIT RATE
          NOTE   SSF1 = SUPPORT SEPARATION FACTORS SMOOTHED

A     SSF1.K=SMOOTH(SSF1Z.K,SSFS)
A     SSF1Z.K=NEF.K*MPF.K*MORALF.K*EEAF.K*.653
A     SSF2.K=SMOOTH(SSF2Z.K,SSFS)
A     SSF2Z.K=NEF.K*MPF.K*MORALF.K*EEAF.K*.600
A     SSF3.K=SMOOTH(SSF3Z.K,SSFS)
A     SSF3Z.K=NEF.K*MPF.K*MORALF.K*EEAF.K*.082
C     SSFS=6

          NOTE  SSFIZ = SUPPORT SEPARATION FACTOR
          NOTE   SSFS = SUPPORT SEPARATIONS SMOOTHING FACTOR

S     TSML.K=SUM(SML(YG))
S     TSMER.K=SUM(SMER.JK(YG))

          NOTE   TSML = TOTAL SUPPORT MANNING LEVEL
          NOTE  TSMER = TOTAL SUPPORT MANNING EXIT RATE

A     SEXP.K=(SUM(SEXPT.K)/SUM(SML.K))*SPSRF.K
A     SEXPT.K(YG)=SML.K(YG)*SEXV(YG)
T     SEXV=4/5/6/6.5
A     SPSRF.K=TABLE(SPSRT,SORTR.K,.8,1.3,.1)
T     SPSRT=.95/.97/1/1/1.04/1.06

          NOTE   SPEX = SUPPORT EXPERIENCE
          NOTE  SEXPT = TOTAL SUPPORT EXPERIENCE
          NOTE   SEXV = SUPPORT EXPERIENCE VALUE
          NOTE  SPSRF = SUPPORT SORTIE REALISM FACTOR

A     SASCF.K=TABLE(SASCT,ASCL.K,5,20,5)
T     SASCT=1.05/1.03/1/.97
A     SMDF2.K=TABLE(SMDFT2,SMDS.K,.5,1.5,.25)
T     SMDFT2=.85/.95/1/1/1.05

          NOTE  SASCF = SUPPORT AIRCRAFT SYSTEM CAPABILITY FACTOR

A     PSCAP.K=DSCAP*SMDF2.K*SEXP.K
A     SCAP.K=DSCAP*MXDSK.K*SEXP.K*SASCF.K*SMDF2.K
C     DSCAP=10

          NOTE  PSCAP = PERCEIVED SUPPORT CAPABILITY
          NOTE   SCAP = SUPPORT CAPABILITY
          NOTE  DSCAP = DESIRED SUPPORT CAPABILITY
```

```
A    MORAL.K=SCAP.K*PIR.K*SORTR.K

        NOTE  MORAL = MORAL OF UNIT
        NOTE    PIR = PRESSURE TO IMPROVE READINESS
        NOTE  SORTR = SORTIE REALISM
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*       WEAPON SYSYTEMS CAPABILITY

L     ASCL.K=ASCL.J+(DT)(ASCIC.JK)
N     ASCL=5

        NOTE   ASCL = AIRCRAFT SYSTEM CAPABILITY LEVER
        NOTE  ASCIC = AIRCRAFT SYSTEM CAPABILITY IMPROVEMENT COMPLETE

R     ASCIC.KL=DELAYP(ASCIR.JK,ASCID.K,CI.K)
N     CI=2
A     ASCID.K=TABLE(ASCIRT,PIR.K,0,10,2)
T     ASCIRT=24/18/16/12/8

        NOTE  ASCIR = AIRCRAFT SYSTEM CAPABILITY IMPROVEMENT RATE
        NOTE  ASCID = AIRCRAFT SYSTEM CAPABILITY IMPROVEMENT DELAY

A     DASC.K=EASC.K*ASCA
C     ASCA=1.3
A     ASCD.K=MAX(DASC.K-CI.K-ASCL.K,.001)
R     ASCIR.K=ASCD.K

        NOTE   DASC = DESIRED AIRCRAFT SYSTEM CAPABILITY
        NOTE   EASC = ENEMY AIRCRAFT SYSTEM CAPABILITY
        NOTE   ASCA = AIRCRAFT SYSTEM CAPABILITY ADVANTAGE
        NOTE   ASCD = AIRCRAFT SYSTEM CAPABILITY DISCREPANCY

L     LOWS.K=LOWS.J+(DT)(EWSAC.JK-EWSR.JK)
N     LOWS=3000
R     EWSAC.KL=DELAYP(EWSAR.JK,EWSAD.K,EWP.K)
N     EWP=2
A     EWSAD.K=TABLE(EWSADT,PIR.K,0,10,2)
T     EWSADT=24/24/24/20/16/14

        NOTE   LOWS = LEVEL OF WEAPON SYSTEMS
        NOTE  EWASC = EXIRTING WEAPON SYSTEM ACQUISITION COMPLETE
        NOTE   EWSR = EXIRTING WEAPON SYSTEM RETIREMENT
        NOTE  EWSAD = EXIRTING WEAPON SYSTEM ACQUISITION DELAY

A     DLOWS.K=USPEC.K/ASCL.K
A     LOWD.K=MAX((DLOWS.K-LOWS.K-EWP.K),.001)
R     EWSAR.KL=MIN(LOWD.K,WSPC.K)
A     WSPC.K=10
A     CRASHF.K=TABLE(CRASHT,SORTR.K,.8,1.3,.1)
T     CRASHT=.0016/.0016/.002/.004/.006/.01
R     EWSR.KL=CRASHF.K*LOWS.K

        NOTE  DLOWS = DESIRED LEVEL OF WEAPON SYSTEMS
        NOTE  USPEC = UNITED STATES PERCEIVED ENEMY CAPABILITY
        NOTE  LOWED = LEVEL OF WEAPON SYSTEM DISCREPANCY
        NOTE  EWSAR = EXISTING WEAPON SYSTEMS ACQUISITION RATE
        NOTE CRASHF = CRASH FACTOR
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```
*        AIRCRAFT AVAILABILITY

A     ASA.K=SMOOTH((DASA.K*ASMDF.K*ASRDF.K*AVLSDF.K*AVMXDF.K),ASAS)
C     ASAS=3
A     DASA.K=TABLE(DASAT,DWSR.K,1.0,4.0,.5)
A     ASAD.K=MAX(DASA.K-ASA.K,0)
T     DASAT=.3/.45/.55/.65/.75/.80/.85
A     AVLSDF.K=TABLE(AVLSDT,LOSDP.K,.5,1.5,.25)
T     AVLSDT=.6/.8/1.0/1.05/1.1
A     AVMXDF.K=TABLE(AVMXDT,MXCAP.K,25,75,10)
T     AVMXDT=.5/.75/.9/1.0/1.05/1.1
A     ASMDF.K=TABLE(ASMDFT,ASML.K,5,10,1)
T     ASMDFT=.55/.7/.85/.95/.97/1
A     ASRDF.K=TABLE(ASRDFT,ASRL.K,5,10,1)
T     ASRDFT=.7/.8/.85/.9/.95/1

        NOTE    ASA = AIRCRAFT SYSTEM AVAILABILITY
        NOTE   DASA = DESIRED AIRCRAFT SYSTEM AVAILABILITY
        NOTE   ASAD = AIRCRAFT SYSTEM AVAILABILITY DISCREPANCY
        NOTE  ASMDF = AIRCRAFT SYSTEM MAINTAINABILITY DISCREPANCY
        NOTE  ASRDF = AIRCRAFT SYSTEM RELIABILITY DISCREPANCY FACTOR
        NOTE AVLSDF = AVAILABILITY LEVEL OF SPAIRS DISCREPANCY FACTOR
        NOTE AVMXDF = AVAILABILITY MAINTENANCE CAP DISCREPANCY FACTOR
        NOTE  ASMDF = AIRCRAFT SYSTEM MAINTAINABILITY DIS FACTOR
        NOTE  ASRDF = AIRCRAFT SYSTEM RELIABILITY DISCREPANCY FACTOR

A     ASMD.K=MAX(ASMD2.K,.00001)
A     ASMD2.K=DASM.K-ASML.K-MI.K
A     DASM.K=CONST
C     CONST=10
L     ASML.K=ASML.J+(DT)(MIC.JK)
N     ASML=5
R     MIC.KL=DELAYP(MIR.JK,MID.K,MI.K)
N     MI=TES1
C     TES1=2
A     MID.K=TABLE(MIDT,PIR.K,0,10,2)
T     MIDT=24/20/18/16/12
R     MIR.KL=ASAD.K*ASMDF2.K
A     ASMDF2.K=TABLE(MDF2T,ASMD.K,0,5,1)
T     MDF2T=.00001/.1/.2/.4/.8/2

        NOTE   ASMD = AIRCRAFT SYSTEM MAINTAINABILITY DISCREPANCY
        NOTE  ASMD2 = AIRCRAFT SYSTEM MAINTAINABILITY DISCREPANCY 2
        NOTE   DASM = DESIRED AIRCRAFT SYSTEM MAINTAINABILITY
        NOTE   ASML = AIRCRAFT SYSTEM MAINTAINABILITY LEVEL
        NOTE    MIC = MAINTAINABILITY IMPROVEMENT COMPLETION
        NOTE    MIR = MAINTAINABILITY IMPROVEMENT RATE
        NOTE    MID = MAINTAINABILITY IMPROVEMENT DELAY
        NOTE ASMDF2 = AIRCRAFT SYSTEM MAINTAINABILITY DISCREPANCY

A     ASRD.K=MAX(ASRD2.K,.00001)
A     ASRD2.K=DASR.K-ASRL.K-RI.K
```

```
A     DASR.K=CONST
L     ASRL.K=ASRL.J+(DT)(RIC.JK)
N     ASRL=5
R     RIC.KL=DELAYP(RIR.JK,RID.K,RI.K)
N     RI=TES2
C     TES2=2
A     RID.K=TABLE(RIDT,PIR.K,0,10,2)
T     RIDT=18/16/14/12/11/11
R     RIR.KL=ASAD.K*ASRDF2.K
A     ASRDF2.K=TABLE(RDF2T,ASRD.K,0,5,1)
T     RDF2T=.00001/.12/.24/.5/1/2.5

          NOTE   ASRD = AIRCRAFT SYSTEM RELIABILITY DISCREPANCY
          NOTE   DASR = DESIRED AIRCRAFT SYSTEM RELIABILITY
          NOTE   ASRL = AIRCRAFT SYSTEM RELIABILITY LEVEL
          NOTE    RIC = RELIABILITY IMPROVEMENT COMPLETION
          NOTE    RIR = RELIABILITY IMPROVEMENT RATE
          NOTE    RID = RELIABILITY IMPROVEMENT DELAY
          NOTE ASRDF2 = AIRCRAFT SYSTEM RELIABILITY DISCREPANCY FACTOR

A     DWSR.K=TABLE(DWSRT,USPD.K,.5,1.5,.25)
T     DWSRT=3.5/2.5/2.0/1.8/1.6

          NOTE   DWSR = DESIRED WARTIME SORTIE RATE
```

```
*         MATERIEL READINESS

L     LOS.K=LOS.K+(DT)(SRC.JK+SAC.JK-SBR.JK-SLR.JK)
N     LOS=8200
A     DLOS.K=(SBR.JK*PLINE*SL)+WRMF.K
C     PLINE=6
C     SL=1.2
A     WRMF.K=SBR.JK*WRL
N     WRL=2
A     LOSD.K=(DLOS.K-SAP.K)-(LOS.K+SIR.K)
A     LOSDP.K=(LOS.K+SIR.K)/DLOS.K

          NOTE     LOS = LEVEL OF SPARES
          NOTE     SRC = SPARES REPAIR COMPLETE
          NOTE     SAC = SPARES ACQUISITION COMPLETE
          NOTE     SBR = SPARES BREAK RATE
          NOTE     SLR = SPARES LOSS RATE
          NOTE    DLOS = DESIRED LEVEL OF SPARES
          NOTE   PLINE = DESIRED PIPELINE LENGTH
          NOTE      SL = SAFETY LEVEL
          NOTE    WRMF = WAR RESERVE MATERIAL
          NOTE    LOSD = LEVEL OF SPARES DISCREPANCY

R     SRC.KL=DELAYP(SRR.K,SRD.K,SIR.K)
N     SIR=15371
A     SRD.K=SPIRF.K*SWSCF.K*TABLE(SRDT,LOSDP.K,.5,1.5,.25)
T     SRDT=4.5/5/6/6.5/7

          NOTE     SRR = SPARES REPAIR RATE
          NOTE     SRD = SPARES REPAIR DELAY
          NOTE   SPIRF = SPARES PRESS URE TO IMPROVE READINESS FACTOR
          NOTE   SWSCF = WEAPON SYSTEMS CAPABILITY FACTOR

A     SPIRF.K=TABLE(SPIRFT,PIR.K,0,10,2)
T     SPIRFT=.6/.75/.9/1/1/1.1
A     SWSCF.K=TABLE(SWSCFT,ASCL.K,5,20,2.5)
T     SWSCFT=1.3/1.2/1.2/1.1/1.0/.9/.8

          NOTE     PIR = PRESSURE TO IMPROVE READINESS
          NOTE    ASCL = AIRCRAFT SYSTEM CAPABILITY LEVEL

R     SAC.KL=DELAYP(SAR.JK,SAD.K,SAP.K)
N     SAP=2
A     SAD.K=SPIRF.K*SWSCF.K*TABLE(SADT,LOSDP.K,.5,1.5,.25)
T     SADT=18/20/24/24/28
R     SAR.KL=CLIP(DSAR.K,.001,DSAR.K,500)*BUY
N     BUY=4
A     DSAR.K=MAX(SASADF.K*SMBF.K*LOSD.K,0)

          NOTE     SAR = SPARE ACQUISITION RATE
          NOTE     SAD = SPARE ADQUISITION DELAY
          NOTE    DSAR = DESIRED SPARE ACQUISITION RATE
```

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    NOTE SASADF = SPARE AIRCRAFT SYSTEM AVAILABILITY DISCREPANCY
    NOTE   SMBF = SPARE MILITARY BUDGET FACTOR

A   SASADF.K=TABLE(SASADT,ASAD.K,0,.4,.1)
T   SASADT=.01/.95/1/1/1
A   SMBF.K=TABLE(SMBFT,MB.K,0,10,2)
T   SMBFT=.5/.7/.9/1.0/1.0/1.2

    NOTE    SBR = SPAIR BREAK RATE

R   SBR.KL=(SR.JK*LOWS.K*SASRLF.K*SPMXCF.K*MOTH)
X   -(SR.JK*LOWS.K*SASRLF.K*SPMXCF.K*MOTH*NRS)
A   SASRLF.K=TABLE(ASRLFT,ASRL.K,0,10,2.5)
T   ASRLFT=.08/.05/.03/.02/.01
A   SPMXCF.K=TABLE(SPMXCT,MXCAP,25,75,10)
T   SPMXCT=1.15/1.1/1.05/1/1/.95
C   MOTH=22

    NOTE      SR = SORTIE RATE
    NOTE    LOWS = LEVEL OF WEAPON SYSTEMS
    NOTE SASRLF = SPAIRS AIRCRAFT SYSTEM RELIABILITY LEVEL FACTOR
    NOTE    ASRL = AIRCRAFT SYSTEM RELIABILITY LEVEL

R   SRR.KL=MIN(SBR.JK,BSRC.K)
A   BSRC.K=DLINF3(DBSRC.K,BSRCD.K)
A   BSRCD.K=TABLE(BSRCDT,LOSDP.K,.5,1.5,.25)
T   BSRCDT=4/5/7/8/9
A   DBSRC.K=SBR.K*DBSRCF.K
A   DBSRCF.K=TABLE(DBSRCT,LOSDP.K,.5,1.5,.25)
T   DBSRCT=2/1.5/1/1.25/1.5

    NOTE    BSRC = BROKEN SPARES REPAIR CAPACITY
    NOTE   BSRCD = BROKEN SPARES REPAIR CAPACITY DELAY
    NOTE   DBRSC = DESIRED BROKEN SPAIRS REPAIR CAPACITY
    NOTE DBSRCF = DESIRED BROKEN SPAIRS REPAIR CAPACITY FACTOR

R   SLR.KL=SR.JK*LOWS.K*SASRLF.K*SPMXCF.K*MOTH*NRS
C   NRS=.02

    NOTE    ASRL = AIRCRAFT SYSTEM RELIABILITY LEVEL
    NOTE     BSL = BROKEN SPARES LEVEL
    NOTE     SLR = SPARES LOSS RATE
    NOTE   BSRCD = BROKEN SPAIRS REPAIR CAPACITY DELAY
    NOTE   DBSRC = DESIRED BROKEN SPAIRS REPAIR CAPACITY
    NOTE DBSRCF = DESIRED BROKEN SPAIRS REPAIR CAPACITY FACTOR
    NOTE      SL = SAFETY LEVEL
```

SELECTED BIBLIOGRAPHY

A. REFERENCES CITED

1. Adams, Colonel Jimmy V., USAF. Assistant Deputy Chief of Staff for Requirements, HQ TAC, Langley AFB VA. Personal interview. 14 February 1980.

2. "Air Force Almanac," Air Force Magazine, Vol. 63, No. 5 (May 1980), pp. 151-167.

3. "Air Force Integrated Readiness Measurement System," Softech Inc., 14 March 1980.

4. "Airpower Comes of Age," Air Force Magazine, Vol. 50, No. 9 (September 1967), pp. 48-58.

5. Barrows, Colonel Ralph E., USAF. Assistant Deputy Chief of Staff for Intelligence, HQ TAC, Langley AFB VA. Personal interview. 13 February 1980.

6. Clark, Lieutenant Colonel Ronald, USAF. Logistics Plans Division, HQ TAC, Langley AFB VA. Personal interview. 14 February 1980.

7. Coyle, R. G. Management System Dynamics. New York: John Wiley and Sons, 1977.

8. Czeluizmak, Lieutenant Colonel Donald R., USAF. Tactical Air Division, Programs Analysis and Evaluation, Assistant Secretary of Defense, Washington DC. Personal interview. 21 February 1980.

9. Demuith, Major Steven H., USAF. Chief, Maintenance Training Branch, 1 TFW, Langley AFB VA. Personal interview. 15 February 1980.

10. "Does Compliance Equate to Readiness?" TIG Brief, Vol. 31, No. 4 (23 February 1979), p. 5.

11. Duerbig, Major Alfred H., USAF. Manpower and Personnel Division, HQ USAF, Washington DC. Personal interview. 22 February 1980.

12. Fitzgerald, Captain Baldwin G., USAF, and Captain Phillip E. Miller, USAF. "A System Dynamics Study of the Factors Used in the Measurement of an Aircraft Wing's Capability." Unpublished master's thesis. LSSR 23-78A, AFIT/LS, Wright-Patterson AFB OH, June 1978.

13. Forrester, Jay W. Collected Papers of Jay W. Forrester. Cambridge MA: Wright-Allen Press, Inc., 1975.

14. ________. Industrial Dynamics. Cambridge MA: M.I.T. Press, 1961.

15. "Future Look." Briefings to XOXLP, HQ USAF, Washington DC, 30 April - 2 May 1980.

16. Gasner, Lieutenant Colonel Robert R., USAF. Readiness Measurement Group, HQ USAF, Washington DC. Personal interviews 21-22 February 1980.

17. General Accounting Office. DOD's Materiel Readiness Report to the Congress. GAO Report B-146896. Washington: Government Printing Office, 1979.

18. Goodman, Michael R. Study Notes in Systems Dynamics. Cambridge MA: Wright-Allen Press, Inc., 1974.

19. Greenwood, Major George R., USAF. Manpower and Personnel Division, HQ USAF, Washington DC. Personal interview. 22 February 1980.

20. Hatch, Lieutenant Colonel Ronald N., USAF. Assistant Deputy Commander for Maintenance, 1 TFW, Langley AFB VA. Personal interview. 15 February 1980.

21. Hawley, Colonel Robert E., USAF. Deputy Commander for Operations, 1 TFW, Langley AFB VA. Personal interview. 15 February 1980.

22. House, Peter W., and John McLeod. Large Scale Models for Policy Evaluations. New York: John Wiley and Sons, 1977.

23. Joblowski, Edward. Airwar. Garden City NY: Doubleday and Company, Inc., 1971.

24. Joint Chiefs of Staff. Force Status and Identity Reports. JCS Publication 6, Vol. 2. Washington: Government Printing Office, 1974.

25. Jones, General David C. "Military Posture for 1980," Supplement to Air Force Policy Letter for Commanders, AFRP 190-2, No. 3-1979 (March 1979), pp. 21-30.

26. McCarthy, Lieutenant Colonel Michael E., USAF. Tactics and Training, HQ USAF, Washington DC. Personal interview. 20 February 1980.

27. Miller, Colonel Donald L., USAF. Comander, 1 TFW, Langley AFB VA. Personal interview. 14 February 1980.

28. Minter, Lieutenant General B. M., USAF. Deputy Chief of Staff, Logistics and Engineering, HQ USAF, Washington DC. Personal interview. 20 February 1980.

29. Musson, Lieutenant Colonel Thomas A., USAF. "Readiness Measurement and Reporting." Unpublished research report No. 429, Air War College, Maxwell AFB AL, 1978.

30. Naylor, Thomas H., and others. Computer Simulation Techniques. New York: John Wiley and Sons, 1968.

31. Pickett, Brigadier General John L., USAF. Deputy Chief of Staff, Plans, HQ TAC, Langley AFB VA. Personal interview. 13 February 1980.

32. "Readiness/Effectiveness," TIG Brief, Vol. 30, No. 9 (28 April 1978), pp. 3-4.

33. "Readiness Evaluations: A Dynamic Challenge," TIG Brief, Vol. 30, No. 6 (17 March 1978), p. 7.

34. "Readiness Now," TIG Brief, Vol. 30, No. 14 (21 July 1979), p. 1.

35. "Readiness and Training Realism," TIG Brief, Vol. 30, No. 2 (20 January 1978), pp. 9-10.

36. Richards, Laurence D., Peter L. Eirich, and Murray A. Geisler. A Concept for the Management of Readiness. Washington: Logistics Management Institute, January 1980.

37. Rogers, General F. Michael, USAF. "Readiness: A Logistician's View," Air University Review, Vol. 28, No. 6 (September-October 1977), pp. 36-41.

38. Schoderbek, Peter P. Management Systems. New York: John Wiley and Sons, 1967.

39. Uher, Colonel Edward L., USAF. Deputy Director, Logistics Plans and Programs, HQ USAF, Washington DC. Personal interview. 21 February 1980.

40. United States Air Force Dictionary. Maxwell AFB AL: Air University Press, 1956.

41. U.S. Department of the Air Force. Assignment Information. AFP 36-6. Washington: Government Printing Office, 1979.

42. ________. Combat Readiness Reporting. AFR 55-15. Washington: Government Printing Office, 1 February 1980.

43. ________. Flying Training. TACM 51-50. Washington: Government Printing Office, 1 July 1979.

44. ________. United States Air Force Basic Doctrine. AFR 1-1. Washington: Government Printing Office, 14 February 1979.

45. Welch, Major General Larry D., USAF. Deputy Chief of Staff for Operations, HQ TAC, Langley AFB VA. Personal interview. 14 February 1980.

B. RELATED SOURCES.

Barker, Colonel Thomas H., USAF. "Combat Unit Readiness Reporting Criteria for Tactical Fighter Aircraft." Unpublished research report No. 4840, Air War College, Maxwell AFB, 1973.

Bell, Chauncey F., and Thomas T. Tierney. "Force Capability Reporting." Rand Corporation Report R-547-PR, Santa Monica CA, September 1970.

Duncan, Captain William D., Jr., USAF and Captain Curtis H. Gwaltney, USAF. "An Evaluation of the Effects of Selected Scheduling Rules on Aircraft Sortie Effectiveness." Unpublished master's thesis. LSSR 10-77A, AFIT/SD, Wright-Patterson AFB OH, June 1977.

Haymont, Colonel Irving, USA. "Measuring Unit Training Proficiency," Military Review, June 1977, pp. 28-35.

Kaffenberger, Susan A. and Captain David P. Martin, USAF. "A Dynamic Policy Model of the Department of Defense Systems Acquisition Process." Unpublished master's thesis. LSSR 179-A, AFIT/SL, Wright-Patterson AFB OH, June 1979.

"UCMS Reporting," TIG Brief, Vol. 28, No. 15 (13 August 1976), p. 11.

BIOGRAPHICAL SKETCHES OF THE AUTHORS

Major Robert P. Andrews graduated from the University of Nebraska in 1966 with a bachelor's degree in Technical Animal Science. He received his commission through the Air Force Reserve Officer Training Corps and was designated a distinguished graduate. Major Andrews completed his Undergraduate Pilot Training at Vance Air Force Base, Oklahoma and was assigned to Nellis Air Force base, Nevada, as an F-111A pilot. After attending the Defense Language Institute in Monteray, California, Major Andrews was assigned to Ubon Air Base, Thailand, as a Forward Air Controller. While assigned at Ubon, he flew 670 hours of combat time in the OV-10A. Major Andrews was then assigned to Cannon Air Force Base, New Mexico, as an aircraft commander in the F-111D. He accumulated over 1700 hours in the F-111 and has been an Instructor Pilot, Flight Commander, and Wing Standardization/Evaluation Flight Examiner. After receiving his Master of Science Degree in Acquisition Logistics Management from the Air Force Institute of Technology, Major Andrews will become a Division Chief in the Tactical Systems Office, Wright-Patterson Air Force Base, Ohio.

Captain James F. Shambo graduated from Bowling Green State University, Bowling Green, Ohio, with a bachelor's degree in Business Administration. He was commissioned in the United States Air Force through the Air Force Reserve Officer Training Corps and entered pilot training at Columbus Air Force Base, Mississippi. Upon graduation from pilot training, Captain Shambo was assigned to Shaw Air Force Base, South Carolina, for upgrade to aircraft commander in the RF-4C. In July 1974, Captain Shambo was assigned to Kadena Air Base, Japan. During his three years at Kadena, Captain Shambo served in the positions of Squadron Functional Check Flight Pilot and Squadron Flying Training Officer. Upon his completion of the tour at Kadena, Captain Shambo was reassigned to Zweibruken Air Base, Germany. While assigned to Zweibruken, Captain Shambo held the positions of Instructor Pilot, Squadron Flying Training Officer, and Chief, Wing Flying Training. Captain Shambo left this assignment to attend the Air Force Institute of Technology at Wright-Patterson Air Force Base, Ohio. After receiving his Master of Science Degree in Logistics Management, he will be assigned to the Logistics Plans Division, Headquarters, Tactical Air Command.