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STRUCTURE AND ANALYSIS OF THE AIR FORCE LOGISTICS SYSTEM

Volume II, A Macro Analysis of
DoD Logistics Systems

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PREFACE

This report presents the results of an effort to lay the basis for a management indicator system to serve the logistics information needs of the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics). Focusing on the U.S. Air Force logistics system, it depicts the system structure, identifies data potentially useful for high level policy and resource decisions, and exhibits the data in formats that facilitate those decisions.

The report should not be read as an assessment of the effectiveness of the Air Force logistics system or the performance of its managers. Nor should it be viewed as prescribing the information the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics) should receive. Rather, the combination of elements presented here—basic knowledge of system components and their linkages, and highly aggregate data from existing systems analyzed in terms of policy level decision-making and expressed as trends—is a significant portion of a system to aid policy formulation and resource allocation in the Office of the Secretary of Defense. A follow-on report will incorporate those elements into the management indicator system.

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CHAPTER 1: INTRODUCTION

PURPOSE OF THIS REPORT

Policy level managers have information needs different from operational managers. Top level managers need highly aggregate information, but to obtain this information requires much more than simply combining data from the operating levels. The aggregate data must be analyzed, organized, and made pertinent to major issues. Management indicators are one means of satisfying this need.

This report presents a number of findings about the Air Force logistics system that demonstrate the usefulness of well designed indicators to top-level management. We attempted to develop indicators based principally on a formal structure of the logistics system and on trend analysis. Further study to demonstrate how policy level managers can use such indicators to identify and evaluate alternative courses of action is already underway.

CONCEPT OF ASD(MRA&L) ROLE

To direct our thinking about the uses of information within the DoD logistics system, we visualized the Secretary of Defense (SecDef) operating in effect as chairman of the board or chief executive officer of a diversified corporation, in which the separate Military Departments function as operating divisions. The SecDef and his Assistant Secretaries would then be engaged in the following activities: provision of broad guidance on organizational goals and resource levels; review of resource requests for compatibility with such goals and planning objectives; allocation of appropriated and available resources to achieve desired objectives; evaluation of performance with these resources; and revision of general policy, by experience and appropriate analysis.

The DoD is a large and complex organization. The Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics) ASD(MRA&L) cannot possibly be involved in highly detailed management and at the same time retain an overall knowledge of what is happening in logistics. Hence, managerial activities at this echelon must be conducted at an appropriately aggregate level. For example, the ASD(MRA&L) would like to be able to present the SecDef, Congress, and the Office of Management and Budget (OMB) with an overall assessment of logistics and to explain how their decisions or activities could affect it. In dealing with a Military Department, he would like to know the overall status of logistics therein and understand how activities at his level would affect it.

These management information needs of ASD(MRA&L) have to a great extent governed the selection of data for this report. We have naturally emphasized his interaction with the Air Force. His relations with other DoD components will become clearer after all the Services have been analyzed.

ASD(MRA&L) MANAGEMENT NEEDS

Our concept of the ASD(MRA&L) role stresses the importance of an aggregate viewpoint, meaning that ASD(MRA&L) should rely heavily on overall system appraisal and evaluation. We all agree that military capability, however defined, represents a desirable criterion for evaluating logistics performance. We are also aware that significant difficulties exist in defining capability so that it is measurable and useful for management decision-making. The DoD is continually trying to obtain an acceptable measure of capability. Such concepts as "readiness" and "sustainability" are often used, each of which has limitations.

The DoD has a formal system of capability measurement, known as the FORSTAT Report, that applies to all the Services. Each combat unit is required to rate its own readiness. The system is largely qualitative and relies heavily on subjective evaluation. Furthermore, the FORSTAT rating (C-rating) cannot easily be related to the more detailed reporting systems that can be used to analyze the causes of variation in capability, and it does not measure logistics performance as such. If a Service is to be able to respond to questions raised at the SecDef level, a measurement of capability more relatable to the operation of its own logistics system is needed.

The Air Force reports continually on the operational readiness of its aircraft inventory. Not operationally ready aircraft are classified according to the general kinds of logistics action needed to bring them back to operational readiness. A similar equipment status reporting system is used for many weapon systems in the other Services. The connection between logistics performance and status reporting could be useful to ASD(MRA&L). The operational readiness reporting system could help meet the need for some means of relating a reasonable measure of capability to logistics system performance.

We recognize the limitations of representing aircraft operational readiness as a general measure of capability. The operational readiness rate, as usually employed, applies to the peacetime status of aircraft, and does not explicitly consider what may be required to employ such aircraft in contingency situations. Still, contingency planning and evaluation can be uncertain and arbitrary. Furthermore, at this stage of our work, the need to create a logistics structure and evaluate it in terms of empirical data was paramount. Consequently, we had to depend on present reporting systems largely concerned with peacetime logistics activities. We feel, however, that the current performance of the logistics system does reflect its capability to operate under emergency or contingency circumstances.

The Air Force has taken an approach to the problem of evaluating its logistics capability somewhat different from ours. It has established a quarterly report on the status of those logistics resources that can affect its capability to respond to contingencies. The report is designed to elicit information from the operational commands, such as Strategic Air Command, Tactical Air Command, and Military Airlift Command, on the status of aircraft, war reserves, maintenance manning and other major resources. The report is intended to help the commands assess their logistics readiness and to provide information to Air Force Headquarters on their resource status. It apparently serves a useful purpose for the Air Force, but it does not meet our need for an explicit relation between a measure of output or capability and inputs or resources.

RELATION OF THIS ANALYSIS TO MANAGEMENT INDICATORS

Management indicators can serve several purposes. They can help in assessing overall logistics systems performance and in suggesting what factors influence it. They can also improve communication between ASD(MRA&L) and such agencies as Congress and OMB, between ASD(MRA&L) and the Services, and within the Office of Secretary of Defense (OSD).

Management indicators must be based on the logistics support structure so that trends can be related to underlying causes. Previous systems, such as the Logistics Performance Measurement and Evaluation System (LPMES), have failed to meet this standard. LPMES was started in 1969 and has not been used since early 1976, because of general dissatisfaction with the results. Having reviewed the concept and performance of LPMES, we feel that one of its significant failings was its lack of structure. An explicit structure can help select indicators that measure logistics on a system-wide basis, guide the level of aggregation appropriate to the ASD(MRA&L) level, and aid in the analysis of trends observed in the indicators.

LPMES also used arbitrary goals. In the dynamic environment of military logistics, goals need to be changed as circumstances dictate. Complex organizations like DoD find it difficult to change goals readily. The alternatives are to make quick changes, which cause confusion among the various levels of management, or to set vague goals that can be less responsive to changed circumstances. Either alternative demonstrates the difficulty of using arbitrary goals in the DoD environment.

Arbitrary goals can also lead to distorted reactions, which tend to vitiate whatever sound purpose may have been originally intended. A classic example is the aircraft NORS (Not Operationally Ready, Supply) standard followed in the Air Force. As our analysis shows, the NORS rate is kept low, but at the expense of distortions in logistics activity, without necessarily leading to the desired benefits from a low NORS rate.

Given the current state of knowledge for analyzing complex systems, we believe that the use of trend analysis to assess logistics system performance is preferable to the use of arbitrary standards. In trend analysis, we observe the changes in significant variables over time and use analysis to try to account for the changes. The approach is necessarily subjective, since it depends on the availability of data and the adequacy of reporting. Furthermore, major policy changes are as likely to affect trends as changes in performance. Such policy changes have to be accounted for in any explanation of the accompanying trends. While we attempted to identify relevant policy changes, they are not always well documented or obvious.

Trend analysis does, however, provide a systematic way of studying a complex system such as logistics through the use of aggregate real world data. The structure defining the relationships in the logistics system thus becomes an important tool, because it helps identify the key variables in the different logistics functions and activities, and suggests which ones should be examined for possible connections. If all we derived from trend analysis was an explanation of past behavior, our results would not satisfy the requirements of DoD top management. Recognizing the importance of looking ahead, we still believe that plans for the future must be based on what has previously been demonstrated to be realistic. The future is not a linear extrapolation of the past, but the knowledge gained from an analysis of past behavior is indispensible to effective future planning.

This report illustrates what can be done with trend analysis. Given the tremendous scope and detail of the Air Force logistics system, we could do only a limited analysis of the available data. Much more needs to be done, but our experience indicates that trend analysis, guided by a structure, is a good means of learning a great deal about the behavior of logistics systems in a relatively short time.

We therefore believe that the same structured approach should be followed in selecting management indicators. The use of such indicators is consistent with the managerial environment at the ASD(MRA&L) level, where rapid learning about the logistics system is essential, and where excessive concern over details can lead to poor allocation of management effort and to conflict with lower-level managers. A sound indicator system can facilitate such rapid learning and consequently be valuable at the top management level of DoD, where turnover is not uncommon. For such an indicator system to be useful, however, OSD management must have the tools with which to implement it. This is a major goal of the study effort now in progress.

This report should provide a useful overall description of trends in Air Force logistics system performance and cost and a necessary step towards the ultimate development of management indicators. Comparable analysis for the other parts of the DoD logistics system will be required to provide ASD(MRA&L) with indicators applicable to all Military Services. The other Services have aircraft, but they also have ships, tanks, and a variety of other weapon systems that are used in very different operational environments and require other kinds of logistics and reporting systems. In many respects, the Air Force structure we have used is much simpler than that of the other Services, so that the extension of the analysis is not a straightforward research task.

OVERALL APPROACH

The overall purpose of LMI Task 76-6 is to analyze the management role of the ASD(MRA&L) and to develop an aggregate management indicator system compatible with that role. The task has been divided into several phases. Phase 1 (Volume I)[1] was a description of significant management aspects of the current DoD logistics system. This report (Volume II) is a part of Phase 2, which uses the Air Force logistics system as a test bed for developing management indicators.

In analyzing the major aspects of Air Force logistics, we focused primarily on the interactions between aircraft operational readiness and logistics system performance. Thus, we did not investigate wartime capability as such, but we believe that the adequate support of aircraft in peacetime is a prerequisite to their availability and operation in wartime. Also, efficient and effective support of aircraft should help to provide more resources for emergency requirements within overall budget availability. Although we did not examine available information on missiles, ammunition, vehicles, etc., we believe the types of analysis performed here on aircraft support could also be performed on these other commodities. Aircraft, however, consume the major portion of logistics resources.

This focus on the interactions between aircraft operational readiness and logistics system performance essentially limited the analysis to the functions of maintenance, supply, and transportation, as related to peacetime operation of aircraft. An analysis of the installations and housing function was also included, to make the functional coverage of Volume II compatible with the logistics system description contained in Volume I. We

[1] Logistics Systems in the Department of Defense, A Macro Analysis of DoD Logistics Systems, Volume I, LMI Task 76-6, December 1976.

did not analyze procurement as an individual function because doing so would have required an extensive analysis of the Defense industrial base in order to develop meaningful management indicators.

Our approach to the Air Force analysis was as follows. First, we developed a structure of the logistics system describing the relationships among the major activities of primary interest to top management, whether in the Air Force or ASD(MRA&L). Such activities were described in terms of logistics functions, support echelons, types of resources, and sources of funding. Using this structure, we then sifted through the many Air Force reporting systems to find those containing the most useful data for analyzing operational readiness and resource management. Finally, we collected the available data, subjected them to trend analysis, and thereby evaluated the significance of the relationships defined by our logistics system structure.

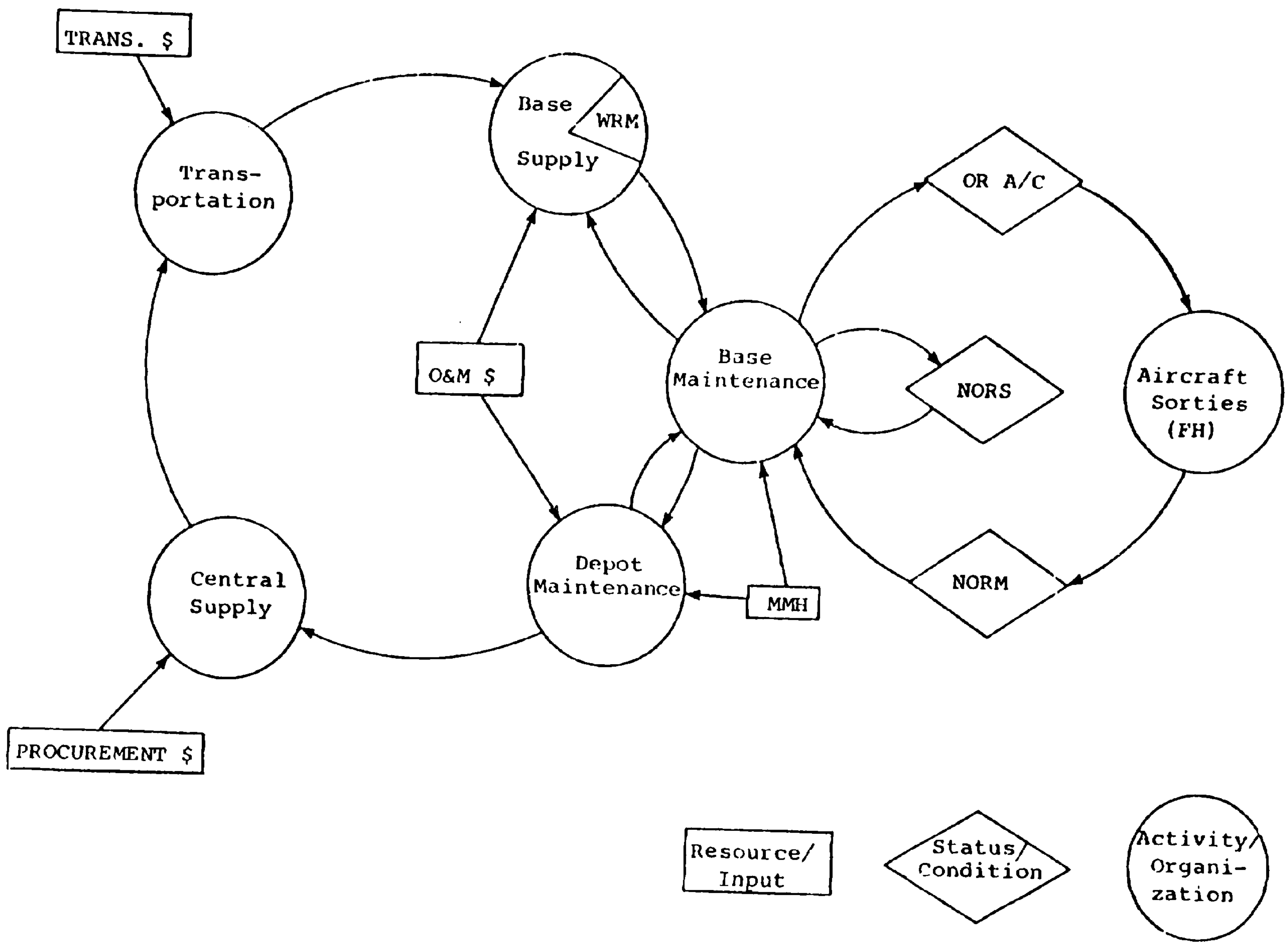
THE LOGISTICS STRUCTURE

The interactions of the various elements of the Air Force logistics structure contributing to aircraft operations are depicted in Figure 1-1, which shows activities or organizations, status or condition, and resources or inputs. Figure 1-1 represents a highly aggregated structure that omits many details and exceptions. A modified version of Figure 1-1 will appear at the beginning of each subsequent chapter to remind the reader of the underlying logistics processes and stress the specific elements of the structure under discussion.

The right side of Figure 1-1 illustrates the flow of aircraft in the operational cycle, while the left side illustrates the flow of aircraft and/or components in the logistics support cycle. In the operational cycle, the use of operationally ready (OR) aircraft produces flying hours (or sorties), which in turn necessarily induce malfunctions. When these occur, aircraft enter a Not Operationally Ready, Maintenance (NORM) status and flow into Base Maintenance. When repaired, aircraft return to an OR status.

The link between the operational and logistics support cycles is Base Maintenance. It is essential in the operational cycle, and is supported in various ways by the other elements of the logistics support cycle. At the base level, the supply and maintenance elements interact closely with each other, the supply element furnishing needed spares and repair parts from its inventory, and the maintenance element generating demands for those items and returning repaired spares to the supply inventory. When the Base Supply element is unable to provide essential spare parts from its inventory immediately, then aircraft may become NORS. At that point, the logistics support cycle expands to include Central Supply. Likewise, if the level of repair required for aircraft or spares is beyond

FIGURE 1-1. AIR FORCE LOGISTICS STRUCTURE



the capability of Base Maintenance, the logistics support cycle expands to include Depot (or Central) Maintenance.

That expansion of the logistics support cycle is complicated by geographical separation of the base and central levels. Hence, the Air Force must employ some form of transportation. With the transportation element included, the Central Supply element acts as the wholesaler for the Base Supply element, acquiring items from industry (or other Government sources) through procurement and providing them to Base Supply. Depot Maintenance behaves in a similar manner, performing overhauls of aircraft and engines and item repairs beyond Base Maintenance capability. Upon completion of overhaul, aircraft are normally returned to their original base. When engines have completed overhaul, or when reparable spares have been repaired, they enter depot stock, and come under the management control of Central Supply as inventories available for redistribution to Base Supply elements.

The resources for, or inputs to, the logistics cycle elements are dollars and/or maintenance man-hours. At the base level, Operations and Maintenance (O&M) funds support both the purchase of items and the repair of aircraft and spares. Maintenance man-hours are input to both Base and Depot Maintenance. Procurement dollars are resources for Central Supply to acquire aircraft engines and exchangeable (reparable) items. Transportation dollars (usually O&M) are the means of paying for shipping freight/cargo to the various destinations.

Stock and industrial funds have been deliberately omitted for simplicity. They are revolving funds to provide capital for purchase of goods or services and are subsequently reimbursed by customers to whom those goods or services are provided. The Air Force Stock Fund supports both Central and Base Supply elements, and the Air Force Industrial Fund supports Depot Maintenance and overseas transportation controlled by the military transportation agencies.

Ancillary to Base Supply is War Reserve Materiel (WRM), which constitutes an emergency inventory of critical demand-supported items. WRM may be used to relieve a NORS condition. Likewise, NORM and NORS aircraft may be cannibalized to return other NORS aircraft to an OR status.

The above description outlines the fundamental process of the Air Force logistics structure for generating a constant level of OR aircraft. In no way does it begin to describe the depth and breadth of the detailed functional activities required to support that structure. What it does is to lay the foundation for a description and analysis of a set of performance measures to monitor the logistics structure.

With the basic logistics structure in mind, we now examine in more detail the current Air Force method of defining aircraft status in relation to it. Figure 1-2 shows an overview of how aircraft status is measured along with the relationships of the logistics elements. At the unit level, OR aircraft from the aircraft inventory produce sorties or flying hours, which eventually result in NORM or NORS aircraft. At this point, the aircraft enter the base echelon. Within the NORM and NORS statuses, there are further subdivisions (defined in Chapter 2) that identify the types of maintenance the aircraft has to undergo, and the severity of the supply shortage with respect to the aircraft's operability. If the base echelon is unable to effect repairs or supply the necessary components, the aircraft and/or components then interact with the depot echelon.

Figures 1-3 and 1-4 are detailed flow charts of Air Force logistics activities at the base and depot levels, respectively. The linkages between aircraft status and the logistics activities are identified by performance measures of these activities. Thus, fill rate is a supply performance measure that affects aircraft operational readiness.

This description of logistics activities identifies both echelon and function. The Air Force has two basic echelons of logistics: base and depot (central). The functions addressed herein include supply, maintenance and transportation, with transportation treated separately in Chapter 8.

Figures 1-3 and 1-4 also define the types of material stocked and maintained at the base and depot echelons. For our purposes we have used: aircraft, engines, exchangeables (or spares), and Economic Order Quantity (EOQ) or expense-type items. Aircraft are maintained at both the base and depot. Exchangeables and engines also involve maintenance and supply at both the base and the depot.

Figures 1-3 and 1-4 extend the concept of funding and resource inputs, such as manpower, to our structure of the logistics system. Funding is achieved through various budget appropriations, industrial fund, and stock fund mechanisms. Thus, depot maintenance of aircraft is industrially funded. EOQ-type items are largely purchased through stock funds. Transportation involves another industrial fund. The types of funding and resources therefore represent another dimension to be considered in assessing logistics management.

The need to picture the logistics structure in several dimensions reflects the complexities of the relationships and activities needed to relate logistics performance and logistics costs. The structure thus reflects appropriate breakdowns and relations among echelons, functions, and physical, financial, and information flows. Figures 1-2, 1-3, and 1-4 are primarily graphical representations of what has been analyzed quantitatively in this report.

REPORT CONTENTS

This report is heavily oriented towards empirical analysis. We felt that a realistic assessment of the Air Force logistics system had to be the starting point for any subsequent normative analysis. The goal of our empirical analysis was, therefore, to provide, insofar as we could, a quantitative description of the Air Force logistics structure at a level of aggregation suitable for ASD(MRA&L) purposes.

In general, our description conforms to the overall structure of the logistics system presented in this chapter. The individual components of the system required the more detailed structures developed in each chapter. These detailed structures enabled us to locate data within the Air Force reporting system. We were usually able to find the required data, although the amount of history readily available is limited, as are certain kinds of cost information. We have attempted to assess the quality of the data presented in each chapter.

The results of the analysis are presented largely in the form of figures and tables. Figures were used extensively because they are a convenient means of displaying trends and patterns of behavior in the data. We emphasized the use of trend analysis to establish the directions in which variables were tending, and to explore the cause and effect behavior of variables that should be related. Such analysis is important to our understanding and evaluation of the structure if we are to be able, in the future, to build a model that can assess the effect of proposed changes in resource allocation or policy on the overall logistics system.

Chapters 2 through 9 are organized in the same way. The first section, "Overview and Structure," defines the importance of the area covered to logistics management, and describes the detailed structure upon which the subsequent trend analysis is based. The second section, "Analysis of Data and Trends," describes the trend analysis and presents much of the data in the form of figures and tables. "Findings and Conclusions" about the trends are discussed in the third section. These findings should be interpreted as serious hypotheses supported by our analysis and meriting additional attention. A final section, "Data and Source Description," offers a detailed description of the sources and derivation of the data; some assessment of the effect of its quality on the results is also made.

The organization of the chapters was determined partly by the overall structure of the logistics system and partly by the nature of the reporting systems. Chapter 2 is devoted to the analysis of aircraft operational status, inventories, and activity rates for the Air Force as a whole and for principal weapon systems. In a sense, Chapter 2 describes the demands made by aircraft operations upon the logistics system, and also how

FIGURE 1-2. AN OVERVIEW OF AIR FORCE LOGISTICS STATUS MEASUREMENT

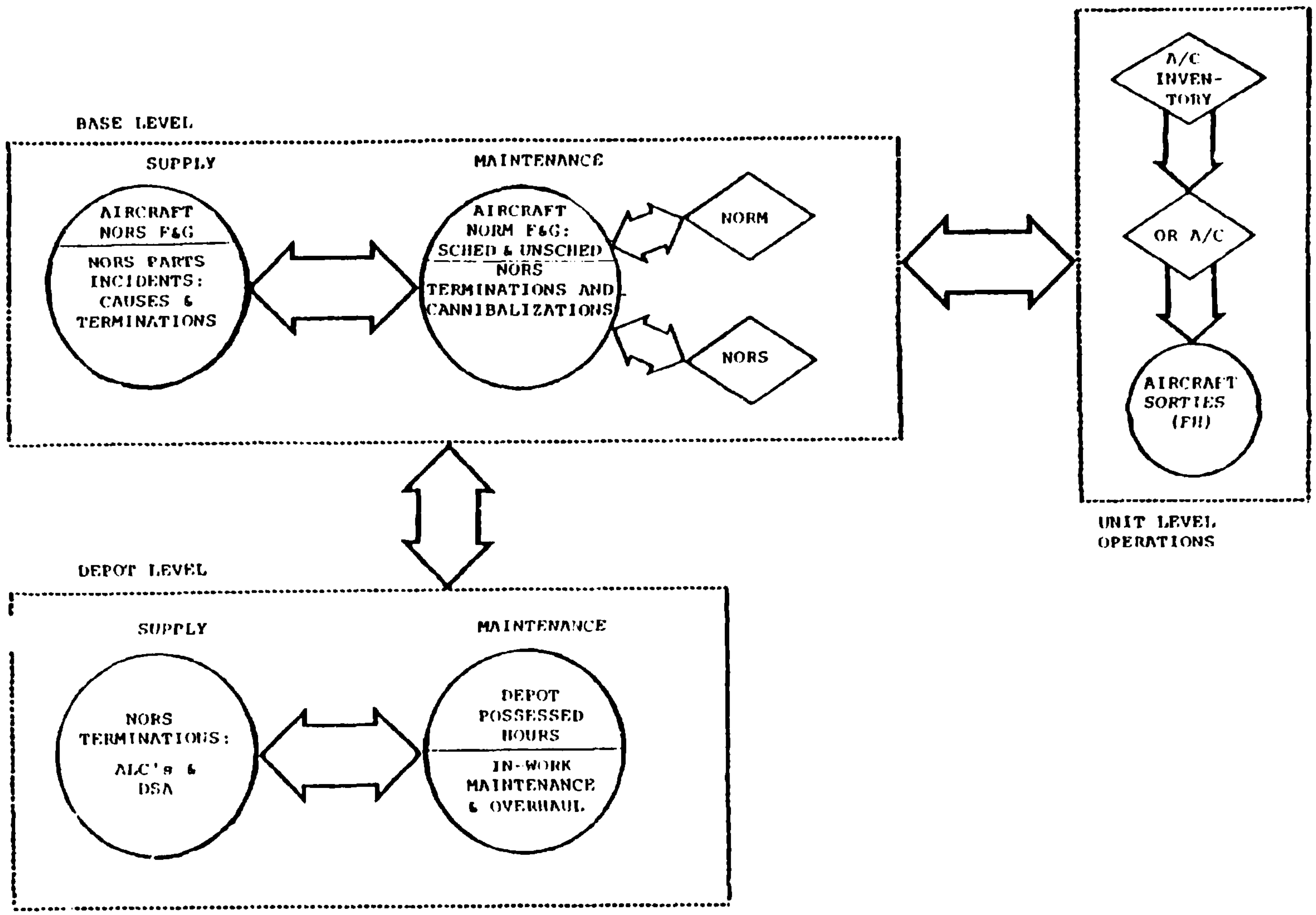


FIGURE 1-3. BASE LEVEL LOGISTICS ACTIVITIES

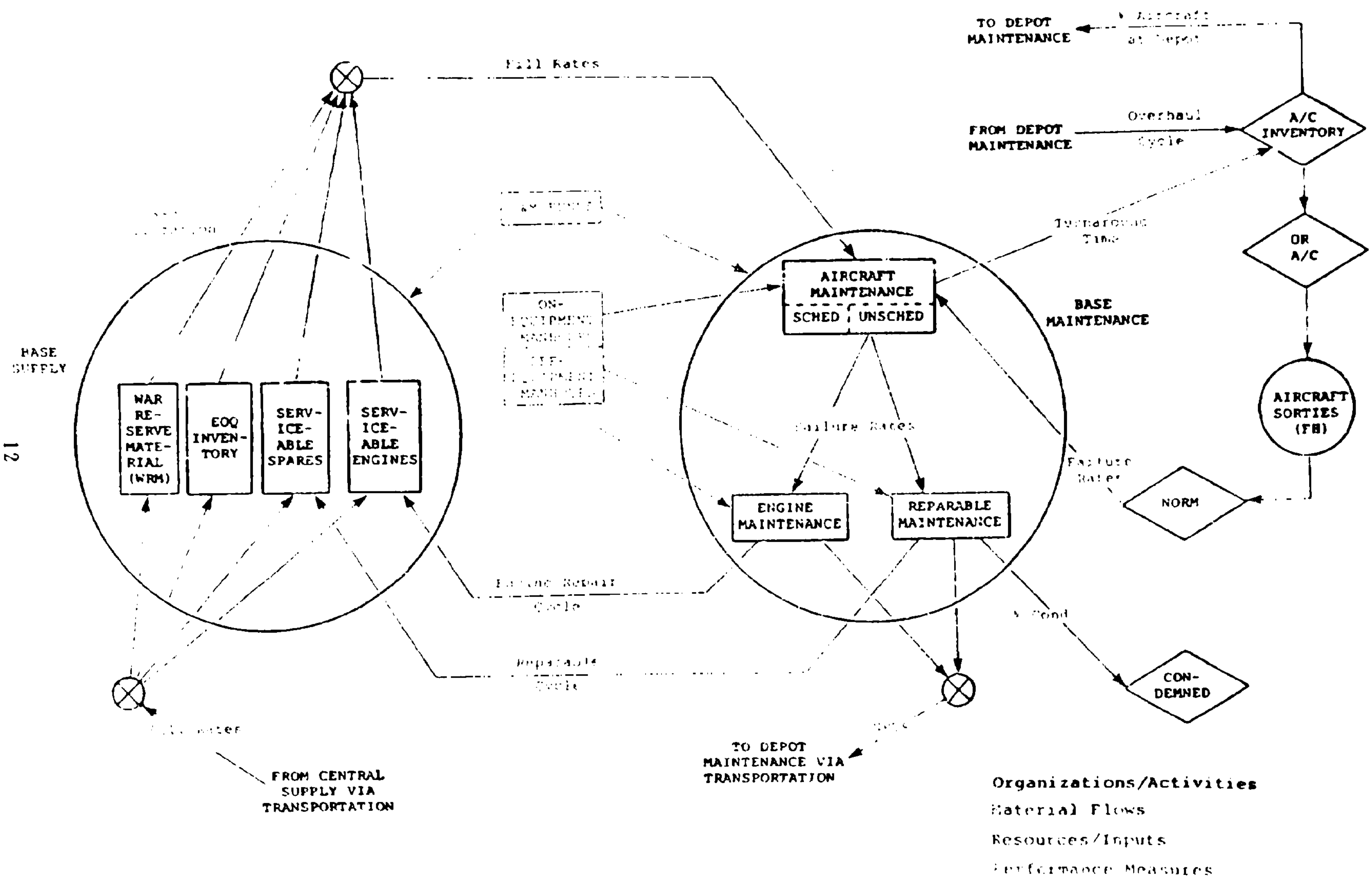
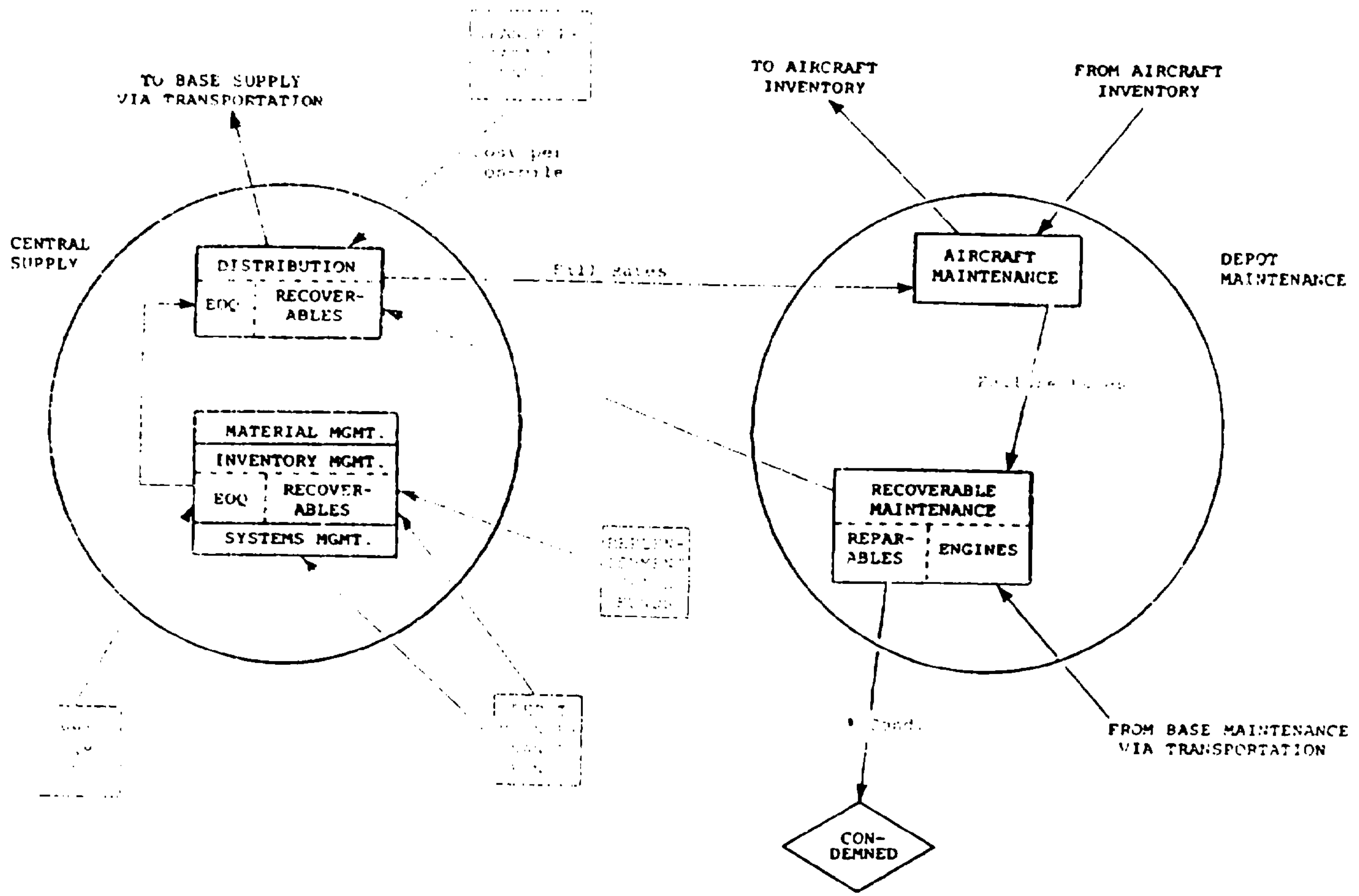


FIGURE 1-4. DEPOT LEVEL LOGISTICS ACTIVITIES



Organizations/Activities

Material Flows

Resources/Inputs

Performance Measures

well these demands are satisfied as revealed by aircraft operational readiness. In addition, it contains overall estimates of logistics system costs and manpower.

The rest of the report is an analysis of how these demands are distributed throughout the logistics system by echelon, logistics function, and type of resource demanded. Chapter 3 reports on the aggregate performance of the supply system by echelon and inventory categories. This chapter also includes an analysis of supply operations in terms of pipeline performance and fill rates. The pipeline data are further subdivided between that part attributable to the supply function and that associated with transportation.

Chapters 4, "Engines," 5, "Exchangeable (Investment) Items," and 6, "System Support Division Stock Fund," represent major inventory resource categories within the Air Force logistics system, the availability of which can significantly affect aircraft operational readiness. In each chapter, the analysis evaluates the Air Force logistics system in terms of both performance and cost in meeting aggregate demands of the particular resource category. Chapter 4 also shows details for engines used in the major weapon systems.

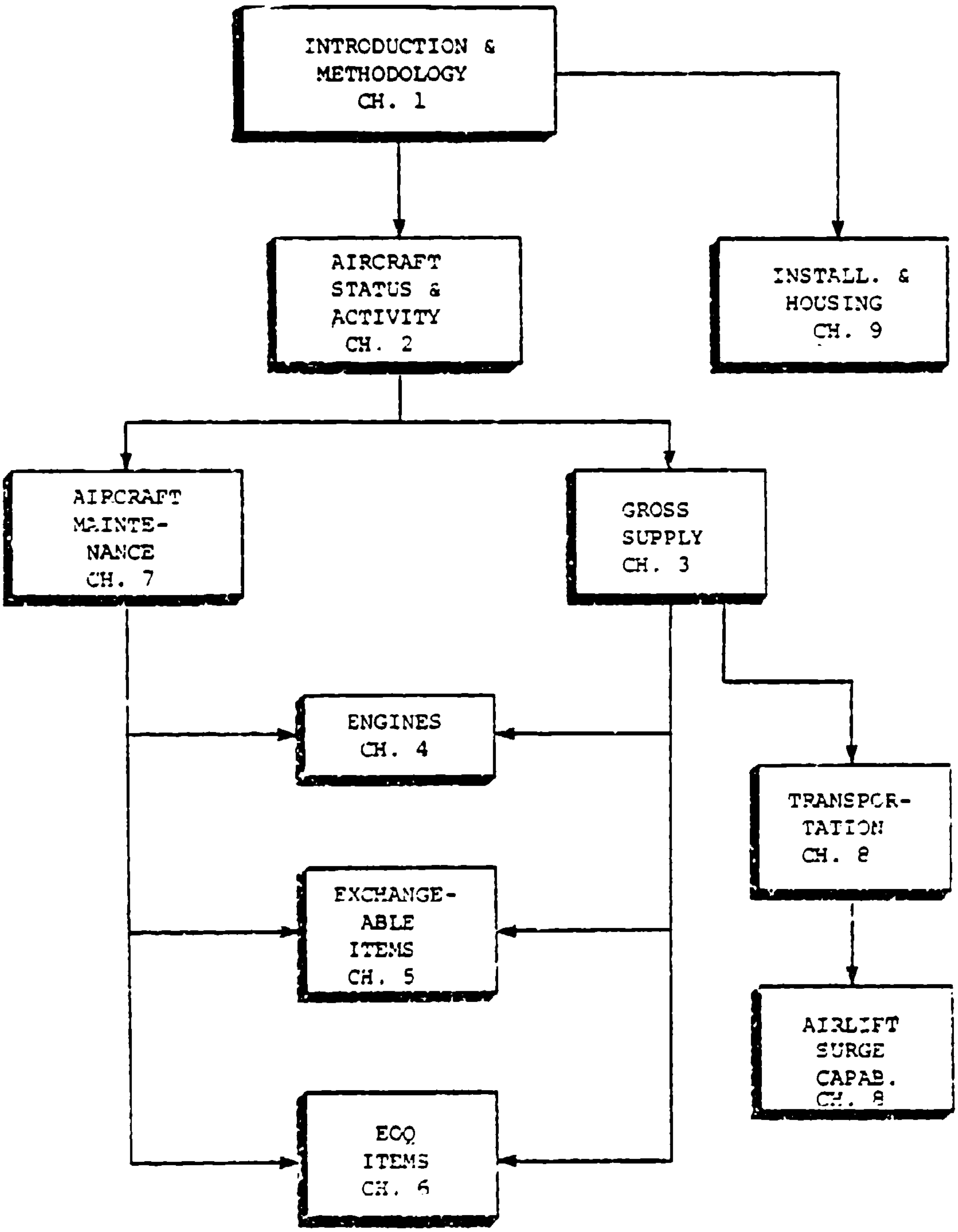
Chapter 7, "Aircraft Maintenance," is especially important, because it covers maintenance of aircraft both at base and depot. The performance of Base Maintenance directly affects aircraft operational readiness. Furthermore, because maintenance personnel represent the largest single group of logistics people in the Air Force, they are an important determinant of logistics cost.

Chapter 8, "Transportation and Airlift," considers the Air Force as Single Manager for airlift, and examines the performance and cost of the Military Airlift Command (MAC). This chapter also contains an analysis of the surge capability of MAC, which is one way of assessing its aircraft readiness.

Chapter 9, "Installations and Housing," is a self-contained chapter that examines that part of ASD(MRA&L) responsibility in this functional area directly relevant to the Air Force. The analysis reflects on the performance of the Air Force and ASD(MRA&L) alike, since both have responsibility in this area.

Figure 1-5 is a graphical sketch of the organization of the chapters and how they might be conceptually related. We feel that the report presents a comprehensive picture of the support of Air Force aircraft. Despite the generally satisfactory quality of Air Force data, we have encountered difficulty in finding strong cause and effect relations. At the same time, the results suggest hypotheses whose further evaluation would require data more detailed than we propose for use at the ASD(MRA&L) level. Such investigations might be well pursued by the Air Force for the benefit of its own management.

FIGURE 1-5. REPORT STRUCTURE



The period covered by this study (principally the 1970's) has been marked by the introduction and operation of complex weapon systems, such as the F-111, F-15, and C-5. Our analysis shows that these new systems have affected operational readiness and logistics performance trends significantly; more and better resources are required to maintain historically observed logistics performance levels. Whether or not there have been compensating gains in operational capability is a question to be answered in studies other than this one.

CHAPTER 2: WEAPON SYSTEM OPERATIONAL STATUS AND ACTIVITY RATES

OVERVIEW AND STRUCTURE

This chapter elaborates on the aircraft operational cycle illustrated in Figure 2–1. The primary topic is Air Force activity as related to operational readiness. The distribution of logistics resources to functional areas - supply, maintenance, transportation, and installations and housing - is also discussed.

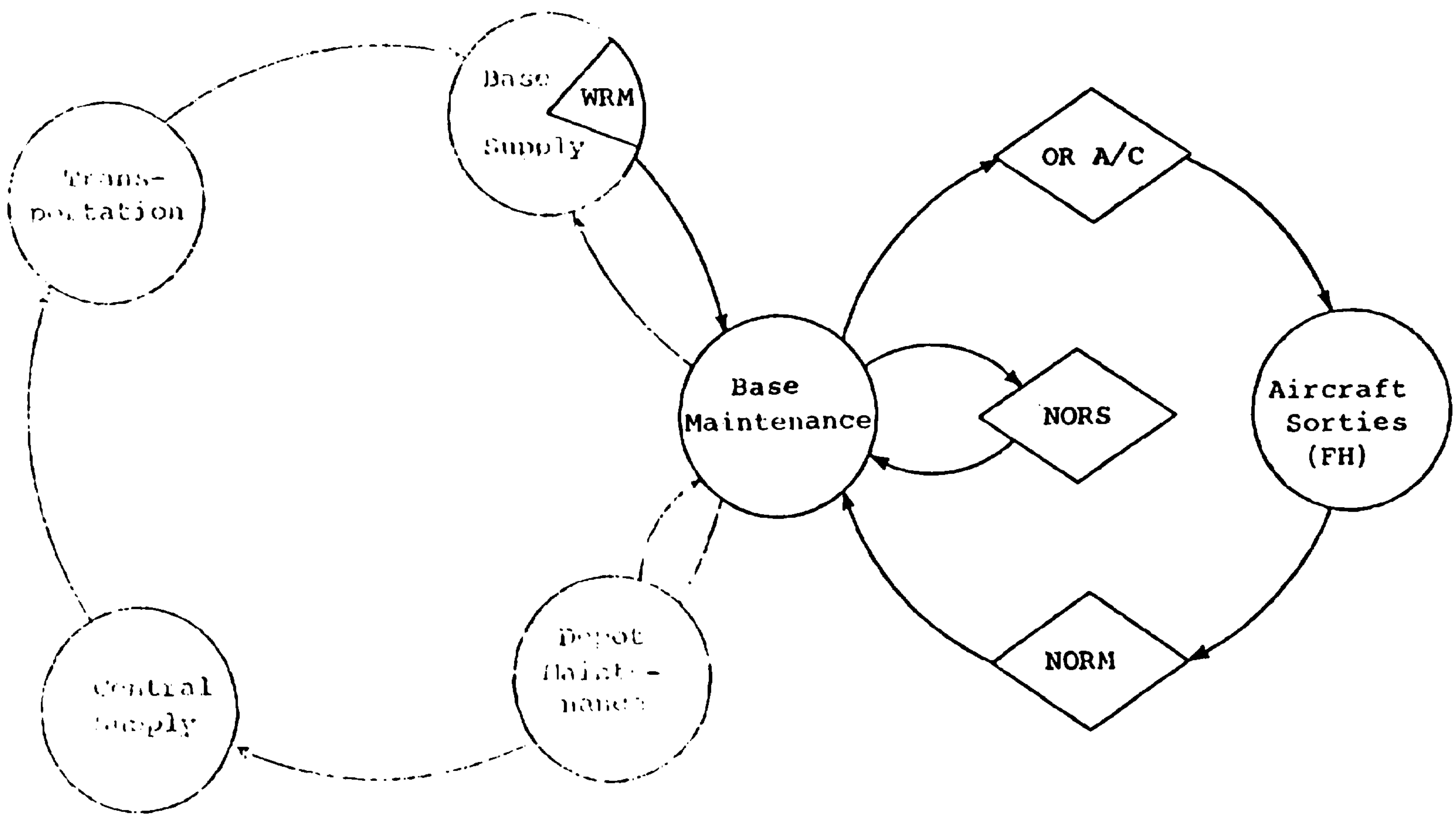
In this study, we have tried to connect the Air Force logistics structure to readiness, but readiness is difficult to define and even harder to quantify. According to the Report of the Secretary of Defense to Congress for FY 1978, "readiness" refers to the capability of responding to a threat and of sustaining that response as long as necessary. Readiness can be subdivided into personnel readiness and materiel readiness. Personnel readiness refers to the training of the armed forces and assumes the appropriate distribution of people according to skills and experience. Materiel readiness refers to inventory levels and the condition of fighting equipment. In this chapter, we are concerned with the former, the capability and availability of weapon systems, and the support needed to keep them operational.

The readiness to respond to a threat and sustain that response depends on many factors, including capability and equipment condition, quantity and location of supplies, adequate training and motivation of troops, and production and distribution of materiel. Besides being difficult to measure, these factors are generally dependent on a particular scenario and an appropriate strategy. Instead of approaching readiness from this scenario–dependent perspective, we may for logistics purposes approach it from a peacetime operational point of view. We thus become concerned with a different issue: how well the support forces are functioning to maintain equipment in a satisfactory condition. Although many factors that are difficult to quantify remain, the problems of performance in a wartime environment are avoided.

The reasons for using equipment readiness rather than combat readiness as a standard are numerous. Presently, an adequate means of measuring combat readiness does not exist. The Air Force's Unit Capability Measurement System (UCMS)[1] is a "C–Rating" reporting system measuring an individual unit's capability, based on availability of crews,

[1] UCMS and other readiness reporting systems in the Air Force are discussed in Appendix A.

FIGURE 2-1. GENERAL STRUCTURE RELATING FLIGHT ACTIVITY AND AIRCRAFT STATUS



equipment, total personnel, essential skills and the judgment of the unit commanders. A percentage for each measured factor is computed by dividing the available figure by the authorized figure. These percentages and the commander's judgment are used to produce a unit C-rating. Although UCMS does provide a measure of a unit's capability, no method of converting these percentages to a theater readiness measure, integrating unit capability with support functions (e.g., supply stockage and transportation pipelines) now exists. Since combat readiness is scenario-dependent, we cannot at this time perform an input-output analysis of resource allocation alternatives with respect to force readiness.

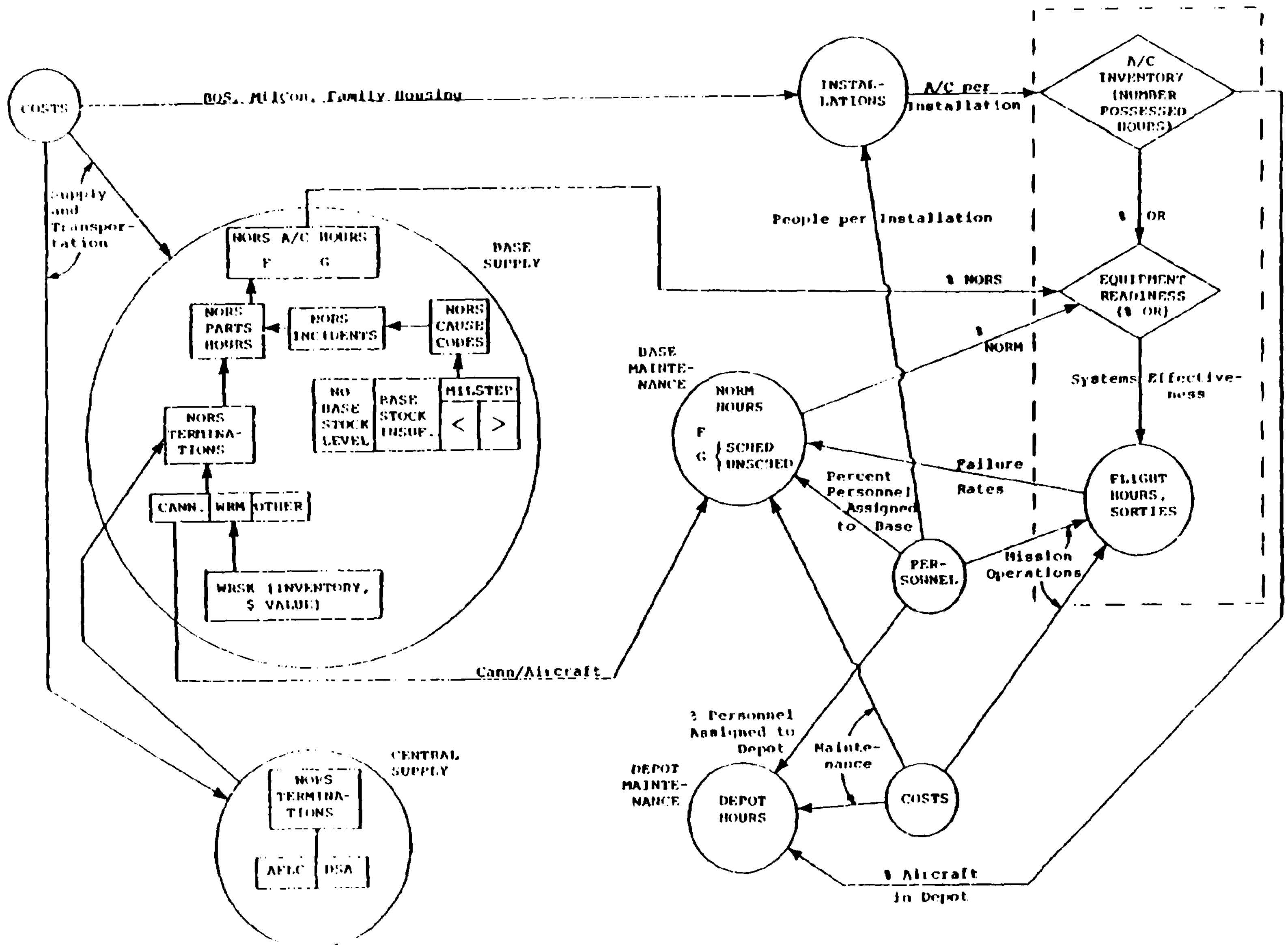
More importantly, the peacetime performance of the logistics system in maintaining aircraft in an operational status is related to its wartime performance. Maintenance skills cannot be attained in a day; supply and transportation elements cannot be run efficiently in wartime if peacetime procedures are ineffective. Even with a high level of motivation, a system as complex as the DoD logistics system could not be expected to operate efficiently in time of war if its peacetime operations were inadequate.

Assuming then that in a peacetime environment logistics is associated with readiness through availability of equipment, we will focus our attention on equipment readiness. Figure 2-2 is a more detailed illustration of the operational cycle in Figure 2-1, depicting equipment readiness and its interactions with logistics. Looking at the dashed box in Figure 2-2, we see that aircraft inventories are the basic inputs, and equipment readiness, flying hours, and sorties are the major outputs. For the Air Force, flight hours or sorties can be viewed as a reasonable measure of peacetime output. To attain this output, aircraft have to be operationally ready to perform their missions. Aircraft that are not ready for flight are in depot or base repair, awaiting maintenance or parts from supply. Proceeding further into the supply system, we can also investigate how parts are obtained and why they are not available.

The major resources that affect flying hours and sorties are aircraft inventories, personnel, and other logistics costs. Installations represent capital resources in that they provide the relatively permanent facilities necessary for supporting any operating or logistics activity. Logistics personnel can be classified as maintenance manpower, supply support, and base operating support. Logistics dollar inputs for parts, labor, transportation, construction, operation, and maintenance of installations can be similarly distributed throughout the system. We would like to measure this distribution of resources to determine their effect on equipment readiness.

Figure 2-2 displays the flows and interactions of aircraft status with activity, but the terminology used is not introduced until later in the chapter. It would therefore be

FIGURE 2-2. RELATIONSHIPS BETWEEN WEAPONS SYSTEM STATUS AND AIR FORCE LOGISTICS



advisable to review Figure 2-2 after reading the chapter. A number of interactions have been omitted from the figure, for the sake of both simplicity and emphasis of those interactions most pertinent to our analysis.

Equipment Readiness

According to Air Force Regulation 65-110 (Standard Aerospace Vehicle and Equipment Inventory, Status, and Utilization Reporting), an aircraft is considered "Operationally Ready (OR) to perform all of its command assigned missions during any 24 hour possessed time period unless reported otherwise." If an aircraft is not operationally ready, it is either Not Operationally Ready due to Maintenance (NORM) or Not Operationally Ready due to Supply (NORS). NORS and NORM conditions are further classified into grounding conditions (NORM-G and NORS-G), where the aircraft is unable to perform its mission; or flyable conditions (NORM-F and NORS-F), where the aircraft is in need of maintenance or a part, but can still be flown. The NORM-G condition is further subdivided into unscheduled and scheduled maintenance categories.

The above conditions are defined in AFR 65-110 (October 1, 1975) as follows:

NORS-G: The aerospace vehicle is not capable of flight (grounded) due to a verified lack of part(s).

NORS-F: The aerospace vehicle can be flown, but it is not capable of performing all of its command assigned missions, due to one or more of its command designated systems or subsystems being inoperative, and part(s) are required to return it to a fully operational status.

NORM-G, Scheduled: The aerospace vehicle is grounded while it is undergoing the "look" or "fix" phase of a maintenance inspection or Time Compliance Technical Order (TCTO).[2]

NORM-G, Unscheduled: The aerospace vehicle requires maintenance that must be performed prior to flight, which is not part of a scheduled inspection or TCTO. This category includes aerospace vehicles undergoing grounding maintenance required after pre-flight, thru-flight, or home station checks, or after basic post-flight inspection or a functional check flight.

[2]A TCTO is an authorized directive issued to provide instructions to Air Force activities for accomplishing one-time changes, modifications, inspection of equipment, or installation of new equipment.

NORM-F: The aerospace vehicle can be flown, but is not capable of performing all of its command assigned missions due to one or more of its command designated systems or subsystems being inoperative. In addition, maintenance must either be in progress or have been deferred for reasons other than lack of parts or supplies to be properly classified as NORM-F.

Figure 2-3 (Figure 2-4 from AFR 65-110) indicates the possible condition of an aircraft when it is not OR. As this flow chart depicts, an aircraft is in a NORM condition unless parts are required to return it to an OR status.

An aircraft is possessed by a command as long as it is physically assigned to that command, whether OR, in Base Maintenance, or awaiting a part from supply. An aircraft at the depot is not considered possessed by the command. NORM time begins when a malfunction is discovered and accrues until maintenance is completed or a NORS condition is reported and verified. NORS hours accumulate in lieu of NORM hours until the part has been received. Possessed hours can thus be subdivided into OR hours, NORS hours and NORM hours. We can compute the percentage of time an aircraft is NORS, NORM or OR. A basic relationship is that

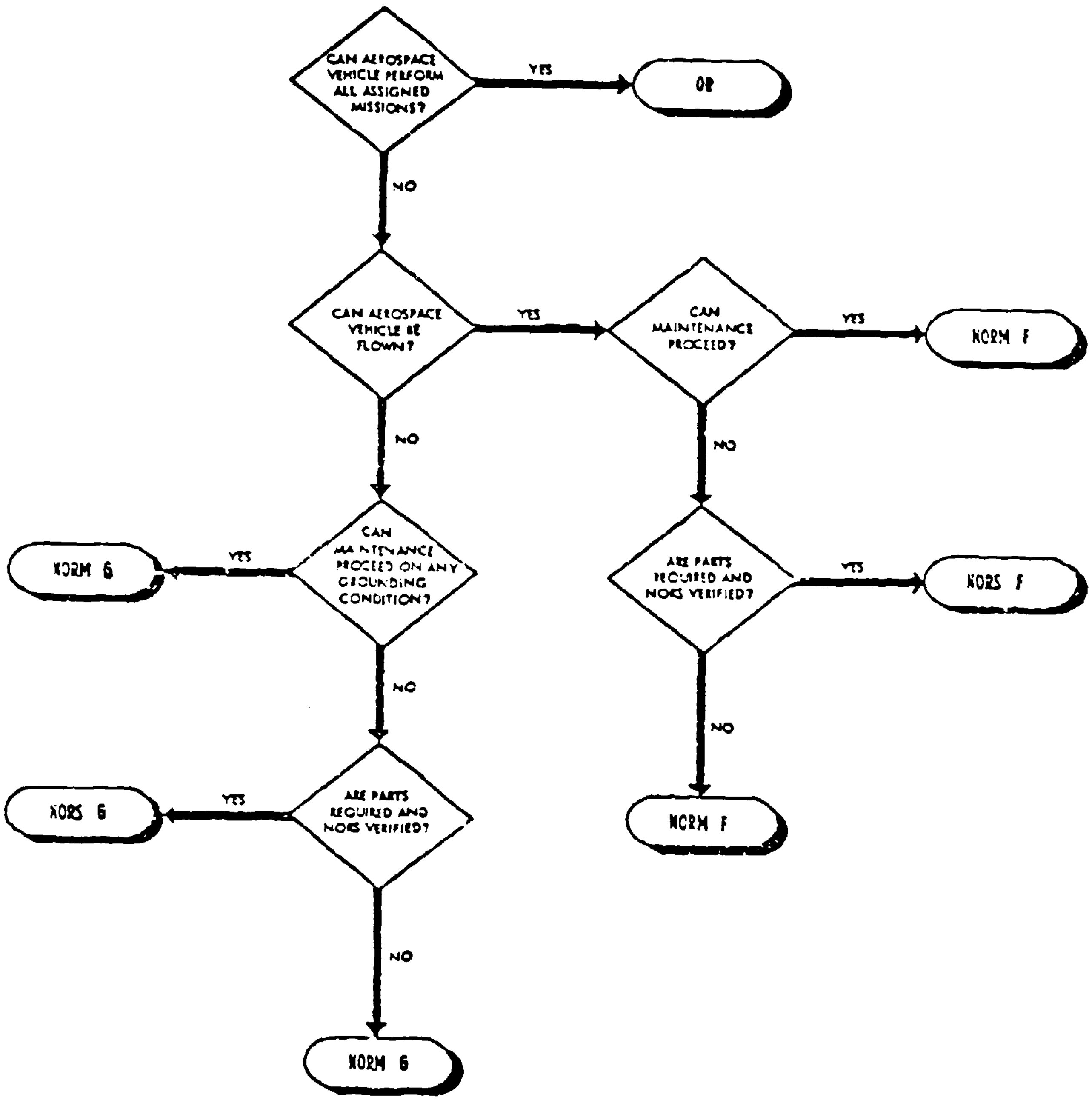
OR Rate + NORM-G Rate + NORM-F Rate + NORS-G Rate + NORS-F Rate = 100%.

One question that arises is whether or not the OR rate is a measure of readiness. From the above relationship, we can see that the OR Rate = 100% - Total NORM Rate - Total NORS Rate. If an aircraft is not in maintenance or awaiting a part, it is operationally ready. However, being in maintenance does not necessarily preclude an aircraft from being able to perform its designated mission(s). For instance, during time of threat, phased inspections and certain types of corrosion control could be deferred. However, deferring these maintenance procedures in peacetime to maximize OR or minimize NORM could have adverse effects on capability.

NORS and NORM reporting also reflect peacetime performance, because the supply and maintenance functions are operating on less than a 24-hour day, generally five days a week. The NORS and NORM clocks are accumulating hours that would not be accumulated during a 24-hour-a-day, seven-days-a-week wartime environment. On the one hand, the peacetime environment tends to reduce the OR rate. On the other, a wartime environment would generate more sorties, which could indicate more malfunctions and possible battle damage, and thus decrease the OR rate.

Certain inherent features of NORS and NORM reporting also contribute to the undesirability of OR as a readiness measure. An aircraft can be reported as NORS or NORM because it is unable to perform one of its assigned missions, but it may be

FIGURE 2-3. CONDITION STATUS DECISION FLOW



SOURCE: AFR 65-110

completely capable of performing others. The aircraft thus does not contribute to the OR rate, but it certainly could contribute to capability in time of war. Further, the OR rate does not reflect output, i.e., sortie capability. One aircraft may be able to fly five sorties to one sortie for another, while each aircraft is OR for the same period of time.

Given the limitations of the OR rate as a readiness measure, it is nevertheless important to this study for the following reasons. First, since logistics serves as a support function, supplying combat forces with materiel and maintaining equipment in an operational status, we can view OR as a logistics readiness measure of equipment. Second, OR data have been reported for many years and are available for historical analysis. Unfortunately, merely maximizing OR does not necessarily produce an optimum level of equipment readiness, for we are constrained by a level of necessary preventive maintenance and by policy decisions within supply.

There are also certain masking features of the NORS and NORM data that we need to consider for analysis purposes. First, an aircraft may be in a NORS condition because it is awaiting a part, but it can be reported NORM if maintenance is performing work on other parts of the aircraft. In January 1977, the Air Force was to have begun testing a new Not Operationally Ready (NOR) category called Not Operationally Ready - All (NORA) to alleviate this masking of NORS by NORM. NORA will accumulate those NORM hours for which an aircraft is also NORS. Second, NORS is not a true indication of supply stockage, since two aircraft can produce the same number of NORS hours if one aircraft is awaiting five parts and the other only one. With this latter problem in mind, the Air Force is reporting NORS incidents and NORS incident hours, which are, respectively, the number of parts needed on an aircraft to satisfy a NORS condition and the hours accumulated until receipt of those parts.

NORS Incident Reporting

The OR and NOR data are reported in the GO33B data base. This data base is described in "Data and Source Description" below. The NORS incidents data are reported in the D165A data base. The Worldwide Grid, produced from this data base, not only gives total NORS incidents and parts hours, but also gives a breakout by NORS termination code and cause code. Termination codes indicate how a NORS incident was terminated, that is, how the part was obtained to end a NORS incident. NORS termination codes are as follows:

Termination Code			Explanation
0	Cancelled	-	The NORS requisition was cancelled, due to an error in diagnosing the problem or a substitution of parts.

1	ALC	-	The part was obtained from an Air Logistics Center.
2	DSA	-	The part was obtained from the Defense Supply Agency.[3]
3	Lateral Support	-	The part was obtained from another air base.
4	Cannibalization To Preclude	-	The part was removed from another aircraft, probably in a NORS or NORM condition, to preclude the aircraft's becoming NORS.
5	Base Procured	-	The part was procured by the base.
6	Release Base Assets	-	The part was obtained from base assets that are held for other than normal maintenance operating procedures.
7	War Reserve Materiel (WRM)	-	The part was obtained from war reserve materiel held at the base.
8	Cannibalization To Satisfy	-	The part was obtained from another aircraft to satisfy a NORS condition.

We have already seen that minimizing the NORM rate may not be beneficial, since necessary preventive maintenance may be deferred. Similarly, NORS rates may be consistently low, but a consistently low NORS rate does not indicate that the supply system is functioning properly. Cannibalizations and the use of WRM give the maintenance and supply functions the flexibility to maintain a consistently low NORS rate. However, draining the war readiness spares kits (WRSKs)[4] could weaken surge capability. Also, a NORS item withdrawn from WRM may have a higher Uniform Material Movement and Issue Priority System (UMMIPS) priority than an item classified just as NORS. (Both a NORS item and an item withdrawn from WRM will have an urgency need designator of "A," but they may have different force activity designators, which could put them in different priority groups.)

[3]Renamed Defense Logistics Agency (DLA) on 31 December 1976.

[4]An air transportable package of selected spares and repair parts required to sustain planned wartime or contingency operations of a weapon system for a specified period of time pending resupply.

The NORS cause code breakout on the Worldwide Grid was established to associate the NORS condition with base stockage policies. The NORS cause codes can be divided into stocked items, non-stocked items and special purpose codes. The following is a list of NORS cause codes and their meanings as defined in AFM 67-1:

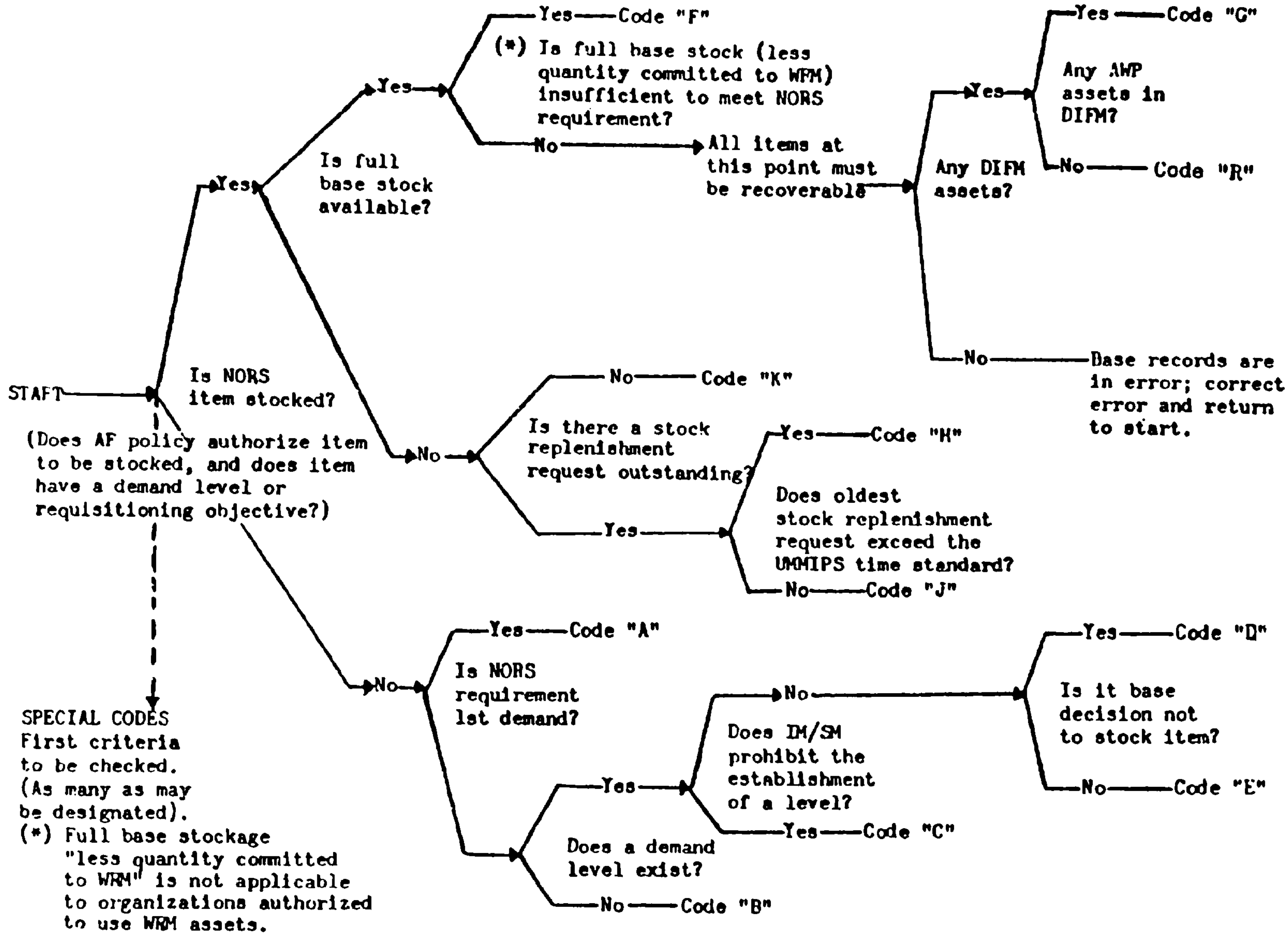
Cause Code	Explanation
Non-Stocked Items	
A	No stock level established - first demand
B	Past demand experienced, but Air Force base stockage policy precluded establishing level
C	Item manager/system manager will not authorize a level
D	Base decision not to stock level
E	Base failed to establish level
Stocked Items	
F	Full base stock-depth of stocks insufficient to meet NORS requirement
G	Full base stock - awaiting parts (AWP) assets on hand at time of NORS
H	Less than full base stock - stock replenishment requisitions exceed UMMIPS time standards by priority group
J	Less than full base stock - stock replenishment requisition does not exceed UMMIPS time standards by priority group
K	Less than full base stock - no due in established
R	Full base stock - assets that cannot be utilized are in other than AWP status
Special Purpose	
Y	Data not available due to computer down for unscheduled maintenance
Z	System/commodity received lacking NORS item (initial shortage).

Figure 2-4 is a flow chart for selection of the appropriate cause code.

With this introduction, Figure 2-2 should be viewed as an attempt to display the interactions between equipment readiness (OR) and the logistics factors affecting it. The remainder of this chapter will be devoted to an explanation of where the data to support this chart can be obtained, what they mean, and how they can be interpreted. "NORS

FIGURE 2-4. DECISION TREE FOR SELECTING NORS CAUSE CODES

CAUSE CODE SELECTION SEQUENCE



SOURCE: AFM 67-1, Vol. 1, Part 1, pp. 2-21.

rate" will indicate an aircraft NORS rate and "NORS incidents" will indicate the number of parts needed on an aircraft to satisfy a NORS condition throughout the rest of the report.

ANALYSIS OF DATA AND TRENDS

As indicated by Table 2-1, aircraft inventories have declined from 13,545 in FY 1970 to 9,289 in FY 1976. Activity in the Air Force has also been steadily decreasing since FY 1970. Total flying hours have been more than halved in the seven-year period from FY 1970 to FY 1976. This decline in activity per aircraft is depicted in Figure 2-5, where the number of flying hours per aircraft has decreased from 502.8 in FY 1970 to 305.7 in FY 1976.

Operational Readiness

Despite the decline in overall activity, we have found a decrease in the OR rate as seen in Figure 2-6. The total NORM rate has steadily increased, while the total NORS rate increased until FY 1974, when it reached the maximum of 14.4% and then slowly decreased. Table 2–1 indicates a fairly consistent NORS-G rate from FY 1972 to FY 1976 of about 5.8% to 6.6%. As a result, the total OR rate has decreased from 75.5% in FY 1970 to 56.9% in FY 1975.

Analyzing the trend displayed in Figure 2-6, we can identify a steady increase in the NORS plus NORM rate from FY 1970 to FY 1973 and then a sharp increase in the NOR rate from FY 1973 to FY 1974. This latter increase seems to be due to the introduction of NORM-F reporting in October 1973. These data are displayed in Table 2-1, where NORM-F and NORM-G reporting are shown as beginning in FY 1974.

The increase in the NOR rates from FY 1970 to FY 1973 could be caused by phasing out older aircraft with high OR rates and phasing in newer aircraft, which are more complex and have lower OR rates. In support of this hypothesis, we have examined both fighter and cargo aircraft with respect to aircraft inventory mix, comparing number of aircraft and their OR rates. If we define "new" aircraft as those still being purchased and "old" aircraft as those being withdrawn, then for FYs 1970-1976 fighter aircraft in the regular Air Force inventory have increased by 1000 new aircraft and decreased by 1000 old aircraft. This leaves in FY 1976 approximately 200 old aircraft and increases the new aircraft inventory to over 2000.

Examining the OR rates of these aircraft for FYs 1974 and 1975, the F-111, a new aircraft, has an OR rate of approximately 45% (see Table 2-20), while the OR rates for the old aircraft have ranged from 54% to 70%. The F-4, also a complex aircraft, has been

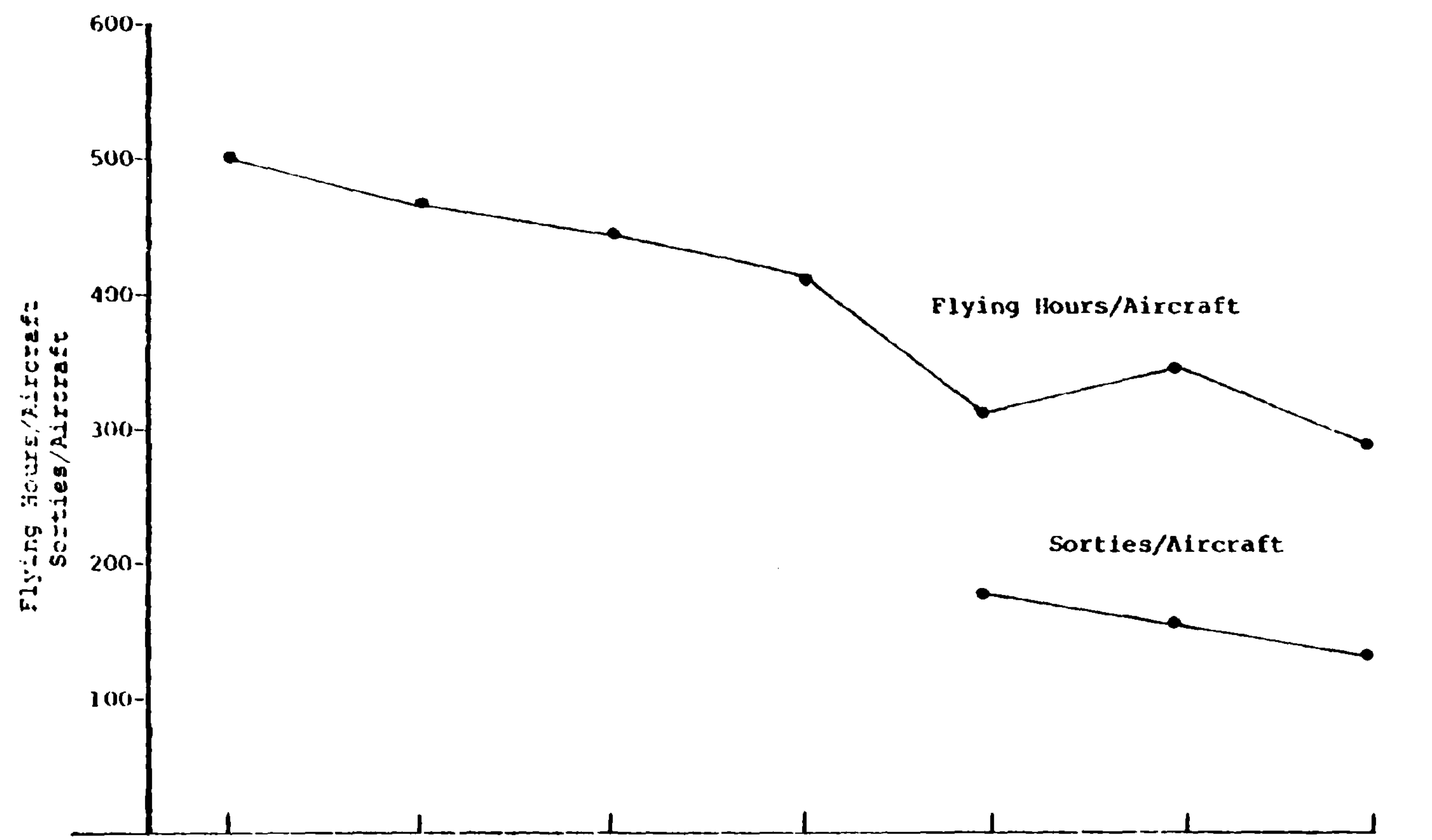
TABLE 2-1. AIR FORCE WORLDWIDE AIRCRAFT DATA

	FY1970	FY1971	FY1972	FY1973	FY1974	FY1975	FY1976	SOURCE
Total Aircraft Inventories	13,545	12,746	11,517	10,799	10,156	9,334	9,289	USAF Summary
Total Flying Hrs. ($x10^6$)	6.81	5.96	5.30	4.74	3.66	3.49	2.84	K008
Total Sorties ($x10^6$)					1.93	1.71	1.52	GO33B
Possessed Hrs. ($x10^6$)			94.54	85.87	83.24	78.48	71.94[1]	GO33B
NORS Hrs.								
NORS-G Hrs. ($x10^6$)			5.48	5.43	5.53	5.17	4.01[1]	GO33B
NFE/NORS-F Hrs. ($x10^6$)			3.23	5.06	6.45	5.47	3.30[1]	GO33B
NORM HOURS								
NORM-G Sched. Hrs. ($x10^6$)			6.76	6.15	6.13	6.37	5.75[1]	GO33B
NORM-G Unsched. Hrs. ($x10^6$)			13.55	13.81	13.01	13.06	11.49[1]	GO33B
NORM-F Hrs. ($x10^6$)					3.15[2]	4.05	3.49[1]	GO33B
OR Rate	75.5	71.8	68.7	64.6	58.8	56.9	59.3[1]	GO33B
NORS Rates	6.0	7.4	9.2	12.2	14.4	13.4	10.5[1]	GO33B
NORS-G	3.8	5.0	5.8	6.3	6.6	6.5	5.8[1]	GO33B
NFE/NORS-F	2.2	2.4	3.4	5.9	7.8	6.9	4.7[1]	GO33B
NORM Rates	18.5	20.8	22.1	23.2	26.8	29.7	30.2[1]	GO33B
NORM-G	18.5	20.8	22.1	23.2	23.0	24.7	25.1[1]	GO33B
NORM-F					3.8	5.0	5.1[1]	GO33B
NORS Parts Incidents ($x10^3$)			240	358	335	422	443	D165A
NORS Parts Hrs. ($x10^6$)			20.0	28.4	28.6	34.1	31.7	D165A

[1] Data incomplete. The GO33B data base underwent some programming modifications during the last quarter of FY 1976 and, as a result, several bases did not report data.

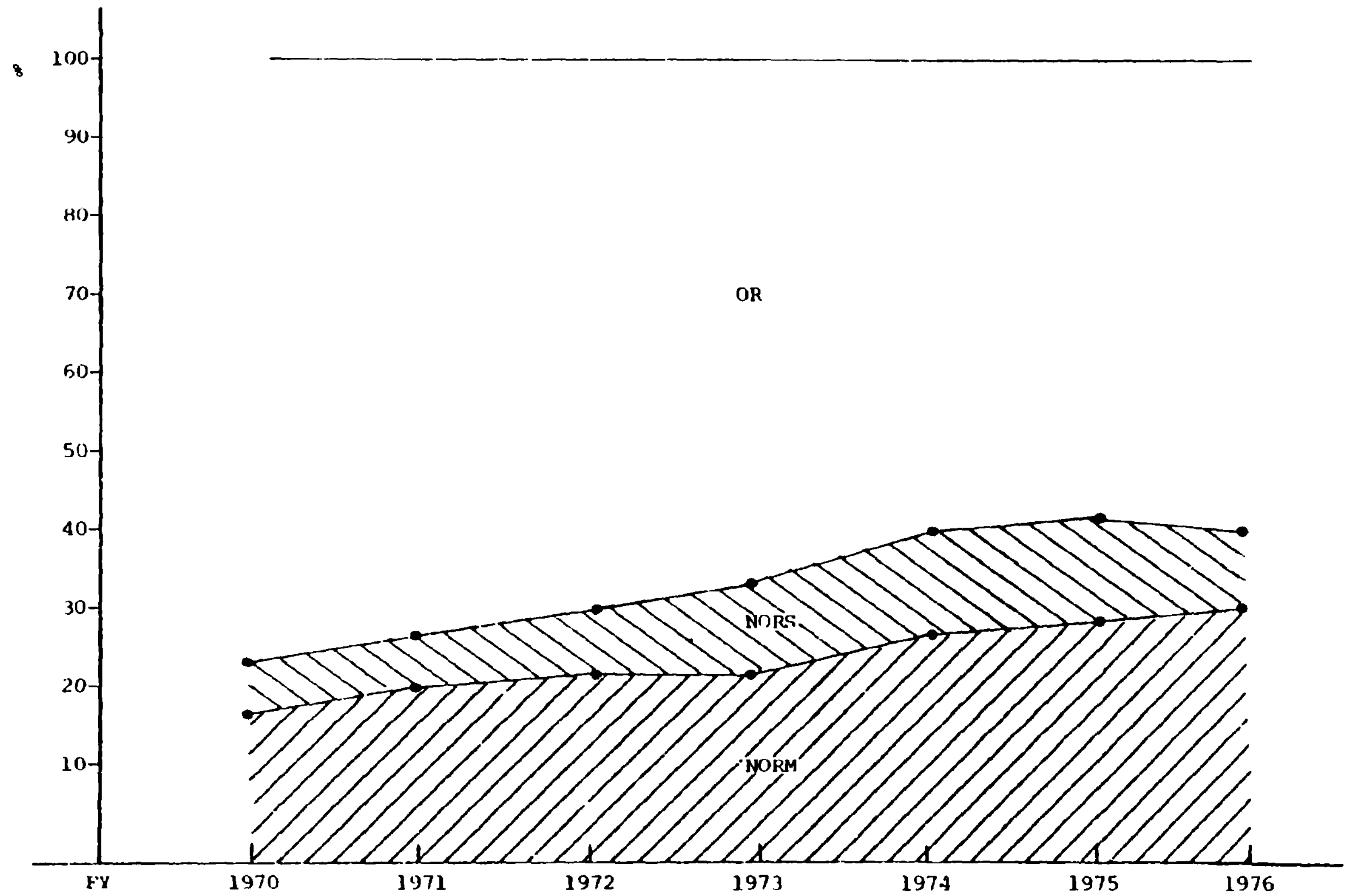
[2] Projected from nine months data. NORM-F reporting began in October of 1973.

FIGURE 2-5. FLYING HOURS AND SORTIES PER AIRCRAFT



FY	1970	1971	1972	1973	1974	1975	1976
Flying Hours/ Aircraft	502.8	467.6	460.2	438.9	360.4	373.9	305.7
Sorties/ Aircraft					190.0	183.2	163.6
Flying Hours/ Sortie					1.90	2.04	1.87

FIGURE 2-6. OPERATIONALLY READY RATES



at the lower end of this scale (see Table 2-18). Similarly, the old cargo aircraft have OR rates ranging from 52% to 85%, while the C-5, a new cargo aircraft, has an OR rate of 10% (see Table 2-15).

These trends in inventories and OR rates seem to imply that the addition of newer aircraft to the Air Force inventory is reducing the OR rate. This tendency could reflect both complexity and reliability problems in the earlier phases of acquisition, an observation discussed in more detail in Chapter 7.

As previously discussed, the NORM rate can be subdivided into NORM-F, NORM-G scheduled, and NORM-G unscheduled. NORM-F indicates that aircraft are still flyable, although needing maintenance, and hence does not totally affect capability. The NORM-G scheduled category includes preventive maintenance, that is, it includes activities which could be deferred in time of threat. The NORM-G unscheduled rate measures maintenance performance when failures ground the aircraft; thus, this rate can affect capability. Figure 2-7 shows the trend of NORM-G unscheduled hours over total flying hours. This figure has increased from 2.56 in FY 1972 to 4.05 in FY 1976. Although both numerator and denominator are essentially decreasing, flying hours are decreasing at a much faster rate than NORM-G unscheduled hours.

An opinion within the Air Force, although not universally accepted, is that sorties are a better measure of stress upon an aircraft than flying hours, because most of the stress on aircraft is due to take-offs and landings and not to the time of actual flight. (An opposing view is based on the fact that some training sorties just practice take-offs and landings.) Figure 2-7 also contains a graph of NORM-G unscheduled hours per sortie.[5] However, NORM hours per unit of activity (whether flying hours or sorties) show an increase, indicating a longer time to complete maintenance actions.

NORM-G unscheduled hours per aircraft are increasing (Figure 2-8) as well as NORM-G unscheduled hours per unit of activity.[6] The same trend is displayed in terms of supply, as shown in the graph of NORS incidents per aircraft in the same figure.

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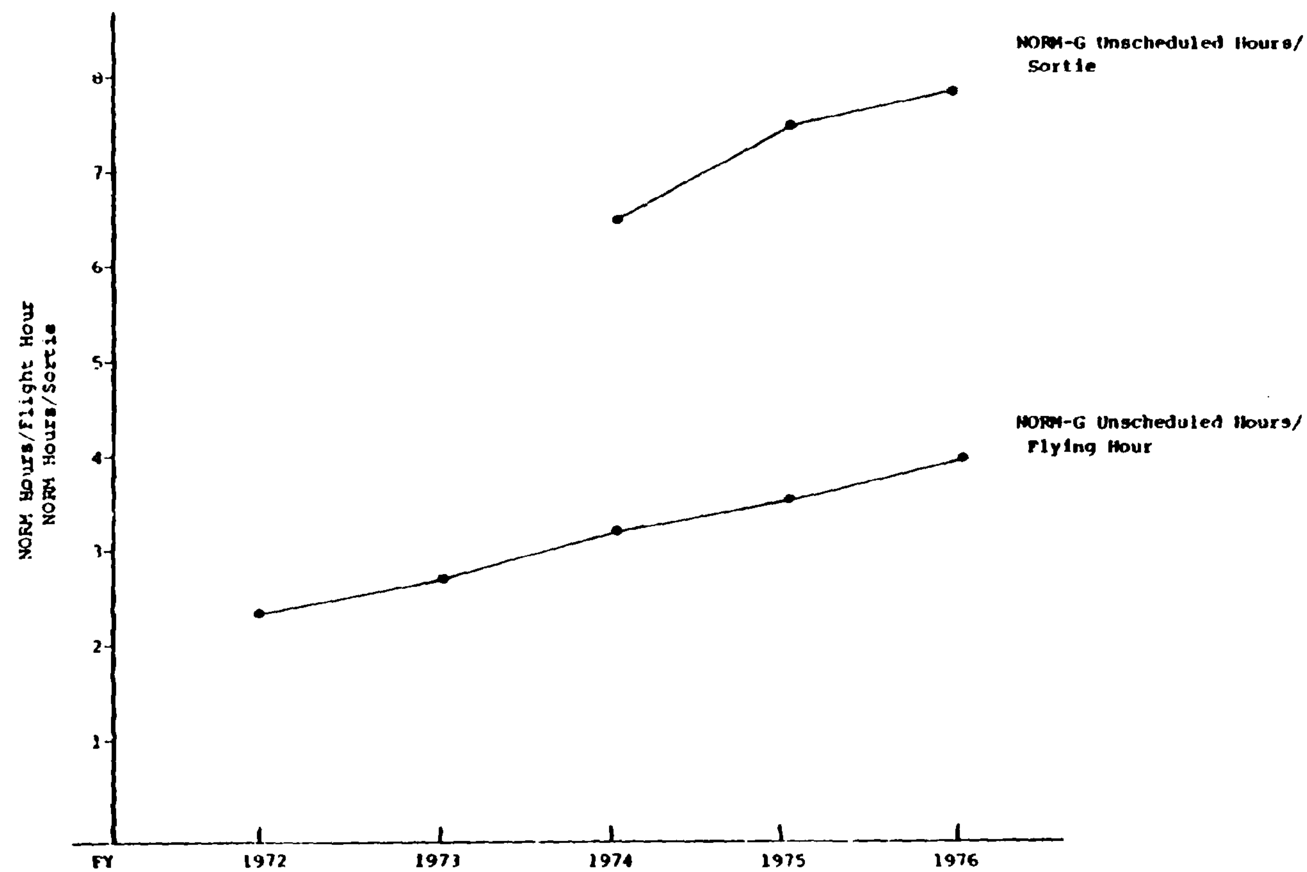
[5] We were unable to obtain more than a three-year historical trend of sorties flown. Although the GO33B data base contains sorties, total Air Force sorties have not been required in reports until FY 1977.

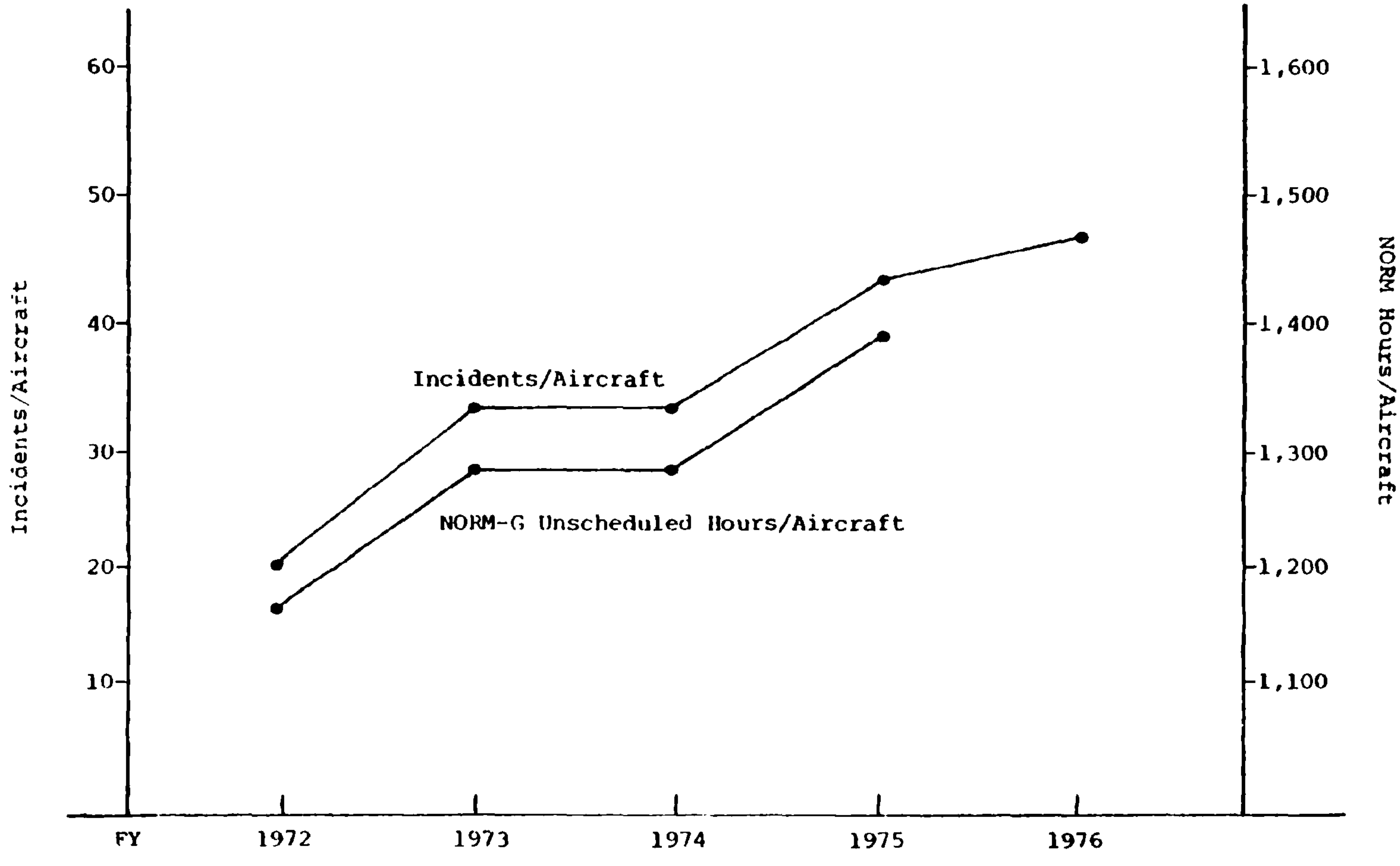
[6] The 1976 point is not included due to the incomplete reporting for the last quarter of FY 1976 in the GO33B data base.

FIGURE 2-7. NORM HOURS PER FLIGHT HOUR AND PER SORTIE



NORM-G Unscheduled Hours/Sortie			6.74	7.64	7.92
NORM-G Unscheduled Hours/Flying Hour	2.56	2.91	3.55	3.74	4.05

FIGURE 2-8. NORS INCIDENTS AND NORM HOURS PER AIRCRAFT



Incidents/Aircraft	20.8	33.2	33.0	45.2	47.7
NORM-G Unscheduled Hours/Aircraft	1,176.5	1,278.8	1,281.0	1,399.2	

NORS Incidents

Although we have already noted in Figure 2-6 that the NORS rate is staying fairly constant, the same trend is not evidenced for NORS incidents. Figures 2–9a and 2–9b display NORS incident hours per possessed hour (NORS incident rate) and NORS aircraft hours per possessed hour (NORS rate). The first graph reflects both NORS-G and F and shows an increase of over 100% in the NORS incident rate from FY 1972 to FY 1976. In FY 1972, the NORS-G and F incident rate was over twice the NORS-G and F rate, and the disparity in FY 1976 was even greater, with the incident rate over four times the NORS rate. Basically, the same trend is indicated in Figure 2-9b, where the NORS–G data are plotted. The NORS–G rate is fairly constant, but the NORS-G incident rate has risen by over 100%. Again, we notice that the NORS-G incident rate is over four times the NORS-G rate for FY 1976. We were not able to obtain the actual NORS-G incident data for FYs 1972 and 1973. Those data were approximated by using Figure 2–9a, since the slopes in Figures 2–9a and 2–9b were fairly consistent from FY 1974 to FY 1976.

To understand the difference in the NORS rate and the NORS incident rate displayed in Figure 2-9, we need to interpret the definitions of these terms. A NORS incident occurs when a part fails and Base Supply does not have a serviceable replacement immediately available. The aircraft must be in a NORS condition to have a NORS incident reported. NORS incident hours accrue from when a NORS requisition is placed until the NORS condition is terminated. The main methods of terminating a NORS condition are by obtaining the part from Central Supply, cannibalizing another aircraft, or using war reserves. NORS aircraft hours measure the amount of time the aircraft is awaiting part(s).

There are several reasons why NORS aircraft hours and NORS incident hours do not coincide. The most apparent reason is that multiple NORS part failures can occur on an aircraft. NORS aircraft hours accumulate until all parts are obtained; NORS incident hours are obtained by summing the total number of hours that accrue in satisfying each part incident. NORS incident hours also do not coincide with NORS aircraft hours because of the masking of NORS by NORM. NORS incident hours will still accrue for an aircraft the status of which has changed from NORS to NORM when the NORS-causing parts have not been received. In this case, the aircraft hours will be reported as NORM, not NORS. Cannibalizations can account for differences between NORS aircraft and NORS incident hours. When a part is taken from a NORS aircraft to relieve a NORS condition on another aircraft, the time needed to obtain the part to fix the original failure contributes to NORS incident hours, but no longer contributes to NORS hours.

FIGURE 2-9. AIRCRAFT NORS AND NORS PARTS INCIDENT RATES

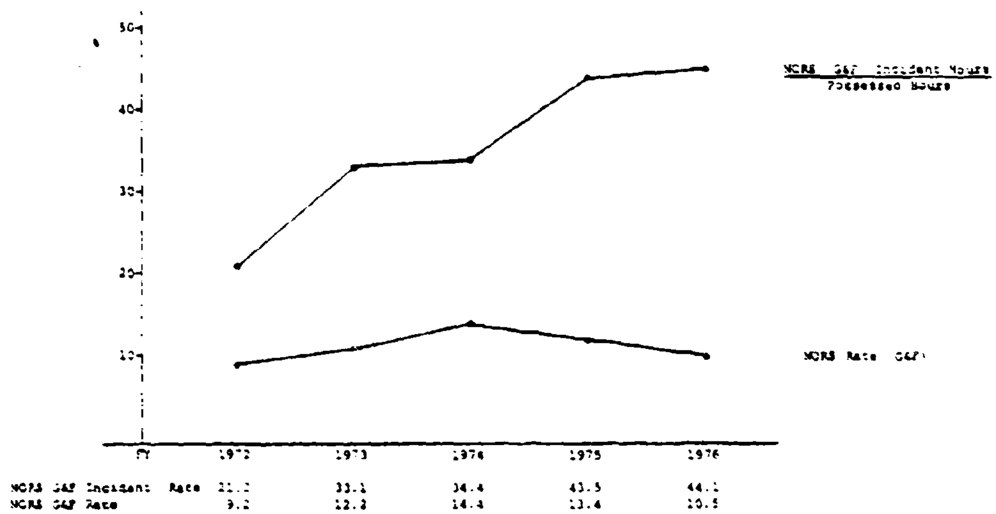


Figure 2-9a

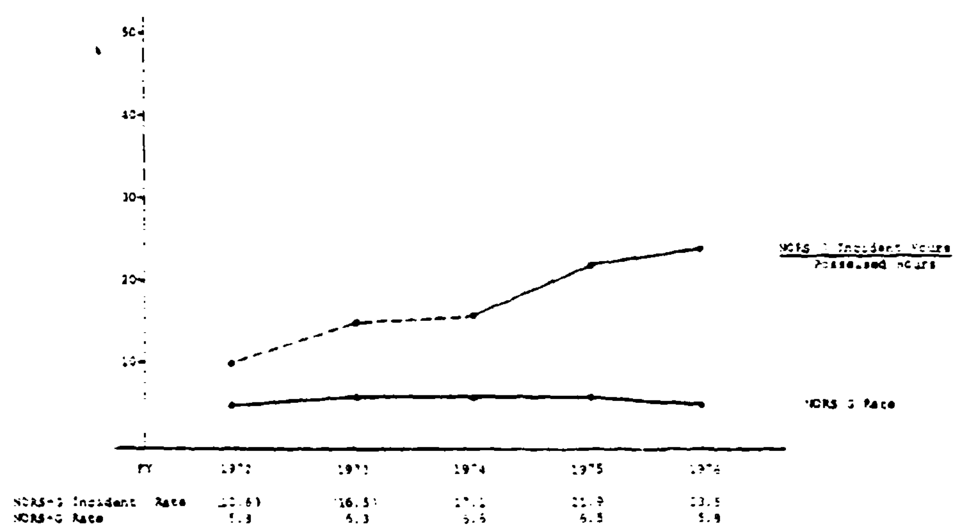


Figure 2-9b

When cannibalizations are used to terminate a NORS condition, more parts incidents may be reported than actual part failures. The original NORS requisition is cancelled when the NORS condition is terminated by cannibalizing a NORS aircraft and a new requisition is then submitted for the "hole" caused by the cannibalization. Two NORS requisitions may thus be submitted to relieve a NORS condition caused by one failure.

Because of this possible "double-counting" in the reporting of NORS incidents, NORS incident hours are probably a better measure of supply performance than NORS incidents. This is especially true when comparing the NORS incident rate to the NORS rate as in Figure 2-9. However, NORS incident hours cannot be used to estimate the number of part failures, because the duration of a NORS incident may vary according to the method of termination. For instance, for FY 1976, the average duration of an incident terminated by Air Force Logistics Command (AFLC) action was 140.9 hours versus 0.9 hours for the duration of an incident terminated by use of war reserves. (See Tables 2-9 and 2-11 in "Data and Source Description.")

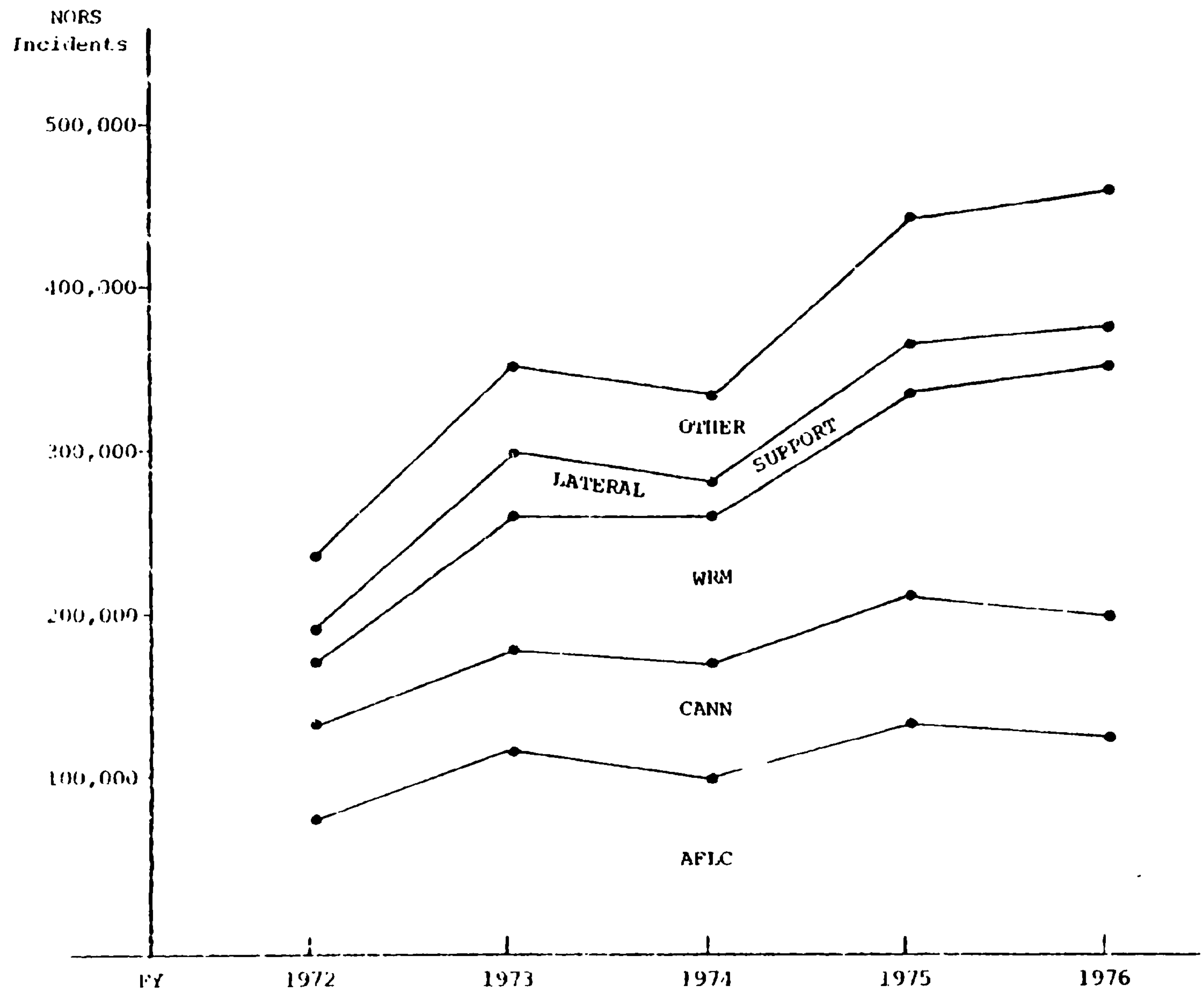
Although there are problems in understanding the NORS incident data, NORS incidents are a better measure of supply system performance than the NORS rate. The different methods of NORS incident terminations allow the supply and maintenance system flexibility in keeping the NORS rate fairly constant. NORS incidents, however, measure the number of parts demanded from the base supply system that it cannot provide from its own stock.

A closer look at NORS incident terminations reveals (Figure 2–10) a historical trend of how incidents were terminated. The figure shows an increase in terminations by the use of war reserves. The associated data in Table 2–2 show that on a relative basis, terminations by cannibalizations have remained constant, terminations by AFLC action

TABLE 2-2. AIR FORCE WORLDWIDE NORS INCIDENTS/TERMINATIONS

	FY1972	FY1973	FY1974	FY1975	FY1976
Incidents ($\times 10^3$)	240	358	335	422	443
Termination ($\times 10^3$)					
Cannabilization	48 (20%)	70 (20%)	68 (20%)	87 (21%)	85 (19%)
WRM Withdrawal	47 (20%)	85 (24%)	95 (28%)	117 (28%)	142 (32%)
Lateral Shipment	20 (8%)	38 (11%)	22 (7%)	28 (7%)	30 (7%)
AFLC Action	82 (34%)	110 (31%)	104 (31%)	131 (31%)	118 (27%)
Other	43 (18%)	56 (15%)	46 (14%)	59 (14%)	69 (16%)
Item NORS Hrs. ($\times 10^6$)	20.0	28.4	28.6	34.1	31.7

FIGURE 2-10. NORS INCIDENT TERMINATIONS

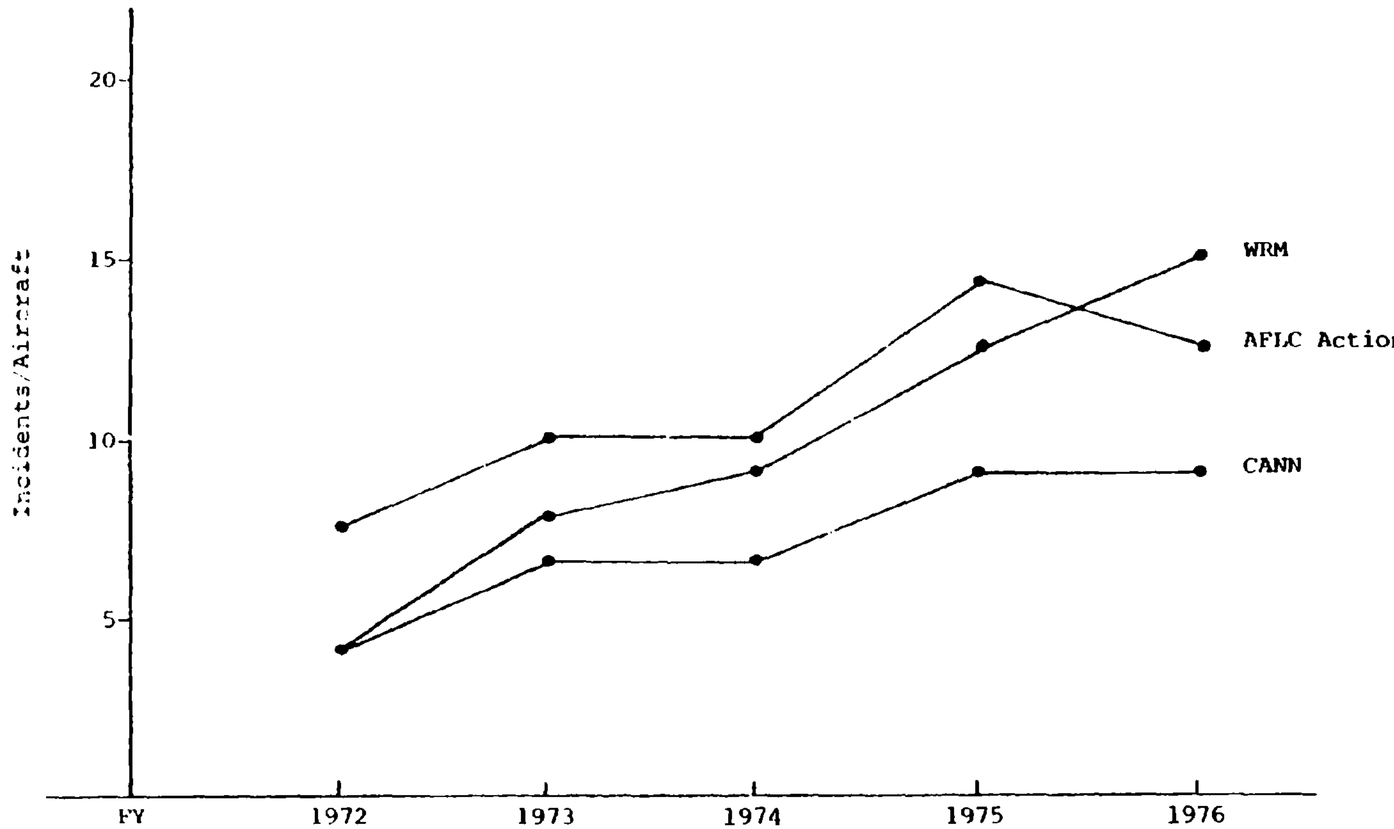


have declined, and terminations by use of war reserves have increased. Figure 2-11 displays the trend of incident terminations per aircraft. Terminations by cannibalization and AFLC action per aircraft exhibited similar behavior until FY 1975, when terminations by AFLC action per aircraft noticably declined. Terminations by use of war reserves per aircraft, however, have steadily been increasing. Data from FY 1975 to FY 1976 show an increase in terminations by use of war reserves per aircraft, with a corresponding decrease in terminations by AFLC action, when measured on a per aircraft basis. The question suggested by Figures 2-10 and 2-11 is what, if any, effect does this increased use of WRM to terminate NORS conditions have on capability? The issue involved may be a matter of trading-off between current operational readiness and preparedness for surge. In a later section of this chapter, we attempt to measure the percentage of depletion of the WRSKs due to withdrawals to terminate NORS.

We have seen that the use of cannibalizations to terminate a NORS incident, the masking of the NORS rate by the NORM rate, and multiple part failures all contribute to the differences in the NORS rate and the NORS incident rate in Figure 2-9. An interesting question is what, if any, effect does the use of war reserves in terminating NORS incidents have on the rates in Figure 2-9? Since using war reserves to terminate a NORS incident has the same effect on both NORS incident hours and NORS hours, both of these rates will be lower than the corresponding rates if war reserves were inviolate. For instance, if we assume that WRM were inviolate, that AFLC action was used to terminate those incidents, and that AFLC time performance remained at the same level in each year from FY 1974 to FY 1976, the NORS-F and G incident hours per possessed hour would have increased from an average of .40 to an average of .65 in this time span. Since NORS incidents can be terminated very quickly by using war reserves, we see that this method is an effective means of maintaining a low NORS rate.

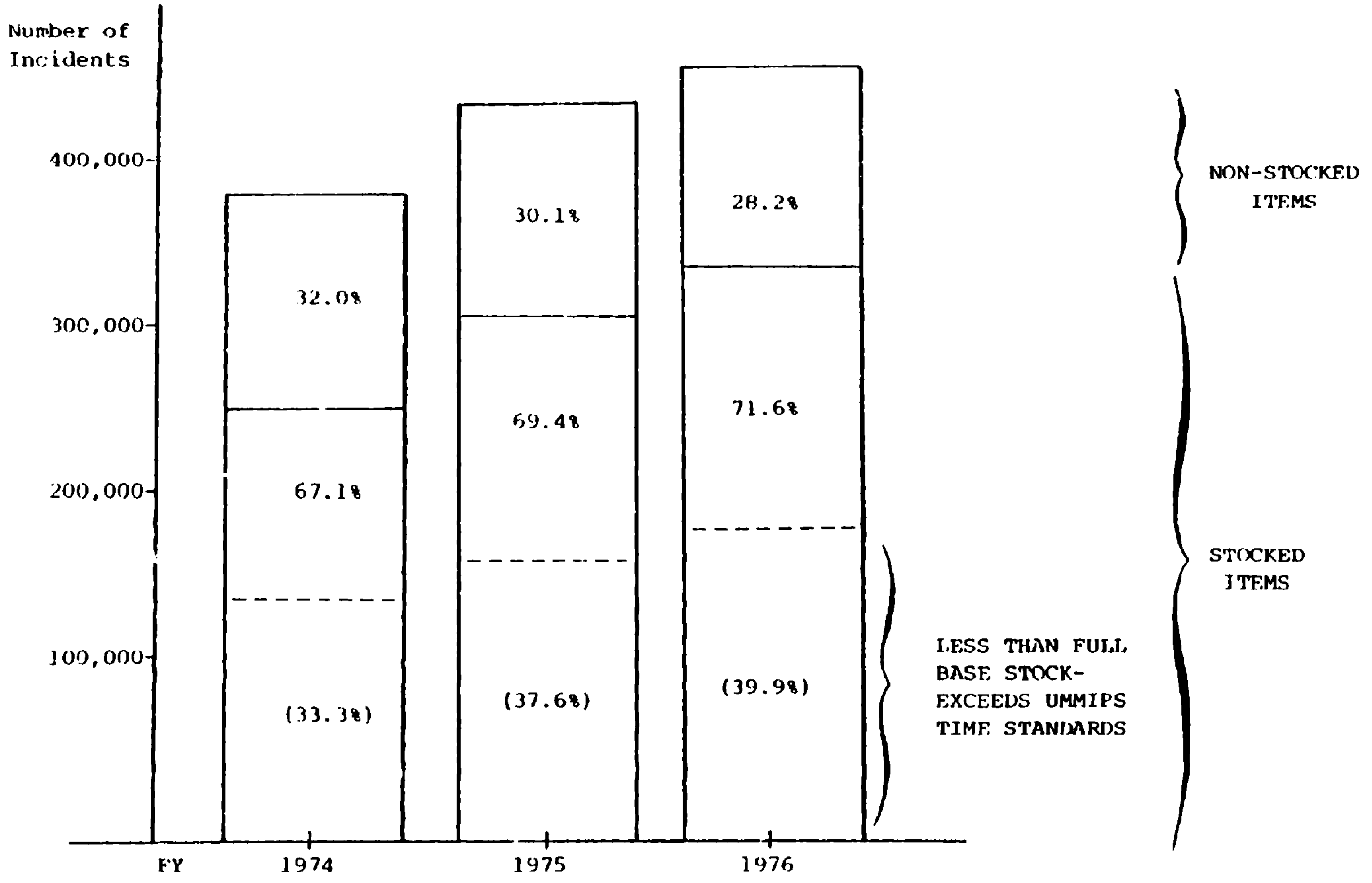
The Worldwide Grid associates NORS conditions with base stockage policies through cause codes. These cause codes can be viewed in terms of whether the required item is stocked or non-stocked and whether the cause for the NORS condition was due to the depot, the base, or to policy. For non-stocked items, cause codes A and B are determined by policy, cause code C by the depot, and cause codes D and E by the base. For stocked items, cause codes F and J are determined by policy, cause codes G and H by the depot, and cause codes K and R by the base. Table 2-3 shows the behavior of causes of NORS incidents from FY 1974 to FY 1976 in the context of stocked versus non-stocked items separated into policy, depot, and base causes. Figure 2-12 displays the trends in Table 2-3, which are: 1) the increase in NORS incidents is caused by insufficient stockage

FIGURE 2-11. NORS INCIDENT TERMINATIONS/AIRCRAFT



FY	1972	1973	1974	1975	1976
CANN/Aircraft	4.2	6.5	6.7	9.3	9.2
WRM/Aircraft	4.1	7.9	9.4	12.5	15.3
AFLC Action/ Aircraft	7.1	10.2	10.2	14.0	12.7

FIGURE 2-12. DISTRIBUTION OF NORS INCIDENTS BY CAUSE



of base stocked items, and 2) cause code H (stock replenishment requisition exceeds UMMIPS time standards by priority) is increasing. In terms of percentage of total incidents, cause code H has steadily increased—in FY 1974, it represented 33.3% of the total incidents, in FY 1975, 37.6% of the total, and in FY 1976, 39.9% of the total.

TABLE 2-3. AIR FORCE WORLDWIDE DISTRIBUTION OF INCIDENTS BY NORS CAUSE CODES[1]

	FY1974 No.	FY1974 %	FY1975 No.	FY1975 %	FY1976 No.	FY1976 %
Non-Stocked						
Policy	122,588	31.8	131,956	21.9	128,718	27.9
Depot	162		86		212	.1
Base	586	.2	700	.2	913	.2
Total	123,336	32.0	132,743	30.1	129,843	28.2
Stocked						
Policy	54,444	14.1	43,457	9.9	60,741	13.1
Depot	189,894 (128,478)[2]	49.2	246,490 (165,714)[2]	55.9	223,517 (184,048)[2]	48.5
Base	14,602	3.8	16,003	3.6	46,016	10.0
Total	258,940	67.1	305,950	69.4	330,274	71.6
Special Purpose	4,146	1.0	2,372	.6	1,032	.3

[1]These incidents include those dropped due to non-receipt. A more detailed table of NORS Incidents by Cause Codes is found in Table 2-10 in the last section of this chapter.

[2]LESS THAN FULL BASE STOCK - Stock replenishment requisition exceeds UMMIPS time standard by priority group.

Cause Code H indicates the number of NORS incidents that result when a part was ordered from Central Supply, but was not received within UMMIPS time standards, using the appropriate time standard for the priority of the requisition. Most NORS-causing items result in a requisition of Priority Group 1. Chapter 3 shows that for FY 1976, Priority Group 1 requisitions are taking much longer than the UMMIPS time standards and that Priority Group 1 affords no advantage in time performance.

To summarize, we have found that the NORS rates have remained fairly stable, but that NORS incidents have increased both in terms of number per aircraft and hours accrued per possessed hour. Essentially, data on incident terminations show that a stable aircraft NORS rate can be maintained by judicious use of cannibalizations and WRM. Both methods of termination have either remained constant or increased as a percentage of total incidents. Yet the cause codes indicate an increase in NORS incidents caused by insufficient base stockage due to the replenishment stocks' exceeding UMMIPS time standards. The immediate questions arising from these findings are: does the base fill-rate reveal the same insufficient base stockage, and what is the cause of replenishment stock requests' exceeding UMMIPS time standards?

In Chapter 3, we show further that the major factor in excessive resupply times is the growth in depot processing times, which we believe occurs because the depot is becoming less able to fill demands off the shelf. Thus, we would expect the increase in NORS incidents to be accompanied by lower base and depot fill rates. However, as Chapter 3 shows, there is no such trend in the fill rates. Our explanation of this apparent inconsistency is that NORS-causing items are only a small fraction of the total supply demands, so that the overall fill-rate indicator does not reflect the relative decline in the availability of NORS causing items. This result would suggest that in order to understand the relationship between the increase in NORS incidents and base supply stockage, we would need to take direct account of NORS-causing items.

Logistics Resources

We have tried to examine the trends in Air Force logistics resource costs with operationally ready rates. Since there is no accepted definition of logistics resources and since there is no report on the costs of logistics resources, we have made our own estimates of such costs, as shown in Tables 2-4A and 2-4B. Table 2-4A shows the distribution of logistics resources by major logistics activity in millions of current year dollars; Table 2-4B shows the same distribution in millions of 1974 dollars.

We have included replenishment spares and military construction expenditures with other operational costs, with the idea that these expenditures are for replacement purposes. No depreciation of capital (investment) costs is recognized in traditional public sector accounting techniques. These costs are nevertheless real and incurred. Therefore, the annual costs for spares and military construction are a rough proxy for the costs of capital used up in the process of producing these national services. Assuming a long-term steady situation in which a fixed capital structure is maintained, these annual expenditures would be a close approximation to actual depreciation.

TABLE 2-4A. ESTIMATED DISTRIBUTION OF AIR FORCE LOGISTICS RESOURCE COSTS[1]

(Current Year Dollars-Millions)

	FY1972	FY1973	FY1974	FY1975	FY1976
Depot Maintenance Costs	1410	1383	1400	1431	1519
Base Maintenance Manpower Costs	1667	1687[2]	1707[2]	1726[2]	1746
Depot Supply Operations	704	695	729	717	686
Replenishment Spares	1936[2]	1759	1821	1999	2455
Receipts					
SSD		(460)	(520)	(599)	(790)
GSD		(767)	(862)	(1029)	(1054)
Exchangeables		(532)	(439)	(371)	(611)
Second Destination Transportation	351	365	282	285	312
Real Property Maintenance Activities	954	1000	1141	1283	1248
Other Base Operating Support[3]	1030	1080	1232	1386	1348
Military Construction	315	263	266	274	351
Family Housing	276	291	345	434	504
TOTAL	8443	8523	8923	9535	10169
Air Force Budget Outlays ($Billion)	24.0	23.6	23.9	25.0	26.5
Logistics Percentage	35.2	36.1	37.3	38.1	38.4

[1]LMI estimates

[2]Interpolated

[3]Other Base Operating Support includes Base Supply, Base Transportation, Base Security, Base Command and Administration, Transient Aircraft Maintenance, and Other Base Services.

NOTE: Sources for this table follow Table 2-4B

TABLE 2-4B. ESTIMATED DISTRIBUTION OF AIR FORCE LOGISTICS RESOURCE COSTS[1]

(1974 Dollars-Millions)

	FY1972	FY1973	FY1974	FY1975	FY1976
Depot Maintenance Costs	1593	1483	1400	1324	1334
Base Maintenance Manpower Costs	1970	1819[2]	1707[2]	1614[2]	1540
Depot Supply Operations	788	743	729	678	649
Replenishment Spares Receipts	1989[2]	1905	1821	1724	1963
SSD		(498)	(520)	(517)	(632)
GSD		(831)	(862)	(888)	(843)
Exchangeable		(576)	(439)	(320)	(489)
Second Destination Transportation	402	387	282	270	295
Real Property Maintenance Activities	1120	1122	1141	1105	996
Other Base Operating Support[3]	1209	1211	1232	1194	1076
Military Construction	393	294	266	245	298
Family Housing	321	317	345	381	414
TOTAL	9785	9281	8923	8535	8565

[1]LMI estimates

[2]Interpolated

[3]Other Base Operating Support includes Base Supply, Base Transportation, Base Security, Base Command and Administration, Transient Aircraft, Maintenance, and Other Base Services.

NOTE: Sources for this table follow immediately.

TABLES 2-4A AND 2-4B - SOURCE INFORMATION

	SOURCE
Depot Maintenance Costs	AFLC Management Indicators FY 1966–FY 1975, prepared by the Directorate of Management and Cost Analysis (ACM). AFLC Fact Book, FY 1976 prepared by the Directorate of Management and Budget (ACR) HQ AFLC.
Base Maintenance Manpower Costs	Manpower Authorization File HAF-010 tape (PM 77-2), March 1975. Manpower Authorization File HAF - PRM (AR) 7102, December 1972. USAF Cost and Planning Factors, AFR 173–10.
Depot Supply Operations	Air Force Central Supply and Maintenance Cost Data Base FY 1965-1974, Paper P-1195, Institute for Defense Analyses, March 1976. Calculated from Program Elements 71111, 71112, 71113, 78011, and 78012. FY 1976 data estimated.
Replenishment Spares Receipts	Budget Estimates for AF SSD; Budget Estimates for AF GSD; BP-15 and DO 41 Formats.
Second Destination Transportation	IDA Report above. Program Element 78010. FY 1976 data estimated.
Real Property Maintenance Activities	PB-27 Budget Estimates
Other Base Operating Support	In the 1978 POM, RPMA is estimated to be 48% of total Base Operating Support (BOS). Other Base Operating Support is total BOS less RPMA.
Military Construction	The Budget of the United States
Family Housing	The Budget of the United States. AF Family Housing outlays are estimated by multiplying DoD Family Housing outlays by the ratio of AF family housing units to DoD family housing units.
Air Force Budget Outlays	USAF Summary, prepared by the Directorate of Management Analysis, Comptroller of the Air Force, October 1976.

In constant 1974 dollars, the annual logistics cost per aircraft has increased from $849,614 to $922,058 from FY 1972 to FY 1976. The following table displays this trend with the corresponding Not Operationally Ready rates:

	FY 1972	FY 1973	FY 1974	FY 1975	FY 1976
Cost/Aircraft	$849,614	$859,431	$878,594	$914,399	$922,058
NOR G	27.9%	29.5%	29.6%	31.2%	30.9%
NOR G & F	31.3%	35.4%	41.2%	43.1%	40.7%

This trend indicates a relatively constant NOR-G rate, but an increasing NOR–F and G rate. Figure 2-13 displays this same concept graphically. Considering those elements of NOR that ground the aircraft for lack of a part or for required maintenance where the scheduling of that work cannot be controlled, the operationally ready rate remains fairly constant at almost 80% from FY 1972 to FY 1976 (Figure 2-13a). However, in Figure 2–13b, where we consider all NOR rates, the operationally ready rate has decreased from 68.7% in FY 1972 to 56.9% in FY 1975, while logistics resource costs per aircraft in constant 1974 dollars have continued to rise (Figure 2-13c).

Total Air Force Budget outlays in billions of current dollars are reported in Table 2–4A from FY 1972 to FY 1976. The logistics percentage of this total budget has increased from 35.2% in FY 1972 to 38.4% in FY 1976.

Although logistics resource costs have continued to rise in current year dollars and per aircraft, the number of Air Force personnel assigned to logistics activities has decreased from FY 1972 to FY 1976 due to reduction in the aircraft inventory. On a per aircraft basis, logistics personnel have remained constant at 52. Table 2–5 displays this trend. The percentage of distribution of personnel to logistics activities has remained fairly constant, with the largest portion assigned to maintenance. In terms of total Air Force personnel, the percentage assigned to logistics has remained fairly stable at 62%.

An Identity Relating Aircraft NORS Rate with NORS Incidents

NORS part incidents and the length of time required to satisfy a NORS part incident should be related to aircraft NORS hours and rates. An increase in NORS part incidents and/or duration of these incidents should result in an increase in aircraft NORS hours. The data on Air Force worldwide NORS incidents show a pronounced increase in NORS part incidents, while the average duration of these incidents has remained relatively stable as greater use has been made of more expeditious supply alternatives (war reserves, cannibalization, lateral support).

As has been previously discussed, the aircraft status reporting conventions used by the Air Force to designate an aircraft as NORM, NORS or OR prevent a direct one-to-one

FIGURE 2-13. LOGISTICS RESOURCES VERSUS OPERATIONALLY READY RATES

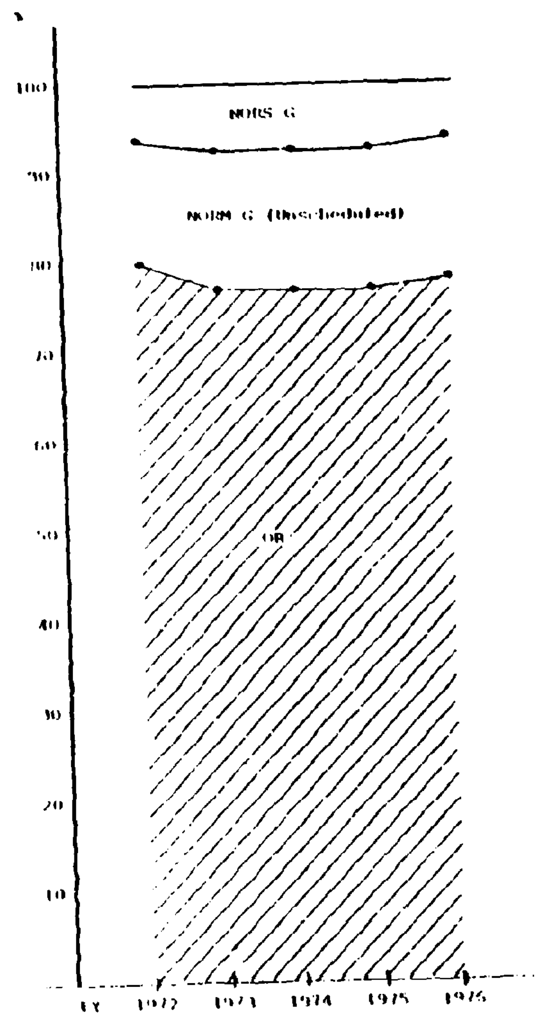


Figure 2-13a

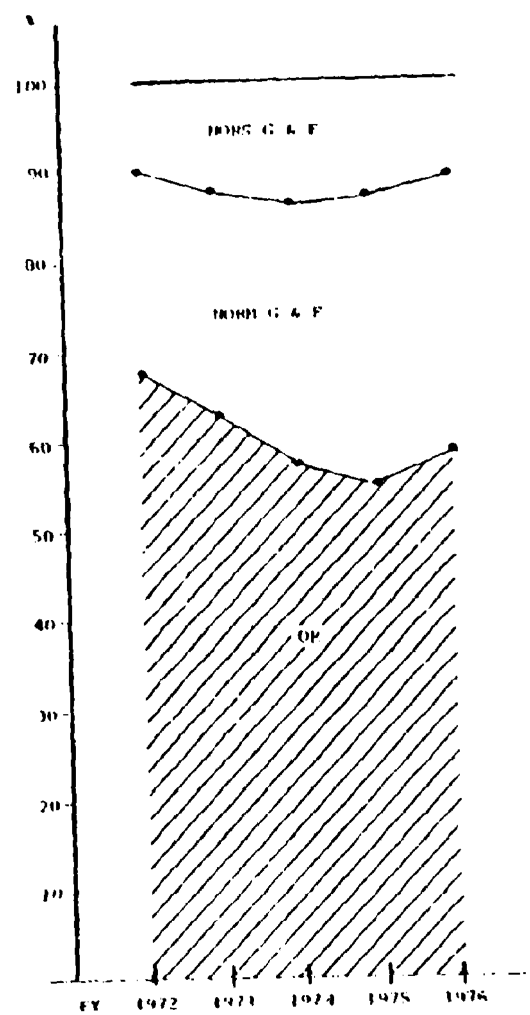


Figure 2-13b

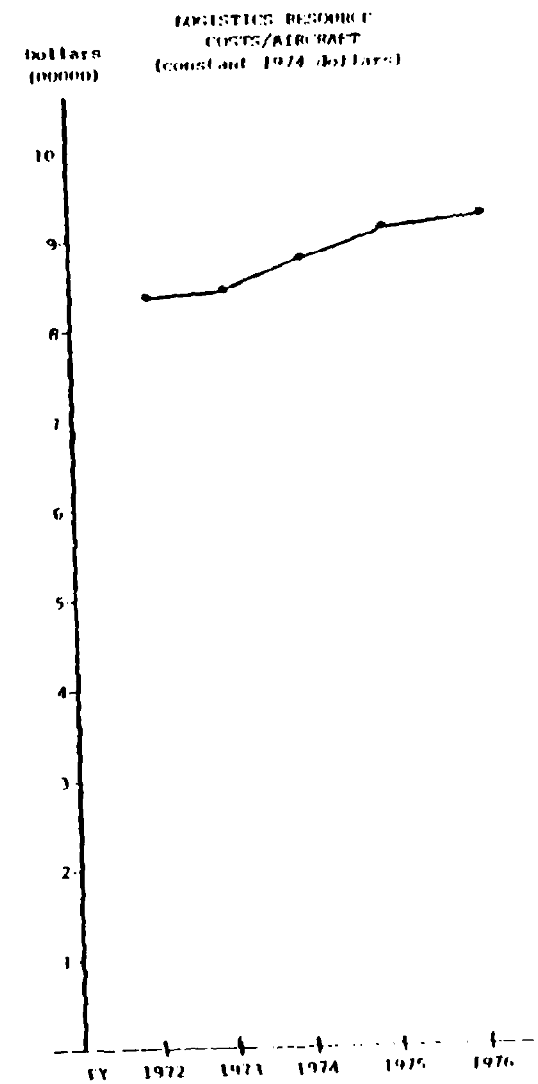


Figure 2-13c

TABLE 2-5. DISTRIBUTION OF AIR FORCE LOGISTICS PERSONNEL

	FY 1972		FY 1976	
	No.	%	No.	%
Maintenance	274,914	45.6	218,189	44.9
Supply	93,985	15.6	79,284	16.3
Transportation	35,427	5.9	27,151	5.6
Base Operating Support[1]	195,118	32.3	160,620	33.1
Other	3,893	.6	214	.0
Total Logistics	603,337	100.0	485,458	100.0
Total Air Force Personnel	964,897		783,606	
Logistics Percentage	62.5		62.0	
Logistics People per Aircraft	52.4		52.3	

Source: Manpower Authorization File, HAF-010 tape, (PM 77-2), March 1975, HAF-PRM(AR)7102, December 1972

[1]Base supply and base vehicle transportation are included in the supply and transportation portions, respectively, not in base operating support.

relationship between NORS part hours (NORS part incidents times NORS parts duration) and aircraft NORS hours. An aircraft can only be reported as NORS when a NORS requisition occurs and when no further maintenance actions, not necessarily related to the NORS-causing part, can proceed. NORS hours are accumulated on an aircraft until all parts are received for that aircraft, i.e., NORS hours equal the hours accumulated by the part that is received last. NORS incident hours are the sum of the total hours accumulated until all parts are received. Based on these definitions, consolidation of NORS parts to a single aircraft through cannibalization (where double-counting may result), or by the natural occurrence of multiple NORS incidents, distorts the relationship between NORS parts hours and NORS aircraft hours.

The following identity has been developed to provide one way of relating aircraft NORS rate to NORS part incident behavior. We think it helps to explain the behavior of factors behind the aircraft NORS rate and the adjustments made by operational managers to maintain a relatively stable aircraft NORS rate while NORS incidents have increased over time.

Aircraft NORS rate = (Frequency) x (Duration) x (Consolidation)

$$\frac{\text{A/C NORS Hours}}{\text{A/C Possessed Hours}} = \left(\frac{\text{NORS Part Incidents}}{\text{A/C Possessed Hours}}\right) \times \left(\frac{\text{NORS Part Hours}}{\text{NORS Part Incidents}}\right) \times \left(\frac{\text{A/C NORS Hours}}{\text{NORS Part Hours}}\right).$$

This identity divides the aircraft NORS rate into three factors: the relative frequency of NORS part incidents in terms of aircraft possessed hours, the average duration of a NORS part incident, and the amount of aircraft NORS hours per NORS part hour. As explained above, the numerator and denominator of the consolidation term differ because of multiple NORS incidents per aircraft, cannibalizations, and the masking of NORS hours by NORM hours.

Table 2-6 shows the results of using this identity for Air Force worldwide NORS–F and G rates from FY 1972 to FY 1976 and for NORS–G from FY 1974 to FY 1976. In both cases, the relative frequency (incidents/possessed hours) is increasing and the consolidation factor (NORS aircraft hours/NORS part hours) is decreasing, while the average duration is remaining fairly stable (about three and one-third days for NORS-G and F and about two and one-third days for NORS-G). These trends support our previous findings that NORS incidents are increasing in frequency, while aircraft inventories (possessed hours) are decreasing; and that the NORS rates can be stabilized, while the number of unfulfilled demands for NORS-causing items on base stock is increasing.

So far, we have looked at NORS incidents for aircraft in terms of incidents for all types of parts. We can classify these incidents by types of NORS–causing items–exchangeables, System Support Division (SSD), or other. Table 2-7 shows the distribution of NORS incidents classified in this manner for aircraft and engines from FY 1974 to FY 1976. For aircraft selected items in FYs 1975 and 1976, about 60% of the incidents were due to exchangeables, 20% to SSD items, and the balance to other items. However, exchangeables are satisfied on the average more expeditiously than the other item types and therefore account for proportionately fewer NORS part hours. Chapter 5 shows that the ability to use WRM accounts for this phenomenon. For engine-related items, each item type accounts for an equal proportion of both NORS part incidents and hours. Chapter 6 discusses the SSD items in more detail.

<u>Operationally Ready Rates and NORS Incidents for Specific Aircraft Systems</u>

We have examined the GO33B and Worldwide Grid data in terms of nine major weapon systems: the A–7, B–52, C–5, C–130, C–141, F–4, F–15, F–111, and KC–135. Our intent was to see if the trends observed for total aircraft could also be observed in these systems. We also wanted to observe if trends in one data base had any effect upon trends in the other. Figures 2-14 through 2-21 display operationally ready rates and NORS incident terminations for eight of the nine systems.[7] The data to support these graphs are found in Tables 2-12 through 2-21 in "Data and Source Description."

[7] Data for the F-15 have only been reported since the beginning of 1975.

TABLE 2-6. DATA AND CALCULATIONS FOR IDENTITY RELATING AIRCRAFT NORS RATE WITH NORS INCIDENTS

NORS F&G	FY1972	FY1973	FY1974	FY1975	FY1976
NORS Incidents ($x10^3$)	240	358	335	422	443
NORS Parts Hrs. ($x10^6$)	20.0	28.4	28.6	34.1	31.7
Possessed Hrs. ($x10^6$)	94.54	85.87	83.24	78.48	71.94
NORS A/C Hrs. ($x10^6$)	8.71	10.49	11.98	10.64	7.31
NORS Incidents/ Possessed Hrs.	$2.54x10^{-3}$	$2.17x10^{-3}$	$4.02x10^{-3}$	$5.38x10^{-3}$	$6.16x10^{-3}$
NORS Parts Hrs./ NORS Incidents	83.3	79.3	85.4	80.8	71.6
NORS A/C Hrs./ NORS Parts Hrs.	.436	.369	.419	.312	.231
NORS F+G RATE	9.2	12.2	14.4	13.6	10.2
NORS G					
NORS Incidents ($x10^3$)			255	301	308
NORS Parts Hrs. ($x10^6$)			14.2	17.2[1]	16.9
Possessed Hrs. ($x10^6$)			83.24	78.48	71.94
NORS A/C Hrs. ($x10^6$)			5.53	5.17	4.01
NORS Incidents/ Possessed Hrs.			$3.06x10^{-3}$	$3.84x10^{-3}$	$4.28x10^{-3}$
NORS Parts Hrs./ NORS Incidents			55.7	57.1	54.9
NORS A/C Hrs./ NORS Parts Hrs.			.39	.3	.2
NORS G Rate			6.6	6.6	5.6

[1] Approximated due to bad data for December 1974. The 11-month total was multiplied by $\frac{12}{11}$ to arrive at the fiscal year total.

TABLE 2-7. OVERVIEW OF AIRCRAFT AND ENGINE NORS INCIDENTS AND HOURS BY ITEM TYPE, FY 1974 - FY 1976

AIRCRAFT

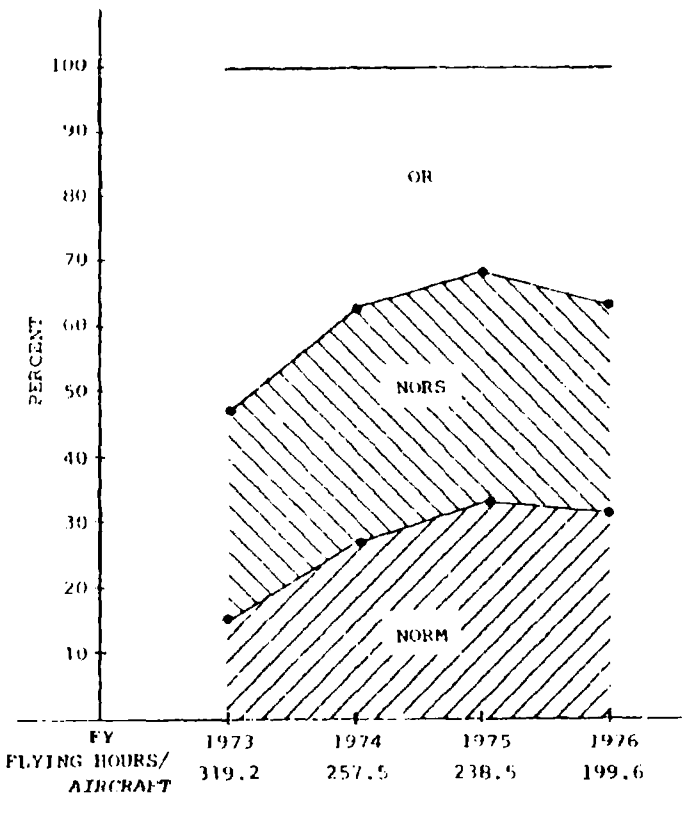
	FY 1974				FY 1975				FY 1976			
	Incidents		Hours		Incidents		Hours		Incidents		Hours	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Exchangeables	78,708	20.4	14,397,536	32.5	236,940	53.7	16,467,171	39.1	291,534	63.2	18,301,629	45.8
SSD	34,056	8.8	3,174,129	7.2	80,562	18.3	9,409,034	22.4	85,988	18.6	10,273,706	25.7
Other[1]	273,598	70.8	26,757,105	60.3	123,563	28.0	16,228,121	38.5	83,715	18.2	11,400,758	28.5
TOTAL	386,422	100.0	44,328,770	100.0	441,065	100.0	42,104,326	100.0	461,237	100.0	39,976,093	100.0

ENGINES

	FY 1974				FY 1975				FY 1976			
	Incidents		Hours		Incidents		Hours		Incidents		Hours	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Exchangeables	23,970	33.5	6,280,754	41.0	25,746	34.7	5,089,879	32.2	31,220	41.2	6,534,900	40.2
SSD	12,429	17.3	1,941,852	12.7	21,634	29.1	4,221,016	26.7	22,029	29.1	4,381,773	27.0
Other[1]	35,281	49.2	7,103,714	46.3	26,647	36.2	6,507,332	41.1	22,449	29.7	5,330,921	32.8
TOTAL	71,680	100.0	15,326,320	100.0	74,227	100.0	15,818,227	100.0	75,696	100.0	16,247,694	100.0

[1] Other items obtained by subtracting Exchangeable and SSD item NORS data from data for Total Items. Included in this figure are General Support Division Items.

FIGURE 2-14. A-7



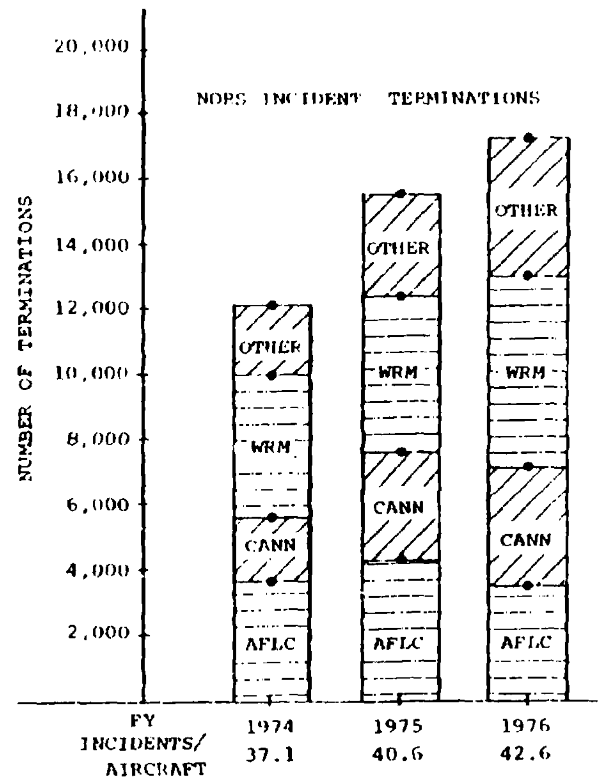


FIGURE 2-15. B-52

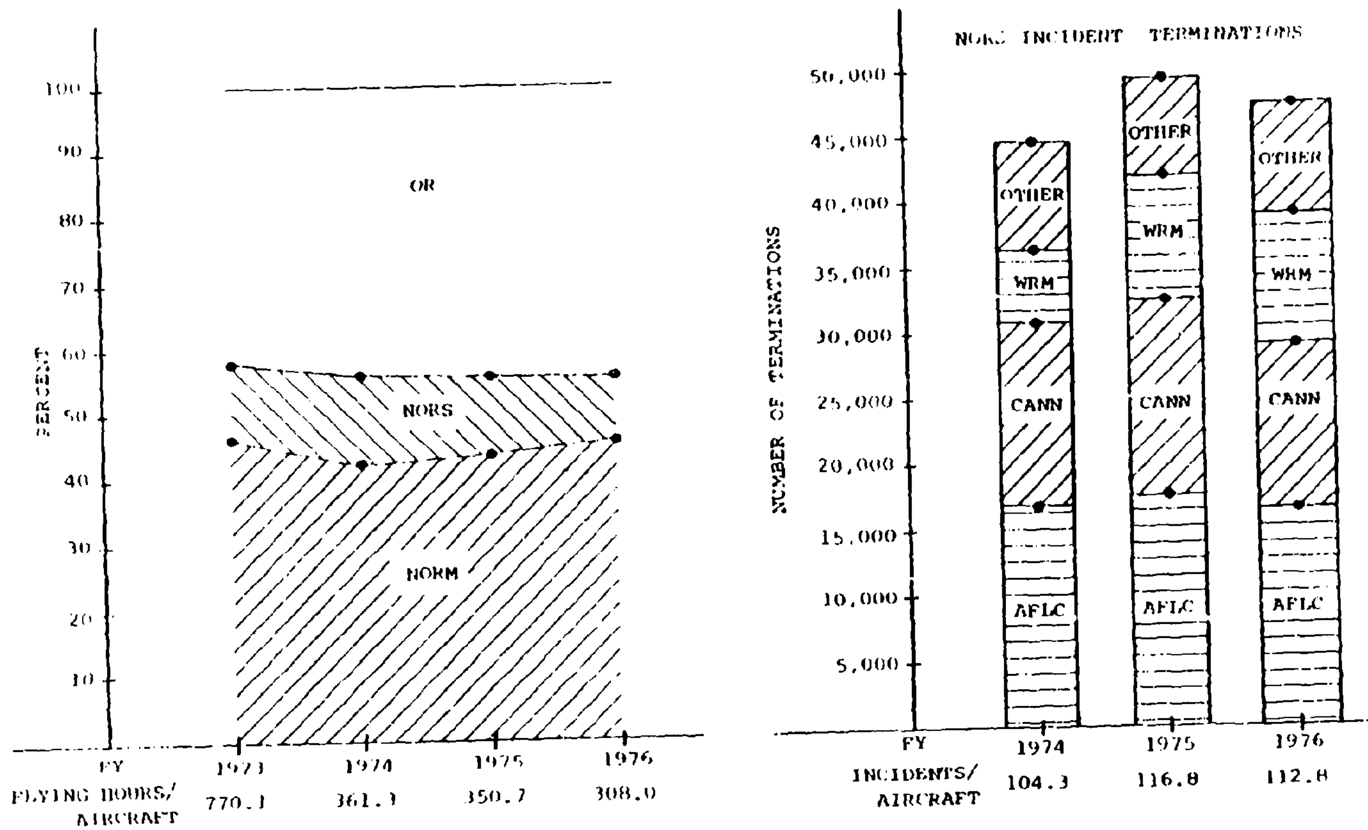


FIGURE 2-16. C-5

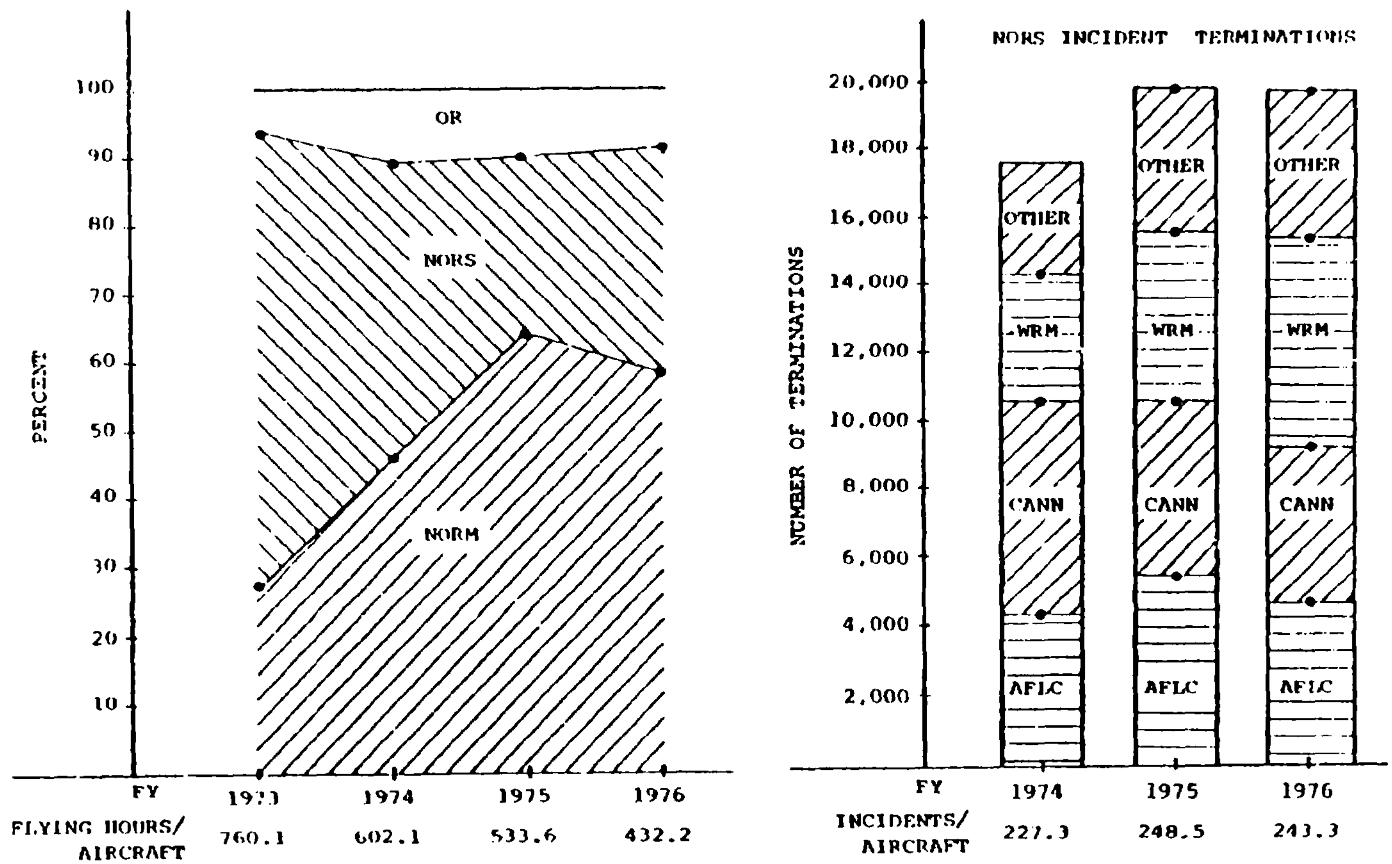


FIGURE 2-17. C-130

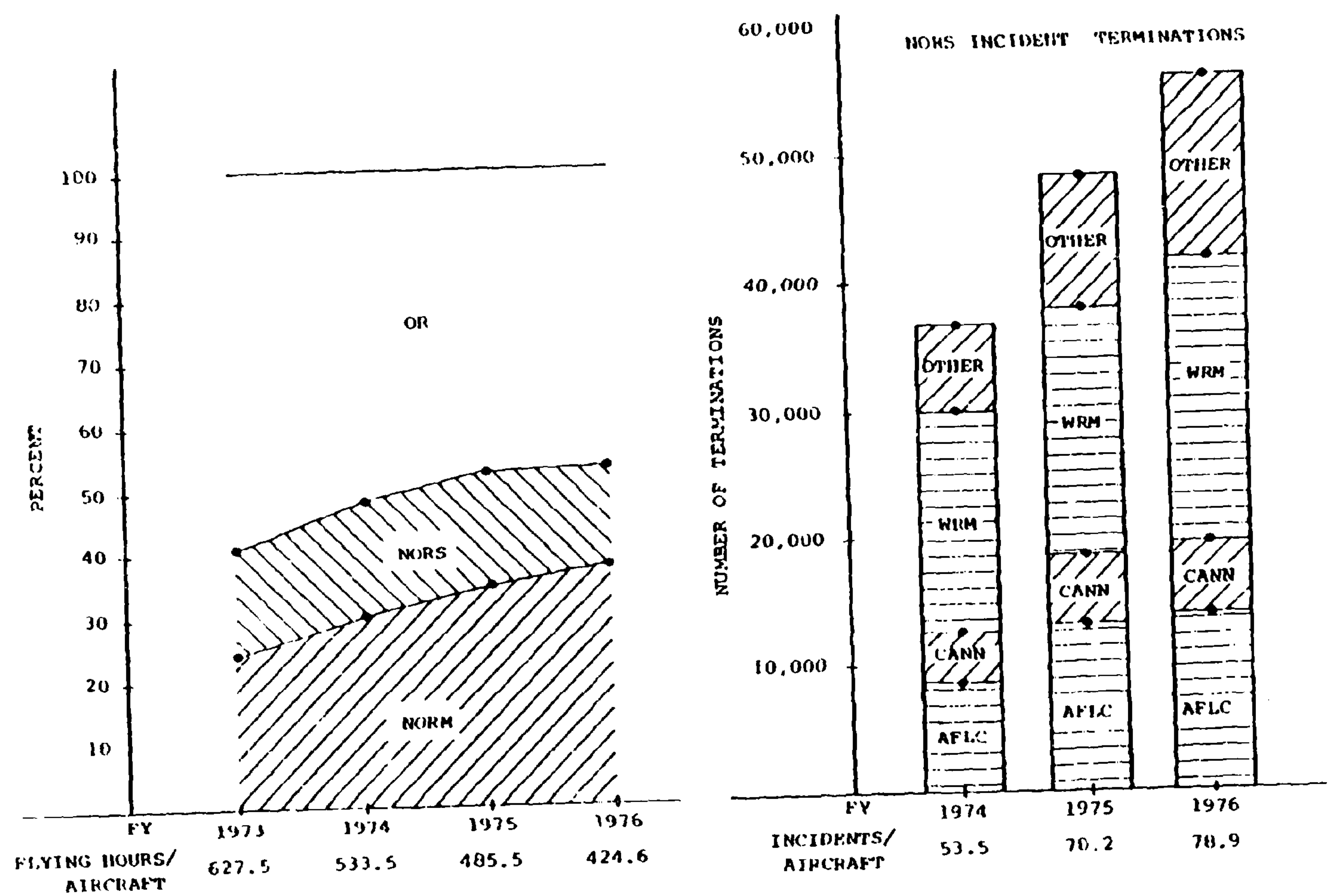
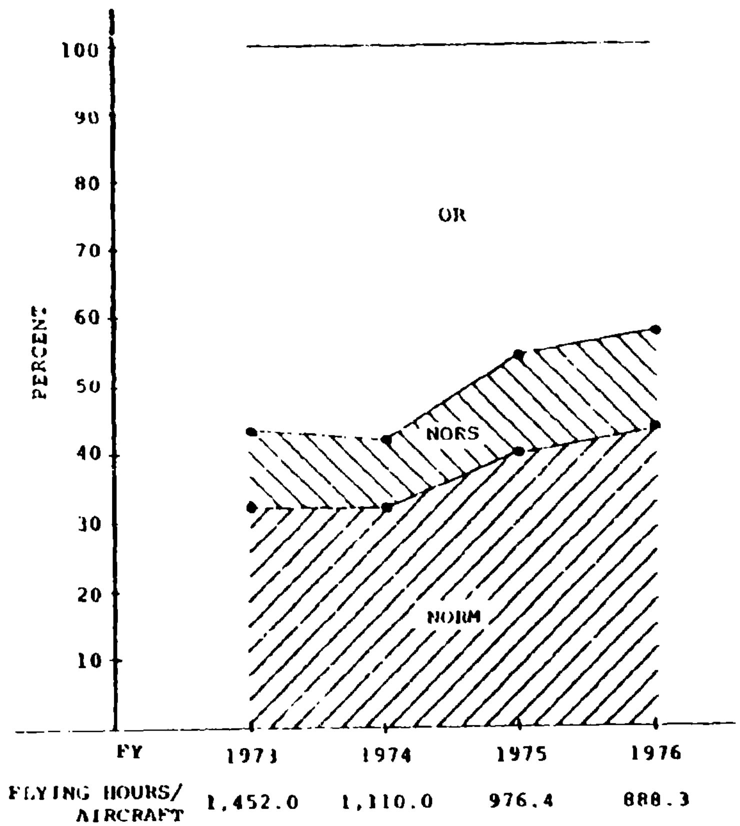


FIGURE 2-18. C-141



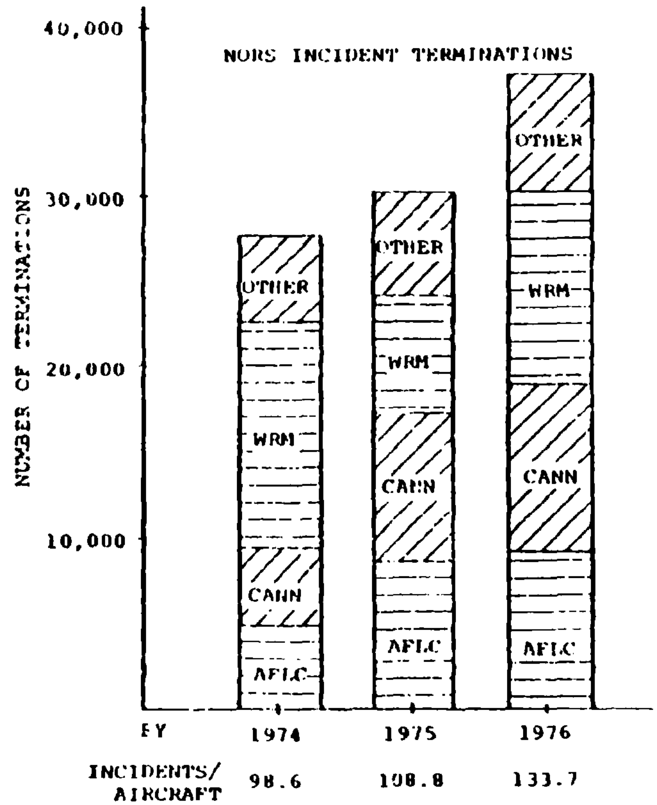


FIGURE 2-19. F-4

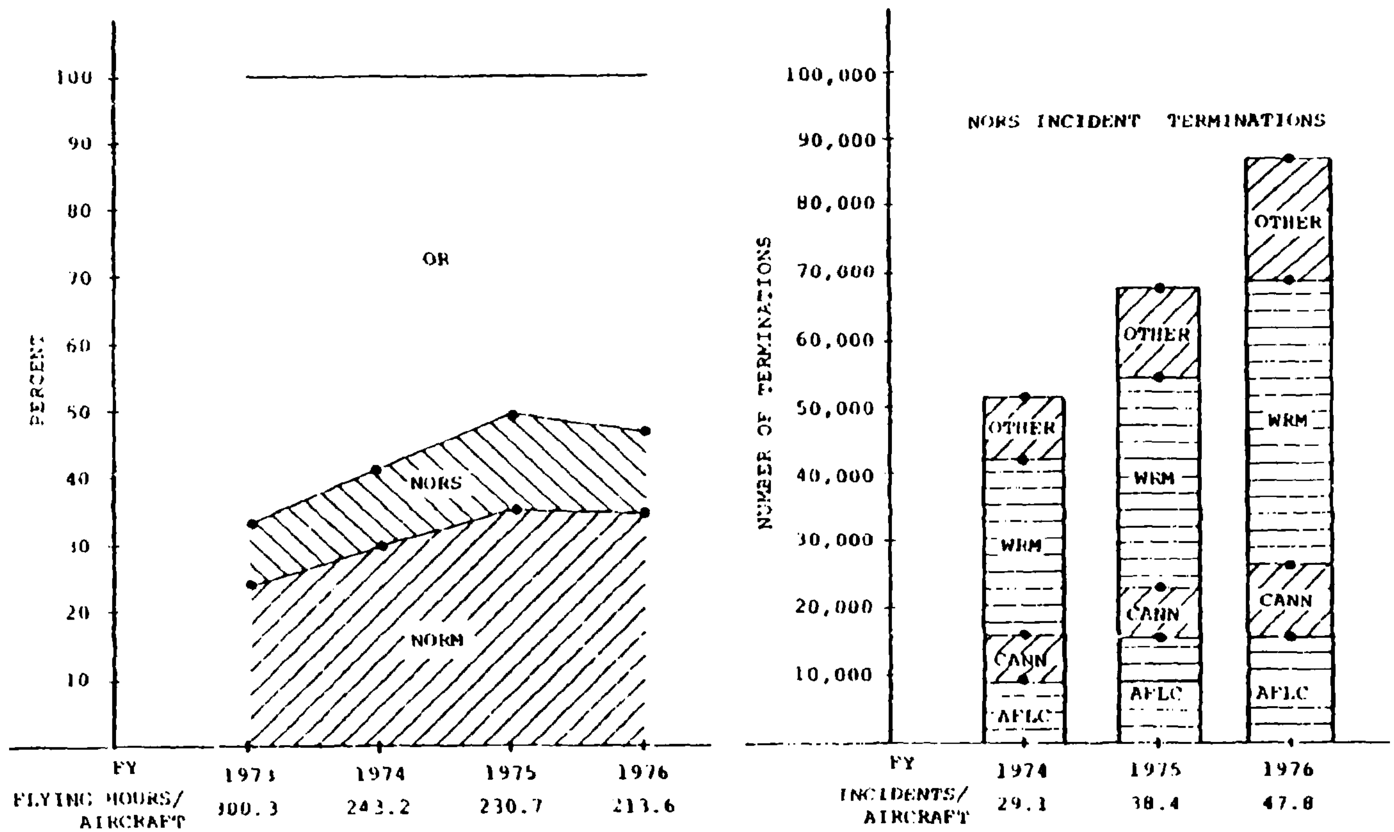


FIGURE 2-20. F-111

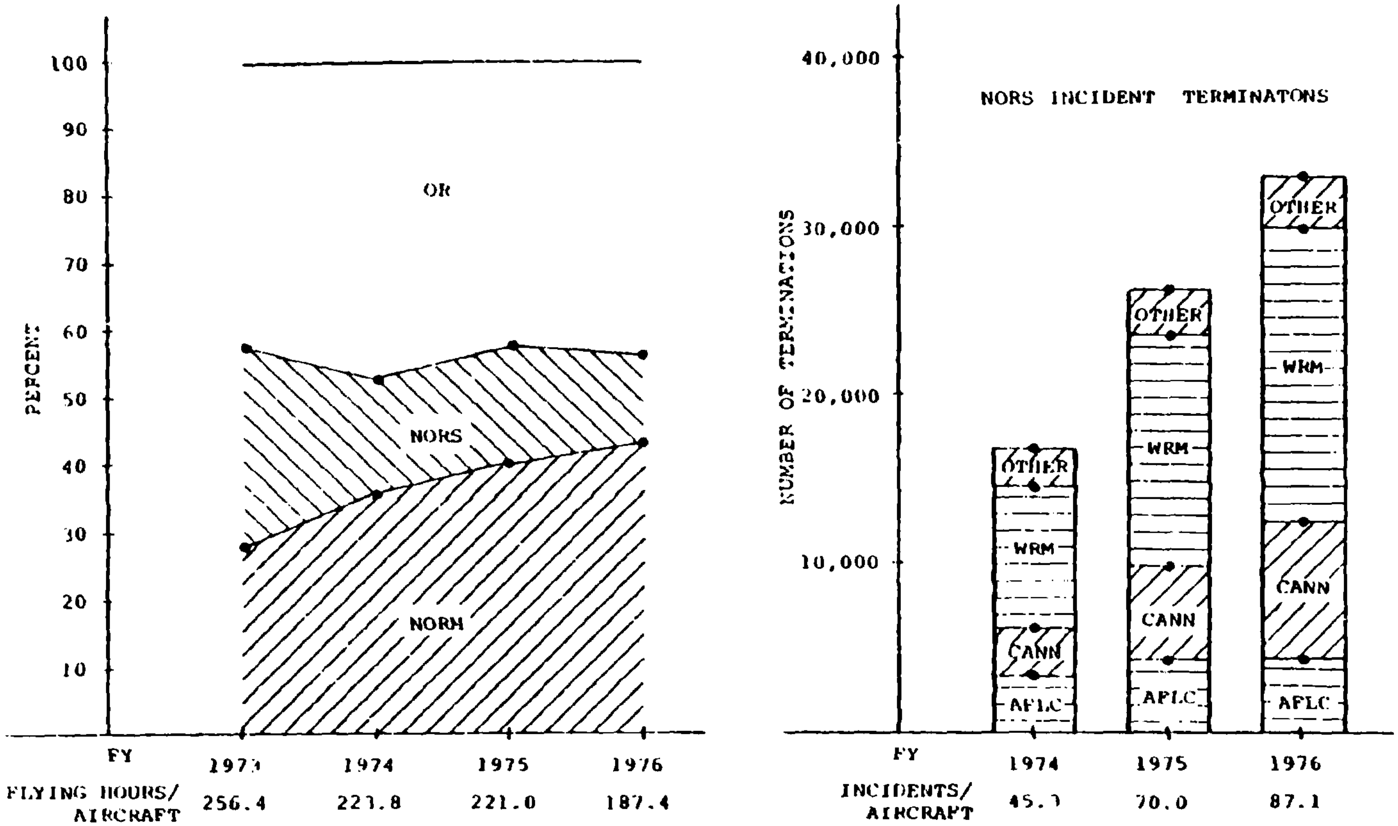
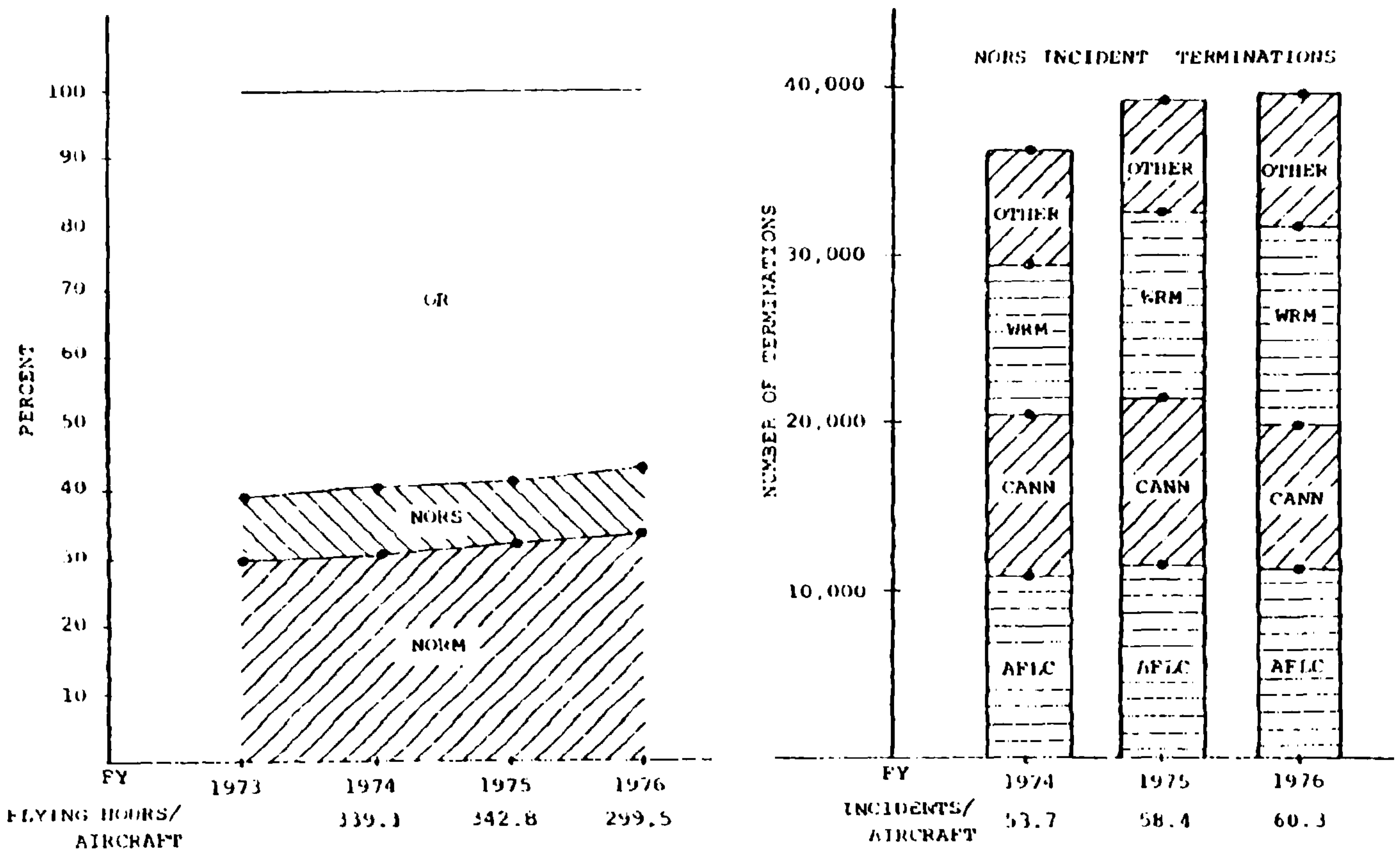


FIGURE 2-21. KC-135



Each weapon system experienced a decrease in activity from FY 1973 to FY 1976 as shown by flying hours per aircraft. Along with decreasing activity, four of the eight weapon systems demonstrated a decreasing OR rate. Those weapon systems were the A–7, C–130, C–141, and the F–4. The B–52 had a fairly stable OR rate averaging 44%, as did the F–111 at 44%, the KC–135 at 59%, and the C–5 at 9%. The C–5 had the worst OR rate of the eight weapon systems; its NORS rate decreased from 60.8% to 32.8%, while its NORM rate increased from 33.8% to 58.6% from FY 1973 to FY 1976.

The decrease in the OR rate for the four previously mentioned systems was due to an increase in the NORM rate. Except for the B-52 and the KC-135, which showed fairly stable NORM rates, the other weapon systems showed an increase in NORM rates. The F–111 and the C–5 showed a decrease in NORS rates, which, accompanied by an increase in NORM rates, maintained a stable OR rate. For the A–7, C–130, C–141, and the F–4, an increasing NORM rate produced a decrease in the OR rates.

Although six of these weapon systems had a stable NORS rate, NORS incidents per aircraft increased from FY 1974 to FY 1976 for all eight. Of the NORS incidents for the B-52, which had a high NORM rate at 45%, 30% were terminated by cannibalizations. Over 40% of the NORS incidents for the C-130 and the F–4 were terminated by war reserves. The C–5, which showed a decrease in NORS rate, also showed a decrease in cannibalizations from 35% in FY 1974 to 23% in FY 1976. Both the C–130 and the C–141 had decreasing OR rates, increasing NORM rates, and showed a decrease in the use of war reserves to terminate NORS incidents from FY 1974 to FY 1975.

The average duration of a NORS incident stayed fairly constant for the C–5, C–130 and KC–135. When incident terminations by AFLC action increased, the average duration of a NORS incident increased. For instance, incident terminations by AFLC action for the C–141 increased from 18% in FY 1974 to 28% in FY 1975. For that same period, the average duration of a NORS incident for the C–141 increased from 40.9 hours to 63.8 hours. Similarly, when incident terminations due to AFLC action for the A–7 decreased from 31% in FY 1974 to 21% in FY 1976, the average duration of a NORS incident for the A–7 decreased from 130 hours to 103 hours.

Another observed trend was in the use of cannibalizations and war reserves to terminate NORS incidents when caused by stocked versus non-stocked items. Cannibalizations were used more frequently to terminate NORS incidents caused by non-stocked items while war reserves were used more frequently to terminate NORS incidents caused by stocked items. For instance, in August 1976, the F–4 had 16.3% of its NORS incidents terminated by cannibalization when caused by non-stocked items (2% for war reserves); while 58% of its incidents were terminated by using war reserves when caused by stocked items (9.7% for cannibalizations). In general, this is what would be expected, since the war reserve stock tends to emphasize items with past demand experience.

War Readiness Spares Kits (WRSKs)

As defined earlier, a WRSK is an air transportable package of selected spares and repair parts required to sustain planned wartime or contingency operations of a weapon system for a specified period pending resupply. Depletion of the WRSKs for peacetime uses could thus affect surge capability. On the other hand, depletion of the WRSKs for peacetime uses stabilizes the NORS rate, which permits more aircraft to be OR, thus making more aircraft immediately ready in time of surge. Because the WRSKs can be used to terminate NORS incidents, we have tried to estimate the percentage of depletion in the WRSKs when this occurs.

We have estimated such depletion on the WRSKs of eight weapon systems. Table 2-8 presents for each of the eight weapon systems the total number of line items in all WRSKs for that weapon system, the dollar value of all those kits, and the percentage of depletion in the WRSK due to peacetime use. The number of line items for each MD[8] was calculated by summing for each Mission Design Series (MDS) and each command the products and the number of line items. The dollar value was obtained by the same procedure.[9] In order to estimate the percentage of depletion in the WRSKs, we approximated the duration in days of receiving an item from the depot for each weapon system by dividing the length of the NORS incidents, when terminated by AFLC action, by the number of those incidents for FY 1976. These figures are included in Table 2-8. Given this cycle time, the number of cycles in a year was calculated by dividing 365 by the appropriate cycle time. Thus, the number of incidents terminated by war reserves for the year divided by the number of cycles gives an estimate of the number of items missing from the kit at any one time. If we assume a one-to-one correspondence between the number of line items and the number of total items in a kit, we can approximate the percentage of depletion in the WRSK due to NORS terminations as reported in Table 2-8.

[8] MD (Mission Design) indicates a specific aircraft type.

[9] The dollar value was calculated from the estimated cost of the WRSK as of October 1976.

TABLE 2-8. ANALYSIS OF WRSK UTILIZATION FOR TERMINATION OF NORS INCIDENTS-WORLDWIDE DATA

Weapon System	Dollar Value[1] (Millions)	Line Items[2]	Estimated Percent Depletion of WRSKs	NORS Incident Duration[3] (Average Days)
A-7	51.3	2664	5.4	8.9
B-52	19.7	3545	3.5	4.7
C-5	53.7	996	15.2	9.0
C-130	35.7	4981	7.1	5.8
C-141	61.6	2079	7.9	5.3
F-4	149.9	21494	2.8	5.2
F-111	207.9	3664	9.4	7.0
KC-135	17.4	4969	2.8	4.2

[1] October 1976 figures

[2] Total line items of all WRSKs worldwide

[3] Average duration to terminate a NORS incident by AFLC action

Analyzing these calculated depletion percentages, two figures appear different from our prior expectations. The F-4 figure appears to be too low at 2.8% and the C-5 figure too high at 15.2%. For both of these aircraft, the inaccuracy could be due to the approximated cycle time. The nine-day figure for the C-5 may be too high, since it was approximated by using the data for terminations by AFLC. The C-5 often lands at bases that do not normally service that aircraft; NORS items may therefore take longer to reach C-5 aircraft than they would to reach the WRSKs, which are located mainly in CONUS. Hence, the actual cycle time for a spare to be replenished to the C-5 WRSK would actually be shorter, increasing the number of cycles and thus decreasing the number of items depleted from the WRSK within any one cycle.

On the other hand, we note that 50% of the F-4 terminations are from using war reserves, and only 20% are from ALC resupply directly, so that the average duration of an ALC NORS termination may not be representative of the average resupply time of the WRM. We postulate that ALC terminations are more likely for items immediately available from stock in the depot, whereas the resupply of the WRM, since it occurs so frequently, is subject to delays in ALC processing due to unavailability of stock. We think that the frequency of such stock unavailability leads to a resupply time represented by the average Military Supply and Transportation Evaluation Procedures (MILSTEP) pipeline time of Priority Group 1 CONUS requisitions. This would make the average resupply time for WRM 17.8 days rather than the 5.2 days of ALC NORS terminations. Using the 17.8 days for the WRM replenishment cycle, we get 9.7% as the expected depletion rate for F-4 WRM, which we think is a more representative value of WRM status.

FINDINGS AND CONCLUSIONS

- Both flight activity and aircraft inventories have decreased in the Air Force. Flying hours per aircraft have declined from FY 1970 to FY 1976 due to a greater decrease in flying hours than in aircraft inventories.

- The OR rate has decreased from 75.5% in FY 1970 to 59.3% in FY 1976, primarily because of an increase in the NORM rate from 18.5% in FY 1970 to 30.2% in FY 1976. A portion of this increase can be attributed to the addition of NORM-F reporting in October 1973. There is also evidence that this trend is due to the changing aircraft mix, that is, the increase in complex aircraft in the inventory.

- The NORS rate has remained fairly stable; the NORS-G rate has averaged 6.2% from FY 1972 to FY 1976. However, the NORS incident rate (NORS incident hours per possessed hour) has increased by over 100% from FY 1972 to FY 1976.

- The NORS rate has remained lower than the NORS incident rate due to both policy decisions and features of the reporting systems, such as the masking of the NORS rate by the NORM rate and the use of cannibalizations to terminate NORS incidents.

- Cannibalizations can cause double-counting in NORS incident reporting if the cannibalization results in a new NORS requisition for the same part failure.

- Both the NORS rate and the NORS incident rate are maintained at a lower level when WRM is used to terminate NORS incidents.

- These findings suggest that we should focus on the increasing NOR rate, as opposed to the increasing NORM rate.

- Essentially, the trends observed in the OR rates for the total Air Force have also been observed in the rates of the individual weapon systems we have examined. The NORM rates have increased, while activity has decreased; the NORS rates have remained fairly stable, while NORS incidents have increased.

- The frequency of use of cannibalizations and war reserves to terminate NORS incidents has varied among the weapon systems, depending on the magnitude of the NORS and NORM rates for the weapon system. High NORM rates are frequently accompanied by a large number of cannibalizations to terminate NORS incidents.

- Logistics resource costs per aircraft in constant 1974 dollars have increased from \$850,000 in FY 1972 to \$922,000 in FY 1976. Logistics costs as a percentage of the total Air Force budget have increased from 35% in FY 1972 to 38% in FY 1976. (These are LMI estimates. See Table 2-4 B.)

- Total logistics personnel in the Air Force has decreased from 603,000 in FY 1972 to 485,500 in FY 1976. Logistics personnel per aircraft has remained constant at 52; and logistics personnel as a percentage of total Air Force personnel has remained constant at 62%.

- From these results, the causes of the declining OR rate are still unclear. Undoubtedly, the increase in NORS incidents suggests that the supply system has not been as stable as the NORS rate would imply. The increasing NORM rate also suggests a lack of stability in maintenance responsiveness that is analyzed further in Chapter 7.

DATA AND SOURCE DESCRIPTION

The principle data sources used in this chapter are the monthly "Aerospace Vehicle Status/Utilization Report" (GO33B data base), the Worldwide Grid (D165A data base), and the "System Effectiveness Reports." The monthly "Aerospace Vehicle Status/Utilization Report" gives data by MDS; command and station; average number of aircraft; possessed hours; NORS-G, NORS-F, NORM-G scheduled, NORM-G unscheduled, and NORM-F hours, with corresponding rates; flying hours; sorties; and total landings. Included are totals by station, command, mission design, and worldwide totals. Rates are calculated by dividing the appropriate hours by possessed hours. In April of 1976, this data base underwent some programming modifications and, as a result, the data for the last quarter of FY 1976 are unreliable. In most of these cases, the data are below anticipated figures, due to bases not reporting their data. These discrepancies have been cited in the tables and corrected figures were utilized when possible.

The Worldwide Grid is also produced monthly and indicates NORS incidents and NORS incident hours by budget, commodity and condition categories. As discussed above, under "NORS Incident Reporting" the data are broken out by termination code and cause code. Totals are reported for these codes, inclusive and exclusive of those incidents dropped due to nonreceipt of the document indicating how the incident was terminated. Budget codes are described in AFM 67-1, Volume 1, Part One, Amendment 8, Attachment 6. Commodity codes used in this report are aerospace vehicles and ECM pods (code K), and aircraft and missile engines (code M). For aircraft, three condition codes are available: G, to relieve a NORS-G condition; F, to relieve a NORS-F condition; and M, battle damage. The data presented in this report are mainly the sum of condition codes G and F.

Except for total Air Force aircraft, the Worldwide Grid data presented in this report were obtained on a monthly basis and aggregated by LMI to produce yearly totals for FY 1974 through FY 1976. Unfortunately, we were unable to obtain any grid data before December 1973, since that information was not saved on magnetic tape. We were also unable to obtain data for June 1973, January 1975, February 1976, May 1976, and June 1976, due to tape processing problems. For each fiscal year, the yearly totals were obtained by averaging the available monthly data and multiplying by 12. For total Air Force aircraft, each month of FY 1976 was obtained for NORS-F and G incidents and each month of FYs 1974, 1975, and 1976 for NORS-G incidents.

The "System Effectiveness Reports" (SER) are quarterly reports of weapon system performance produced from the KO51 data base. The "System Effectiveness Reports" consist of four parts: force summary, trend data, effectiveness models, and manual effectiveness analysis. The data we have used from the SER are contained in Parts I and II. Part I provides possessed hours, flying hours, sorties, and the following system statistics:

System Effectiveness - The probability of a weapon system being capable of performing all assigned missions

Flight Reliability - The probability of satisfactorily completing the flight portion of a mission

Before Flight Reliability - The probability of the alert available force becoming airborne as planned

Operational Readiness - The probability of the weapon system under control of the operating commands being available to react to an execution order

Alert Availability - The probability of the weapon system being available to react to an execution order.

Part II contains NORM hours per flying hour and scheduled NORM hours. Since the KO51 data base is fed by the GO33B data base, some of the SERs were not produced for the quarter ending June 1976.

The data reported in Chapter 2 were gathered from many sources. Although the original data base is cited as the source, the actual numbers were obtained from various reports and Air Force agencies. In most cases where data from several sources coincided, no two numbers agreed exactly. We feel that the numbers cited in this chapter are accurate in magnitude, but that the actual number may not be accurate in the number of significant digits presented.

TABLE 2-9. WORLDWIDE AIRCRAFT-NORS G&F INCIDENT TERMINATIONS

No. of Incidents		FY1974 No.	FY1974 %	FY1975 No.	FY1975 %	FY1976 No.	FY1976 %
0	Cancelled	23,940	6.7	20,156	4.8	15,451	3.5
1	ALC	108,446	30.4	130,313	31.1	117,759	26.6
2	DSA	24,768	6.9	32,998	7.9	38,581	8.7
3	Lateral	23,364	6.6	27,487	6.6	29,761	6.7
4	Cann Preclude	39,652	11.1	47,320	11.3	46,007	10.4
5	Base Procured	436	.1	915	.2	2,132	.5
6	Release Base Assets	22	-	4,926	1.2	12,466	2.8
7	WRM	103,972	29.1	116,293	27.7	141,810	32.0
8	Cann Satisfy	32,090	9.0	38,986	9.3	39,419	8.9
	Total Term Codes	356,690	100.0	419,393	100.0	443,275	100.0
	Dropped Due to Non-Receipt	29,732		21,672		17,862	
TOTAL		386,422		441,065		461,237	

No. of Hours		No.	%	No.	%	No.	%
0	Cancelled	3,296,200	11.2	2,551,742	7.5	2,080,307	6.6
1	ALC	17,999,310	61.3	20,315,157	59.6	16,590,005	52.3
2	DSA	3,162,468	10.8	4,717,348	13.8	5,861,908	18.5
3	Lateral	2,043,440	7.0	2,503,035	7.3	2,599,846	8.2
4	Cann Preclude	1,116	-	75	-	7	-
5	Base Procured	70,856	.2	133,148	.4	323,802	1.0
6	Release Base Assets	838	-	521,969	1.5	1,098,741	3.5
7	WRM	109,880	.4	121,082	.4	122,821	.4
8	Cann Satisfy	2,659,280	9.1	3,196,790	9.4	3,041,458	9.6
	Total Term Codes	29,343,388	100.0	34,060,346	100.0	31,718,895	100.0
	Dropped Due to Non-Receipt	14,985,382		8,043,980		8,257,198	
TOTAL		44,328,770		42,104,326		39,976,093	

TABLE 2-10. WORLDWIDE AIRCRAFT-NORS G&F CAUSE CODES

		FY1974		FY1975		FY1976	
No. of Incidents		No.	%	No.	%	No.	%
A	Org. Level First Demand	69,350	18.0	75,547	17.1	85,832	18.6
B	No Level Past Demand	53,238	13.8	56,410	12.8	42,886	9.3
C	Level not Auth.	162	-	8.6	-	212	.1
D	Base Not Level	586	.2	700	.2	913	.2
E	Base Failed Level	-	-	-	-	-	-
F	Base Stock Insuf.	392	.1	3	.1	169	0.0
G	FBS AWP Assets	61,416	15.9	80,7[illegible]	18.3	39,469	8.6
H	<FBS Reqn>Mil	128,478	33.3	165,714	37.6	184,048	39.9
J	<FBS Reqn>Mil	54,052	14.0	43,142	9.8	60,572	13.1
K	FBS No Due In Estb	14,602	3.8	16,003	3.6	18,276	4.0
R	FBS Assets Unavail	-	-	-	-	27,740	6.0
Y	No Data Comp Down	1,718	.4	1,592	.4	261	.1
Z	Init Short	2,428	.6	780	.2	771	.2
TOTAL		386,422	-	441,065	-	461,237	-
No. of Hrs.		No.	%	No.	%	No.	%
A	Org Level First Demand	10,524,506	23.7	10,196,668	24.2	11,431,868	28.6
B	No Level Past Demand	7,583,852	17.1	7,027,914	16.7	5,584,142	14.0
C	Level Not Auth	4,032	0.0	2,710	0.0	7,629	0.0
D	Base Not Level	69,518	.2	62,414	.2	79,136	.2
E	Base Failed Level	-	-	-	-	-	-
F	Base Stock Insuf.	78,388	.2	35,020	.1	17,526	0.0
G	FBS AWP Assets	2,625,300	5.9	2,851,141	6.8	996,765	2.5
H	<FBS Reqn>Mil	14,821,924	33.4	16,591,834	39.4	14,937,505	37.4
J	<FBS Reqn>Mil	5,916,014	13.4	3,534,775	8.4	4,243,233	10.6
K	FBS No Due in Estb.	1,472,962	3.3	1,341,27[illegible]	3.2	1,319,312	3.3
R	FBS Assets Unavail	-	-	-	-	1,096,222	2.7
Y	No Data Comp Down	397,754	.9	212,488	.5	60,475	.2
Z	Init Short	834,520	1.9	248,088	.6	203,280	.5
TOTAL		44,328,770	-	42,104,326	-	39,976,093	-

TABLE 2-11. WORLDWIDE AIRCRAFT-NORS-G INCIDENT TERMINATIONS

No. of Incidents		FY1974 No.	FY1974 %	FY1975 No.	FY1975 %	FY1976 No.	FY1976 %
0	Cancelled	14,625	5.7	11,714	3.9	8,722	2.8
1	ALC	63,663	25.0	75,323	25.1	65,688	21.3
2	DSA	14,691	5.8	21,116	7.0	25,271	8.2
3	Lateral	17,101	6.7	21,211	7.1	21,158	6.9
4	Cann Preclude	34,347	13.5	38,294	12.7	38,693	12.5
5	Base Procured	226	.1	703	.2	1,784	.6
6	Release Base Assets	14	0.0	2,484	.8	6,963	2.3
7	WRM	87,368	34.3	100,656	33.5	111,760	36.2
8	Cann Satisfy	22,924	9.0	29,189	9.7	28,434	9.2
	Total Term Codes	254,959	100.0	300,690	100.0	308,473	100.0
	Dropped Due to Non-Receipt	16,288		13,716		11,318	
TOTAL		271,247		314,406		319,791	

No. of Hrs.	FY1974 No.	FY1975 No.	FY1976 No.
Total Term Codes	14,150,483	17,213,853[1]	16,902,530
Total (Term Codes and Dropped Due to Non-Receipt)	20,792,396	22,094,595[2]	21,916,491

[1] Approximated due to bad data for December 1974. $(\frac{12}{11}) \times (15,779,365)$

[2] Approximated due to bad data for December 1974. $(\frac{12}{11}) \times (20,253,379)$

TABLE 2-12. NORS INCIDENTS/TERMINATIONS

Item NORS Hours in Millions

A-7	FY1974	FY1975	FY1976
Incidents	12,128	15,687	17,270
Termination			
Cannibalization	1,912 (16)	3,298 (21)	3,568 (21)
WRM Withdrawal	4,364 (36)	4,784 (31)	5,950 (35)
Lateral Shipment	166 (1)	315 (2)	435 (3)
AFLC Action	3,796 (31)	4,421 (28)	3,562 (21)
Other	1,890 (16)	2,871 (18)	3,755 (22)
Item NORS Hours-AFLC Action (M)	1.04	1.01	.77
Item NORS Hours-Total (M)	1.58	1.78	1.77
B-52			
Incidents	44,624	49,764	47,473
Terminations			
Cannibalization	13,728 (31)	14,872 (30)	13,445 (28)
WRM Withdrawal	5,592 (13)	9,733 (20)	9,633 (20)
Lateral Support	1,562 (4)	2,012 (4)	2,765 (6)
AFLC Action	17,184 (30)	17,647 (36)	15,693 (33)
Other	6,558 (15)	5,501 (11)	5,937 (13)
Item NORS Hours-AFLC Action(M)	2.10	2.17	1.77
Item NORS Hours-Total (M)	3.65	3.66	3.28
C-5			
Incidents	17,728	18,885	18,733
Terminations			
Cannibalization	6,224 (35)	5,133 (27)	4,364 (23)
WRM Withdrawal	3,646 (21)	4,890 (26)	6,171 (33)
Lateral Support	624 (4)	654 (4)	608 (3)
AFLC Action	4,510 (25)	5,673 (30)	4,868 (26)
Other	2,724 (15)	2,536 (13)	2,723 (15)
Item NORS Hours-AFLC Action (M)	1.24	1.59	1.05
Item NORS Hours-Total (M)	2.38	2.54	1.90
C-130			
Incidents	36,936	48,462	55,138
Terminations			
Cannibalization	3,770 (10)	5,397 (11)	6,031 (11)
WRM Withdrawal	17,360 (47)	19,350 (40)	22,280 (40)
Lateral Support	2,310 (6)	2,748 (6)	3,414 (6)
AFLC Action	8,904 (24)	13,155 (27)	13,788 (25)
Other	4,592 (12)	7,613 (16)	9,623 (17)
Item NORS Hours-AFLC Action (M)	1.41	1.84	1.91
Item NORS Hours-Total (M)	2.20	3.19	3.70

TABLE 2-12. NORS INCIDENTS/TERMINATIONS (Continued)

Item NORS Hours in Millions

C-141	FY1974	FY1975	FY1976
Incidents	27,604	30,234	37,170
Termination			
Cannibalization	4,804 (17)	8,901 (30)	9,701 (26)
WRM Withdrawal	13,176 (48)	6,780 (22)	11,313 (30)
Lateral Shipment	1,322 (5)	2,176 (7)	1,764 (5)
AFLC Action	4,834 (18)	8,448 (28)	9,285 (25)
Other	3,468 (13)	3,931 (13)	5,107 (14)
Item NORS Hours-AFLC Action (M)	.48	1.04	1.18
Item NORS Hours-Total (M)	1.13	1.93	2.32
F-4			
Incidents	51,508	67,575	86,957
Terminations			
Cannibalization	5,960 (12)	7,922 (12)	10,608 (12)
WRM Withdrawal	26,848 (52)	31,566 (47)	42,678 (49)
Lateral Support	5,006 (10)	5,688 (8)	7,731 (9)
AFLC Action	9,802 (19)	15,445 (23)	16,065 (19)
Other	3,892 (8)	6,953 (10)	9,874 (11)
Item NORS Hours-AFLC Action (M)	1.20	1.99	2.00
Item NORS Hours-Total (M)	2.11	3.48	4.11
F-15			
Incidents		562	3,030
Terminations			
Cannibalization		173 (31)	1,119 (37)
WRM Withdrawal		-	-
Lateral Support		2 (0)	41 (1)
AFLC Action		226 (40)	1,169 (39)
Other		163 (29)	701 (23)
Item NORS Hours (000)		25.8	177.3
F-111			
Incidents	16,672	26,304	32,848
Terminations			
Cannibalization	2,486 (15)	5,732 (22)	7,987 (24)
WRM Withdrawal	8,424 (51)	13,866 (53)	17,906 (55)
Lateral Support	78 (1)	111 (0)	165 (1)
AFLC Action	3,700 (22)	4,345 (17)	4,442 (14)
Other	1,984 (12)	2,250 (9)	2,349 (7)
Item NORS Hours-AFLC Action (M)	.61	.78	.75
Item NORS Hours-Total (M)	.94	1.22	1.22

TABLE 2-12. NORS INCIDENTS/TERMINATIONS (Continued)

Item NORS Hours in Millions

KC-135	FY1974	FY1975	FY1976
Incidents	36,178	39,218	39,629
Terminations			
Cannibalization	9,494 (26)	10,147 (26)	8,569 (22)
WRM Withdrawal	9,116 (25)	11,040 (28)	11,917 (30)
Lateral Support	2,250 (6)	2,167 (6)	2,729 (7)
AFLC Action	10,800 (30)	11,444 (29)	11,387 (29)
Other	4,518 (13)	4,421 (11)	5,026 (13)
Item NORS Hours-AFLC Action (M)	1.21	1.28	1.16
Item NORS Hours-Total (M)	2.27	2.31	2.15

TABLE 2-13. A-7 AIRCRAFT DATA

	FY1973	FY1974	FY1975	FY1976	SOURCE
Total Aircraft Inventories	280	327	384	403	Air Force Statistical Digest & USAF Summary
Total Flying Hrs.	89,372	84,203	91,585	80,426	RCS-SS-A-41[1] and SER
Total Sorties		43,541	51,185	46,865	SER
Possessed Hrs. ($x10^6$)		3.17	3.24	3.15	SER
NORS Hrs.		1,153,880	1,153,440	1,017,450	
NORS-G Hrs.		399,420	635,040	825,300	Calculated from
NFE/NORS-F Hrs.		754,460	518,400	192,150	Possessed Hrs. and
NORM Hrs.		846,390	1,056,240	982,800	OR-NOR Rates below
NORM-G Hrs.		592,790	696,600	727,650	
NORM-F Hrs.		253,600	359,640	255,150	
System Effectiveness Rate		6.73	5.86	5.51	SER
OR Rate	53.3	36.9	31.5	36.5	GO33B
NORS Rates	31.5	36.4	35.6	32.3	GO33B
NORS-G	7.1	12.6	19.6	26.2	GO33B
NFE/NORS-F	24.4	23.8	16.0	6.1	GO33B
NORM Rates	15.2	26.7	32.9	31.2	GO33B
NORM-G		18.7	21.8	23.1	GO33B
NORM-F		8.0	11.1	8.1	GO33B
NORS Incidents		12,128	15,687	17,270	D165A
NORS Parts Hrs. ($x10^6$)		1.58	1.78	1.77	D165A
NORS Incidents/Pos. Hrs.		$3.83x10^{-3}$	$4.84x10^{-3}$	$5.48x10^{-3}$	
NORS Parts Hrs./ NORS Incidents		130.3	113.5	102.5	
NORS A/C Hrs./NORS Parts Hrs.		.730	.648	.575	
NORS Rate (F+G)		36.4	35.6	32.3	
NORS Parts Hrs./NORS A/C Hrs.		1.4	1.5	1.7	

[1]History of USAF Flying Hrs. for Planning and Reference.

TABLE 2-14. B-52 AIRCRAFT DATA

	FY1973	FY1974	FY1975	FY1976	SOURCE
Total Aircraft Inventories	446	428	426	421	Air Force Statistical Digest and USAF Summary
Total Flying Hrs.	343,484	154,647	149,419	129,687	RCS-SS-A-41[1] and SER
Total Sorties		21,152	21,116	18,525	SER
Possessed Hrs. ($x10^6$)		3.41	2.93		Calculated From NORS-G Rate & NORS-G Hours
NORS Hrs.		460,537	331,185		
NORS-G Hrs.		208,197	102,645		GO33B
NFE/NORS-F Hrs.		252,340	228,540		Calculated from Possessed Hours and OR-NORS Rates below.
NORM Hrs.		1,439,020	1,295,060		
NORM-G Hrs.		1,282,160	1,107,540		
NORM-F Hrs.		156,860	187,520		
System Effectiveness Rate		59.2	63.2		SER
OR Rate	41.8	44.3	44.5	44.8	GO33B
NORS Rates	12.2	13.5	11.3	9.2	GO33B
NORS-G	9.9	6.1	3.5	2.6	GO33B
NFE/NORS-F	2.3	7.4	7.8	6.6	GO33B
NORM Rates	46.0	42.2	44.2	46.0	GO33B
NORM-G		37.6	37.8	38.2	GO33B
NORM-F		4.6	6.4	7.8	GO33B
NORS Incidents		44,624	49,764	47,473	D165A
NORS Parts Hrs. ($x10^6$)		3.65	3.66	3.28	D165A
NORS Incidents/Pos. Hrs.		1.31×10^{-2}	1.70×10^{-2}		
NORS Parts Hrs./NORS Incidents		81.8	73.5		
NORS A/C Hrs./NORS Parts Hrs.		.126	.090		
NORS Rate (F+G)		13.5	11.2		
NORS Parts Hrs./NORS A/C Hrs.		7.9	11.1		

[1] History of USAF Flying Hours for Planning and Reference.

TABLE 2-15. C-5 AIRCRAFT DATA

	FY1973	FY1974	FY1975	FY1976	SOURCE
Total Aircraft Inventories	67	78	76	77	Air Force Statistical Digest & USAF Summary
Total Flying Hrs.	50,928	46,964	40,555	33,281	RCS-SS-A-41[1] and SER
Total Sorties		9,617	8,939	7,275	SER
Possessed Hrs. ($x10^3$)		670	767		SER
NORS Hrs.		293,460	179,816		
NORS-G Hrs.		79,730	34,476		Calculated from
NFE/NORS-F Hrs.		213,730	145,340		Possessed Hours and
NORM Hrs.		308,200	428,584		OR-NOR Rates below
NORM-G Hrs.		265,990	293,384		
NORM-F Hrs.		42,210	135,200		
System Effectiveness Rate		60.0	55.7		SER
OR Rate	5.4	10.2	10.0	8.6	GO33B
NORS Rates	60.8	43.8	26.6	32.8	GO33B
NORS-G	15.8	11.9	5.1	6.5	GO33B
NFE/NORS-F	45.0	31.9	21.5	26.3	GO33B
NORM Rates	33.8	46.0	63.4	58.6	GO33B
NORM-G		39.7	43.4	47.6	GO33B
NORM-F		6.3	20.0	11.0	GO33B
NORS Incidents		17,728	18,885	18,733	D165A
NORS Parts Hrs. ($x10^6$)		2.38	2.54	1.90	D165A
NORS Incidents/Pos. Hrs.		$2.65x10^{-2}$	$2.79x10^{-2}$		
NORS Parts Hrs./NORS Incidents		134.3	134.5		
NORS A/C Hrs./NORS Parts Hrs.		.123	.071		
NORS Rate (F+G)		43.8	26.6		
NORS Parts Hrs./NORS A/C Hrs.		8.1	14.1		

[1] History of USAF Flying Hours for Planning and Reference.

TABLE 2-16. C-130 AIRCRAFT DATA

	FY1973	FY1974	FY1975	FY1976	SOURCE
Total Aircraft Inventories	690	690	690	699	Air Force Statistical Digest & USAF Summary
Total Flying Hrs.	433,000	368,092	334,991	296,802	RCS-SS-A41[1] and SER
Total Sorties		118,737	119,582	135,176	SER
Possessed Hrs. ($x10^6$)		5.59	5.61	5.51	SER
NORS Hrs.		1,017,380	992,970	854,050	
NORS-G Hrs.		335,400	375,870	363,660	Calculated from
NFE/NORS-F Hrs.		681,980	617,100	490,390	Possessed Hours and
NORM Hrs.		1,688,180	1,957,890	2,104,820	OR-NOR Rates below.
NORM-G Hrs.		1,363,960	1,531,530	1,647,490	
NORM-F Hrs.		324,220	426,360	457,330	
System Effectiveness Rate		65.9	59.4	62.4	SER
OR Rate	59.2	51.6	47.4	46.3	GO33B
NORS Rates	16.8	18.2	17.7	15.5	GO33B
NORS-G	5.4	6.0	6.7	6.6	GO33B
NFE/NORS-F	11.4	12.2	11.0	8.9	GO33B
NORM Rates	24.0	30.2	34.9	38.2	GO33B
NORM-G		24.4	27.3	29.9	GO33B
NORM-F		5.8	7.6	8.3	GO33B
NORS Incidents		36,936	48,462	55,138	D165A
NORS Parts Hrs. ($x10^6$)		2.20	3.19	3.70	D165A
NORS Incidents/Pos. Hrs.		$6.61x10^{-3}$	$8.64x10^{-3}$	$10.01x10^{-3}$	
NORS Parts Hrs./NORS Incidents		59.6	65.8	67.1	
NORS A/C Hrs./NORS Parts Hrs.		.462	.311	.231	
NORS Rate (F+G)		18.2	17.7	15.5	
NORS Parts Hrs./NORS A/C Hrs.		2.2	3.2	4.3	

[1] History of USAF Flying Hours for Planning and Reference.

TABLE 2-17. C-141 AIRCRAFT DATA

	FY1973	FY1974	FY1975	FY1976	SOURCE
Total Aircraft Inventories	281	280	278	278	Air Force Statistical Digest & USAF Summary
Total Flying Hrs.	408,026	310,818	271,440	246,936	RCS-SS-A-41[1] and SER
Total Sorties		78,609	76,489	72,283	SER
Possessed Hrs. ($x10^6$)		2.16	2.15	1.84	SER
NORS Hrs.		216,000	311,750	252,080	
NORS-G Hrs.		101,520	105,350	82,800	Calculated from
NFE/NORS-F Hrs.		114,480	206,400	119,280	Possessed Hours and
NORM Hrs.		689,040	860,000	800,400	OR-NOR Rates below.
NORM-G Hrs.		663,120	769,700	616,400	
NORM-F Hrs.		25,920	90,300	184,000	
System Effectiveness Rate		65.5	61.1	63.6	SER
OR Rate	56.4	58.1	45.5	42.8	GO33B
NORS Rates	11.4	10.0	14.5	13.7	GO33B
NORS-G	4.4	4.7	4.9	4.5	GO33B
NFE/NORS-F	7.0	5.3	9.6	9.2	GO33B
NORM Rates	32.2	31.9	40.0	43.5	GO33B
NORM-G		30.7	35.8	33.5	GO33B
NORM-F		1.2	4.2	10.0	GO33B
NORS Incidents		27,604	30,234	37,170	D165A
NORS Parts Hrs. ($x10^6$)		1.13	1.93	2.32	D165A
NORS Incidents/Pos. Hrs.		$1.28x10^{-2}$	$1.41x10^{-2}$	$2.02x10^{-2}$	
NORS Parts Hrs./NORS Incidents		40.9	63.8	62.4	
NORS A/C Hrs./NORS Parts Hrs.		.191	.162	.109	
NORS Rate (F+G)		10.0	14.6	13.7	
NORS Parts Hrs./NORS A/C Hrs.		5.2	6.2	9.2	

[1] History of USAF Flying Hours for Planning and Reference.

TABLE 2-18. F-4/RF-4 AIRCRAFT DATA

	FY1973	FY1974	FY1975	FY1976	SOURCE
Total Aircraft Inventories	1,786	1,769	1,760	1,819	Air Force Statistical Digest & USAF Summary
Total Flying Hrs.	536,313	430,255	406,077	388,566	RCS-SS-A-41[1] and SER
Total Sorties		244,638	265,931	265,077	SER
Possessed Hrs. ($x10^6$)		15.24	15.08		SER
NORS Hrs.		1,737,360	2,111,200		
NORS-G Hrs.		807,720	919,880		Calculated from Possessed Hours and OR-NOR Rates below.
NFE/NORS-F Hrs.		929,640	1,191,320		
NORM Hrs.		4,572,000	5,293,080		
NORM-G Hrs.		3,886,200	4,267,640		
NORM-F Hrs.		685,800	1,025,440		
System Effectiveness Rate		66.0	64.8		SER
OR Rate	66.1	58.6	50.9	53.7	GO33B
NORS Rates	9.7	11.4	14.0	12.2	GO33B
NORS-G	4.9	5.3	6.1	5.8	GO33B
NFE/NORS-F	4.8	6.1	7.9	6.4	GO33B
NORM Rates	24.2	30.0	35.1	34.1	GO33B
NORM-G		25.5	28.3	26.8	GO33B
NORM-F		4.5	6.8	7.3	GO33B
NORS Incidents		51,508	67,575	86,957	D165A
NORS Parts Hrs. ($x10^6$)		2.11	3.48	4.11	D165A
NORS Incidents/Pos. Hrs.		$3.38x10^{-3}$	$4.48x10^{-3}$		
NORS Parts Hrs./NORS Incidents		41.0	51.5		
NORS A/C Hrs./NORS Parts Hrs.		.823	.607		
NORS Rate (F+G)		11.4	14.0		
NORS Parts Hrs./NORS A/C Hrs.		1.2	1.6		

[1] History of USAF Flying Hours for Planning and Reference.

TABLE 2-19. F-15 AIRCRAFT DATA

	FY1973	FY1974	FY1975	FY1976	SOURCE
Total Aircraft Inventories	7	16	36	94	Air Force Statistical Digest & USAF Summary
Total Flying Hrs.		211	2,221	7,533	PCN: RRA-00023[1] and SER
Total Sorties		156	1,825	5,912	PCN: RRA-00023[1] and SER
Possessed Hrs.				312,000	SER
NORS Hrs.					
NORS-G Hrs.					
NFE/NORS-F Hrs.					
NORM Hrs.					
NORM-G Hrs.				82,723	SER
NORM-F Hrs.					
System Effectiveness Rate				48.9	SER
OR Rate		85.6	71.4		GO33B
NORS Rates					
NORS-G		3.3	8.9	15.8	GO33B
NFE/NORS-F		.3	2.8		GO33B
NORM Rates					
NORM-G		10.8	15.2	36.0	GO33B
NORM-F		.0	1.7		GO33B
NORS Incidents			562	3,030	D165A
NORS Parts Hrs.			25,758	177,312	D165A
NORS Incidents/Pos. Hrs.				9.71×10^{-3}	
NORS Parts Hrs./NORS Incidents				58.5	
NORS A/C Hrs./NORS Parts Hrs.					
NORS Rate (F+G)					
NORS Parts Hrs./NORS A/C Hrs.					

[1] AF Man-hour per Flying Hour Trend Report

TABLE 2-20. F-111 AIRCRAFT DATA

	FY1973	FY1974	FY1975	FY1976	SOURCE
Total Aircraft Inventories	337	368	376	377	Air Force Statistical Digest & USAF Summary
Total Flying Hrs.	86,41[illegible]	82,362	83,098	70,646	RCS-SS-A-41[1] and SER
Total Sorties		30,455	30,105	26,325	SER
Possessed Hrs. ($x10^6$)		3.20	3.24	3.14	SER
NORS Hrs.		566,400	560,520	392,500	
NORS-G Hrs.		252,800	304,560	254,340	Calculated from
NFE/NORS-F Hrs.		313,600	255,960	138,160	Possessed Hours &
NORM Hrs.		1,149,000	1,299,240	1,365,900	OR-NOR Rates below.
NORM-G Hrs.		876,800	1,040,040	1,124,120	
NORM-F Hrs.		272,200	259,200	241,780	
System Effectiveness Rate		65.2	81.2	54.0	SER
OR Rate	42.6	46.4	42.6	44.0	GO33B
NORS Rates	29.3	17.7	17.3	12.5	GO33B
NORS-G	11.9	7.9	9.4	8.1	GO33B
NFE/NORS-F	17.4	9.8	7.9	4.4	GO33B
NORM Rates	28.1	35.9	40.1	43.5	GO33B
NORM-G		27.4	32.1	35.8	GO33B
NORM-F		8.5	8.0	7.7	GO33B
NORS Incidents		16,672	26,304	32,848	D165A
NORS Parts Hrs.		936,680	1,220,241	1,216,685	D165A
NORS Incidents/Pos. Hrs.		$5.21x10^{-3}$	$8.12x10^{-3}$	$10.46x10^{-3}$	
NORS Parts Hrs./NORS Incidents		56.2	46.4	37.0	
NORS A/C Hrs./NORS Parts Hrs.		.605	.459	.323	
NORS Rate (F+G)		17.7	17.3	12.5	
NORS Parts Hrs./NORS A/C Hrs.		1.7	2.2	3.1	

[1] History of USAF Flying Hours for Planning and Reference.

TABLE 2-21. KC-135 AIRCRAFT DATA

	FY1973	FY1974	FY1975	FY1976	SOURCE
Total Aircraft Inventories	660	674	672	657	Air Force Statistical Digest & USAF Summary
Total Flying Hrs.		228,549	230,380	196,759	RCS-SS-A-41[1] and SER
Total Sorties		49,244	49,799	41,199	SER
Possessed Hrs. ($x10^6$)		5.78	5.75	5.47	SER
NORS Hrs.		624,240	546,250	470,420	
NORS-G Hrs.		300,560	230,000	202,390	Calculated from
NFE/NORS-F Hrs.		323,680	316,250	268,030	Possessed Hours &
NORM Hrs.		1,762,900	1,845,750	1,843,390	OR-NOR Rates below.
NORM-G Hrs.		1,572,160	1,633,000	1,630,060	
NORM-F Hrs.		190,740	212,750	213,330	
System Effectiveness Rate		65.5	68.4	67.6	SER
OR Rate	60.9	58.7	58.4	57.7	GO33B
NORS Rates	9.2	10.8	9.5	8.6	GO33B
NORS-G	6.4	5.2	4.0	3.7	GO33B
NFE/NORS-F	2.8	5.6	5.5	4.9	GO33B
NORM Rates	29.9	30.5	32.1	33.7	GO33B
NORM-G		27.2	28.4	29.8	GO33B
NORM-F		3.3	3.7	3.9	GO33B
NORS Incidents		36,178	39,218	39,629	D165A
NORS Parts Hrs. ($x10^6$)		2.27	2.31	2.15	D165A
NORS Incidents/Pos. Hrs.		$6.26x10^{-3}$	$6.82x10^{-3}$	$7.24x10^{-3}$	
NORS Parts Hrs./NORS Incidents		62.7	58.9	54.3	
NORS A/C Hrs./NORS Parts Hrs.		.275	.236	.219	
NORS Rate (F+G)		10.8	9.5	8.6	
NORS Parts Hrs./NORS A/C Hrs.		3.6	4.2	4.6	

[1] History of USAF Flying Hours for Planning and Reference.

CHAPTER 3: GROSS SUPPLY SYSTEM PERFORMANCE

OVERVIEW AND STRUCTURE

This chapter addresses the relationship of the Air Force supply system to the overall logistics structure. Specifically, it examines the relationships between Base Supply and Base Maintenance, and between this lower echelon and Central (or Depot) Supply, as supported by Transportation; additionally, it examines the impact of supply performance upon the occurrence of NORS incidents. These elements of the logistics structure are accentuated in Figure 3-1.

In the Air Force, items of supply are identified as exchangeables (investment-type items reparable at base or depot) or Economic Order Quantity (EOQ) items, also called expense-type items. EOQ items are further distinguished as System Support Division (SSD) items (Air Force Stock Fund, usually purchased from ALCs) or General Support Division (GSD) items (Stock Fund, purchased from GSA or DSA). EOQ items peculiar to specific weapon systems are generally classified as SSD; all others are classified as GSD. All items are assigned National Stock Numbers (NSNs).

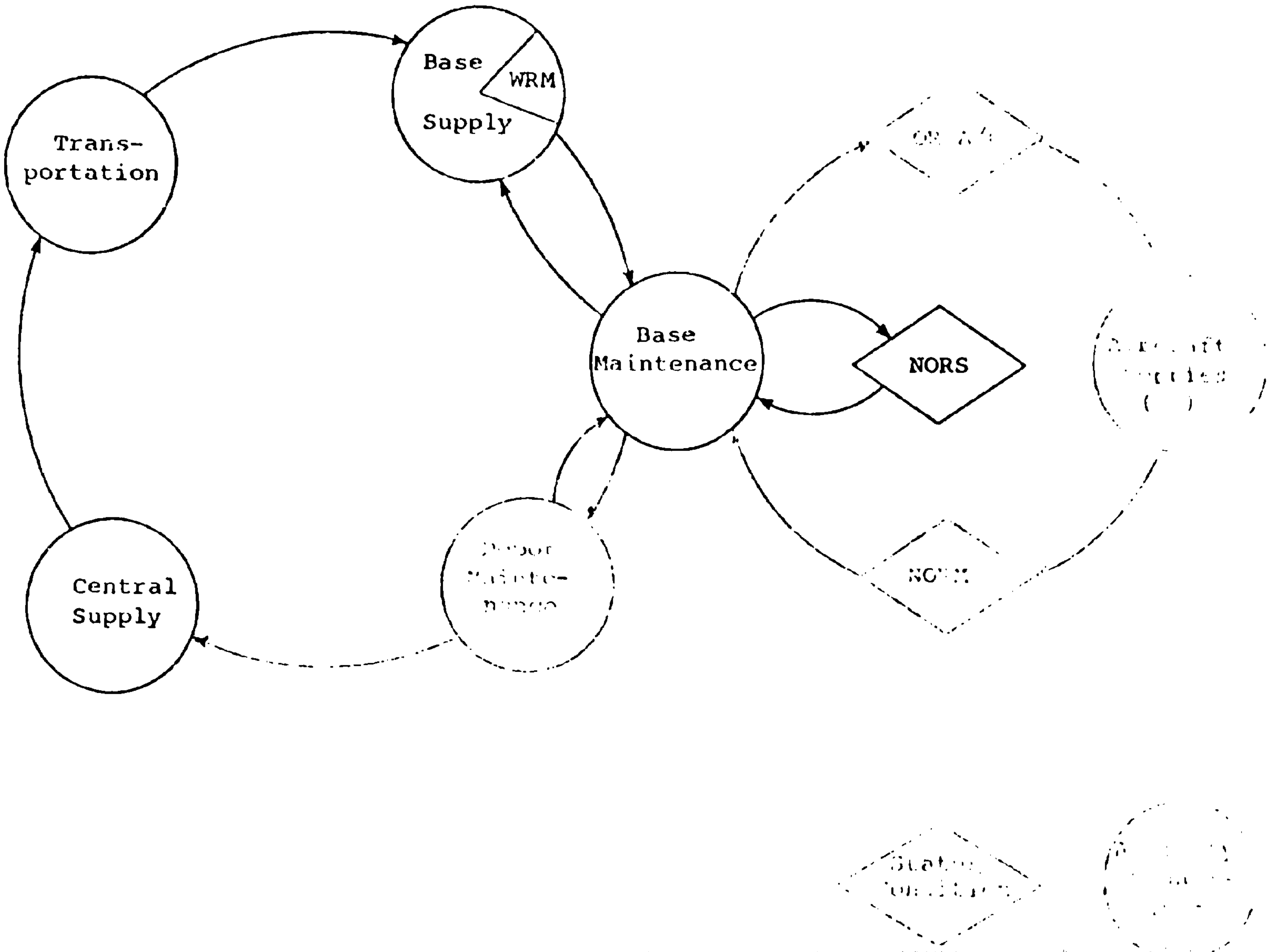
At the base level, all requisitioning units levy their demands upon Base Supply. Any such demand filled immediately from stock on-hand is called an issue; all other demands are deemed to be backorders. In the same way, each Base Supply levies its demands upon the appropriate Central Supply, such demands consisting of stock replenishment requisitions or backordered unit-level requisitions passed on to Central Supply.

At both Base Supply and Central Supply, resources and activity are measured by inventory values, values of demands, inventory turnovers (values of demands divided by inventory values), and number of demands. However, a backorder at the base level becomes a demand at the depot level; additionally, unfilled unit level requisitions are occasionally consolidated and passed on to the depot level. Hence, the numbers of demands at the base and depot levels are not meaningfully additive.

Supply performance is generally measured in terms of fill rate, or the ratio of the number of issues to the number of issues plus backorders. Other performance measures include the number of NORS incidents and the frequency of NORS incidents per demand, both measures being distinguished between exchangeables and EOQ items.

Since Base Supply and Central Supply are not normally collocated geographically, the issue of not-in-stock or unstocked items to the requisitioning unit is delayed. A

FIGURE 3-1. AIR FORCE SUPPLY SYSTEM LOGISTICS STRUCTURE



measure of this delay is pipeline performance, which relates only to the wholesale portion of the Air Force supply system. It includes, however, any delays incurred in procuring items from DSA/GSA or industry. A more detailed depiction of the flow of requisitions and material is contained in Figure 3-2.

Pipeline performance is measured in days required in the time segments defined by Military Supply and Transportation Evaluation Procedures (MILSTEP), illustrated in Figure 3-3. The upper portion of Figure 3-3 shows the supply system time segments from the date of requisition to the date the material is made available to the wholesale consignor transportation officer for shipment. The Air Force supply system has but two echelons and usually only one wholesale supply source for each requisitioned item. Hence, the Passing Action segment in Figure 3-3 is disregarded, leaving only the Requisition Submission, Inventory Control Point (ICP) Availability Determination, and Depot/Storage Site Processing time segments to consider.

The lower portion of Figure 3-3 refers to the transportation time phase of the overall supply system; it includes the remainder of the total pipeline time, up to the date of receipt by the requisitioning installation. The MILSTEP transportation performance is reported in separate ledgers for overseas and CONUS shipments. (See "Data and Source Description" below for a discussion of the MILSTEP reports.) MILSTEP data are categorized by Priority Group (PG). PG 1 refers to requisitions submitted under Priority Designators (PDs) 01 through 03; PG 2, PDs 04 through 08; and PG 3, PDs 09 through 15. For each PG, the ledgers specify the report periods concerned, including previous periods for historical information. In addition, the ledgers report the Elapsed Number of Days, and the number of shipments and percentage of total shipments for each of the time segments described in Figure 3-3. The ICP Availability Determination time segment is further subdivided into Immediate, Delayed, and All issues. In this manner, the ledgers show that "x" number of shipments, representing "y" percent of the total shipments submitted in that report period, satisfied each time segment within "z" number of elapsed days.

The distinction between Immediate and Delayed issues is currently being revised, but, very simply, Immediate issues are those requisitions for which Material Release Orders (or their equivalent) are produced on the first pass through the Central Supply ADP system. Delayed issues, then, are all others, for whatever reasons.

ANALYSIS OF DATA AND TRENDS

Base and Central Supply Performance

Figure 3-4 displays four years of data on Air Force inventory values and values of demands (in constant FY 1976 dollars), distinguished by SSD, GSD, and exchangeable

FIGURE 3-2. DETAILED SUPPLY SYSTEM LOGISTICS STRUCTURE

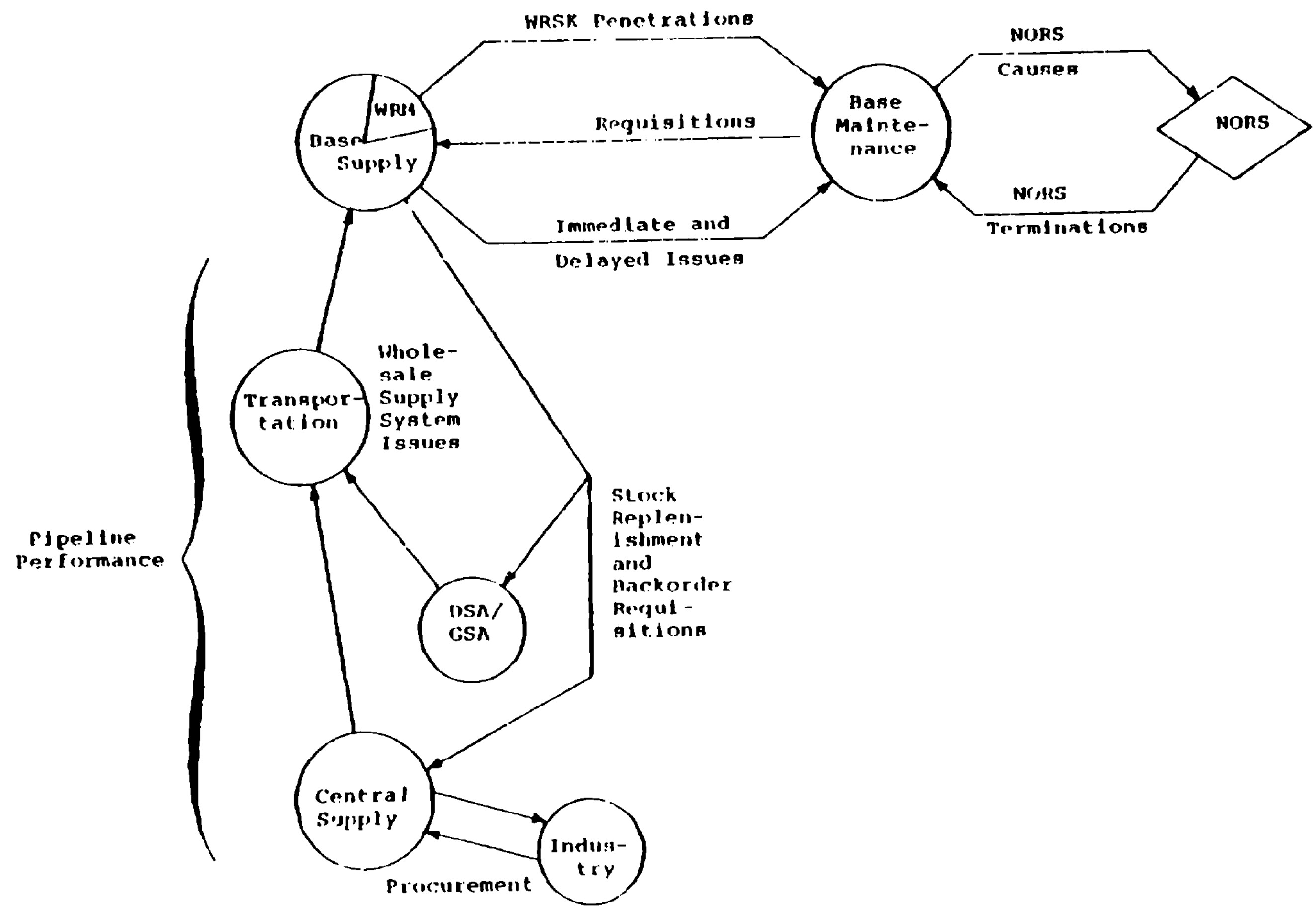


FIGURE 3-3. MILSTEP SUPPLY AND TRANSPORTATION TIME SEGMENTS

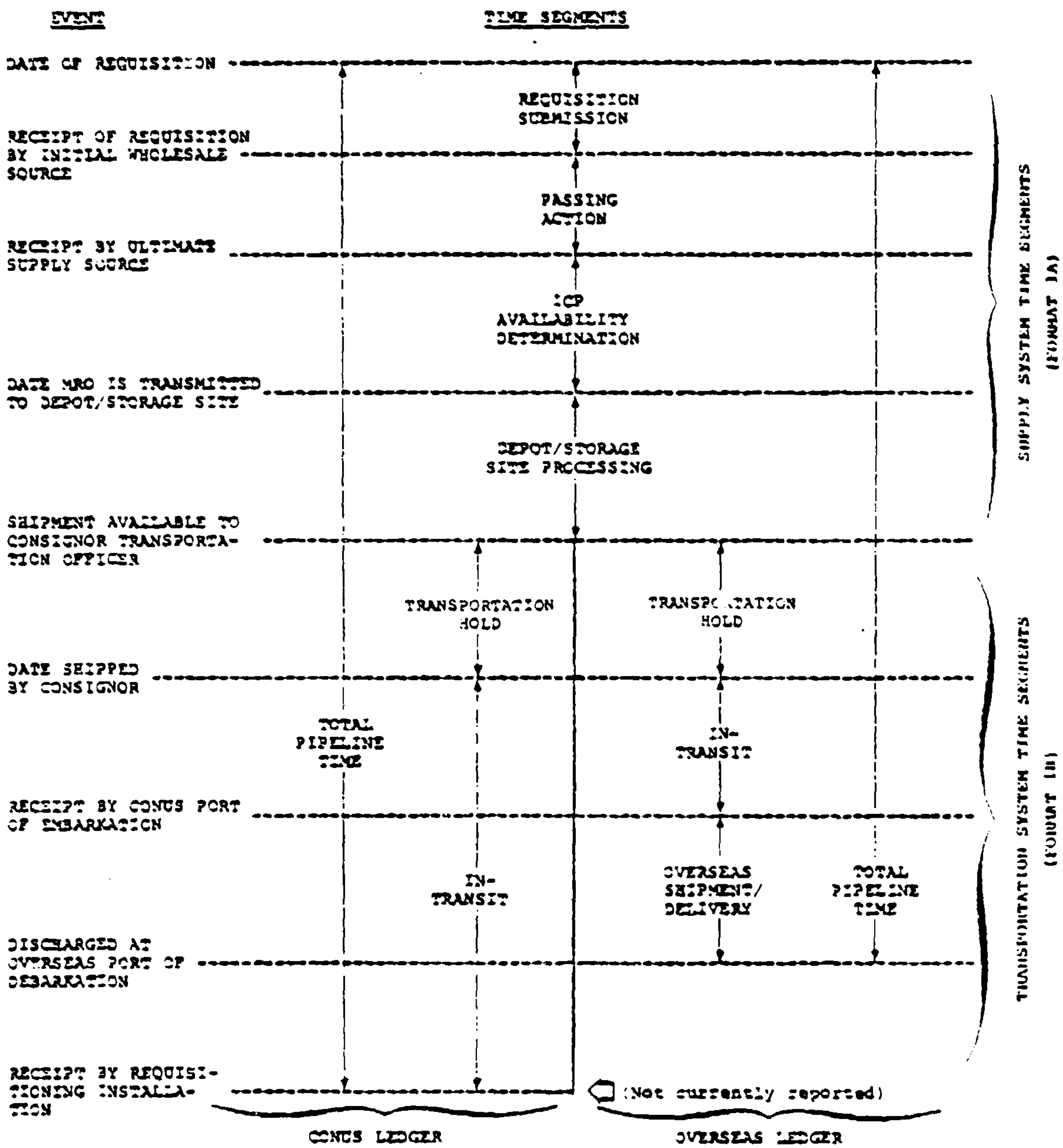
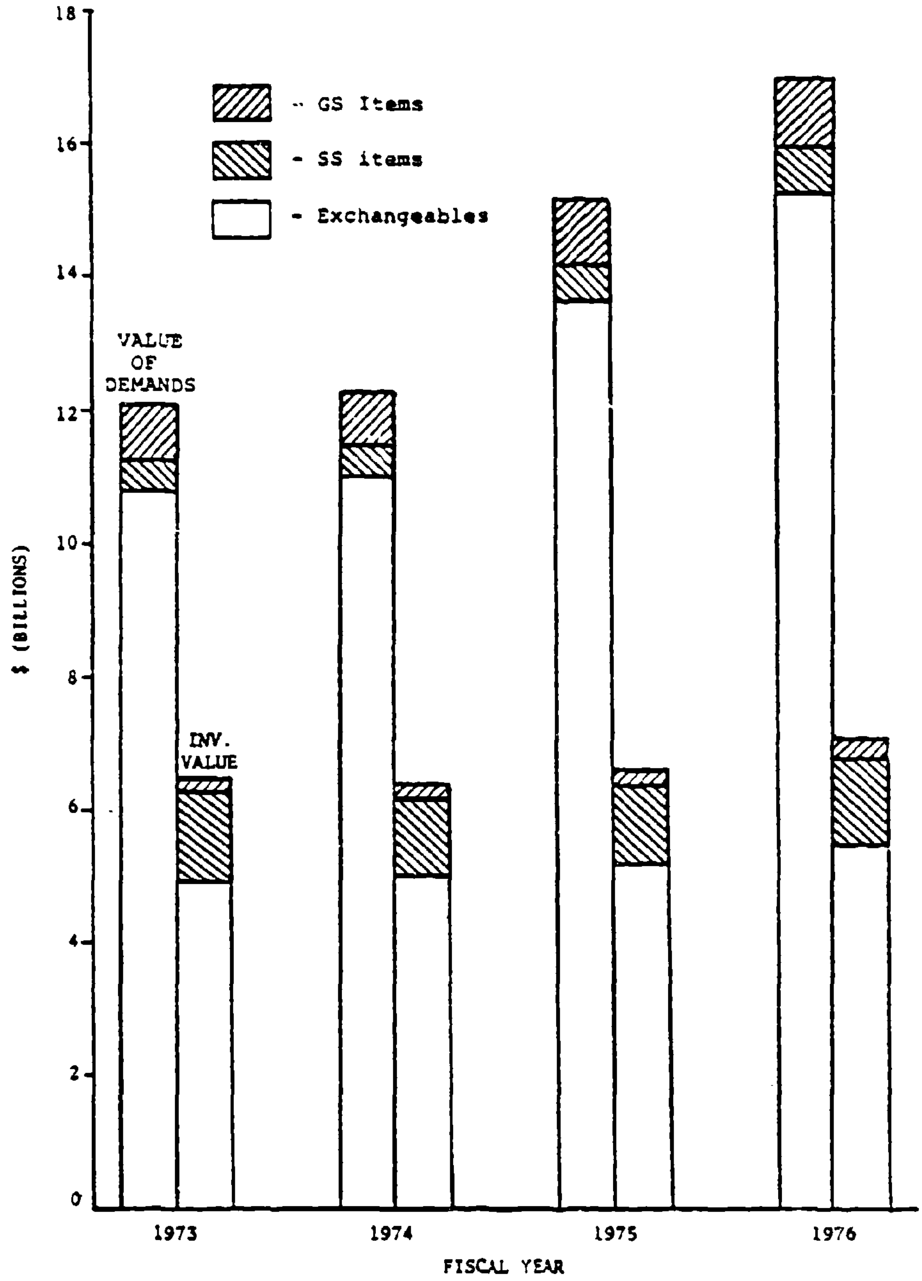


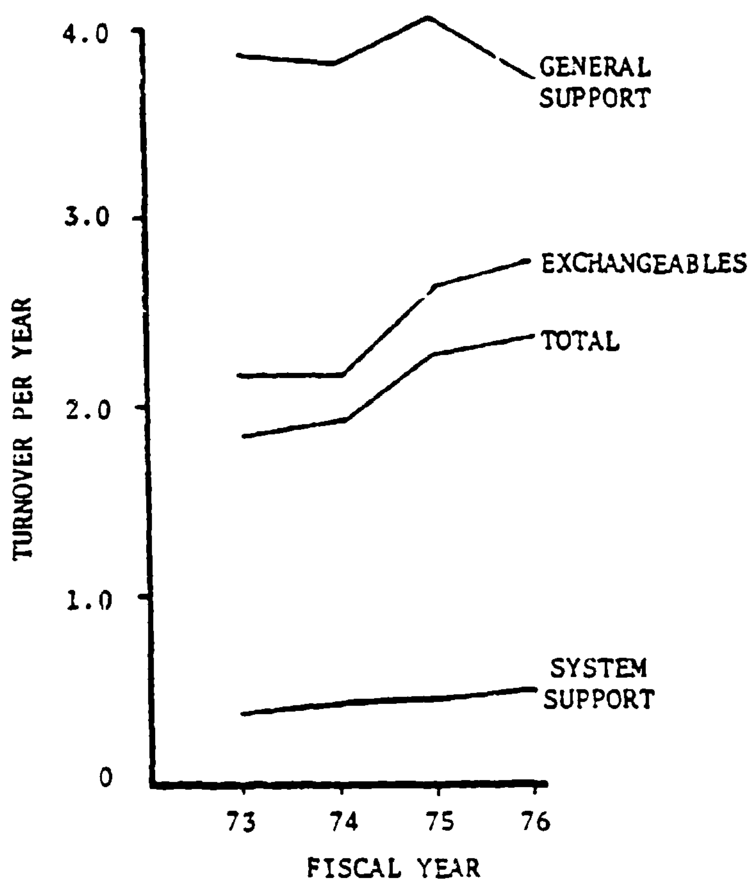
FIGURE 3-4. AIR FORCE INVENTORY VALUES AND VALUES OF DEMANDS



items. In FY 1976, the Air Force stocked over 1.4 million NSN items; SSD and GSD items accounted for 31% and 63.5%, respectively, of that total, with exchangeables accounting for only 5.5%. On the other hand, Figure 3–4 shows that exchangeables accounted for almost 78% of the inventory value and 90% of the value of demands. In the four-year period, inventory values (measured at the beginning of each period) have shown little change, while values of demands have climbed 40%; almost all of that increase is attributable to exchangeables. These data illustrate the extent of Air Force selective management of high value, reparable items. They also reflect the increasing complexity of Air Force aircraft, which rely more and more on sophisticated reparable components. (See Figure 3–9, p. 93, for an examination of the impact of exchangeables on the number of NORS incidents.)

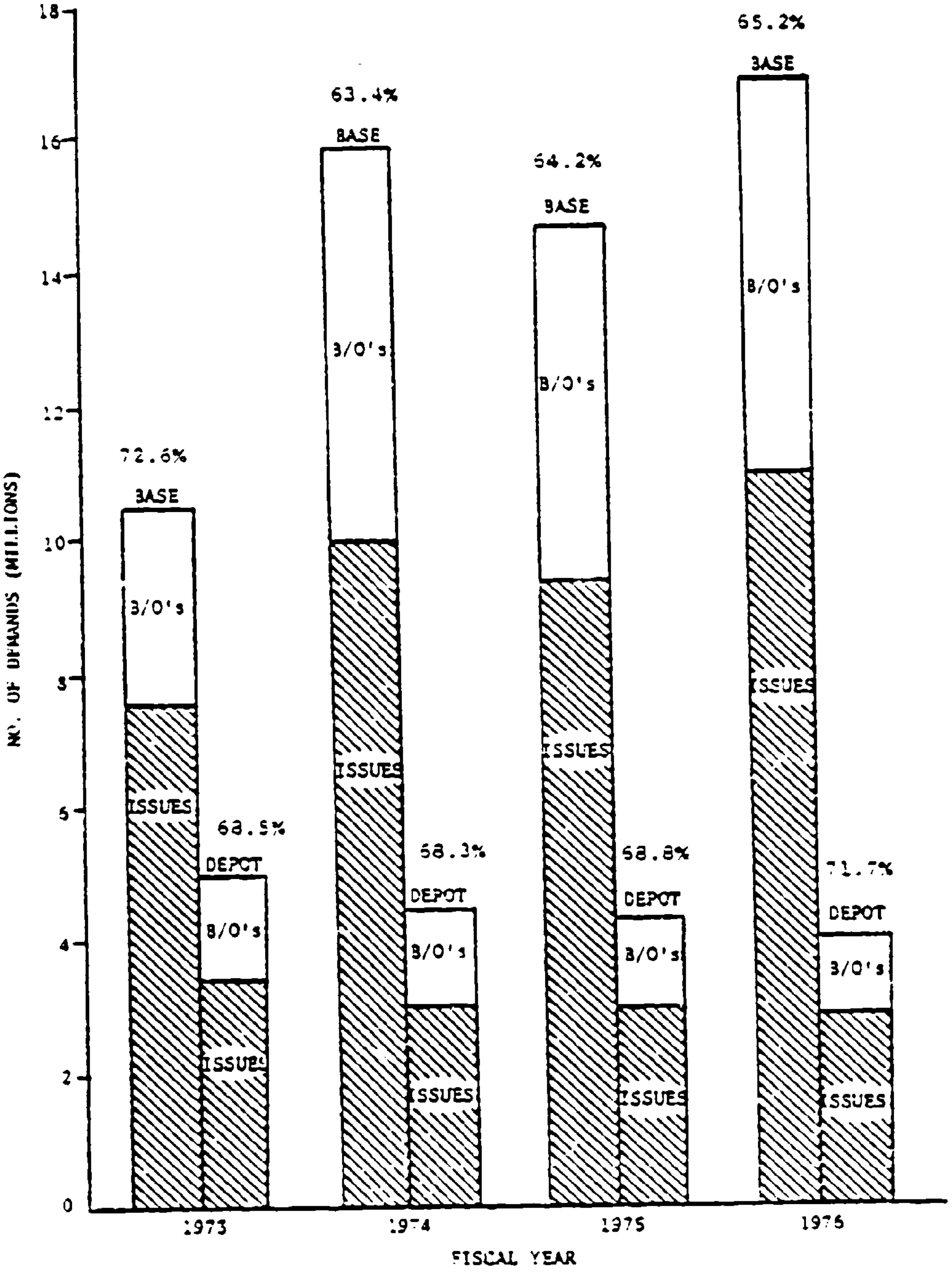
Figure 3–5 shows the inventory turnover rates for that same period. The rate for exchangeables has increased almost 30%, while the rates for EOQ items have remained fairly constant.

FIGURE 3-5. AIR FORCE INVENTORY TURNOVERS



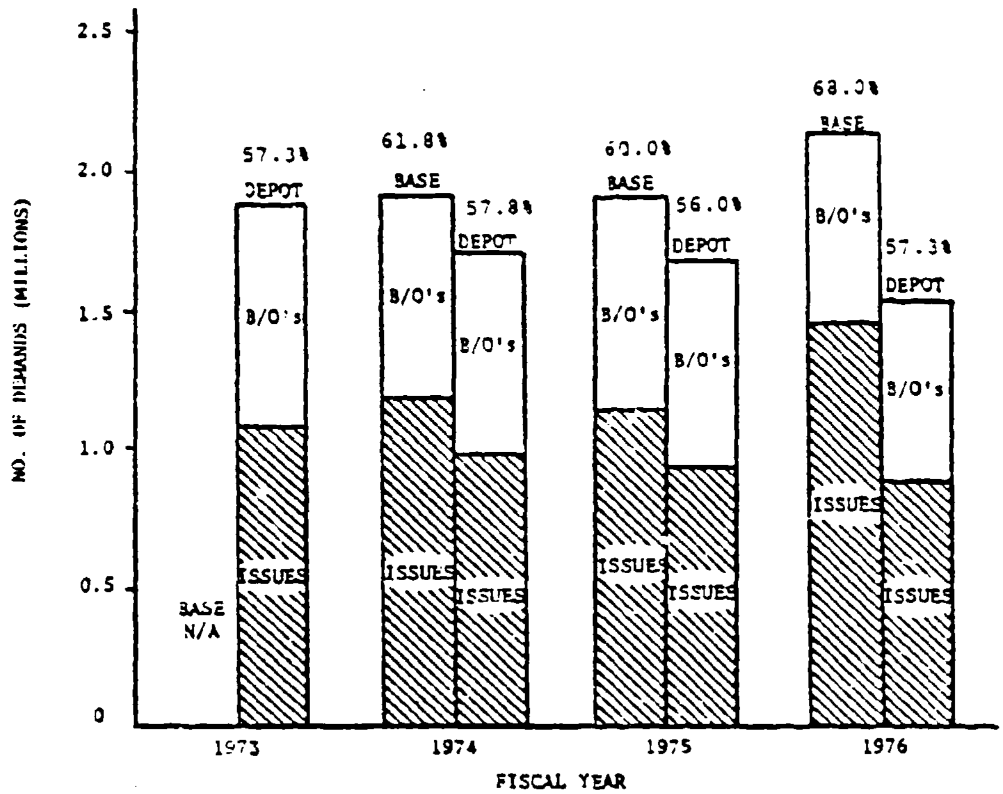
The volume of business handled by the Air Force supply system from FY 1973 through FY 1976 is also indicated by the number of demands (issues plus backorders) depicted for all items in Figure 3–6. (Fill rate percentages are shown at the top of each

FIGURE 3-6. AIR FORCE DEMANDS, ISSUES, BACKORDERS, AND FILL RATES - ALL ITEMS



bar.) Issues consistently constitute about two-thirds of all demands. While the number of depot demands has decreased slowly but steadily during that period, the number of demands at the base has shown a general increase. Fill rates show no appreciable change, indicative of some improvement in efficiency at the base level in light of the increased number of demands. Figures 3-7 and 3-8 display the same information for exchangeables and EOQ items, respectively. (Base demands for FY 1973 were not available.) In these figures, depot demands show the same slow but steady declines in both cases, while base demands show no clear trend.

FIGURE 3-7. AIR FORCE DEMANDS, ISSUES, BACKORDERS, AND FILL RATES - EXCHANGEABLES



Figures 3-9 and 3-10 display trends from FY 1974 to FY 1976 for the number of aircraft and engine NORS part incidents (distinguished between investment and expense-type parts), and the frequency of those NORS part incidents per demand, respectively. NORS incidents are increasing for investment items (see discussion of Figure 3-4), as is the frequency of demand. Incidents and incident frequency for expense items are decreasing somewhat.

FIGURE 7 3. AIR FORCE DEMANDS, ISSUES, BACKORDERS, AND FILL RATES - EOQ ITEMS

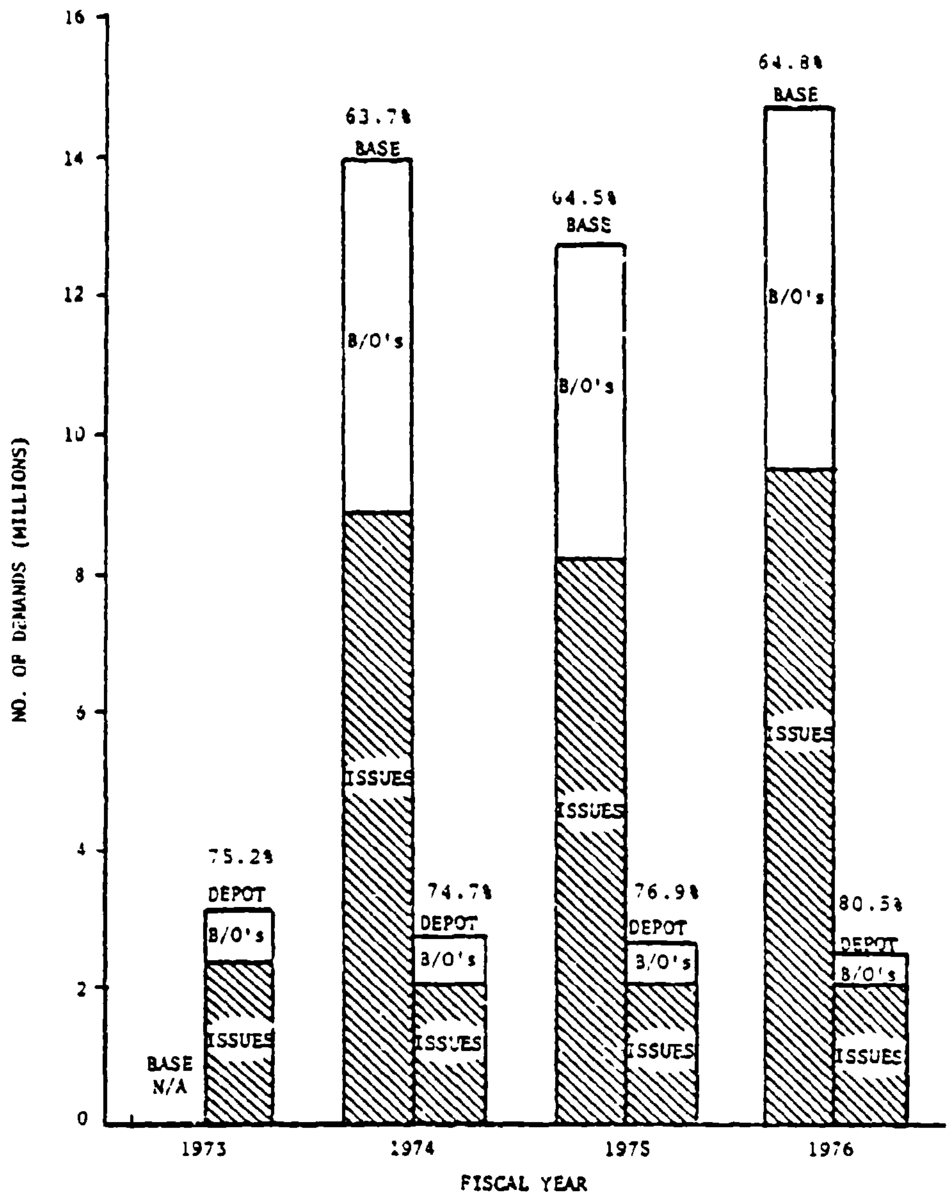


FIGURE 3-9. AIR FORCE NORS INCIDENTS

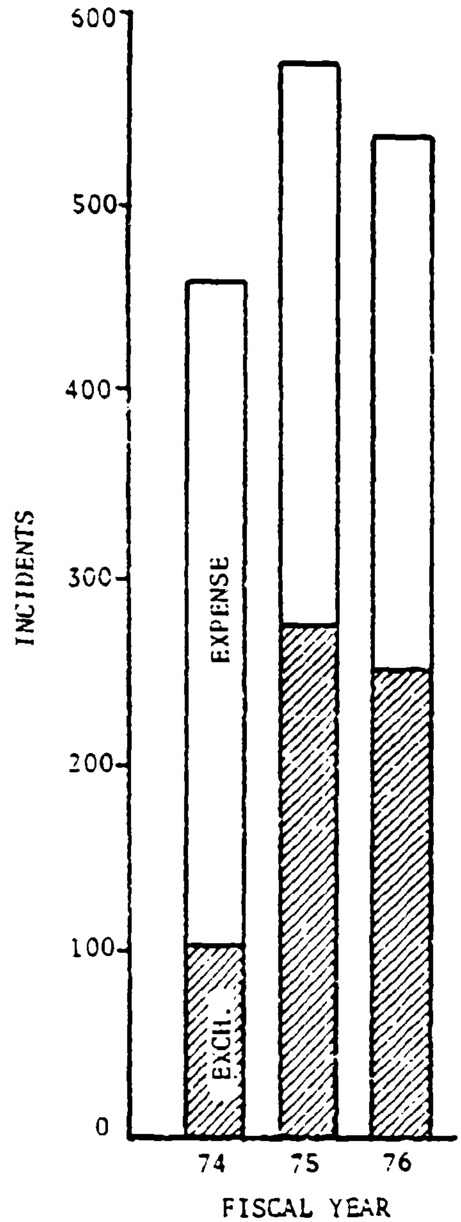
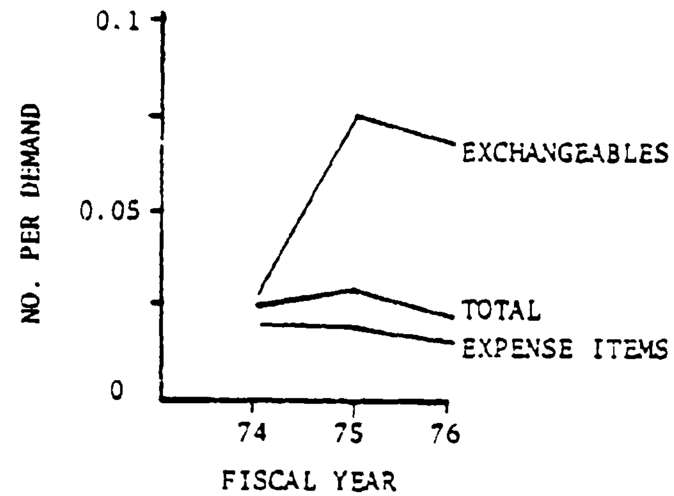


FIGURE 3-10. AIR FORCE NORS INCIDENT FREQUENCY PER DEMAND



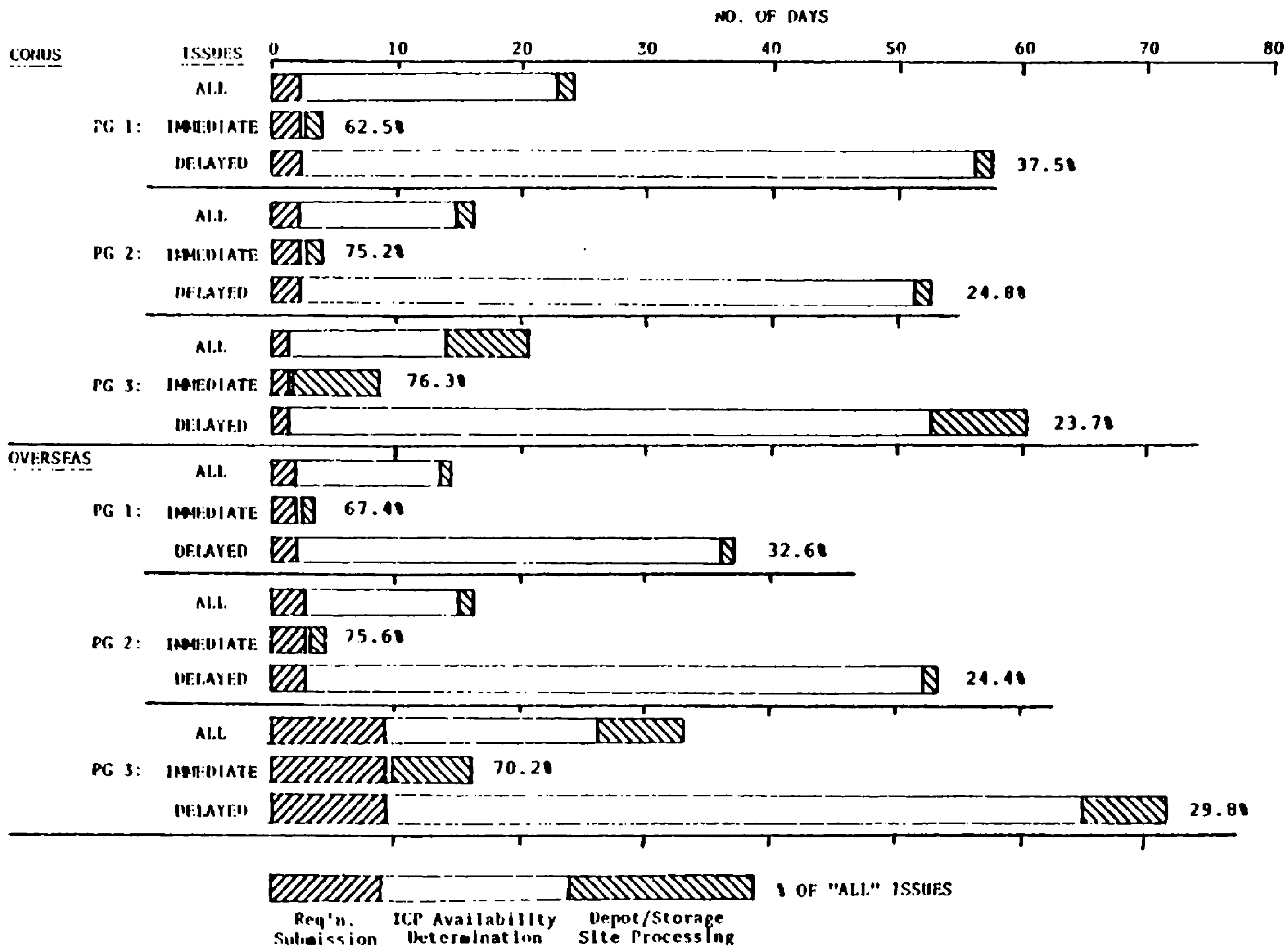
Pipeline Performance

The pipeline performance may be evaluated by two methods. The first compares actual performance to what might be expected in an ideal system; the second compares actual performance to those DoD standards prescribed by the Uniform Materiel Movement and Issue Priority System (UMMIPS). The performance discussed herein refers to the arithmetic mean number of days (M/Days) in each time segment.

Figure 3-11 displays that part of the total pipeline time attributable to supply segments for FY 1976 for shipments to both CONUS and overseas requisitioners, PGs 1, 2, and 3. For each PG, three total pipelines are shown, representing, first, the pipeline that includes all issues within the ICP Availability Determination time segment, second, the Immediate issues, and third, the Delayed issues. The percentages of all issues represented by Immediate and Delayed issues are shown to the right of their respective pipeline times. In this section, the term "issues" refers to all requisitions processed by the wholesale supply segment, regardless of when they are filled.

Strictly speaking, it is mathematically incorrect to represent the Immediate and Delayed issue times as part of a total pipeline time, because the number of requisitions in each represents a smaller population than those for the Requisition Submission and Depot/Storage Site Processing time segments. Nonetheless, this method of display is useful to indicate the large time differences between Immediate and Delayed issues and between PGs, and is probably not significantly inaccurate.

FIGURE 3-11. PIPELINE TIMES ATTRIBUTABLE TO SUPPLY SEGMENTS AIR FORCE - FY 1976



Figures 3–12 and 3–13 display total supply pipeline time trends from FY 1974 to FY 1976, by quarter, for CONUS and overseas requisitions. In each, the ICP Availability Determination time segment represents "All" issues. The unusually large dips in ICP Availability Determination for the third quarters of FY 1974 and FY 1975 were the result of an Air Force computer programming error in calculating elapsed time using Julian dates. To eliminate the effect of that error, we have connected the second and fourth quarter data points in each of those graphs with dashed lines.

To analyze the information in Figures 3-11, 3-12, and 3-13, we shall first postulate what type of performance might be expected from an idealized, priority-governed supply system. In such a system, we would expect PG 1 requisitions to require less time, on the average, to pass through the supply system than PG 2 requisitions, and PG 2 requisitions less time than PG 3 requisitions. Additionally, since the ICP Availability Determination and Depot/Storage Site Processing time segments are completely internal to the wholesale supply system, it would seem that there should be little, if any, difference in those time segments for CONUS and overseas requisitions.

Upon examining Figure 3-11, we note that, for CONUS requisitions, the supply pipeline time for PG 1 exceeds those for PG 2 and PG 3, contrary to our expectation. The difference, clearly, is in the ICP Availability Determination time segment. In comparing PG 1 times, we note that the CONUS pipeline is substantially greater than the overseas pipeline. The situation is just reversed for PG 3; the overseas pipeline is much larger. In fact, the overseas PG 3 pipeline is larger than any other pipeline time.

In Figure 3-12 (CONUS trends), PG 1 pipeline times have consistently been greater than PG 2 times, but not until the fourth quarter of FY 1975 did PG 1 times exceed PG 3 times. The increase in PG 1 times in this three-year period contrasts with the relative stability of PG 2 and PG 3 times. Requisition Submission and Depot/Storage Site Processing times have been exceptionally stable, aside from the fourth quarter of FY 1976, when PG 3 Depot/Storage Site Processing time increased unaccountably by two days. Less significant, but equally unaccountable, is the slightly lower Requisition Submission time for PG 3, compared to PG 1 and PG 2.

Looking next at Figure 3-13 (Overseas Trends), we observe that the PG 1 pipeline time was greater than PG 2 for the second quarter of FY 1974, but subsequently dropped below PG 2 until the fourth quarter of FY 1976. Although PG 2 pipeline times increased substantially in FY 1975, they have subsequently decreased almost to FY 1974 levels. PG 3 pipeline times, on the other hand, climbed markedly in FY 1975 and early FY 1976, and decreased only slightly in late FY 1976. Those variations are due to an unexplained increase in ICP Availability Determination times in FY 1975 and to a doubling of

FIGURE 3-12. AIR FORCE MILSTEP RESPONSE TIMES - TRENDS

Format 1A: FY 1974 - FY 1976 CONUS

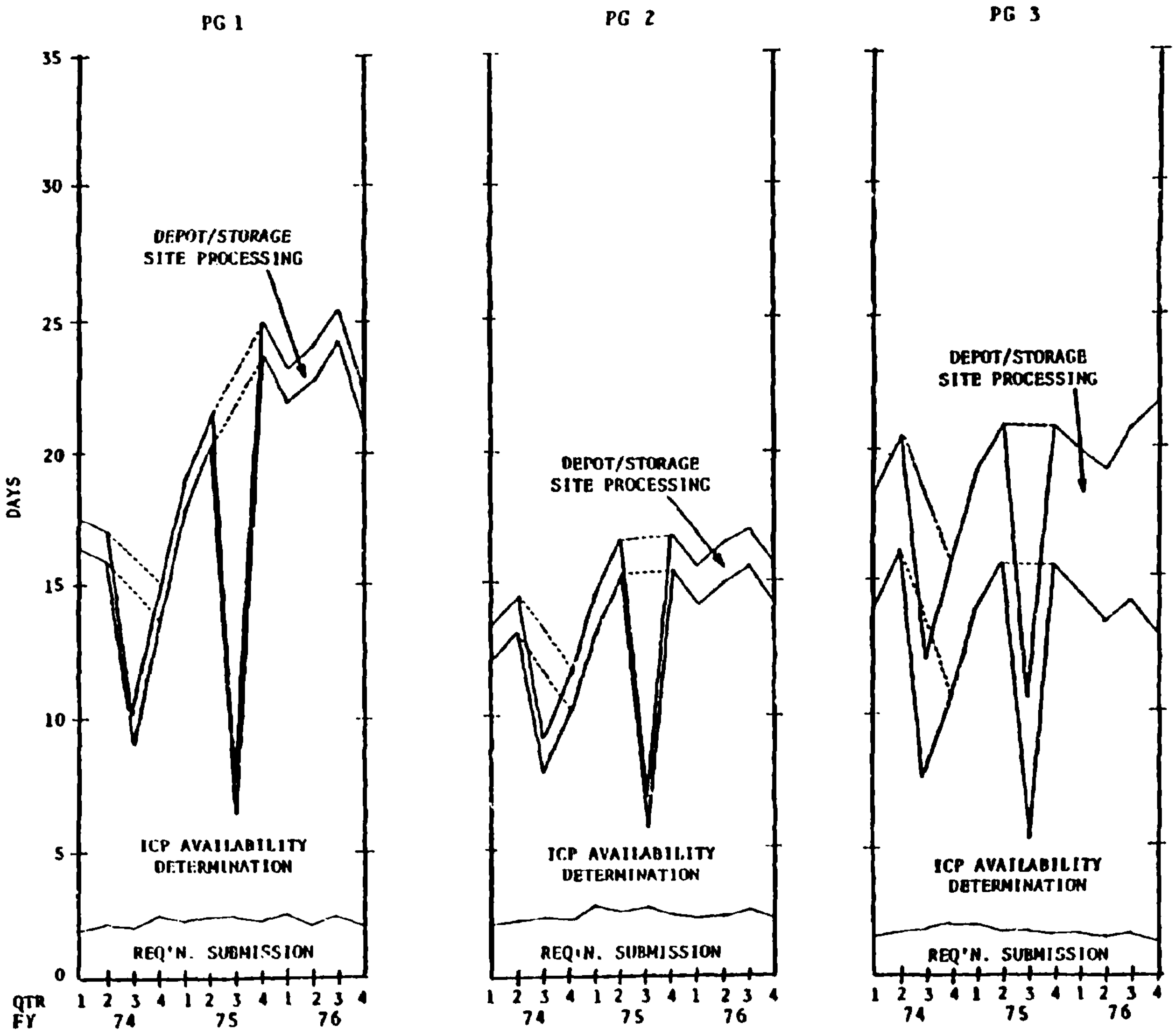
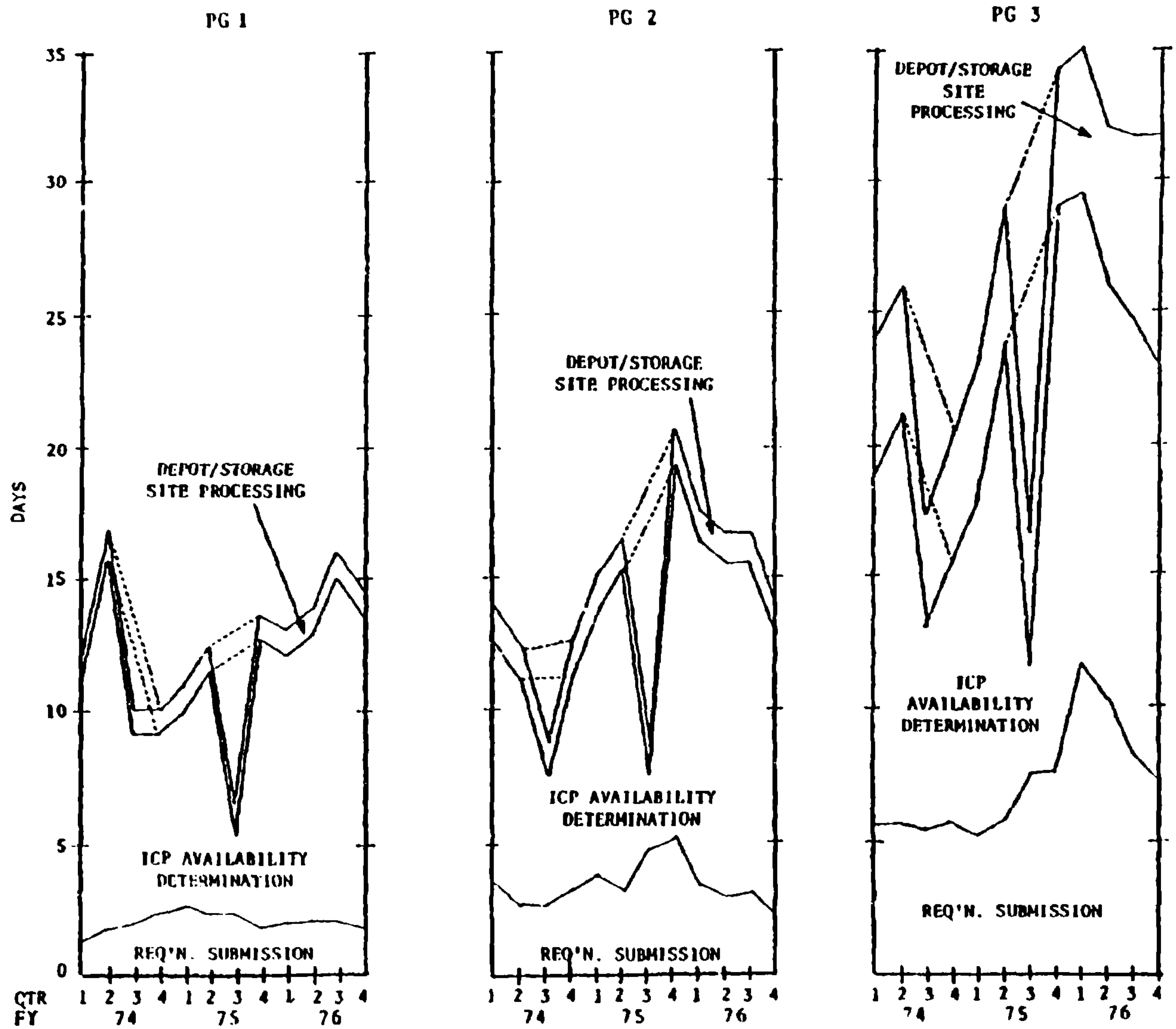


FIGURE 3-13. AIR FORCE MILSTEP RESPONSE TIMES - TRENDS

Format IA: FY 1974 - FY 1976 Overseas



Requisition Submission times in early FY 1976. As we noted in Figure 3-12, Depot/Storage Site Processing time increased by two days in the fourth quarter of FY 1976.

We have no ready explanation for these departures from our idealized supply system. It has been suggested, however, that the excessive CONUS PG 1 times may stem from ICP challenge procedures designed to restrict the use of high priority requisitions. Such administrative procedures may, in fact, lengthen that segment of the pipeline time.[1] If these procedures do restrict the use of PG 1, the restriction is not apparent in terms of the number of requisitions for PG 1 as a percentage of the total requisitions for all PGs. That percentage has remained relatively constant (18-20%) during the three-year period.

The UMMIPS supply time standards, identical for CONUS and overseas shipments, are shown below in Table 3-1. Applying these standards to the data in Figure 3-11, we note that Air Force performance for Immediate issues appears to satisfy the standards in every case but PG 3 shipments overseas. In every case, the average ICP Availability Determination Times are less than one day. For Delayed and All issues, however, the actual performance is far in excess of the UMMIPS standards.

TABLE 3-1. UMMIPS TIME STANDARDS, SUPPLY

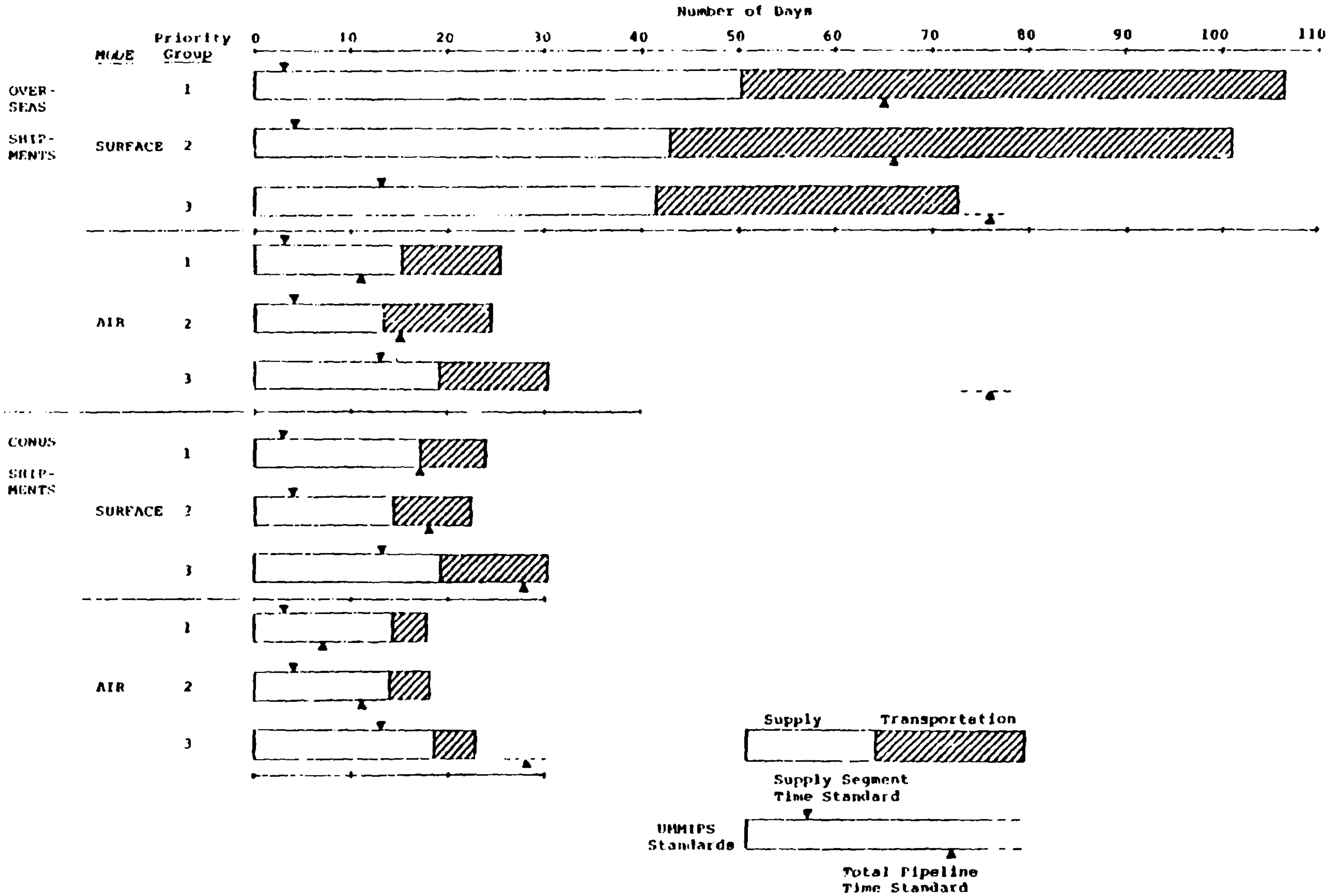
(Days)

SEGMENT	PG 1	PG 2	PG 3
Requisition Submission	1	1	2
ICP Availability Determination	1	1	3
Depot/Storage Site Processing	1	2	8

For the transportation portion of the supply system, the MILSTEP data is presented in the same way. Figure 3-14 displays the total pipeline times, divided between total supply time and total transportation time. The supply times do not correspond to the times shown in Figure 3-11, due not only to a difference in the methods of tabulating

[1] AFLC has suggested that the longer supply time on CONUS PG 1 is probably due to the smaller volume of, and the preferential treatment provided to, overseas requests.

FIGURE 3-14. SUPPLY AND TRANSPORTATION SEGMENTS OF AIR FORCE MEAN PIPELINE TIMES (FY 1976)



supply and transportation time segment data, but also to an unaccountable difference in population sizes between those data. Figures 3–15 through 3–18 display total pipeline time trends by quarter from FY 1974 through FY 1976 (except for Figure 3–17, which starts with third quarter data for FY 1975 for CONUS and overseas shipments, surface and air.

To analyze the information in Figures 3–14 through 3–18, we shall postulate further on the performance to be expected from an idealized, priority-governed supply system, and include the transportation segment. Again, PG 1 times should be less than PG 2, which in turn should be less than PG 3. Next, there seems to be no compelling reason why the Transportation Hold segment should differ between destination (CONUS and overseas) or mode (surface and air). Certainly, the In-Transit segment should be shorter for air transportation than surface. Because the In-Transit segment for overseas surface shipments terminates upon receipt at a CONUS port of embarkation, it should at least approximate the CONUS surface In-Transit segment, which terminates upon receipt by the requisitioning installation. Finally, the Overseas Shipment/Delivery segment should be substantially less for air shipments than for surface shipments, and within each mode there should be little difference among PGs.

Upon examining Figure 3-14, we see no discernible reason for any Air Force requisitioner to expect the use of PG 1 to expedite shipments. The inversion of pipeline times for overseas surface shipments is obvious; for overseas air shipments, the inversion is less marked, but still exists. It seems clear that there is no distinct advantage to the use of PG 1.[2]

The Transportation Hold segment for overseas shipment is much greater for the surface mode than the air mode; we have no ready explanation for that phenomenon. The In-Transit segment is significantly greater for various surface shipments than for CONUS surface shipments. One possible explanation for this may rest with the current MILSTEP In-Transit Data Card (IDC) reporting procedures, which record the end of that segment as the date <u>accepted</u> by the water port of embarkation rather than the date first <u>offered</u> by the carrier.

We would naturally expect overseas surface shipments to take longer than other modes or destinations. We find it difficult, however, to accept the sheer magnitude of the total pipeline times, which range from two and one-half to four times the lengths of other pipelines. We hasten to point out that this problem is <u>not</u> peculiar to the Air Force; it

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[2] AFLC considers that many PG 1 requisitions result from the inability of the wholesale system to fill routine stock replenishment requests from Base Supply, thus resulting in longer backorder times for PG 1 on a few problem items than for routine requests.

FIGURE 3-15. AIR FORCE MILSTEP RESPONSE TIMES - TRENDS

Format 1B: FY 1974 - FY 1976 CONUS - Surface Shipments

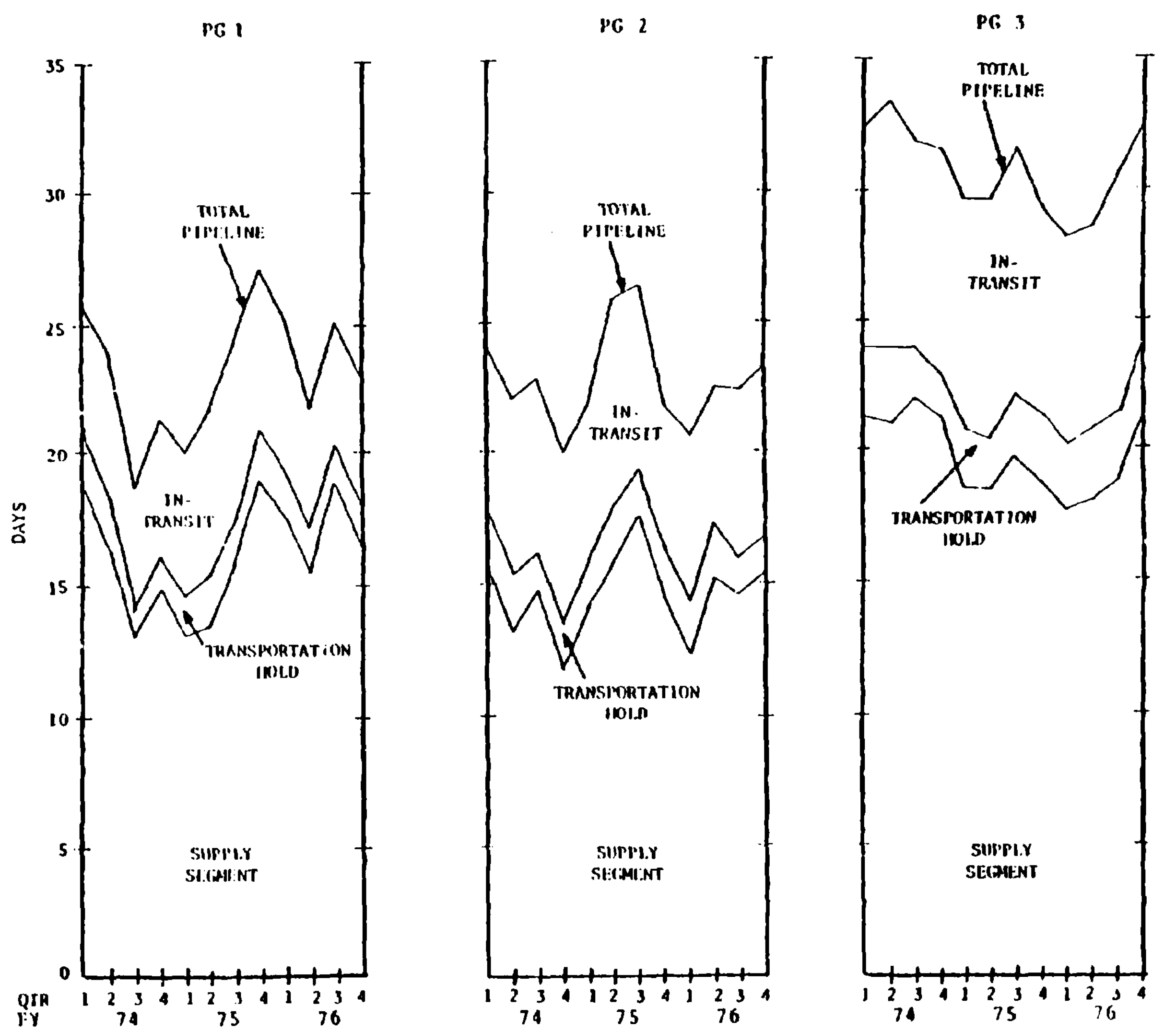


FIGURE 3-16. AIR FORCE MILSTEP RESPONSE TIMES - TRENDS

Format 1B: FY 1974 - FY 1976 CONUS - Air Shipments

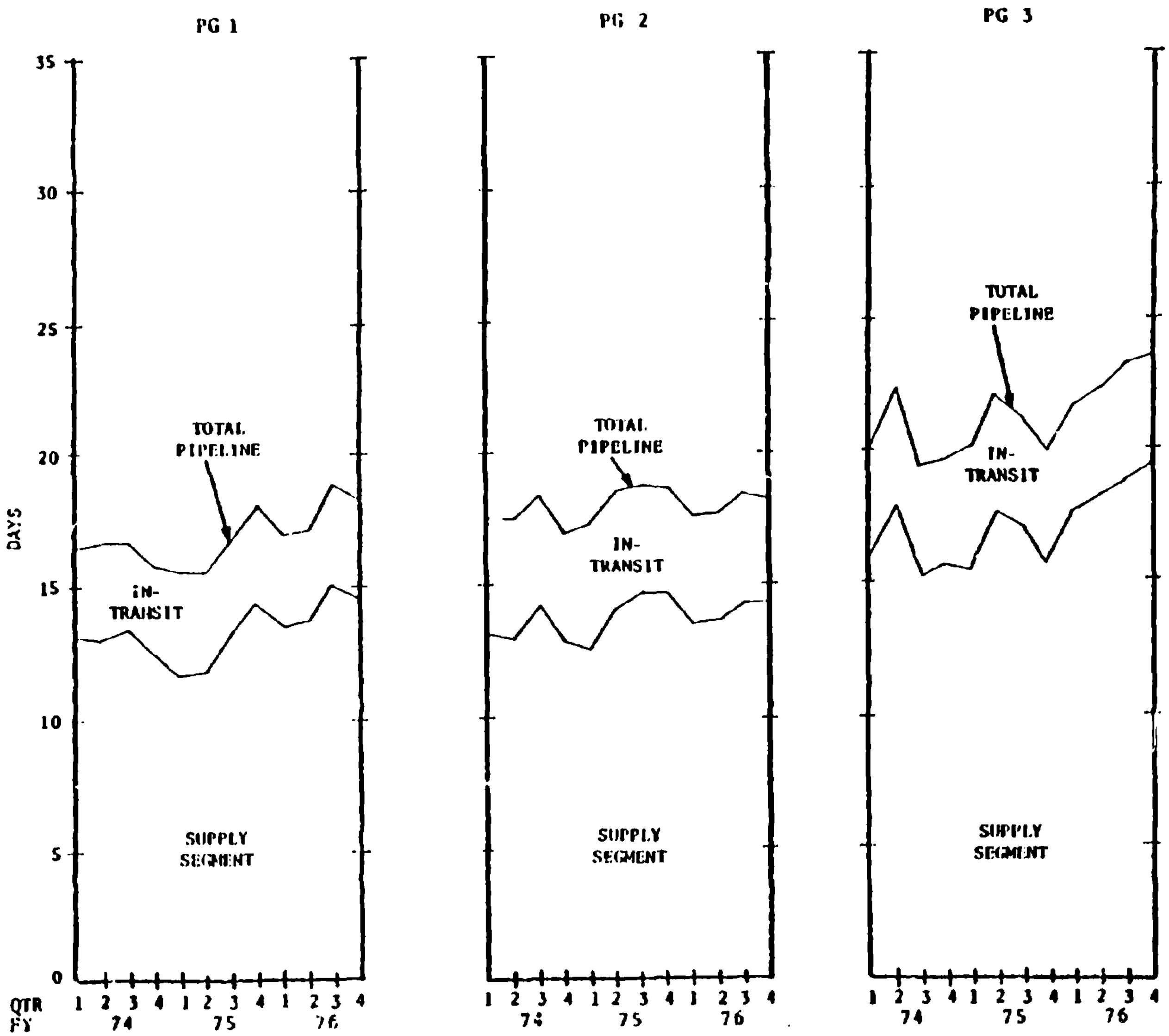
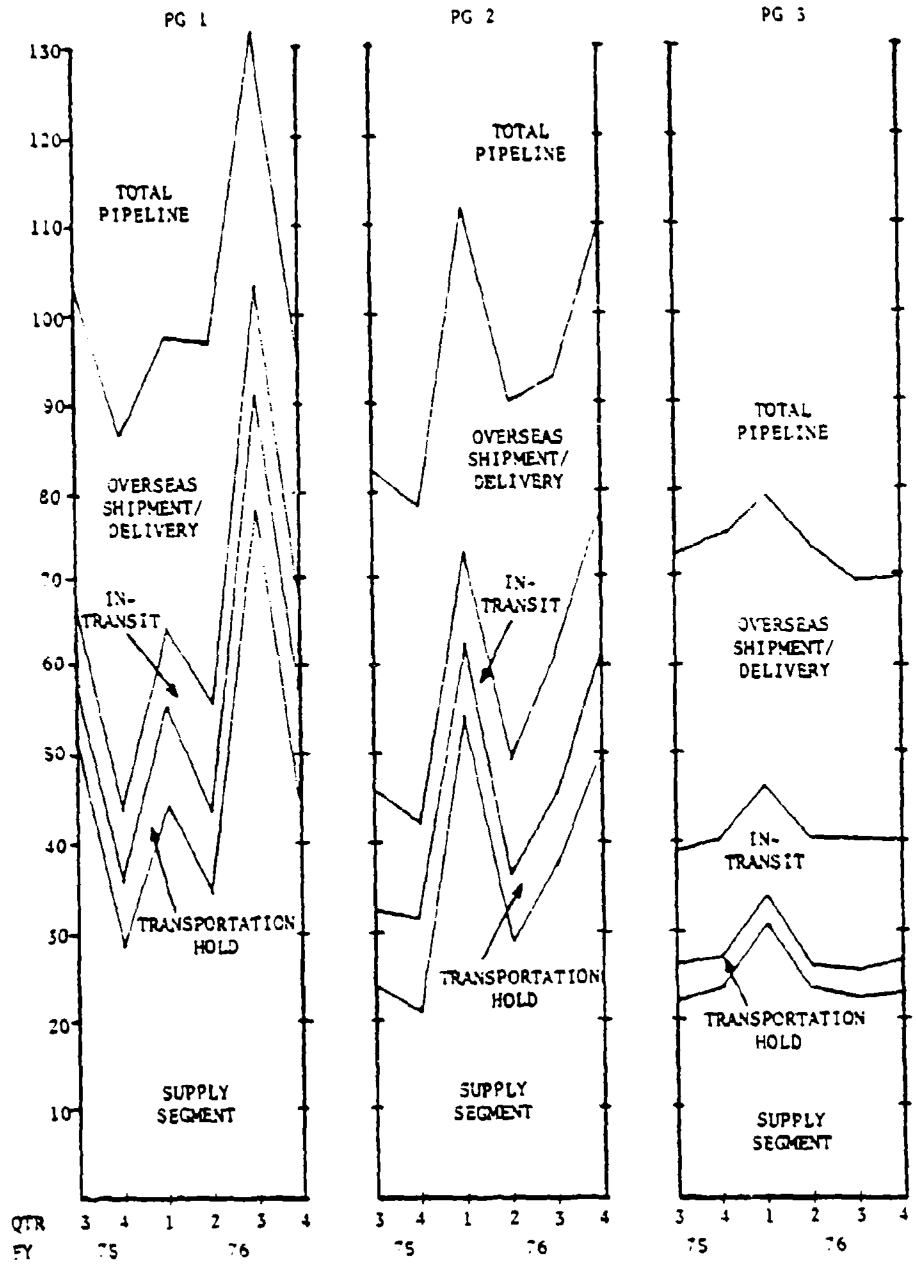


FIGURE 3-17. AIR FORCE MILSTEP RESPONSE TIMES - TRENDS

Format 1B: FY 1975 - FY 1976 Overseas - Surface Shipments

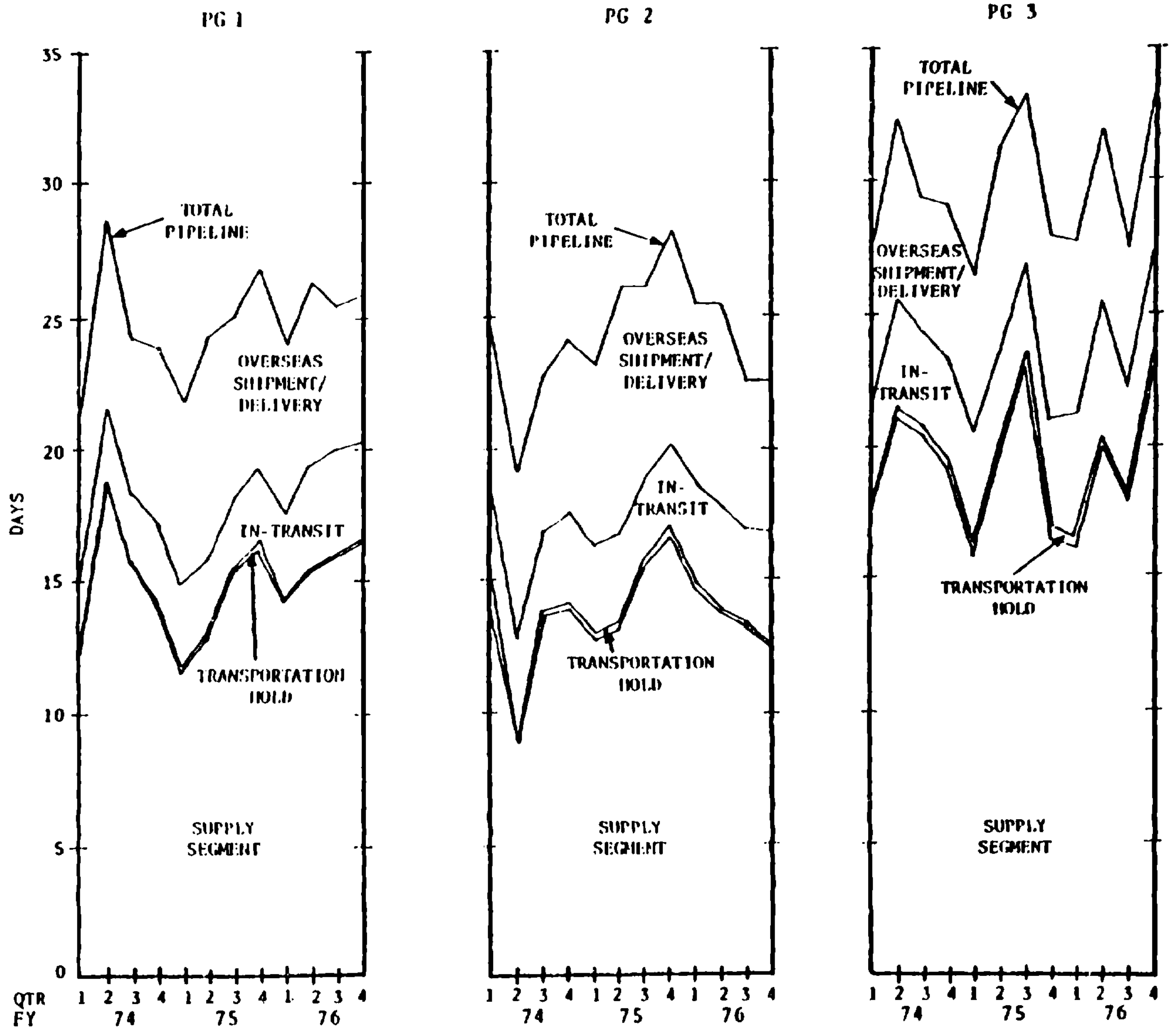


NOTE: 1st & 2nd quarter FY 75 data not available.

FIGURE 3-18. AIR FORCE MILSTEP RESPONSE TIMES - TRENDS

Format 1B: FY 1974 - FY 1976

Overseas - Air Shipments



occurs in the other Military Services as well. What is particularly disturbing is that the supply segment comprises so much of the total pipeline time.

On the other hand, in terms of total volume of shipments, surface shipments comprise only 29% of all overseas shipments. Additionally, PG 1 and PG 2 overseas surface shipments, both having total average pipeline times in excess of 100 days, constitute only 2% of all overseas surface shipments, and less than 1% of all overseas shipments, surface and air. To that extent, then, the impact of lengthy pipeline times on the needs of requisitioners is fortunately ameliorated.

Figures 3-15 through 3-18 reveal that the transportation segments of the total pipeline have remained, for the most part, very stable over the past three fiscal years. Note that the quarterly variations in the total pipeline time are almost invariably caused by the quarterly variations in the supply segment time. We are unable to discern any obvious trend for any PG in Figures 3-15 through 3-18. The large variations in PG 1 and PG 2 in Figure 3-17 are most likely the result of the extremely small number (100-200) of shipments in either case.

The UMMIPS standards for transportation are necessarily different for CONUS and overseas shipments, and are shown below in Table 3-2. The overall UMMIPS time

TABLE 3-2. UMMIPS TIME STANDARDS, TRANSPORTATION

(Days)

		CONUS		OVERSEAS/AIR			OVERSEAS/SURFACE		
				GEOG. AREA*			GEOG. AREA*		
Segment	PG	Air	Surface	1	2	3	1	2	3
Transportation	1	3	13	3	3	3	3	13	13
Hold +	2	6	13	6	6	6	13	13	13
In-Transit	3	13	13	13	13	13	13	13	13
Overseas	1			4	4	5	38	43	53
Shipment/	2			4	4	5	38	43	53
Delivery	3			38	43	53	38	43	53
Total	1	7	17	11	11	12	55	60	70
Pipeline	2	11	18	15	15	16	56	61	71
Time	3	28	28	66	71	81	66	71	81

*Area 1 - Western Hemisphere
Area 2 - Europe, Africa, and the Near East
Area 3 - Far East and Western Pacific

standards are also included in Figure 3-14. We note that PG 3 is the only priority group that meets or exceeds these standards; in most cases, the excess of actual pipeline performance over the standards is directly attributable to the excessive lengths of the supply segments.

Throughout our inquiry on the employment of MILSTEP data, we have repeatedly been warned by representatives from all the Services of its inaccuracy and untrustworthiness. Some of the inconsistencies we have noted on our own, so we are inclined to agree with the warnings. Nevertheless, we are convinced of the important contribution that the MILSTEP system provides to the evaluation of the military supply system performance.

If, then, the MILSTEP data are indeed inaccurate, inconsistent, and/or untrustworthy, then the MILSTEP Administrator and the top-level logistics managers within the Military Services should be tasked to correct that state of affairs. But if the data as currently presented are approximately accurate, then the Military Services should be tasked to improve their supply systems and the Defense Transportation System so that they conform more to the UMMIPS standards and to the idealized, priority-governed system we postulated earlier. In either event, positive action is required.

FINDINGS AND CONCLUSIONS

Base and Central Supply Performance

- In the last four years, inventory values have remained steady, while value of demands has increased 40%, mostly because of exchangeables.
- Inventory turnover has increased in the same period, also because of exchangeables.
- The number of demands on the depot has decreased, while the number of demands on the base has increased, but with no appreciable change in fill rates at either site.
- The number of aircraft and engine NORS part incidents is increasing, due mostly to exchangeables.
- The number of NORS incidents per demand is increasing for exchangeables, but decreasing for EOQ items.
- Based on the limited number of years of data, it is difficult to formulate any reliable conclusion regarding changes in supply performance at the base level.

Pipeline Performance, Supply

- In CONUS, PG 1 requisitions require more time than PG 2 or PG 3 requisitions, with the bulk of delays being consumed in the ICP Availability Determination time segment.

- The same CONUS PG 1 requisitions require more time than overseas PG 1 requisitions, which is also directly attributable to the ICP Availability Determination time segment, and possibly caused by ICP challenge procedures for high priority requisitions.

- For overseas, PG 1 requisitions require less time than PG 2 or PG 3 requisitions, but overseas PG 3 requisitions require more time than CONUS PG 3 requisitions.

- The Requisition Submission and Depot/Storage Site Processing time segments show exceptional stability for FYs 1974-1976; almost all of the total supply segment variations can be traced to the ICP Availability Determination time segments.

- For Immediate issues, the Air Force performance satisfies the UMMIPS standards in all cases except overseas, PG 3; for Delayed and All issues, performance is far in excess of those standards.

Pipeline Performance, Transportation and Total Pipelines

- The use of PG 1 affords no distinct advantage in expediting shipments.

- Total pipeline times for overseas surface shipments require from two and one-half to four times the lengths of other pipelines, with the supply segment consuming a substantial portion of those lengths.

- Those overseas surface shipments for PG 1 and PG 2, however, constitute only a small fraction of the total for all overseas surface shipments.

- The individual transportation time segments also appear to be exceptionally stable for FYs 1974-1976.

- Any variations in the total pipeline times appear to be caused by variations in the supply segments (specifically, ICP Availability Determination), not the transportation segments.

- PG 3 shipments appear to be the only category that consistently meets or betters the UMMIPS total pipeline standards; none of the categories satisfies the UMMIPS supply standards.

- Some DoD action seems required, either to correct inaccurate, inconsistent, and/or untrustworthy MILSTEP data, or to improve supply and transportation systems to conform to UMMIPS standards.

DATA AND SOURCE DESCRIPTION

Supply Performance

Figures 3-4 through 3-10 were prepared from the data contained in Tables 3-3 through 3-6 below, which in turn were derived from various sources. The numbers of items in those tables were obtained from the DO-41A recoverable item system data for BP-15 exchangeables (FY 1976 only) and from the AFLC Fact Books (USAF Inventory) for System Support and General Support Division for consumables. Inventory values were also obtained from the DO-41A data for exchangeables and from the USAF Budget Stock Fund Presentation for the corresponding Actual Fiscal Year Data for SSD and GSD items. Value of issues was obtained, again, from the DO-41A data for exchangeables and from the AFLC Fact Books for SSD and GSD Items. The DO-41A data were the source for number of issues, backorders, and demands at base level for exchangeables; depot level transaction data for exchangeables and consumables were derived from stock availability data in the AFLC Fact Books. Base level transaction data for consumables were provided by the AF Data Systems Design Center, extracted from the Selected Item Review and Supply Management Data Bank. NORS incident data were derived from the Worldwide Grid (DI65A reports).

Pipeline Performance

MILSTEP

The MILSTEP reports are broadly divided into two ledgers: Format 1A (Requisition Submission and ICP and Depot Processing Time) and Format 1B (Transportation and Total Pipeline Time), as shown in Figure 3–3. Formats 1A and 1B are further divided into two ledgers, CONUS and Overseas. Because the Format 1B ledgers further distinguish shipments by mode, i.e., surface or air, while Format 1A does not, it is impossible to reconstruct a total pipeline time analysis showing all the time segments in supply and transportation. It is possible, however, to reconstruct from Format 1B the total of the supply time segments for, say, overseas surface shipments, by subtracting the Transportation Hold, In-Transit, and Overseas Shipment/Delivery time segments from the total surface pipeline time. That total cannot, however, be related to any specific Format 1A report.

The gro supply system performance reported within the Air Force does not correspond exactly to the MILSTEP system, although it is based on the same inputs, i.e., IDCs. AFLC reporting is distinguished between CONUS and overseas shipments, and thus provides a total pipeline time analysis, including all the segments shown in Figure 3–3. Additionally, for overseas shipments, the total pipeline time (termed "Total Order and Ship Time") includes the date from discharge at the overseas port of debarkation to the date of receipt by the requisitioning installation. Figure 3–3 also shows that, for the Overseas Shipment/Delivery and Total Pipeline Time segments, the final date is the discharge at the overseas port of debarkation. This convention applies to the performance of the Air Force as reported to the MILSTEP system. However, internal Air Force reports extend those two segments to the date of receipt by the requisitioning installation

The MILSTEP Format 1B ledgers follow the same general layout as the Format 1A ledgers described earlier. However, CONUS and overseas shipments are reported in physically separate ledgers, and each is divided into two sections, surface shipments and air shipments. Both ledgers have headings for PG, Report Period, and Elapsed Number of Days, as described for Format 1A. The CONUS ledger displays the Transportation segment, which includes Depot Transportation Hold, In-Transit, and Hold + In-Transit, and lists the number of lines and percentage for each. (The Hold + In-Transit segment is the only one for which a UMMIPS standard has been specified.) A Receipt Takeup By Requisitioner is included, but is not currently used. The Total Pipeline Time segment is divided into Immediate Issues and All Issues, and includes number and percentage.

The overseas ledgers not only have an additional time segment (Overseas Shipment/Delivery) to report, but also divide that segment and the total pipeline segment into the same three geographical areas mentioned earlier. As a result, the number of lines under each segment had to be omitted because of space limitations, leaving only the percentage.

The information in Figures 3–11 through 3–13 was obtained from the MILSTEP 1A ledger for the Air Force. The information in Figures 3–14 through 3–18 was obtained from the MILSTEP 1B ledger for the Air Force.

AFLC Pipeline Report

The internal AFLC pipeline reporting system (0025E) provides a variety of reports. The one discussed here is the "Material Pipeline Time Report - Part 3, Total AFLC Shipments" (0025EK71L), prepared monthly. It includes both supply and transportation segments, but at this point we will discuss only the supply segments.

The AFLC report, divided between CONUS and Overseas Shipments, is further categorized by the ALC that processes the shipments. Within such ALCs, the report distinguishes between PG 1 NORS (including "999" shipments), PG 1 total, PG 2 NORS, PG 2 total, and PG 3 shipments. For each time segment, the report gives the UMMIPS time standard, the percentage of total shipments meeting that standard, and the average number of days to complete each segment.

The overseas portion of the AFLC report, in addition to the categorizations discussed above, is also divided into three geographical areas as shown in Table 3–2. Part 1 and Part 2 of this AFLC report are identical in format to Part 3. Part 1, however, reports only on Off-Shelf Shipments (corresponding to Immediate issues in MILSTEP), and Part 2 reports only on Delayed Shipments. Similarly, other versions report by command and Stock Record Account Number (SRAN).

Another AFLC document, the monthly "Command IDC Response Rate Report" (0025ER91L), shows the number of shipments to each Air Force command and the number and percentage of usable responses (i.e., returns of IDCs with valid date information). Response rates less than 75% generate follow-ups by AFLC and base reviews.

The internal AFLC report (0025E) also contains monthly transportation summaries, as an extension of the supply pipeline data and in the same format. The Transportation Hold and In-Transit segments are combined into one segment. Under that segment for CONUS are listed seven separate modes of transportation: Air Parcel Post, Weapon Systems Pouch, LOGAIR, Other Air, All Air, Surface, and All Modes; for overseas, only two categories are listed: All Air and Surface. Under the Overseas Shipment/Delivery segment, two principal categories are listed: Air and Surface. In some instances, two additional categories are included: MAC and Other Air.

Under the Total Order and Ship Time (Total Pipeline) for CONUS are the same seven categories as for Transportation Hold and In-Transit Time. For overseas, the categories may include MAC as well.

TABLE 3-3. SUPPLY PERFORMANCE DATA, FY 1976

		Exchange-ables	System Support Div. (SSD)	General Support Div. (GSD)	Total
No. of Items		78,817	75,800	916,000	1,467,617
Inventory Value ($x10^9$)		\$ 5.558	\$ 1.330	\$ 0.270	\$ 7.158
Value of Issues ($x10^9$)		\$15.323	\$ 0.659	\$ 1.012	\$ 16.994
			System and General Support		
No. of Issues ($x10^6$)	Base	1.454	9.517		10.971
	Depot	0.877	2.031		2.908
	Total	2.331	11.548		13.879
No. of Back-orders ($x10^6$)	Base	0.685	5.173		5.858
	Depot	0.653	0.492		1.145
	Total	1.338	5.665		7.003
No. of Demands (Issues + Backorders) ($x10^6$)	Base	2.139	14.689		16.828
	Depot	1.530	2.524		4.054
	Total	3.669	17.213		20.882
NORS Incidents (A/C & Engines)		250,419	286,516*		536,935
% of Total NORS Incidents		46.6	53.4		100.0
Incident Frequency		.068	.017		.026

*Residual, obtained by subtracting exchangeable NORS incidents from total NORS incidents.

TABLE 3-4. SUPPLY PERFORMANCE DATA, FY 1975

		Exchangeables	System Support Div. (SSD)	General Support Div. (GSD)	Total
No. of Items		N/A	449,900	917,700	N/A
Inventory Value ($x10^9$)		$ 5.202	$ 1.189	$ 0.243	$ 6.634
Value of Issues ($x10^9$)		$ 13.662	$ 0.529	$ 0.987	$15.178
			System and General Support		
No. of Issues ($x10^6$)	Base	1.145	8.217		9.362
	Depot	0.945	2.062		3.007
	Total	2.090	10.279		12.369
No. of Backorders ($x10^6$)	Base	0.764	4.517		5.281
	Depot	0.742	0.620		1.362
	Total	1.506	5.137		6.643
No. of Demands (Issues + Backorders) ($x10^6$)	Base	1.910	12.734		14.643
	Depot	1.687	2.681		4.369
	Total	3.597	15.415		19.012
NORS Incidents (A/C & Engines)		273,264	302,028*		575,292
% of Total NORS Incidents		47.5	52.5		100.0
Incident Frequency		.076	.020		.030

*Residual, obtained by subtracting exchangeable NORS incidents from total NORS incidents.

TABLE 3-5. SUPPLY PERFORMANCE DATA, FY 1974

		Exchange-ables	System Support Div. (SSD)	General Support Div. (GSD)	Total
No. of Items		N/A	443,800	875,200	N/A
Inventory Value ($x10^9$)		$ 5.077	$ 1.122	$ 0.215	$ 6.414
Value of Issues ($x10^9$)		$11.000	$ 0.481	$ 0.826	$12.307
			System and General Support		
No. of Issues ($x10^6$)	Base	1.187	8.877		10.064
	Depot	0.985	2.071		3.056
	Total	2.172	10.948		13.120
No. of Back-orders ($x10^6$)	Base	0.732	5.069		5.801
	Depot	0.719	0.701		1.420
	Total	1.451	5.770		7.221
No. of Demands (Issues + Backorders) ($x10^6$)	Base	1.919	13.945		15.864
	Depot	1.704	2.772		4.476
	Total	3.623	16.717		20.340
NORS Incidents (A/C & Engines)		102,615	355,487*		458,102
% of Total NORS Incidents		22.4	77.6		100.0
Incident Frequency		.028	.021		.023

*Residual, obtained by subtracting exchangeable NORS incidents from total NORS incidents.

TABLE 3-6. SUPPLY PERFORMANCE DATA, FY 1973

		Exchange-ables	System Support Div. (SSD)	General Support Div. (GSD)	Total
No. of Items		N/A	N/A	N/A	N/A
Inventory Value ($x10^9$)		\$ 4.965	\$1.327	\$0.204	\$ 6.496
Value of Issues ($x10^9$)		\$10.804	\$0.520	\$0.792	\$12.116
			System and General Support		
No. of Issues ($x10^6$)	Base	N/A	N/A		7.600
	Depot	1.081	2.353		3.434
	Total	N/A	N/A		11.034
No. of Back-orders ($x10^6$)	Base	N/A	N/A		2.865
	Depot	0.805	0.776		1.581
	Total	N/A	N/A		4.446
No. of Demands (Issues + Backorders) ($x10^6$)	Base	N/A	N/A		10.465
	Depot	1.886	3.130		5.016
	Total	N/A	N/A		15.481
NORS Incidents (A/C & Engines)		N/A	N/A		N/A
% of Total NORS Incidents		N/A	N/A		N/A
Incident Frequency		N/A	N/A		N/A

CHAPTER 4: ENGINES

OVERVIEW AND STRUCTURE

The overall picture of Air Force jet engines from FY 1973 through FY 1976 can be characterized as one of stable inventory and decreasing number of engine hours, but increasing removal rates, overhaul backlog, and overhaul costs.

Figure 4-1 depicts that portion of the Air Force aggregate logistics structure devoted to engine maintenance and supply. Figure 4-2 describes the flow of aircraft engines through the maintenance cycle in much more detail. This flow is a dynamic process, one in which the status of engines is constantly changing. Hence, while the asset levels at any instant may be meaningless, the cumulative flow through any status condition during any given period may provide significant information.

Organizational (unit) or base (field) maintenance levels remove installed engines for repair or to facilitate maintenance on other components of an aircraft. Usage removals, those requiring some form of maintenance, are then either repaired at Base Maintenance, or shipped to a depot for overhaul and/or repair. Non-usage removals may not necessarily require repairs; those that do not are re-installed or returned either to the base pool of serviceable engines or to depot stock. If it is determined during base maintenance that an engine is Not Repairable This Station (NRTS), it is shipped to the depot. Engines repaired at Base Maintenance are eventually returned to the base serviceable pool. Engines overhauled at a depot are sent to depot stock. Engines sent to a depot for overhaul are normally exchanged for engines in depot stock. Upon completion of the overhaul, they are returned to the serviceable pool for eventual installation on aircraft as necessary. Thus, engines are treated much like other investment items in the Air Force inventory.

The Air Force keeps records on the periodic cumulative totals for each of the status conditions shown in Figure 4-2. With these totals and the inventory levels of installed and spare engines, we can generate a number of performance measures. In generating these measures, we found it necessary to make certain assumptions regarding the flow in Figure 4-2. First, we assumed that repairs on all base maintenance usage removals were accomplished in the same fiscal year. Second, we assumed that the base maintenance non-usage removals were all returned directly to the serviceable pool of spare engines, and that the depot non-usage removals were all returned directly to depot stock. The

FIGURE 4-1. AIR FORCE ENGINE LOGISTICS STRUCTURE

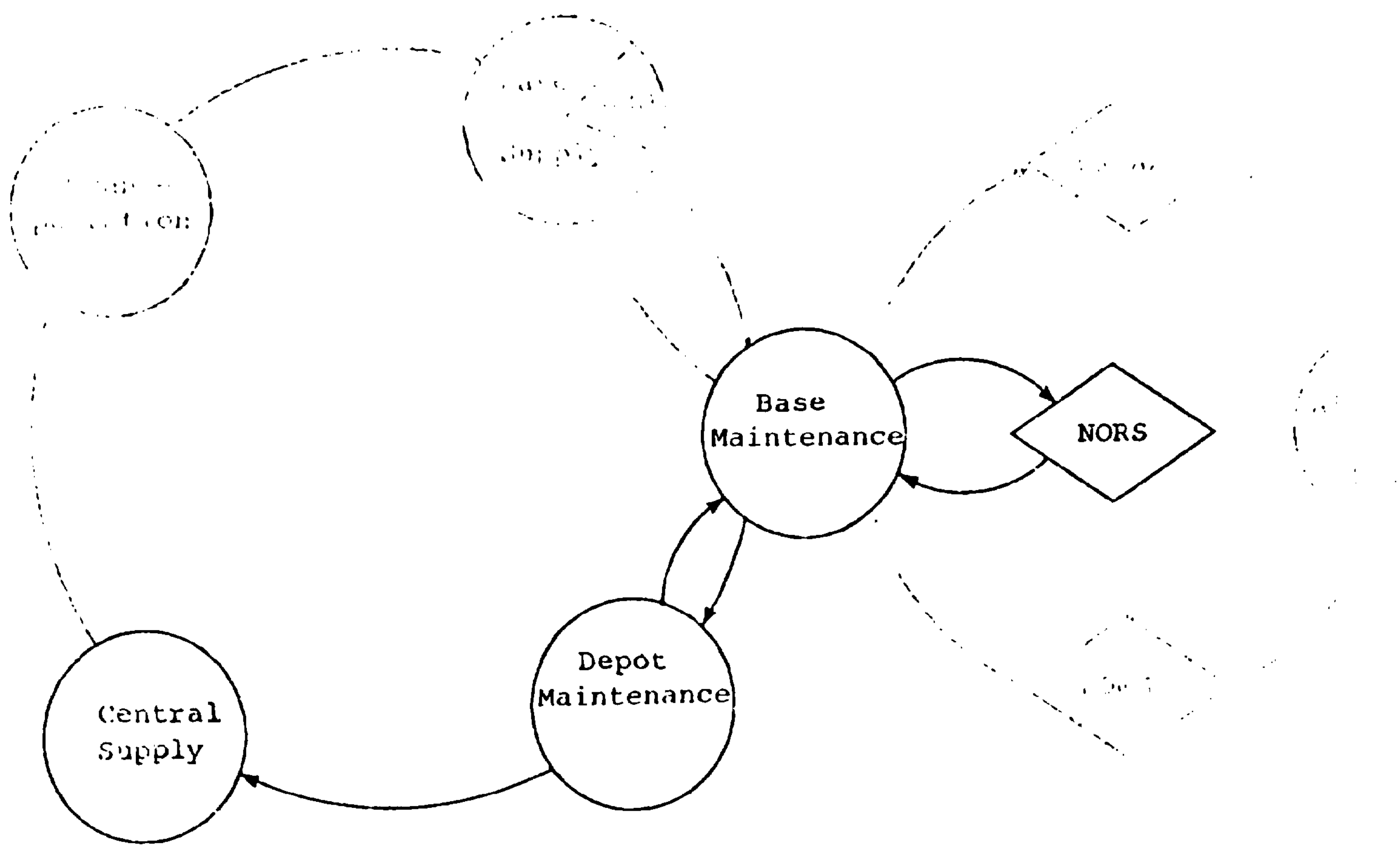
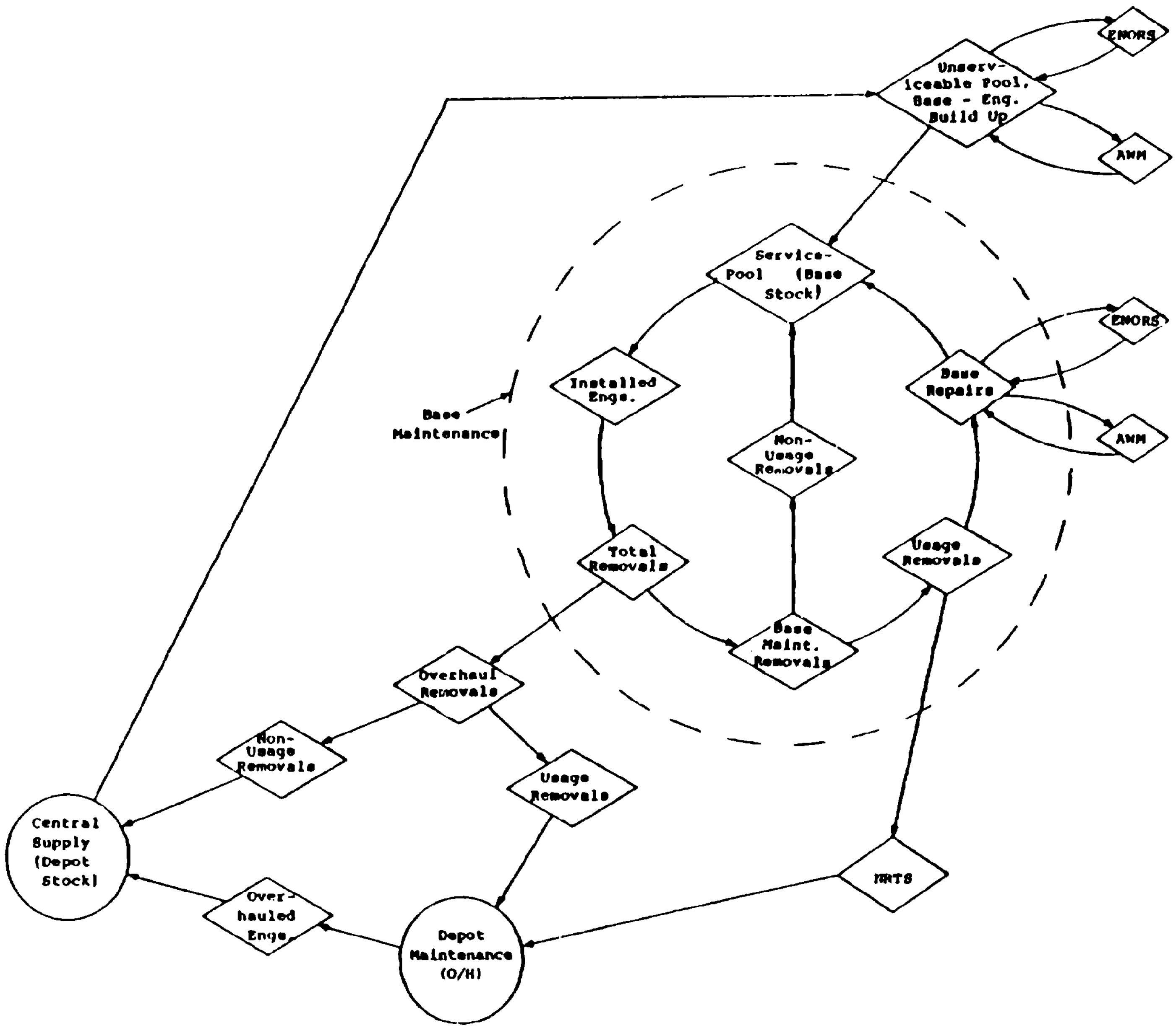


FIGURE 4-2. ENGINE MAINTENANCE CYCLE



effect of that assumption may be to overstate the number of returns. Third, the overhaul backlog was computed as the sum of the engines' input to the depot (usage removals plus NRTS plus prior year backlog, if any) less the number of overhauls completed during the fiscal year. That computation assumes that all inputs to the depot are destined for overhaul, whereas in fact some may receive only limited repairs. Since we have no data on overhaul backlog in FY 1972, we assumed a zero backlog for FY 1973.

The following section includes analyses of engine maintenance and supply performance data contained in several sources. We decided to extract data from a sample of jet engines to reduce the number of computations for the analyses. That sample contains engines for certain current operational aircraft for which at least several years of data were available and for which the sample engine hours would constitute a major portion of the total fleet engine hours. Sampled engines and aircraft on which they were installed include the following:

J57-P-19/29: B-52
J57-P-43: B-52, KC-135
J57-P-59: C, KC-135
J79-GE-15: F, RF-4
J79-GE-17: F-4E
TF30-P-3: F-111
TF30-P-9: F-111D
TF30-P-100: F-111
TF33-P-3: B-52H
TF33-P-7/7A: C-141
TF41-A-1: A-7
TF39-GE-1/1A: C-5A.

ANALYSIS OF DATA AND TRENDS

The first topic addressed is the engine maintenance cycle. The figures that follow summarize the trend data from FY 1973 to FY 1976 for the flows of engines through the engine maintenance cycle depicted in Figure 4-2. Figure 4-3 shows inventory levels for the engine fleet and our sample of engines; Figure 4-4 shows the number of engine hours for both the fleet and our sample; Figure 4-5 displays inventory values, again for both the fleet and our sample. The remaining figures display information relating only to our sample of engines; these include:

- Figure 4-6 - number of removals
- Figure 4-7 - engine removal rates
- Figure 4-8 - engine returns
- Figure 4-9 - overhaul costs
- Figure 4-10 - overhaul backlog.

We must point out that there are certain problems and inconsistencies relative to these engine data, which are discussed in detail under "Data and Source Description."

FIGURE 4-3. INVENTORY LEVELS

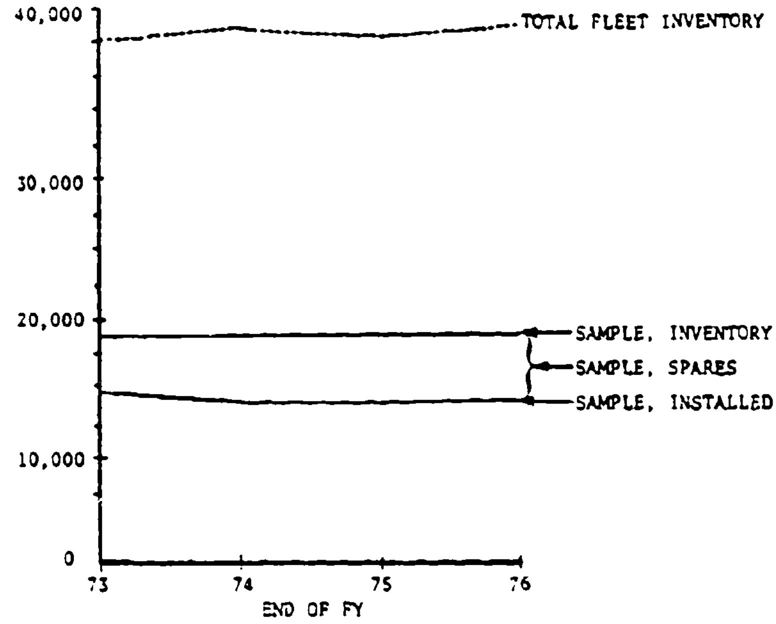


FIGURE 4-4. FLEET ENGINE HOURS

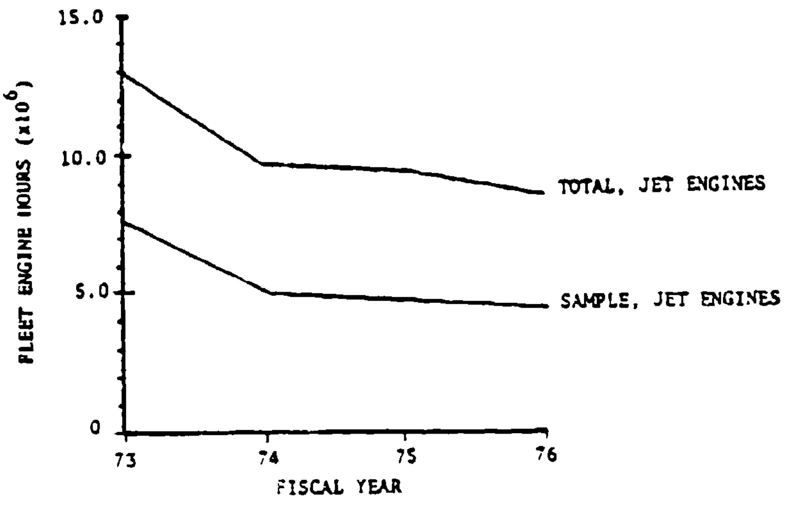


FIGURE 4-5. ENGINE INVENTORY VALUES

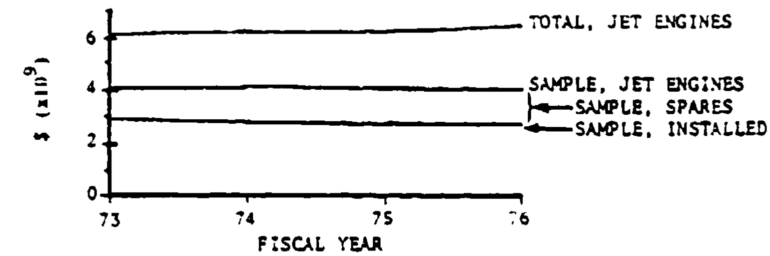


FIGURE 4-6. SAMPLE REMOVALS

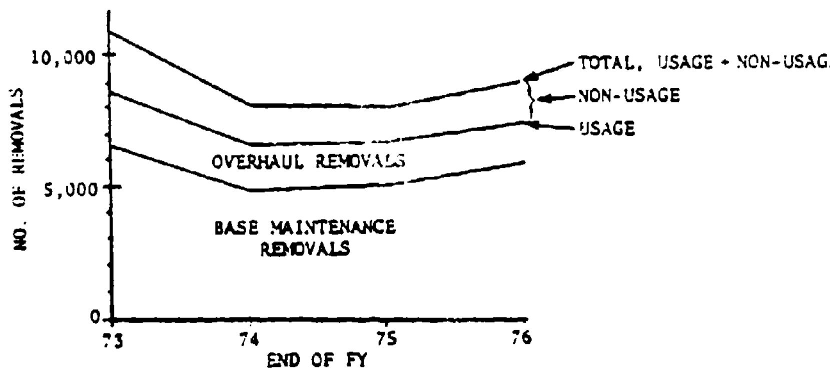


FIGURE 4-7. ENGINE REMOVAL RATE

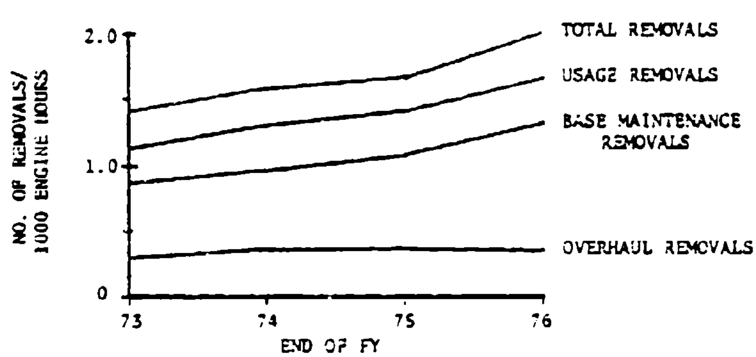


FIGURE 4-8. ENGINE RETURNS

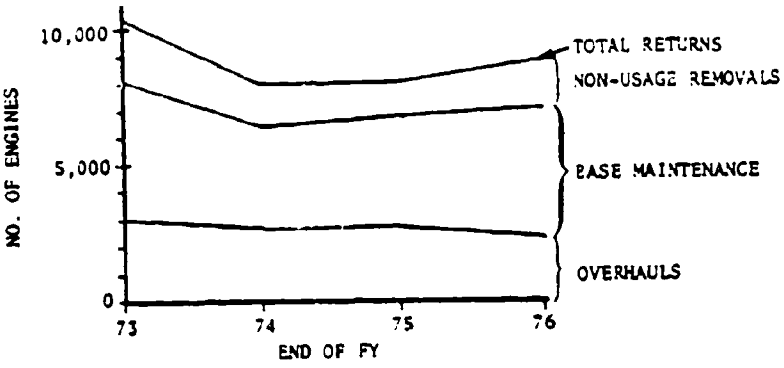


FIGURE 4-9. OVERHAUL COSTS
(Constant FY 1976 $)

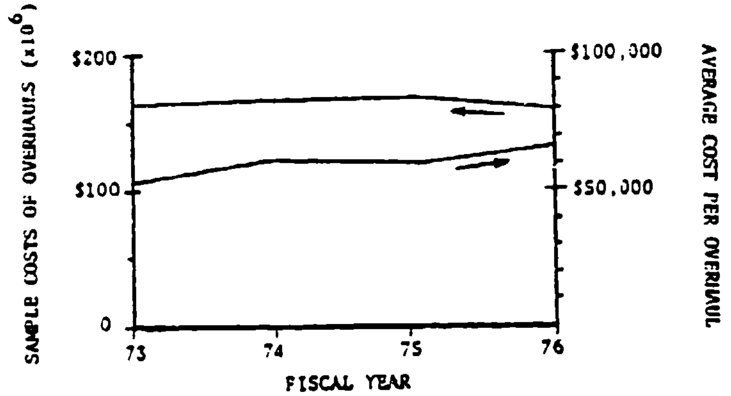
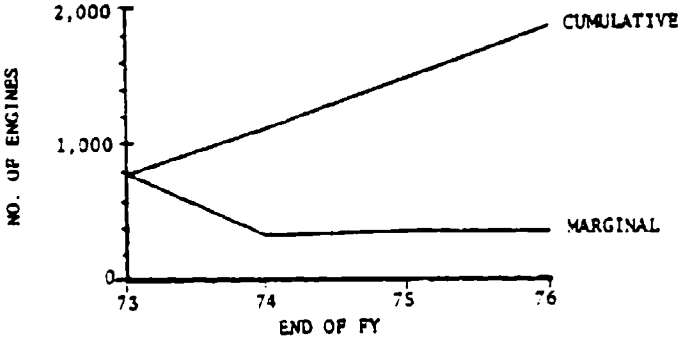


FIGURE 4-10. OVERHAUL BACKLOG



As should be expected with mature Air Force aircraft, engine inventory levels and values have remained quite stable over the four-year period. On the other hand, total jet engine hours have decreased by a third; jet engine hours for our sample have decreased by more than 40%. This would lead us to expect a reduction in removals, which did in fact occur between FYs 1973 and 1974. However, since FY 1974, removal rates have increased by over 40%, usage removal rates by 45%, and base maintenance removal rates by over 50%. Overhaul removal rates, on the other hand, have remained stable, an unsurprising occurrence in the face of a gradual reduction in overhaul removals and engine hours.

A closer examination[1] of engine removal trends (Figures 4–6 and 4–7) reveals that of the 12 engine families in our sample, five account for around 80% of the total usage removals, base maintenance usage removals, and total engine hours. These include: the J57–43, the J57–59, the J79–15, the J79–17, and the TF33–7. In fact, just three of them, the J57–43, J57–59, and the TF33–7 engines, account for over 60% of the total engine hours over the last four fiscal years. However, the usage removal rate for the TF33–7 engine has been substantially below the average, while the usage removal rates for the J57–43 and J57–59 engines have been above the average. The TF30–3 and the TF41–1 have had usage removal rates consistently well above the average, and appear to be increasing faster than the average. The TF41–1 engine, for example, has had more usage removals in the last three fiscal years than the TF33–7, while accumulating less than 9% of the engine hours amassed by the TF33–7.

The trend in usage removals appears to favor Base Maintenance over overhauls. Overhaul removals continue to drop, while base maintenance removals have gradually increased since FY 1974. Only some of the newer engines (the TF41–1, TF30–9, and TF30–100) appear to go against that trend.[2]

Historically, the J57–59 and the J79–15 are the two biggest contributors to the total costs of overhauls, although the TF41–1 has surpassed the J57–59 costs for the last two fiscal years. The total costs of overhaul (in constant FY 1976 dollars) have remained relatively stable over the four-year period, falling and rising as the number of overhauls falls and rises. The average cost per overhaul, however, has risen more than 25% in that same period.

No clear picture emerges as to which engines that overhaul cost increase can be attributed. The unit overhaul costs for the J57–59 engine and the TF39–1 engine were

[1]See Table 4-3 under "Data and Source Description."

[2]AFLC noted that the increased usage removals for the TF41 resulted from technical problems experienced with the engine and from the lack of any Jet Engine Intermediate Maintenance (JEIM) capability until late FY 1976. The TF30-P9/100 also experienced technical problems that increased usage removals.

significantly higher than the average in FYs 1973 and 1974 and accounted for about one-third of the total overhaul costs. The two engines with the highest unit costs in FY 1975 were the TF30–100 and the TF39–1 engines, but these two accounted for only about one-sixth of the total costs. In FY 1976, the TF30–9 and TF–100, along with the TF39–1, had unit costs much higher than the average unit costs, but accounted for only 18% of the total costs. We note that unit costs per overhaul for all engines have generally increased from FY 1973 to FY 1976, even though some engines have shown downward fluctuations from year to year.[3]

Trend analysis of the data in Tables 4-3 and 4-4 (see "Data and Source Description" below) suggests an interesting observation: four of the engines in our sample—the TF30–3/9/100 and the TF41-1/1A—appear to be the source of more problems related to maintenance and overhaul workload and cost than the remainder of the sample engines. We selected the following measures for the trend analysis: number of usage removals and non-usage removals, total costs of overhaul, and unit cost for overhaul. The percentage changes

from FY 1973 to FY 1976 are shown below:

	TF30-3/9/100 & TF41-1/1A	Remaining Sample Engines
No. of Usage Removals	+128%	-27%
No. of Non-Usage Removals	+171%	-57%
Total Overhaul Costs	+406%	-37%
Unit Cost per Overhaul	+167%	-13%

Note that the FY-1976 inventory of the TF30-3/9/100 and the TF41/1A was less than 10% of the total engine inventory, and contributed only 5% to the total fleet engine hours. Yet the same engines contributed to 21% of the total usage removals, 48% of the total non-usage removals, 41% of the total overhaul costs, and 35% of the total number of overhauls.

The cumulative overhaul backlog has apparently risen sharply, even though the marginal backlog has remained fairly steady. This would appear to indicate a bottleneck for overhauls at the depot level. At the same time, total overhaul costs are fairly stable, while average costs per overhaul are rising.

[3]AFLC noted that the J57-59 overhaul cost increase was caused by increased contractor labor costs and more quality assurance provisions added by the Air Force. The TF39–1 overhaul cost increase resulted from a configuration upgrade to a TF39-1A model, thus extending the maximum time between overhauls.

The cumulative overhaul backlog must be interpreted cautiously.[4] First of all, we are not prepared to say that engine removal for overhaul actually means that there is a specific requirement for an overhauled engine in the inventory. In view of the reduced flying hour program, it might well be appropriate to allow for a pool of unserviceable engines at the depot level.

Second, it is not yet clear that NRTS engines (base maintenance removals minus base maintenance returns; see Figure 4–2) are actually destined for overhaul. It is quite likely that some portion of NRTS engines may receive a level of repair short of overhaul, and then be returned to the depot stock. In such cases, the overhaul backlog would be less than indicated, or might even vanish. Indeed, it is difficult to reconcile the apparently large (134%) increase in backlog from FY 1973 to FY 1976 with the relatively stable rate of input (overhaul removals plus NRTS) to output (completed overhauls) during the same period.

It might appear, then, that the Air Force flight hour reduction program has not paid off in reduced base and depot level engine maintenance costs or workload. But before accepting that hypothesis, let us postulate an alternative. First, in the absence of any evidence of a declining base maintenance capability, the increase in base maintenance removal rates appears to reflect a conscious shift from overhaul-type repairs to base maintenance repairs. If nothing else, this would tend to support the belief that base maintenance efficiency is increasing. Second, every engine repaired at Base Maintenance, instead of being overhauled at a depot, must represent a significant reduction in pipeline time for replenishing the base serviceable engine pool.

We next sought information on the amount of base maintenance performed on engines. What limited data were available were identified only by the aircraft model, and not the engine type. Only FY 1975 and FY 1976 data were available for comparison with the number of base maintenance returns for those engines in our sample that corresponded generally with the aircraft identified with maintenance man-hours. Table 4-1 compares base maintenance man-hours for engines with base maintenance returns for these two fiscal years.

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[4] AFLC does not calculate nor monitor an overhaul backlog; they also pointed out that many unscheduled engine overhauls occurred in FYs 1975 and 1976 due to TF30 and TF41 inventory turnarounds through the depot. An output reduction, relative to input, may also reflect parts shortages, extended repair times, and test cell reject problems on engines undergoing overhaul rather than a waiting line of unrepaired engines. Additionally, output data do not account for engines processed by Depot Maintenance for other major/minor overhaul.

TABLE 4-1. BASE LEVEL ENGINE MAINTENANCE MAN-HOURS AND MAINTENANCE RETURNS

Aircraft Models	Maintenance Man-Hours		% Change	Engine Type	Maintenance Returns		% Change
	FY 75	FY 76			FY 75	FY 76	
B-52D, G,H	231,599	256,780	+11%	J57-19/29, TF33-3	336	461	+37%
C-5A	317,951	445,633	+40%	TF39-1/1A	101	110	+9%
C-141	492,199	358,896	-27%	TF33-7/7A	481	554	+15%
KC-135A[1]	39,165	25,579	-35%	J57-59	876	1104	+26%
F-111A, D,E, F	129,127	131,271	+2%	TF30-3/9/100	207	224	+8%
C130B/E	210,250	201,443	-4%	T56A-7	265	253	-5%

[1]Data include only Support General man-hours; other categories of man-hours were not reported for FY 1976.

It does not appear that any useful conclusions can be drawn from the data in Table 4–1, except that the data are contradictory. Note that the engines showing the second (TF33–7/7A) and third (J57–59) largest increases in number of maintenance returns are nominally those installed in the two aircraft (C–141 and KC–135A) showing the two largest decreases in maintenance man-hours.

The last topic addressed is ENORS, or Engine Not Operationally Ready, Supply. This classification applies only to engines that have been removed from aircraft, and then only at the base level. Our treatment of ENORS should be considered only as exemplary of what could be derived. In theory, the ENORS rate can be partitioned into three factors, each of which can be considered a performance measure. This partitioning is identical in concept to the partitioning of the aircraft NORS rate discussed in Chapter 2. The basic equation is as follows:

$$\text{Engine NORS rate} = (\text{Frequency}) \times (\text{Duration}) \times (\text{Consolidation})$$

$$\frac{\text{ENORS Hours}}{\text{Eng. Possessed Hours}} = \frac{\text{ENORS Parts Incidents}}{\text{Eng. Possessed Hours}} \times \frac{\text{ENORS Parts Hours}}{\text{ENORS Parts Incidents}} \times \frac{\text{ENORS Hours}}{\text{ENORS Parts Hours}} .$$

The following example illustrates briefly how specific values for the above factors can be generated. However, we emphasize that our example is based on inexact and incommensurate data.

The overall FY 1975 ENORS rate (FY 1976 data were unavailable) for jet engines was 10.8%. The number of engine possessed hours for FY 1975 for our sample, can be estimated in two ways. One method, which may overstate that variable, is to compute the number of uninstalled engines at the base as the difference between the spares inventory and the cumulative overhaul backlog, and multiply by 24 hours times 365 days. In the sample of engines examined in our analysis, that method produces a figure of 30.14 million possessed hours. The possible overstatement arises from our failure to account for engines actually undergoing depot overhaul and in depot stock.

Another method is to estimate the number of uninstalled engines at the base as the average number of base usage removals per quarter. This method is strictly empirical, but it appears to produce values that correlate well with the number of uninstalled assets derived from other sources. The results for this method gave 1,256 engines x 8760 hours, or 11.0 million possessed hours.

In the example below, we stress that the data values used were drawn from different populations, i.e.:

- The ENORS rate applies only to jet engines.
- The number of parts incidents and parts hours apply to all Air Force engines, both jet and reciprocating.
- The ENORS hours and engine possessed hours apply only to the sample of engines examined in our analysis.

Based on the above two values for engine possessed hours, and 15.819 million ENORS parts hours and 74,227 ENORS parts incidents, we can obtain upper and lower bounds for the factors in our equation, as shown below:

Factor	Engines: Upper Bound	Engines: Lower Bound	A/C NORS Values[1]
Incidents/ Possessed Hrs.	.00246	.00675	.00538
Parts Hrs./ Incidents	77	77	80.8
NORS Hrs./ Parts Hrs.	.206	.075	.312

[1]See Table 2-6.

The inferences are: one, the derived ENORS frequency factor is probably substantially lower than the aircraft NORS frequency factor; two, the ENORS duration factor is very close to the aircraft NORS duration factor; and three, the derived ENORS consolidation factor is probably lower than the aircraft NORS consolidation factor. The first inference seems to have a logical basis if we consider that engines can go ENORS only when uninstalled at the base. In that condition, the engines are not accumulating any operating hours, the principal cause of failed parts. Aircraft, on the other hand, can go NORS at any time except when at a depot. In addition, engine parts that fail while engines are installed on aircraft generate only aircraft NORS conditions, not ENORS, unless and until the failed engines are removed. Further, aircraft NORS conditions can be generated for many reasons other than engine parts failures. The second inference also seems to have a logical basis, inasmuch as the ENORS duration factor depends to a great extent upon the same supply and transportation system that supports the aircraft NORS duration factor.

The third inference appears to have no logical foundation based on experience. The reciprocal of the consolidation factor represents, in essence, the likelihood of occurrence of more than one ENORS parts incident per ENORS occurrence. There seems to be no reason why that likelihood of occurrence should be substantially different for engines than for aircraft.

FINDINGS AND CONCLUSIONS

Engine Maintenance Cycle

- Engine inventory levels and values have remained stable, while engine operating hours have decreased by a third.

- Although the number of engine removals dropped initially, they have begun to increase.

- Total engine removal rates have increased 40%, due mostly to an increase in base maintenance usage removals.

- Total engine returns also dropped initially and then began to increase.

- Total overhaul costs are fairly stable, while average costs per overhaul are rising.

- The cumulative overhaul backlog may have risen sharply, even though the marginal backlog is stable.

- The increase in base maintenance removal rates appears to reflect a conscious shift from overhaul-type repairs to base maintenance repairs.

- Every engine repaired at Base Maintenance (instead of being overhauled at a depot) must represent a significant reduction in the time required to replenish the base serviceable engine pool.

- The TF30-3/9/100 and TF41-1/1A are recognized by AFLC as problem engines, especially with respect to overhaul workload and cost.

ENORS

- The ENORS frequency factor (i.e., incidents per possessed hour) is probably substantially lower than the aircraft NORS frequency factor.

- The ENORS consolidation factor (ENORS hours per ENORS parts hour) is probably close to the aircraft NORS consolidation factor; i.e., aircraft and all engines appear to experience about the same number of multiple NORS occurrences.

DATA AND SOURCE DESCRIPTION

The principal data source used in developing the performance measures discussed earlier is the "Engine Actuarial Data Summary" (EADS) (AFLC Form 992), compiled from DO24F actuarial data. EADS is submitted quarterly for the current fiscal year by the Oklahoma City and San Antonio ALCs; however, prior years' data are summarized on a complete year basis. Engine inventory level (based on DO24BDT10 reports) and engine overhaul and cost data were provided by the Propulsion Systems Directorate of AFLC(LOP) upon our request. ENORS rates for FY 1973 through FY 1975 were obtained from AFLC Management Indicators.

More detailed ENORS information and breakdown by engine family are contained in the DO24BBJ1W reports, which were also the source of data on number of uninstalled assets used in our treatment of ENORS. Base maintenance man-hour data were obtained from AFLC report LOC-MNO(AR)7185, "Maintenance Man-Hours per Flying Hour By Weapon, Command, and System." Partial ENORS data were also obtained from the "AFLC ALS Evaluation Reports," Measure Identifier 138. Ancillary data relating to aircraft engine maintenance are contained in the Department of the Air Force, President's Budget, Exhibit OP-19 (number and cost of engine overhauls); "SAC COMPASS Report" (ENORS data for SAC aircraft); "Aerospace Engine Life Data" (Gas Turbine Engines), AFLC Form 986 (various engine data); and the D165A monthly grid report for engines.

In "Analysis of Data and Trends," we mentioned certain problems and inconsistencies relating to the engine data. First, both the EADS and the AFLC DO24DBT10 report contain inventory levels of installed engines, but those levels do not agree. The three largest discrepancies for June 1976 are shown below:

Engine	No. of Installed Engines		
	AFLC	EADS	Δ
J57-19/29	1662	1033	629
J57-43	1860	1550	310
J79-17	1465	1364	101

AFLC is investigating the discrepancies, but they have not yet been resolved.

Second, prior year total inventory levels (installed and spares), contained in the DO24DBT10 data, were provided to us as of the end of each calendar year, rather than the fiscal year as were the EADS data. To account for these two problems, we interpolated the total inventory level data to fiscal year positions, and then subtracted the EADS installed inventory levels to obtain the spares inventory levels. This adjustment assumes, in effect, that the DO24BDT10 data are correct regarding total inventory levels.

Third, in computing the total number of engine returns, we have applied the actual JEIM Return Rate (Item 9 on the EADS) to the base maintenance usage removals (premature and periodic inspection, Items 17 and 18 in the EADS format) to obtain the number of engines repaired at the base. This assumes that repairs on all such usage removals were accomplished in the same fiscal year.

Fourth, in cases where AFLC-furnished overhaul data on the sample engines do not agree with the OP-19 data, we relied on and accepted the AFLC data.

Fifth, total engine inventory value data (from DO24DBT10), being end of calendar year positions, were also interpolated in the same manner as total inventory levels.

Sixth, overhaul cost data are based on third or fourth quarter reports provided by AFLC. These costs are generally greater than those shown in the OP-19 data, because they include not only the industrial fund costs but also the extra costs of exchangeables and other management items subject to repair.

The ENORS rate is reported in AFLC Management Indicators, with separate rates for jet and reciprocating engines. The ENORS parts incidents and parts hours are reported in the AFLC D165A monthly grid report, but are not reported by engine families. The terms of the ENORS rate (ENORS hours and engine possessed hours) are reported in the DO24BBJ1W report on a monthly basis by engine families.

Table 4-2, below, displays total fleet jet engine hours from FY 1973 to FY 1976 and the cumulative changes.

TABLE 4-2. TOTAL FLEET JET ENGINE HOURS

	FY 73	FY 74	FY 75	FY 76
Oklahoma City ALC	8,336,941	5,632,156	5,361,719	4,968,102
San Antonio ALC	4,641,398	4,090,969	4,089,133	3,682,701
Total	12,978,339	9,723,125	9,450,852	8,650,803
Δ (Cumulative)	-	-3,255,214	-3,527,487	-4,327,536
% Change (Cumulative)	-	-25%	-27%	-33%

Table 4-3 provides sample engine data derived from the sources discussed above. It reports inventory levels, numbers of usage removals and returns, cumulative overhaul backlog, and fleet engine hours and the changes thereto for each year. Table 4-4 provides engine overhaul and cost data on the same sample engines. The cost data provided by AFLC were corrected for inflation by OSD (Comptroller) deflators of civilian pay for "Unit Cost of DMA Rate" and of O&M for "Unit Cost of CP Repair." While some inaccuracies may have resulted (e.g., use of civilian pay deflators for contractor overhaul costs), the discrepancies are minor. Total overhaul costs were obtained by multiplying unit cost by number of overhauls.

During the period FYs 1973 to 1976, the Air Force changed the workload mix among types of engines and the cost structure and accounting procedures for costing engine overhauls. The effect of these changes on the data in Table 4-4 has not been addressed.

TABLE 4-3. SAMPLE ENGINE DATA

Engine/Aircraft	FY	INVENTORY (End of Fiscal Year) Total	Installed	Spares	USAGE REMOVALS Total	Base Maint.	Overhaul	RETURNS Total	Base Maint.	Overhauls	Non-Usage Removals	Cumul. Overhaul Backlog	Fleet Engine Hours	Flt. Eng Hours Δ
J57-P-19/29: B-52	73	2,448	1,068	1,380	911	734	177	977	604	188	185	119	897,219	
	74	2,223	1,040	1,183	403	267	136	480	187	189	104	146	375,936	-521,283
	75	2,118	989	1,129	269	206	63	240	161	51	28	203	287,684	-88,252
	76	2,117	1,033	1,084	303	242	61	349	194	110	45	202	233,118	-54,566
J57-P-43 B-52, KC-135	73	1,937	1,717	220	1,663	1,280	383	1,721	1,009	387	325	267	1,593,581	
	74	2,435	1,634	801	1,125	892	233	1,214	733	366	115	293	801,715	-791,866
	75	2,427	1,657	770	964	754	210	951	611	281	59	365	710,730	-90,985
	76	2,420	1,550	870	942	768	174	901	626	210	65	471	654,179	-56,551
J57-P-59: C,KC-135	73	3,133	2,623	510	1,736	1,306	430	1,802	1,008	580	214	148	1,452,050	
	74	3,126	2,586	540	1,281	1,022	259	1,485	844	419	222	166	961,282	-490,768
	75	3,124	2,600	524	1,284	1,043	241	1,378	876	359	143	215	915,946	-45,336
	76	3,117	2,630	481	1,458	1,269	189	1,425	1,104	259	62	310	836,393	-79,553
J79-GE-15: F,RF-4C/D	73	2,952	2,251	701	1,529	1,237	292	2,316	1,009	680	627	0	695,840	
	74	2,837	2,151	686	1,273	1,035	238	1,704	848	537	319	0	577,821	-118,019
	75	2,827	2,088	739	1,234	1,057	177	1,878	909	562	407	0	573,846	-3,975
	76	2,785	2,144	641	1,233	1,051	182	1,772	895	520	357	0	538,794	-35,052
J79-GE-17: F-4E	73	1,510	1,181	329	834	685	149	1,402	565	429	408	0	437,015	
	74	1,562	1,103	459	479	384	95	861	310	282	269	0	307,141	-129,874
	75	1,617	1,113	504	635	541	94	1,034	463	354	217	0	306,686	-455
	76	1,723	1,364	359	671	582	89	843	507	209	127	0	307,937	+1,251
TF30-P-3: F-111	73	561	355	206	394	196	198	449	101	205	143	88	116,012	
	74	530	339	191	436	252	184	406	152	199	55	173	100,452	-15,560
	75	524	313	211	364	223	141	443	141	212	90	184	87,949	-12,503
	76	517	292	225	345	190	155	643	105	228	310	196	67,971	-19,978
TF30-P-9: F-111D	73	236	178	58	25	19	6	25	14	10	1	1	25,933	
	74	234	180	54	57	43	14	61	32	20	9	6	33,176	+7,243
	75	233	181	52	75	57	18	62	46	8	8	27	35,181	+2,005
	76	232	116	116	159	112	47	199	79	47	73	60	32,675	-2,506

TABLE 4-3. SAMPLE ENGINE DATA (Continued)

Engine/Aircraft	FY	INVENTORY (End of Fiscal Year) Total	Installed	Spares	USAGE REMOVALS Total	Base Maint.	Overhaul	RETURNS Total	Base Maint.	Overhauls	Non Usage Removals	Cumul. Overhaul Backlog	Fleet Engine Hours	Flt. Eng Hours Δ
TF30-P-100: F-111	73	200	149	51	69	51	18	84	38	29	17	2	39,290	
	74	231	164	67	46	27	19	47	16	26	5	6	37,946	1,311
	75	257	172	85	80	40	40	235	20	115	100	0	46,550	+8,604
	76	268	165	103	130	72	58	450	40	100	310	0	45,418	-1,152
TF33-P-3: B-52H	73	888	773	115	202	148	54	326	111	135	80	0	312,555	
	74	889	758	131	282	232	50	350	194	108	48	0	296,009	16,546
	75	894	732	162	295	223	72	260	175	72	13	48	347,403	+51,394
	76	896	738	158	344	303	41	355	267	63	25	62	294,315	53,088
TF33-P-7/7A: C-141	73	1,413	1,233	210	815	635	180	776	501	204	71	110	1,741,255	
	74	1,430	1,111	319	580	466	114	680	378	216	86	96	1,242,214	499,041
	75	1,410	1,094	316	666	555	111	740	481	159	100	122	1,177,606	64,608
	76	1,385	1,101	284	696	620	76	783	554	143	86	121	1,188,079	+10,473
TF39-GE-1/1A: C-5A	73	464	277	187	225	142	83	252	100	129	23	0	211,028	
	74	464	278	186	178	118	60	242	89	114	39	0	189,336	-21,692
	75	462	275	187	170	121	49	265	101	98	66	0	167,822	-21,514
	76	460	285	175	142	123	19	223	110	45	68	0	169,549	+1,727
TF41-A-1/1A: A-7	73	447	314	133	183	68	115	250	26	99	125	58	96,671	
	74	507	248	259	436	123	313	484	35	227	222	232	111,403	+14,732
	75	532	291	293	654	200	454	626	64	509	53	313	100,745	10,658
	76	550	400	400	882	504	378	848	289	476	83	430	95,270	5,475
Totals	73	16,219	12,119	4,100	8,586	6,501	2,085	10,380	5,086	3,075	2,219	793	7,618,449	
	74	16,468	11,592	4,876	6,576	4,861	1,715	8,014	3,818	2,703	1,493	1,118	5,088,431	-2,530,018
	75	16,425	11,507	4,918	6,690	5,020	1,670	8,112	4,048	2,780	1,284	1,477	4,758,148	330,283
	76	16,470	11,824	4,646	7,305	5,836	1,469	8,791	4,770	2,410	1,611	1,852	4,463,698	294,450

TABLE 4-4. ENGINE OVERHAUL AND COSTS (CONSTANT FY 1976 DOLLARS)

ENGINE	FY 1973 No. of O/H's	FY 1973 Unit Cost of DMA Rate	FY 1973 Unit Cost of CP Repair	FY 1973 Total Unit Cost	FY 1973 Total Cost (x 10³)	FY 1974 No. of O/H's	FY 1974 Unit Cost of DMA Rate	FY 1974 Unit Cost of CP Repair	FY 1974 Total Unit Cost	FY 1974 Total Cost (x 10³)
J57-19	106	$ 37,163	$13,345	$ 50,508	$ 5,353.5	108	$23,196	$ 36,146	$ 59,342	$ 6,408.9
J57-29	82	38,043	15,215	53,258	4,367.2	61	23,281	36,126	59,407	4,312.0
J57-43	387	42,114	10,989	53,103	20,550.9	366	23,699	43,673	67,372	24,658.2
J57-59	580	44,696	14,457	59,153	34,308.7	419	64,080	12,223	76,303	31,971.0
J79-15	680	39,507	2,630	42,137	28,653.2	537	23,523	19,702	43,225	[illegible].8
J79-17	429	37,505	4,103	41,608	17,849.8	282	20,033	25,409	45,442	12,814.6
TF30-3	205	32,031	8,954	40,985	8,401.5	199	24,291	18,407	42,698	8,496.9
TF30-9	10	28,232	4,808	33,040	330.4	20	22,582	18,063	40,645	812.9
TF30-100	29	36,902	11,981	48,883	1,417.6	26	30,847	18,063	48,910	1,271.7
TF33-3	135	33,321	10,007	43,328	5,849.3	108	20,021	33,450	53,471	5,774.9
TF33-7/7A	204	34,136	12,957	47,093	9,607.0	216	21,254	35,015	56,269	12,154.1
TF39-1/1A	129	132,306	43,782	181,088	23,360.4	114	32,330	128,832	161,162	18,372.5
TF41-1/1A	99	29,407	2,360	30,767	3,045.9	227	61,171	5,822	66,993	15,207.4
TOTALS	3,075	---	---	---	$163,096.1	2,703	---	---	---	$165,966.9
AVG. COST	---	---	---	$ 53,039	---	---	---	---	$ 61,401	---

ENGINE	FY 1975 No. of O/H's	FY 1975 Unit Cost of DMA Rate	FY 1975 Unit Cost of CP Repair	FY 1975 Total Unit Cost	FY 1975 Total Cost (x 10³)	FY 1976 No. of O/H's	FY 1976 Unit Cost of DMA Rate	FY 1976 Unit Cost of CP Repair	FY 1976 Total Unit Cost	FY 1976 Total Cost (x 10³)
J57-19	30	$ 25,381	$34,432	$ 59,813	$ 1,794.4	62	$24,669	$ 32,411	$ 57,080	$ 3,539.0
J57-29	21	26,238	34,412	60,650	1,273.7	46	24,243	29,686	53,929	[illegible]
J57-43	281	25,507	39,533	65,040	18,276.2	210	23,565	35,822	59,387	12,471.3
J57-59	339	35,807	18,941	54,779	18,565.5	259	41,724	22,051	63,775	16,517.7
J79-15	562	25,603	27,239	52,847	29,700.0	520	27,640	25,335	52,975	27,547.5
J79-17	354	24,389	24,422	48,811	17,279.1	209	25,163	24,752	49,915	10,432.2
TF30-3	212	28,857	26,660	55,517	11,769.5	228	41,951	41,768	83,719	19,087.9
TF30-9	8	27,098	31,382	58,480	467.8	47	41,060	30,694	[illegible]	[illegible]
TF30-100	115	53,229	31,382	84,611	9,730.3	100	52,280	94,758	147,038	14,703.8
TF33-33	72	21,507	41,121	62,628	4,509.2	63	20,410	42,948	63,358	3,991.6
TF33-7/7A	159	20,162	32,029	52,191	8,298.4	140	18,654	43,213	61,867	8,847.0
TF39-1/1A	98	32,031	138,541	170,572	16,716.1	45	34,913	148,187	183,100	8,239.5
TF41-1/1A	509	30,915	25,149	56,065	28,537.1	476	45,073	12,163	57,236	27,244.3
TOTALS	2,780	---	---	---	$168,017.2	2,410	---	---	---	$160,332.6
AVG. COST	---	---	---	$ 60,438	---	---	---	---	$ 66,777	---

CHAPTER 5: EXCHANGEABLE (INVESTMENT) ITEMS
BP 15 AIRCRAFT REPLENISHMENT SPARES

OVERVIEW AND STRUCTURE

Exchangeables, variously denoted by the Air Force as repairables, recoverables or investment items, constitute the inventory of weapon system spare parts. Of the total dollar inventory of investment items, 81% are related to various aircraft systems in the Air Force inventory, and the rest are spares for other end items or support equipment such as missiles and communications equipment. The relative proportions of aircraft-related and other items in the Air Force inventory of exchangeables have remained stable over the past four years. Although our emphasis is on aircraft and engine-related exchangeable items, data for all Air Force investment items are presented in some instances, since separate breakouts by item type are not always available.

In principle, inventories of exchangeable items are held for the sole purpose of meeting various maintenance pipeline requirements. Since these pipelines are longer when an item is repaired at the depot, inventory and repair requirements are developed to reflect where repair will occur, as well as item-specific demand rates. Because some fraction of the inventory cannot be repaired and is therefore condemned, procurement lead times for inventory replenishment are also considered in the determination of inventory and repair requirements.

Figure 5-1 diagrams the exchangeable flow process in relation to the entire support and aircraft operational cycles. The diagram indicates the broad spectrum and geographical dispersion of the various activities involved in the exchangeable repair and supply process. The provision of serviceable items to final users at base and depot and the repair of unserviceables involves maintenance and supply at both depot and base levels. Furthermore, the lack of a required serviceable asset at Base Supply, which may result in an aircraft's being reported NORS, can be caused by either a supply or a maintenance deficiency. Base Maintenance may not be able to repair an item in a timely fashion, perhaps because supply cannot furnish the necessary "bits and pieces," or the supply system itself may not be able to deliver a serviceable replacement from central inventory to the user expeditiously.

A more detailed picture of the exchangeable process is presented in Figure 5-2, which shows the physical flow of exchangeables and relationships among Central and Base Supply, Depot and Base Maintenance, and using commands. At the base level, users return

FIGURE 5-1. GENERAL STRUCTURE OF THE EXCHANGEABLE FLOW PROCESS

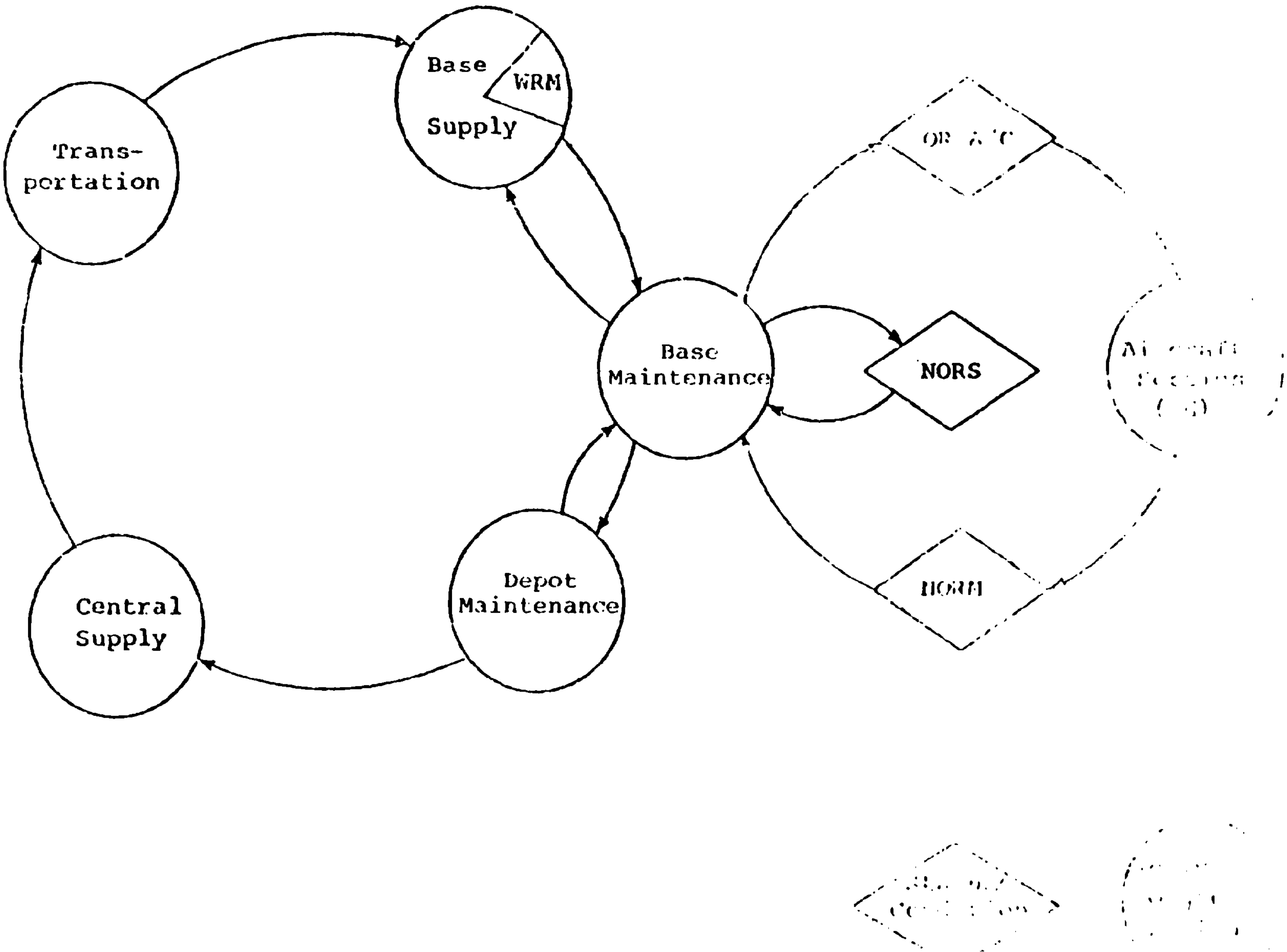
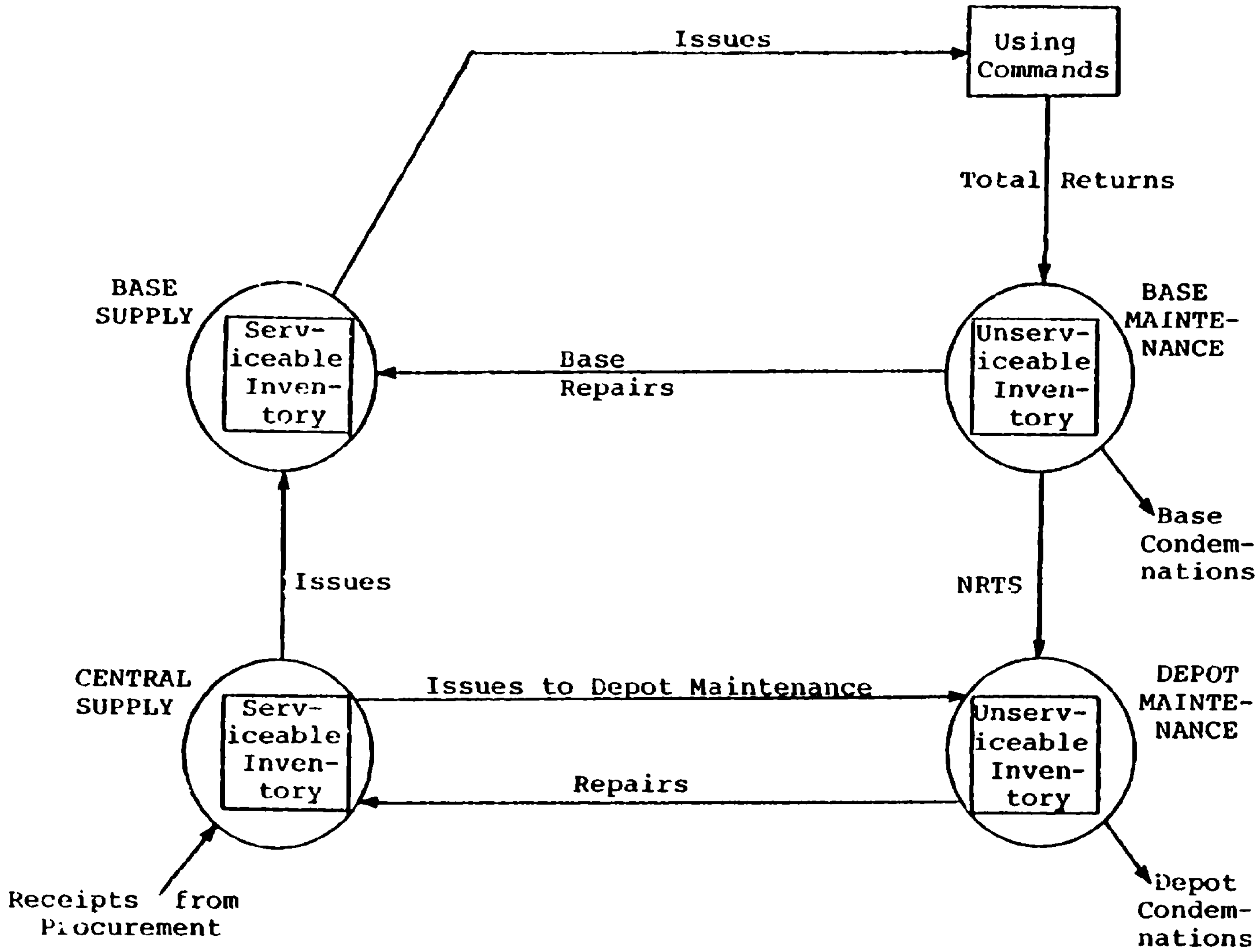


FIGURE 5-2. DETAILED STRUCTURE OF THE EXCHANGEABLE FLOW PROCESS



unserviceable assets to Base Supply for repair. Base Supply exchanges the unserviceable asset for a serviceable replacement, provided it is available. If such a replacement is not available at Base Supply, several alternative actions are possible. The item can often be quickly repaired at base or backordered by Base Supply and requisitioned from Central Supply. Other alternatives include cannibalization, use of WRM and lateral support from another base. When Base Maintenance cannot or should not repair an item due to lack of required resources, the item is sent to the assigned depot facility for repair (NRTS). Items repaired at depot level facilities become part of the central level inventory of serviceable assets held to meet demands made by Depot Maintenance in conjunction with aircraft and engine overhauls, and demands made by Base Supply to satisfy stock requirements or backorders.

The exchangeable repair process is thus quite complex, involving two levels of supply and maintenance and requiring coordination across logistics functions. Furthermore, the system is neither closed nor static, since changes occur because of condemnations and new procurements; new systems are constantly introduced, and old ones retired. The performance of the maintenance and supply activities for exchangeable items affects aircraft operational status through aircraft NORS hours. The inability to repair and supply these items expeditiously when and where they are needed can cause aircraft to be recorded as NORS.

The magnitude of activity represented by the exchangeable process is significant. In FY 1976, the inventory value of aircraft-related exchangeables amounted to $5.7 billion, while total exchangeable items (aircraft, missiles, and others) represented an inventory of $7.1 billion. There are over 142,000 separate line items in this inventory. The cost to repair aircraft and engine-related exchangeables by depot level maintenance activities is also large in absolute and relative terms. Approximately 37% of Air Force depot maintenance expenditures, or about $370 million, were used for repair of aircraft and engine exchangeables in FYs 1974 and 1975. For FY 1976, this expenditure had climbed to over $550 million and represented 47% of total depot maintenance costs.

From an aggregate perspective, a high rate of utilization occurs with these items. The turnover rate (issues relative to average total assets) increased from approximately two in FY 1973 to a high of nearly three by FY 1976. Since issues generate a repair action typically accomplished within the year, this turnover rate implies that the typical item is utilized, replaced and repaired two to three times per year. Of course, our aggregate data are mainly in dollars and thus represent average experience based on component value. Many low cost items may in fact seldom enter the replace-repair-return cycle, while others may do so many more times than the average.

An important consideration in the analysis of trends in the exchangeable process is the change in composition and mix of aircraft in the Air Force inventory. Different aircraft place vastly different demands upon the exchangeable item support system, depending on their mission, performance, and complexity, and the inherent reliability of their subsystems. To illustrate this point, we have examined data from the DO41A recoverable item system, prepared by the Air Force. System-specific data have been extracted from this system. As of June 1976, there were 75,817 separate BP-15 items with master stock numbers. About one-third of all BP-15 items are associated with the nine important systems we have selected for close examination. These active systems certainly account for a much higher percentage of the total inventory count in comparison to the number of separate items in the inventory. In the following table, we have listed these nine systems in order of increasing number of associated recoverable items.

BP-15 Recoverable Items by MDS (1 October 1976)

MDS	No. of Recoverable Items
C-135A	1,177
A-7	1,460
F-4C, D, E Average	1,573
C-130A, B, E Average	1,828
C-141A	2,337
B-52G, H Average	2,831
F-111A	3,495
F-15A	3,834
C-5A	6,497
TOTAL	25,032
ALL BP-15	75,817

SOURCE: VSL DO41A System and DO41 Recoverable Items-Application Analysis by MDS, 1 Oct. 76 Processed by LMI

The complexity of the newer systems, as measured by the number of associated recoverable items, is apparent. The C-5A has more than three times the number of items as the C-130 and C-141A, while the F-15 has twice the number of items as the F-4. The change in the composition of the flying hour program caused by the introduction of the more complex systems is unlikely to produce a reduction in repair requirements proportional to the reduction in aggregate flying hours.

The balance of Chapter 5 presents an analysis of data and trends for the exchangeable process, with emphasis on aircraft-related items. First, the relationship and contribution of these items to aircraft operational status are described. Next, the behavior of aircraft activity rates and demands for these items is reviewed and measures of performance against available resources are described. Findings and conclusions about the details of production and performance trends are then presented, and the final section describes relevant data and data sources.

ANALYSIS OF DATA AND TRENDS

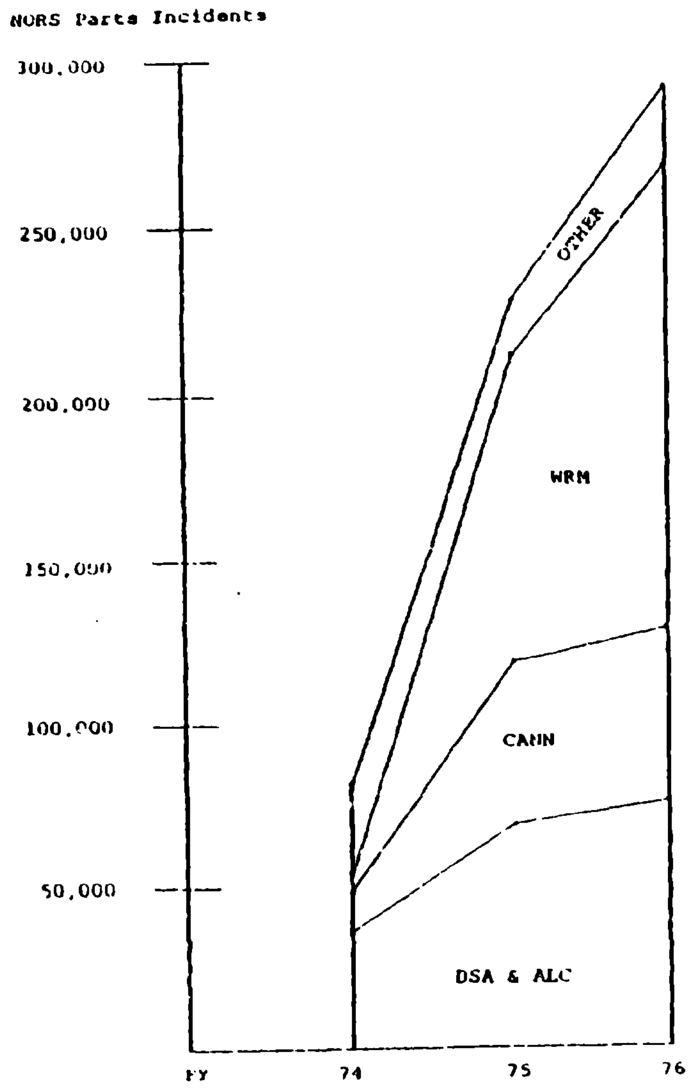
Data extracted from the Worldwide Grid report indicate separately for aircraft and engine exchangeables the number of NORS incidents, their duration, and the method by which they were terminated. These data link the exchangeable repair system with aircraft operational status.

A NORS incident occurs when a serviceable item is not locally available, an unserviceable replacement cannot quickly be repaired at base, and the aircraft is reported NORS. During FYs 1974 to 1976, the number of NORS incidents for aircraft and engine-related exchangeables grew by over 200%. The number of accrued NORS hours for these items increased by only 20% over the same period. This apparent discrepancy can be partly explained by the methods used to terminate NORS incidents. Greater reliance on methods such as cannibalization and the use of WRM, which can satisfy incidents in the shortest possible time, has substantially reduced the average duration of a NORS incident. Figure 5-3 displays the number of NORS incidents for aircraft and engine exchangeable items and the methods by which the incidents were terminated. For the more important aircraft-rela .ed items, the increased reliance on cannibalization and WRM is evident. Because of double counting, absolute growth in the number of cannibalizations can lead to an increase in reported NORS incidents. NORS incident hours are therefore a more reliable indicator of the relative performance of the maintenance and supply system for exchangeable items.[1]

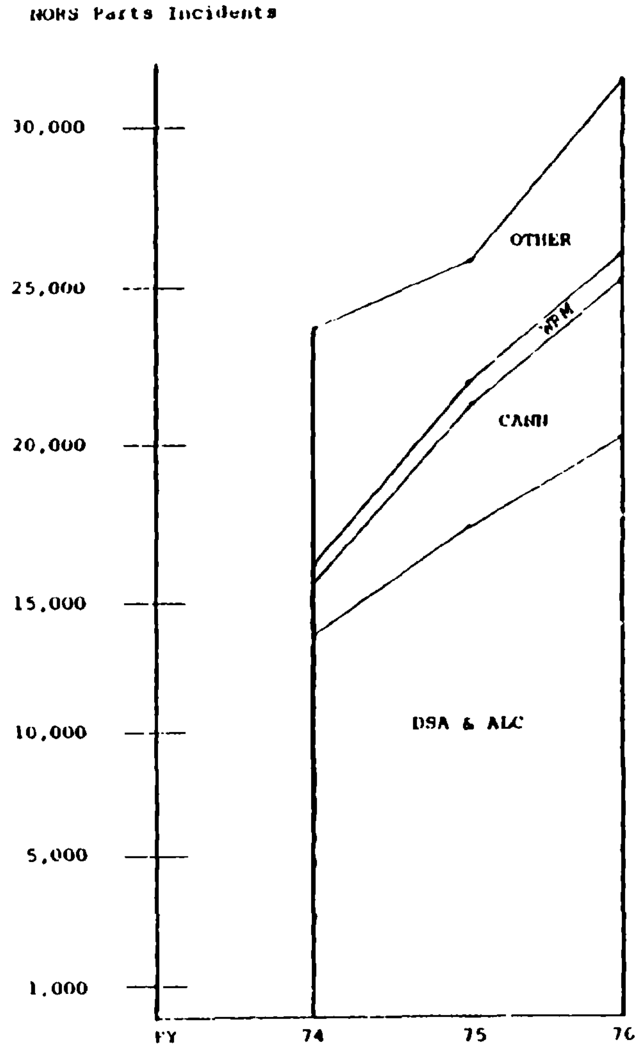
The linkage between NORS incidents and aircraft NORS is thus based on NORS incident hours. Focusing on aircraft-related exchangeables (engine-related items create ENORS), we see that they accounted for approximately 33% of total NORS incident hours in FY 1974 and increased to nearly 46% of total NORS incident hours by FY 1976. It was demonstrated in Chapter 2 that one NORS incident hour translates into considerably less

[1] See Chapter 2 for a complete discussion of NORS hours and NORS incident reporting.

FIGURE 5-3. NORS PARTS INCIDENTS AND METHODS OF TERMINATION FOR AIRCRAFT AND ENGINE EXCHANGEABLES



NORS PARTS INCIDENTS FOR AIRCRAFT EXCHANGEABLES



NORS PARTS INCIDENTS FOR ENGINE EXCHANGEABLES than one NORS aircraft hour. Assuming that the ratio of NORS incident hours to NORS aircraft hours is the same across all NORS-causing items, we can therefore conclude that aircraft exchangeables accounted for between 33% (FY 1974) and 46% (FY 1976) of all aircraft NORS hours.

We turn next to an examination of the level of demands made by users (through Base and Depot Maintenance) for serviceable exchangeable items. In Figure 5-4, the level of demands received by Base and Central Supply, respectively, is displayed along with the number of issues. The ratio of issues to demands received is the fill rate or proportion of demands that are filled.[2]

Base Supply receives demands for serviceable items from using commands. Figure 5-4 shows that the number of such demands for all exchangeable items has increased by 6% between FYs 1974 and 1976. During this period, aggregate flying hours declined by 22%, while the number of aircraft in the active inventory declined by 8.5%. This discrepancy between the decrease in flying hours and the increase in demands from Base Supply is difficult to rationalize. The obvious explanation—that the composition of flying hours has changed with the introduction of more complex aircraft—is not borne out over this period. Only minor changes in the composition of flying hours have occurred.

Base plus central demands are not strictly additive to total demands. Double counting occurs to the extent that demands by Base Supply are backordered and sent to Central Supply. Not all such demands by Base Supply are base level backorders; some demands arise from changes in demand levels, replacements for NRTS items and base condemnation actions.

To estimate total system-wide demands and correct for double counting, the sum of central demands plus base issues can be computed. Base demands that are backorders can thus be counted only once as part of central demands. This calculation places total system-wide demands at 2.991 million items, 3.1431 million, and 3.0553 million for FYs 1974, 1975 and 1976, respectively. Thus, the number of demands for exchangeable items is seen to vary only slightly over this period, despite the decline in both aggregate flying hours and active aircraft inventory.

Note that at the central level, the fill rate, which measures the ratio of issues to demands received, held constant at 57%, despite a decline in demands from 1.89 million in FY 1973 to 1.53 million in FY 1976. In contrast, Base Supply increased its fill rate from 64% in FY 1974 to 68% in FY 1976, while demands increased from 2.02 million to 2.14 million over the same period.

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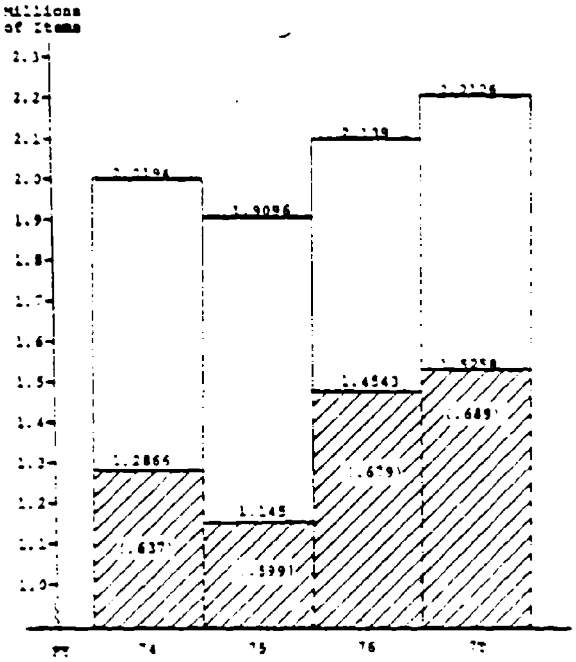
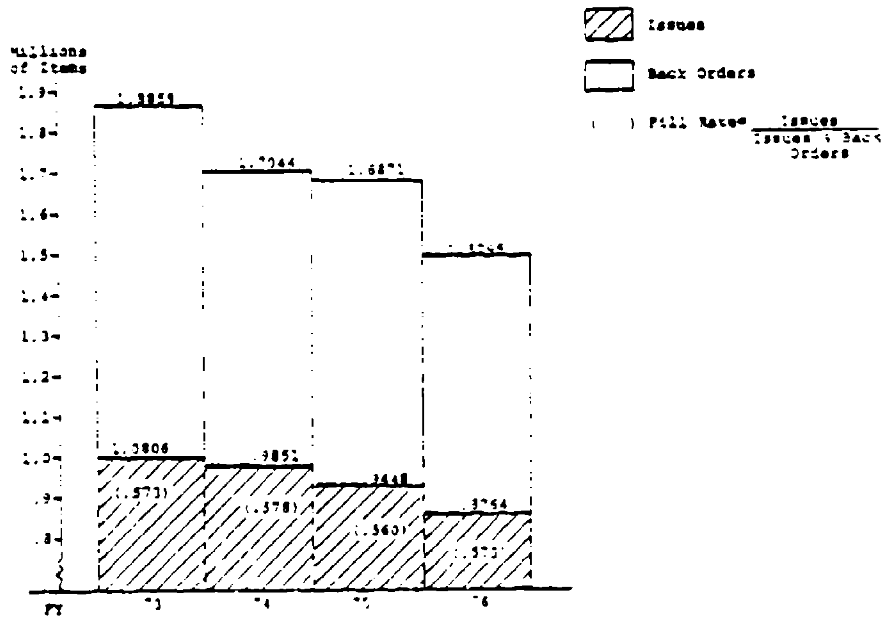
[2] If action by Base Maintenance can satisfy a demand, the item is not backordered, but rather called a "due in" from maintenance. When Base Maintenance completes the repair, the demand becomes an issue from Base Supply.

FIGURE 5-4. BASE AND CENTRAL DEMANDS, ISSUES AND FILL RATES



BASE DEMANDS, ISSUES AND FILL RATE
(All Investment Items)



CENTRAL DEMANDS, ISSUES AND FILL RATE
(All Investment Items)

Data on aircraft-related exchangeables describing the value of unserviceable returns to base and depot can be used in conjunction with data on the value of unserviceable assets and condemnations to infer the relative amount of repairs accomplished at base and depot. Figure 5-5 displays two series; the lower trend shows the number of reparable generations (unserviceable returns) over a 10-year period from a sample of 30 Air Force bases. We do not have other data for this sample that describe flying hours or fleet composition, so we can therefore only conclude that the level of unserviceable returns appears to trend in approximately the same way as the behavior of aggregate flying hours, provided that our sample is representative of the Air Force. The more limited trend in the top portion of Figure 5-5 shows the value, as opposed to the number, of aggregate unserviceable returns to Base and Depot Maintenance for FYs 1973 to 1976. The value data include the impact of inflation for this period, since the items are revalued at the latest acquisition price.

From Figure 5-5, especially the value data in the upper diagram, the demands for repair of exchangeables placed upon Base and Depot Maintenance are apparent. Although the total value of exchangeable items to be repaired has grown, this growth most likely represents a stable physical level, as indicated by the demand data from Figure 5-4. On a relative basis, a more revealing trend is evident—a greater proportion of exchangeable items is being retained at Base Maintenance for repair. The NRTS rate, which represents the proportion of items sent by Base Maintenance to the depots for repair, declined from 29.3% in FY 1973 to 22% by FY 1976. Furthermore, the value of returns to Depot Maintenance was nearly constant over this period, despite inflation in item values.

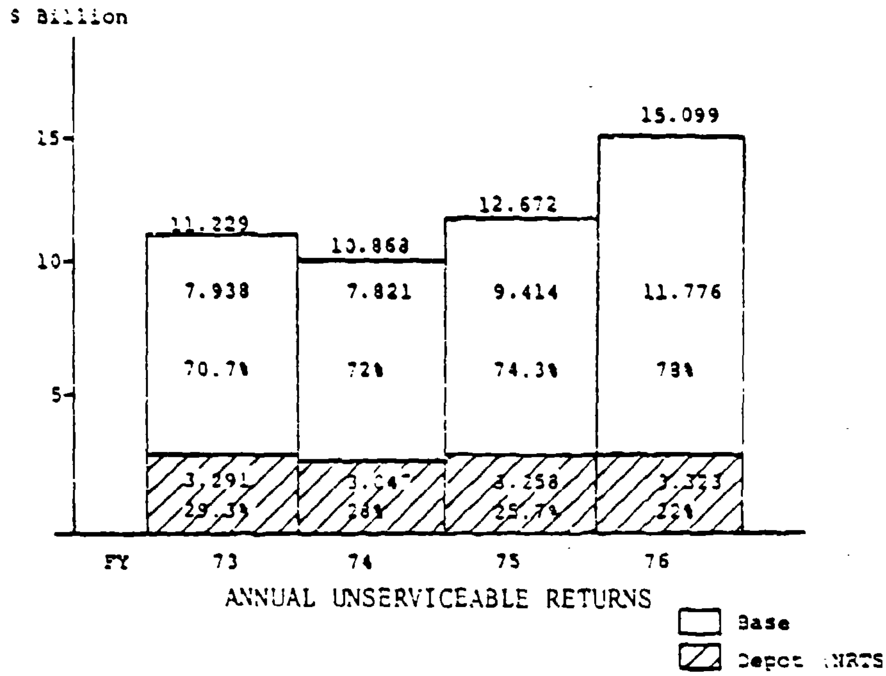
These data, combined with information on the annual change in the inventory value of unserviceable exchangeable items and condemnations, can be used to infer the value of exchangeable items repaired by Base and Depot Maintenance. An unserviceable item returned to maintenance is either repaired and returned to the serviceable inventory, backlogged as unserviceable, or condemned. If we assume that the changes in the unserviceable backlog take place at Depot Maintenance (the average time between induction and repair is quite short at base), then the following identities can be used to determine the annual value of base and depot repair.

Repair at depot = return to depot (NRTS) - change in unserviceable assets - depot condemnations.

Repair at base = returns to base - base condemnations - NRTS.

Figure 5-6 displays the value of repairs for aircraft-related exchangeable items computed with these identities for FYs 1973 to 1976. The system-wide increase is evident, although a large but unknown factor accounting for this growth arises from

FIGURE 5-5. REPAIRABLE TRENDS: TOTAL AIR FORCE AND SAMPLE OF BASES



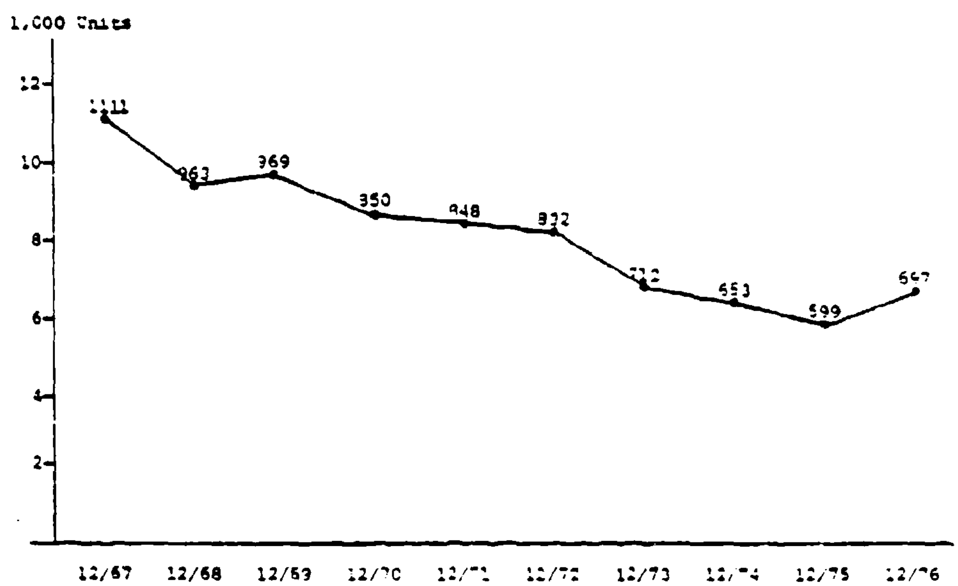
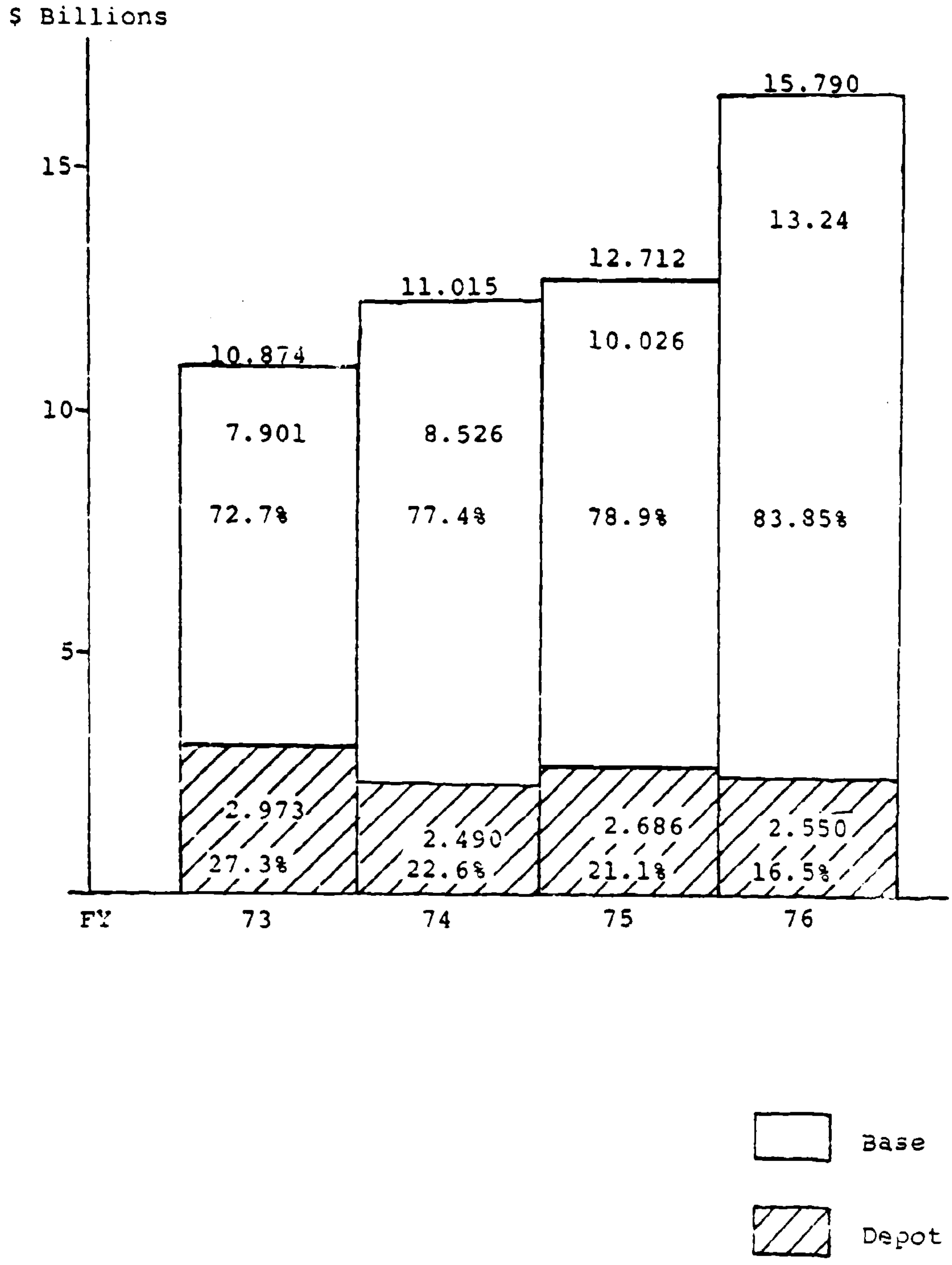


FIGURE 5-6. ANNUAL VALUE OF REPAIRS: TOTAL, BASE, AND DEPOT
(BP-15 Items)



inflation in item value. However, the most revealing aspect of this display is the decline in both the proportion and value of repair accomplished at Depot Maintenance. Over this period, the value of items repaired at depot declined from $2.97 billion in FY 1973 to $2.55 billion by FY 1976, and the percentage of total repair accomplished at depot facilities declined from 27% to 16.5%.[3]

This trend towards greater reliance on base level repair is significant, since maintenance pipeline requirements are thereby reduced and user organizations become more self-sufficient. As more repairs are accomplished at the base level, both the need for spares inventory and the amount of depot expenditures for repair of exchangeable items should be reduced. Figure 5-7 displays the value of aircraft-related items repaired per dollar of depot maintenance costs for exchangeable repairs, and its reciprocal, exchangeable repair costs as a percentage of the value of the repair item. Both trends indicate that expenditures for exchangeable repair have increased more than in proportion to the amount of repair accomplished (in dollar value) between FYs 1974 and 1976, resulting in higher repair cost per dollar of repaired item value.

Figure 5-8 shows the year-to-year change in the level of unserviceable assets (i.e. the backlog of unserviceables), which is derived from considering the total level of unserviceable assets between the beginning and end of each fiscal year. Most of these unserviceable assets are held at the depots, so that the annual change in the unserviceable backlog indicates the extent to which repair kept pace with the induction of items awaiting repair. The backlog was actually reduced in FY 1973, but in the three subsequent years, increases of $223 million, $276 million and $47 million occurred. Despite a substantial increase of $281.7 million in FY 1976 budgeted expenditures for depot repair of aeronautical exchangeables (compared to a total budget of $371.4 million in FY 1975), the backlog of unserviceable assets actually increased in FY 1976. The additional $281.7 million merely reduced the number of additions to the unserviceable backlog and did not diminish the existing backlog. Had depot maintenance "productivity," as measured by the value of items repaired per dollar of depot maintenance expenditure, remained in FY 1976 at the FYs 1974 and 1975 level of about $7, a total of $3.8 billion worth of items would have been repaired. Our estimate of repair value actually accomplished at the depots in FY 1976 is $2.5 billion, so that about $1.3 billion of the cumulative backlog would have been worked off.

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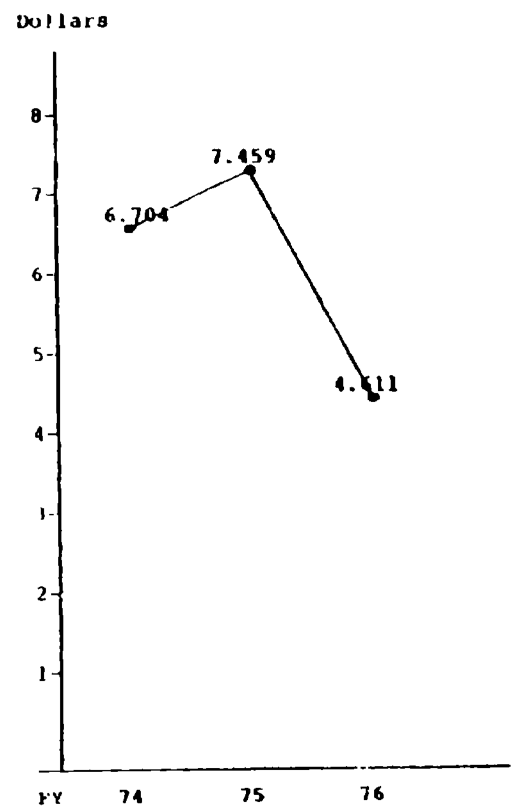
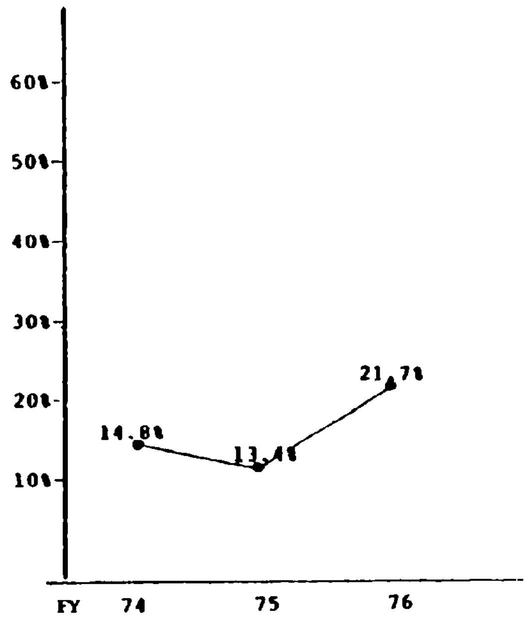
[3]Trend behavior for the value of items repaired at depot is based on the identity presented above. The GO19C MISTR System places the value of MISTR items repaired organically at depot at $3.47 billion. Although this value does not coincide with that derived from the above identity, LMI knows of no evidence to contradict the conclusion that repairs accomplished by Depot Maintenance have declined over time.

FIGURE 5-7. DEPOT MAINTENANCE PRODUCTIVITY MEASURES



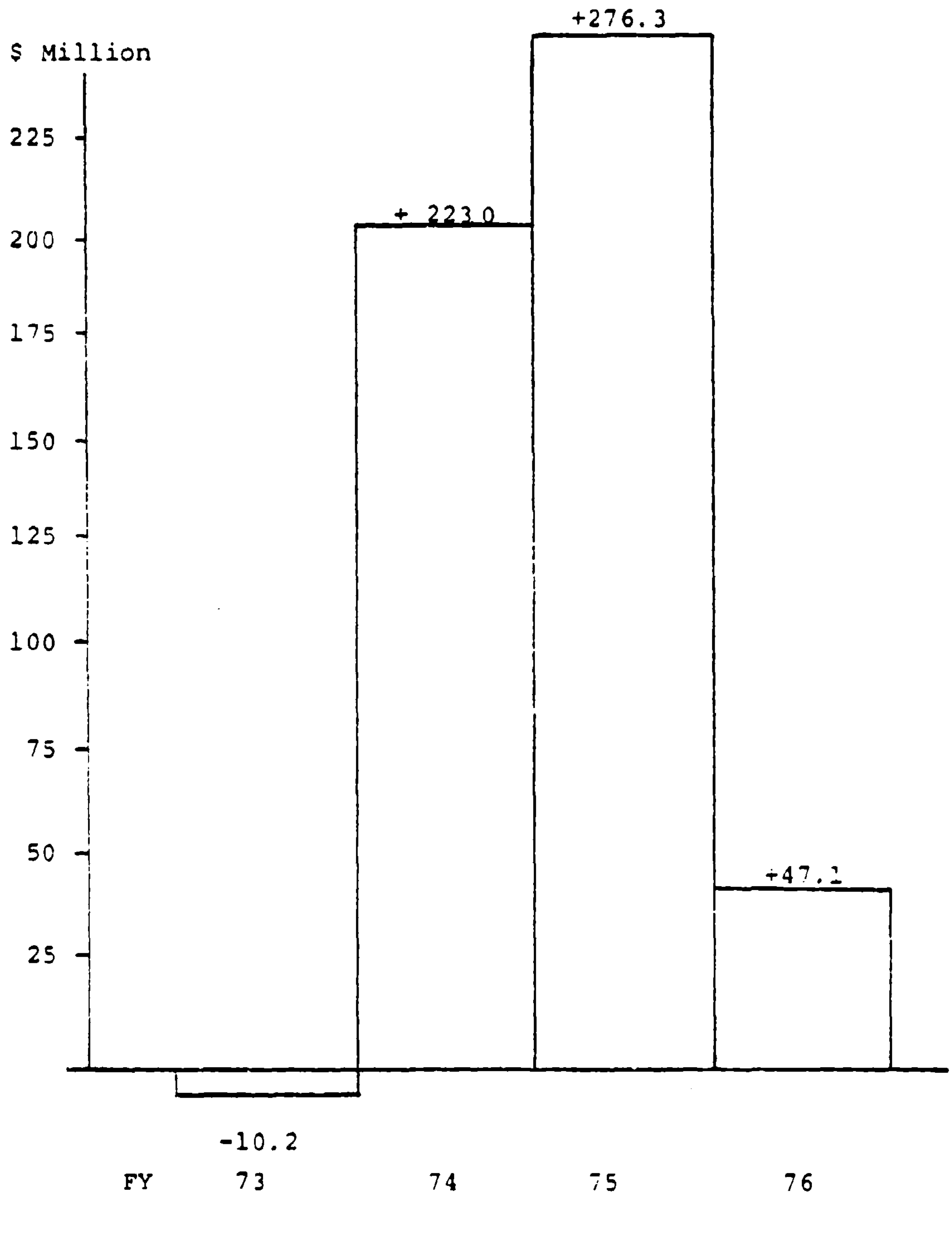
VALUE OF ITEMS REPAIRED AT DEPOT PER DOLLAR OF D-M COSTS FOR EXCHANGEABLE REPAIRS

or reciprocal



AVERAGE EXCHANGEABLE REPAIR COST AS A PERCENTAGE OF ITEM VALUE

FIGURE 5-8. ANNUAL CHANGE IN UNSERVICEABLE ASSETS

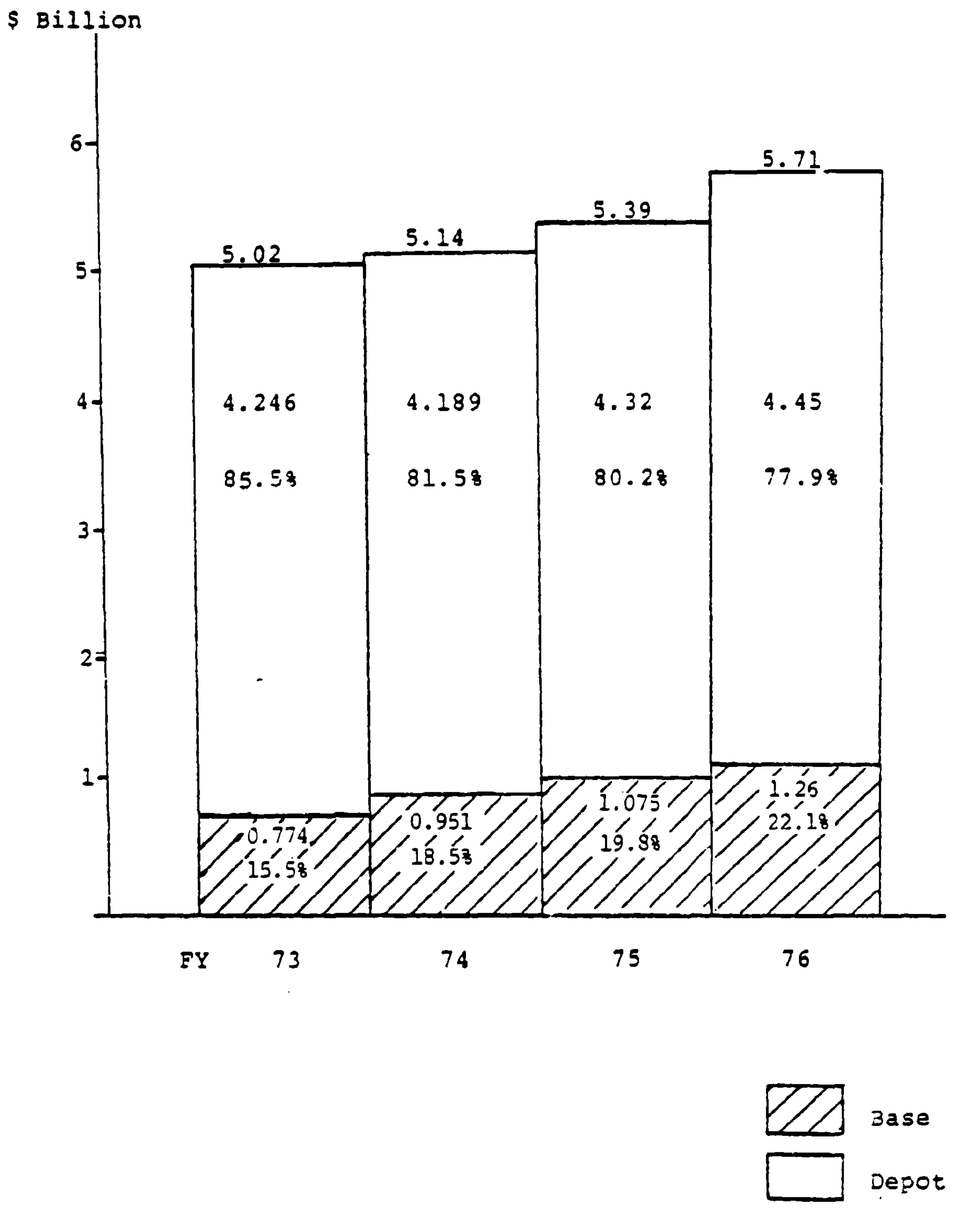


As previously mentioned, increased efficiency in the maintenance and supply system for exchangeables can be manifested in two ways--reduced repair costs, or reduced inventory relative to demands satisfied. We have seen that the amount of repair accomplished at Depot Maintenance has decreased relative to demands satisfied. We have also noted that the amount of repair accomplished at Depot Maintenance has decreased relative to expenditures for maintenance. Figure 5-9 displays the average value of aircraft-related exchangeable inventory as between Base and Central Supply for FYs 1973 to 1976. The value of this inventory has increased slightly (nearly 14%) over this period. However, inflation affects the inventory value of items subject to new procurement. Since it is not possible to deflate the inventory, we have concentrated on examining the relative distribution of assets between Base and Central Supply and comparing the behavior of issues to inventory levels. (Both figures are measured in current dollars.) From Figure 5-9, it is clear that the proportion of assets held at the base level has substantially increased from 15.5% of total assets in FY 1973 to over 22% in FY 1976. As base demands and repair have increased and demands on the depots have declined, more assets have been concentrated at the base level. Over the same period, the ratio of aggregate value of issues to aggregate exchangeable inventory has increased from 2.15 to 2.7, indicating that more use is being made of the existing inventory. This increase in turnover is merely another manifestation of more base repair relative to depot maintenance for these items, since base repair is accomplished quickly and results in reduced inventory tied up in the maintenance pipeline.

Another measure of turnover rate is the ratio of the number of items issued to the dollar value of the inventory level. Unfortunately, the measure can be distorted by inflation. At the base level, this ratio remained constant at 1.35 issues per thousand dollars of inventory in FYs 1974 and 1975, then decreased to 1.21 in FY 1976. The comparable rate for central issue and inventory remained constant at about 0.24 issues per thousand dollars of inventory over FYs 1973 to 1975, and then declined to 0.20 in FY 1976. Thus, base inventory supports about six times the number of issues as depot inventory, and the number of issues supported by base inventory has increased relative to the comparable figure for central inventory.

These results are not entirely consistent with the analysis made of NORS incidents for exchangeable items at the beginning of this chapter. For example, the number of aircraft exchangeable NORS incidents terminated by Central Supply (ALC) has increased from 22,342 in FY 1974 to 72,869 in FY 1976, while the average time required to satisfy these demands has decreased from 228.6 hours to 107.9 hours (Table 5-4). Over the same

FIGURE 5-9. AVERAGE BASE, DEPOT, AND TOTAL ASSETS FOR AIRCRAFT REPLENISHMENT SPARES (BP-15)
(In Current Dollars)



period, the total number of demands made to Central Supply has declined from 1.89 million to 1.53 million, while the ALC fill rate has remained constant (Figure 5-4).

At the base level, the number of total demands for exchangeables was nearly constant; the fill rate increased from 64% to 69%, yet the number of exchangeable NORS incidents increased from 78,768 in FY 1974 to 291,530 by FY 1976. These results suggest that total demand for exchangeables has been steady and that supply is satisfying total demands at rates comparable to past performance. Yet, NORS incidents (demands that cause an aircraft to be NORS) are rapidly growing. There is reason to conclude that some of the growth in NORS incidents results from bias in the reporting system, particularly because cannibalizations have increased and a single parts failure is reported as multiple NORS incidents. This seems plausible since NORS incident hours have exhibited much less growth than NORS incidents.

FINDINGS AND CONCLUSIONS

The major findings and conclusions from the review of data and trends in the exchangeable supply and maintenance process can be summarized as follows.

- Aircraft-related exchangeable items accounted for an increasing share of total NORS incident hours, 33% of such hours in FY 1974, as compared to 46% by FY 1976.

- Between FYs 1974 and 1976, Air Force flying hours declined by 22%, and the number of aircraft in the active inventory declined by 8.5%. Over this period, aircraft-related exchangeable items sustained a 27% increase in NORS incident hours, from 14.4 million in FY 1974 to 18.3 million in FY 1976.

- NORS incidents are not as reliable a measure of system performance as NORS incident hours, because increased use of cannibalization to terminate NORS incidents can lead to double counting of incidents. In recent years, the use of cannibalizations and WRM as methods to terminate NORS incidents has increased.

- Despite a 22% reduction in Air Force aggregate flying hours and an 8.5% reduction in the active aircraft inventory, total item demands for exchangeables increased slightly from 2.991 million in FY 1974 to 3.055 million in FY 1976.

- The number of exchangeable demands has increased at Base Supply and declined at Central Supply from FY 1973 to FY 1976. In contrast, the base fill rate increased while the central fill rate held constant.

- While the total value of unserviceable returns increased, returns to depot (NRTS) exhibited a decline on a relative basis from 29% of total returns in FY 1973 to 22% in FY 1976. The dollar value of depot returns, which includes the effect of inflation, held nearly constant between FYs 1973 and 1976, indicating a decline in the absolute number of returns.

- Repair accomplished by Depot Maintenance declined in absolute dollar terms (measured by the value of items repaired), and more strikingly, the percentage of total repair accomplished by Depot Maintenance declined from 27% of the total in FY 1973 to 16.5% in FY 1976.

- The value of unserviceable assets in the inventory of exchangeable items grew significantly in FYs 1974 and 1975. Despite a large increase in budget funding for depot repair of aeronautical exchangeables, the value of unserviceable items in the inventory continued to grow in FY 1976. If Depot Maintenance "productivity" remained at FYs 1974 and 1975 levels, as measured by the value of items repaired per dollar of depot repair expenditure, $1.3 billion of additional repair would have been accomplished.

- The inventory value of aircraft-related exchangeables increased between FYs 1973 and 1976, but inflation accounted for some unknown proportion of this increase. The concentration of these assets increased at base level from 15.5% in FY 1973 to over 22% by FY 1976. Over this period, the aggregate inventory turnover rate (the ratio of the value of issues to inventory value) increased from 2.15 to 2.75, indicating the increased importance of Base Maintenance. The number of issues supported by a dollar of inventory is six times higher at base than at depot.

DATA AND SOURCE DESCRIPTION

The data developed for analysis of the exchangeable item remove-repair process represent inventory and transactions information, resource costs for repair where available, and certain performance measures. In most instances, the data are expressed in terms of dollars, where valuation is at latest acquisition prices. We have also uncovered a limited amount of historical information on an item or unit basis, covering all Air Force investment items for a sample of 30 bases.

Since the inventory value data are at the latest acquisition price, a serious problem exists in devising an inventory price deflator to convert the inventory on a constant dollar basis. We are prevented from using the DoD procurement deflator, since not all items in the inventory are revalued, only those for which procurement occurred during the period. We have chosen to represent the data on an undeflated (current dollar) basis, since a suitable deflator is not available. The reader should be aware that this convention imparts an upward bias to the data, and that the actual deflator for these data over the period of FYs 1973 to 1976 could be as large as 35%—the increase observed in the overall DoD procurement price index between FY 1973 and FY 1976. The preparation of an inventory deflator, based on the actual number of items undergoing price revision and the magnitude of the price increases for these items, would be a useful enterprise.

The data tables are located at the end of this section. Table 5-1 presents inventory and transactions data over the past four fiscal years for all investment items in the Air

Force inventory. These data were prepared by AFLC at LMI's request. Although data in this format are not currently presented to OSD, they are derived from the DO41 system used to construct the various relevant budget program exhibits, and could be made available with minimum effort on AFLC's part.

From the data in Table 5-1, we see that the inventory increased from an average $6,215.85 million in FY 1973 to $7,122.75 million in FY 1976. This increase was matched by a decline in the number of separate line items (not total inventory count of items) in the exchangeable inventory, from 163,840 to 142,139 over the same period. If it is assumed that the inventory composition and the depth of stockage remained stable, the average unit price for each line item in the exchangeable category increased from $37,950 to $50,120. This average line item value translates into annual price increases, which yield year-to-year inventory deflators of 1.02, 1.06, and 1.32 for FYs 1974, 1975 and 1976, respectively (1973 = 1.00). These price deflators, applied to the inventory and issue data, show a declining constant dollar inventory, with a relatively stable level of annual issues.

Table 5-2 presents a more detailed picture of BP-15 items directly related to aircraft systems. The inventory and transactions data in this table were also prepared for LMI by AFLC from ongoing reporting systems. Again, these data are expressed in terms of current year dollars, since we lack a precise method to deflate to a constant price basis.

We have added additional data to those supplied by AFLC. In particular, we have derived the value of repairs (serviceable returns): in total, at the base and at the depot. This derivation is accomplished by computing the change in the unserviceable backlog, assuming the backlog is at the depot, and subtracting the change in the backlog and depot condemnations from total unserviceable returns to the depot. Additional data are presented for depot maintenance costs for aircraft exchangeables, base level off-equipment maintenance man-hours for selected systems, and performance measures such as the base and depot fill rates. Finally, note that Budget Program 15 data prior to FY 1975 include expendability, recoverability, reparability category (ERRC) code XD plus XF2, while for data pertaining to FY 1975 and beyond, XF2 items are excluded, having been transferred to the Systems Support Stock Fund.

Table 5-3 contains two types of item data, as opposed to the dollar value data of the previous tables. The first grouping covers all Air Force investment items, while the second grouping is from a sample of 30 Air Force bases that has been maintained by AFLC Headquarters. The first group of data (A) lists issues and demands at the base and depot. The fill rate previously reported in Table 5-2 is merely the ratio of issues to demands

TABLE 5-1. INVENTORY AND FINANCIAL TRANSACTIONS: ALL INVESTMENT ITEMS

(BP-15, 17, 25, 8-M, 82, 83, 84, 85)

($ x 10^3)

A. Asset Position	FY 73	FY 74	FY 75	FY 76	
Total Assets BOP	6,150,083	6,273,561	6,441,072	7,012,515	AFLC workup for IMI from DO-41 system
Total Assets EOP	6,273,561	6,441,072	7,012,515	7,233,037	
Serviceable Assets BOP	3,266,460	3,427,348	3,444,672	3,608,340	
Serviceable Assets EOP	3,427,348	3,344,672	3,608,340	3,824,000	
Unserviceable Assets BOP	2,891,623	2,846,213	3,096,400	3,404,175	
Unserviceable Assets EOP	2,846,213	3,096,400	3,404,175	3,409,037	
Base Assets BOP	814,196	1,209,172	1,348,810	1,535,847	
Base Assets EOP	1,209,172	1,348,810	1,535,847	1,654,568	
Depot Assets BOP	5,343,887	5,064,389	5,092,262	5,476,668	
Depot Assets EOP	5,064,389	5,092,262	5,476,668	5,570,469	
Number of Items (Midyear)	163,840	164,338	166,455	142,139	AFLC Fact Book
B. Flows					
Issues	12,241,623	12,500,008	15,169,212	16,232,486	AFLC workup for IMI from DO-41 system
Total NRTS	4,395,188	4,146,283	4,310,119	4,150,118	
Condemnations	402,805	393,100	331,299	754,429	
Returns to Base = Issues - NRTS not NRTS	7,846,435	8,353,725	10,859,093	12,482,362	Derived
Net Demand for Recoverable Items (Millions of Items)	1.886	1.704	1.687	1.530	AFLC Fact Book

TABLE 5-2. INVENTORY AND FINANCIAL TRANSACTIONS: ALL INVESTMENT ITEMS
(BP 15)
($ x 10^3)

	FY73	FY74	FY75	FY76	Sources
A. Asset Position					
Total Assets BOP	4,964,681	5,077,113	5,202,351	5,558,274	AFLC workups for LMI based on DO-41 system
Total Assets EOP	5,077,113	5,202,351	5,581,274	5,864,650	
Serviceable Assets BOP	2,584,334	2,707,006	2,609,206	2,711,808	
Serviceable Assets EOP	2,707,006	2,609,206	2,711,808	2,948,064	
Unserviceable Assets BOP	2,380,347	2,370,107	2,593,145	2,869,466	
Unserviceable Assets EOP	2,370,107	2,593,145	2,869,466	2,916,586	
Base Assets BOP (Serviceable plus Unserviceable)	637,421	911,183	990,894	1,157,624	
Base Assets EOP "	911,183	990,894	1,157,624	1,358,210	
Depot Assets BOP "	4,327,260	4,165,930	4,211,457	4,423,650	
Depot Assets EOP "	4,165,930	4,211,457	4,423,650	4,506,440	
B. Flows					
Total Issues	10,804,111	10,999,957	13,661,859	15,322,983	
Total Returns	11,228,855	10,867,781	12,672,045	15,099,308	
Returns to Base	7,937,591	7,821,091	9,413,713	11,776,376	
Returns to Depot (NRTS)	3,291,264	3,046,690	3,259,322	3,322,932	
Total Condemnations	365,048	370,752	316,527	737,787	
Base Condemnations	47,101	36,639	20,701	12,060	
Depot Condemnations	317,947	334,113	295,766	725,727	
Receipts from Procurement	532,468	439,171	170,967	610,629	P-18c (Includes BP-15 & 16)

TABLE 5-2. INVENTORY AND FINANCIAL TRANSACTIONS: ALL INVESTMENT ITEMS (Continued)
(BP 15)
($ x 10^3)

C. Resources					
Depot Maintenance Costs for All Exchangeable Items (organic and contract)		569,575	571,618	688,565	OP-19 Exhibit P.E. 72207F
Depot Maintenance Costs for Aircraft Exchangeable (includes engine components)		371,403	360,119	553,076	
Base Level Maintenance Manhours Expended for off-equipment repair (per flying hr.)					
B52 D, G, H			1,398,561 (9.36)	1,302,057 (10.04)	LOG MMO (AR) 7185
C5A			637,524 (15.72)	751,817 (22.59)	
F4 C, D, E			N/A	2,409,986 (7.86)	
C141-A			1,260,245 (4.66)	975,901 (3.97)	
A-7D			N/A	345,831 (4.3)	
KC 135A			1,303,950 (5.66)	159,374 (.81)	
F-15				62,297 (8.27)	
F111			874,218	860,205	
C130			776,464 (2.84)	940,506 (3.44)	
Base Fill Rate		.637	.599	.679	USAF Data Systems Design Center for LMI
Depot Fill Rate	.573	.578	.560	.573	

TABLE 5-3. ITEM DATA: ALL INVESTMENT ITEMS

A. All Investment Items ($x\ 10^3$)	FY 74	FY 75	FY 76	FY 77T	Source
Base Issues	1,286.6	1,145.6	1,454.3	1,525.8	USAF Data Systems Design Center
Base Issues plus Back Orders (Demands)	2,019.4	1,909.6	2,139.0	2,212.6	
Depot Issues	1,080.6	985.1	944.8	876.4	AFLC Management Indicators
Depot Issues plus Back Orders (Demands)	1,885.8	1,704.4	1,687.1	1,529.5	

	FY 75 (Day 53)	FY 76 (52nd Day)	Source
Selected Reparable Backlog Due to Supply Deficiency	86,042	76,412	GO 19C

B. Sample Data (30 bases)	12/67	12/68	12/69	12/70	12/71	12/72	12/73	12/74	12/75	12/76	Source
Reparable Generations(1,000 units)	1,111	963	969	850	848	832	712	651	599	697	Special on going AFLC indicator report, unpublished
	9/67	9/68	9/69	9/70	9/71	9/72	9/73	9/74	9/75	9/76	
Average Spares Operating Stock Level Units per Base	5,417	4,358	4,024	2,954	3,119	3,071	2,755	1,997	2,166		

(issues plus backorders). Also note that system aggregate issues or demands cannot be derived from these data, since not all base orders automatically become depot demands.

Table 5-4 is a Worldwide Grid analysis of NORS parts, incidents and hours for aircraft and engine exchangeable components covering FYs 1975 and 1976. The data in Table 5-4 have been expressed on an annual basis, since certain monthly observations were not available. In most cases, this procedure was reasonable, since only a few months were missing from an otherwise complete annual series. The FY 1974 figures for aircraft components are somewhat questionable, as only six months of data were available. Table 5-4 displays NORS parts incidents and hours separately for aircraft and engine exchangeables by termination code. We have computed on an annual basis the percentage distribution of incidents and their average duration (in hours) by termination category. The annual percentage represented by aircraft and engine exchangeables incidents in the total of all NORS parts incidents is presented at the bottom of the table.

TABLE 5-4. NORS INCIDENTS: EXCHANGEABLE ITEMS

	FY 74			FY 75			FY 76		
	No. ($x10^3$)	%	Average Duration (hrs.)	No. ($x10^3$)	%	Average Duration (hrs.)	No. ($x10^3$)	%	Average Duration (hrs.)
Aircraft Exchangeables									
Total Incidents	787.68		182.8	2,369.4		69.5	2,915.30		62.8
Terminated by:									
Cancelled	70.82	8.9	193.3	72.76	3.3	115.0	51.94	1.8	123.1
ALC	223.42	28.4	228.6	683.30	28.8	150.4	728.69	25.0	107.9
DSA	144.34	18.3	161.1	0.32	-	152	0.40	0	209.9
Lateral Support	76.68	9.7	137	50.39	2.1	151.8	84.81	2.9	108.2
Cannibalization (precluded and satisfied)	131.90	16.7	13.8	502.75	21.2	22.1	563.38	19.3	31.0
Base Procured	1.34	-	-	1.19	0	101.8	0.04	0	288.8
Release Base Assets	0.34	-	-	33.82	1.4	96.8	89.07	3.1	85.1
WRM	34.34	4.4	11.5	941.39	39.7	.93	1,312.55	45.0	.82
Dropped Due to Non-receipt	104.8	13.3	667.5	83.48	3.5	304.5	84.42	2.9	434.9
Total Hours ($x 10^6$)	14.398			16.467			18.302		
Engine Exchangeables									
Total Incidents	239.70		262	257.46		197.7	312.2		209.3
Terminated by:									
Cancelled	26.70	11.1	193.3	11.55	4.5	165.9	9.40	3.0	164.2
ALC	95.06	39.7	228.6	174.12	67.6	210.2	205.43	65.8	225.6
DSA	47.46	19.8	161.1	0.14	0	950	0.12	0	151.1
Lateral Support	13.10	5.3	137.0	3.47	1.4	290.2	6.64	2.2	204
Cannibalization (precluded and satisfied)	18.56	7.7	121.5	39.85	15.5	96.6	47.26	15.1	72.9
Base Procured	0.14	0	292.4	0.08	0	282.4	0.01	0	115
Release Base Assets	-	0	-	4.14	1.6	151.5	14.38	4.6	138.6
WRM	2.50	1.1	1.1	4.60	1.8	30.9	6.34	2.0	2.13
Dropped Due to Non-receipt	36.18	15.1	567.5	19.51	7.6	338.2	22.62	7.3	485.6
Total Hours ($x 10^6$)	6.281			5.090			6.535		
Grand Total All Items									
Incidents ($x 10^3$)	4,581.32			5,152.92			5,369.35		
Hours ($x 10^6$)	59.655			57.923			56.224		
A/C Exchangeables as % of Total									
Incidents	17.2%			45.9%			54.3%		
Hours	24.1%			28.4%			32.6%		
Engine Exchangeables as % of Total									
Incidents	5.2%			5.0%			5.8%		
Hours	10.5%			8.8%			11.6%		

Source: Grid Report, D 165A

CHAPTER 6: SYSTEMS SUPPORT DIVISION STOCK FUND

OVERVIEW AND STRUCTURE

The Systems Support Division (SSD), a division of the Air Force Stock Fund, procures and manages the expense-type items for which the Air Force is the Inventory Control Point (ICP). These items are repair parts, generally systems-or-weapons-related. The management and performance of the SSD affects aircraft readiness and is therefore of interest in this study.

Referring to the general logistics structure used throughout this report, Figure 6–1 outlines the major activities involved in the use and distribution of SSD items. Figure 6–2 shows the more detailed structure used in the analysis of SSD activity. SSD buyers are basically Base and Depot Maintenance, who pay with O&M dollars. The SSD manager, in turn, uses the money paid to him to purchase SSD items from vendors or DSA.

Procurement and management of these items are accomplished by AFLC, using a vertical stock fund concept. As of June 1976, there were 477,805 separate items in the SSD. A stock fund such as the SSD is a revolving fund that operates with money generated through sales. It sometimes obtains goods through capitalization, i.e., it assumes ownership of materiel in the supply system. Thus, on June 1, 1975, approximately 28,000 field–reparable items were added to the SSD stock fund and capitalized. When material is capitalized, the stock fund does not have to pay for it.

Figure 6-3 shows the financial operations of a stock fund. A stock fund is not intended to be self-sustaining. The sales prices do not recover such operating expenses as salaries and storage costs. The expenses that the fund attempts to recover are materiel costs, transportation costs, and foreseeable net inventory losses. Beginning in FY 1976, the SSD was permitted to include a price stabilization surcharge to help reflect the difference between the price of goods sold by the fund and the costs of reprocurement at inflated prices. This adjustment was tacit recognition of the SSD's revolving (self-sustaining) nature.

Since stock funds operate with money from sales, they should have greater financial flexibility than programs funded through direct appropriations. Because most stock funds are still subject to appropriation–type controls, this flexibility has not been fully used. OSD and OMB, through their apportionments, limit the amount of materiel the SSD can purchase for resale. These apportionments are made as part of the annual budget cycles, with quarterly reviews and adjustments as required.

FIGURE 6-1. GENERAL SYSTEM SUPPORT DIVISION STRUCTURE

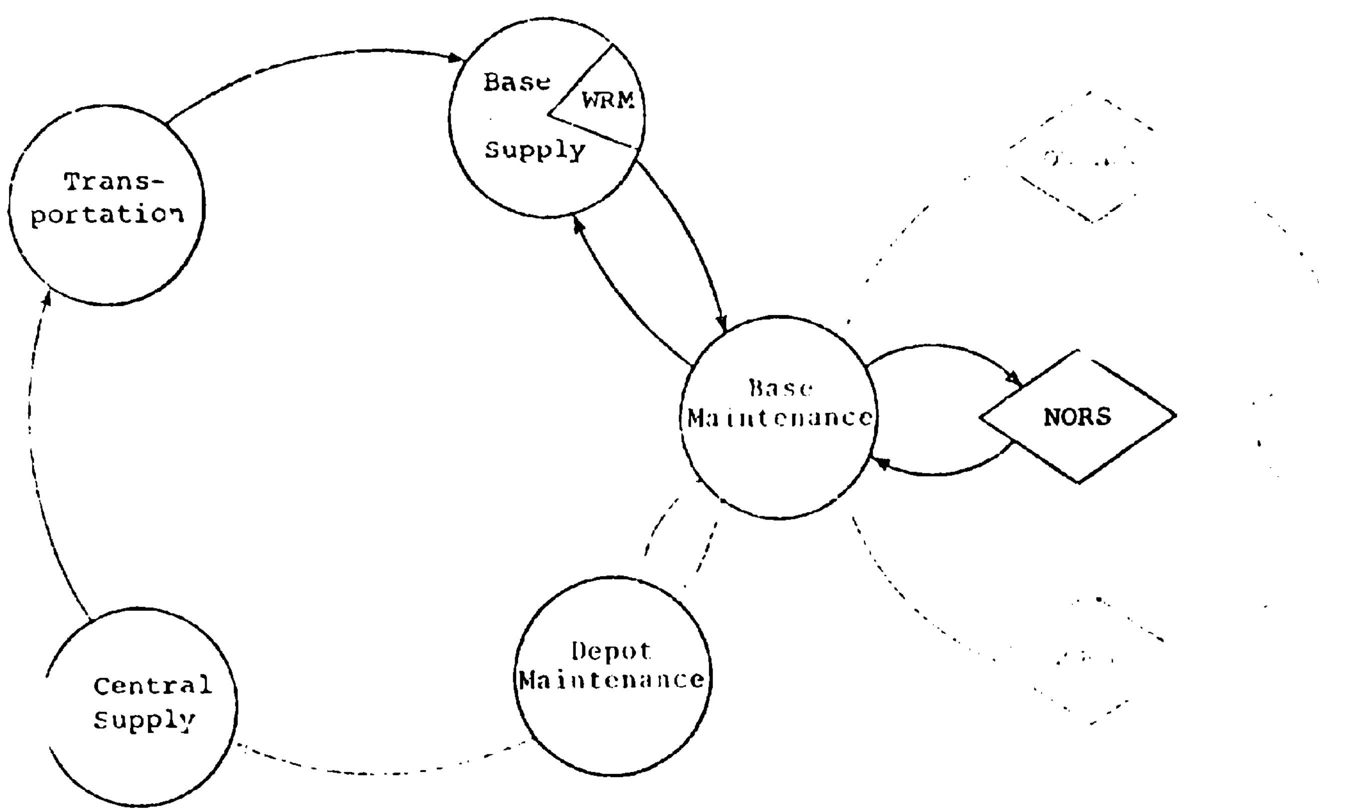


FIGURE 6-2. DETAILED SYSTEM SUPPORT DIVISION STRUCTURE

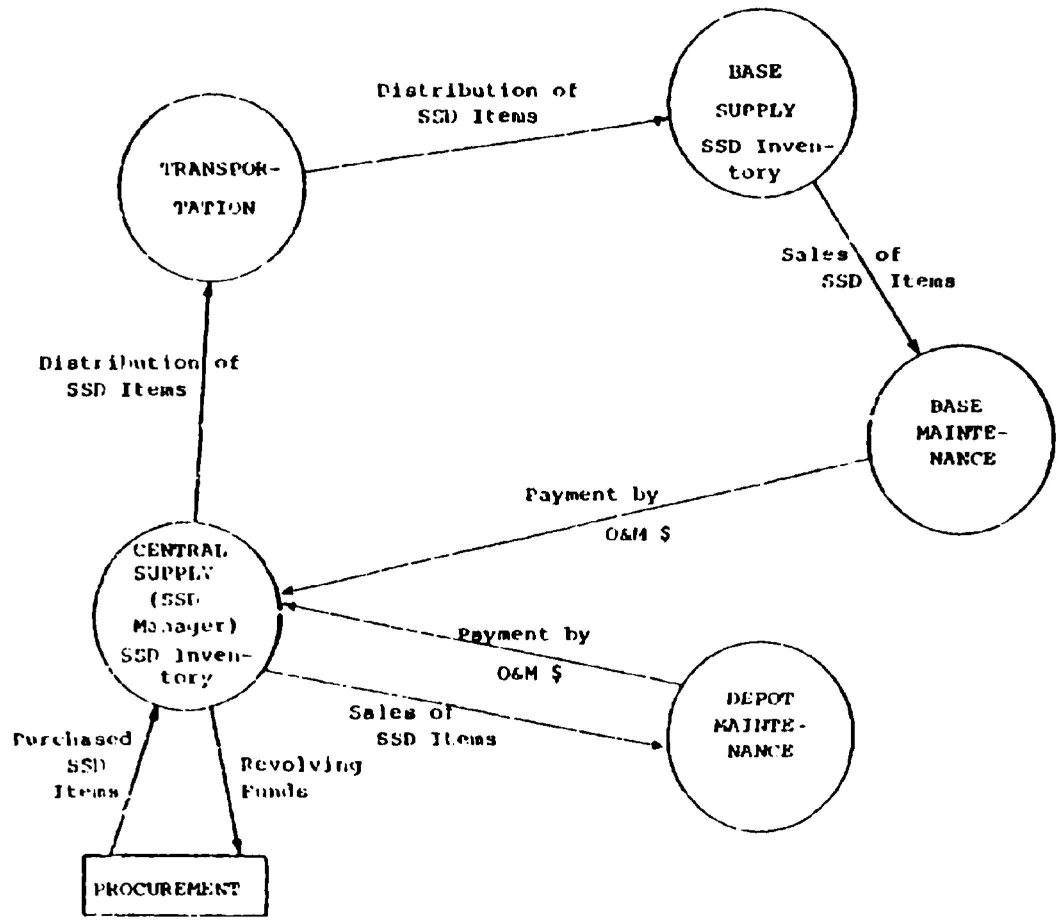
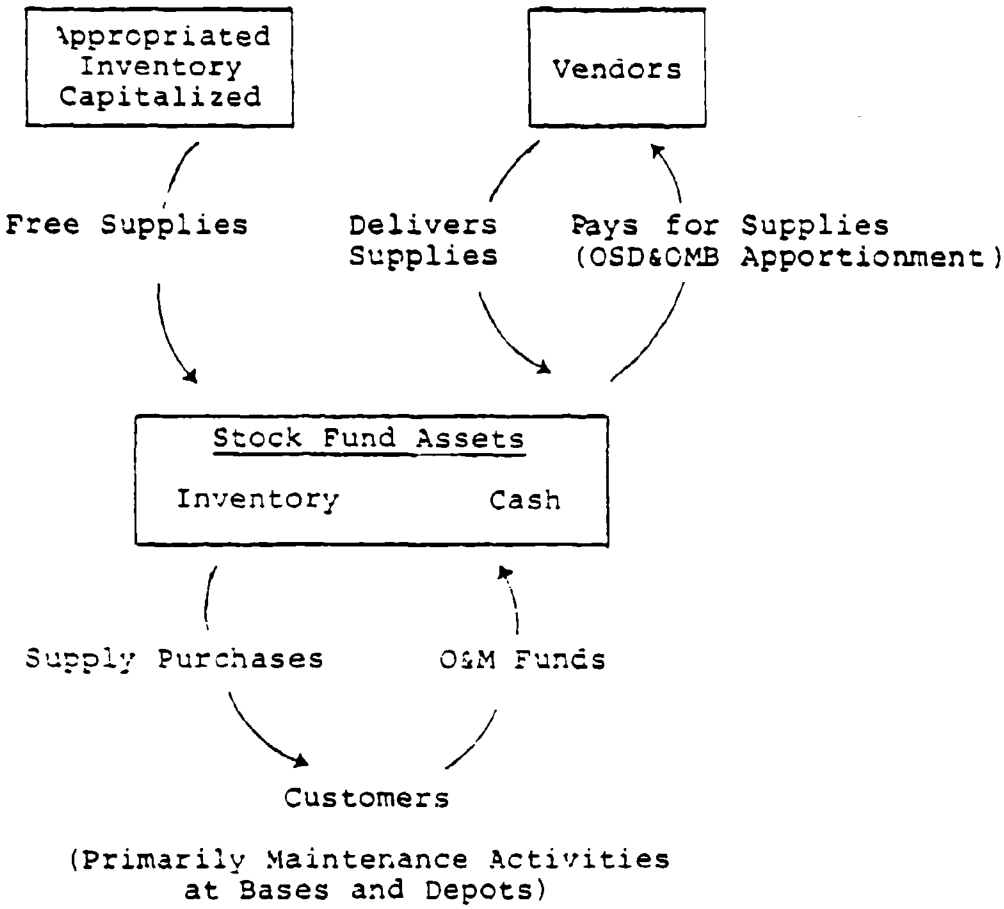


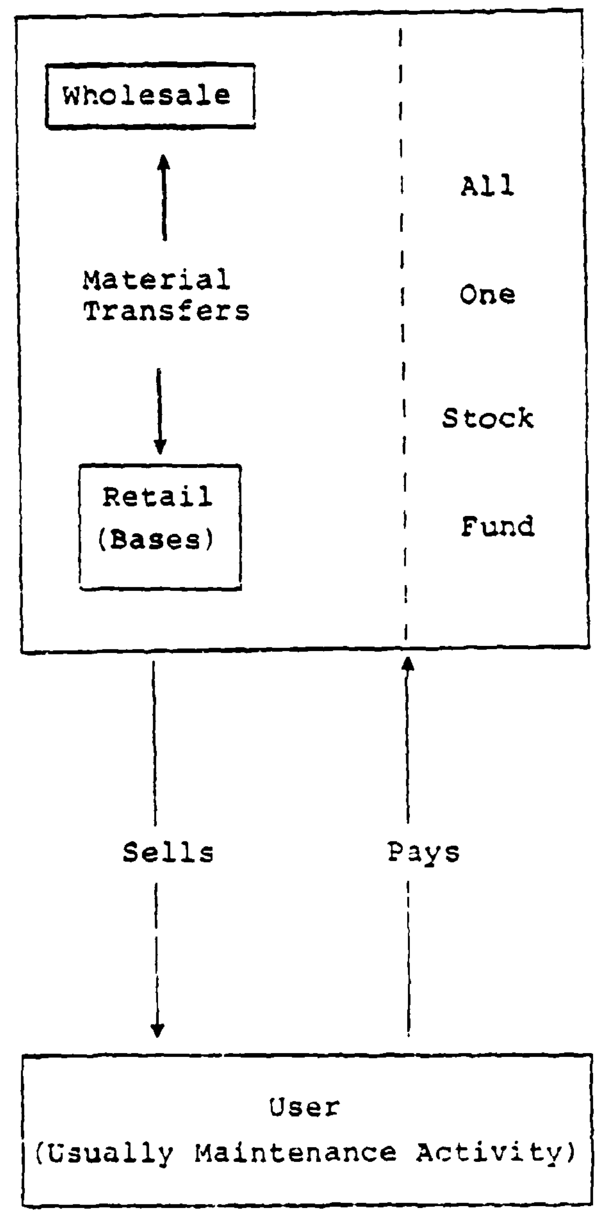
FIGURE 6-3. SYSTEM STOCK FUND OPERATION



The SSD stock fund is known as a vertical stock fund. According to this concept, the wholesaler procures inventory from commercial (or occasionally DSA) sources with the fund's working capital. The inventories are maintained either at the fund's wholesale storage facility or at its various retail outlets. Reimbursement takes place when the stock fund issues items to the ultimate users, not when it transfers items from wholesale to the retail levels. Thus, regardless of where the inventory is maintained, it is owned and controlled by a designated ICP. Currently, however, there is no visibility of individual SSD stock-funded items at base level. Figure 6-4 shows the vertical stock fund concept schematically.

Operating alongside the stock fund system is the standard Air Force supply distribution system, which prescribes stock level and ordering policies for the retail and wholesale (central) levels of the supply system. The retail level includes the Air Force

FIGURE 6-4. VERTICAL STOCK FUND STRUCTURE



base and depot maintenance activities that repair aircraft and components. The wholesale echelon is represented by the inventory manager's supply depot. Supply policies are set to meet certain supply performance (fill rate) standards. For the purpose of computing supply requirements, transfers of stock to bases by requisition are considered as issues, but they are not bought from the stock fund until the user at the base level demands stock. Such dual inventory management can lead to conflict and inconsistency, because the available funds may not permit bases to satisfy all their stock levels. Figure 6–5 represents the supply distribution system.

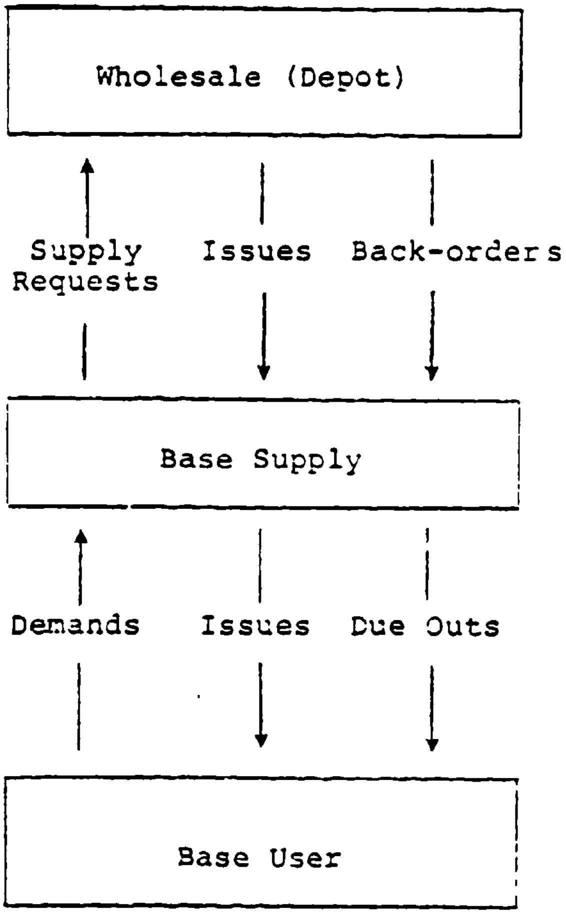
ANALYSIS OF DATA AND TRENDS

Table 6-1 shows the significant financial and performance data describing the experience of the SSD stock fund. The changes in inventory position and sales over FYs 1973-1977 are shown in Items 1-6. Item 6 shows that the average yearly inventory over FYs 1973-1976, measured in then current (nominal) dollars, increased from $1225 million to $1602 million. The significant rise in FY 1976 inventory value is due to the capitalization of the base reparable (XF-2) inventory items transferred to the SSD. Item 8 shows the average SSD inventory in constant 1973 dollars, with the increase being much more modest. Deflation was accomplished by using the surcharge amounts that the SSD passed on to users over this period. Sales data are given by Item 4 in nominal dollars. The increases in sales and average inventories, given by Items 4 and 6, are about the same — 31% over FYs 1973-1976.

The distribution of the inventory between the bases and the central supply system is shown by Item 5 of Table 6–1, in then current dollars; about 93% of the inventory value is held centrally, and 7% at the bases. The sales distribution, measured in the same dollar units as given by Item 4, shows that about 30% of final sales occur at the bases and about 70% are to the depot industrial maintenance users. Amounts, distribution, and turnover rates for inventory and sales for FYs 1973–1976 are displayed in Figure 6–6. The disparity between inventory and sales distribution may help to explain why the bases have consistently lower fill rates for expense-type items, compared with the depot or central level. The nature of financial control will undoubtedly lead to more centralized inventory control and positioning, with lower effectiveness at base level. The impact of this system on operational effectiveness will be further described below.

Item 8 of Table 6–1 shows the inventory on hand at central and base locations, measured in deflated dollars, which better reflect physical volume changes over time. Item 9 shows the corresponding fill rates, insofar as the data permit. Figure 6–7 presents limited trend data for inventory levels and fill rates at central and base locations. We note that the changes in central system fill rates follow the changes in inventory amount

FIGURE 6-5. SUPPLY SYSTEM OPERATION



$$\text{Wholesale Fill Rate} = \frac{\text{Issues}}{\text{Supply Requests}} \qquad \text{Base Fill Rate} = \frac{\text{Issues}}{\text{Demands}}$$

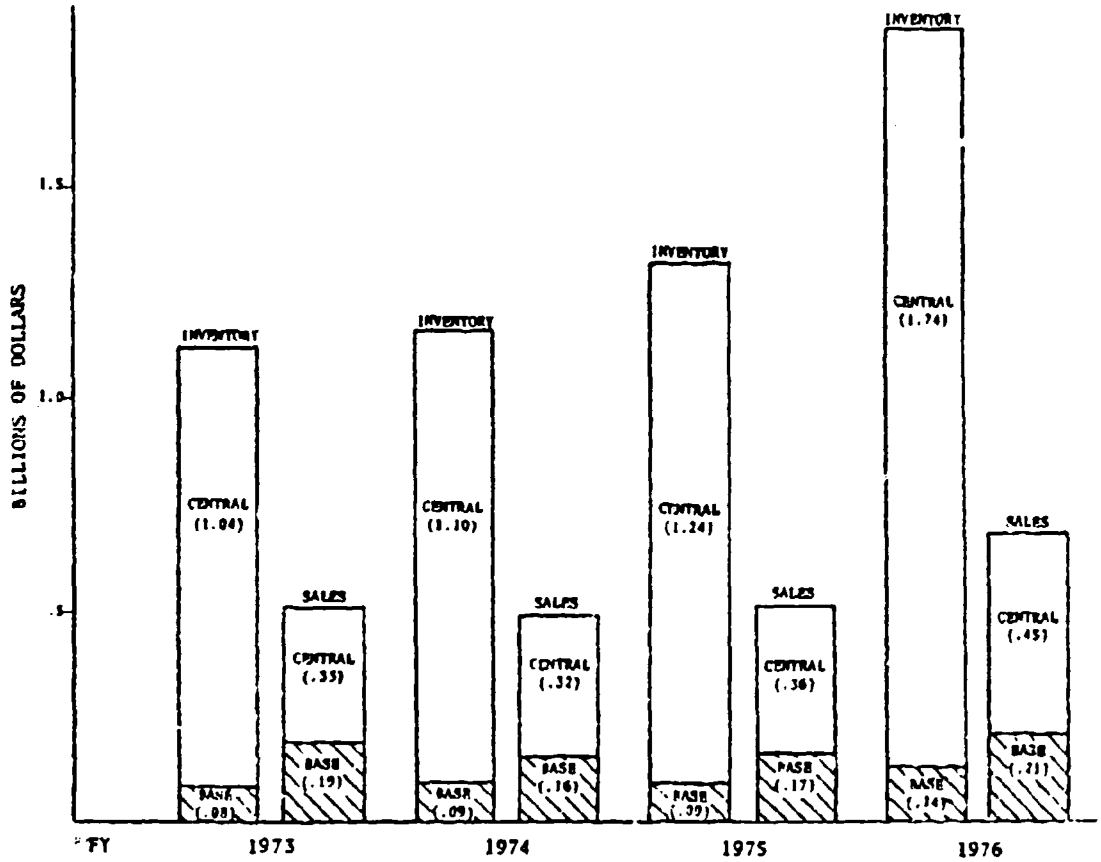
All issues are measured as off-the-shelf fills

TABLE 6-1. SYSTEM SUPPORT DIVISION FINANCIAL ANALYSIS

(Dollar Values in Millions)

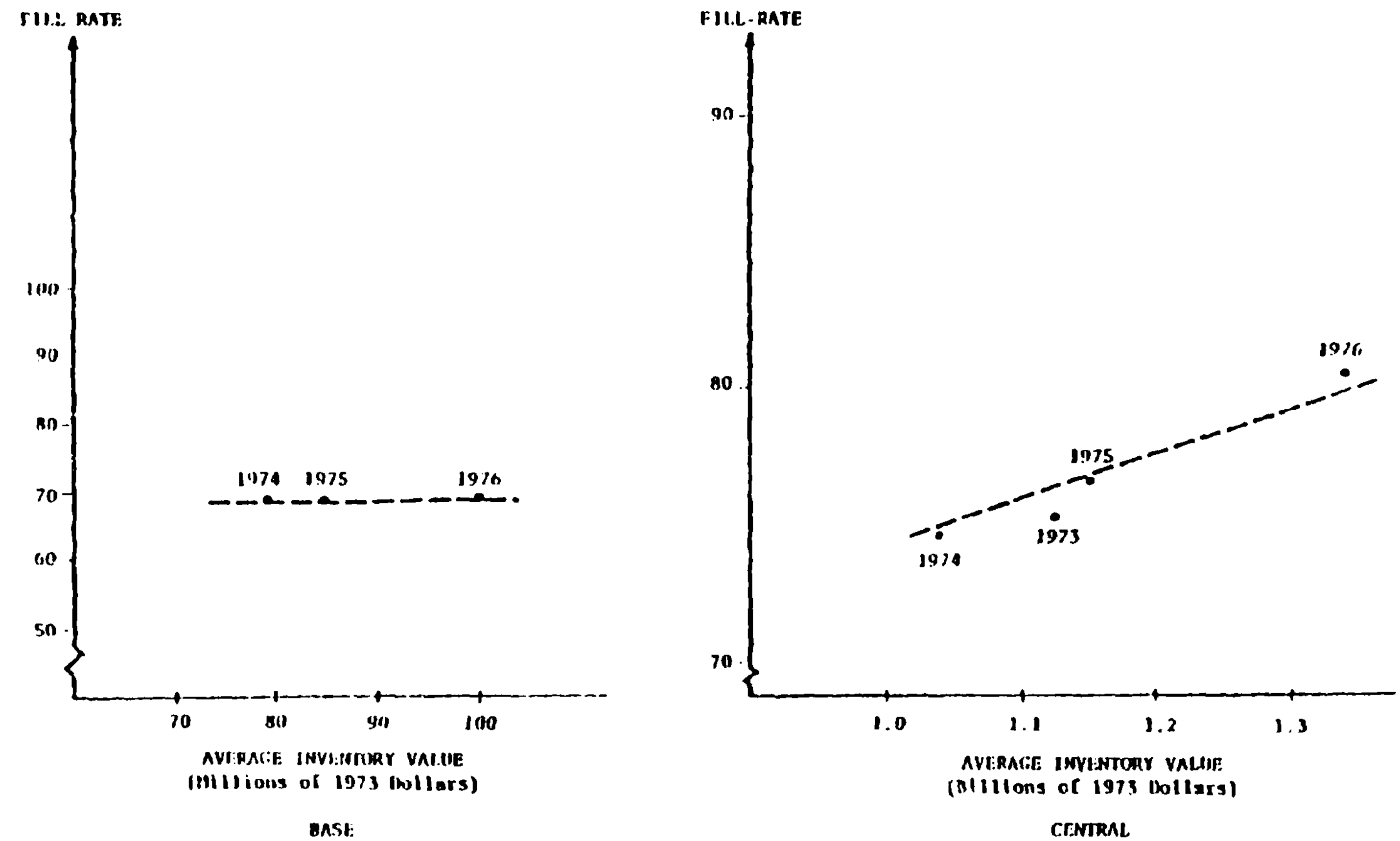
	Fiscal Years 1973	1974	1975	1976	1977
1. Inventory - Beginning of Period	1327	1122	1189	1330	1874
A. Central	NA	1040	1103	1236	1742
% of Total		93%	93%	93%	93%
B. Base	NA	82	86	94	132
% of Total		7%	7%	7%	7%
2. Receipts	460	520	599	790	-
3. Adjustments	-145	+28	+71	+413	
A. Transfers	-118	+34	+80	+327	
B. Price Increases	+15	+40	+40	+170	-
C. Returns	-42	-46	-49	-84	
4. Net Sales	520	481	529	659	
A. Central	333	324	356	445	
B. Base	187	157	173	214	
5. Inventory - End of Period	1122	1189	1330	1874	
A. Central	1040	1103	1236	1742	
% of Total	93%	93%	93%	93%	
B. Base	82	86	94	137	
% of Total	7%	7%	7%	7%	
6. Average Inventory on Hand (current $)	1225	1155	1260	1602	
7. Price Increases	15	40	40	170	
8. Average Inventory on Hand (1973 $)	1210	1115	1220	1432	
A. Central	1125	1037	1135	1332	
% change		-8%	+9%	+17%	
B. Base	85	78	85	100	
% change		-8%	+9%	+18%	
9. Fill Rate					
A. Central	75.2%	74.7%	76.9%	80.5%	
% change		-1%	+3%	+5%	
B. Base		63.7%	64.5%	64.4%	
% change			+1%	0%	
10. Net Sales (1973 $)	514	464	512	589	
11. Total Flying Hours ($x10^6$)	4.74	3.66	3.49	2.84	
12 Net Sales/Flying Hours ($)	108	127	147	208	
13. Net Demands - EOQ Items ($x10^6$)	3.130	2.772	2.681	2.523	
14. Net Demands/Flying Hour	0.66	0.76	0.77	0.89	

FIGURE 6-6. SYSTEM SUPPORT DIVISION INVENTORY (END OF PERIOD) AND SALES



TURNOVER RATE	1973	1974	1975	1976
Base	2.28	1.83	1.84	1.56
Central	.32	.29	.29	.26
Total	.46	.40	.40	.35

FIGURE 6-7. RELATIONSHIP BETWEEN AVERAGE INVENTORY VALUE AND FILL RATE



reasonably well. It appears that a 3% increase in inventory value is accompanied by about a 1% increase in fill rate. This is a very rough and hypothetical rule based on limited data points, but it is encouraging to see the consistency of the data. The bases show no such pattern, perhaps because the tendency to keep such a large fraction of the inventory centrally works against higher base level fill rates.

We note from reading the budget presentation material for SSD that the emphasis, in terms of funding requests, has been on the behavior of the AFLC fill rate for expense-type items, with the standard for SSD set at 80%, the rate observed in FY 1976. The results could also be contaminated because the fill rates include all expense-type data rather than just those assigned to the SSD fund. The latter has a more important bearing on the readiness of the Air Force's mission equipment.

We also looked at the trend in flying hours in relation to net sales measured in deflated dollars. Presumably, the ratio of deflated sales dollars to flying hours (Item 12 in Table 6-1) should be relatively constant, except for changes in the composition of SSD items. We notice that Item 12 was relatively stable during FYs 1973–1975, but shows a large increase in FY 1976. One explanation is that the sales data now include the XF-2 items shifted to SSD at the start of FY 1976.

Another more subtle explanation for the increase in the ratio of deflated dollars to flying hours could be that we have not adequately deflated the sales data. We took the deflation factors from the inventory deflators. Inventory deflators tend to be less volatile, because they reflect only changes in newly procured items. On the other hand, sales data tend to include many more active and currently purchased items and therefore call for the application of a larger deflator. Such a deflator might be closer to 20% than the 10% used, since the new receipts are about 50% of the average inventory. In this case, the deflated sales would be $427 million in FY 1976, and the net sales/flying hour would be $185. If a somewhat similar argument were applied to FY 1975, the value of deflated sales per flying hour would be $140.

To understand further the relation between aircraft activity and supply demands, we have calculated the net demands for EOQ items per flying hour on the central system. The net demands are shown as Item 13 in Table 6-1, and the demand rate is Item 14. The trend in demand rate is slightly upward, increasing by about 33% from FY 1973 to FY 1976, much less of an increase than that produced by the sales/flying hour data.

We tried to take the analysis of SSD logistics management one step further by assessing the impact of SSD items on aircraft and engine NORS behavior. The D165A (Air Force Monthly Grid) Report was used to analyze the NORS behavior of SSD items.[1] These

[1]The report lists NORS items separately for aircraft and engines.

items accounted for 19% of all aircraft NORS incidents and 26% of NORS incident hours in FY 1976; they thus contribute significantly to aircraft NORS condition. The data available were for four months in FY 1974, eleven months in FY 1975, and nine months in FY 1976. To permit comparison over the three years, the data were converted to annual figures by multiplying the annual totals by the appropriate factor, e.g., three for FY 1974.

The trend in NORS incidents and hours for both aircraft and engines is upward in each of the three years, as shown in Table 6-2. The major increase occurred between FYs 1974 and 1975, when the aircraft NORS incidents and aircraft and engine NORS hours more than doubled. Because of its magnitude, the significance of this increase in SSD NORS incidents and hours is questionable. The total NORS incidents and hours for all items, presented in Chapter 3, show no such large trend. The apparently low value for FY 1974 could reflect under-reporting of SSD incidents, or else the classification of SSD items could have changed significantly between FYs 1974 and 1975, resulting in many more items being placed in the SSD category in FY 1975.

The data for FYs 1975 and 1976 seem more stable and reasonable in terms of overall trends. The aircraft NORS incidents for SSD items increased by about 7%, and the NORS hours by about 10%, between FYs 1975 and 1976. Over the same years, the engine NORS incidents increased by about 2%, and the engine NORS hours caused by SSD items increased by about 4%. These NORS results seem consistent with the observed behavior in base fill rates for expense-type items between FYs 1975 and 1976, when there was no appreciable change in base fill rates.

Terminations of NORS incidents were primarily accomplished by resupply from the ALCs, as shown in Table 6–3. (DSA accounted for less than 1% of all terminations for SSD items.) The ALCs terminated about half of the aircraft NORS incidents and almost 70% of the engine NORS incidents. The frequent use of ALC terminations contributed to the long duration of aircraft and engine NORS shown in Table 6–2. Figure 6–8 is a graphical representation of the distribution of methods used to terminate aircraft and engine NORS incidents.

The exchangeable items exhibited a termination distribution markedly different from that of the SSD items. The former were much more frequently terminated by the use of WRM, which probably means that SSD items are not heavily stocked as WRM.

FINDINGS AND CONCLUSIONS

- Sales and inventories of SSD items at both the base and central levels have increased from FY 1973 to FY 1977. Turnover rates at these levels have concurrently decreased.

TABLE 6-2. DISTRIBUTION OF SYSTEM SUPPORT DIVISION INCIDENTS, HOURS, AND DURATION

	Aircraft NORS			Engine NORS		
Year	No. of Incidents	No. of Hours	Duration (Hr./Incd.)	No. of Incidents	No. of Hours	Duration (Hr./Incd.)
FY 1974	34,056	3,174,129	93.2	12,429	1,941,852	156.2
FY 1975	80,562	9,409,034	116.8	21,634	4,221,016	195.1
FY 1976	85,988	10,273,706	119.5	22,029	4,381,773	198.9

TABLE 6-3. DISTRIBUTION OF NORS PARTS INCIDENT TERMINATIONS FOR SYSTEM SUPPORT DIVISION AIRCRAFT AND ENGINE ITEMS, FYs 1974 - 1976

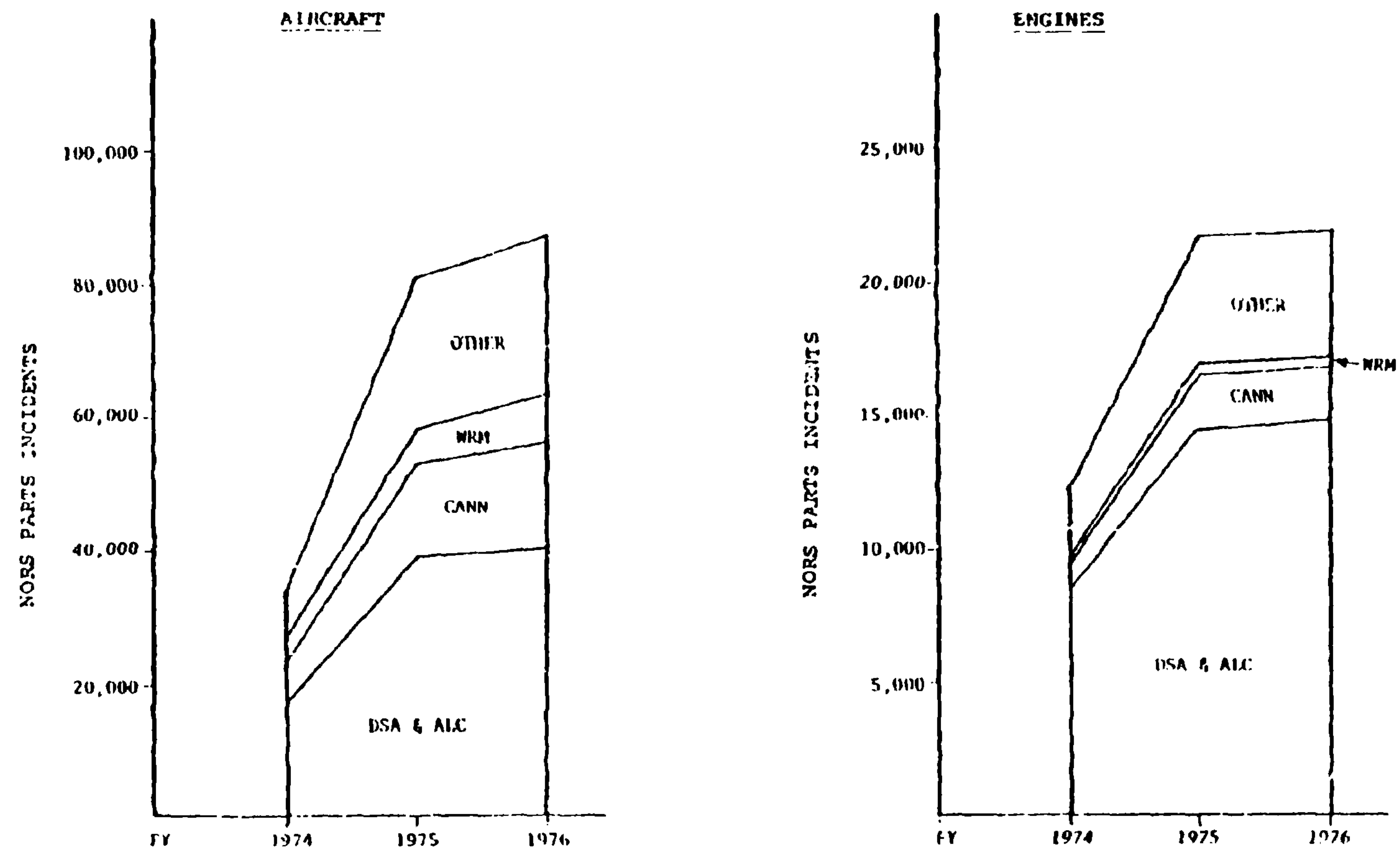
AIRCRAFT

	FY 1974		FY 1975		FY 1976	
	No.	%	No.	%	No.	%
DSA & ALC	17,043	50.1	39,543	49.1	40,268	46.8
CANN	6,360	18.7	13,742	17.1	15,779	18.3
WRM	3,168	9.3	5,389	6.7	7,534	8.8
OTHER	7,485	21.9	21,888	27.1	22,406	26.1
TOTAL	34,056	100.0	80,562	100.0	85,987	100.0

ENGINES

	FY 1974		FY 1975		FY 1976	
	No.	%	No.	%	No.	%
DSA & ALC	8,514	68.5	14,619	67.6	14,916	67.7
CANN	813	6.6	1,958	9.1	1,856	8.4
WRM	48	0.4	109	0.5	136	0.6
OTHER	3,054	24.5	4,948	22.8	5,121	23.3
TOTAL	12,429	100.0	21,634	100.0	22,029	100.0

FIGURE 6-8. NORS PARTS INCIDENT TERMINATIONS



- The fill rates of SSD items at bases have remained relatively level at about 64%, but have increased for the central system, rising to 80% in FY 1976. Th rise in central system fill rates seems to follow closely the rise in central system inventories.

- Aircraft and engine NORS incidents caused by SSD items increased over FYs 1974 to 1976. The sharp increase between FYs 1973 and 1974 may have been due to reporting problems, but the trend is clearly upward. The change in NORS incidents for FYs 1975 to 1976 seems consistent with the fill rate behavior observed.

- NORS incidents for both aircraft and engines were terminated primarily by ALC action. This pattern is much different from that noted for exchangeables, where WRM terminations are much more frequent.

- Generally, the central system shows an upward trend in fill rate as more assets become available; it also serves as the principal source for NORS terminations. To increase base fill rates and reduce NORS incidents would require more assets at base than the current budgets could support.

DATA AND SOURCE DESCRIPTION

All data used in Chapter 6 are based on historical sources; that is, data reflecting actual experience. The major sources are: the Air Force Budget Stock Fund presentations, AFLC Fact Book tables, special data on base level supply performance obtained from Air Force Headquarters Data Systems Design Center, and the Worldwide Grid (D165A).

Referring to Table 6-1, the data on Inventory-Beginning of Period (Item 1), Receipts (Item 2), Adjustments (Item 3), Net Sales (Item 4), and Inventory-End of Period (Item 5) for FYs 1973 to 1976 (including Item 1 for FY 1977) were taken from Statement 4a of the USAF Budget Stock Fund Presentation for the corresponding Actual Fiscal Year data. The breakdowns between Central and Base in Items 1, 4, and 5 were computed from the appropriate table on the Air Force Stock Fund in the AFLC Fact Books for FYs 1974 to 1976.

The data on Adjustments (Item 3) require some explanation. Item 3B was taken from Line 6d in Statement No. 4a, entitled "Standard Price Changes (net)," Item 3C was taken from Line 6b in Statement No. 4a entitled "Material Returns from Customers for Credit," and Item 3A was then computed as Line 6 minus Line 6d of Statement 4a. This, in effect, corrects for the fact that in our Table 6-1, we are using Net Sales rather than Gross Sales as presented in Statement No. 4a. The difference between Gross and Net Sales is Line 6b in Statement No. 4a. Thus, Item 3 (Adjustments) of Table 6-1, is obtained by totalling Items 3A, B, and C.

The Average Inventory on hand (current dollars), Item 6 of Table 6-1, is computed by averaging the beginning and ending inventory in each fiscal year. Price Increases (Item 7) is the same as Item 3B in Table 6-1. Average Inventory On Hand (1973 dollars), Item 8, is computed by subtracting Item 7 from Item 6 in Table 6-1. The distribution between Central and Base Inventories (Items 8A and B) is computed by using the same allocation percentages as given in Items 1 and 5 for inventory value. The annual changes in inventory value of Table 6-1 are then computed by determining the percentage change in inventory value from one year to the next in the table.

The Fill Rate for the Central System (Item 9A) is taken directly from the stock Availability Tables for EOQ Items given in the AFLC Fact Books. The stock availability rate is taken as the fill rate, that is, the ratio in percentage terms of issues to net demands. The Fill Rate for Bases is computed from data in a special report sent to LMI by Air Force Headquarters Data Systems Design Center. Only the data from July 1973 to September 1976 break out expense items separately, and the data on available months in each fiscal year were then inflated to 12-month estimates. These fill rate data are not completely satisfactory, since they report EOQ items and expense-type items, both of which include more than the SSD items, such as the GSD items purchased by DSA and GSA. In addition, the need to inflate the base level data to annual totals adds more uncertainty to the resulting fill rates. However, the data do seem to be consistent with our expectations.

Item 10, Net Sales (deflated) in Table 6-1 was obtained by computing the percentage of deflation in the Average Inventory On Hand caused by price changes, that is Item 8 divided by Item 6, and applying this same percentage to Item 4, Net Sales, to get Item 10, Net Sales (deflated). Item 11, Total Flying Hours (millions), is taken from the flying hour activity reported and documented elsewhere in this report. Item 12, Net Sales/Flying Hours, was then computed by dividing Item 10 by Item 11. Finally NORS incidents, hours, and terminations were derived from the Worldwide Grid.

CHAPTER 7: AIRCRAFT MAINTENANCE

OVERVIEW AND STRUCTURE

Maintenance of the Air Force aircraft inventory is a key element in the logistics cycle. Base maintenance resources, primarily manpower, materiel and equipment, are used to perform pre-and-post-flight inspections, calibrations, and tests, to prepare aircraft for flight and to repair aircraft on a scheduled and unscheduled basis. Depot Maintenance conducts periodic overhauls of aircraft as well as modifications and repairs beyond the capability of Base Maintenance. Maintenance is the focal point of logistics activity, where resources and services from other parts of the system are brought together to produce operationally ready aircraft.

Figure 7-1 shows the area of interest in this chapter relative to the overall logistics structure. The critical position of maintenance within the support cycle and its impact on aircraft operational status (the operational cycle) can be seen in the more detailed structure of Figure 7-2. The output of maintenance can be viewed as operationally ready aircraft and the activity (flying hours, sorties) accomplished by these aircraft. Improved maintenance performance translates into more successful sorties with fewer systems failures and aborts, reduced time per flying hour or sortie to restore aircraft to operationally ready status, and fewer resources required to achieve desired activity levels and operationally ready rates.

From Figure 7-2, we can see that maintenance is accomplished at two echelons: base level, which includes field and organizational units, and depot level. Each echelon imposes two kinds of costs: incurred costs from necessary manpower, materials, and indirect (overhead) costs; and an imputed cost for the aircraft inventory in the process, or awaiting the completion of, maintenance (i.e., NORM hours and aircraft-in-depot-hours). The latter imputed cost represents the linkage between maintenance and aircraft operational status. The incurred costs, or the inputs to maintenance, are also of interest. An increase in the amount of resources required to accomplish maintenance of the fleet, for example, which is equivalent to a reduction in logistics performance, affects the readiness and capability of the fleet. Unless the increased level of required resources is funded, operational readiness and capability will be reduced.

In Chapter 7, we attempt, as far as possible, to deal only with on-equipment maintenance of aircraft, accomplished either at base or depot. Off-equipment maintenance is discussed in Chapters 4 and 5. For each echelon of activity, we attempt to

FIGURE 7-1. GENERAL AIRCRAFT MAINTENANCE STRUCTURE

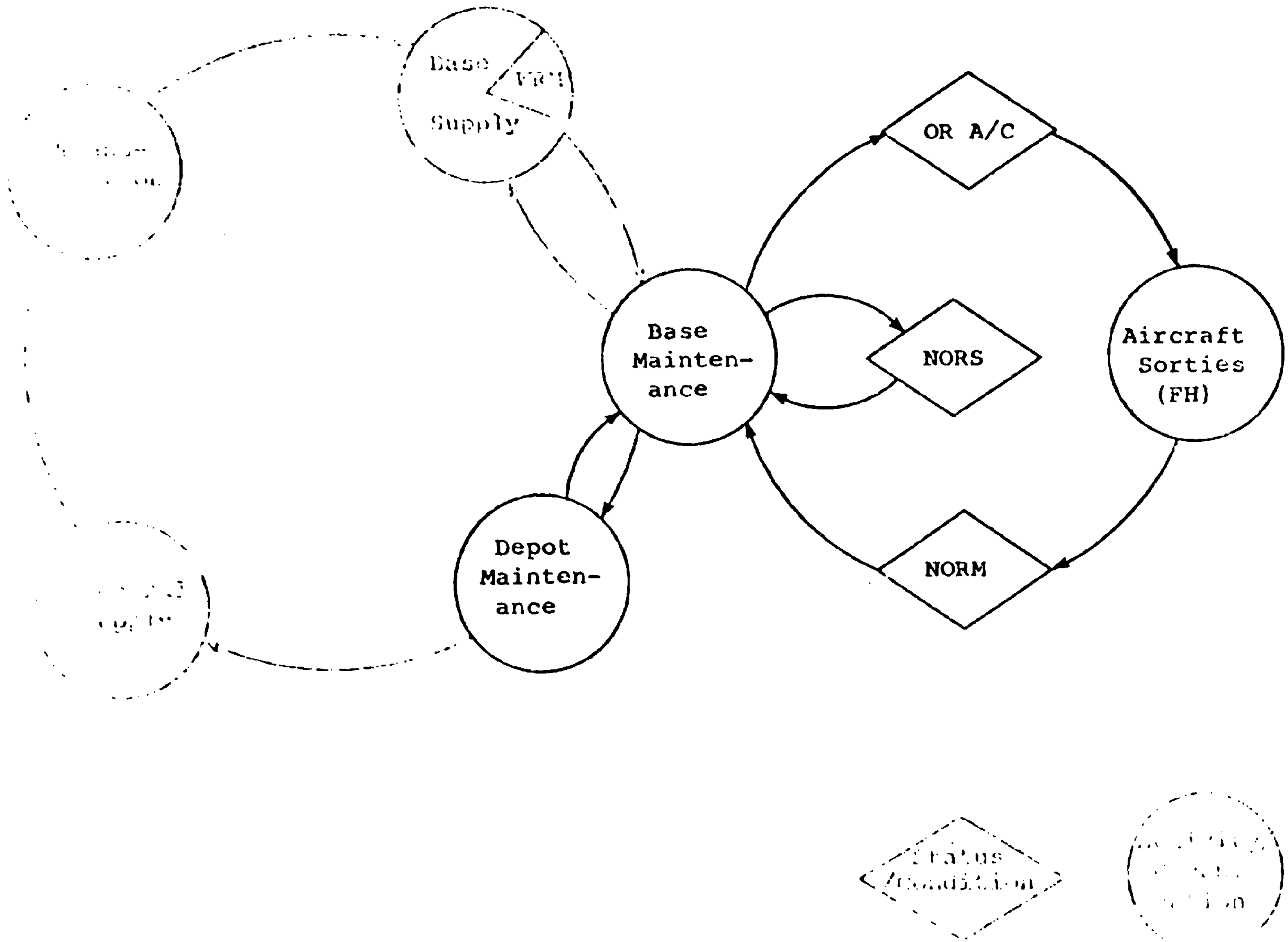
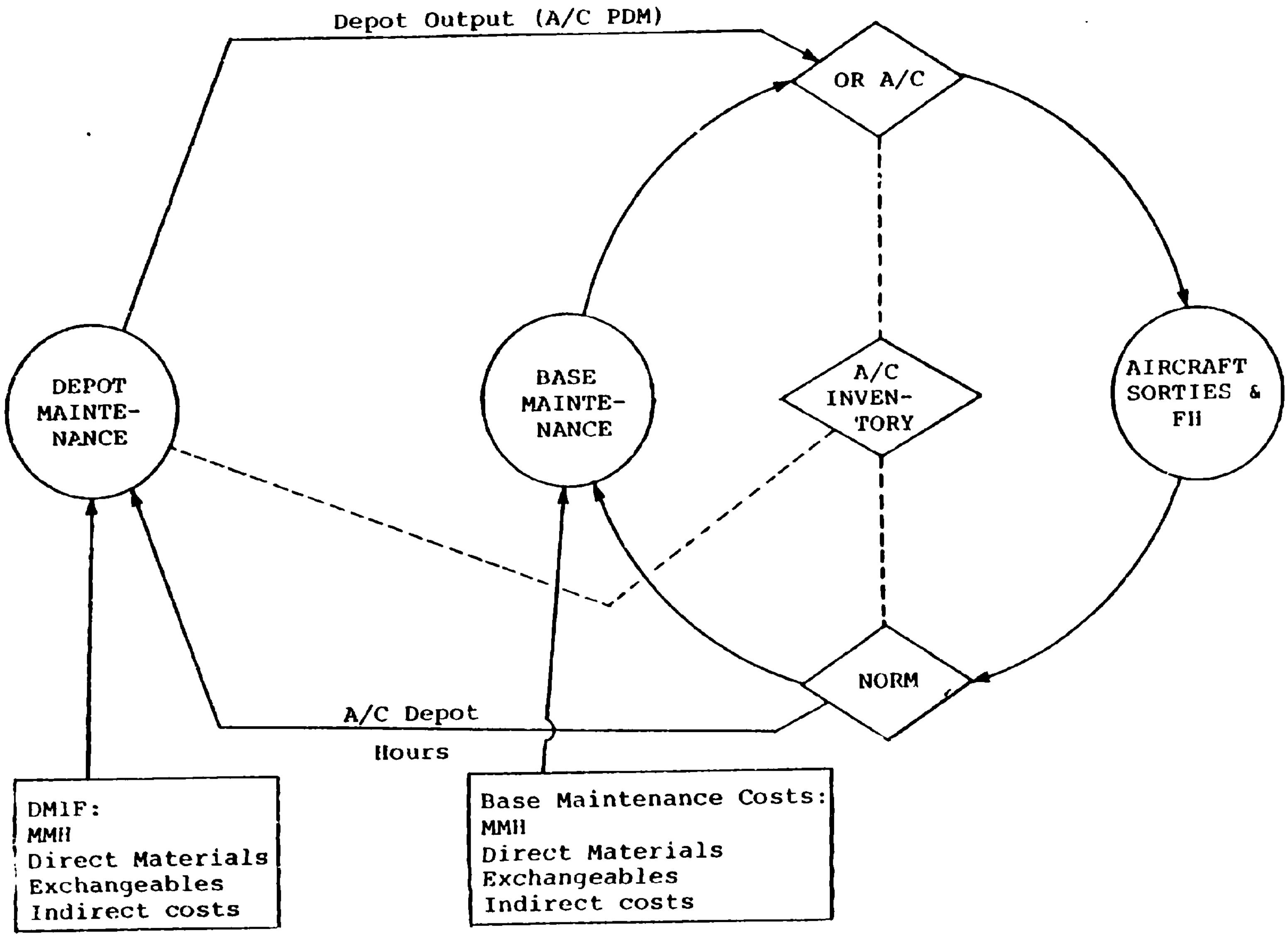


FIGURE 7-2. AIRCRAFT MAINTENANCE PROCESS FLOW



measure and analyze the accomplishments, costs, and productivity of maintenance organizations. We also analyze the amount of time required to accomplish maintenance–the linkage between maintenance performance and the operational cycle.

ANALYSIS OF DATA AND TRENDS

The following trend analysis presents maintenance costs, both directly incurred and imputed from aircraft in non-operational status, and maintenance accomplishments. Separate analyses are performed for depot and below depot (field plus organizational) maintenance. For each echelon, aggregate trends are presented first, followed by system-specific information.

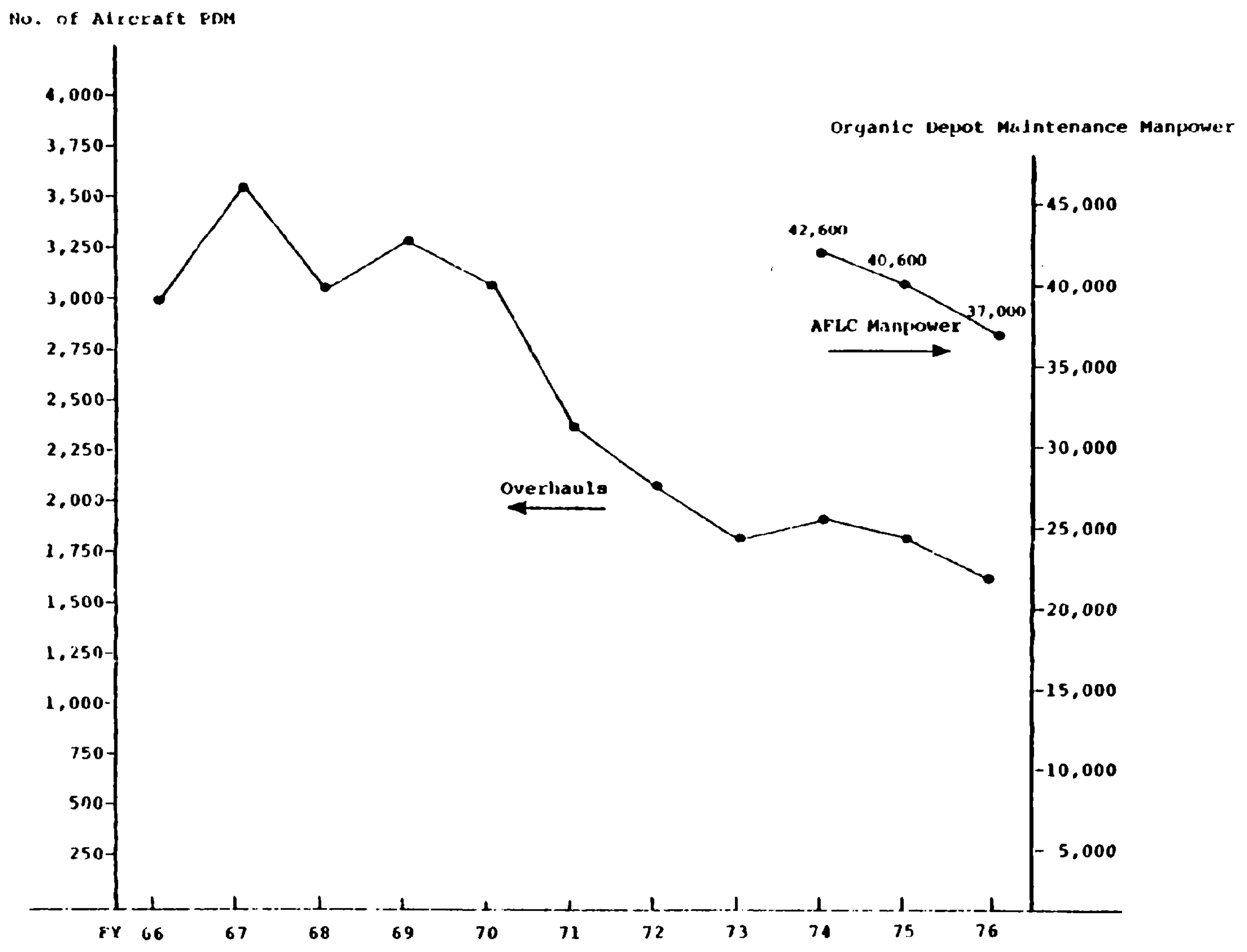
Before proceeding to the analyses, some indication of the relative magnitudes of the resources and costs at each echelon and in total is appropriate. On the basis of a sample of systems, we can infer that approximately equal expenditures for aircraft maintenance occur at base and depot. For these direct expenditures, manpower costs represent between 30% and 60% of total maintenance costs, depending on the type of aircraft model. Base maintenance manpower amounted to 22% of Air Force manpower in FY 1972 and 28% in FY 1976. On a flying hour basis, base maintenance manpower increased from 42.3 man-years per 1,000 flying hours in FY 1972 to 61.5 man-years per 1,000 flying hours in FY 1976. Adding civilian depot maintenance manpower to the base total for FY 1976 produces an additional 13 man-years per 1,000 flying hours, for a grand total of nearly 75 man-years per 1,000 flying hours. Finally, the percentage of aggregate fleet time that aircraft spent in maintenance during FY 1975 amounted to 24% of user possessed hours at base and 12% of fleet hours at depot. Thus, total maintenance requirements impose a large penalty on aircraft operational readiness.

Depot Level

Depot level aircraft production activity includes programmed depot maintenance (PDM), repair, and modifications. Aircraft PDMs are usually scheduled on a time-contingent basis and thus tend to be dependent on the number of aircraft in the active inventory and the age distribution of the inventory. In Figure 7-3, the number of aircraft PDMs (including modification done concurrently with PDM) accomplished by both organic facilities and contractors is displayed for FYs 1966 to 1976. Over this period, PDMs declined by 19.2%, a figure that coincides almost exactly with the decline in active inventory levels. Flying hours declined by 46% during the same period. The empirical information thus confirms the proposition that the active inventory level, rather than the activity rate, has determined the production level for depot level overhaul.

Organic production maintenance manpower is also displayed in Figure 7-3. AFLC production manpower declined by 13% between FYs 1974 and 1976, compared with a

FIGURE 7-3. NUMBER OF AIRCRAFT PDM (CONTRACT AND ORGANIC) AND ORGANIC DEPOT MAINTENANCE MANPOWER



decline of 15% in the number of aircraft PDMs. Since certain PDMs are accomplished by contractors and organic depot maintenance manpower is utilized for other purposes, this trend does not necessarily indicate a decline in depot productivity.

The AFLC computes two measures of organic depot maintenance performance: the number of direct product earned hours per man-day, a measure of manpower utilization; and direct labor effectiveness, a measure of labor accomplishments. The number of direct product earned hours per man-day indicates the average number of hours of work accomplished per available man-day, based on jobs accomplished per man-day and the number of hours rated by engineering standards for each completed job. The lower series in Figure 7–4 tracks this measure and shows that organic manpower consistently earned about four hours per available man-day worked.

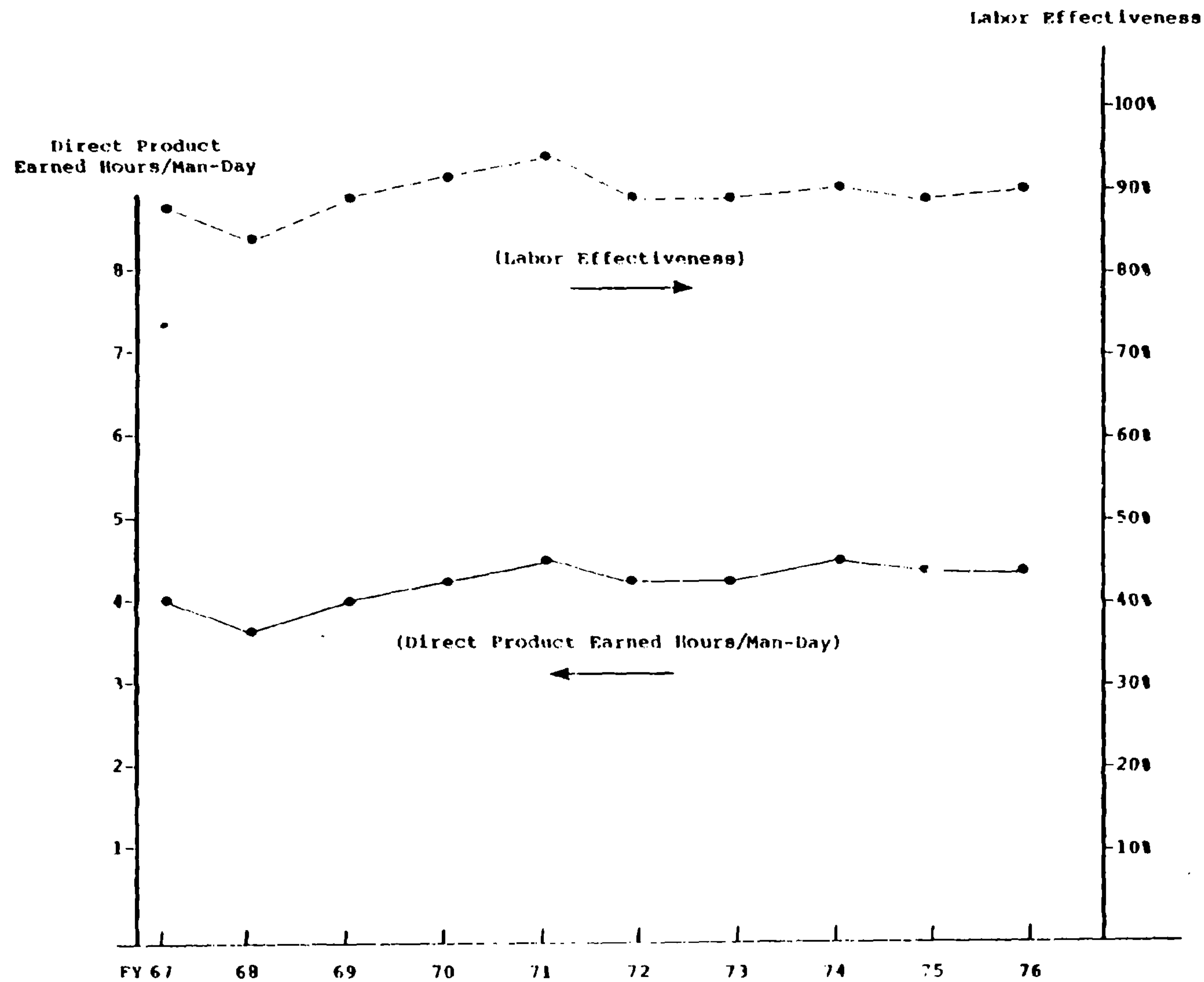
The upper series in Figure 7–4 tracks organic depot maintenance manpower effectiveness, defined as the ratio of hours earned using jobs standards to actual direct hours worked. A value of 90%, for example, implies that for every 100 hours of actual direct labor, jobs rated as requiring 90 hours of work were accomplished. The labor effectiveness ratio remained nearly constant between FYs 1967 and 1976.

Neither measure of depot maintenance performance shown in Figure 7–4 is a completely reliable indicator of performance trends over time. At each point in time, the measures are valued on the basis of current performance versus then-current work standards. Standards and hence output are updated to reflect changes in methods, processes, work content and other considerations in work control and scheduling policy. Thus the job standards applied to the changed composition of depot work may be more stringent and thus mask increased labor productivity. Alternatively, job standards may be revalued to conform to actual labor input so that the measure becomes self-fulfilling and obscures reduced productivity.

As previously mentioned, one of the implicit costs of maintenance is the time aircraft are non-operational while undergoing necessary maintenance. Two alternative valuations of this cost are possible: a monetary cost based on the value of aircraft inventory required to fill the maintenance pipeline, and a cost measured by the impact of maintenance pipeline time on aircraft operational status. The latter measure has been adopted to maintain the linkage between logistics and aircraft operational status that is the basis of this report.

At the depot level, a measure analogous to the NORM rate can be constructed. This measure counts the number of hours the aggregate Air Force fleet is in Depot Maintenance, and calculates a NORM rate for the entire active inventory, based on the

FIGURE 7-4. DEPOT LABOR UTILIZATION AND EFFECTIVENESS



number of available fleet hours. Comparison of the depot and base NORM rates is not strictly correct, since the base NORM rate is calculated on user possessed hours. We have therefore recalculated the base NORM rate, using available fleet hours instead of user possessed hours. In Figure 7-5, the lower series displays the percentage of fleet hours spent in Depot Maintenance from FY 1972 to FY 1976. This rate varies from a low of 4% to a high of nearly 12% and averaged 7.5% over FYs 1972-1976. A comparable base level NORM-G rate, based on fleet hours, ranged from 20% in FY 1972 to 24% in FY 1975 and averaged 21.6% over this period. Consequently,the impact of depot maintenance production on overall fleet availability amounts to roughly one-third of the time consumed by base level maintenance.

The upper series in Figure 7-5 displays average time, in days, between the induction of an aircraft into the depot for maintenance and the completion of the required maintenance. This rate has remained relatively constant at about 40 days per aircraft inducted.

A composite picture of depot maintenance activity can be constructed from the trends evident in Figures 7-3 and 7-5. From FY 1973 to FY 1975, the percentage of fleet time spent in Depot Maintenance declined, while the average time to complete maintenance increased slightly from 35 days to 40 days. Over the same period, the number of aircraft PDMs remained stable. Further, data from Table 7-5[1] for FYs 1973 and 1974 shows that the number of repairs and modifications declined from 5,587 to 2,659. The reverse behavior is evident for FYs 1975 and 1976. Depot fleet time increased, average flow time was constant, and aircraft PDMs declined.

The actual incurred costs for depot level maintenance by both contract and organic facilities can be analyzed for the aggregate Air Force and for selected aircraft systems. At the aggregate level, an examination of program element 72207F (the Air Force program for industrially funded depot maintenance) indicates the annual total expenditure for aircraft maintenance—aircraft maintenance and modifications, engine overhaul and repairs, and the cost for repairing aeronautical exchangeables. Expressing these cost totals on a per-aircraft basis for FYs 1974 through 1976 reveals a steady increase in the cost of depot maintenance per aircraft of 43% and 25% respectively, measured on either a current or constant dollar basis. The results of these calculations are reproduced in Table 7-1.

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[1] See "Data and Source Description," below.

FIGURE 7-5. PERCENTAGE OF FLEET IN DEPOT-MAINTENANCE AND DEPOT FLOW TIME

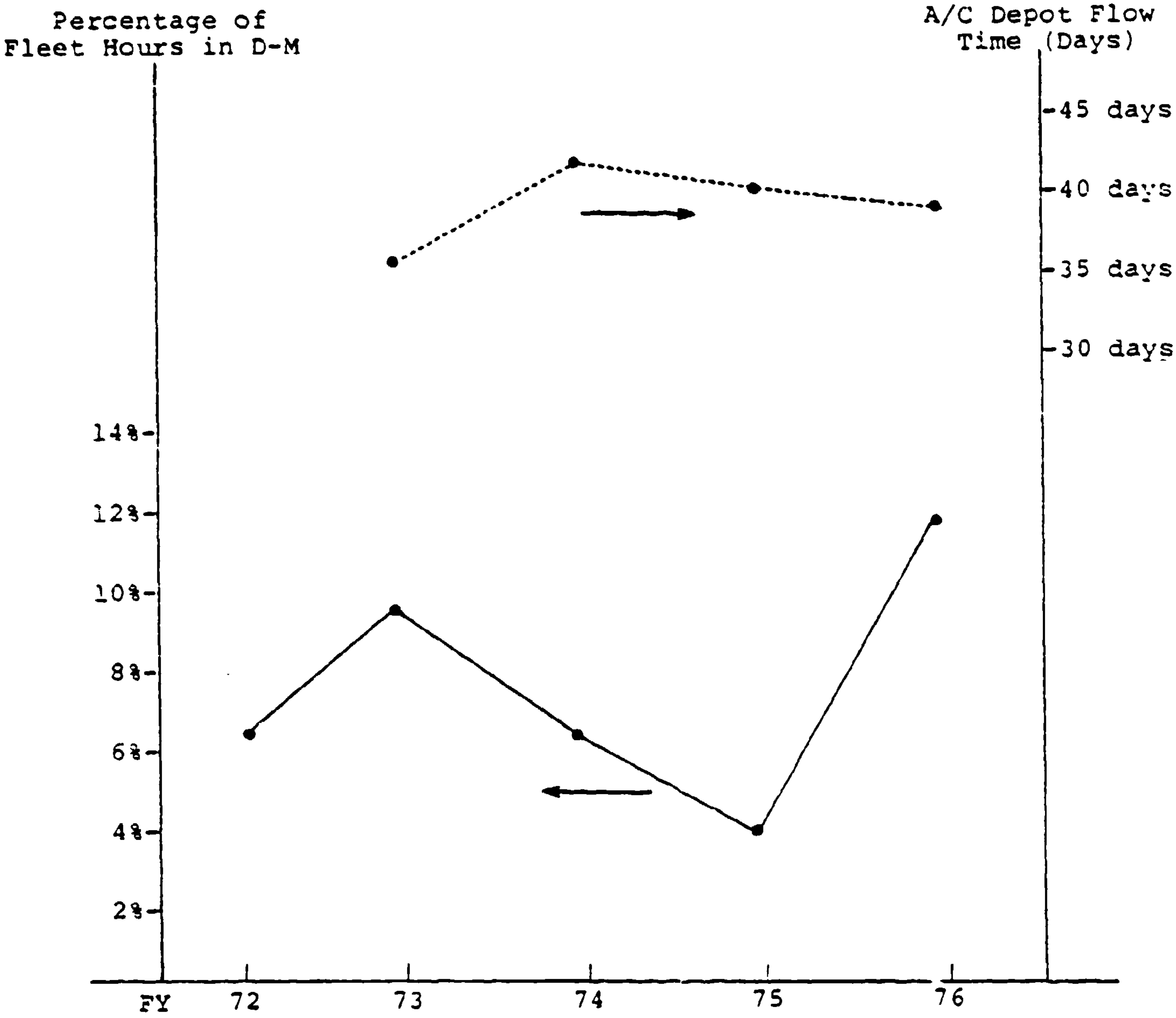

TABLE 7-1. AGGREGATE DEPOT MAINTENANCE COSTS FOR AIRCRAFT, FYs 1974 - 1976

	1974	1975	1976	% Change 1974-1976
Aircraft Maintenance & Modifications ($\$ \times 10^3$)	247,037	294,233	282,545	14.4
Engine Overhaul & Repair ($\$ \times 10^3$)	100,874	102,293	105,011	4.1
Aeronautical Exchangeables ($\$ \times 10^3$)	371,403	360,119	553,076	48.9
TOTAL ($\$ \times 10^3$)	719,314	756,645	940,632	30.8
Cost per Aircraft (Current \$)	70,827	81,063	101,263	43.0
Cost per Aircraft[1] (1974 \$)	70,827	75,058	88,827	25.4

[1]The dollar deflator used to obtain depot maintenance costs in constant 1974 dollars was the index for civilian pay, taken from AFR-173-10, Table 49, Department of Defense Deflators.

Table 7-1 shows that the cause of the substantial increase in depot maintenance costs is the increase in FY 1976 repair cost of aeronautical exchangeable items—the other two cost accounts remained relatively level over the three-year period, in terms of both current and constant dollars. Chapter 5 presents a detailed analysis of aircraft-related exchangeable maintenance.

To pursue the impact of exchangeable items on aircraft maintenance costs further, we can utilize data presented below in Table 7-4, listing base, depot, and total maintenance costs per aircraft and per flying hour for the six systems consuming the largest amounts of Air Force maintenance resources in FY 1976. These six systems account for 35% of the aircraft inventory and nearly 50% of total flying hours. Statistical regressions were computed, first for maintenance costs per aircraft, and second using costs per flying hour against the number of exchangeable items associated with each aircraft. Linear and log-linear forms were both employed, producing estimates of the impact of the introduction of more complex aircraft into the fleet on costs per flying hour and per aircraft.

A significant variable, explaining 56% of the variability observed in maintenance cost per flying hour across the six-system sample, was the number of different components on an aircraft. Maintenance costs per flying hour were found to increase at least in proportion to increases in the number of different components. The evidence was somewhat less significant for costs per aircraft. For this relationship, the log-linear form proved superior, with the number of components per aircraft statistically significant at the 10% level and explaining 42% of the observed variability in cost per aircraft. The evidence indicates that maintenance costs per aircraft increased slightly less than in proportion to the number of different exchangeable components per aircraft.[2]

<u>Base Level</u>

Maintenance at the base level (organizational and field) involves nearly 25% of Air Force manpower and requires about 20% of the available fleet hours to accomplish. The following discussion of Base Maintenance concentrates, first, on trends in the time required to accomplish maintenance, second, on the man-hours available and utilized for aircraft maintenance, and third, on the total incurred costs (labor and materials) of maintenance.

On an aggregate Air Force basis, the NORM–G rate, including both scheduled and unscheduled maintenance actions, shows a slight upward trend from FYs 1972 to 1976. This rate reflects the percentage of possessed hours that the total active Air Force fleet is undergoing maintenance to correct conditions that cause aircraft to be grounded. NORM–G hours are further divided into those that result from scheduled and unscheduled maintenance. The NORM rate is expressed relative to possessed hours, so that changes in activity rates (flying hours and sorties) are only indirectly reflected in NORM rates. In the analysis below, we deal with NORM–G hours-per-flying-hour trends, which capture the impact of activity levels on the total time required to restore grounded aircraft to operationally ready status.

Figure 7–6 shows a slight upward trend in the total NORM–G rate over FYs 1972 to 1976, accounted for by nearly equal growth in scheduled and unscheduled NORM–G rates.

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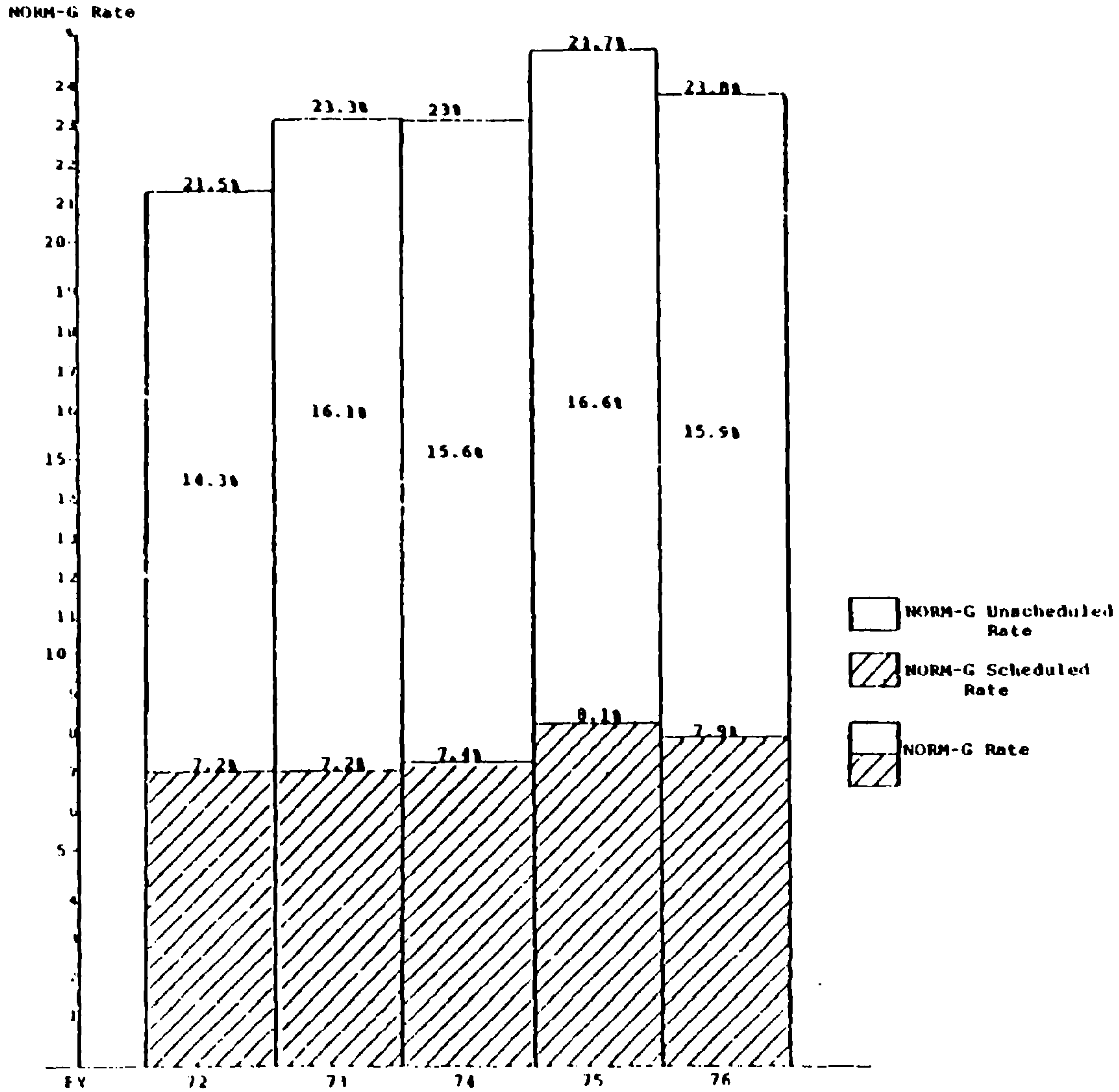
[2] The estimated relationships for maintenance cost per flying hour (C/FH) and cost per aircraft (C/A–C) against the number of different components (I) were as follows (t-value in parentheses):

$$C/FH = \underset{(-0.67)}{-557} + \underset{(2.694)}{0.95\text{[illegible]}6I}, \quad R_A^2 = .56$$

$$\ln(C/A\text{-}C) = \underset{(-0.348)}{-0.5126} + \underset{(2.143)}{0.95134 \ln(I)}, \quad R_A^2 = .42$$

FIGURE 7-6. NORM-G RATES



On either a flying hour or sortie basis, NORM–G hours have increased by 50% during this period, implying that a 50% increase in average elapsed time per flying hour to restore aircraft to operationally ready status has also occurred. One explanation for this longer maintenance time could be that the composition of aggregate flying hours among the various systems within the fleet has changed substantially. However, although aggregate flying hours did decline markedly from FY 1972 to FY 1976, the relative utilization of the various systems remained reasonably constant.

To further explore the aggregate impact of maintenance time on operational status and to begin to link maintenance time with activity levels and manpower, we have computed three ratios, using data for FYs 1972 and 1976. These ratios are authorized maintenance man-years per 1,000 flying hours, authorized maintenance man-years per NORM–G hour, and NORM–G hours per 1,000 flying hours. The values for these ratios in FYs 1972 and 1976 are reproduced in Table 7–2. Note that these values are for available maintenance man-years as distinct from man-years utilized to accomplish maintenance, while NORM–G hours and flying hours are actual values. These ratios show that available maintenance man-years per flying hour increased by 45% over FYs 1972 to 1976. At the same time, NORM–G hours per flying hour increased by 58%.

TABLE 7-2. MAINTENANCE MAN-HOURS PER FLYING HOUR TREND FACTORS

	FY 1972	FY 1976
Authorized Mission Equipment Maintenance Manpower	224,104	174,643
Authorized Maintenance Man-Years per 1,000 Flying Hours	42.3	61.5
Authorized Maintenance Man-Years per NORM-G Hour	0.011	0.010
NORM-G Hours per 1,000 Flying Hours	3,832	6,070

Over this period, available maintenance man-years declined at the same rate as that observed for NORM–G hours, so that the number of maintenance man-years available per NORM–G hour remained constant. This measure of available manpower intensity suggests that there has been no change in the available man-years that could be applied per actual NORM–G hour experienced.

Given that the number of NORM–G hours per flying hour has shown an upward trend in the recent past, it would be worthwhile to determine whether or not there has been any change in the intensity of actual maintenance man-years applied. To do this, system-specific data were utilized, since base maintenance man-hours utilized are available only for individual systems. To obtain data over the longest possible time interval, the NORM rate used for system-specific analysis includes both NORM–F and G hours for FYs 1973 to 1975.

The trends in manpower utilization, intensity, and duration represented by maintenance man-hours per flying hour, maintenance man-hours per NORM hour, and NORM hours per flying hour, respectively, for each specific aircraft system have been graphed in Figure 7–7. Note that manpower utilization is the product of manpower intensity and maintenance duration. Since this relation is the product of two terms, the data have been converted to logarithms (base e) to allow the addition of $\log_e$ man-hours per NORM hour and $\log_e$ NORM hours per flying hour values to produce $\log_e$ man-hours per flying hour. Because the data have been graphed in logarithmic scales, the reader is cautioned that equal absolute distances represent equal percentage changes. Although the actual data values cannot be directly read from Figure 7–7, the trend behavior of the ratios is quite apparent:

- Utilized maintenance man-hours per flying hour (field, organizational, and avionics) have increased from FY 1973 to FY 1975 for all systems, except the A–7 and C–5.

- The time to restore each aircraft system to operationally ready status, as measured by NORM hours (F&G) per flying hour, has expanded greatly over this period.

- The intensity with which maintenance manpower is actually applied, as measured by utilized maintenance man-hours per NORM hour, has generally declined–the exceptions being the B–52 and KC–135 systems.

The aggregate Air Force data presented above established that available maintenance personnel could have been employed as intensively (per NORM hour) in FY 1976 as in FY 1972. Available Air Force maintenance manpower declined, but in proportion to the decline in total NORM hours. The system-specific data show that in all instances, with the exception of the B–52 and the KC–135, utilized manpower declined on a NORM hour basis.[3] Since authorized maintenance manpower was available in the aggregate to maintain a stable intensity of maintenance manpower applied, we think it is pertinent and reasonable to ask what was the impact of lower utilization of manpower per NORM hour on aircraft operational status.

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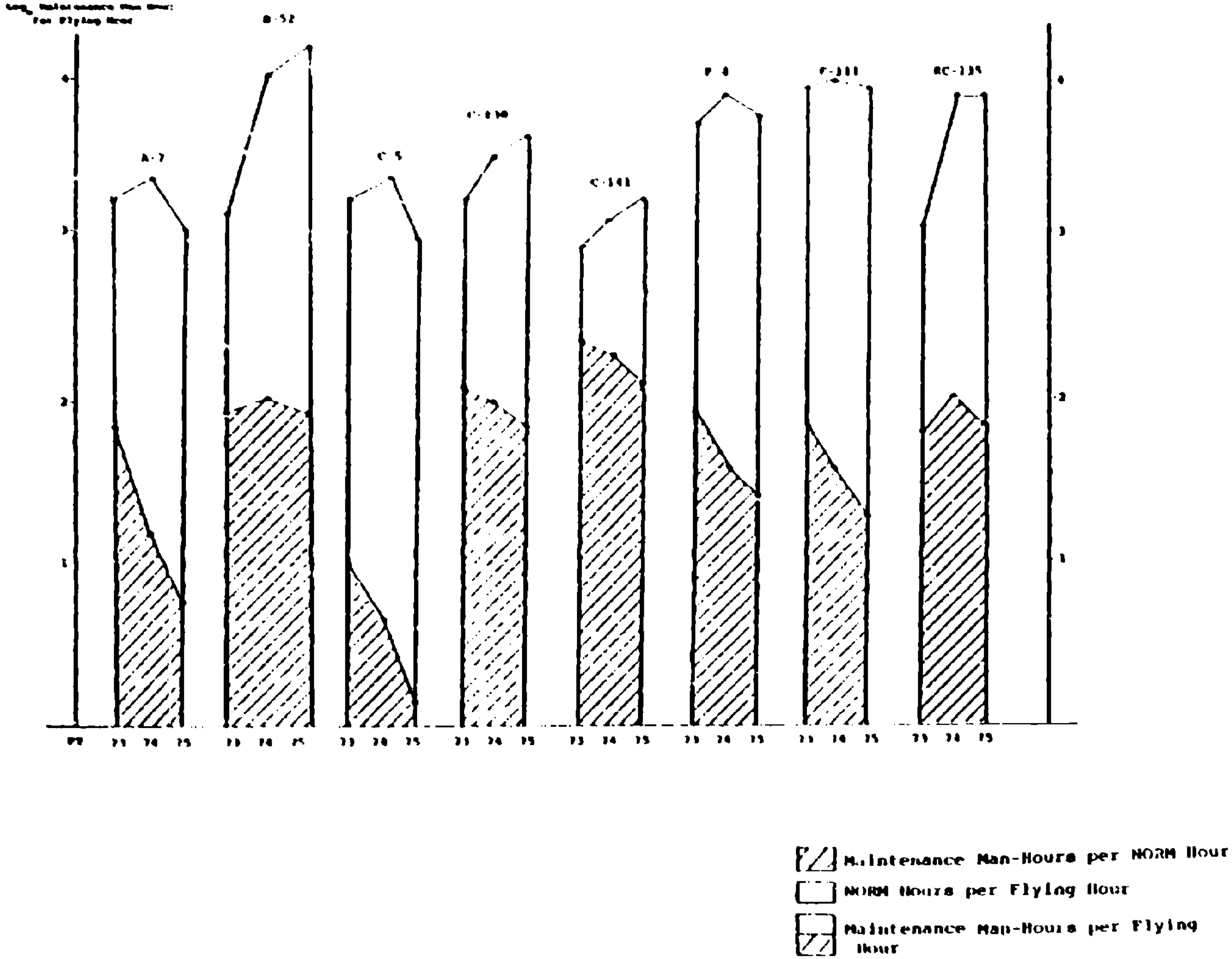
[3] This reversal in trend suggests that SAC is making more intensive use of its maintenance personnel in FY 1975 compared with FY 1973, which is not the case for the other commands whose aircraft were analyzed on this basis.

FIGURE 7-7. MAINTENANCE MAN-HOUR, MAN-HOUR INTENSITY AND DURATION TRENDS BY SYSTEM
(Log$_e$ Scale)



For each system except the B–52 and KC–135, we have computed the level of NORM hours per flying hour in FY 1975, assuming that the level of intensity (maintenance man-hours per NORM hour) remained at the higher FY 1973 level. This computation assumes that the required maintenance actions could have been completed by the same number of maintenance man-hours per flying hour in FY 1975, but worked more intensively. We have therefore used the actual level of maintenance man-hours per flying hour, as was recorded in FY 1975, along with the maintenance man-hours per NORM hour in FY 1973, to obtain the hypothetical NORM hours per flying hour in FY 1975. This resulting hypothetical value for FY 1975 NORM hours per flying hour was then converted into a NORM rate, using actual flying hours and possessed hours in FY 1975.

Note that in FY 1973, separate NORM–G and NORM–F categories were introduced. We have therefore assumed that the FY 1973 standard is equivalent to the NORM–G of later years. Thus, we have compared the calculated hypothetical value of NORM–G and the actual NORM–G rate observed in FY 1975. (See Table 7–3.) The actual NORM rate (unweighted) in FY 1975 averaged 31.5% as opposed to the hypothetical average level of 24.0% that could have been achieved in FY 1975 had the intensity of maintenance remained at the higher FY 1973 level. The alternative assumption that NORM in FY 1973 is equivalent to NORM (F + G) in FY 1975 produces a much greater difference between actual and hypothetical values than is reflected in Table 7–3.

TABLE 7-3. ACTUAL FY 1975 NORM-G RATE VERSUS NORM-G RATE IF INTENSITY OF MAINTENANCE HAD REMAINED AT FY 1973 LEVEL

	Actual FY 1975 NORM-G Rate	Hypothetical NORM-G Rate
A-7	21.8	10.8
C-5	43.4	23.4
C-130	27.3	28.0
C-141	35.8	33.0
F-4	28.3	23.2
F-111	32.1	25.7
6-System Average	31.5	24.0

The trend in utilization of base maintenance manpower can also be surmised from the above data. We have previously seen that available maintenance manpower increased by 45%, on a per flying hour basis, between FY 1972 and FY 1976. The rate of increase in available manpower can be compared to the rate of increase for utilized maintenance manpower. When the available manpower growth rate exceeds the utilized manpower growth rate, the actual utilization of available manpower declines, and conversely. Data for FYs 1972 and 1975 from nine important weapon systems, which together account for about one-third of the aircraft inventory and one-half of the aggregate flying hours, show that utilized direct production man-hours per flying hour increased by 62%. For this sample of Air Force systems, the use of man-hours per flying hour increased at a faster rate than the rate of increase in aggregate available man-hours. We therefore conclude that the actual utilization of available Air Force maintenance manpower has increased. Nevertheless, the time aircraft spend in NORM status has also increased.

To gauge the magnitude of relative maintenance costs across weapon systems, a comparative display of maintenance costs per flying hour and per aircraft has been compiled in Table 7-4. The data cover the six largest consumers of maintenance resources among the Air Force weapon systems for FY 1976 and are compiled on a fully allocated basis–indirect costs and exchangeable material are assigned on the basis of direct product labor.

Information extracted from Table 7–4 on total maintenance cost per flying hour is displayed in Figure 7–8, where the six systems are displayed in ascending order of costs. Note that the high cost systems on a flying hour basis do not necessarily preserve their ranking on a cost per aircraft basis, since flying hours per aircraft appreciably differ across the systems. Thus, the C–141 has one of the lowest cost per flying hour levels, but due to the high flying activity rate, ranks as the second highest system on a cost per aircraft basis. Similarly, the F–111, with the lowest flying hours per aircraft, has the highest cost per flying hour, but is third in terms of cost per aircraft. Note also the variability of average cost per flying hour across systems. Some of this variability is explained by system differences in average flying hours per aircraft, as fixed costs are spread across different amounts of flying hours. Earlier we saw that aircraft complexity explained 58% of the observed variability in cost per flying hour. These cost differences can have a large impact on life cycle cost–the differences between the F–111 and the six-system average amount to $4.5 million per aircraft (undiscounted), using current Air Force average flying hours per aircraft and a 10–year active life.

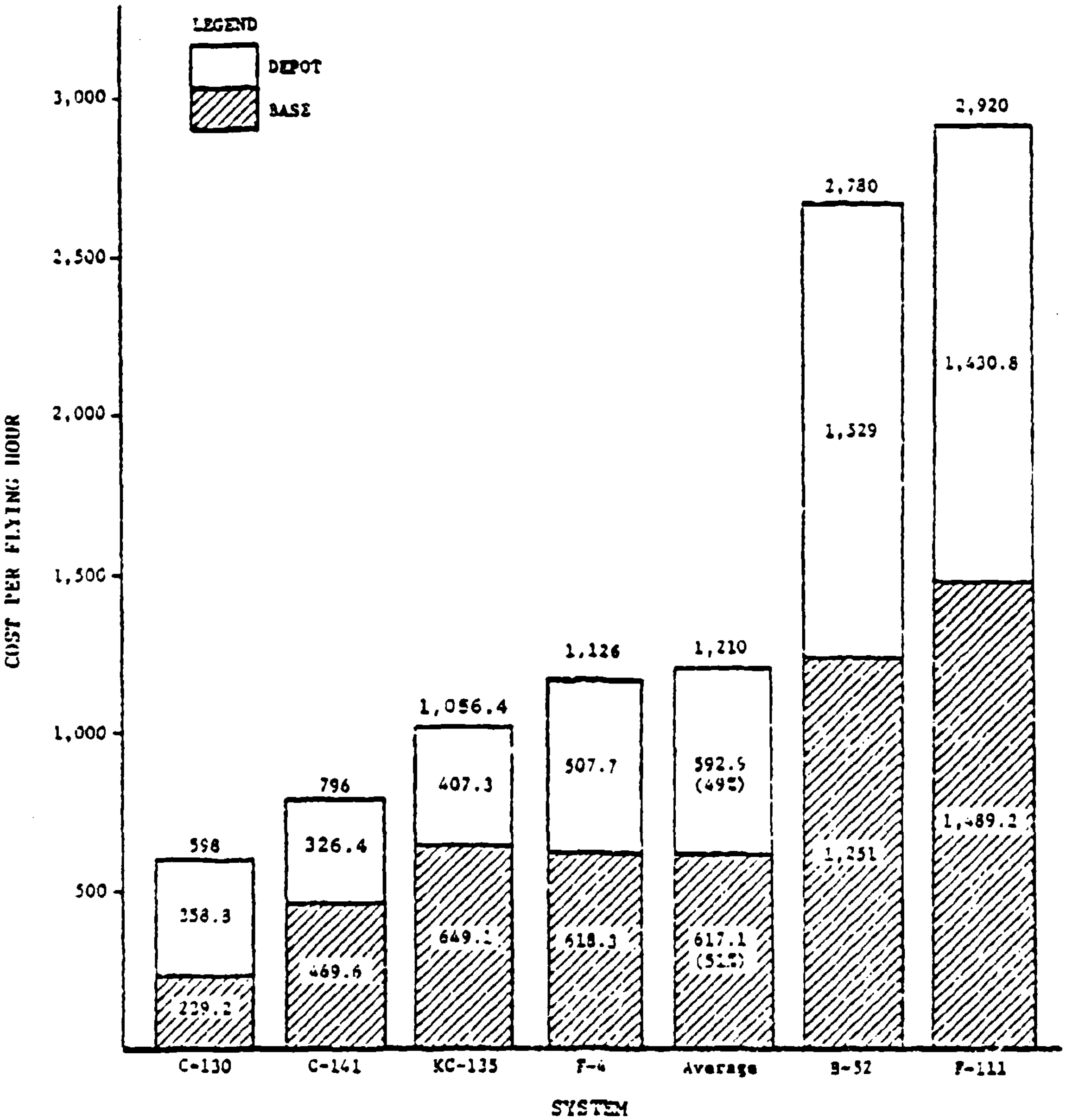
TABLE 7-4. BASE, DEPOT AND TOTAL AVERAGE MAINTENANCE COST PER FLYING HOUR AND PER AIRCRAFT (FY 76)

System	Complexity		Cost Per Flying Hour			Cost Per Aircraft		
	No. of Components	Index (KC 135=100)	Base $	Depot $	Total	Base $	Depot $	Total
B-52	2,831	253	1,251 (45%)	1,529 (55%)	2,780	385,200 (45%)	470,800 (55%)	856,000
F-111	3,459	310	1,489.2 (51%)	1,430.8 (49%)	2,920	279,066.9 (51%)	268,123.1 (49%)	547,190
C-130	1,828	164	239.2 (40%)	358 (60%)	598	101,660 (40%)	152,490 (60%)	254,150
C-141	2,337	209	469.6 (59%)	326.4 (41%)	796	417,066.3 (59%)	289,825.7 (41%)	706,892
KC-135	1,117	100	649.1 (62%)	407.3 (38%)	1,056	194,306.8 (62%)	119,091.2 (38%)	313,398
F-4	1,573	141	618.3 (52%)	507.7 (48%)	1,126	131,821.6 (52%)	121,681.4 (48%)	253,503
Six System Average			617.1 (51%)	592.9 (49%)	1,210	192,897.3 (51%)	185,332.7 (49%)	378,230

Grand Totals: Base 824,515
Depot 783,355

Total 1,607,870

FIGURE 7-8. TOTAL MAINTENANCE COSTS PER FLYING HOUR, BASE, DEPOT AND TOTAL, SIX HIGHEST COST SYSTEMS (FY 1976)



FINDINGS AND CONCLUSIONS

The major findings and conclusions from the analysis of data and trends in performance, costs, performance and accomplishment of aircraft maintenance can be summarized as follows.

Depot Level

- Trend analysis indicates that fleet size, not the flying hour program, historically correlates best with the number of aircraft undergoing PDM. Consequently, depot maintenance activity can be expected to be more sensitive to fleet size than to aircraft utilization, if the current overhaul policy remains in effect. However, the cost of performing PDM is also sensitive to changes in fleet complexity and mix and to maintenance policy affecting work packages, PDM cycles and other considerations.

- Aircraft hours spent in Depot Maintenance averaged 7.5% of total available fleet hours from FY 1972 to FY 1976, compared to an average 22% of fleet hours in Base Maintenance (NORM).

- Aircraft flow time at the depot increased from 35 to 40 days per aircraft from FY 1973 to FY 1974 and has remained at 40 days per aircraft thereafter.

- Aggregate depot maintenance costs per aircraft increased from $70,827 to $101,263 in current dollars from FY 1974 to FY 1976 (43%), and from $70,827 to $88,827 in constant 1974 dollars (25%). The depot repair costs of exchangeables used on aircraft and engines accounted for most of this increase. The six highest cost aircraft systems in terms of depot maintenance account for two-thirds of total depot maintenance costs.

- Aircraft complexity, as measured by the number of different exchangeable components per aircraft, accounted for 42% of the observed variability in total maintenance cost per aircraft and 56% of the observed variability in total maintenance cost per flying hour. A 10% increase in the number of components increases the maintenance cost per flying hour by at least 10%, and maintenance cost per aircraft by slightly less than 10%.

- Generally, Depot Maintenance seemed to be getting more expensive both on a current and constant dollar basis, with aircraft tending to spend about the same fraction of their life in Depot Maintenance.

Base Level

- The NORM-G rate increased slightly between FYs 1972 and 1976, but no substantial change occurred in the relative contribution of scheduled vs. unscheduled maintenance to NORM-G status.

- NORM hours per flying hour increased by 58% between FYs 1972 and 1976, as aggregate flying hours substantially decreased, with no significant change in the composition of flying hours by weapon system.

- Authorized maintenance manpower per flying hour increased by 45% (FYs 1972 to 1976), while NORM-G hours per flying hour increased by 58%. Based on authorized manpower levels, the intensity of maintenance manpower utilization per NORM hour could have remained stable over this period, however.

- If the actual intensity of maintenance personnel utilization per NORM hour had remained constant, the NORM-G rate would have been 24.0% in FY 1975 instead of the reported 31.5%. The independence of the overall productivity of maintenance personnel from the intensity of utilization is assumed, as is the absence of gross system failures that could distort NORM reporting for any particular time period.
- The utilization rate for base maintenance personnel appears to have increased, as maintenance man-hours per flying hour increased faster than available maintenance man-hours per flying hour for nine important aircraft systems.
- Although the utilization rate of maintenance manpower increased, the time that aircraft spend in maintenance is also increasing, suggesting that other factors, such as supply shortages, could conceivably distort aircraft maintenance status reporting.

DATA AND SOURCE DESCRIPTION

The data compiled for analysis of aircraft maintenance are divided into depot and below-depot exhibits. Each echelon is then further subdivided into sections which deal with aggregate Air Force information and weapon system-specific data.

Depot Level

Table 7-5 is aggregate in nature and presents three categories of data: production, resources consumed, and performance. In the production category, we have displayed long-term trends for the number of aircraft for which programmed depot maintenance has been accomplished-both at organic facilities and by contractors. A series on the number of repairs and modifications performed is also included. The totals for both sub-categories include all work performed by Depot Maintenance and contractors for all customers, including the active Air Force, MAC, Guard and Reserves and others. These are aggregate data, and no attempt has been made to indicate the composition of these activities by aircraft type.

The next two data elements are closely related and indicate, respectively, the number of aircraft hours spent in depot repair, and the percentage of fleet hours represented by these depot hours. The data are for the aggregate active Air Force inventory, and were derived by subtracting the number of possessed hours that the inventory was in the hands of users from the annual average active inventory. Air Force planning generally allocates 10% of the fleet to fill depot maintenance pipeline requirements.

The final data element in the production category shows the average number of elapsed days between the time an aircraft is placed in work and the time it passes acceptable flight tests. Although such data are available on a weekly basis for all aircraft

TABLE 7-5. DEPOT MAINTENANCE - AIRCRAFT
Aggregate Measures

A. Production FY:	66	67	68	69	70	71	72	73	74	75	76	Sources
Programmed Depot Maintenance (Complete overhauls, all customers)												
Total	3,009	3,576	3,182	3,323	3,183	2,445	2,127	1,803	2,017	1,881	1,708	LOG MA(M) 7409 and AFLC Factbook
Contract									836	667	541	
% Contract									41%	35%	32%	
Number of Repairs, Modifications, etc. (not concurrent with PDM).	7,999	4,297	6,156	9,448	3,932	3,717	4,[illegible]13	5,587	2,659	844*		AFLC Factbook
(* - modifications only)												
Aircraft Depot Hours (x 10^6)							6.35	8.73	5.73	3.29	9.43	
% of Fleet at Depot							6.3%	9.3%	6.4%	4.0%	11.6%	
Aircraft Flow Time at Depot (organic only) - in days								35.24	41.48	40.01	39.35	G037D
B. Resources												
AFLC Total Authorized Manpower (end of FY) (x 10^3)					124.6	118.0	113.1	111.3	107.9	100.3	92.5	AFLC Factbook
Organic Depot Maintenance Manpower (x 10^3)									42.6	40.6	37.7	E5011NJ4L
Aircraft Maintenance and Modification Cost (DIFM, PE72207F) ($ x 10^3)									247,037	294,233	282,545	OP-19
C. Organic Depot Performance												
Number of Direct Product Earned Hours per Man-day		4.01	3.81	4.03	4.23	4.42	4.29	4.28	4.41	4.30	4.32	AFLC Indicators
Direct Labor Effectiveness		88%	85%	89%	91%	92%	89%	89%	90%	89%	90%	AFLC Indicators

completing flight tests within that week, we have aggregated the data for an entire fiscal year to determine the average annual aircraft flow time.

The second category of data in Table 7–5, resources consumed, includes authorized organic manpower and industrially-funded equipment maintenance (PE 72207F) costs. Two displays of manpower are presented. The first is for AFLC, and includes total authorized manpower levels for central logistics activities, including materiel management, distribution, procurement, and other activities at the five ALCs and other facilities, such as Aerospace Guidance Maintenance Center (AGMC), Military Aircraft Storage Depot Center (MASDC) and Air Force Contract Management Center (AFCMC). The second, organic depot maintenance manpower authorization level, includes manpower assigned to maintenance activities at the five organic ALCs plus AFLC Headquarters, and represents authorized organic production manpower assigned for direct maintenance production, and excludes administration, base support, and other indirect activities.

The cost for depot maintenance of active Air Force aircraft, including manpower, direct materials, and other operating costs, is also included in this section. These data are taken from Exhibit OP–19, Depot Maintenance Industrial Fund (PE 72207F), for Air Force expenditures on aircraft maintenance and modifications. These expenditures cover only "funded" costs for work accomplished on airframes–exchangeables, engines and other equipment are not included. Table 7–10, below, presents fully allocated expenditures for engines, accessories, airborne electronic and communications equipment, armaments, and ground support equipment associated with six high cost weapon systems. The costs presented in this series do not include any attribution for the cost of repair for exchangeable items–the latter accounts for between 37% and 57% of total depot maintenance costs. (See Chapters 4 and 5 for analyses of engines and exchangeables.)

Performance measures for organic depot activities are taken from AFLC's Management Indicators publication. The first performance measure represents the earned maintenance output per man–day at organic facilities. This measure considers the standard hours associated with the tasks completed at these facilities, and displays the annual average standard hours earned, divided by the total number of available man–days. The associated variable, direct labor effectiveness, compares hours earned using job standards with actual direct hours worked. A value of 90%, for example, implies that for every 100 hours of direct labor, actual jobs rated at 90 hours were accomplished.

Table 7–6 displays depot maintenance costs from Exhibit OP–19, industrially funded depot maintenance for selected weapon systems. The major category of interest is aircraft maintenance and modification (airframes), although we have included engines as a separate category. These data have been recorded for FYs 1973 through 1976. For

TABLE 7-6. DEPOT MAINTENANCE COSTS

System Specific Cost Data
($ x 10^3)

	OP-19, PE72207F, CMIF			Special Report for I&L (prepared from CSCR)	
	FY 74	FY 75	FY 76	FY 76	
A-7					
Aircraft Maintenance and Modification	5,575	5,891	5,321	N/A	
Engine Overhaul and Repair	7,127	10,662	15,920		
B52: (D, F, G, H)					
Aircraft Maintenance and Modification	62,588	101,897	106,808	109,698	Airframe
Engine Overhaul and Repair	12,355	9,166	8,406	8,086	Engines
				50,936	Accessories
				10,618	Airborne Elect. & Communication
				19,525	Armament
				1,113	AGE
				199,976	Total
C130: (B, D, E)					
Aircraft Maintenance and Modification	24,367	16,075	8,229	28,166	Airframe
Engine Overhaul and Repair	1,929	1,809	5,971	8,234	Engines
				64,018	Accessories
				7,468	Airborne Elect. & Communication
				2,028	Armament
				619	AGE
				110,533	Total
C5A					
Aircraft Maintenance and Modification	1,414	1,038	1,666	N/A	
Engine Overhaul and Repair	157	060	175		
C141					
Aircraft Maintenance and Modification	1,390	1,862	2,779	29,648	Airframe
Engine Overhaul and Repair	331	-	-	3,526	Engines
				41,537	Accessories
				4,757	Airborne Elect. & Communication
				0	Armament
				639	AGE
				50,127	Total

TABLE 7-6
(continued)

	FY 74	FY 75	FY 76	FY 76	
F-4(C, D, E)					
Aircraft Maintenance and Modification	54,520	64,054	67,314	83,783	Airframe
Engine Overhaul and Repair	14,297	17,512	16,354	20,385	Engines
				77,946	Accessories
				15,278	Airborne Elect. & Communication
				18,709	Armament
				2,598	AGE
				219,199	Total
F-15					
Aircraft Maintenance and Modification	-	122	258	N/A	
Engine Overhaul and Repair	-	939	-		
F-111 (A, D, E, F)					
Aircraft Maintenance and Modification	7,629	11,197	23,476	25,603	Airframe
Engine Overhaul and Repair	5,286	12,635	15,495	15,310	Engines
				40,807	Accessories
				14,979	Airborne Elect. & Communication
				2,633	
				69	AGE
				99,401	Total
KC-135					
Aircraft Maintenance and Modification	25,416	27,360	27,705	30,565	Airframe
Engine Overhaul and Repair	15,741	11,311	10,926	14,539	Engines
				28,906	Accessories
				4,215	Airborne Elect. & Communication
				-	Armament
				328	AGE
				78,553	Total
Subtotal Aircraft Maintenance and Modification	182,899	230,096	243,556		
Subtotal Engine Overhaul and Repair	57,283	64,094	73,247		
Total Aircraft Maintenance and Modification	247,037	294,233	282,545		
Total Engine Overhaul and Repair	100,374	102,293	[illegible]		
GRAND TOTAL	347,911	396,526	38[illegible]56		
Other System Maintenance and Modification	64,138	64,137	39,989		
Other System Engine Overhaul and Repair	43,391	38,199	31,764		

FY 1976, an additional data series, covering six systems and several additional equipment categories has been compiled. This series is based on a special compilation by the Air Force for ASD(MRA&L) from the new Operating and Support Cost Reporting system (OSCR). This system is designed to allocate all costs (direct and indirect, funded and unfunded) to weapons systems.

Base Level

Base level aircraft maintenance data for specific aircraft systems show trend behavior for the resources and time required to perform base maintenance. Direct and indirect labor account for from 23% to 62% of fully allocated maintenance costs for the six systems costed by the Air Force for ASD(MRA&L).[4] Table 7-7 presents aggregate Air Force trend data for activity rates, NORM hours and rates, and authorized available mission equipment maintenance manpower. Table 7-8 contains similar data for nine important weapon systems, except that actual direct production man-hours are used instead of available man-hours.

In Table 7-7, aggregate inventory, possessed hours, flying hours, and sorties are displayed first. The definition and sources of these series have previously been discussed. NORM-G hours, in total and for scheduled and unscheduled maintenance, are displayed for a five-year period. These data show a slight but steady upward trend in NORM hours relative to possessed hours (the NORM rate), despite the fact that flying hours per possessed hour (aircraft) have markedly declined. Based on authorized maintenance manpower in FYs 1972 and 1976, three ratios are then computed: authorized maintenance man-hours per NORM-G hour, NORM-G hours per 1,000 flying hours, and the product of these ratios, authorized maintenance man-hours per 1,000 flying hours:

$$\frac{\text{Maintenance Man-Hours}}{\text{Flying Hours}} = \frac{\text{Maintenance Man-Hours}}{\text{NORM-G Hours}} \cdot \frac{\text{NORM-G Hours}}{\text{Flying Hours}} .$$

Table 7-9 presents measures that serve as proxies for the quality of aircraft and related systems maintenance. These data either were not considered important enough to be discussed in the previous section or exhibited little variability either over time or across aircraft systems. At the top of Table 7-9, the aggregate Air Force accident rate per 100,000 flying hours is observed to have decreased steadily over a nine-year period. System-specific reliability rates on both a pre- and in-flight basis, which are calculated as

[4] These figures come from a special report prepared by the Deputy Chief of Staff Systems and Logistics, Air Force Headquarters, using the new Base Maintenance Costing System. Organic labor costs as a percentage of total systems costs were B-52-31%, F-111-23%, C-130-34%, C-141-45%, KC-135-62% and F-4-40%.

TABLE 7-7. BASE LEVEL AIRCRAFT MAINTENANCE
Aggregate Measures

A. Air Force Worldwide	FY: 72	73	74	75	76	
Aircraft Inventory	11,517	10,799	10,156	9,334	9,289	USAF Summary
Possessed Hours (x 10^6)	94.54	85.87	83.24	78.48	71.94	G033B
Flying Hours (x 10^6)	5.3	4.74	3.66	3.49	2.84	K008 data base
Sorties (x 10^6)			1.93	1.71	1.52	G033B
Average Sortie Length (Hours)			1.9	2.04	1.87	
NORM-G Scheduled Hours (x 10^6)	6.76	6.15	6.13	6.37	5.75	
NORM-G Scheduled Rate	7.15%	7.2%	7.4%	8.1%	7.9%	
NORM-G Unscheduled Hours (x 10^6)	13.55	13.81	13.01	13.06	11.49	
NORM-G Unscheduled Rate	14.3%	16.1%	15.6%	16.6%	15.9%	
Total NORM-G Hours (x 10^6)	20.31	19.96	19.14	19.43	17.24	
Total NORM-G Rate	21.5%	23.2%	23%	24.8%	24%	
Authorized Mission Equipment Maintenance Manpower	224,104				174,634	HAF-010 TAPE
Authorized Maintenance Man-Years per 10^3 Flying Hours	42.3				61.5	
Authorized Maintenance Man-Years per NORM-G Hour	0.011				0.010	
NORM-G Hours per 10^3 Flying Hours	3,832				6,070	

TABLE 7-8. BASE LEVEL AIRCRAFT MAINTENANCE FOR SPECIFIC SYSTEMS

B. System-Specific Maintenance Data

	FY: 72	73	74	75	76	
A-7						
Average Aircraft Reported	146.8	250.7	276.7	282.7		
Possessed Hours (x 10^6)	1.286	2.196	2.424	2.476		
Flying Hours	43,535	88,576	80,390	81.306		PCN:RRA-00023 AF man-hour per-flying hour trend report
Direct Production Maintenance Man-Hours (x10^6)	1.279	2.088	2.061	1.623		(same as above)
NORM F & G Rate		15.7	26.7	32.9	31.2	GO33B
NORM F & G Hours (x10^3)		344.8	647.2	814.8		
Maintenance Man-Hours Per Flying Hour	29.4	23.6	25.6	20.0		
Maintenance Man-Hours Per NORM Hour		6.06	3.18	1.99		
NORM Hours Per Flying Hour		3.89	8.05	10.02		
B-52						
Average Aircraft Reported		395.3	286.5	310.4	332.8	
Possessed Hours (10^3)		2,509.7	2,719.1	2,915.3		
Flying Hours	244,977	343,351	154,398	150,701		PCN:RRA-00023 man-hour per-flying hour trend report
Direct Production Maintenance Man-Hours (x10^3)	4,072.0	7,720.0	9,200.0	9,444.8		(same as above)
NORM F & G Rate		46.0	42.2	44.2	46.0	GO33B
NORM F & G Hours (x10^3)		1,154.5	1,147.5	1,288.5		
Maintenance Man-Hours Per Flying Hour	16.6	22.5	59.6	62.7		
Maintenance Man-Hours Per NORM Hour		6.69	8.02	7.33		
NORM Hours Per Flying Hour		3.36	7.43	8.55		
C-5						
Average Aircraft Reported	36.1	50.3	59.4	57.3		
Possessed Hours (x10^3)		440.6	520.3	501.9		
Flying Hours	31,525	50.503	46,983	50,291		PCN:RRA-00023 AF man-hour per-flying hour trend report
Direct Production Maintenance Man-Hours (x10^3)	2,318.7	2,530.0	3,662.6	4,126.2		(same as above)
NORM F & G Rate		33.8	46.0	64.4	58.6	GO33B
NORM F & G Hours (x10^3)		742.3	1,115.0	1,594.8		
Maintenance Man-Hours Per Flying Hour	29.4	23.6	25.6	20.5		
Maintenance Man-Hours Per NORM Hour		2.81	1.85	1.02		
NORM Hours Per Flying Hour		8.38	13.87	19.62		
C-130						
Average Aircraft Reported	324.3	309.4	372.6	361.6		
Possessed Hours (x10^3)		2,710.3	3,264.0	3,167.6		
Flying Hours	255,067	225,607	250,488	224,263		PCN:RRA-00023 AF man-hour per-flying hour trend report
Direct Production Maintenance Man-Hours (x10^3)	6,314.3	5,368.8	7,170.9	6,814.4		(same as above)
NORM F & G Rate		24.0	30.2	34.9	38.2	GO33B
NORM F & G Hours (x10^3)		650.5	985.7	1,105.5		
Maintenance Man-Hours Per Flying Hour	24.8	23.8	28.6	30.4		
Maintenance Man-Hours Per NORM Hour		8.25	7.27	6.16		
NORM Hours Per Flying Hour		2.88	3.94	4.93		

TABLE 7-8. BASE LEVEL AIRCRAFT MAINTENANCE FOR SPECIFIC SYSTEMS (continued)

FY:	72	73	74	75	76	
C-141						
Average Aircraft Reported	255.8	268.3	248.5	243.9		
Possessed Hours ($x10^3$)	2,240.8	2,350.3	2,176.9	2,136.6		
Flying Hours	482,981	408,702	310,887	302,918		PCN:RRA-00023 AF man-hour per-flying hour trend report
Direct Production Maintenance Man-Hours ($x10^3$)	8,743.2	7,722.0	6,615.2	7,203.4		(same as Above)
NORM F & G Rate		33.2	31.9	40.0	43.5	G033B
NORM F & G Hours ($x10^3$)		756.8	694.4	854.6		
Maintenance Man-Hours Per Flying Hour	18.1	18.9	21.3	23.8		
Maintenance Man-Hours Per NORM Hour		10.2	9.53	8.43		
NORM Hours Per Flying Hour		1.85	2.23	2.82		
F-4						
Average Aircraft Reported	1,335.7	1,239.3	1,423.7	1,421.5		
Possessed Hours ($x10^3$)		10,856.3	12,471.6	12,452.3		
Flying Hours	484,670	432,602	408,551	412,948		PCN:RRA-00023 AF man-hour per-flying hour trend report
Direct Production Maintenance Man-Hours ($x10^3$)	16,839.8	16,208.0	18,592.1	17,822.1		(same as above)
NORM F & G Rate		24.2	30.0	35.1	34.1	G033B
NORM F & G Hours ($x10^3$)		2,627.2	3,741.5	4,370.8		
Maintenance Man-Hours Per Flying Hour	34.7	37.5	45.5	43.2		
Maintenance Man-Hours Per NORM Hour		6.17	4.97	4.08		
NORM Hours Per Flying Hour		6.07	9.16	10.58		
F-15						
Average Aircraft Reported				1.2	13.0	
Possessed Hours ($x10^3$)					113.9	
Flying Hours				211	2,221	PCN:RRA-00023 AF man-hour per-flying hour trend report
Direct Production Maintenance Man-Hours ($x10^3$)				2.9	79.4	(same as Above)
NORM F & G Rate					32.5	G033B
NORM F & G Hours ($x10^3$)					37.0	
Maintenance Man-Hours Per Flying Hour				13.9	35.7	
Maintenance Man-Hours Per NORM Hour					2.15	
NORM Hours Per Flying Hour					16.66	
F-111						
Average Aircraft Reported	205.3	300.3	292.6	306.2		
Possessed Hours ($x10^3$)	1,748.4	2,630.6	2,563.2	2,682.3		
Flying Hours	61,452	86,272	81,693	82,912		PCN:RRA-00023 AF man-hour per-flying hour trend report
Direct Production Maintenance Man-Hours ($x10^3$)	2,983.6	4,455.0	4,515.3	4,164.0		(same as Above)
NORM F & G Rate		28.1	35.9	40.1	43.5	G033B
NORM F & G Hours ($x10^3$)		739.2	920.2	1,075.6		
Maintenance Man-Hours Per Flying Hour	48.55	51.7	55.3	50.22		
Maintenance Man-Hours Per NORM Hour		6.23	4.90	3.87		
NORM Hours Per Flying Hour		7.69	11.26	12.97		

TABLE 7-8. BASE LEVEL AIRCRAFT MAINTENANCE FOR SPECIFIC SYSTEMS (continued)

FY:	72	73	74	75	76	
KC-135						
Average Aircraft Reported	597.6	504.2	507.6	563.7		
Possessed Hours ($\times 10^3$)		4,416.7	4,446.6	4,938.0		
Flying Hours	318,829	318,389	226,840	218,843		PCN: RAA-OC023 AF man-hour per-flying hour trend report
Direct Production Maintenance Man-Hours ($\times 10^3$)	3,581.1	7,680.2	9,828.6	9,795.8		(same as above)
NORM F & G Rate		29.9	30.5	32.1	33.7	G033B
NORM F & G Hours ($\times 10^3$)		1,320.6	1,356.2	1,585.1		
Maintenance Man-Hour Per Flying Hour	11.2	24.1	43.3	44.7		
Maintenance Man-Hour Per NORM Hour		5.82	7.25	6.18		
NORM Hours Per Flying Hour		4.15	5.[illegible]	7.24		

TABLE 7-9. MAINTENANCE QUALITY MEASURES

Quality Measures	FY: 66	67	68	69	70	71	72	73	74	75	76	
AF Worldwide Accident Rate Per 10^5 Flying Hours	4.9	4.5	3.9	4.0	3.0	2.5	3.0	2.3	2.9	2.6		AFLC Indicators
Before Flight Reliability (BFR)												System Effectiveness Report
In Flight Reliability (IFR)												" " "
A-7												
BFR									.967	.965	.961	
IFR									.961	.984	.992	
B-52 (G&H)												
BFR									.988	.987		
IFR									.968	.975		
C-5												
BFR									.979	.975		
IFR									.973	.97		
C-141												
BFR									.99	.988	.992	
IFR									.991	.992	.994	
F-4												
BFR									.958	.961		
IFR									.986	.984		
F-111												
BFR									.96	.959	.960	
IFR									.988	.992	.991	
F-15												
BFR											.93	
IFR											.983	
KC-135												
BFR									.979	.983	.979	
IFR									.991	.992	.993	
C-130												
BFR									.973	.975	.975	
IFR									.981	.981	.983	

the ratio of sorties flown to sorties attempted, are seen to exhibit virtually no change over a three-year period.

The final display, Table 7-10, lists system-specific maintenance costs distributed by activity category and echelon for FY 1976. These data were prepared by the Office of the Deputy Chief of Staff, Systems and Logistics, Air Force Headquarters, at the request of ASD(MRA&L), using the new Air Force Base Level Maintenance Costing System. The report underlying the data displayed in Table 7-10 lists dollar costs in terms of labor, materiel (expense-type at depot, expense and exchange materiel at base), other direct, overhead, and contract for each equipment category presented.

TABLE 7-10. COST OF MAINTENANCE (FY 1976)

($ x 10^3)

MDS		Airframe		Engine		Aircraft & Engine Accessories		Airborne Electronic & Comm. Equip.		Armament		AGE		Total	
		$000	%	$000	%	$000	%	$000	%	$000	%	$000	%	$000	%
B-52	Base	87,902	44	31,727	80	9,969	16	30,276	74	407	02	0	-	160,376	45
	Depot	109,698	56	8,086	20	50,936	84	10,618	26	19,525	98	1,113	100	200,014	55
	Total	197,600	100	39,813	100	60,905	100	40,894	100	19,932	100	1,113	100	360,390	100
	% of Grand Total		55		11		17		11		06		00		100
F-111	Base	34,831	58	28,420	65	2,732	06	40,257	73	588	18	60	47	106,888	51
	Depot	25,603	42	15,310	35	40,807	94	14,979	27	2,633	82	69	53	99,402	49
	Total	60,434	100	43,730	100	43,539	100	55,236	100	3,221	100	129	100	206,290	100
	% of Grand Total		29		21		21		27		02		00		100
C-130	Base	50,985	64	8,476	51	6,314	09	5,733	43	9	01	39	06	71,556	40
	Depot	28,166	36	8,234	49	64,018	91	7,468	57	2,028	99	619	94	106,093	60
	Total	79,151	100	16,710	100	70,332	100	13,201	100	2,037	100	658	100	177,649	100
	% of Grand Total		45		09		40		07		01		00		100
C-141	Base	79,963	73	16,925	83	6,884	14	12,594	73	1	100	22	03	116,389	59
	Depot	29,648	27	3,526	17	41,537	86	4,757	27	0	-	629	97	80,127	41
	Total	109,611	100	20,451	100	48,421	100	17,351	100	1	100	601	100	196,516	100
	% of Grand Total		56		10		25		09		00		00		100
KC-135	Base	88,161	74	20,961	59	7,326	20	10,822	72	19	100	55	14	127,354	62
	Depot	30,565	26	14,539	41	28,906	80	4,215	28	0	-	328	86	78,549	38
	Total	118,733	100	35,500	100	36,232	100	15,037	100	19	100	383	100	205,903	100
	% of Grand Total		58		17		18		07		00		00		100
F-4	Base	165,900	66	25,753	56	9,792	12	37,897	71	2,427	11	159	06	241,952	52
	Depot	83,781	34	20,885	44	77,946	88	15,278	29	18,709	89	2,598	94	219,170	48
	Total	249,681	100	46,632	100	87,738	100	53,175	100	21,136	100	2,757	100	461,122	100
	% of Grand Total		54		10		19		12		05		01		100

Source: Special report prepared for I&L by DSC System and Logistics Headquarters, USAF

CHAPTER 8: TRANSPORTATION AND AIRLIFT

OVERVIEW AND STRUCTURE

In many of the earlier chapters, transportation has been mentioned as an essential element of the logistics structure; indeed, in Chapter 3 we evaluated the role of transportation as a link between Central Supply and Base Supply, using pipeline performance times. But transportation has other significant roles. In Chapter 8 we discuss those roles as they relate to the Air Force; specifically, we address the scope of transportation services utilized by the Air Force, the transportation services provided by the Military Airlift Command (MAC) as the Single Manager Transportation Agency operating under the Secretary of the Air Force, and the surge capability of MAC in an emergency environment.

The data we present on transportation costs to the Air Force and MAC airlift services to DoD components are not amenable to the same type of analysis used in the earlier chapters. The reason for this may be traced to the extent of commercial resources in the DoD transportation system itself. A substantial portion (about one-fifth in FY 1975) of MAC's air transportation is provided by commercial charter aircraft. Likewise, at least one-third of the Military Sealift Command (MSC) operations involve commercial charter ships. Additionally, almost all DoD surface and air transportation within CONUS is provided by commercial carriers.

This heavy reliance upon commercial carriers tends to blur the results of any cost or performance analysis of DoD transportation. The cost and performance of commercial carriers, however they may be measured, must be considered as exogenous variables, not within DoD control and certainly not within Air Force control. While the Air Force can, in many cases, procure the most economical carrier by means of competitive bids, it cannot control what cost or performance will result. Any analysis of such cost and performance would amount to an analysis of the competitive bid process, rather than an analysis of Air Force logistics management effectiveness.

In place of the type of analysis performed in earlier chapters, we present here an analysis of what capability might be expected of our total military airlift assets in an emergency condition. It should be considered only as a brief and not necessarily definitive example of surge transportation capability analysis.

ANALYSIS OF DATA AND TRENDS

Air Force Transportation

The Air Force utilizes a wide range of transportation services for moving passengers, freight, petroleum, and personal property. These services include the three Single Manager Transportation Agencies, i.e., MAC, MSC, and the Military Traffic Management Command (MTMC), as well as commercial carriers of all kinds. The services of MAC, MSC, and MTMC are in essence restricted to transportation of persons and things to and from CONUS, or within and between overseas areas. Within CONUS, the Air Force deals directly with commercial carriers. Summary costs of Air Force transportation expenses are shown in Table 8-1.

TABLE 8-1. AIR FORCE TRANSPORTATION EXPENSES, FY 1975
(Millions of Dollars)

	Agency				
Type Service	MAC	MSC	MTMC	Other	Total
Passenger	$ 54.7	-	-	$ 56.3	$111.0
Cargo	176.0	$107.2	-	259.2	542.4
Other	223.2	15.8	$20.3	-	259.3
Total	$453.9	$123.0	$20.3	$315.5	$912.7

Of the $56.3 million the Air Force spent on passenger transportation, almost 97% was spent on commercial airlines. Of the $259.2 million spent on cargo, over 70% was spent on personal property, including household goods and unaccompanied baggage. The remainder, $76.4 million, was spent on volume traffic (carloads, truckloads, contract commercial air, pipeline, etc.), and small shipment traffic (less than carload, less than truckload, air freight, air express, etc.).

A detailed breakdown of Air Force transportation costs and performance measures is shown in Table 8-2. Data on non-industrially funded transportation services by Service prior to FY 1974 is not available.

MAC Transportation

MAC provides passenger and cargo services to all the Military Services and other DoD agencies. MAC's principal assets consist of C-5, C-130, and C-141 aircraft. MAC also possesses helicopters and utility aircraft for rescue and recovery service, as well as other transport aircraft for special assignment airlift missions. In addition, MAC charters commercial carriers as necessary to satisfy peacetime airlift requirements. Under

TABLE 8-2. AIR FORCE TRANSPORTATION COSTS AND PERFORMANCE MEASURES, FY 1975

		Tons ($x10^3$)	Ton-Miles ($x10^6$)	Cost per Ton-Mile			Total Cost ($x10^6$)
CARGO							
Industrial Fund	MAC	141.8	590.2	$.298			$176.0
	MSC	1,593M*	7,430M	.014			105.3
		28L*	11L	.171			1.9
Non-Industrial Fund	Freight	810	732	.104			76.4
	Personal Property	372	925	.198			182.4
Totals		1,324	2,247	--			$542.4
		1,593M	7,430M	--			
		28L	11L	--			
PASSENGER		No. ($x10^3$)	Pass. Miles ($x10^6$)	Cost per Pass. Mile	Pass. Ton-Miles ($x10^6$)	Cost per Pass. T/M	
Industrial Fund	MAC	370.2	Not Reported	Not Reported	164.3	$.333	$ 54.7
Non-Industrial Fund	Rail	23.0	4.0	$.025	Not Reported	Not Reported	0.1
	Air	570.0	616.0	.088			54.3
	Bus	346.0	50.0	.038			1.9
Totals		1,309.2	670.0	--	164.3	--	$111.0
Other - MTMC		-- Tariff from Ocean Terminal Services --					$ 20.3

*M - Measurement Tons
L - Liquid (petroleum) Tons

TABLE 8-3. STRATEGIC AND TACTICAL AIRLIFT RESOURCES (Number of Aircraft)

Military Airlift Aircraft						
MAC	ATC[1]	AFLC/ Depots	ANG/ AFRES[2]	Totals	Type Aircraft	Maximum Load
55	5	15	-	75	C-5	107 Tons
255	-	15	236	506	C-130	14-20 Tons
230	15	28	-	273	C-141	32 Tons
540	20	58	236	854		

Civil Reserve Air Fleet (CRAF)					
Domestic, Alaskan, and Short-Range Int'l.	Long-Range Int'l.- Pass.	Long-Range Int'l.- Cargo	Totals	Type Aircraft	Maximum Load
45	-	-	45	B727	23 Tons
5	-	-	5	DC-9	16 Tons
12	-	-	12	L100	26 Tons
14	-	-	14	L188	N/A
5	-	-	5	B737	18 Tons
2	-	-	2	C-46	7.5 Tons
1	-	-	1	SC-7	2.5 Tons
3	-	-	3	F27	6.5 Tons
1	-	-	1	DC-6	N/A
-	10	42	52	B707	189 Pass. or 47 Tons
-	67	14	81	B747	374-500 Pass. or 86-127 Tons
-	16	11	27	DC-10	250-380 Pass or 62-78 Tons
-	-	67	67	DC-8	44-54 Tons
88	94	134	316		

1. Air Training Command
2. Air National Guard and Air Force Reserve

mobilization, MAC can draw upon the assets of the Civil Reserve Air Fleet (CRAF) for transportation of cargo and passengers. Table 8-3 shows the number and disposition of the principal MAC aircraft and CRAF resources considered as strategic and tactical airlift resources.

The volume of transportation services provided by MAC in FY 1975 is shown in Table 8-4. Included are data on passenger, cargo, and other services. Note that the Air Force was the source of more than half of MAC's total revenues for that year; indeed, the Air Force costs exceeded the sum of the other components' costs in all categories except passengers.

TABLE 8-4. MAC AIRLIFT SERVICES, FY 1975

Component	No. of Pass. ($x10^3$)	Pass. Ton-Miles ($x10^6$)	Cost to Comp. ($x10^6$)	Cargo Tons ($x10^3$)	Cargo Ton-Miles ($x10^6$)	Cost to Comp. ($x10^6$)	Other Costs[1] ($x10^6$)	Total Costs ($x10^6$)
Army	407.1	169.3	$ 58.9	55.9	191.3	$ 56.3	$ 50.7	$166.0
Navy	265.4	115.3	40.4	71.0	255.2	79.2	36.5	156.1
Air Force	370.2	164.3	54.7	141.8	590.2	176.0	223.2	453.9
Other DoD	48.8	9.9	3.6	4.7	10.9	3.4	95.8	102.8
Total	1,091.5	458.8	$157.6	273.3	1,047.6	$314.9	$406.3	$878.7

[1]Special Assignment Airlift, APO/FPO Mail, Exercises/Joint Airborne Training, Air Force Mission Responsibility, etc.

As a Single Manager Operating Agency, MAC is, of course, industrially funded. Hence, the Military Services reimburse MAC for transportation services rendered on the basis of tariffs periodically revised to adjust for a breakeven position on revenues and expenses. In Figures 8-1 through 8-3, we examine the trends in those revenues and expenses from FY 1970 through FY 1975, especially in relation to ton-miles of airlift services provided. Figure 8-1 compares revenues with expenses in constant FY 1975 dollars. Figure 8-2 displays ton-miles flown by MAC in the four categories of principal airlift forces: Cargo, Passengers, Special Assignment Airlift (SAA), and Exercises/Airborne Training (Ex/ABT). Figure 8-3 shows revenue earned per ton-mile in constant FY 1975 dollars for those four categories, along with overall revenue per ton-mile.

FIGURE 8-1. MAC REVENUES AND EXPENSES
(Constant FY 1975 $)

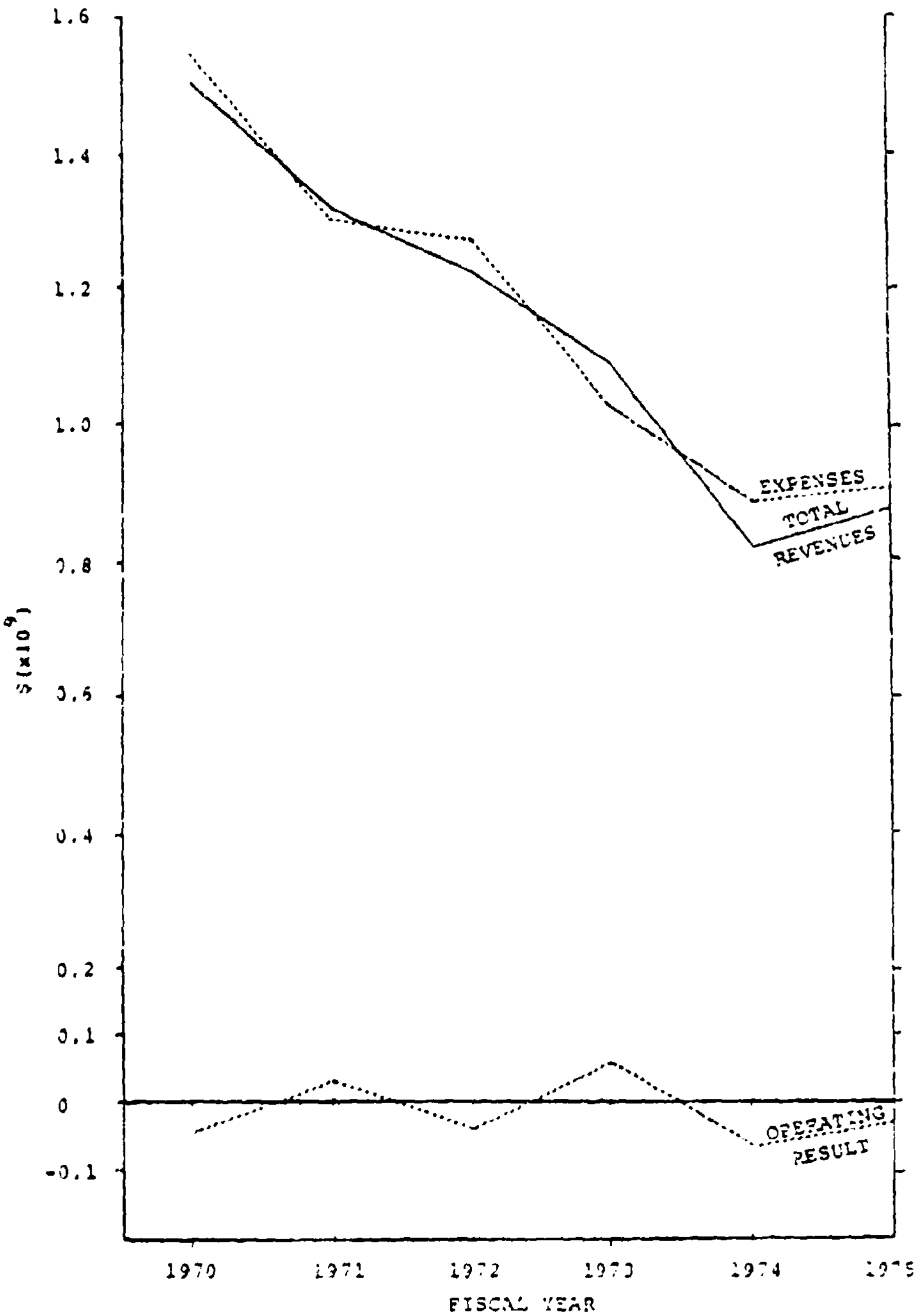


FIGURE 8-2. MAC TON-MILES FLOWN

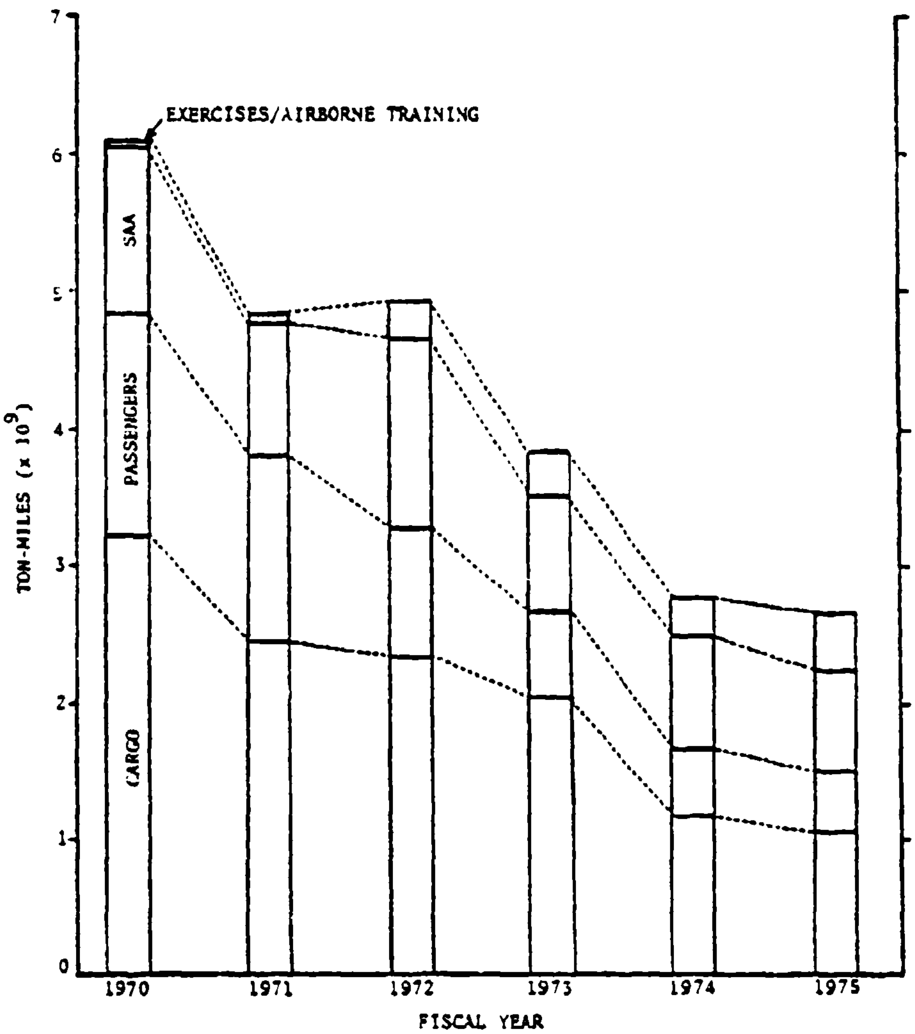
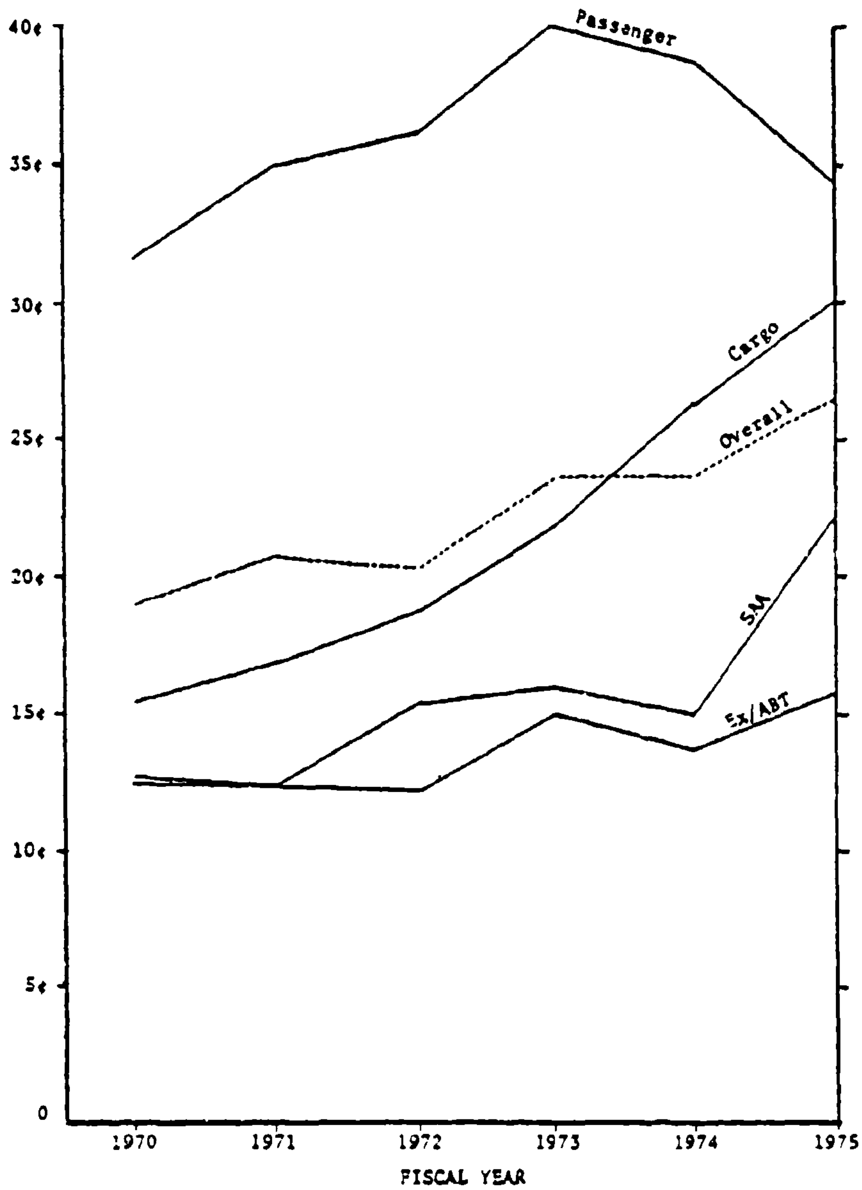


FIGURE 8-3. REVENUE EARNED PER TON-MILE
(Constant FY 1975 $)



In general, revenues and expenses have decreased to about the same degree as ton-miles flown; while the year-to-year operating results vary between "profit" and "loss," the cumulative MAC deficit in operating results totaled almost $100 million. Passenger ton-miles have shown the largest decrease (71%) during the six-year period, followed closely by cargo ton-mile decreases (68%). SAA ton-miles have, on the other hand, decreased only 39%, while Ex/ABT ton-miles have skyrocketed. Indeed, SAA and Ex/ABT ton-miles constituted 43% of the total in FY 1975, whereas they amounted to less than 2% of the total in FY 1970. Combining these two indicators in Figure 8-3, we observe that revenue earnings per ton-mile have in general increased in this period by 39%. The largest gains were posted by cargo (95%) and SAA (78%). Passenger revenue earnings, while rising in the early 1970's, have fallen off and have registered only a 9% net increase.

The expectation would be, we believe, for total ton-miles to continue to decrease in the face of austerity in the defense budget, along with the steady increase in revenue rates. Level or diminishing funds for transportation, coupled with rising tariff rates, will compel MAC's customers either to cut back on their transportation requirements or to seek other, cheaper modes of transportation. The crisis is undeniably self-perpetuating, and most likely will not be solved by any means short of drastic revision of current funding procedures and policies.

If MAC's assets (i.e., aircraft, crews, and support personnel) could be adjusted to satisfy current and projected needs, this problem would be of much smaller magnitude. Such is not the case, however. MAC must retain the capability to respond almost immediately to emergency or wartime requirements for massive airlift of combat troops and supplies. Consequently, MAC has to maintain a large and relatively underutilized airlift fleet and a fully trained force of aircrew and support personnel, not just a cadre. These demands levy a cost out of proportion to the amount of airlift services MAC provides in peacetime, but if national security should call for MAC's surge capability, the cost must be paid. In the next section, we examine quantitatively some aspects of that surge capability.

Strategic Airlift Surge Capability

As stated earlier, the following analysis is not intended to be definitive, but is rather an example of how many facets of DoD transportation might be evaluated. Note that the assumption of an emergency or wartime environment is crucial. This assumption may well be common to any such transportation capability assessment, e.g., an evaluation of domestic truck transport capability to support a general mobilization plan.

Our determination of surge capability depends upon five factors:

- Anticipated scenario
- Aircraft availability

- Aircrew availability
- Maintenance crew workload capability
- Total fuel requirements, CONUS and overseas.

To arrive at that determination, we will examine each factor and assess its impact on surge capability.

Anticipated Scenario

Obviously, the scenario is the one independent variable in this determination. It should be realistic, probable, and demanding; otherwise, the assessment may be meaningless. We have selected the same scenario considered in a recent GAO evaluation[1] of MAC airlift capability, i.e., a 30-day maximum-level airlift to the European Theater, with a round-trip distance of 9,516 nautical miles from the center of the U. S. Both MAC and CRAF Long-Range International Fleet would be employed. The GAO scenario did not set forth any minimum tonnage requirements, but assumed each aircraft would be flown an average of 10 hours per day. We also assume no minimum tonnage requirements, but will let the other factors determine the average number of daily flying hours. We also assume the following aircraft factors related to movement of cargo:

Aircraft	Number	Average Payload(tons)	Average Speed(knots)	Flying Hours Round Trip[3]
MAC				
C-5A	55[1]	77	410	23.2
C-141	230[1]	23.5	410	25.2
CRAF				
B747	14[2]	94	460	20.7
DC-10	11[2]	55.8	460	20.7
DC-8 & B707	109[2]	34.4[4]	460	20.7

[1]The GAO report used 70 C-5A's and 234 C-141's. The "Monthly Aerospace Vehicle/Utilization Report" (GO33B), August 1976, lists 52 C-5A's and 223 C-141's in MAC units. The above figures are taken from Table 8-3.

[2]From Table 8-3, Long-Range International Fleet Cargo.

[3]Round trip distance (9,516 nm) ÷ average speed.

[4]Assumed from the GAO report. For some models, maximum load may be much less.

[1]Comptroller General of the United States, Information on the Requirements for Strategic Airlift, June 8, 1976.

Aircraft Availability

To assess this factor for MAC aircraft, we employ the concept of mission cycle time,[2] i.e., the complete cycle between successive departures of an aircraft on an assigned round trip. The mission cycle time is the sum of the following elements:

> Flying hours + post-flight checks + time spent on maintenance (scheduled and unscheduled) + time spent waiting for parts not immediately available + additional time + pre-flight checks.

"Additional time" refers to operationally ready aircraft not scheduled for flight. For simplicity, we will ignore time spent on additional time and pre- and post-flight checks. Then the minimum mission cycle time must be the sum of flying hours, essential maintenance time, and time awaiting essential parts.

What constitutes "essential maintenance time" and "time awaiting essential parts?" The limitations of the OR rate as a measure of wartime readiness were addressed in detail in Chapter 2. For the reasons explained there, the use of NORM and NORS to evaluate these times may be labeled as suspect. However, to avoid a time-consuming in-depth analysis (which might answer the question), it seems appropriate to eliminate NORM-F and NORS-F time, since we are considering an emergency type of scenario. This is especially true of airlift aircraft that do not require the same sophisticated electronic equipment needed on combat aircraft. If those airlift aircraft are physically capable of flying and possess the bare minimum capabilities for navigation and communication, they could be scheduled and flown.

Shown below are the NORS, NORM, and OR rates (from the GO33B report) along with mission cycle times for 21st and 22nd Air Force airlift aircraft:

Aircraft	NORS-G	NORM-G (Sched.)	NORM-G[1] (Unsched.)	Total	OR	Mission Cycle Time (hrs.)[2]
C-5A	6%	9%	43%	58%	42%	55.2
C-141	4%	4%	32%	40%	60%	38.7

[1]Derived from the GO33B report for August 1976. Yearly averages for these measures were not available at the time the analysis was made.

[2]Mission cycle time = flying hours per round trip ÷ OR rate.

[2]This concept was developed earlier by C. F. Bell and T. T. Tierney in Force Capability Reporting, the RAND Corporation, R-547-PR, September, 1970.

Based on those mission cycle times, the number of round trips each aircraft can fly in 30 days is equal to the number of hours in 30 days (30 x 24), divided by the mission cycle time. For the C-5A, this number is 13.1; for the C-141, 18.6. In terms of cargo <u>deliveries</u> to Europe, this means each C-5A can deliver 13 loads and each C-141, 19 loads.

Next, each C-5A would fly an average of 13.1 x 23.2 ÷ 30 = 10.1 hours per day; each C-141 would fly 18.6 x 23.2 ÷ 30 = 14.4 hours per day. Whether these averages can be maintained over 30 days is a question to be answered in part by examining the remaining three factors.

We assume that, in a mobilization environment, MAC would most likely defer as much NORM-G scheduled maintenance as possible until the end of the 30-day period. MAC would also attempt to reduce NORS-G rates wherever possible by WRSK penetrations, to a greater extent than is the current practice. We will assume that NORS-G rates may be cut in half by using WRSKs. This assumption attempts to balance out the impact of the lack of stockage "depth" (on-hand quantity for each item) of WRSK, the response times for replenishing WRSK shortages, the capability of transport aircraft to carry essential spares on airlift missions, and the demand-supported nature of WRSK stockage criteria. With this assumption, then, the NORS, NORM, and OR rates would be as follows:

Aircraft	NORS-G	NORM-G (Unsched.)	Total	OR
C-5A	3%	43%	46%	54%
C-141	2%	32%	34%	66%

The corresponding mission cycle times, number of round trips and deliveries, and average flight hours per day are shown below.

Aircraft	Mission Cycle Time	No. of Round Trips	No. of Deliveries	Flying Hours/Day
C-5A	43.0	16.7	17	12.9
C-141	35.2	20.5	21	15.8

For CRAF aircraft, we assume the same 10 flying hours per day used in the GAO report. Since those aircraft undergo a different maintenance cycle, we cannot apply the same technique used for MAC aircraft. At 300 hours in a 30-day period, with 20.7 flying hours per round trip, each aircraft can accomplish 14.5 round trips, or 15 deliveries, in that period.

Aircrew Availability

MAC has 192 active and Reserve Associate aircraft crews for the C-5A and 737 crews for the C-141. The average number of flying hours per crew for the 30-day period is shown below for the two values of mission cycle time:

Aircraft	Mission Cycle Time	Flying Hours/Crew
C-5A	55.2	82
	43.0	105
C-141	38.7	131
	35.2	143

The C-5A aircrew workload should not be considered excessive, having been exceeded in other emergency situations by military airlift crews. The C-141 aircrew workload, on the other hand, may well be excessive. Realistically, 120 flight hours in a 30-day period should be considered as an upper limit, based on crew fatigue and flight safety factors. This would change the mission cycle time and average aircraft hours per day to 42.0 hours and 13.2 hours, respectively. That would reduce the number of deliveries to 17 loads.

We assume the CRAF aircraft would be provided with sufficient crews from their parent commercial airline to meet flying hour requirements.

Maintenance Crew Workload Capability

We have been unable to make a quantitative assessment of the capability of maintenance crews to handle these workloads. Certainly, some of the MAC maintenance crews would have to deploy to European bases, as well as to the Azores. Nonetheless, with deferral of NORM-F and scheduled NORM-G maintenance and replacement of NORS-F parts, we assume that the total mandatory workload would be within existing capabilities. Likewise, we assume that commercial airline maintenance facilities would be adequate to handle minimum requirements.

Total Fuel Requirements, CONUS and Overseas

The total fuel consumption by the MAC and CRAF aircraft for the 30-day period is shown below.

Aircraft	No.	Fuel Consumption (lbs/hr. per A/C)	Total Flying Hours Per 30-Day Period	Total Fuel Consumption (gallon)
C-5A	55	20,610[1]	21,285	73,100,000
C-141	230	12,960[1]	91,080	196,800,000
B747	14	26,666[2]	4,200[3]	18,700,000
DC-10	11	17,471[2]	3,300[3]	9,600,000
DC-8 & B707	199	12,034[2]	32,700[3]	65,600,000
			Total	363,800,000 gals.

[1] From USAF Cost and Planning Factors, AFR 173-10, Vol. 1.

[2] Estimated from data obtained in Jane's All the World's Aircraft, 1975-76 edition.

[3] Assuming 300 hours per month per aircraft.

That total is about 8.7 million barrels (42 gals. = 1 barrel).

We now seek some estimate of jet fuel available in the European Theater. USAF jet fuel issues for all of FY 1966 (from the USAF Statistical Digest, AFR 178-10) are estimated as approximately 37.5 million barrels for all overseas Air Force bases. Although AFR 178-10 does not indicate how much of that total was issued in the European Theater, we will estimate that amount as one-half, or 18.75 million barrels. Of the 8.7 million barrel requirement, approximately one-half, or 4.3 million barrels, must be located in the European Theater. Hence, 22% of the total yearly jet fuel issues in Europe must be made available to airlift aircraft in a 30-day period. Stated another way, the MAC and CRAF fuel requirements constitute 2.7 times the normal European monthly fuel requirements. This sudden surge demand for fuel must give rise to some doubt as to the capacity of in-place overseas fuel quantities for satisfying both the airlift requirements and the increased flying hour requirements of intra-theater Air Force tactical aircraft to be anticipated in a mobilization environment.

Total Cargo Airlift Tonnage

If we ignore European refueling constraints, then, based on the number of aircraft and flying hours derived earlier, the total cargo airlift tonnage capability would be:

Aircraft	Tonnage	Average Tons/Days
C-5A	72,000	2,400
C-141	91,900	3,063
B747	19,700	658
DC-10	9,200	307
DC-8 & B707	55,600	1,853
Totals	248,400	8,281

Combat Troop Airlift Capability

We assume that combat troops would be airlifted on CRAF aircraft, because MAC aircraft are much better adapted for loading and unloading combat support equipment than are commercial aircraft. Hence, the optimum use of MAC aircraft in this scenario would be in a cargo airlift role. We also assume the following aircraft factors:

Aircraft	Number	Average Number of Passengers
B747	67	383
DC-10	17	380
B707	10	189

A simple computation reveals that, in one round trip, the CRAF Long-Range International Fleet (Passenger) could airlift over 34,000 troops, something in excess of two divisions. We doubt that more than two divisions could be made available for airlift on a 30-day period, due to training and readiness requirements and to the magnitude of the logistics problems involved in assembling combat troops for airlift.

Implications

Under the assumptions made, this analysis provides an upper bound on airlift surge capability, with regard to both airlift rates (i.e., daily lift capacity) and duration for which those rates can be maintained. In an actual emergency, the overseas fuel supply problem could become critical, rapidly reducing the daily lift capacity.

We re-emphasize the dependency of our results upon the scenario and the assumptions made. We also think it appropriate to point out some questions, not even considered in this analysis, the assumptions behind which could adversely affect the results. For example, to what European destinations (i.e., airfields) would those airlift aircraft be flown? What are the unloading capabilities at those airfields? How rapidly could CRAF aircraft be transferred to Air Force control? What would be the impact of this massive diversion of military airlift upon the supply pipeline for high priority NORS items? Would returning aircraft be used to evacuate military dependents? To what extent would the Air Force be able to control and coordinate the movements of some 400 airlift aircraft per day?

To sum up, it appears that MAC and CRAF possess the potential for airlifting troops and supplies at a massive rate. The sustainability of the rate, however, seems to be highly vulnerable to the rigors imposed by realistic scenario conditions.

FINDINGS AND CONCLUSIONS

MAC Transportation

- The Air Force was the source of more than half of MAC's total revenues for 1975.

- MAC revenues, expenses, and ton-miles flown have all shown a substantial decrease from FY 1970 to FY 1975.

- MAC operating results have varied from year to year, but the cumulative deficit totaled almost $100 million in FY 1975.

- MAC revenue earnings per ton-mile have increased by 39% from FY 1970 to FY 1975, with the largest gains posted by cargo and Special Assignment Airlift.

- We anticipate that total ton-miles flown will continue to decrease, and that revenue rates will increase.

Strategic Airlift Surge Capability

- Using MAC and CRAF aircraft, our strategic airlift forces are capable of moving over 8,000 tons per day in an European contingency scenario.

- The duration for which this capability can be maintained is critically dependent upon the refueling capacity within the European Theater.

Combat Troop Airlift Capability

- The CRAF Long-Range International Fleet (Passenger) is capable of airlifting at least two divisions of combat troops to the European Theater in one round trip.

DATA AND SOURCE DESCRIPTION

Time Base

The base year for presenting current cost and performance data is FY 1975; at the time of data collection, FY 1976 information was either incomplete or unavailable. Gross trend data are presented from FY 1970 to FY 1975, but some MAC performance data are available as far back as FY 1959.

Air Force Transportation Expenses

The data in Table 8-1 were :rived from the A-11 Budget Submission for MAC, MSC, and MTMC for FY 1977, which contained FY 1975 information in the "Prior Year" columns. These data do not always agree precisely with data reported in other documents. For example, the MAC Airlift Data Summary reports that, for FY 1975, passenger revenues from the Air Force were $58.3 million (vice $54.7 million in Table 8-1), and cargo revenues from the Air Force were $179.4 million (vice $176.0 million in Table 8-1). For consistency, we chose to use the Budget Submission.

Passenger and cargo data under "other" in Table 8-1 were obtained from MTMC's "Progress Report," broken out by branch of Service. That report sets forth the extent of all non-industrially funded transportation in CONUS.

The detailed breakdown of Air Force transportation costs in Table 8-2 was obtained from the same sources as Table 8-1.

Strategic and Tactical Airlift Resources

Military airlift aircraft resource data were obtained from the MAC Command Data Book, December 1975. CRAF resource data, current as of November 1976, were obtained from various sources: Jane's All the World's Aircraft, 1975-76; Aviation Week magazine (various "Forecast and Inventory" issues), and the MAC Command Data Book.

MAC Transportation

The data in Table 8-4 and Figure 8-1 were derived from the Air Force A-11 Budget Submissions. Data on ton-miles and revenue earned per ton-mile in Figure 8-2 and 8-3 were obtained from MAC Airlift Data Summaries.

Strategic Airlift Surge Capability

Various data sources were consulted, including:

- Comptroller of the U. S., Information on the Requirements for Strategic Airlift, June 8, 1976 - data on CRAF aircraft average speeds and various scenario assumptions

- "Air Force Monthly Aerospace Vehicle/Utilization Report" (GO33B), August 1976 - data on NORS-G and NORM-G rates for C-5A and C-141 aircraft

- MAC Command Data Book - data on number of qualified crews for MAC aircraft

- USAF Cost and Planning Factors, AFR 173-10, Vol. 1 - data on MAC aircraft fuel consumption

- Jane's All the World's Aircraft, 1975-76 - data on CRAF aircraft fuel consumption and cargo capacities

- USAF Statistical Digest, APR 178-10 - FY 1966 data on annual fuel issues (more recent information is classified)

- Aviation Week magazine, various "Forecast and Inventory" issues - data on CRAF aircraft cargo capacities.

CHAPTER 9: INSTALLATIONS AND HOUSING

OVERVIEW AND STRUCTURE

The Installations and Housing (I&H) function cannot be related to measures of operational capability as directly as the other logistics functions previously discussed. (See Figure 9-1.) Still, I&H operates and maintains the real property assets needed to accomplish the Air Force mission, and deficiencies in this area can greatly limit what is operationally possible. Furthermore, some I&H functions are absolutely essential to the day-to-day performance of aircraft operations, e.g., firefighting, snow removal, and utilities.

From the aggregate point of view appropriate to the top management role of OSD, I&H functions can be classified as follows:

- Determining real property requirements (including special projects and initiatives)
- Acquiring and disposing of facilities to meet requirements
- Operating and maintaining real property assets
- Financing real property activities (in coordination with OASD(C)).

The principal variables involved in these functions and their relationship to real property assets are depicted in Figure 9-2. This structural graph shows only those variables critical to an aggregate perspective on DoD real property management. The arrows do not represent flows, but the impact of one variable upon another. A dotted line symbolizes a relationship that must, as of the completion of the present study, remain hypothetical. A line without an arrowhead indicates a relationship in which neither variable can be determined to have a strong effect upon the other.

We emphasize that Figure 9-2 represents a management structure, not necessarily actual I&H policy-making processes. It reflects the considerations one would logically expect to influence managerial decisions in these areas, but does not indicate the many constraints that prevent this ideal from being fully realized. For example, operational activity may in fact be somewhat tailored to accommodate the installation structure, rather than vice versa. Likewise, a given installation structure generates its own personnel requirements regardless of operational activity. Also, funding of construction and Real Property Maintenance Activities (RPMA) is as much affected by traditional funding levels as by actual requirements for these funds.

Family housing is the one category of real property for which OSD serves as resource manager. (See Figure 9-3.) Hence, an individual analysis of family housing is

FIGURE 9-1. GENERALIZED AIR FORCE INSTALLATIONS AND HOUSING STRUCTURE

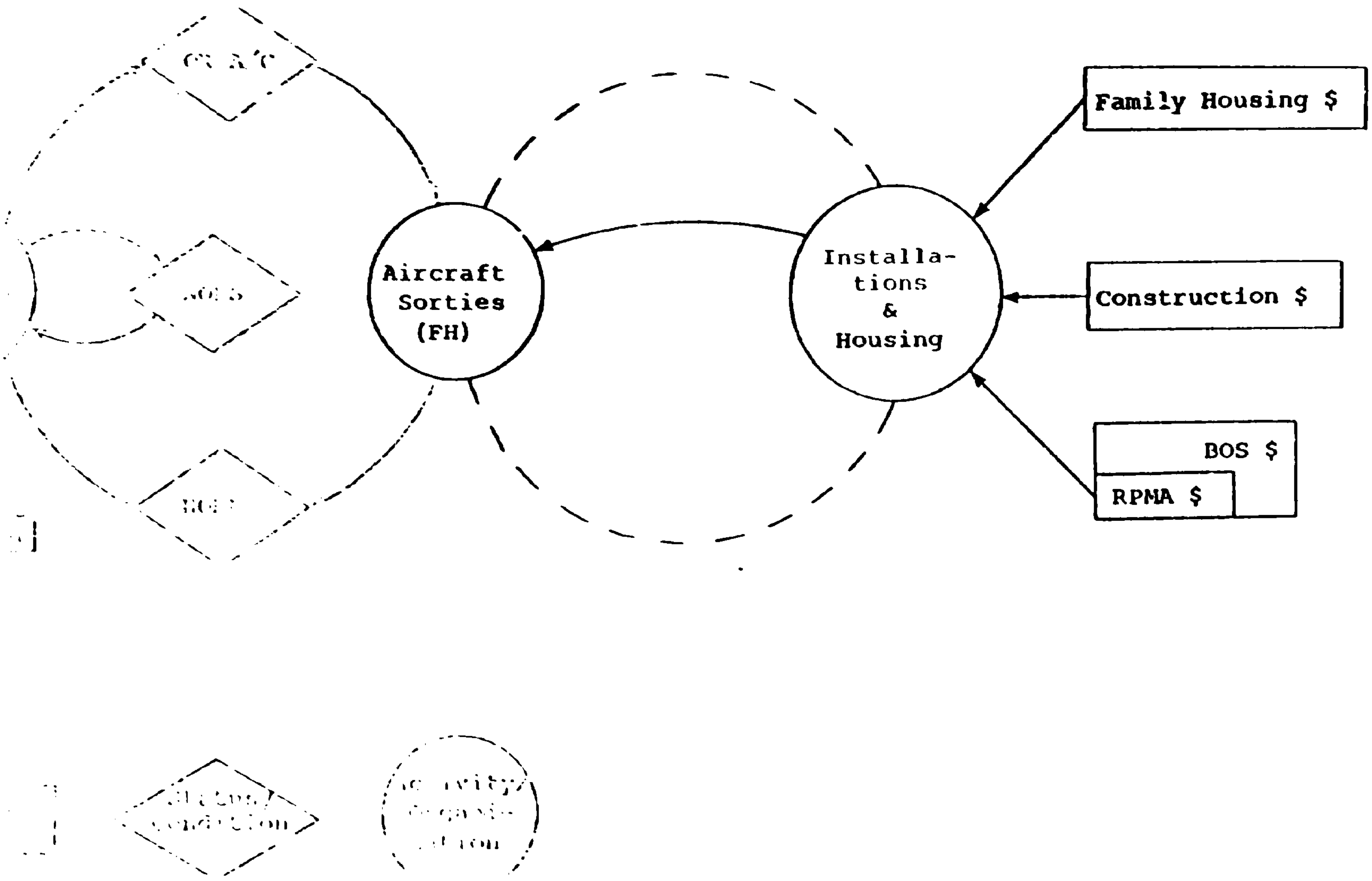


FIGURE 9-2. DETAILED STRUCTURE OF AIR FORCE REAL PROPERTY MANAGEMENT

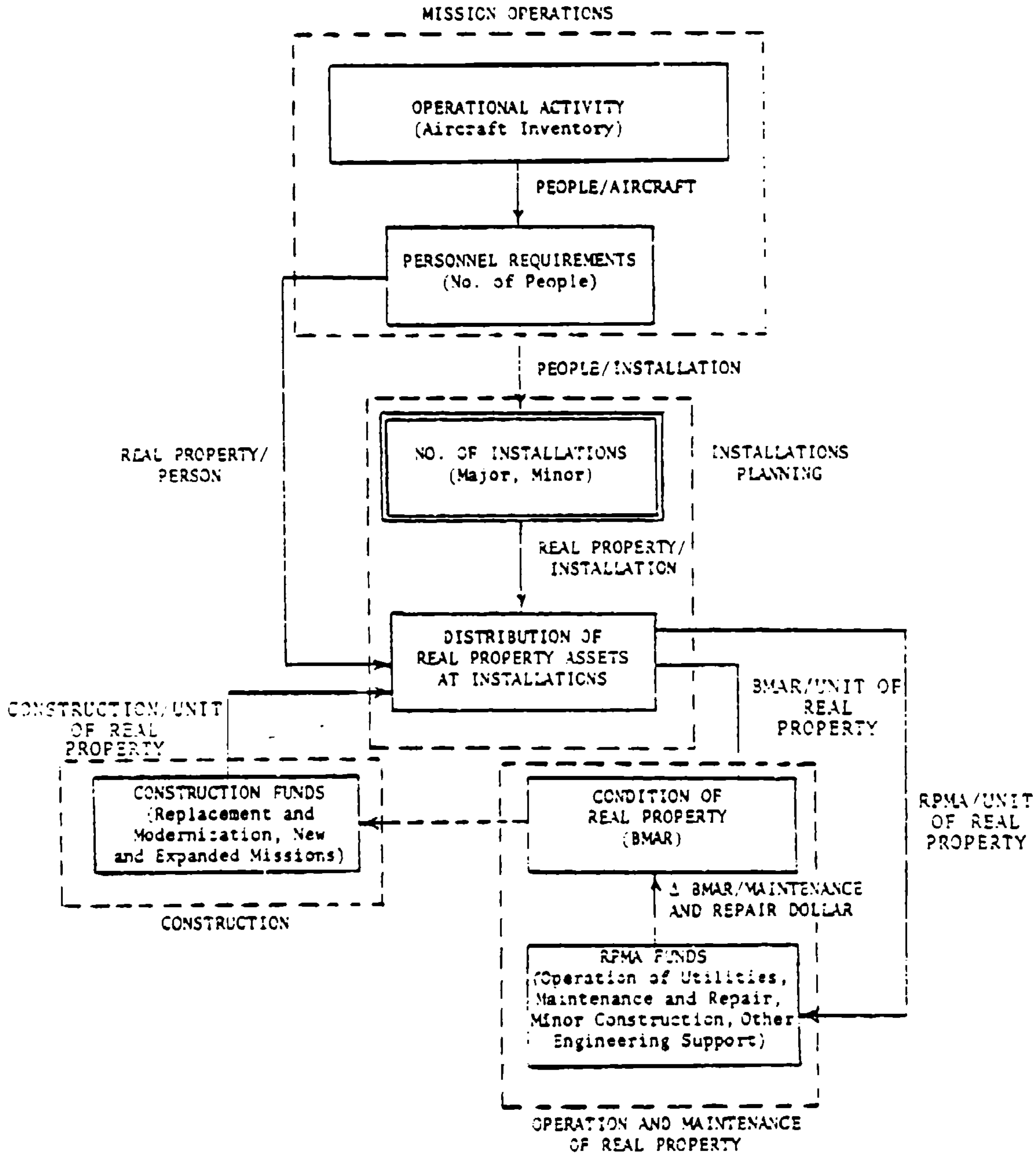
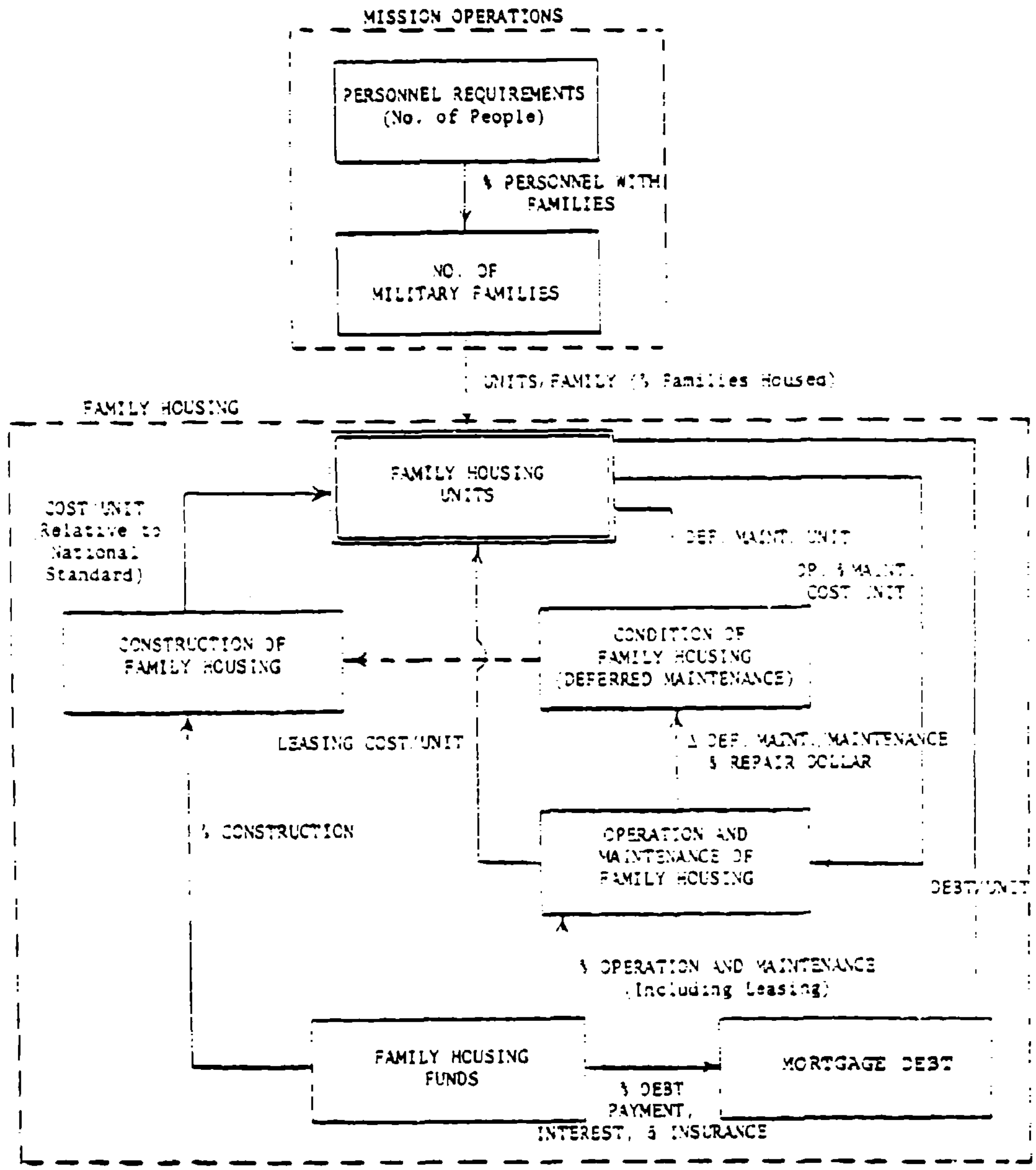


FIGURE 9-3. DETAILED STRUCTURE OF DOD FAMILY HOUSING MANAGEMENT



appropriate for OSD purposes. Because resource management responsibility for all other real property is delegated to the Military Departments, similar analyses of the other categories exclusive of family housing should be performed by them. Information at the real property category level of detail can most appropriately be reported to OSD on an exception basis. One example of such information is the Backlog of Maintenance and Repair (BMAR) profiles reported in the Program Objectives Memorandum (POM). We do not, however, support the utility of making extended projections of these data based on hypothetical future budgets, as is currently done.

In the remainder of this chapter, the analysis of family housing will be described separately from that for other real property. To the extent that the cost accounting and budgeting systems of the Military Departments will allow, a similar analysis could hypothetically be performed for any category of real property.

Data analysis aimed at developing diagnostic management tools presents some problems in the I&H functions. Changes in the relevant variables tend to be slow and protracted (i.e., more than one year). Furthermore, the consequences of action in this area have long-term implications, as opposed to the short-term ones observable in other logistics activities. Problems in I&H tend to build up over time and require an extended period to resolve. The peacetime construction budget, for example, could hypothetically be discontinued for a year with little, if any, impact on the ability of the military forces to conduct a war in that year, but such an action could produce undesirable consequences in subsequent years.

The purpose of this analysis of I&H functions, then, is not to diagnose specific problems requiring immediate attention, but rather to supply an overview of the current state of DoD real property activities relative to long-term trends. Such an overview helps provide the conceptual understanding necessary before a management system for enhancing OSD participation in long-range planning, policy-making, and budgeting can be developed.

The analysis presented here does not, for the most part, represent new and unusual material. What is new is the development of a framework for integrating the various management functions now treated relatively independently. The use of historical data, while helpful in verifying partial relationships, does limit the scope of the analysis; at the same time, by demonstrating the need for new analytical methods, it suggests a point of departure for further research.

In the structural diagram of Air Force real property (Figure 9–2), the two central boxes represent the real property assets controlled by the Air Force and their distribution at the various locations. The primary factors involved in changes in real property assets are changes in operational requirements (top of diagram) and changes in the funds available for construction, operation, and maintenance of real property (bottom of diagram). An increase in assets requires construction funds, while a decrease in assets can result from an installation closing/consolidation or other form of real property disposal.

While Figure 9-2 depicts operational requirements as independent from financial considerations, the two are, of course, interrelated. But in addition to operational requirements, there are many other factors that do and should have an impact upon funding decisions. We have therefore chosen to omit connections between the two, treating funding levels as constraints on I&H's ability to meet operational requirements. That is, the resulting inventory of real property assets and its physical condition, while ideally determined by operational activity, is in fact heavily constrained by the availability of construction and RPMA funds and the many factors entering into their allocation.

For purposes of real property requirements, the aircraft inventory has been chosen as the principal measure of operational activity. Because the size of the aircraft inventory sets requirements for support personnel, we assume that personnel requirements also influence real property requirements directly.

The bulk of expenditures for operating and maintaining real property are reported in one of the four RPMA accounts, as shown in Figure 9–2. The need for these funds depends primarily on the quantity of real property owned/controlled and its geographical and size distribution among the installations. For example, as will be shown below, the funds needed to operate and maintain a unit of real property at a small installation are, on the average, greater than at a larger installation.

The principal measure of the adequacy of RPMA funds is the reported condition of real property, i.e., BMAR, which is not a totally objective variable. The preferences of the occupants contribute to the measurement. An office space unpainted for four years may be perfectly acceptable to those currently occupying it, but may provide new occupants with an excuse to change the color. The effect of occupant turnover, however, is thought to be minimal. As long as these subjective factors remain relatively constant, they will not affect the aggregate measurement of BMAR.

New construction funds are needed for meeting new requirements and for replacing and modernizing existing facilities. There is some disagreement as to which factors most affect the replacement rate. The average age of the facilities could be a factor. We think the quality of the original construction and the level of maintenance and repair are more significant, but such quality is highly variable (most often by plan) and therefore not easily measurable. Furthermore, a relationship between the level of maintenance and repair and replacement construction could not be verified on the basis of historical data, and we believe it unlikely that such a relationship will ever be quantitatively verifiable. The proposed relationship must remain hypothetical, as shown by the dotted line in Figure 9–2.

Associated with each line connecting two variables in Figure 9–2 is a ratio. An historical trend of one of these ratios establishes a relationship between the two respective variables. Restraint must be exercised in implying causality from these relationships alone, however. The direction of the arrows depicted in the diagram is based more on intuition than on any results of the analysis performed. The establishment of relationships in this manner does not take into consideration lead-lag effects, multiple-variable effects, and extraneous variable effects, for example.

While the structural diagram for family housing (Figure 9–3) is similar to that for other real property, a few differences deserve mention. To imply that requirements for family housing depend only on the number of military families is misleading. Family housing requirements are actually based on the ability of the local community to provide adequate and affordable housing. However, for the purpose of establishing a ratio, the number of families has proven a useful measure. The measure of family housing assets chosen was number of units. Although mortgage debt is not currently used to finance new family housing, the payment of debt, interest, and mortgage insurance still represents a significant portion of the family housing budget, and as such deserves inclusion. This debt was originally used to finance Wherry and Capehart units from 1950 to 1964.

Each of the next two sections is divided into two parts, one for real property exclusive of Family Housing, and one for Family Housing. The analysis of other real property is limited to the Air Force, while that of family housing is DoD-wide (except for the percentage of families housed). The data tables upon which the analysis was based are included in the final section of the chapter, "Data and Source Description."

ANALYSIS OF DATA AND TRENDS

Real Property (Exclusive of Family Housing)

The aircraft inventory, personnel, and major and minor installations data were extracted from the USAF Summary (October 1976). While the reported information differs slightly from source to source, the numbers serve as adequate approximations for developing trends. The Air Force defines a major installation as follows:

> A major installation is one at which full-time flying or missile operations are conducted either by a permanently assigned squadron, its equivalent, or higher active or reserve Air Force unit. (It may be an Air Force or other Service installation, or a civil airport.) A major installation is also one at which flying or missile operations are not conducted, but which does have assigned to it a wing headquarters, its equivalent, or a higher level Air Force organization.

A minor installation, on the other hand, includes auxiliary air fields, missile sites, electronics stations or sites, general support annexes, and Air National Guard installations. These definitions leave something to be desired, but will be maintained here in the interest of consistency.

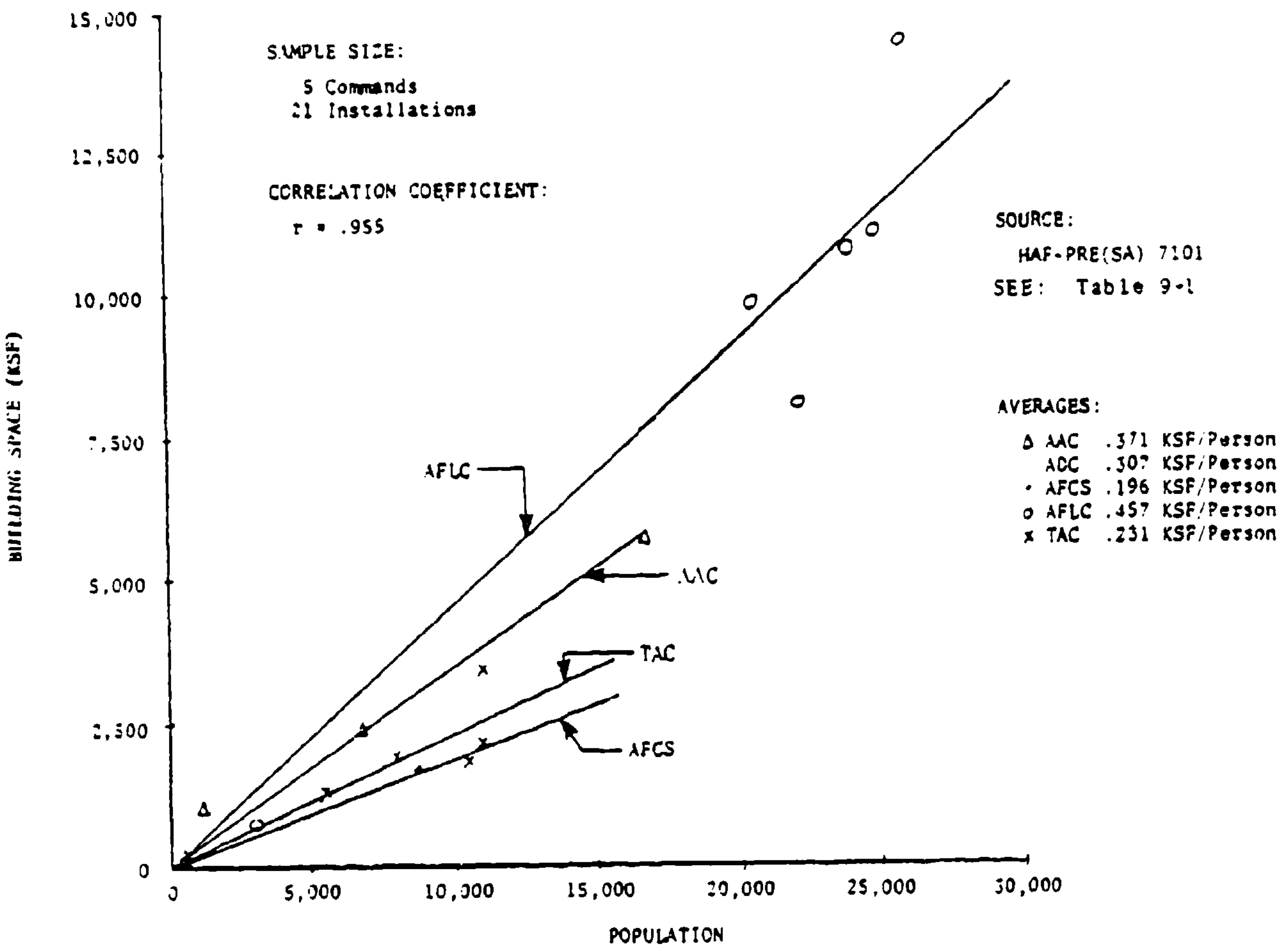
The measurement of real property owned/controlled presented a more serious data problem. The alternative measures were:

- Acquisition cost
- Replacement value
- Number of units of each facility category
- Building space
- Population

Acquisition cost is misleading and not at all representative of total assets. Replacement value, on the other hand, could be a very useful measurement if reported properly. As used here, replacement value is not what current assets could be sold for on the open market, but the estimated cost of replicating current facilities. We attempted to measure total real property assets by acquiring four years of replacement value estimates from the Military Construction (MilCon) and Special Programs Division in the Office of the Deputy Assistant Secretary of Defense (Installations and Housing) (DASD(I&H)). To measure the distribution of real property, however, we needed data on an individual installation basis and accurate replacement value information was not available for this purpose. While we could have estimated the number of units of each facility category from the detailed inventory, the process would have been too time-consuming, and there would have been no easy way to combine the unit measurements to get a single measure of assets.

Building space was the first measurement we considered that could have served as a representative proxy for real property assets. Buildings represent an estimated 60% of DoD real property (on an acquisition cost basis). By adding unit quantities from ten accounts of the Air Force Civil Engineer Cost Accounting Report (HAF-PRE(SA) 7101), the amount of building space per installation could have been acquired. Because this effort also proved too time-consuming, another proxy, installation population, was chosen. A 10% sampling of installations yielded a high correlation between building space and population ($r = .955$), although we found that commands differed slightly with respect to building space per person. (See Figure 9-4.) The population data were acquired from the same civil engineering report as building space, and included all personnel employed at each installation and resident dependents. It should be noted that while there is a correlation between installation building space and population, the average units of building space (KSF) per person can change over the years if changes in personnel levels exceed changes in building space.

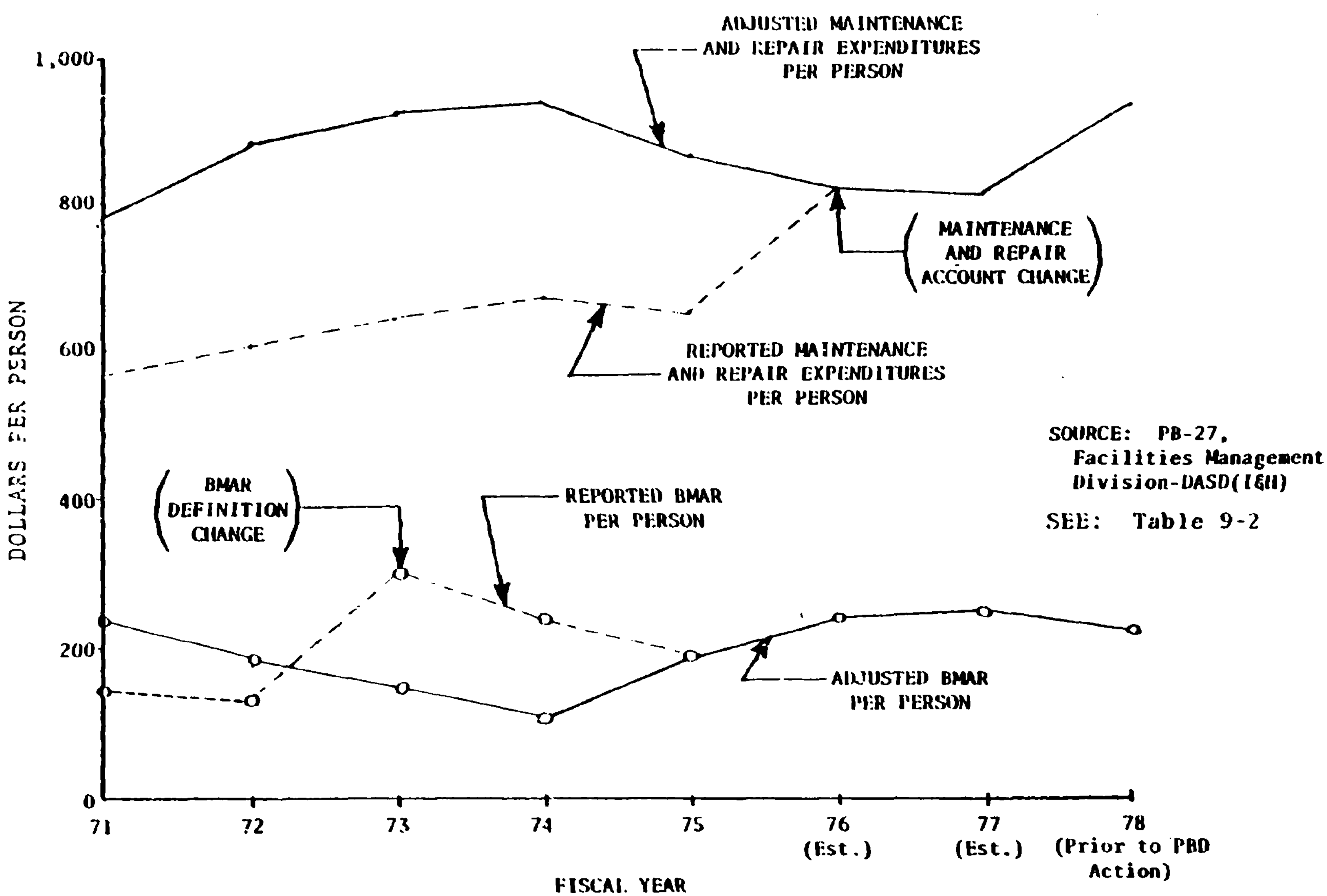
FIGURE 9-4. RELATIONSHIP BETWEEN AIR FORCE INSTALLATION BUILDING SPACE AND POPULATION, 1976



To measure trends in the operation and maintenance of real property, we extracted Air Force-wide RPMA expenditures (O&M and MilPers) and BMAR data from budget reports (PB-27) made available by the Facilities Management Division in the Office of the DASD(I&H). On an individual installation basis, the RPMA expenditures were extracted from the "Civil Engineering Cost Accounting Report," and the BMAR per installation was acquired from a special computer run.

Two definitional changes, one in the Air Force portion of the DoD Maintenance and Repair Account, the other in BMAR, required some manipulation in order to present an accurate trend. In 1975, the Air Force transferred a significant portion of expenditures, previously reported under Other Engineering Support, to Maintenance and Repair. We adjusted the trend of Maintenance and Repair expenditures by estimating what they would have been if the new procedure had been in effect. (See Figure 9-5.) The definitional change in BMAR (formerly BEMAR) occurred between 1972 and 1973. We adjusted BMAR

FIGURE 9-5. AIR FORCE MAINTENANCE AND REPAIR EXPENDITURES PER PERSON AND BMAR PER PERSON (CONSTANT 1977 DOLLARS)



for 1973 and 1974 as shown in Figure 9–5, by changing the reported numbers to what would have been expected, given a logical relationship between Maintenance and Repair expenditures and change in BMAR.

Actual outlays for new construction were extracted from the historical information provided in the Budget of the United States. The figures on percentage of new construction devoted to replacement and modernization were provided by the MilCon and Special Programs Division. Wherever a variable is measured in dollars, the published DoD deflator tables have been used to convert to constant 1977 dollars.

As might be expected, the trends in Air Force personnel, aircraft inventory and number of major installations, depicted in Figure 9-6, correspond very closely. Additionally, increases in aircraft inventory have historically been preceded by increases in personnel and installations, again as expected. Figures 9–7a, b, and c demonstrate the linearity of the relationships, the primary exception being attributed to the Vietnam buildup (1965-1969). Figure 9–8 subdivides major installations into CONUS and overseas, showing that the bulk of the reduction in major installations has occurred overseas. Also, the reduction in minor installations has been comparable to that of major installations.

The Air Force portion of DoD real property, as measured by replacement value, is depicted in Figure 9-9a. During the four-year period represented, the Air Force percentage of the DoD total dropped almost ten points. These data are highly suspect, however. Only recently has the Air Force instituted a formal procedure for estimating replacement value. Figure 9-9b shows an even more dramatic decrease in the ratio of replacement value per person. As long as the decrease represents a reduction in slack assets, economies can be realized. However, if crowding results, personnel morale, and hence Defense performance and capability, will eventually be adversely affected.

The I&H functional area that lends itself best to quantitative analysis is the operation and maintenance of real property. While Air Force RPMA funds have increased steadily when measured in current dollars, Figure 9–10 shows that constant RPMA dollars per person have remained fairly stable. The 1978 data used in all graphs are based on budget requests and subsequent estimated BMAR. These requests have already been substantially cut. However, the original request and estimates will be maintained here to demonstrate how such requests can be evaluated.

Hypothetically, a decrease in RPMA funds available can only be absorbed by an increase in BMAR, and, likewise, an increase in funds should be accompanied by a reduction in BMAR. Returning to the adjusted Maintenance and Repair and BMAR trends previously discussed (Figure 9–5), these two measures do indeed appear to be inversely related. The change (Δ) in BMAR per person and the change (Δ) in Maintenance and

FIGURE 9-6. TRENDS IN AIR FORCE PERSONNEL, AIRCRAFT, AND MAJOR INSTALLATIONS

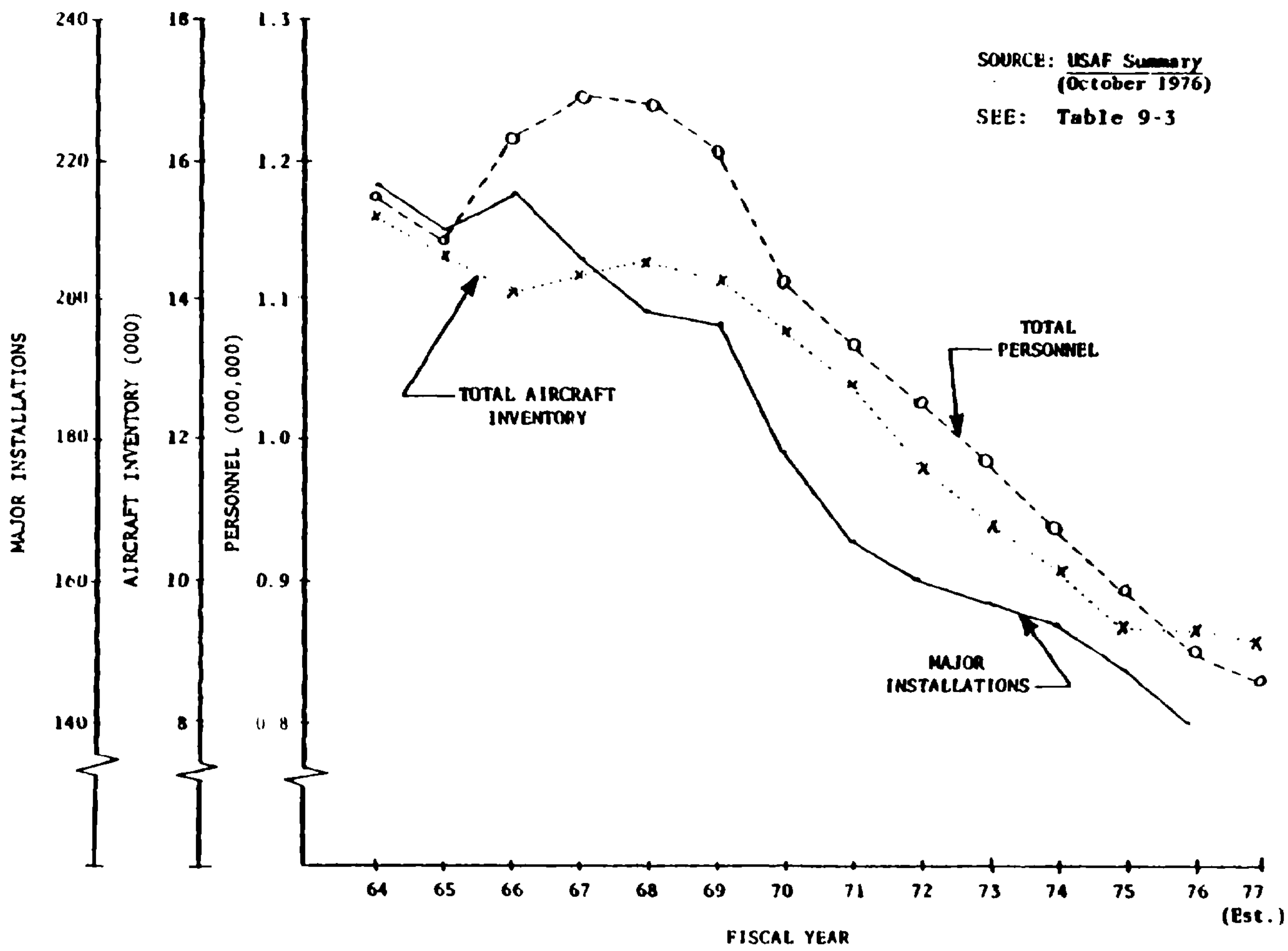
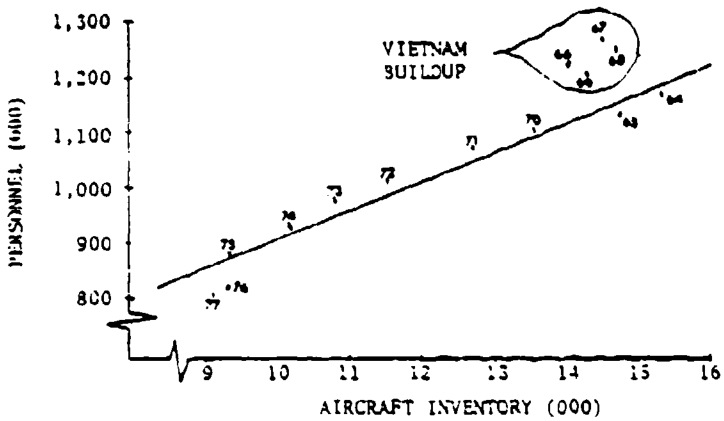


FIGURE 9-7. RELATIONSHIPS BETWEEN AIR FORCE AIRCRAFT, PERSONNEL, AND MAJOR INSTALLATIONS



SOURCE: USAF Summary (October 1976)

FIGURE 9-7a

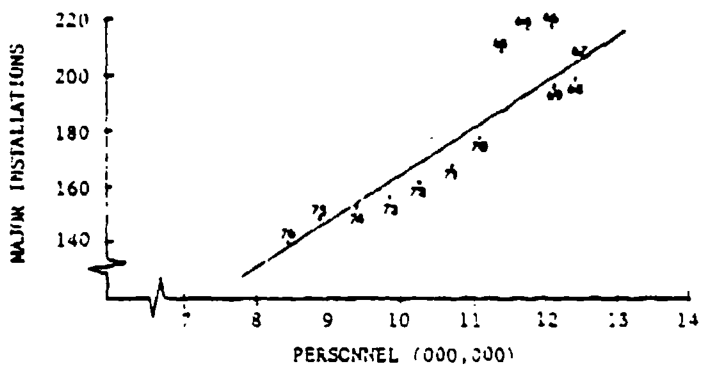


FIGURE 9-7b

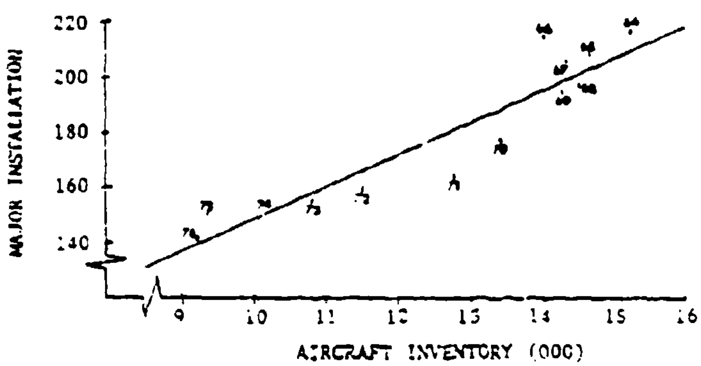
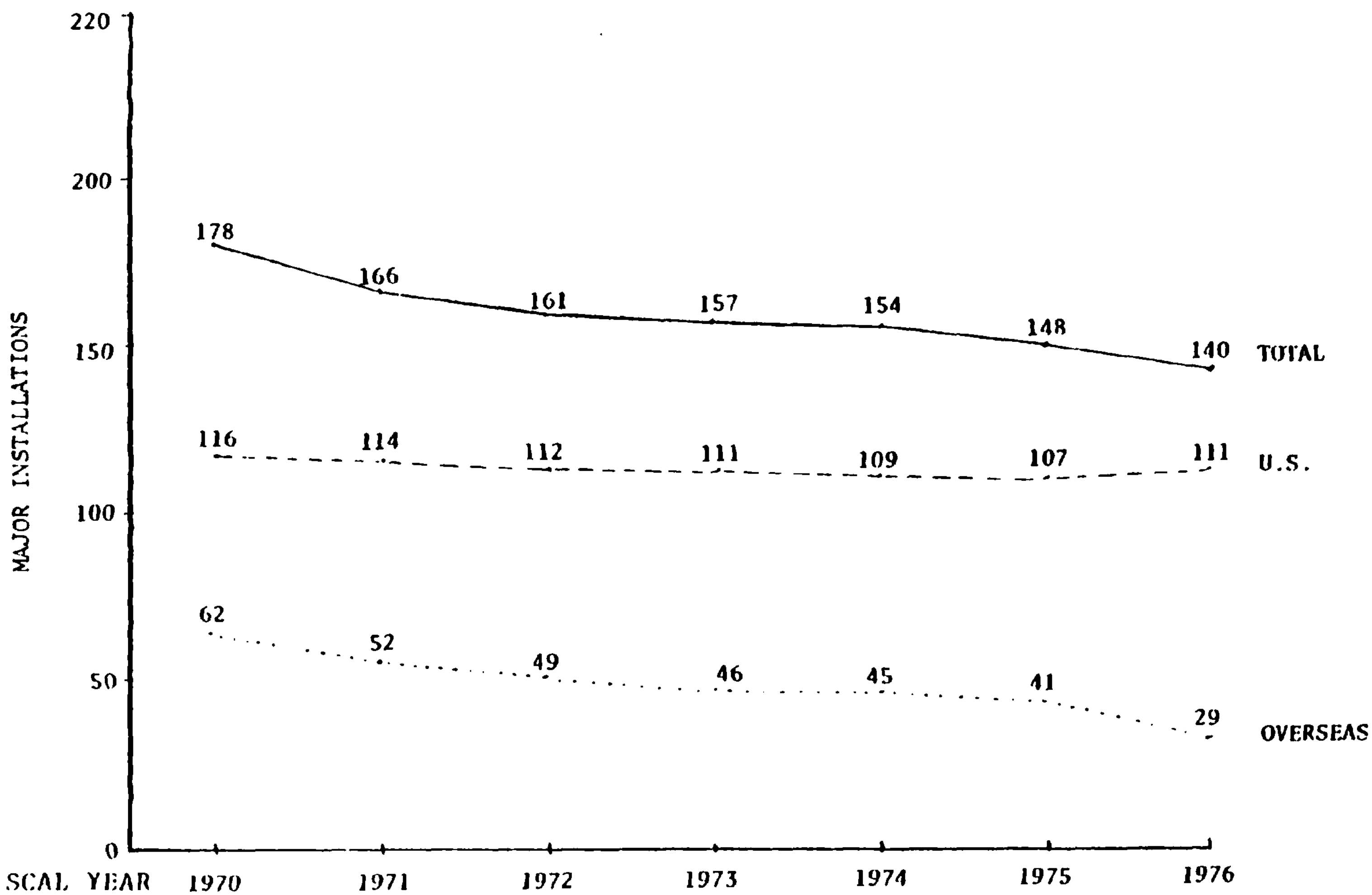


FIGURE 9-7c

FIGURE 9-8. TRENDS IN NUMBER OF AIR FORCE INSTALLATIONS

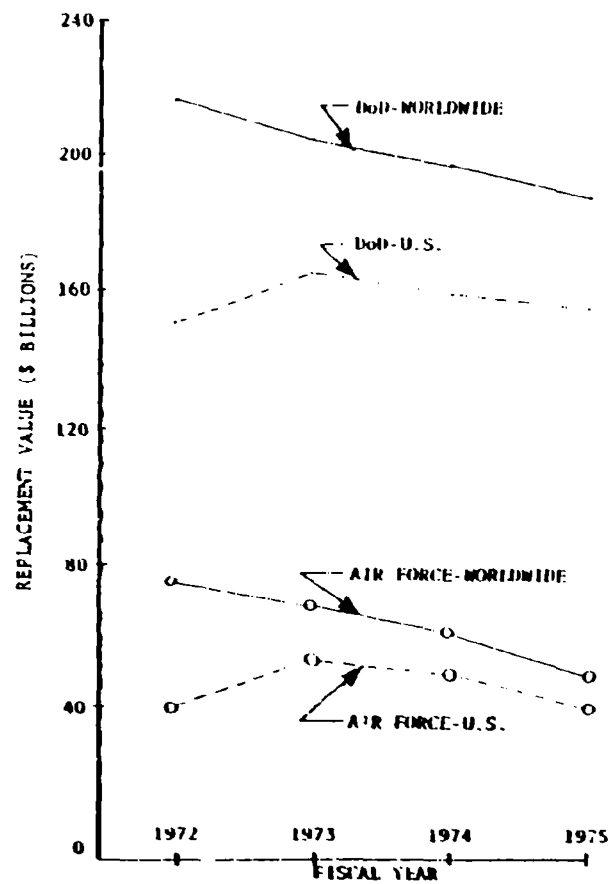


MINOR INSTALLATIONS	3,557	3,424	3,396	3,074	3,083	3,043	3,030

SOURCE: USAF SUMMARY (October 1976)

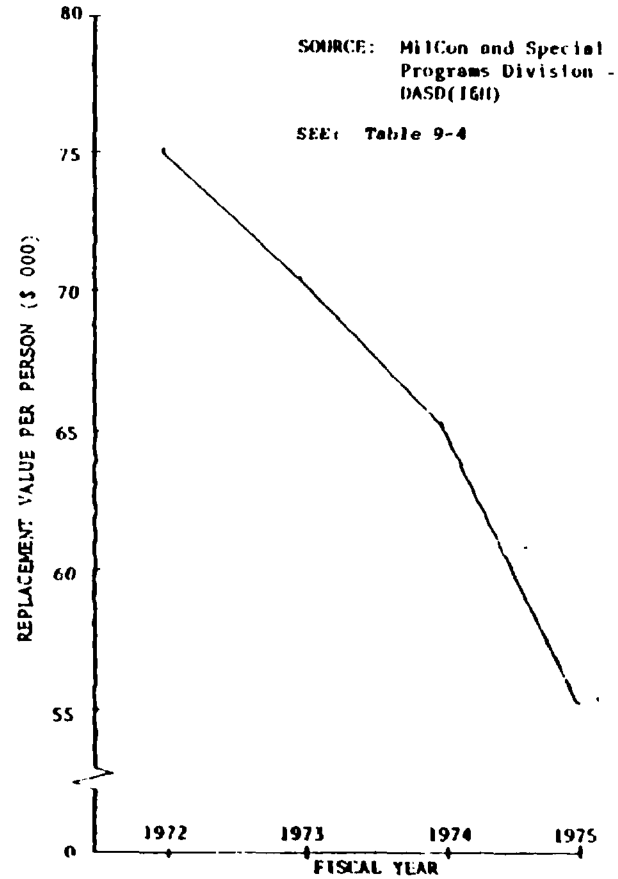
FIGURE 9-9. <u>TRENDS IN AIR FORCE REPLACEMENT VALUE</u>
<u>(CONSTANT 1977 DOLLARS)</u>

NOTE: The Air Force estimates upon which these graphs are based are highly suspect.



AIR FORCE % OF DoD:

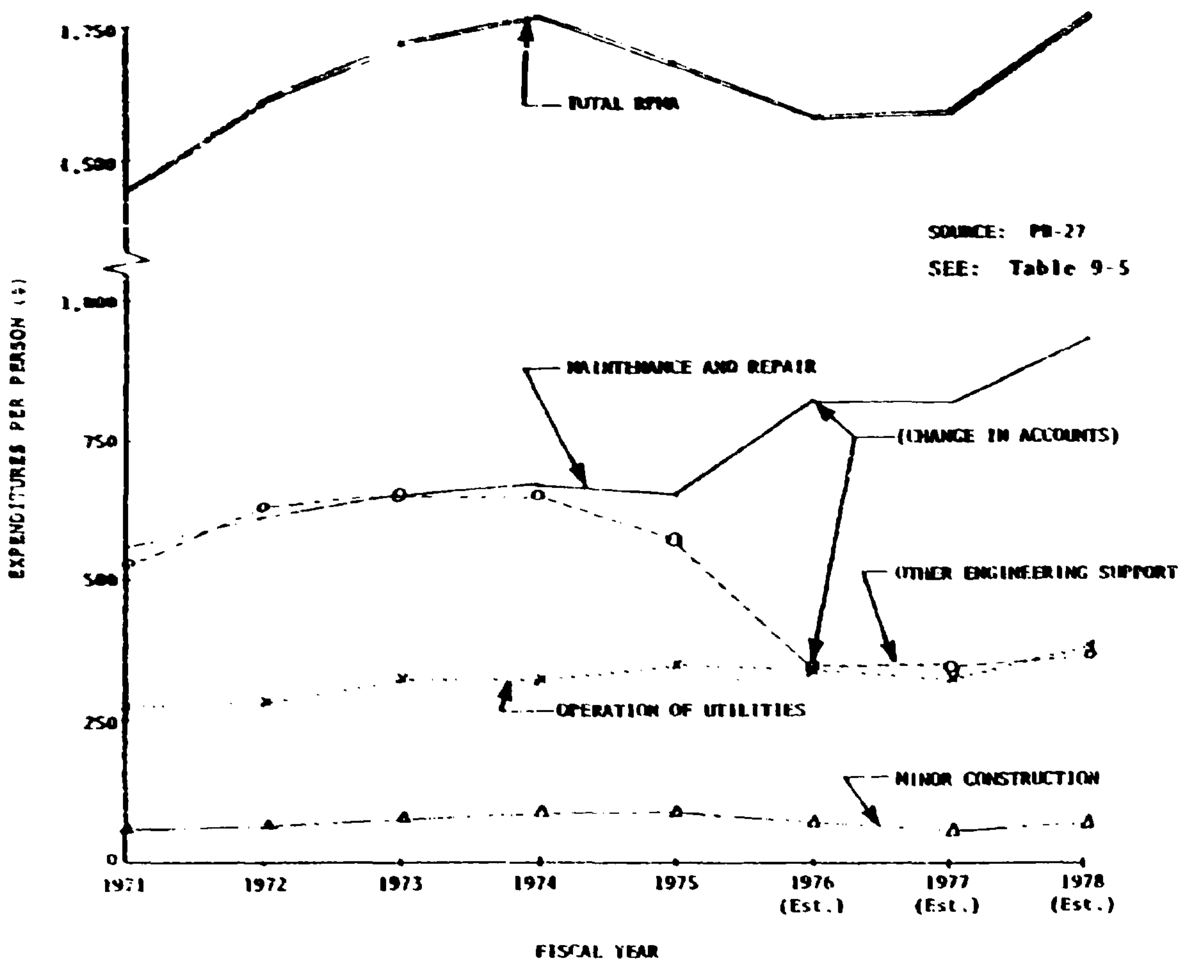
	1972	1973	1974	1975
Worldwide	36.1	34.3	31.9	26.7
U.S.	27.4	24.0	21.7	26.8



% DECREASE:

	1973	1974	1975
Per Person	5.5	6.1	16.7
Per Major Inst.	7.4	8.7	17.3

FIGURE 9-10. TRENDS IN AIR FORCE RPMA EXPENDITURES (CONSTANT 1977 DOLLARS)



Repair expenditures per person should also be inversely related. This is confirmed in Figure 9–11a. The change in Δ Maintenance and Repair expenditures per person and the change in Δ BMAR per person should also be inversely related. Figure 9–11b supports this relationship in all years except 1978. The implication is that either the 1978 budget request was overstated, or the BMAR reduction was underestimated. This correspondence between BMAR and Maintenance and Repair expenditures does not take into account the possibility of a more rapid change in personnel than in real property disposal. In this case, a need would arise for increased RPMA funds for caretaker purposes.

Caution must be exercised, however, in inferring too much from these graphs. First, the number of years of data available is not sufficient at present to draw broad-ranging conclusions about the relationships. Also, while the one-to-one correspondence is a reasonable assumption, there may be circumstances, such as productivity changes, that could cause the average recurring maintenance cost to shift. Nothing in the data indicates that such changes have taken place in recent years, however. Lastly, many factors enter into the accuracy of reported BMAR, not the least of which is managerial interest and concern.

The cost of operating and maintaining an installation is only one factor entering into the installation planning function, but it is the one most susceptible to quantitative analysis. Data on over 200 Air Force installations for FYs 1975 and 1976 were used to produce the scatter diagram of Figure 9–12. An installation lying on the horizontal axis of the diagram had funds available to meet only its annual maintenance and repair requirements. Installations below the horizontal axis had funds available for meeting annual requirements as well as for reducing BMAR. Installations above the horizontal axis did not have sufficient funds available to meet their annual requirements. Note that these measurements are on a per person basis.

The use of such a diagram can point out those installations that may be less efficient than others. Installations lying between two of the superimposed diagonal lines are relatively comparable with respect to maintenance and repair cost per person. Installations lying to the left of the leftmost diagonal are anomalies in that they report a BMAR reduction greater than the maintenance and repair funds expended. By comparing scatter diagrams for different years, shifts in the clusters of installations can be observed. Such shifts may represent changes in the efficiency of the installation structure.

As an example of how Figure 9-12 could be used, let us look at the proposed reduction of operations at Loring AFB. According to the diagram, Loring is not an inefficient installation with respect to maintenance and repair. Hence, the proposed reduction should be justified on other grounds.

FIGURE 9-11a. ANALYSIS OF THE CHANGE IN BMAR PER PERSON VS. THE CHANGE IN MAINTENANCE & REPAIR EXPENDITURES PER PERSON

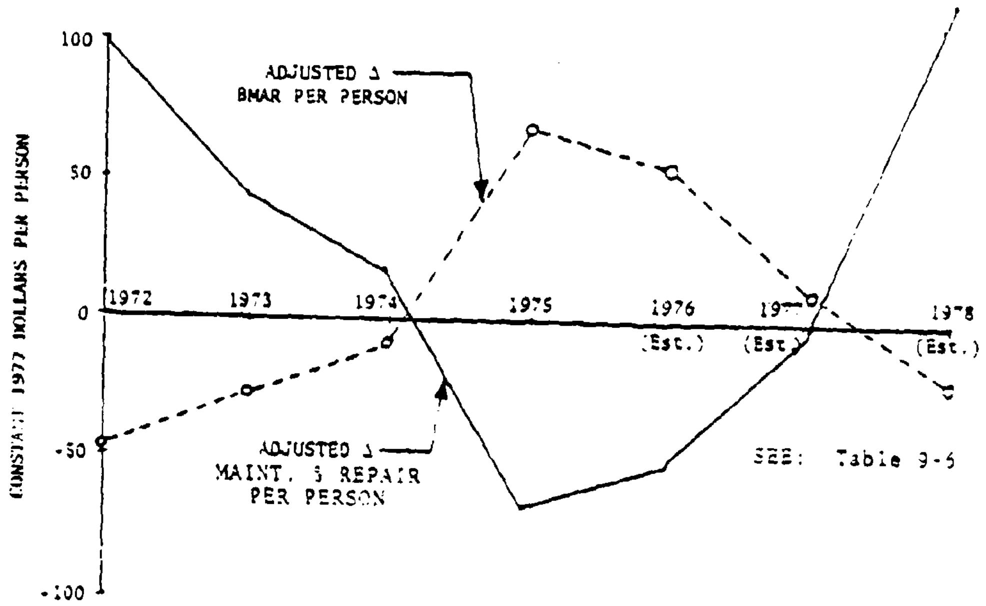


FIGURE 9-11b. ANALYSIS OF THE CHANGE IN Δ(BMAR PER PERSON) VS. THE CHANGE IN Δ(MAINTENANCE & REPAIR EXPENDITURES PER PERSON)

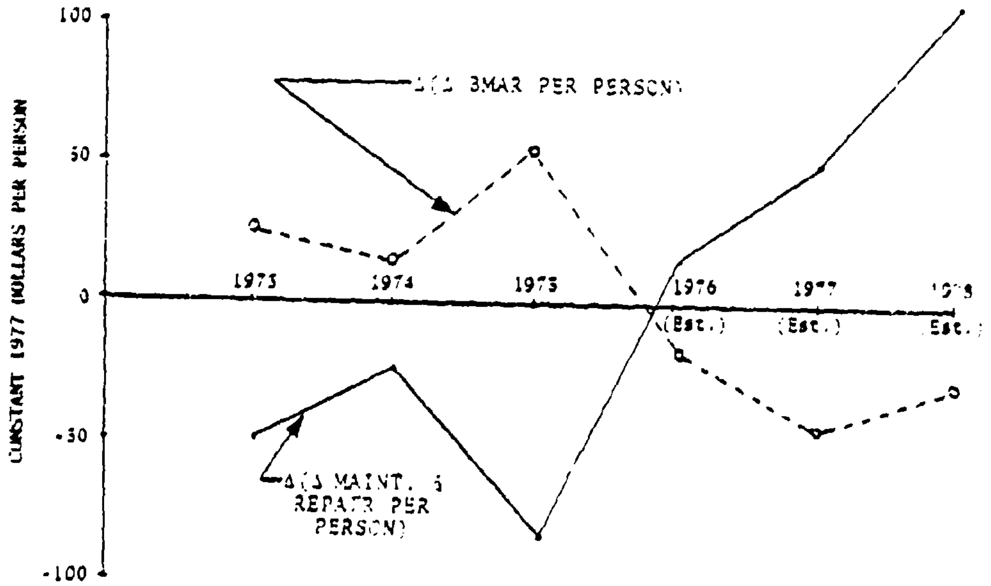
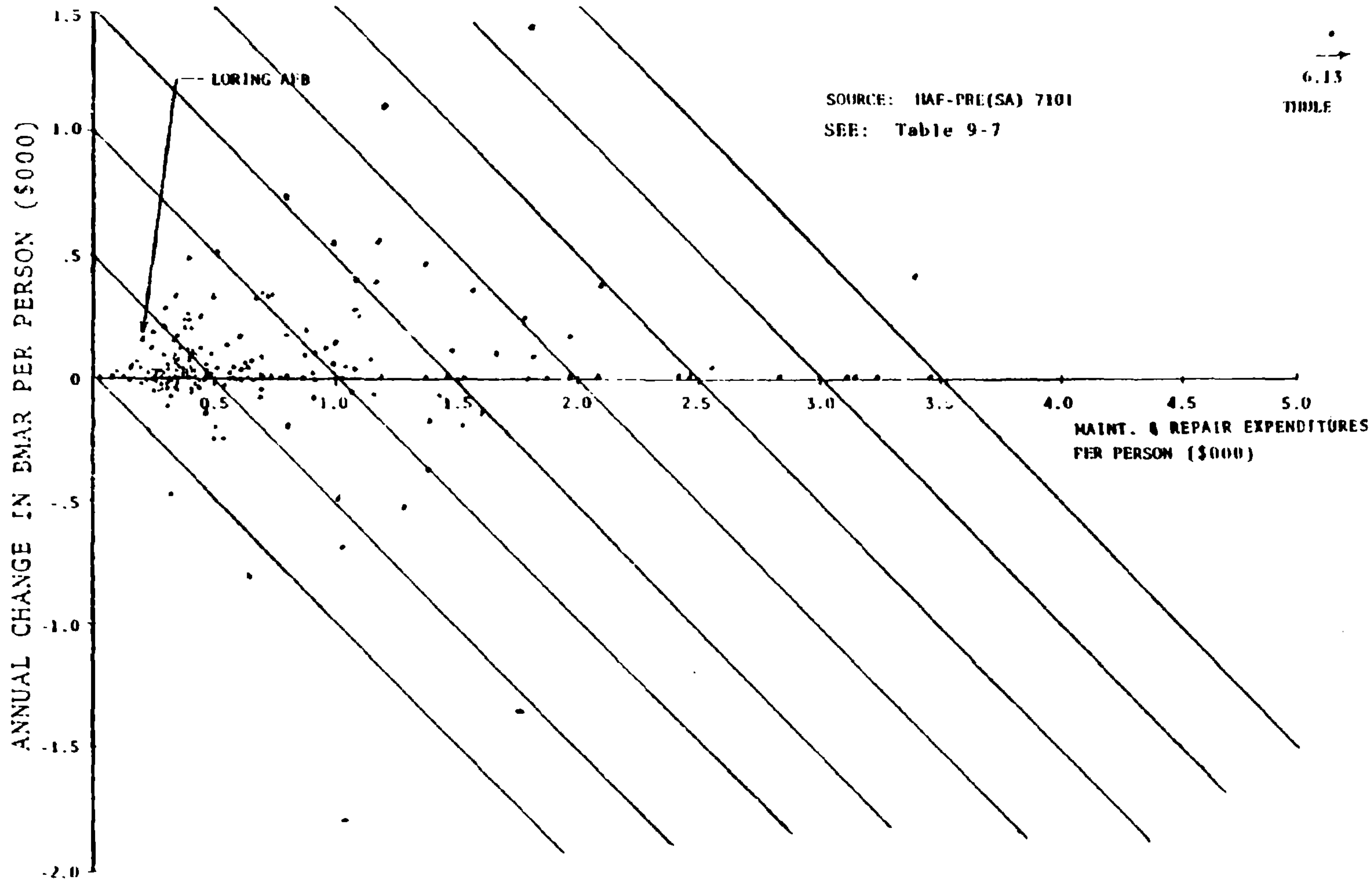


FIGURE 9-12. SCATTER DIAGRAM OF AIR FORCE INSTALLATIONS WITH RESPECT TO THE COST OF MAINTENANCE AND REPAIR AND THE CHANGE IN BMAR PER PERSON, 1976



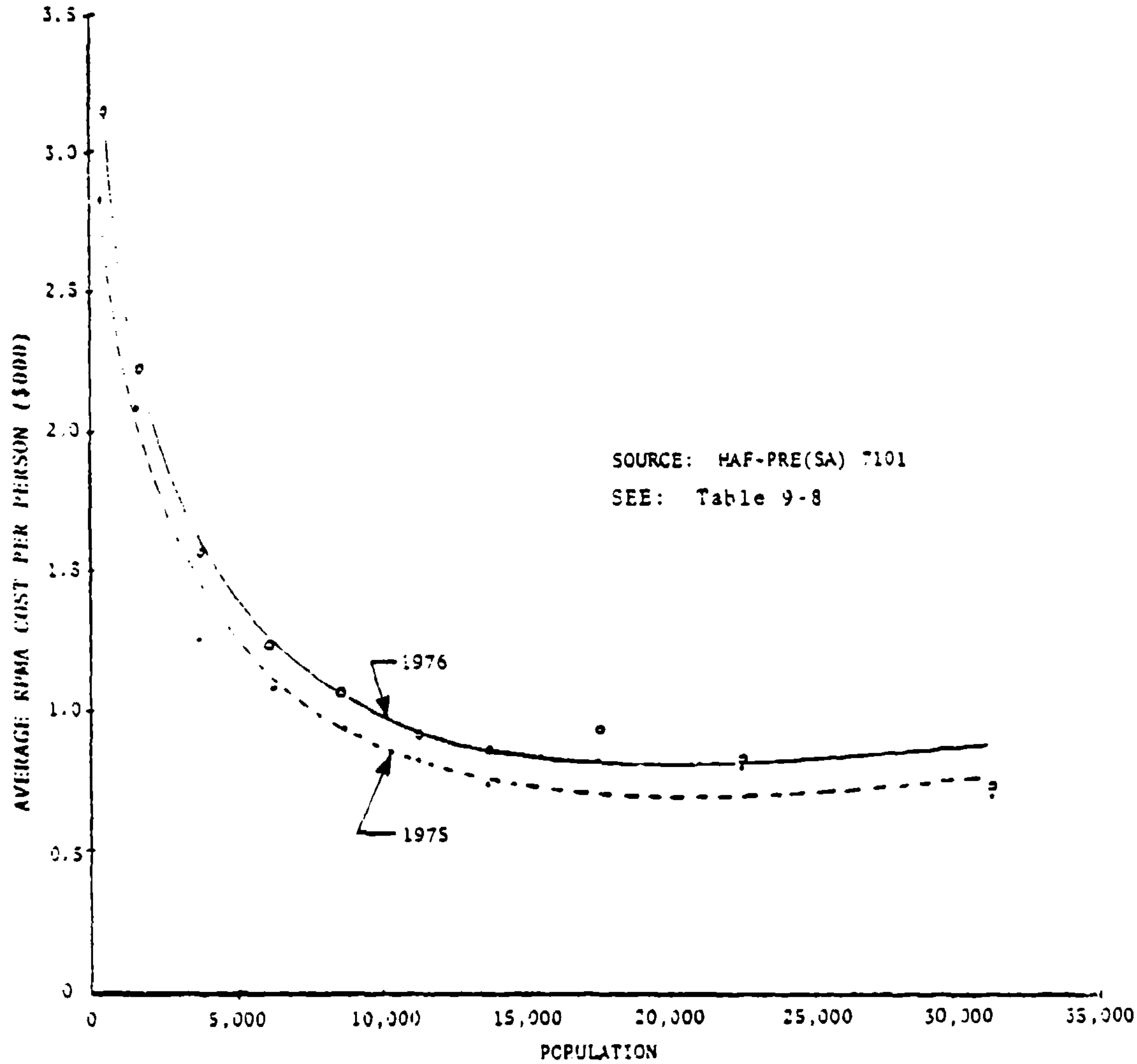
Comparisons between installations can be very misleading. Diagrams for more than one year should be evaluated to ascertain whether or not an apparent inefficiency is a one-time occurrence. There are numerous reasons why some installations may cost more to operate and maintain than others. For example, those located to the right in Figure 9-12 are, with a few exceptions, small and located in northern latitudes. Size and geography can affect the efficiency of an installation.

The effect of size, as measured by population, on the cost per person of operating and maintaining the installation, as measured by RPMA expenditures, is shown in Figure 9-13. In order to reduce the variation caused by factors other than installation size, we grouped installations into population intervals. The graph clearly suggests that smaller installations are, on the average, more expensive to operate and maintain than larger ones. However, above a population of 12,000-15,000, the potential economies of increased installation size no longer apply. It is important to note, however, that the largest installations in the Air Force are AFLC bases, which are generally more expensive to operate and maintain than those of other commands. Hence, even greater economies may be possible than those suggested by Figure 9-13. When studied in conjunction with the proportion of total population in each interval, shifts in the installation structure over time can be observed. Nothing in the data indicates that such shifts have resulted in efficiencies of size, but recall that size is being measured in terms of population, not assets controlled.

Before drawing this conclusion however, a similar analysis of geographical location is necessary. As it turns out, there is a strong correlation between size and location. We divided the U.S. into five geographical areas for the purpose of categorizing installations (Figure 9-14). The correlation between installation size and geographical location is demonstrated in Figure 9-15a. With the exception of Area V (Alaska), there is little correlation between RPMA cost per person and geographical location (Figure 9-15b). A good portion of the high cost per person at the Alaskan installations can be attributed to their smaller size. While this seems to imply that the geographical latitude chosen for an installation location is not as significant for efficiency as installation size, the latitude is a factor in determining what size an installation will be. In addition, the specifics of a particular location will certainly have an impact on both efficiency and the mission chosen to occupy that installation.

There is little formal analysis that can be of assistance to the OSD management of construction. Construction projects are of necessity evaluated individually, and so many factors enter into the prioritization of projects that quantification is practically impossible. Projects are classified as to whether they are for replacement and

FIGURE 9-13. RELATIONSHIP BETWEEN AIR FORCE INSTALLATION POPULATION AND AVERAGE RPMA COST PER PERSON (CURRENT DOLLARS)



NO. OF INSTALLATIONS IN INTERVALS:

	0-1000	1001-2500	2501-5000	5001-7500	7501-10000	10001-12500	12501-15000	15001-20000	20001-25000	25001+
75	72	12	24	31	20	16	11	8	10	[illegible]
76	72	11	24	26	20	17	11	8	11	6

% OF TOTAL POPULATION:

75	1.5	1.5	6.4	13.7	12.3	12.6	10.6	9.8	15.9	15.7
76	1.5	1.3	7.0	11.7	12.7	13.3	10.5	10.0	18.2	13.7

% OF TOTAL RPMA COST:

75	4.7	3.4	8.7	16.3	12.7	11.2	5.6	8.6	13.8	12.0
76	4.7	2.9	10.6	14.2	13.5	11.7	8.8	9.2	14.8	9.7

FIGURE 9-14. GEOGRAPHICAL AREAS FOR THE CLASSIFICATION OF INSTALLATIONS

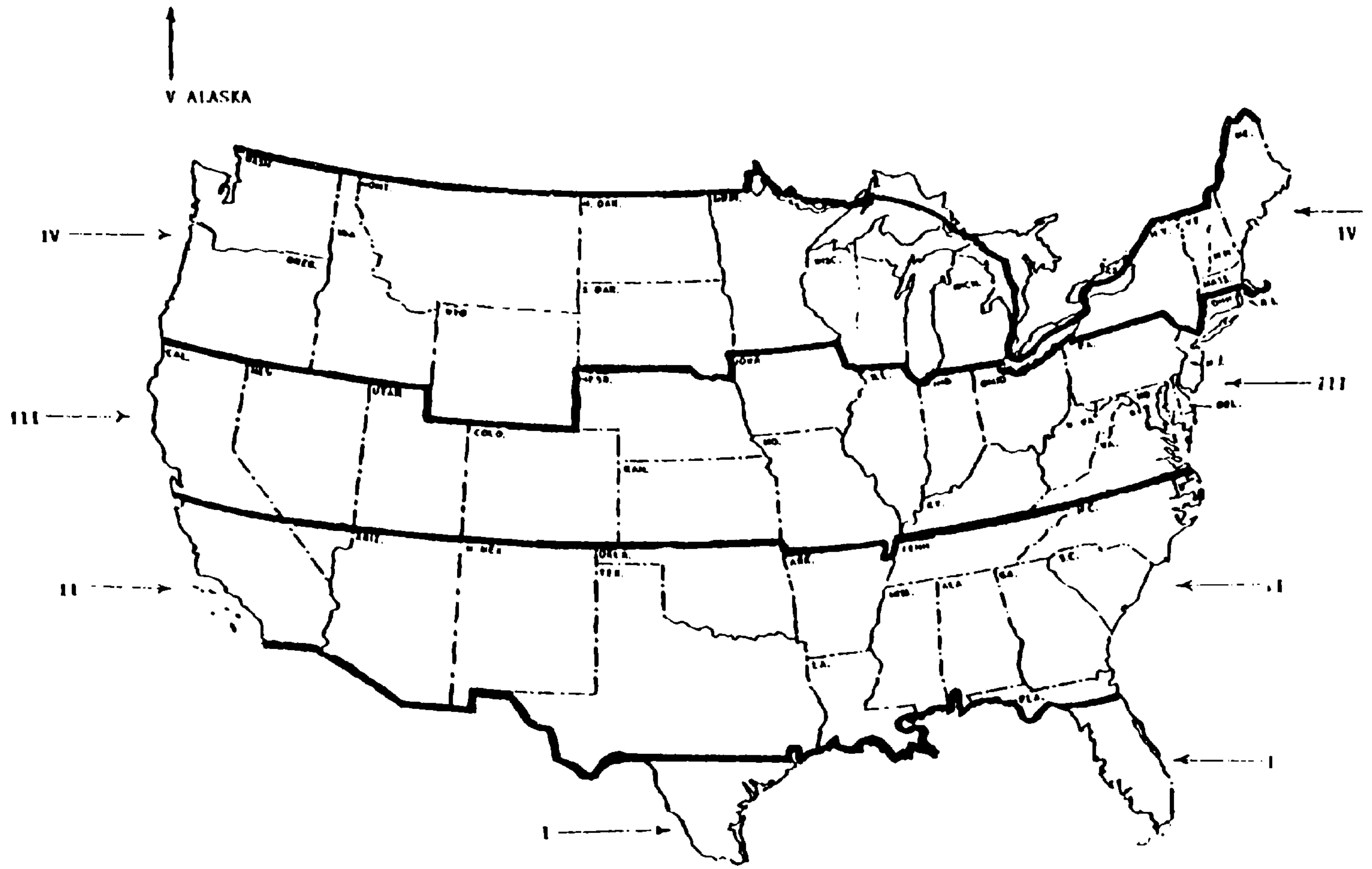
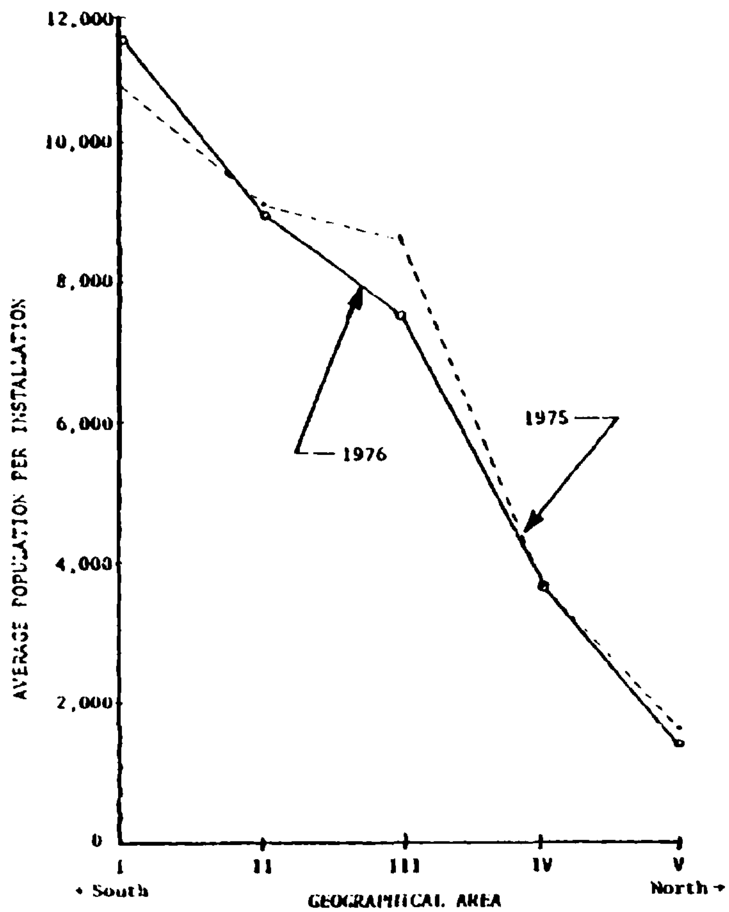


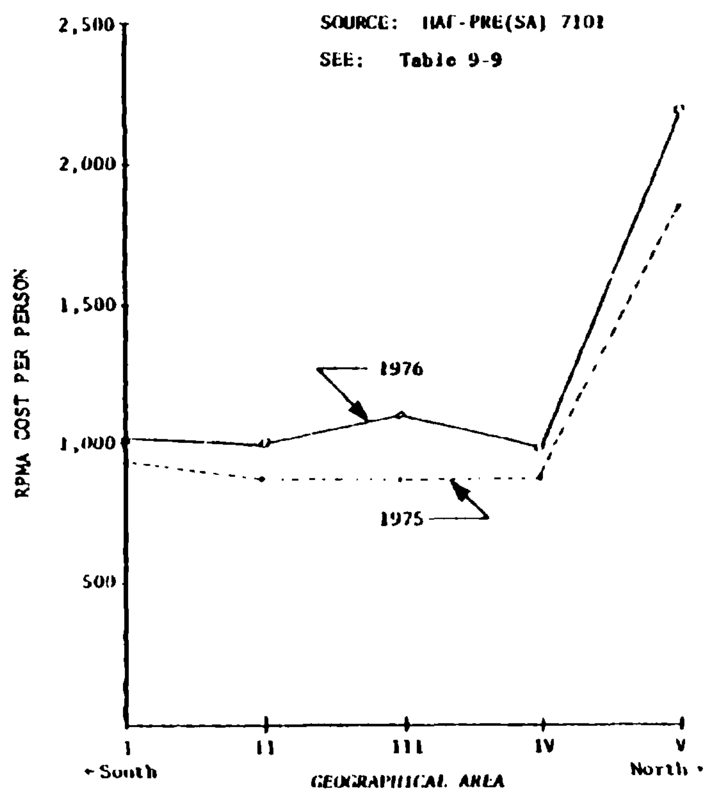
FIGURE 9-15a. RELATIONSHIP BETWEEN GEOGRAPHICAL LOCATION AND INSTALLATION POPULATION



NO. OF PEOPLE:

75	107,657	412,652	421,240	196,289	27,884
76	114,117	415,404	230,413	193,256	26,629

FIGURE 9-15b. RELATIONSHIP BETWEEN GEOGRAPHICAL LOCATION AND AIR FORCE RPMA COST PER PERSON



NO. OF INSTALLATIONS:

75	10	45	37	53	17
76	10	46	37	52	17

modernization, or for some other purpose (expansion of current missions or new missions). However, attempts to establish relationships between the replacement rate and other factors were not productive.

Figure 9-16a shows that Air Force construction expenditures have been reduced considerably since the 1960's. As a percentage of the Air Force budget, construction is now one-half of what it was in 1964 (although it has remained fairly constant since 1970). Construction funds per person have been cut to about one-third the level of 1964 (Figure 9-16b). Replacement and modernization as a percentage of the Air Force construction program increased between 1971 and 1974, but have decreased steadily since (Figure 9-16a). This trend probably reflects a shifting policy emphasis.

Family Housing

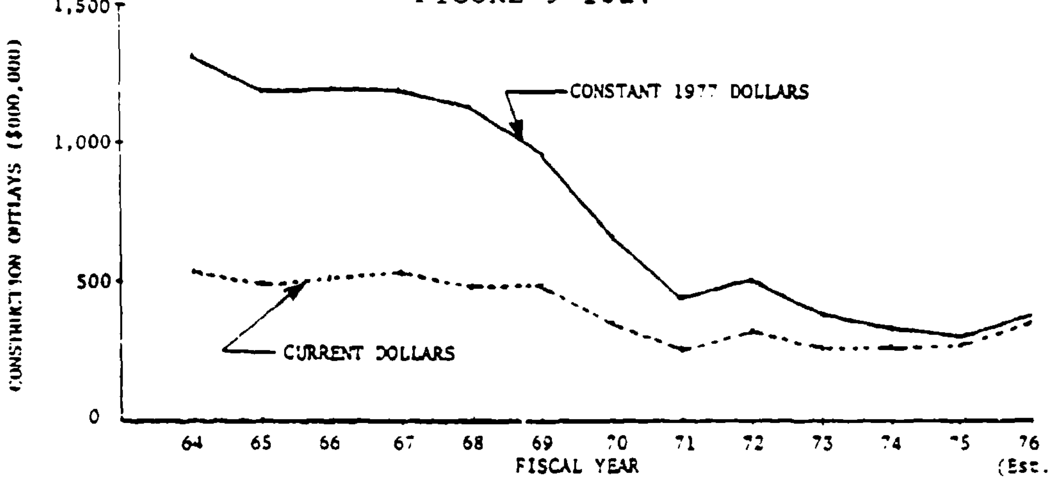
Most of the family housing data are aggregated into DoD totals. A few of the measurements are subdivided into Service detail (number of units and Deferred Maintenance), but our analysis was limited to the Air Force only for those variables associated with requirements. We extracted data on military personnel and families from the USAF Summary (October 1976). The data on family housing units and Deferred Maintenance were provided by the Housing Programs Division in the Office of the DASD(I&H). The number of units includes all units owned or controlled by DoD, including leased units and trailer homes. The financial information was extracted from the Budget of the United States. While these measurements are based on the budget plan and proposed construction, for the purposes of determining percentages and average costs per unit, they serve as adequate approximations. Finally, the national median price of new single-family homes was acquired from The Statistical Abstract of the United States.

Trends in Air Force family housing are depicted in Figure 9-17. While the percentage of officer families housed in DoD owned/controlled housing still exceeds that of enlisted families, the gap was closed between 1971 and 1974. In addition, while the number of Air Force housing units has remained fairly constant, the number of Air Force military personnel has steadily decreased. The result is an increase in the percentage of total Air Force families housed. Figure 9-19a shows that the Air Force has held (and continues to hold) the greatest number of units of the four Military Services.

The trend in the DoD-wide family housing budget is shown in Figure 9-18a. It is evident that the Operations and Maintenance portion of the budget is consuming an increasing share of the funds. This is even more dramatically depicted in Figure 9-18b, which estimates that 80% of the 1977 budget will be expended for the operation and maintenance (including leasing) of family housing. Another striking trend in this figure is the decline in construction of family housing. This reflects the reduction in the DoD family housing program deficit as depicted in Figure 9-19a.

FIGURE 9-16. TRENDS IN AIR FORCE CONSTRUCTION

FIGURE 9-16a.



	64	65	66	67	68	69	70	71	72	73	74	75	76 (Est.)
% OF AF BUDGET	2.9	3.0	2.8	2.6	2.1	2.0	1.5	1.1	1.4	1.1	1.2	1.1	1.3

% REPLACEMENT & MODERNIZATION:	1971	1972	1973	1974	1975	(Est.) 1976	(Est.) 1977
DoD	26	41	45	47	40	32	19
AIR FORCE	18	44	41	69	38	30	8

FIGURE 9-16b.

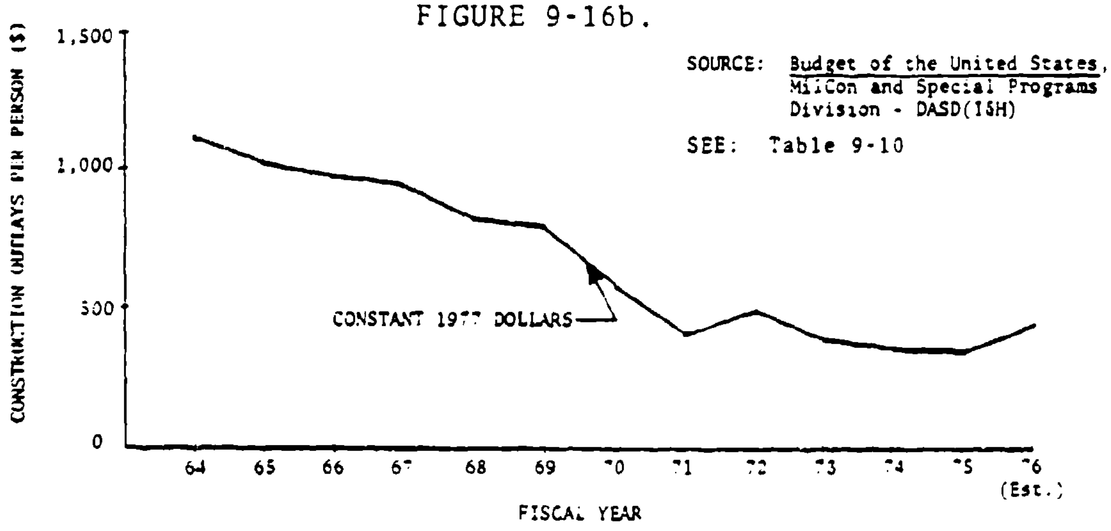
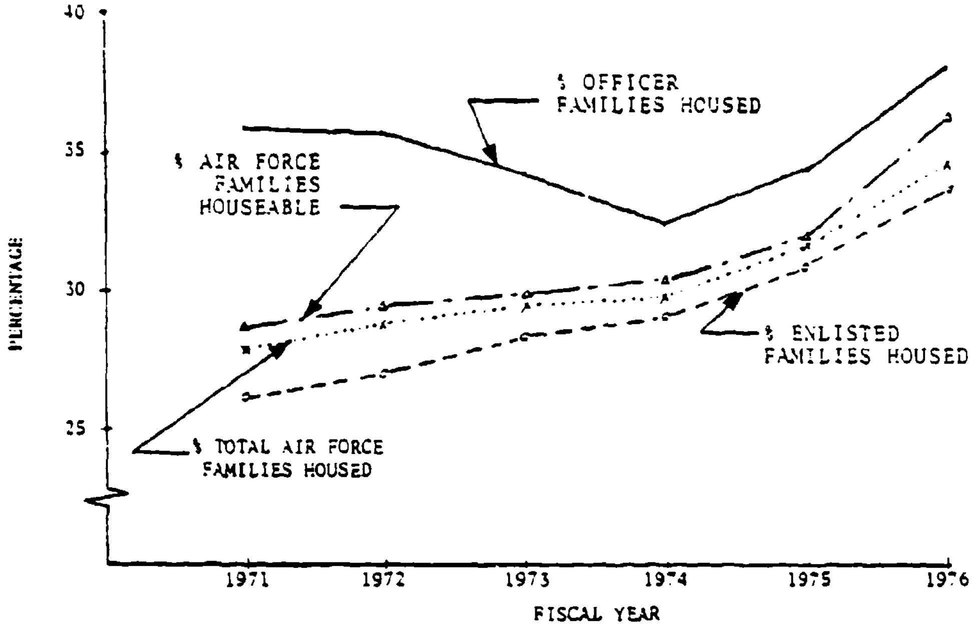


FIGURE 9-17. TRENDS IN GOVERNMENT PROVIDED AIR FORCE FAMILY HOUSING



	1971	1972	1973	1974	1975	1976
% PERSONNEL WITH FAMILIES	67.1	68.5	69.0	71.1	70.3	68.4
NO. OF OFFICER FAMILIES	104,124	101,235	97,750	92,698	88,679	81,472
NO. OF ENLISTED FAMILIES	399,269	392,598	376,245	361,776	338,974	315,507
NO. OF HOUSING UNITS	143,772	145,371	140,371	137,421	135,124	143,907

SOURCE: USAF Summary (October 1976)

SEE: Table 9-11

FIGURE 9-18. TRENDS IN THE DOD-WIDE FAMILY HOUSING BUDGET

FIGURE 9-18a

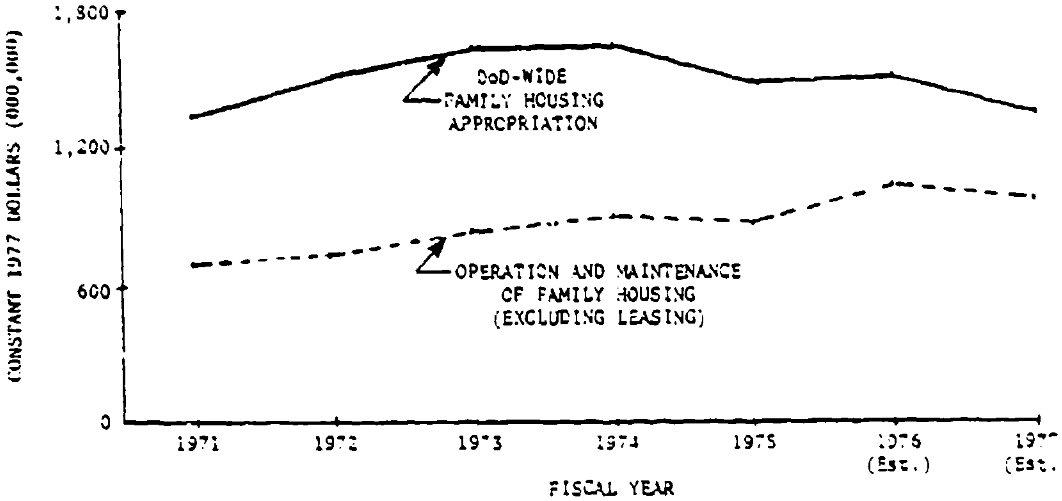
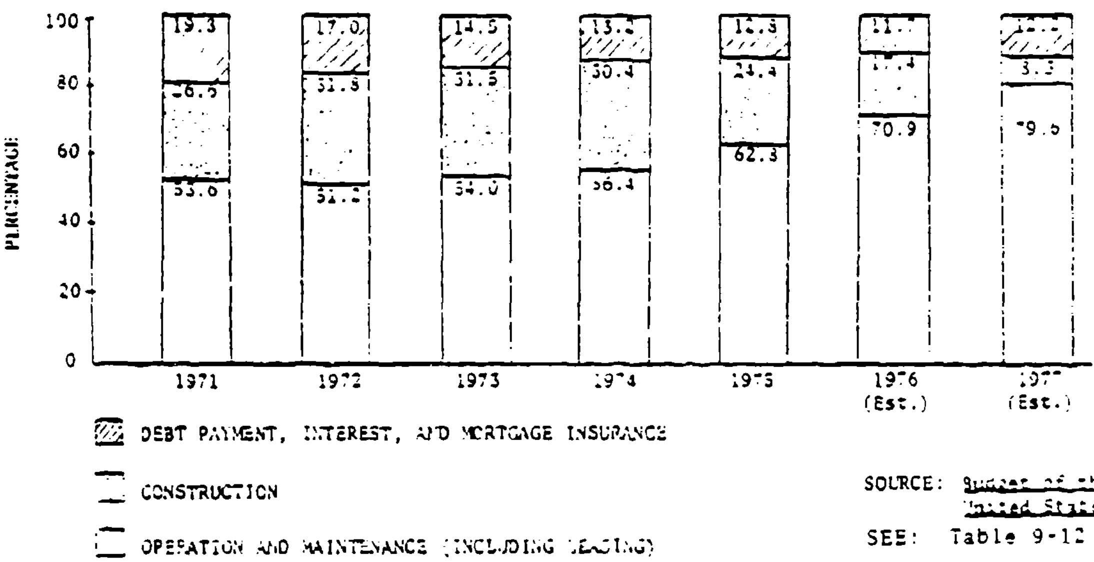


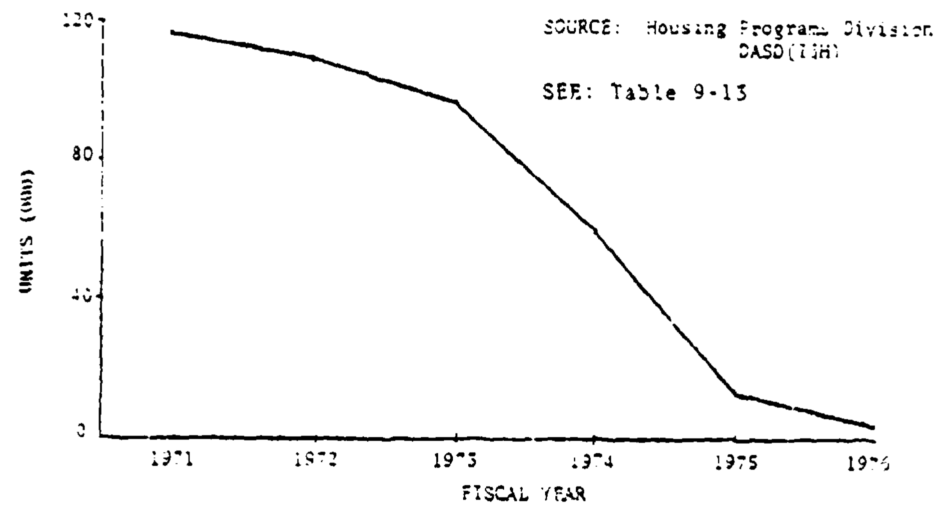
FIGURE 9-18b



SOURCE: Budget of the United States

SEE: Table 9-12

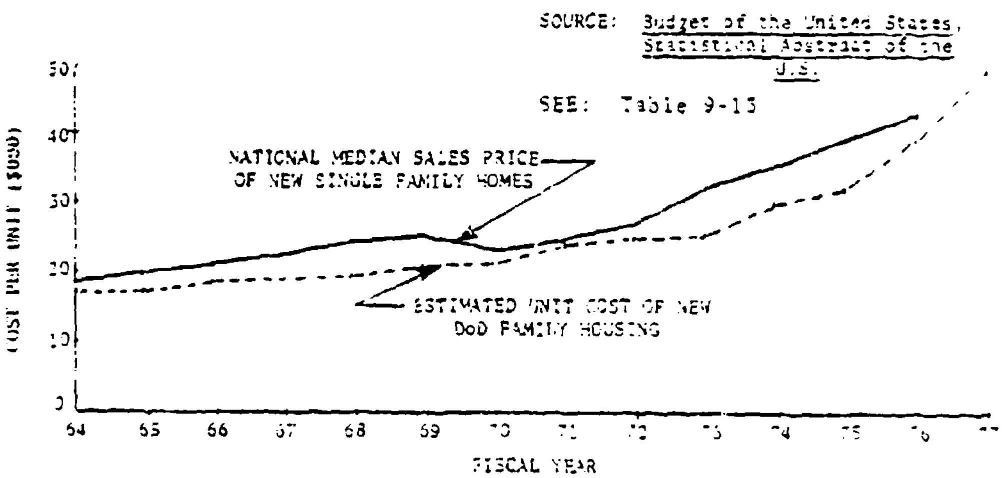
FIGURE 9-19a. TREND IN DOD FAMILY HOUSING PROGRAM DEFICIT



TOTAL UNITS OWNED OR CONTROLLED:

ARMY	132,604	135,334	137,498	137,334	139,158	136,297
NAVY	71,455	69,505	71,973	74,376	77,474	74,010
MARINE CORPS	18,419	18,263	17,693	18,362	19,235	20,545
AIR FORCE	151,611	151,910	151,585	149,065	149,154	147,650

FIGURE 9-19b. TREND IN PROPOSED UNIT COST OF DOD FAMILY HOUSING CONSTRUCTION (CURRENT $)



The DoD family housing program deficit is calculated by subtracting DoD family housing assets from requirements, less a program safety factor. Assets include availability of private housing and are adjusted for an occupancy rate. Requirements include all eligible personnel, both military and civilian. The reduction in the deficit has resulted from increased military pay scales and from the reduction in total military personnel.

Family Housing is one I&H function where comparisons with non-DoD averages may be meaningful. In Figure 9-19b, the proposed construction cost per new family housing unit is plotted along with the national median sales price of new single-family homes. Since the construction cost of DoD housing units does not include the cost of land, it is to be expected that the cost per unit would be less than the national median sales price. If the national median sales price were reduced by 15–20% to account for the cost of land, the DoD average cost per unit would be slightly greater than the national median.

Deferred Maintenance is as much a problem for Family Housing as it is for other real property. Figure 9–20a shows the correspondence between the Maintenance and Repair of family housing per unit and Deferred Maintenance per unit. Except for 1976, the inverse correspondence is very close. Figure 9–20b presents the Deferred Maintenance per unit for each Military Service. The trends indicate an emphasis on improving the condition of Army housing at the expense of the other Services, but the Army Deferred Maintenance is still above the DoD average.

Finally, the DoD-wide mortgage debt per unit is shown to be decreasing steadily in Table 9–15 (under "Data and Source Description"). This decrease reflects the fact that new family housing has not been financed with mortgage debt since 1964. A significant increase (2.7 times) in leased housing has occurred since 1971 (Figure 9–21), which indicates another shift in family housing financing policy. The choice of family housing financial mix is considered to be an important OSD function, although there are numerous constraints on its determination.

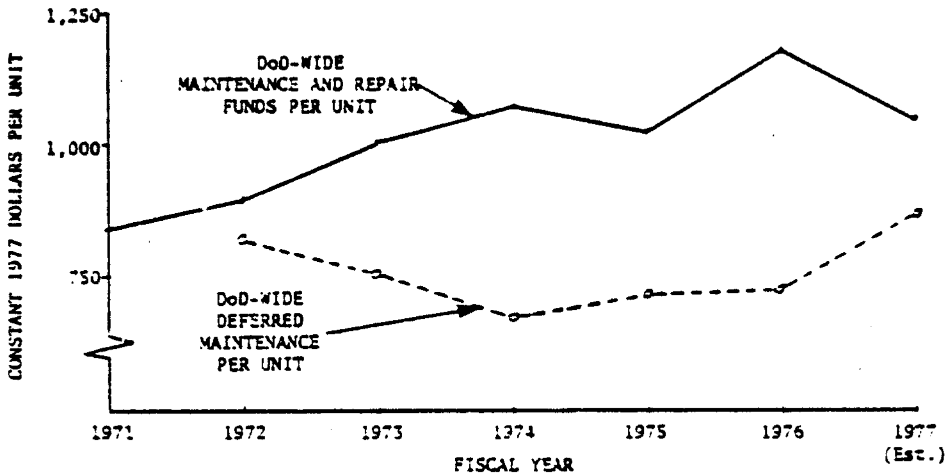
FINDINGS AND CONCLUSIONS

Real Property (Exclusive of Family Housing)

- Reductions in aircraft inventory have generally been accompanied by equivalent reductions in personnel levels and in number of major installations. Over the past six years, however, the bulk of the reduction has occurred overseas, with the possible result of introducing bias into the aggregate analysis performed here.

- The choice of population as a proxy for real property assets proved very useful. However, because operational activity and personnel levels can generally change more rapidly than assets, it is important to recognize that facilities require some minimum level of support, regardless of how they are being utilized.

FIGURE 9-20. TRENDS IN THE DEFERRED MAINTENANCE OF DOD-WIDE FAMILY HOUSING



SOURCE: Budget of the United States, Housing Programs Division - DASD(I&H)

SEE: Table 9-14

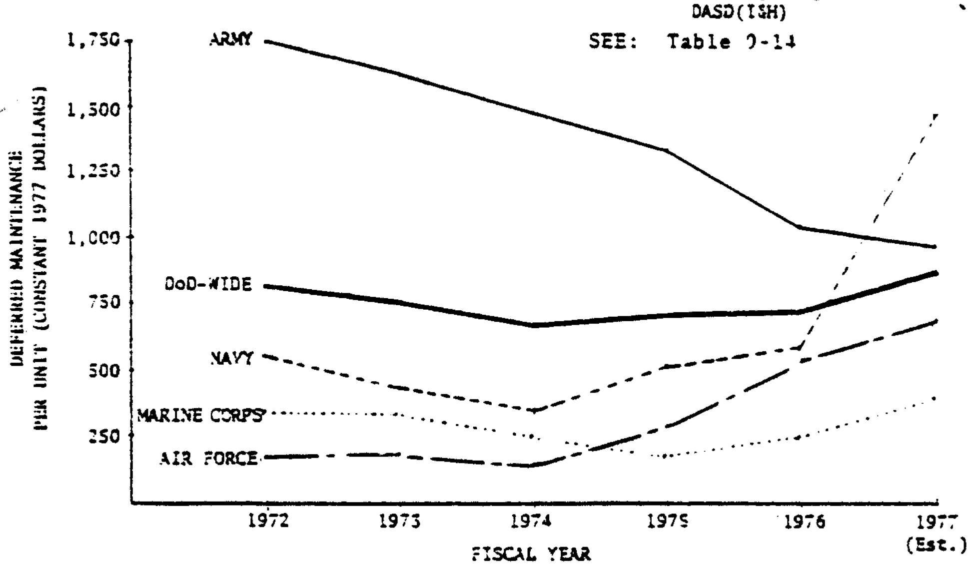
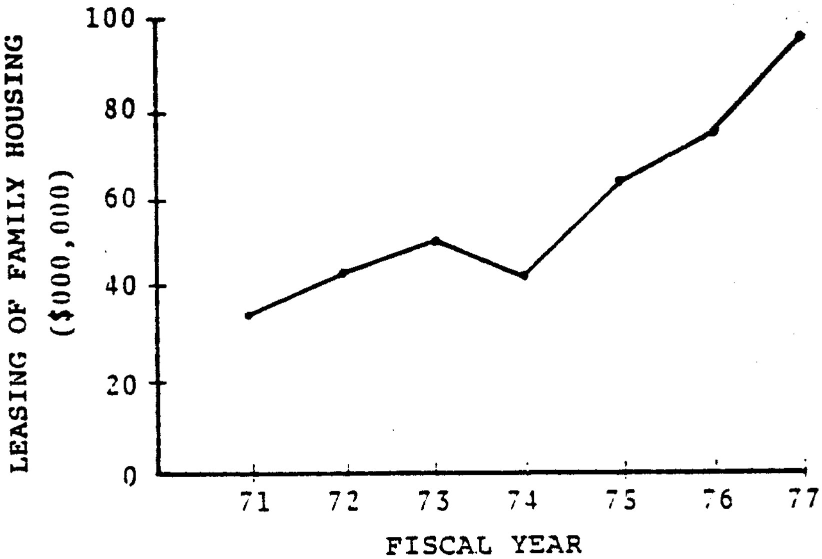


FIGURE 9-21. TREND IN THE LEASING OF DOD FAMILY HOUSING (CONSTANT 1977 $)

SOURCE: Budget of the United States

SEE: Table 9-12



- While it is important to recognize that many factors enter into decisions to close or consolidate installations, there is strong evidence that economies of scale can be realized through such actions.

- RPMA expenditures per person (in constant dollars) throughout the Air Force have remained relatively constant over the past six years. It is, nevertheless, difficult to infer any trend in productivity without knowing what portion of these expenditures went to labor and also what changes in facilities controlled accompanied changes in personnel levels.

- Given annual operational requirements along with relatively accurate BMAR estimates, the reasonability of a RPMA budget request can be evaluated. (The original 1978 budget request, for example, appears out of line with the accompanying BMAR estimate.)

While the analysis does not directly support the following conclusions, they deserve consideration:

- The decline in new construction, and in particular replacement and modernization construction, may have unanticipated and undesirable consequences: namely, (1) increased RPMA requirements and (2) reduced personnel morale (and hence performance).

- Similarly, if BMAR is allowed to continue to increase, it may have an undesirable impact on new construction requirements as well as personnel morale.

Family Housing

- The percentage of Air Force officer families housed still exceeds that of enlisted families, but the gap has been closed by 5.2 percentage points since 1971.

- The percentage of the DoD-wide family housing budget devoted to Operations and Maintenance has increased from 54% in 1971 to an estimated 80% in 1977, and is expected to continue to do so as the construction of new Family Housing is de-emphasized and mortgage debt is liquidated.

- DoD-wide leasing of Family Housing has increased 2.7 times since 1971 (on a constant dollar basis).

- New Family Housing standards DoD-wide compare favorably with national standards.

- While Deferred Maintenance per unit has declined in the Army, there is reason for concern about recent Deferred Maintenance increases in the other three Services.

- Unless increased Maintenance and Repair funds are made available for Family Housing, Deferred Maintenance can be expected to increase, the consequences of which could prove undesirable.

DATA AND SOURCE DESCRIPTION

The data supporting the analysis in this chapter are presented in the following 15 tables. The source for Tables 9–1, 9–7, 9–8, and 9–9 was the "Air Force Civil Engineering Cost Accounting Report" (HAF-PRE(SA) 7101). This is an annual report, showing expenditures for real property operation and maintenance by individual account for all commands and each installation within a command. The report also contains information on installation building space and population. The accounts are more detailed than the DoD RPMA accounts, requiring aggregation to conform to DoD definitions.

The source for Tables 9–2, 9–5, and 9–6 was the PB–27 budget exhibit. The Facilities Management Division in the office of DASD(I&H) assisted in explaining the various entries in the exhibit. Included in this exhibit are detailed data on RPMA budget requests and previous years' expenditures for each account, as well as actual BMAR in past years and estimated future BMAR levels. While there is no reason to question the accuracy of the expenditure figures, BMAR presents some problems. Because of a DoD-wide change in definition of BMAR commencing in 1973, it cannot yet be determined if

BMAR is being accurately and consistently reported. For the Air Force data, the BMAR, M&R and Other Engineering Support (OES) figures had to be adjusted to reflect changes in definitions. The expenditure figures used include both O&M and MILPERS expenditures.

The source for Tables 9-3 and 9-11 was the USAF Summary (October 1976). The report was made available by the Air Force Comptroller's office.

The source for Table 9-4 and for the replacement and modernization data in Table 9-10 was the MilCon and Special Programs Division of DASD(I&H). The data on replacement value represent Service estimates and, as such, are subject to the same limitations as any gross estimation. Replacement value is also reported in current dollars, and our attempt to convert to constant dollars could be inaccurate. Since construction projects are categorized as either replacement and modernization projects or new and expanded mission projects, replacement and modernization construction is simply the sum of those projects in the MilCon program categorized as such.

The source for the gross construction and family housing outlays and appropriations of Tables 9-10, 9-12, 9-14, and 9-15 was the Budget of the United States. It is important to make a distinction between outlays and appropriations in the MilCon program, as outlays represent actual expenditures in a given year, but appropriations can be approved that require outlays over a number of years. The subdivision of family housing funds into its seven components required the use of the family housing Budget Plan. The estimated cost of proposed new construction of family housing (Table 9-13) was also acquired from the Budget of the United States.

The source for the family housing program deficit data of Table 9-13 and the family housing Deferred Maintenance data of Table 9-14 was the Housing Programs Division of DASD(I&H). Both of these figures are calculated and reported annually. The program deficit, of course, represents current standards for making that calculation, not the least of which is a rather substantial program safety factor. The Deferred Maintenance estimates are provided by the Services and may reflect the intensity of managerial concern with respect to the accuracy of the estimates.

Finally, the source of the figures on national median sales prices of new single family homes was the Statistical Abstract of the United States. It should be remembered that this sales price includes the cost of land.

TABLE 9-1. SELECTED AIR FORCE INSTALLATION BUILDING SPACE AND POPULATION (1976)

Installation	Building Space ($x10^3$ sq.ft.)	Population
AAC		
Eielson	2438	6777
Elmendorf	5729	16709
Galena	13	374
King Salmon	106	483
Shemya	1017	743
ADC		
Almaden	79	228
Antigo	80	244
Baudette	91	437
Bedford	67	123
AFCS		
Richards-Gebaur	1703	8706
AFLC		
Hill	8098	22160
Kelly	14416	25996
McClellan	9856	20563
Newark	749	2921
Robins	10808	23940
Tinker	11125	24859
TAC		
Bergstrom	1913	7923
England	1381	5427
Luke	3401	10989
Mt. Home	1762	10630
Seymoure Johnson	2167	10977

TABLE 9-2. ADJUSTMENTS TO AIR FORCE MAINTENANCE AND REPAIR EXPENDITURES AND BMAR

(Dollars)

	1971	1972	1973	1974	1975	(Est.) 1976	(Est.) 1977	1978*
Reported Maintenance and Repair ($x10^6$)	338.2	362.3	381.0	437.6	501.7	646.7	676.8	816.3
Maintenance and Repair (constant 1977 $ $x10^6$)	607.8	628.6	641.3	630.2	584.3	696.0	676.8	768.4
Maintenance and Repair per Person (constant 1977 $)	569	613	655	675	656	820	817	931
Adjusted Maintenance and Repair per Person	785**	883**	925**	941**	872**	320	817	931
Reported BMAR ($x10^6$)	92.1	82.0	179.3	159.3	150.3	197.0	213.9	205.0
BMAR (constant 1977 $ $x10^6$)	BEMAR 165.5	142.3	301.8	229.4	175.1	212.0	213.9	193.0
BMAR per Person (constant 1977 $)	155	139	308	246	197	250	258	234
Adjusted BMAR per Person	219**	172**	147**	137**	197	250	258	234

* Prior to PBD action
** Adjusted

TABLE 9-3. AIR FORCE STATISTICS

Year	Aircraft Inventory	Personnel $(\times 10^3)$	Major Installations
1964	15,214	1178.2	216
1965	14,668	1142.3	209
1966	14,019	1219.4	216
1967	14,570	1249.3	206
1968	14,470	1246.5	198
1969	14,266	1212.3	197
1970	13,545	1118.6	178
1971	12,746	1067.6	166
1972	11,517	1025.2	161
1973	10,799	978.6	157
1974	10,156	933.2	154
1975	9,334	890.6	148
1976	9,289	846.9	140
1977 (Est.)	9,137	827.1	---

TABLE 9-4. DOD AND AIR FORCE REPLACEMENT VALUE

(Dollars)

	1972	1973	1974	1975
DoD Reported Replacement Value ($x10^9$)				
Worldwide	137.4	145.6	156.9	166.4
U.S.	95.9	117.6	126.2	138.2
DoD Replacement Value (constant 1977$ $x10^9$)				
Worldwide	217.0	205.9	198.7	188.4
U.S.	151.5	166.3	159.8	156.5
Air Force Reported Replacement Value ($x10^9$)				
Worldwide	49.6	50.0	50.0	44.4
U.S.	26.3	40.0	40.0	37.1
Air Force Replacement Value (constant 1977 $ $x10^9$)				
Worldwide	78.3	70.7	63.3	50.3
U.S.	41.5	56.6	50.7	42.0
Air Force Replacement Value per Person (constant 1977 $ $x10^3$)				
Worldwide	76.4	72.2	67.8	56.5
Air Force Replacement Value per Major Installation (constant 1977 $ $x10^6$)				
Worldwide	486.3	450.3	411.0	339.9
U.S.	370.5	509.9	465.1	392.5

TABLE 9-5. AIR FORCE RPMA EXPENDITURES
(Includes O&M and MilPers Appropriations for Active Installations Only)

(Dollars)

	1971	1972	1973	1974	1975	(Est.) 1976	(Est.) 1977	(Est.) 1978
Reported ($x10^6$)								
Operation of Utilities	166.2	173.2	194.1	215.9	272.6	274.2	271.3	333.6
Maintenance and Repair	338.2	362.3	381.0	437.6	501.7	646.7	676.8	816.3
Minor Construction	40.3	42.1	44.3	57.3	65.4	53.8	45.2	59.7
Other Engineering Support	322.2	376.8	380.8	426.5	442.8	273.4	288.2	327.0
Total RPMA	866.9	954.4	1000.2	1141.4	1282.5	1248.4	1314.7	1554.9
Constant 1977 Dollars ($x10^6$)								
Operation of Utilities	298.7	300.5	326.7	310.9	317.5	295.1	271.3	314.0
Maintenance and Repair	607.8	628.6	641.3	630.2	584.3	696.0	676.8	768.4
Minor Construction	72.4	73.0	74.6	82.5	76.2	57.9	45.2	56.2
Other Engineering Support	579.1	653.7	641.0	614.2	515.7	294.2	288.2	307.8
Total RPMA	1558.1	1656.8	1683.7	1643.6	1493.7	1343.6	1314.7	1463.7
Per Person (constant 1977 dollars)								
Operation of Utilities	280	293	334	333	356	348	328	381
Maintenance and Repair	569	613	655	675	656	820	817	931
Minor Construction	68	71	76	88	85	68	55	68
Other Engineering Support	542	638	655	658	570	347	348	373
Total RPMA	1459	1615	1720	1760	1676	1583	1588	1774

TABLE 9-6. ANALYSIS OF AIR FORCE BMAR PER PERSON AND MAINTENANCE AND REPAIR EXPENDITURES PER PERSON
(Adjusted, Constant 1977 Dollars)

	1972	1973	1974	1975	(Est.) 1976	(Est.) 1977	(Est.) 1978
Δ Maintenance and Repair per Person	98	42	16	-69	-52	-3	114
Δ BMAR per Person	-47	-25	-10	60	53	8	-24
Δ (Δ Maintenance and Repair per Person)		-56	-26	-85	17	49	117
Δ (Δ BMAR per Person)		23	15	70	-7	-45	-32

TABLE 9-7. AIR FORCE MAINTENANCE AND REPAIR EXPENDITURES AND Δ BMAR PER PERSON BY INSTALLATION (1976)

Installation*	People	Maintenance and Repair Dollars per Person	ΔBMAR Dollars per Person
AAC			
Campion	120	1380	450
Cape Lisburne	108	910	0
Cape Newenham	111	1220	1090
Cape Romanzof	120	1480	0
Cold Bay	111	770	0
Eielson	6777	880	80
Elmendorf	16709	450	240
Fort Yukon	118	1200	0
Galena	374	1160	70
Indian Mt.	163	1490	100
King Salmon	483	1980	160
Kotzebue	103	1820	1420
Murphy Dome	185	1380	0
Shemya	743	3430	400
Sparrevohn	160	1540	0
Tatalina	134	2850	0
Tin City	110	1080	-1860
ADC			
Almaden	228	660	-820
Antigo	244	1170	540
Baudette	437	510	-260
Bewton	205	160	40
Blaine	228	730	330
Bucks Harbor	201	960	120
Calumet	360	390	480
Cambria	149	3130	0
Cape Charles	127	1670	90
Caswell	106	2450	0
Charleston	302	1010	140
Duluth	3637	360	-4
Empire	110	2110	360
ENT	17968	150	-5
Finland	267	1440	-90
Finley	305	700	-60
Fortuna	275	330	-490
Ft. Fisher	416	1090	-70

*The installations selected are those with two years of data as reported in the HAF-PRE(SA) 7101, Civil Engineering Cost Accounting Report.

TABLE 9-7. AIR FORCE MAINTENANCE AND REPAIR EXPENDITURES AND Δ BMAR PER PERSON BY INSTALLATION 1976 (Continued)

Installation	People	Maintenance and Repair Dollars per Person	ΔBMAR Dollars per Person
Gibbsboro	177	1470	-100
Hancock	3672	410	-50
Havre	267	1110	240
Kalispell	201	1170	-80
Kingsley	1377	620	20
Klamath	243	910	10
Lockport	220	1000	50
Makah	1668	110	20
Mica Peak	58	2100	0
Mill Valley	240	1090	260
Minot	335	520	-210
Mt. Hebo	342	660	60
Mt. Laguna	398	1040	-700
NORAD Com.	1751	1780	230
North Bend	215	1030	-50
North Charleston	166	2470	0
North Truro	300	1400	-190
Opheim	282	710	330
Othello	9	20	0
Otis	2401	640	0
Pt. Arena	272	800	720
Pt. Austin	155	640	40
Roanoke Rapids	272	810	0
Saratoga	134	1540	-200
Sault Ste. Marie	166	1620	-160
St. Albans	103	1170	370
Tyndall	7818	520	40
Watertown	136	1840	-1380
Thule	1363	6130	1390
Woomera	337	870	0
AFCS			
Richards-Gebaur	8706	440	-50
AFLC			
Hill	22160	380	200
Kelly	25996	250	-4
McClellan	20563	330	70
Newark	2921	570	10
Robins	23940	250	180
Tinker	24859	310	-1
Wright-Patterson	33457	370	30

TABLE 9-7. AIR FORCE MAINTENANCE AND REPAIR EXPENDITURES AND Δ BMAR PER PERSON BY INSTALLATION 1976 (Continued)

Installation	People	Maintenance and Repair Dollars per Person	ΔBMAR Dollars per Person
AFSC			
Arnold	3636	3250	0**
Brooks	3618	590	0**
Eastern Test Range	6401	3140	0
Edwards	16230	290	1**
Eglin	24042	470	3**
Kirtland	10946	420	20**
L.G. Hansom	9655	240	0**
Los Angeles	4399	490	0
New Hampshire	244	1970	0
Patrick	4269	1050	40
Sunnyvale	3049	570	0
AFR			
Chicago-O'Hare	3548	270	10
Dobbins	1178	930	100
Ellington	1835	490	0
Gen. B. Mitchell	351	700	-90
Greater Pittsburgh	396	990	540
Hamilton	234	3480	0
Niagara Falls	703	1090	390
Westover	622	2570	30
Willow Grove	465	1580	350
Youngstown	370	1830	70
ATC			
Chanute	15987	320	-50
Columbus	5888	360	70
Craig	4402	430	0
Keesler	22558	230	-10
Lackland	30451	280	-30
Laughlin	5005	470	10
Lowry	13388	310	20
Mather	10119	350	-30
Randolph	11549	340	-5
Reese	5216	400	220
Sheppard	17994	330	-10
Vance	2899	670	-20
Webb	4218	460	-20
Williams	6275	400	-4

**Does not include BMAR reported in RDT&E accounts.

TABLE 9-7. AIR FORCE MAINTENANCE AND REPAIR EXPENDITURES AND Δ BMAR PER PERSON BY INSTALLATION 1976 (Continued)

Installation	People	Maintenance and Repair Dollars per Person	ΔBMAR Dollars per Person
AU			
Gunter	3520	330	-10
Maxwell	8578	380	-4
HQC			
Andrews	18082	460	-10
Bolling	5577	540	-260
MAC			
Altus	5468	480	-140
Charleston	9257	580	30
Dover	12684	330	-20
Lajes	5231	640	2
Little Rock	13788	280	20
McChord	7726	340	80
McGuire	12556	340	60
Norton	10269	360	10
Pope	5505	410	70
Rhein Main	4749	400	1
Scott	14207	270	-60
Travis	20304	250	120
PAC			
CCK	692	630	60
Clark	46468	130	3
Hickam	25210	320	-80
Kadena	4330	410	-60
Kunsan	4330	820	-220
Kwang Ju	520	1040	0
Osan	5759	930	-90
Taegu	598	230	0
Taipei	528	260	0
Utapao	1146	1400	-390
Yokoto	21400	320	-1
SAC			
Andersen	9008	710	80
Barksdale	9381	410	90
Beale	10813	310	-4
Blytheville	6919	350	160
Carswell	10069	290	-50
Castle	9973	270	-60
Davis-Monthan	13210	310	-30
Dyess	8141	340	40

TABLE S-7. AIR FORCE MAINTENANCE AND REPAIR EXPENDITURES AND ΔBMAR PER PERSON BY INSTALLATION 1976 (Continued)

Installation	People	Maintenance and Repair Dollars per Person	ΔBMAR Dollars per Person
Ellsworth	12106	330	70
F. E. Warren	6847	410	180
Fairchild	8786	400	100
Grand Forks	12913	260	-10
Griffiss	10258	420	40
Grissom	6566	390	10
K. I. Sawyer	8719	240	20
Kincheloe	7535	320	-40
Loring	16605	210	150
Malstrom	11159	340	40
March	8977	440	-20
McConnell	6631	550	-40
Minot	23718	160	40
Offut	22326	210	-20
Pease	7519	430	80
Plattsburgh	10759	260	-20
Rickenbacker	7068	670	310
Vandenburg	16346	370	10
Whiteman	6636	430	-40
Wurtsmith	7032	470	50
TAC			
Bergstrom	7923	490	10
Cannon	7811	400	60
Eglin	4090	810	160
England	5427	450	110
George	9718	300	200
Holloman	12915	340	330
Homestead	12598	300	270
Howard	7019	570	3
Langley	10414	370	110
Luke	10989	450	-50
MacDill	10873	520	500
Moody	4162	510	90
Mt. Home	10630	310	20
Myrtle Beach	5884	400	0
Nellis	13079	240	10
Seymoure Johnson	10977	360	40
Shaw	10533	270	-10

TABLE 9-7. AIR FORCE MAINTENANCE AND REPAIR EXPENDITURES AND Δ BMAR PER PERSON BY INSTALLATION 1976 (Continued)

Installation	People	Maintenance and Repair Dollars per Person	ΔBMAR Dollars per Person
USAFE			
Alconbury	5517	240	-20
Ankara	1996	260	-30
Aviano	3302	620	-20
Bentwaters	10000	230	2
Bitburg	12998	200	40
Diyarsakir	542	610	150
Greenham Common	906	1300	-540
Hahn	6882	310	80
Incirlik	4721	390	230
Izmir	3336	90	4
Lakenheath	10302	260	20
Mildenhall	4371	440	-40
Moron	785	1090	20
Ramstein	25064	180	60
Sembach	3616	510	310
Spangdahlem	5925	430	80
Torrejon	7119	340	150
Upper Heyford	6418	350	-50
Wethersfield	618	880	180
Wiesbaden	9430	320	-130
Zaragoza	3617	430	20
Zweibruecken	5403	310	40
USAFSS			
Goodfellow	2807	390	20
Iraklion	2127	570	-10
Misawa	9207	390	250
San Vito	4018	300	10
ShuLinKou	1014	560	120

TABLE 9-8. AIR FORCE INSTALLATION POPULATION AND RPMA COST PER PERSON

Population Interval	1975 RPMA ($x10^3)	1975 Population	1975 RPMA/ Person	1976 RPMA ($x10^3)	1976 Population	1976 RPMA/ Person
0-1000	60019.9	21235	2830	64972.4	20713	3140
1001-2500	42821.4	20556	2080	39789.5	17856	2230
2501-5000	111088.9	89378	1240	147844.7	94907	1560
5001-7500	206739.7	190742	1080	197831.1	159994	1240
7501-10000	161586.4	170835	950	187414.5	173868	1080
10001-12500	142752.6	175475	810	161788.0	181819	890
12501-15000	109205.6	147615	740	121592.9	144336	840
15001-20000	109226.9	137103	800	127741.3	135921	940
20001-25000	174647.2	222278	790	20551.6	249115	820
25001 And Above	151958.1	218957	690	134144.5	186646	720

TABLE 9-9. AIR FORCE INSTALLATION POPULATION AND RPMA COST PER PERSON BY GEOGRAPHICAL LOCATION

Area	RPMA ($\$x10^3$)	Population	RPMA/ Person	Installations	People/ Installation
I					
1975	101627.9	107657	944	10	10765.7
1976	115709.9	114117	1014	10	11411.7
II					
1975	370026.2	412652	897	45	9170.0
1976	421929.6	415404	1016	46	9030.5
III					
1975	288892.0	321240	899	37	8682.2
1976	310342.0	280413	1107	37	7578.7
IV					
1975	173091.8	196289	882	53	3703.6
1976	189503.4	193256	981	52	3716.5
V					
1975	51379.4	27884	1843	17	1640.2
1976	58061.7	26629	2180	17	1566.4

See Figure 9-14 for Geographical Areas

TABLE 9-10. AIR FORCE CONSTRUCTION PROGRAM

	Outlays ($\$x10^6$)	Outlays (constant 1977 $ $x10^6$)	Outlays/Person (constant 1977 $)
1964	535.9	1315.6	1117
1965	489.6	1178.3	1032
1966	516.1	1195.2	980
1967	536.9	1192.8	955
1968	476.7	1018.5	817
1969	480.5	963.7	795
1970	348.2	638.8	571
1971	251.9	428.2	401
1972	315.4	504.7	492
1973	263.2	373.7	382
1974	266.0	336.9	361
1975	274.3	310.0	348
1976(Est.)	351.0	377.8	445

	Construction Appropriation Approved ($\$x10^6$)		Replacement and Modernization ($\$x10^6$)	
	DoD	Air Force	DoD	Air Force
1971	1233	284	325	53
1972	1182	289	479	127
1973	1357	266	610	110
1974	1535	247	719	171
1975	1705	456	679	172
1976(Est.)	2127	551	689	165
1977(Requested)	2050	802	398	64

TABLE 9-11. AIR FORCE FAMILY HOUSING

	1971	1972	1973	1974	1975	1976
Units per Family	.286	.294	.297	.302	.316	.363
% Officer Families Housed	35.7	35.7	34.3	32.4	34.3	38.0
% Enlisted Families Housed	26.0	26.8	28.1	28.8	30.6	33.5
% Total Families Housed	27.8	28.6	29.3	29.5	31.4	34.4

TABLE 9-12. DOD FAMILY HOUSING BUDGET PLAN

	1971	1972	1973	1974	1975	(Est.) 1976	(Est.) 1977
CURRENT DOLLARS ($x10^6$)							
Construction	211.0	298.6	360.0	388.3	315.1	241.3	109.2
Operating Expenses	217.0	230.5	289.7	340.2	393.9	495.2	550.4
Leasing	22.5	28.7	36.2	32.4	55.1	70.6	97.5
Maintenance	188.8	219.3	252.1	303.3	340.6	415.8	403.2
Interest	69.7	66.0	62.1	58.1	54.0	49.8	44.3
Mortgage Insurance	6.5	6.7	6.1	5.2	4.9	4.8	4.2
Debt Reduction	89.3	93.0	96.7	100.4	104.2	107.6	112.5
Total	804.8	942.8	1102.9	1227.9	1267.8	1385.1	1321.3
CONSTANT 1977 DOLLARS ($x10^6$)							
Construction	354.4	471.6	509.0	491.8	356.7	259.8	109.2
Operating Expenses	362.8	366.0	439.7	460.4	459.1	534.9	550.4
Leasing	35.8	43.7	51.6	42.5	63.5	75.9	97.5
Maintenance	315.7	348.3	382.7	410.4	397.0	449.1	403.2
Interest	111.0	100.5	88.5	76.1	62.2	53.6	44.3
Mortgage Insurance	10.4	10.2	8.7	6.8	5.6	5.2	4.2
Debt Reduction	142.2	141.6	137.9	131.6	120.0	115.7	112.5
O&M (excluding leasing)	678.5	714.3	822.4	870.8	856.1	984.0	953.6
O&M (including leasing)	714.3	758.0	874.0	913.3	919.6	1059.9	1051.1
Total	1332.3	1401.9	1618.1	1619.6	1464.1	1494.2	1321.3

TABLE 9-13. DOD FAMILY HOUSING PROGRAM DEFICIT AND AVERAGE COST OF PROPOSED CONSTRUCTION

	1971	1972	1973	1974	1975	1976
Program Deficit (number of units)	116,700	110,733	96,700	59,782	12,341	5,568

	Average Proposed Cost of New Family Housing Construction (current $)			National Median Sales Price of New Single Family Homes (current $)
	Proposed Construction $(x10^6)$	No. Units	Cost/Unit $(x10^3)$	$(x10^3)$
1964	214.0	12100	17.7	18.0
1965	224.0	12500	17.9	18.9
1966	231.0	12500	18.5	20.0
1967	0	0	--	21.4
1968	247.1	12500	19.8	22.7
1969	42.9	2000	21.5	24.7
1970	113.9	5244	21.7	25.6
1971	198.0	8027	24.7	23.4
1972	244.1	9684	25.2	25.2
1973	315.1	12181	25.9	27.6
1974	351.9	11688	30.1	32.5
1975	337.4	10460	32.3	35.9
1976	136.7	3441	39.7	39.3
1977	52.1	1054	49.4	42.8

TABLE 9-14. DOD MAINTENANCE APPROPRIATIONS AND DEFERRED MAINTENANCE PER UNIT (FAMILY HOUSING)

	1971	1972	1973	1974	1975	1976	(Est.) 1977
Maintenance Appropriations (constant 1977 $ x10^6)	315.7	348.3	382.7	410.4	397.0	449.1	403.2
Units	374967	376174	379430	379733	385736	378991	(380000)
Maintenance $/Unit	842	926	1009	1081	1029	1185	1061
Deferred Maintenance (current $ x10^6)							
Army		156.3	157.0	155.0	161.8	132.8	133.0
Navy		25.9	22.0	19.3	35.1	40.8	90.6
Marine Corps		4.1	4.1	3.7	3.0	4.8	6.9
Air Force		17.3	20.7	18.0	38.5	77.5	102.4
Total		203.6	203.8	196.0	238.5	255.6	332.9
Deferred Maintenance (constant 1977 $ x10^6)							
Army		237.9	223.8	203.1	186.3	142.8	133.0
Navy		39.4	31.4	25.3	40.4	43.9	90.6
Marine Corps		6.2	5.8	4.8	3.5	5.2	6.9
Air Force		26.3	29.5	23.6	44.3	83.4	102.4
Total		309.9	290.6	256.8	274.6	274.9	332.9
Deferred Maintenance per Unit (constant 1977$)							
Army		1752	1628	1479	1339	1048	978
Navy		567	436	341	522	593	1224
Marine Corps		342	330	264	180	251	345
Air Force		173	195	158	297	564	692
Total		824	766	676	712	725	876

TABLE 9-15. DOD MORTGAGE DEBT

	1971	1972	1973	1974	1975	(Est.) 1976	(Est.) 1977
Mortgage Debt (current $ x10^6)	1679.9	1583.8	1480.8	1378.0	1272.8	1164.6	1024.4
Mortgage Debt per Unit (current $)	4480	4210	3903	3629	3300	3073	2696
Mortgage Debt per Unit (constant 1977$)	7134	6409	5576	4756	3800	3305	2696

GLOSSARY AND ABBREVIATIONS

Air Force Glossary:

AFCMC	-	Air Force Contract Management Center.
AGMC	-	Aerospace Guidance Maintenance Center.
Aircraft Depot Hours	-	The difference between total Air Force active inventory hours and user possessed hours.
Aircraft Flow Time at Depot	-	The average time in days between the placement of an aircraft in work and the successful flight test of the aircraft after completion of work.
Aircraft Maintenance and Modification Costs	-	Organic and contract costs for overhaul and repair of active Air Force aircraft, excluding costs for exchangeables and other unfunded costs, such as materials financed by procurement appropriations and depreciation of facilities. (As presented in Exhibit OP-19 for PE 72207F, EEIC 541.)
Air Force Stock Fund	-	Seven supply divisions of which the Systems Support and General Support Divisions are of principal interest. (See General Support Division, Horizontal Stock Fund, Systems Support Division, Vertical Stock Fund.)
ALC	-	Air Logistics Center.
Authorized Manpower (AFLC)	-	The year-end military and civilian manpower that AFLC is authorized to employ, including manpower for Command, staff, maintenance, materiel management, distribution, comptroller, procurement, base operation support at HQ ALC, five ALCs, AGMC, MASDC, AFCMC, and miscellaneous support squadrons.
AWP	-	Awaiting Parts.
BASS	-	Base Augmentation Support Set; An assembly of the necessary utilities, housekeeping facilities and essential equipment to convert a bare base into an austere operational facility to support a deployed force.
Before-Flight Reliability	-	The ratio of sorties flown to sorties attempted.
BLSS	-	Base Level Self-sufficiency Spares; WRM spares and repair parts intended for use as base support for units which plan to operate in place during wartime, considering the available maintenance capability.

BMAR, BEMAR - Backlog of Maintenance and Repair of Real Property; formerly BEMAR, Backlog of Essential Maintenance and Repair. In the Air Force, BMAR includes only the backlog of projects to be contracted out; excludes family housing.

Cannibalization - The authorized removal of specific components from one item of Air Force property for installation on another item to meet priority requirements, with the obligation of replacing the removed components.

Capehart Housing - Privately financed housing constructed under the Capehart program with FHA insured 100% mortgages, and operated by the Government (FY 1956 to October 1, 1962).

Condemnations - The number or dollar value of exchangeable items disposed of as not repairable at base, or sent to depot for repair (NRTS), and disposed of at the depot as not repairable.

Correlation Coefficient - In Chapter 9, Pearson's product moment:

$$r = \frac{n\Sigma XY - \Sigma X \cdot \Sigma Y}{\sqrt{n\Sigma X^2 - (\Sigma X)^2} \cdot \sqrt{n\Sigma Y^2 - (\Sigma Y)^2}}$$

where,

X,Y = values of the two variables to be correlated

n = number of observations.

CRAF - Civil Reserve Air Fleet.

DASD(I&H) - Deputy Assistant Secretary of Defense (Installations and Housing).

Depot Maintenance Costs for Exchangeable Repairs - Overhaul and repair costs for exchangeable items including direct materials, civilian labor, Government Furnished Material (GFM) supplied contractors and other direct costs; excludes unfunded costs financed by other appropriations or activities such as military personnel costs, items financed through procurement appropriations, certain command and headquarters costs, and depreciation of facilities and equipment.

Direct Labor Effectiveness - Direct Product Earned Hours per year divided by the available direct man-hours per year for organic maintenance manpower.

Direct Product Earned Hours - The total number of standard man-hours accumulated on all jobs performed for which standards have been established.

DLA (DSA)	-	Defense Logistics Agency; formerly the Defense Supply Agency.
EADS	-	Engine Actuarial Data Summary.
ENORS	-	Engine Not Operationally Ready, Supply.
EOQ Items	-	Economic Order Quantity Items; i.e., expense-type items, not repairable.
Ex/ABT	-	Exercises/Airborne Training.
Exchangeable Items	-	Also called repairables, recoverables, and investment-type items; those items that are potentially repairable and can be returned to the active spares inventory following a failure. The exchangeable inventory is augmented periodically by the procurement of replenishment spares.
Facility	-	An individual building, structure, or other real property improvement, which is subject to separate reporting in the DoD real property inventory.
Facility Category	-	A type of facility given a specific category code number in DoDI 4165.16.
Fill Rate	-	Total physical issues from stock on-hand divided by the sum of issues plus back orders.
GSA	-	General Services Administration.
GSD	-	General Support Division; includes base funded expense-type items procured by base level supply activities from sources other than the Air Force depot supply system, and not included in any other divisions of the Air Force Stock Fund.
Horizontal Stock Fund	-	A form of stock fund in which the wholesale level (central or depot) sells inventory to the retail level (bases), which in turn sells to the users or customers (maintenance).
Housekeeping Set	-	Selected WRM items of housekeeping and administrative equipment and supplies, exclusive of subsistence, and vehicles, prepositioned at designated locations. Housekeeping sets augment materiel assets located at existing operating bases and may be used to provide a source of assets at standby bases.
ICP	-	Inventory Control Point.
IDC	-	In-Transit Data Cards.

In-Flight Reliability	-	The ratio of sorties that are not aborted in-flight to total sorties flown: $\frac{\text{sorties minus in-flight aborts}}{\text{sorties}}$
Installation Structure	-	The number of installations, their geographical distribution, and the distribution of real property, personnel, and weapons systems at them. (See Chapter 9 for definitions of major and minor installations.)
Inventory Turnover	-	Value of annual demands divided by inventory value.
Issues	-	The number of items issued by Central or Base Supply upon demand by a user.
LOGAIR	-	Logistics Air Transportation Command.
M&R	-	Maintenance and Repair of real property.
MASDC	-	Military Airlift Storage Depot Center.
MD	-	Mission Design.
MDS	-	Mission Design Series.
MilCon	-	Military Construction; refers to the appropriation of that name and to the managerial function responsible for it.
MilPers	-	Military Personnel; refers to the appropriation of that name.
MILSTEP	-	Military Supply and Transportation Evaluation Procedures.
Minor Construction	-	Construction that qualifies as minor under provisions of DoDD 4270.24 or DoDD 1225.5, funded from either the O&M or MilCon Appropriation.
MOSS	-	Maintenance/Operations Support Set; specifically configured air transportable squadron maintenance shelters and associated equipment assigned to designated tactical squadrons and field maintenance squadrons.
MSC	-	Military Sealift Command.
MTMC	-	Military Traffic Management Command.
NFE	-	Not Fully Equipped; the condition of an aerospace vehicle that is capable of performing one or more of its primary missions, but needs a part(s) to be considered in a fully operational status.

NORM-F	-	Not Operationally Ready, Maintenance-Flyable; the condition of an aerospace vehicle that can be flown, but is not capable of performing all of its assigned missions due to one or more of its systems or subsystems being inoperative. Maintenance must either be in progress or have been deferred for reasons other than lack of parts or supplies.
NORM-G, Scheduled	-	Not Operationally Ready, Maintenance-Grounded for Scheduled Maintenance; the condition of an aerospace vehicle that cannot be flown because it is undergoing a phased maintenance inspection or TCTO.
NORM-G, Unscheduled	-	Not Operationally Ready, Maintenance-Grounded for Unscheduled Maintenance; the condition of an aerospace vehicle that requires maintenance which is not part of a scheduled inspection or TCTO.
NORS-F	-	Not Operationally Ready, Supply-Flyable; the condition of an aerospace vehicle that can be flown, but is not capable of performing all of its assigned missions due to one or more of its systems or subsystems being inoperative, and a part(s) being required to return it to a fully operational status. (Formerly NFE)
NORS-G	-	Not Operationally Ready, Supply-Grounded; the condition of an aerospace vehicle that is not capable of flight due to a verified lack of parts.
NORS Cause Code	-	An alphabetic letter, A-H, J, K, R, which indicates the reason for NORS condition in terms of base stockage policies.
NORS Incident Hours	-	The sum of all AWP hours accumulated while aircraft are in a NORS condition.
NORS Incident Rate	-	NORS Incident Hours divided by Possessed Hours.
NORS Incidents	-	The number of component failures associated with NORS conditions.
NORS Termination Code	-	A number, 0-8, which indicates how a component was obtained to end a NORS incident.
NRTS	-	Not Reparable This Station; the percentage of items returned to depot for repair because they were not repairable at base level. (Calculated on either a dollar or an item basis.)
NSN	-	National Stock Number.
O&M	-	Operations and Maintenance; refers either to the appropriation of that name or to the portion of the family housing appropriation set aside for that purpose.

OASD(MRA&L)	- Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics).
OES	- Other Engineering Support; one of the four RPMA accounts: includes fire protection, custodial services, entomology services, refuse collection and disposal, snow removal, administration, etc.
Off-Equipment Maintenance Man-Hours	- All maintenance man-hours expended by field level activities.
OR Rate	- Operationally Ready Rate; 100 minus the sum of the NORS-F rate, the NORS-G rate, the NORM-F rate, and the NORM-G rate.
PD	- Priority Designator.
PDM	- Programmed Depot Maintenance; the number of complete overhauls accomplished at organic and contract facilities during a fiscal year; does not include modifications and other repair.
PG	- Priority Group.
POM	- Program Objectives Memorandum.
Possessed Hours	- The sum of all hours that aircraft are physically assigned to a command.
Program Deficit (Family Housing)	- The number of family housing units not yet acquired, for which a need has been determined.
Recurring Maintenance and Repair (real property)	- That level of maintenance and repair that must be accomplished annually to preclude an increase in BMAR.
Repairs	- The number or dollar value of unserviceable exchangeables returned to a serviceable status; may also refer to the cost of repairing items.
Reparable Backlog Due to Supply	- The number of reparable units in backlog at a specific point in time for which a repair requirement exists under Precedence I or II, and which cannot be repaired due to lack of parts, carcasses or other supply conditions.
Reparable Generations	- The number or dollar value (at latest acquisition price) of unserviceable exchangeables returned to Base or Depot Maintenance for repair.
Replacement and Modernization (construction)	- Construction performed for the purpose of replacing or modernizing currently existing facilities, as opposed to providing for new or expanded missions.

RPMA	-	Real Property Maintenance Activities; a DoD-wide program for managing and reporting Operation of Utilities, Maintenance and Repair of Real Property, Minor Construction (O&M), and Other Engineering Support; excludes Family Housing.
SAA	-	Special Assignment Airlift.
SER	-	System Effectiveness Report; quarterly reports of weapon system performance derived from the K051 data base.
Serviceable and Unserviceable Assets	-	The dollar value of investment-type items in the inventory, reported as either in a serviceable condition or in need of repair.
SSD	-	Systems Support Division; a vertical stock fund which includes primarily expense-type items in support of Air Force systems; items are centrally procured and stored in the depot system for further distribution or use.
Station Set	-	Selected WRM items of mission-type support equipment prepositioned at designated locations. Station sets will augment materiel assets located at existing operating bases or may provide a source of assets at stand-by bases.
System Effectiveness	-	The probability of a weapon system being capable of performing all assigned missions.
TCTO	-	Time Compliance Technical Order; an authorized directive issued to provide instructions to Air Force activities for accomplishing one-time changes, modifications, inspection of equipment, or installation of new equipment.
Total Exchangeable Assets	-	The dollar value of all investment items in the Air Force inventory as of the beginning and end of the fiscal year (BOP, EOP), valuated at the latest acquisition price.
Total Exchangeable Repairs	-	The dollar value of all reparable generations minus (plus) any increase (decrease) in the unserviceable backlog minus condemnations.
TRAP	-	An acronym identifying aircraft external fuel tanks, racks, adapters, and pylons.
UCMS	-	Unit Capability Measurement System.
UMMIPS	-	Uniform Materiel Movement and Issue Priority System.

Vertical Stock Fund - A form of stock fund in which the wholesaler (central or depot) places some of the stock on consignment in the warehouses of retailers (bases). Stocks are then available to the retailer for sale to his customers (maintenance), yet the wholesaler retains ownership and control of them until the sale is made.

Wherry Housing - Privately financed housing constructed under Title VIII of the National Housing Act with FHA insured mortgages, and subsequently acquired by the Government. (FYs 1950–1955).

WRM - War Reserve Materiel; that materiel required in addition to peacetime assets, to support the planned wartime activities reflected in the USAF war and mobilization plan (WMP). WRM includes station sets, housekeeping sets, munitions, and other war consumables, spares and repair parts, ground communications-electronics-meteorological equipment, air transportable housekeeping equipment and supplies, biological defense equipment and supplies, aviation and ground petroleum, oil and lubricants (POL), rations and other equipment and supplies designated or authorized as WRM according to the policies in AFR 400–24.

WRSK - War Readiness Spares Kit; an air transportable package of WRM spares, repair parts and related maintenance supplies required to support planned wartime or contingency operations of a weapon system or support system for a specified period of time pending resupply. WRSKs may support aircraft, vehicles, command control, and communications systems and other equipment as appropriate. WRSKs are normally prepositioned with the using unit.

Air Force Command Abbreviations:

AAC - Alaskan Air Command.

ADC - Aerospace Defense Command.

AFCS - Air Force Communications Service.

AFLC - Air Force Logistics Command.

AFRES (AFR) - Air Force Reserve.

AFSC - Air Force Systems Command.

ANG - Air National Guard.

ATC - Air Training Command.

AU - Air University.

HQC	-	Headquarters Command.
MAC	-	Military Airlift Command.
PAC (PACAF)	-	Pacific Air Forces.
SAC	-	Strategic Air Command.
TAC	-	Tactical Air Command.
USAFE	-	United States Air Forces in Europe.
USAFSS	-	United States Air Force Security Service.

APPENDIX A: OTHER READINESS REPORTING SYSTEMS

INTRODUCTION

As mentioned in Chapter 2, there is no universal definition of readiness. Readiness can refer to the ability either to respond to a threat or to sustain that response; it can also refer to how well forces are trained or how much equipment is available. The purpose of this study was to develop a system to monitor readiness, specifically, the effects of logistics on readiness. We therefore surveyed the readiness reporting systems in the Air Force to see which could serve as sources of data and which could be related to logistics management.

The words "combat," "personnel," and "materiel" are frequently used with reference to readiness. Materiel readiness, which refers to the status of equipment, is measured by operational readiness. Operational readiness, which is discussed in detail in Chapter 2, is the focus of this report, since it provides both the data and the connection to the logistics system necessary for a coherent document. However, there are other readiness reporting systems and they are discussed, but not evaluated, in this appendix.

We begin with a brief description of the FORSTAT (Force Status and Identity Report) System, through which each Service is required to report its readiness status to the JCS. Several other reporting systems used by the Air Force, each of which is geared to a specific aspect of readiness, are also discussed.

FORSTAT

FORSTAT is the best known readiness reporting system.[1] It was implemented in 1969 and was designed to furnish the Services with a means of monitoring their readiness and the JCS with indicators of combat readiness. The JCS FORSTAT system reports readiness in terms of "C-ratings" received from the Services. A C-rating is an indication of a unit's capability to perform its mission; it is thus an estimate of the degree to which the unit's potential capability can be achieved.

There are four C-ratings defined by the JCS as follows:

Fully Ready (C1)	-	a unit fully capable of performing the mission for which it is organized or designed
Substantially Ready (C2)	-	a unit has minor deficiencies which limit its capability to accomplish the mission for which it is organized or designed

[1]The readiness data contained in FORSTAT are described in JCS Publication 6, Volume II, Part 2, Chapter 1, Section 6.

Marginally Ready (C3)	-	a unit has major deficiencies of such magnitude as to limit severely its capability to accomplish the mission for which it is organized or designed
Not Ready (C4)	-	a unit not capable of performing the mission for which it is organized or designed

Although all of these definitions are qualitative, the JCS has requested the Services to base their C-ratings on quantitative criteria insofar as possible.

Each Service is required to submit a C-rating in four resource areas: personnel, equipment/supplies on hand, equipment readiness, and training. The overall C-rating of a unit is the lowest of these four C-ratings, unless that rating is changed by the commander and accompanied by an explanation for the change.

UCMS

The Air Force readiness reporting system which feeds into the JCS FORSTAT system is called the Unit Capability Measurement System (UCMS).[2] This system applies to all combat and combat support organizations of the regular Air Force, the Air Force Reserve, and the Air National Guard. The frequency of UCMS reporting is daily for the regular Air Force, bi-monthly for the National Guard, and monthly for the Reserve.

UCMS measures the capability of a unit to accomplish a specified mission for which it was organized or designed. Such a mission is called a Designed Operational Capability (DOC). DOCs are categorized as primary or secondary according to the level of training required of the unit for that mission. If a unit is assigned more than one DOC, a percentage is calculated for the unit's capability to accomplish each one.

A unit is authorized a level of resources sufficient to accomplish the tasks identified in each DOC. When quantifiable, a percentage of the amount available over the amount authorized is calculated for each resource. The unit commander provides an evaluation of those non-quantifiable factors that can affect the unit's capability. If his estimate differs from the calculated capability percentage by 5% or more, his estimate is also included.

Five major resource categories are considered in determining capability – major equipment, crews, total military personnel excluding aircrews, total essential skill equivalents, and logistics. A percentage is computed for each category by dividing the amount available by the amount authorized. Both the available and authorized personnel in each skill level are weighted by a skill factor and then summed over all skill levels. The percentage for total essential skill equivalents is computed by dividing the weighted available figure by the weighted authorized figure.

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[2] UCMS is described in Annex A to JCS Publication 6, Volume V, Part 2, Chapter 1.

Given the percentages calculated for these major resource categories, a capability figure is computed for each category by using tables applicable to the specific DOC provided in Annex C of JCS Publication 6, Volume V, Part 2, Chapter 1. The tables in Annex C are organized by DOCs, which are in turn classified according to whether a unit fights in place or is a SIOP or mobility unit. In the former case, there are separate tables for aircraft units and missile units. The standard aircraft table is displayed in Figure 1. The table for SIOP-committed units consists of only two resource categories: major equipment and crews. In the case of SIOP-committed units, the percentage of crews available is calculated by dividing the number of major equipments authorized into the number of available crews.

The logistics resource category for mobility DOCs is based on four logistics areas – mobility equipment, WRSKs, spare engines, and test stations. A percentage is computed for each of these areas. For both mobility equipment and WRSKs, the percentage is calculated by dividing the amount assigned by the amount authorized. The percentage for spare engines is computed by dividing the number of spare engines that can be brought to a serviceable condition within the deployment time frame specified in the DOC by the number of required spare engines.

A criteria table is used to determine the percentage for test stations. Annex C contains a logistics table for mobility DOCs, where a logistics support percentage is calculated for each of these areas. The lowest percentage is used in the mobility tables.

Once the resource percentages are calculated and a capability figure is obtained by using the appropriate table in Annex C, the unit's computed capability figure, which is the lowest capability of each resource, is obtained. Besides this computed capability figure, the unit commander can supply an estimated capability figure based on the computed figure and his judgment of how non-measurable factors affect the computed value. Such factors include: morale, weather, shortages in a single essential skill, and supply levels. When the unit commander determines that the computed capability does not reflect the true capability, he must supply with his estimate of the unit's capability a statement indicating which factors caused the change.

Several hundred reason codes exist which the commander can use to explain any differences in these percentages. These reason codes appear in Table 12, Appendix A, JCS Publication 6, Volume II, Part 2, Chapter 1. Commanders are also responsible for ensuring that valid capability ratings are reported and narrative remarks are submitted whenever the capability ratings are below an established operation level. Ten cards per remark are permitted, which allows the commander approximately 500 characters. If the

FIGURE 1. STANDARD AIRCRAFT ORGANIZATION CRITERIA

This table will be used to compute capability of a unit to support its assigned DOCs. The procedure to follow will be to determine the capability for each of the four areas listed; using the lowest of the four resultant capabilities, determine and report the computed capability. The commander will evaluate this computed capability and adjust it, if necessary, for factors which are not directly measured. The resultant would be the commander's estimate of capability. Columns two through five are the percentages of equipment and personnel available to the unit. This percentage is obtained by dividing the available resources by the authorized resources. This table is applicable to all Air Force units with major equipment designed to operate on a continuing basis.

Capability	Percent Aircraft Avail/Auth	Percent Crews Avail/Auth	Percent Personnel Avail/Auth	Percent Skill Equiv Avail/Auth
100	71	79	90	90
99	70	78	88	88
98	69	77	86	86
97		76	84	84
96	68		82	82
95	67	75	81	81
94		74	79	79
93	66	73	78	78
92	65	72	76	76
91	64		74	74
90		71	73	73
89	63	70	71	71
88	62	69	70	70
87		68	69	69
86	61		68	68
85	60	67	66	66
84	59	66	65	65
83		65	64	64
82	58	64	63	63
81	57		61	61
80		63	60	60
79	56	62	59	59
78	55	61	58	58
77	54		57	57
76		60	56	56
75	53	59	55	55
74	52	58	54	54
73		57	53	53
72	51		52	52
71	50	56	51	51
70	49	55	50	50
69		54		
68	48	53	49	49
67	47		48	48
66		52	47	47
65	46	51	46	46
64	45	50	45	45
63		49		
62	44		44	44
61	43	48	43	43
60	42	47	42	42
59		46		
58	41		41	41
57	40	45	40	40
56		44		
55	39	43	39	39
54	38	42		
53	37		38	38
52		41	37	37
51	36	40		
50	35	39	36	36

FIGURE 1. STANDARD AIRCRAFT ORGANIZATION CRITERIA (Continued)

Capability	Percent Aircraft Avail/Auth	Percent Crews Avail/Auth	Percent Personnel Avail/Auth	Percent Skill Equiv Avail/Auth
49		38		
48	34		35	35
47	33	37		
46		36	34	34
45	32	35		
44	31	34	33	33
43	30		32	32
42		33		
41	29	32	31	31
40	28	31		
39	27			
38		30	30	30
37	26	29		
36	25	28	29	29
35		27		
34	24			
33	23	26	28	28
32		25		
31	22	24	27	27
30	21	23		
29	20			
28		22	26	26
27	19	21		
26	18	20		
25		19	25	25
24	17			
23	16	18		
22	15	17	24	24
21		16		
20	14			
19	13	15		
18		14	23	23
17	12	13		
16	11	12		
15	10			
14		11	22	22
13	9	10		
12	8	9		
11		8		
10	7			
9	6	7		
8	5	6	21	21
7		5		
6	4	4		
5	3			
4		3		
3	2	2		
2				
1	1	1		
0	0	0	20	20

SOURCE: Annex C to JCS Publication 6, Volume V, Part 2, Chapter 1.

accompanying remarks are either too complex or lengthy for the remark cards, a Commander's Situation Report (SITREP) must be submitted. A SITREP number must be included on the remark card along with the FORSTAT capability rating report when capability is below the established level.

The Air Force uses the computed capability percentage and the unit commander's percentage, when submitted, for each DOC to evaluate the readiness capability for each unit. C-ratings are determined for the FORSTAT system by using the original resource categories excluding skill equivalents. Only the primary DOC for each unit is used. Presently, UCMS data are converted into C-ratings by mathematical formulae. Instructions for this conversion are contained in Annex E to JCS Publication 6, Volume V, Part 2, Chapter 1. Eventually this conversion to C-ratings will be handled by a simple relationship between UCMS percentages and the C-ratings.

Data from UCMS are entered directly into the FORSTAT system each day. New data are entered into a computer by batch processing and a magnetic tape is produced, which is hand-carried to Washington where it enters the FORSTAT system. The data may be delayed for several days because of bad weather, system failures, or computer tape parity errors. Since these data are used for readiness and mobilization, they should be kept as current as possible.

SITREPs

SITREPs were originally designed as a means for Air Force commanders to report unusual circumstances affecting a unit's readiness. There are several types of SITREPs at present. One was mentioned in the preceding section, the SITREP that is prepared when unit deficiencies require a longer explanation than can be accommodated on the UCMS remark cards. A more regular type of SITREP is the semiannual reports prepared by component commanders, which are given to the Commanders-in-Chief (CINC) and the Air Staff. These SITREPs contain detailed information on units and their deficiencies in terms of readiness. The CINC condenses the information in these reports into a theater-level report, which is then submitted to the JCS and the Air Staff. The JCS in turn incorporates this information into a report for the Secretary of Defense.

The Air Staff, which receives both the SITREPs developed by the component commanders and the theater-level version prepared by the JCS, prepares a report semiannually for the Chief of Staff of the Air Force, the Secretary of the Air Force, and the Secretary of Defense. The report, called the Air Force Semiannual Readiness Report (AFSRR), not only incorporates the information contained in the SITREPs, but also contains UCMS, Inspector General, and logistics data. The AFSRR is intended to be both a summary of the important readiness factors contained in the preceding sources and a management document for senior staff members. It is presently being revised to improve its utility as a management document; in the interim, a semiannual readiness report will be prepared for senior staff use.

ORIs and MEIs

The Air Force also uses surprise field tests and spot checks, known as the Operational Readiness Inspection (ORI) and the Management Effectiveness Inspection (MEI), to measure unit readiness. In this respect, the ORI and the MEI are like the UCMS. They are different from the FORSTAT reports, however, because they measure how resources are utilized rather than what level of resources is available.

The ORI is a surprise field test to simulate wartime operations. It measures "wartime" performance based on from three to seven eight-hour days and is performed approximately every 18 months for each unit. After each ORI, a report is written for the use of the commanders and the Air Staff. Presently there is some interest in simulating more of a "wartime" environment, for example, by conducting the field tests during a 24-hour rather than an eight-hour day.

An MEI is a spot check of a unit's performance based on the unit's records for the past six months. MEIs are frequently performed in conjunction with ORIs. This practice often creates problems; for instance, a custodian of a safe needed for a MEI may be flying maneuvers in the ORI.

Quarterly World-Wide Logistics Report

The Quarterly World-Wide Logistics Report is an evaluation of the capability of the Air Force logistics system to support the current wartime tasking. It is classified SECRET.

The report is prepared by the Air Force Logistics Readiness Assessment Team (LRAT) in accordance with Deputy Chief of Staff/Systems and Logistics (DCS/S&L) Operating Instruction 11-2, June 1, 1976. This operating instruction requires the LRAT to:

1) Identify, define and monitor logistics readiness indicators

2) Develop and maintain a comprehensive Air Force Logistics Readiness assessment and measurement system

3) Identify Air Force logistics readiness issues

4) Task appropriate Air Force agencies to provide assistance and data on logistics readiness issues

5) Analyze and evaluate selected logistics readiness issues

6) Enhance Air Force logistics readiness through initiatives raised for consideration by the LRAT, the Air Force Readiness Initiatives Group (AF/RIG) and Air Staff functional managers

7) Monitor the progress and implementation of logistics initiatives identified for action.

The LRAT was established in January 1975. Since then, its membership has grown from two to fifteen members. The LRAT initially identified 70 quantifiable logistics factors which have been incorporated into their report. They are limited to using only currently reported data.

The Quarterly World-Wide Logistics Report was designed to provide indicators of logistics readiness, defined as "that degree of capability, within the USAF logistics systems, to fully support worst case operational requirements contained within current operation plans."[3] The data in the report are computed as the percentage of the amount available over the amount authorized, where requirements are based on the worst case situation. Where Air Force standards exist, these data are compared to them.

The contents of the Quarterly World-Wide Logistics Report are listed in Figure 2. The data are shown by command. Two world-wide summary pages report, by command, both independent factors and factors specifically related to weapon systems. The tables are color-coded: green indicates that a particular standard is met; yellow indicates that one or more of the components of a factor are marginal compared to the standard; and red indicates that one or more of such components are unsatisfactory compared to the standard. When an item is not applicable to a weapon system or an assessment procedure has not yet been determined, the entry is not colored.

The weapon system table shows logistics support of weapon systems in terms of spare part levels, ground support equipment, TRAP, WRSK, BLSS, MOSS, BASS, station sets, outstanding TCTOs, spare engine levels, and depot reparable spares backlog.[4] The other summary table shows logistics support to the commands for items such as missiles, housekeeping sets, motor vehicles, fuel, personnel, and skills.

The first World-Wide Quarterly Logistics Report was published in June of 1976. The report is primarily used to identify whether the commands have sufficient logistics resources and how their logistics readiness could be improved. It is not designed to

[3] DCS/S&L Operating Instruction 11-2.

[4] See Glossary for an explanation of terms.

FIGURE 2. TABLE OF CONTENTS
QUARTERLY WORLD-WIDE LOGISTICS REPORT

INTRODUCTION
COMMAND SUMMARY (FACTORS BY WPN SYSTEM)
NORS/NORM
NORS INCIDENTS (BY MDS)
SPARE PART LEVELS (SURGE MARGINAL)
DEP REP SPARES BACKLOG
WAR READINESS SPARES KITS (WRSK)
BASE LEVEL SELF-SUFFICIENCY SPARES (BLSS)
SUPPORT EQUIPMENT (WPN SYSTEM PECULIAR)
SUPPORT EQUIPMENT (COMMON)
MAINTENANCE/OPERATIONS SUPPORT SETS (MOSS)
BASE AUGMENTATION SUPPORT SETS (BASS)
STATION SETS
HOUSEKEEPING SETS
HARVEST EAGLE
AIR TRANS HYD SYS
TANKS, RACKS, ADAPTERS & PYLONGS (TRAP)
CHAFF
GUNS/GUN BARRELS
SUBSISTENCE
MISC WAR CONSUMABLES
SPARE ENGINE LEVELS
CONVENTIONAL MUNITIONS
TACTICAL MISSILES
POL/JP-4
TCTOS
MOTOR VEHICLES (BY TYPE)
MOTOR VEHICLES (BY FUNCTION)
MAINT PERSONNEL AND SKILLS
WORLD-WIDE SUMMARY (FACTORS BY WPN SYSTEM)
WORLD-WIDE SUMMARY (FACTORS BY COMMAND)
DISTRIBUTION

SOURCE: Quarterly World-Wide Logistics Report measure the performance of a command or how well a command utilizes its resources. Presently, this report emphasizes levels of logistics resources (input measures). A goal for future reporting is to tie logistics with overall readiness and capability (output measures).

LCMS

In contrast to the data reporting systems previously discussed, the Logistics Capability Measurement System (LCMS) is a computer simulation used to assess the effect of logistics on overall capability and readiness. LCMS is still being developed; the idea behind it is to determine whether the logistics system can support a specified war plan. The Air Force is also using this model in response to DoD and Congressional pressure to manage logistics by weapon system.

The LCMS study was begun in early 1974, its first objective being to assess, by MDS, the Air Force's logistics capability to support a specified war plan. After examining existing computer models, two models, originally developed by the RAND Corporation with help from AFLC, were selected to be part of LCMS. These models are the Multi-Echelon Technique for Reparable Item Control (METRIC) and the Logistics Composite Model (LCOM). These models are used in LCMS for requirements generation, capability assessment, and management planning.

METRIC is a computer model of a base and depot supply system. Given a specified level of investment, METRIC determines an optimum level of system performance. As part of the LCMS effort, LMI is presently extending a METRIC-based model to include a capability for allocating repair and procurement dollars and developing a method for producing a budget format for initial spares (BP-15) and replenishment spares (BP-16). This model is the LCMS FYDP/Budget Planning Model. The purpose of this model is to allocate funds for spares among aircraft types, to assist managers in developing budgets for spares, and to display the results of various resource allocations.

The LMI model defines an aircraft as available if it is not waiting for a component to be repaired or to be shipped. The output of the model is a "shopping list" indicating the number of spares, the cost, and the number of aircraft available, given a specified level of procurement funds.

LCMS uses LCOM to generate requirements and to assess capability. Given a level of activity and aircraft specifications, LCOM determines supply and maintenance requirements. Using these requirements and a given level of resources, LCOM then computes sortie capability. Synergy Corporation has been tasked to expand the model to consider several MDSs within one or more war plans, increase reparable items above the level of the WRSK, and include critical EOQ items.

A top-level capability report is produced as output. The output contains the planned exercise and its duration, the number of aircraft in the plan with their sortie rates, the number of sorties required and accomplished, whether or not the available assets can provide adequate support, the reasons for any unaccomplished sorties, and the total cost of reparables and shortages.

LCMS is an evaluation tool for planning, budgeting, and assessing capability. A possibility for the future is to use LCMS as a complement to UCMS. For a specified level of resources and for prescribed operations requirements, LCMS can produce estimates of capability, which can then be compared to actual data reported by UCMS.

APPENDIX B

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

INSTALLATIONS AND LOGISTICS

DATE: 16 June 1976

TASK ORDER SD-321-47
(Task 76-6)

1. Pursuant to Articles E-1 and E-3 of the Department of Defense Contract SD-321 with the Logistics Management Institute, the Institute is requested to undertake the following task:

A. TITLE: A Macro Analysis of DoD Logistics Systems

B. BACKGROUND: The DoD logistic system is really a composite of the individual logistics systems of the separate Services, augmented by DoD agencies, such as the Defense Supply Agency. The management and physical composition of the separate Service logistics systems vary widely and may not be well rationalized from a changing DoD viewpoint. An examination of this DoD logistics complex from a macro point of view would be a useful aid in understanding OSD's role with respect to DoD logistics, and in providing appropriate tools for the exercise of that role.

This task initiates such an examination. In view of its breadth, it is subdivided into three subtasks. The first subtask is to define OSD's role and responsibilities through an analysis of DoD logistics systems. The second subtask is to develop a set of logistics indicators and performance measures to be used by OSD. The third subtask is to develop an analytical framework for OSD use of the indicators in the exercise of its logistics responsibilities.

The task will be conducted in the following way. The first subtask will analyze the DoD-wide logistics complex to identify OSD's current and appropriate future role. The other two subtasks on logistics indicators for OSD use will take a DoD-wide perspective and will use the Air Force for specific analysis and testing. The logistics indicators will cover both the effect of logistics on mission readiness and the efficiency of logistics performance. The reason for a selective study is to establish the feasibility and demonstrate the usefulness of this approach to the OSD role in logistics.

C. SUBTASK 1 - TITLE: DoD Logistics Systems Analysis

OBJECTIVE: To describe the current Services and DoD-wide logistics systems by analyzing their functional and management characteristics in order to refine OSD's logistics role.

SCOPE OF WORK: In performing this subtask, LMI will:

1) Study policies, processes, practices and systems related to logistics management, including operations and control, planning, programming, and budget activity.

2) Develop a description of the DoD logistics systems related to operations and control, planning, programming and budget activity, and associated information systems, covering the following:

a) Service logistics systems
b) DoD-wide logistics agencies
c) Interfaces among the Services and DoD-wide agencies
d) OSD activities for monitoring and planning logistics activities

3) Compare such management functions as operations and control, planning, programming, and budget activity for DoD logistics systems with those for other systems for similar purposes.

4) Define and specify the role which should be exercised by OSD over logistics activities conducted by various echelons of the DoD, including audit for policy conformance.

SCHEDULE: The findings of this task will be presented to the Principal Deputy Assistant Secretary of Defense (I&L) in draft form by 30 September 1976. A final report will be issued by 30 November 1976.

SUBTASK 2 - TITLE: Management Information Needs of OSD

OBJECTIVE: To develop a series of indicators for logistics oriented activities to assist OSD in exercising its responsibilities. Indicators will be suggested to reflect operational readiness and efficiency measures of logistics activities.

The indicators to be emphasized will focus on logistics activities at the DoD and Service level, where logistics is intermediate to operations, and where performance is measurable in terms of mission operations and objectives. Secondary emphasis will be placed on central support management and performance where output coincides with the logistics activity performed.

SCOPE OF WORK: In performing this subtask, LMI will:

1) Define output/performance measures. At some levels of activity the logistics output is measured by operating performance, e.g., flying hours, while at other levels the measurement is by logistics activity *per se*, e.g., ships overhauled, items supplied, available cargo airlift capacity.

2) Define inputs or costs--both operating costs and capital expended. Since actual input utilization is not always available, assigned manpower will be used, where necessary, as will trends in productivity. Such data may indicate the extent of slack. For some activities, capital costs and capacity are relevant; e.g., stock fund working capital levels and available ton-miles in MAC.

3) Analyze sources of data needed to support the indicators, including:

a) Availability of data
b) Reliability and specificity of data
c) Consistency of data collected across Services and agencies

4) To the extent that data are readily available, compile and evaluate trends in performance and cost, devise ratio measures of productivity, and interpret ratios and trends for use in management analyses. A formal mechanism for continued compilation and evaluation will not be attempted in this preliminary feasibility effort.

SCHEDULE: A preliminary set of indicators and trend results will be presented to the Principal Deputy Assistant Secretary of Defense (I&L) in draft form by 31 January 1977. A final report will be issued by 31 March 1977.

SUBTASK 3 - TITLE: Analytical Techniques to Use Indicators for OSD Management

OBJECTIVE: To develop an analytical framework for use of the performance and cost indicators by OSD consistent with its defined roles and responsibilities as developed under Subtask 1.

SCOPE OF WORK: In performing this subtask, LMI will:

1) Develop an analytical framework for utilization of the indicators of readiness status for operation (mission)-oriented systems, including the meanings of the indicators, their usefulness at pinpointing management deficiencies, and the corrective intervention procedure for OSD. Corrective procedures to be reviewed include OSD policy statements, intervention with Service managers and possibly OSD-initiated management studies.

2) For indicators of efficiency trends in logistics activities, indicate how productivity trends developed from the indicators can be used for trade-off analysis among budget categories (e.g., new procurement vs. more maintenance of available equipment) and for major resource allocation decisions. In addition, the types of intervention by OSD in logistics management to correct productivity deficiencies will be analyzed and the preferred mechanism(s) for control through budget review, policy statement, etc., will be identified.

3) Using the results of 1) and 2), define a process by which OSD can exercise its responsibilities for short and long range program monitoring and planning.

SCHEDULE: The findings of this task will be presented to the Principal Deputy Assistant Secretary of Defense (I&L) in draft form by 31 March 1977. A final report will be issued by 31 May 1977.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
This report on the second phase of Task 76-6 provides a basis for an aggregate logistics management indicator system for the Office of the Secretary of Defense. The Air Force logistics system was chosen as a prototype for a descriptive structure relating support activities to operational readiness. Relevant logistics data were then obtained and subjected to trend analysis to evaluate the significance of the structural relationships.

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