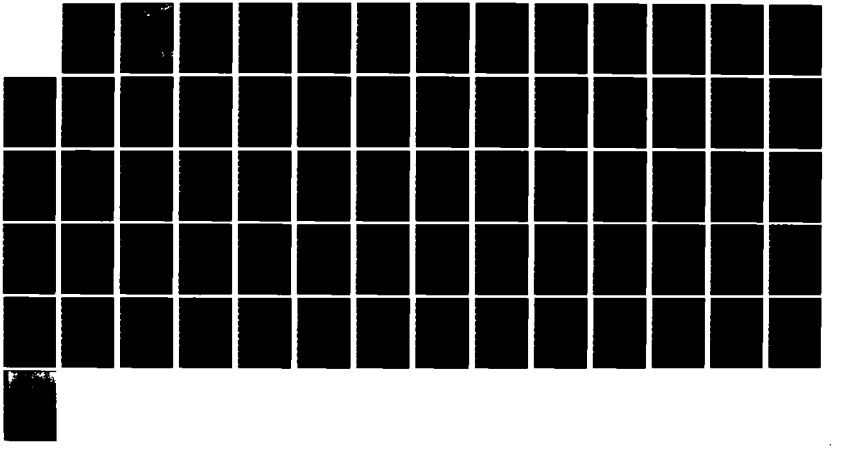
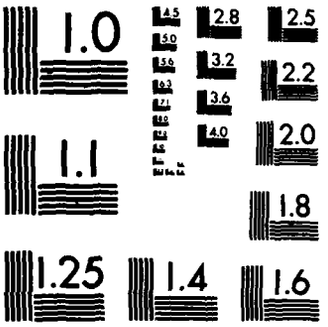
AD-A135 005 MANAGEMENT OF THE AIR FORCE BACKLOG OF MAINTENANCE AND REPAIR(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYSTEMS AND LOGISTICS T L SANDERS SEP 83 1/1

UNCLASSIFIED AFIT-LSSR-55-83 F/G 15/5 NL





MANAGEMENT OF THE AIR FORCE BACKLOG OF MAINTENANCE AND REPAIR

Troy L. Sanders, Captain, USAF

LSSR 55-83

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

MANAGEMENT OF THE AIR FORCE BACKLOG OF MAINTENANCE AND REPAIR

Troy L. Sanders, Captain, USAF

LSSR 55-83

The contents of the document are technically accurate, and no sensitive items, detrimental ideas, or deleterious information are contained therein. Furthermore, the views expressed in the document are those of the author(s) and do not necessarily reflect the views of the School of Systems and Logistics, the Air University, the Air Training Command, the United States Air Force, or the Department of Defense.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER LSSR 55-83	2. GOVT ACCESSION NO. AD-A135005	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) MANAGEMENT OF THE AIR FORCE BACKLOG OF MAINTENANCE AND REPAIR		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Troy L. Sanders, Captain, USAF		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS School of Systems and Logistics Air Force Institute of Technology, WPAFB OH		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Department of Communication AFIT/LSH, WPAFB OH 45433		12. REPORT DATE September 1983 13. NUMBER OF PAGES 66
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Approved for public release: IAW AFR 190-17.
LYNN E. WOLAVER
Dean for Research and Professional Development
Air Force Institute of Technology (ATC)
Wright-Patterson AFB OH 45433
15SEP 1983

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Air Force Budget
Air Force Facilities
Maintenance
Repair
Backlog

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Thesis Chairman: Al Tucker, Maj, USAF

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

The backlog of maintenance and repair (BMAR) is considered the most important indicator of how adequately real property maintenance is performed. From 1965 to 1978, the DOD BMAR rose from $850 million to $2500 million in constant 1980 dollars. That would seem to indicate a severe shortfall in the adequacy of real property maintenance. This thesis originally was going to produce a model to predict the BMAR at an Air Force base. One conclusion in the thesis was that currently the BMAR is unpredictable. A systems analysis model of the planning, programming, budgeting, and executing of the maintenance and repair work for a base for one year was devised. This demonstrated the complexity and flexibility of the system that has BMAR as one output. One major weakness in the system is that the Air Force does not use the same definition of BMAR as DOD. Air Force constrains the BMAR to only include contract work that is backlogged, excluding the in-house work. Having two different definitions is unreasonable, and having two backlogged work outputs of the system precludes predicting the level of one. The recommendations include definitions for two separate BMAR figures (essential and total) to be used throughout DOD.

LSSR 55-83

MANAGEMENT OF THE AIR FORCE BACKLOG OF MAINTENANCE AND REPAIR

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirement for the

Degree of Master of Science in Engineering Management

By

Troy L. Sanders, BSMAE
Captain, USAF

September 1983

This thesis, written by

Captain Troy L. Sanders

has been accepted by the undersigned on behalf of the faculty on the School of Systems and Logistics in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN ENGINEERING MANAGEMENT

DATE: 28 September 1983

COMMITTEE CHAIRMAN

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

AF	Air Force
AFP	Air Force Pamphlet
AFR	Air Force Regulation
AFSC	Air Force Systems Command
ASD	Aeronautical Systems Division
ASIF	Airlift Support Industrial Funds
BMAR	Backlog of Maintenance and Repair
CE	Civil Engineering
CECORS	Civil Engineering Contract Reporting System
CSU	Customer Service Unit
DCS	Deputy Chief of Staff
DOD	Department of Defense
DTIC	Defense Technical Information Center
GAO	General Accounting Office
HIPO	Hierarchy Plus Input-Process-Output
HQ	Headquarters
ICAM	Integrated Computer-Aided Manufacturing
IDEF	ICAM Definition Method
IPO	Input-Process-Output
IWP	In-service Work Plan
MAC	Military Airlift Command
MAJCOM	Major Command

MRP	Maintenance of Real Property
OMB	Office of Manning and Budget
OSD	Office of the Secretary of Defense
O&M	Operations and Maintenance
PACAF	Pacific Air Forces
Prime BEEF	Prime Base Engineer Emergency Forces
RDT&E	Research, Development, Testing, and Evaluation
RED HORSE	Rapid Engineers Deployable Heavy Operations Repair Squadron, Engineering
RPMA	Real Property Maintenance Activities
SAC	Strategic Air Command
SAF	Secretary of the Air Force
U.S.	United States
USAF	United States Air Force
SMART	Structural Maintenance and Repair Team
SPSS	Statistical Package for the Social Sciences

CHAPTER 1

INTRODUCTION

Research Overview/Problem Statement

For more than twenty years, the Congress, Department of Defense, and individual services have been very concerned about the growth in the dollar value of the deferred maintenance for the defense real property assets (9:5-6). Figure 1 is a graphical representation of the amount expended each year for maintenance and repair of real property in the Department of Defense and the amount of backlogged maintenance and repair work at the end of each year from 1965 through 1978 (9:19). All the amounts have been converted to constant fiscal 1980 dollars based on defense deflators for military construction. After accounting for inflation, the DOD backlog almost tripled in that thirteen year period. Appendix A is a listing (current dollars) of the DOD and Air Force planned expenditures, maintenance floor, actual expenditures, and BMAR for 1965 through 1979 (9:41; 10:2).

The most important issue is whether this dollar growth represents a decrease in overall condition of defense facilities which could be related to a potential decrease in national defense readiness. In addition to the defense readiness concern, there is also a question of using federal budget funds in the most effective manner possible.

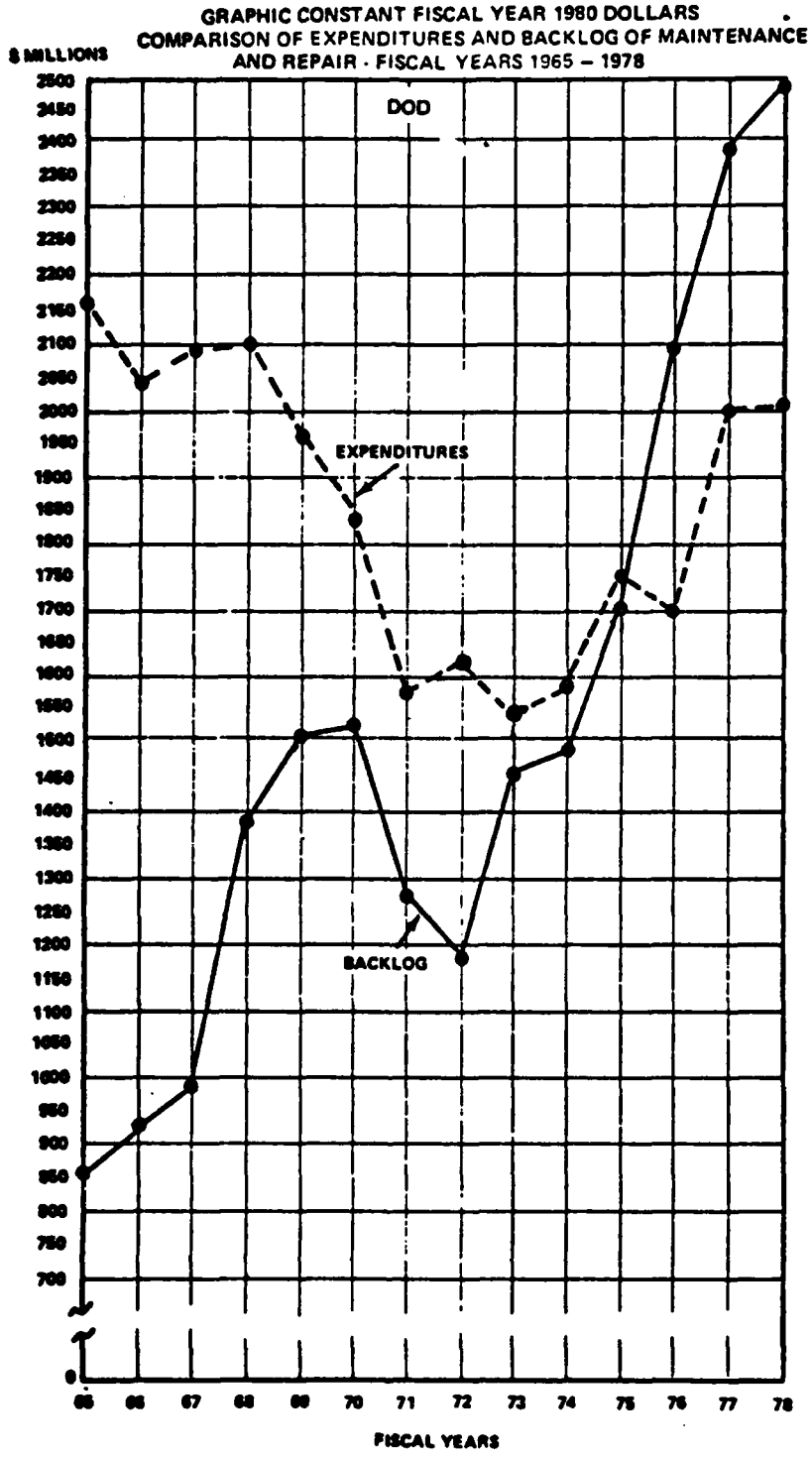


FIGURE 1

BMAR GRAPH

It is generally recognized that a large backlog level indicates inadequate funding of maintenance of real property. The U. S. Air Force considers the backlog of maintenance and repair to be "the most important indicator of how adequately real property maintenance is funded [12:p.8-3]." Similarly, the General Accounting Office referred to the backlog as being "recognized as a key indicator of the adequacy of the annual maintenance and repair funding [10:3]." Throughout the services and continually through the last twenty years, this indicator has reflected a distinct shortfall in maintenance and repair funding. This occurred despite several redefinitions of BMAR by DOD in attempts to insure the BMAR actually reflected the adequacy of funding and new procedures and extra funding by Congress in order to control the BMAR and eventually decrease it to a manageable level. All attempts by all agencies have failed to reduce or even manage the BMAR level.

The underlying problem is determining how the backlog of maintenance and repair can be managed. There have been some statements by the individual services on what the ideal level of the backlog should be, but before the goal of a particular level can be reached, a method of controlling the growth of the backlog must be found. The continual growth of the BMAR despite efforts by all agencies certainly demonstrates that a viable control method has not yet been found.

The problem of managing the BMAR has three facets to it. The first is to have the proper definition of BMAR, which has been the responsibility of DOD and the services. The definition must truly represent the feature of the system that needs to be managed. The second facet is a system of managing the BMAR once it is properly defined. This is the responsibility of the services and the subordinate commands at all levels. It encompasses management of the information sources included in the system, management of the funds to be applied to maintenance and repair, and control of the various manpower and contracting resources that perform the maintenance and repair. The third aspect of managing the BMAR is to determine the proper amount of funds to be applied to maintenance and repair in order to keep the backlog at any desired level. This is the responsibility of Congress, and it cannot be effectively performed until the definition is perfected and the management system properly designed.

Background/Literature Review

In the early 1960s, members of the House of Representatives became aware that funds that had been justified for physical plant maintenance were actually being diverted to operational requirements. Thus, funds that were needed and authorized for keeping facilities in good condition were not being used for that purpose. To remedy that situation, Congress institutued in the fiscal year 1963 appropriation act a minimum limit that the defense agencies

were required to spend on maintaining real property with funds from the operations and maintenance appropriation (Public Law 87-577). The statutory floor for maintenance and repair of facilities has been included in each subsequent appropriation act. (9:5)

In an April 1962 report, (House Report no. 1607, 87th Congress, 2d session), the House Committee on Appropriations indicated that it wanted to separate the maintenance of real property appropriation from the appropriation for operations. It was willing to grant specific authority for installations to transfer funds from the operations appropriation to the maintenance one, but DOD stated that it thought there would be too much loss of flexibility because of potentially long delays awaiting transfer approval from the Bureau of the Budget. Instead, DOD proposed the establishment of the statutory floor on the funds spent on maintenance on real property out of the combined operations and maintenance appropriation. As stated, Congress approved this concept and has included a floor in each year's operations and maintenance appropriation. (9:5)

In the annual DOD budget request, the services include a figure that represents the expected expenditure for maintenance of real property (MRP). In fiscal years 1963 to 1971, Congress set the MRP floor to coincide with the expected maintenance expenditure for each of the services. Starting in 1972, Army and Air Force requested and received

floors substantially less than their planned expenditures. In 1975 and subsequent years, Navy and Marine Corps also requested and received floors below expected requirements. The result of these artificially low floors was to allow the services to once again divert funds planned and appropriated for maintenance of real property to operations. (9:6)

Starting in 1978, Congress increased both the floor and the appropriated funds for maintenance of real property. This was an attempt to stop the growth of BMAR, but it did not work. The 1978 backlog was set by Congress as a baseline not to be exceeded, but the 1979 BMAR was $193 million higher. As attempts to stop the growth failed, the Senate Committee on Appropriations asked the General Accounting Office to review DOD's backlog program. (10:29)

In August 1979, the General Accounting Office published a report title, "DOD's Real Property Maintenance and Repair Backlog"(LCD-79-314). It generally provided the historical view and trends of the BMAR. The scope of that report did not include many conclusions and recommendations, but the GAO did note that lack of adequate funds was the most frequently heard reason for the inability to reduce the BMAR. The report then raised the question of how can there be any hope of being able to maintain new facilities requested in every budget submission if the maintenance funds cannot maintain the present facilities. The one recommendation in the report concerned the level of management of the BMAR problem. It

noted that the problem was being treated as a service problem rather than a DOD level problem and recommended that DOD improve central control, priority setting, and monitoring. (9:40)

In Februaury 1981, the GAO published the final report in response to the Congressional request. It was titled, "Congress Cannot Rely on the Military Services' Reported Real Property Maintenance and Repair Backlog Data."(LCD-81-19) As can be detected from that title, the GAO did not feel that the BMAR had been brought under control. The largest concern was the fact that the individual services each had tneir own definition of BMAR and system of reporting the backlog. For several reasons the reported backlog fell very short of the actual backlog. In particular for the Air Force, the practice of reporting only the part of the real property deficiencies to be corrected by commercial contract while leaving out the in-house work was criticized. Further, the report noted that some commands and installations had, in violation of regulations, constrained the reported backlog, and in general the required inspections and cost estimates for correcting deficiencies were inadequate and resulted in understating the backlog. Once again, the main recommendation was for DOD to take a much more active role in the management of the BMAR. The general finding of the two reports is that there is a need for DOD level standardized definition of BMAR, DOD specified manageable level, and DOD

requirements for the services to improve their inspections and reporting.

While the Congress was attempting to find a method and proper amount of funding to control the BMAR, the DOD was working on the definition of BMAR. The definition is extremely critical because it can include or exclude various amounts of maintenance and repair in the BMAR. Small changes in the wording can make large changes in the amount reported as backlogged maintenance. Th. concern is to insure that what is reported is in fact that which DOD and Congress are really interested in.

In a DOD Instruction in 1960, the requirement was established for the services to report the costs incurred for real property maintenance activities. It also included a requirement to report the backlog of essential maintenance deferred. The definition of essential maintenance was given in DOD Instruction 4150.9 as:

> 1. The routine recurring work required to keep a facility (plant, building, structure, ground facilities, utilities systems, or any ral property) in such a condition that it may be continuously utilized at its original designated capacity and efficiency, for its intended purpose.
> 2. The restoration of a facility to a condition substantially equivalent to its original or designed capacity and efficiency by replacement, overhauling, or reprocessing of constituent parts or materials. (9:7)

The 1960 definition for essential maintenance was practically equivalent to the definitions of maintenance and repair. At that point, the only real requirement to be

included in the reported figure was that the work was deferred at fiscal year end. In 1963, the definition was changed to exclude work estimated at below $10,000 in order to make sure the reported work was readily identifiable. Also, essential was defined as impairing military readiness and capability. The new definition of essential maintenance was:

> Those items of maintenance and repair ... over $10,000 which cannot be accomplished during the current fiscal year due to lack of resources. An item is considered essential when delay for inclusion in a future program will impair the military readiness and capability, or will cause significant deterioration of real property facilities. (9:7)

In 1973, the definition for deferred essential maintenance was replaced by a definition for backlog of maintenance and repair. The 1973 definition deleted the $10,000 limit and the word essential. The 1973 definition of BMAR in DOD Istruction 4165.58 is still the current DOD definition:

> The backlog of maintenance and repair (BMAR) is the end of fiscal year measurement of maintenance and repair work remaining as a firm requirement of the installation work plans ... but which lack of resources prohibit accomplishment in that fiscal year.

The Air Force uses a different definition for the BMAR. The primary differences between the Air Force and the Department of Defense definitions are that Air Force constrains the BMAR to be only that work planned to be done by contract, and that Air Force constrains the resource that caused the deferral to be funds. Under the DOD definition,

manpower could be the resource which was lacking, and the work could be counted as BMAR. The Air Force definition of BMAR is:

> The backlog of maintenance and repair means maintenance and repair projects (by contract) scheduled to be done in a previous fiscal year, but deferred because of lack of funds. (12:p.2-1)

Justification for Study

This thesis was started in response to a request from the Engineering and Services Directorate of the Air Force Logistics Command for a model to estimate BMAR. In addition to the request, the apparently out-of-control growth of the BMAR is in itself worthy of study. Descartes said, "The end of study should be to direct the mind towards the enunciation of sound and correct judgments on all matters that come before it (2:1)." Any process that has the importance of the BMAR should be understood fully enough to be able to effectively manage it, and it appears that the understanding of the growth process is not at that stage which permits sound and correct judgments.

Research Objective

The objective of this thesis was to examine the Air Force system of tracking and reporting the backlog of maintenance and repair in order to find its weaknesses. The overall goal was to offer some insight into the management of the backlog level and the capability to estimate the future backlog dependent on spending levels.

Research Questions

In order to achieve the objective of analyzing the present process which results in the BMAR level, two research questions were answered:

1. What affects the year-end level of the backlog?
2. What is being done at MAJCOM level to control BMAR?

Scope and Limitations of Study

The primary scope of the study was restricted to the Air Force BMAR. The DOD definition of BMAR was examined in order to set the context for the Air Force definition and procedures. Occasionally, a DOD, Congressional, or GAO view of BMAR was considered. This study attempted to analyze the Air Force BMAR from several aspects, including the viewpoints of those outside agencies.

The primary limitation to the study was a lack of current information concerning maintenance of real property in general. The original scope was to include a mathematical model to predict the dollar value of the BMAR. During the literature review, it became apparent that very little has been written in relation to MRP. One source called maintenance "one of the least 'glamorous' topics in operations management (1:657)." This dearth of information led to scoping down the thesis.

The author had expected to find some examples of validated models being used by industry to program their annual MRP budgets. Having not found any already validated models, an attempt to originate one was made. The original concept was to devise a model based on depreciation techniques from accounting practice, with possible inputs such as total area of facilities on a base, construction type, and age of facilities.

In attempting to build a predictive model for the year-end level of BMAR, a search for factors that influence the backlog was conducted. This led to tracking the process whereby the BMAR total is calculated each year. The process is sufficiently complicated to benefit from having a visual diagram model which describes the inputs, controls, and outputs.

The final scope of this thesis was to describe the present system used by the Air Force in a manner that is both easily understood and sufficiently detailed to see the interrelations of the actions relating to the BMAR. Combining that model with the responses from the major commands was intended to give a full understanding of the process and to demonstrate where the weaknesses are. The final chapter presents conclusions and recommendations concerning the existing methods and possible improvements.

CHAPTER 2

METHODOLOGY

In order to achieve the objective of analyzing the present process which results in the BMAR level, two research questions were addressed:

1. What affects the year-end level of the backlog?
2. What is being done at MAJCOM level to control BMAR?

A literature review (chapter one) was performed to provide a background in maintenance planning in general and in management of the BMAR in particular. A mostly unsuccessful search was made through business and real estate journals looking for techniques to estimate required funds for maintenance and repair of real property facilities. Several computer searches made by the Defense Technical Information Center (DTIC) resulted only in two GAO reports and two theses done from the Navy and Marines viewpoints. The information from the GAO reports form the primary part of the background and history portion of this thesis. The information for the systems analysis chapter came from AFR 85-1, AFR 86-1, and personal experience.

To answer the first research question, a full, detailed descriptive model was designed using the systems analysis hierarchy plus input-process-output modeling technique. This technique and its applications are detailed in chapter three. Systems analysis allows complete understanding of the entire BMAR process and all interactions between actions

related to the BMAR. After the discussion of each of the inputs, outputs, controls, mechanisms, and interactions, potential weaknesses in the present system were pointed out in the conclusions chapter.

The second research question was answered by requesting information from each of the major command's Deputy Chief of Staff for Engineering and Services. A letter was sent to ten commands (see Appendix B) requesting any techniques and justifications used to present their annual budgets for contract maintenance and repair. The request for information was made intentionally vague to prevent the question from guiding the responses. The intent was to insure that anything related to their annual budgeting for BMAR was included in their answers. After receiving the responses, a search for common ideas or for innovative ideas was made. The techniques and ideas offered by the commands were discussed in chapter four.

CHAPTER 3

SYSTEMS ANALYSIS

Overview

Model Explanation. A variation of the systems analysis charting technique known as hierarchy plus input-process-output was used to better understand the process that determines the level of the backlog on maintenance and repair. The particular variation used is called the activity diagram in the ICAM Definition Method (IDEF) designed by SofTech, Inc. under contract with the Air Force Materials Laboratory. (7:p.2-2) The activity diagram is a structured modeling technique that facilitates understanding a system and communicating how the various sub-systems interact.

A system can be defined as "a network of interrelated procedures that are joined together to perform an activity or to accomplish a specific objective (3:5)." A procedure is further defined as:

> A precise series of step-by-step instructions that explain
> 1. What is to be done.
> 2. Who will do it.
> 3. When it will be done.
> 4. How it will be done. (3:5)

The objective was to analyze the "network of interrelated procedures" in such a way as to lead to a thorough understanding of the BMAR and to be able to find an effective method of managing the backlog level. The input-process-output (IPO) concept is beneficial in achieving this objective.

The basic IPO module is a processor that takes one or more inputs, possibly transforms them, and outputs some results (see Figure 2). A common addition to this structured analysis technique is the control, a condition or circumstance that governs the transformation. (5:29) The variation used by IDEF is to add the mechanism, the person or device which carries out the activity. (7:p.2-4)

The entire system can usually be broken down into sub-systems, which might be broken down into even smaller sub-systems. These sub-systems could then be viewed as making up the original system. This is the hierarchy aspect of the hierarchy plus input-process-output model. (see Figure 3) Each level down depicts increasing detail, while each level up represents a more overall view of the system. The detail boxes can be thought of as fitting inside the parent boxes. In this way, the system can be modeled to any desired degree of detail.

BMAR Model. The entire system that results in the Air Force year-end BMAR total for an individual base is modeled in Figure 4. It shows all the inputs, controls, mechanisms, and outputs. The overall system is best described as the civil engineering planning, programming, and budgeting process. Figure 5 is the decomposed model with three separate processes demonstrated. Figures 6 through 8 are just larger views of the three sub-systems. A discussion of the system and sub-systems follows.

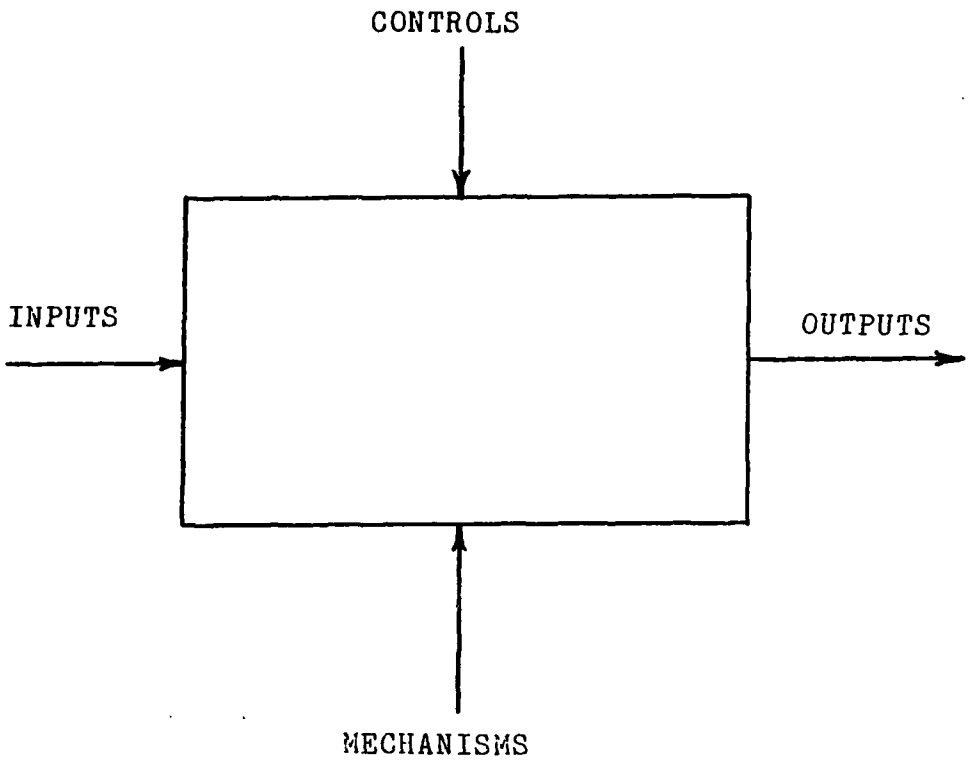


FIGURE 2

INPUT-PROCESS-OUTPUT

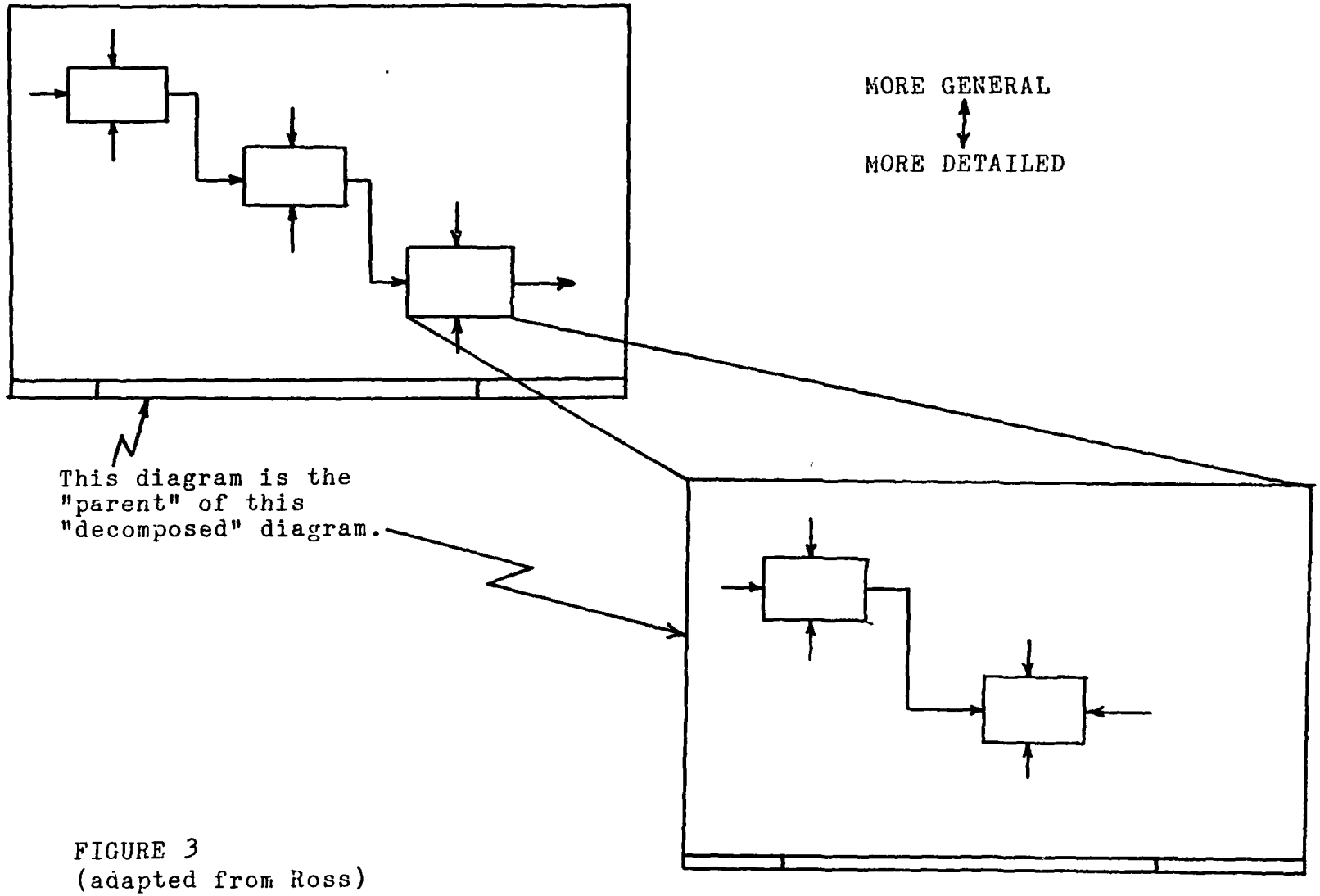


FIGURE 3
(adapted from Ross)
HIERARCHY

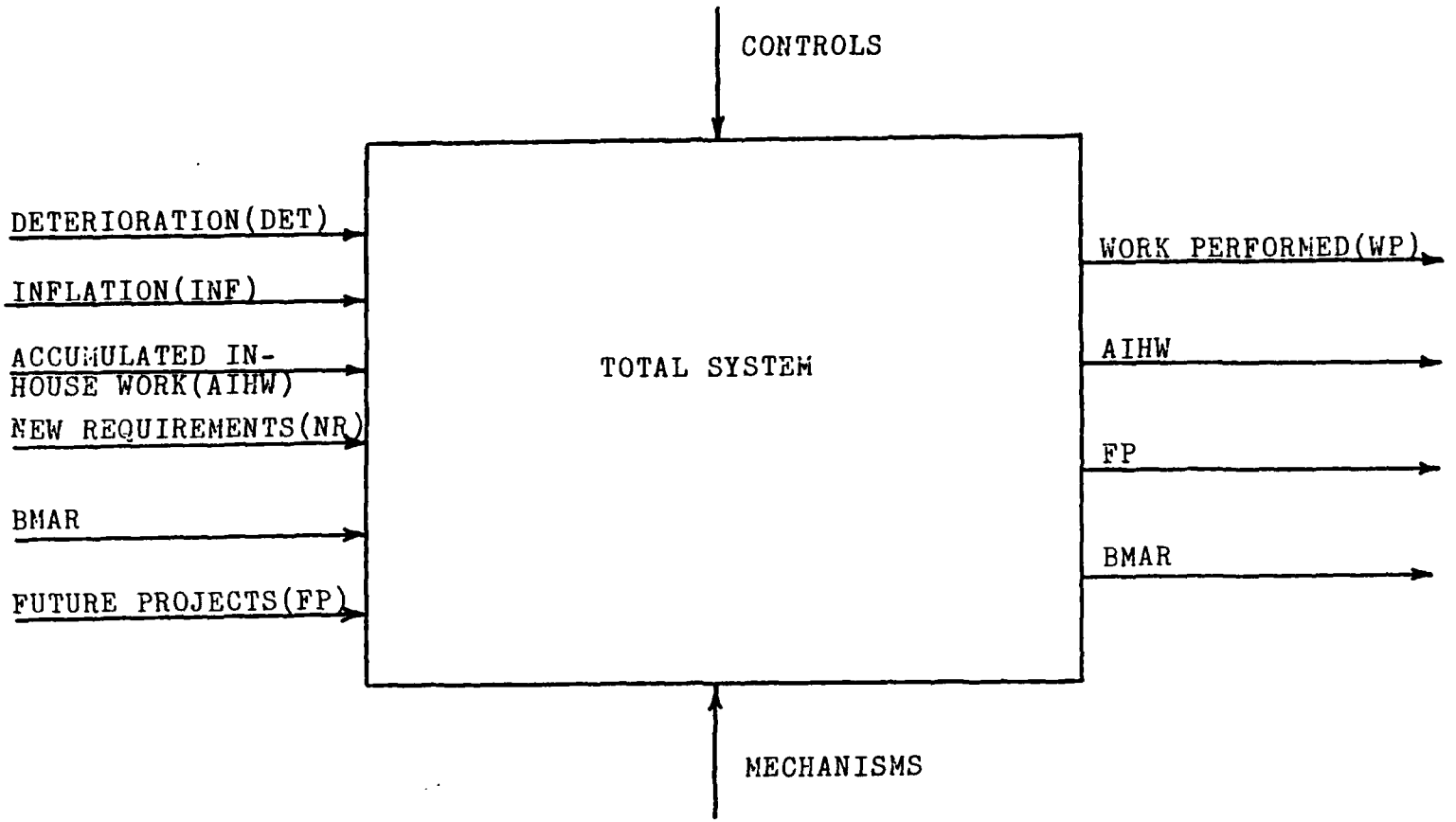


FIGURE 4

TOTAL SYSTEM

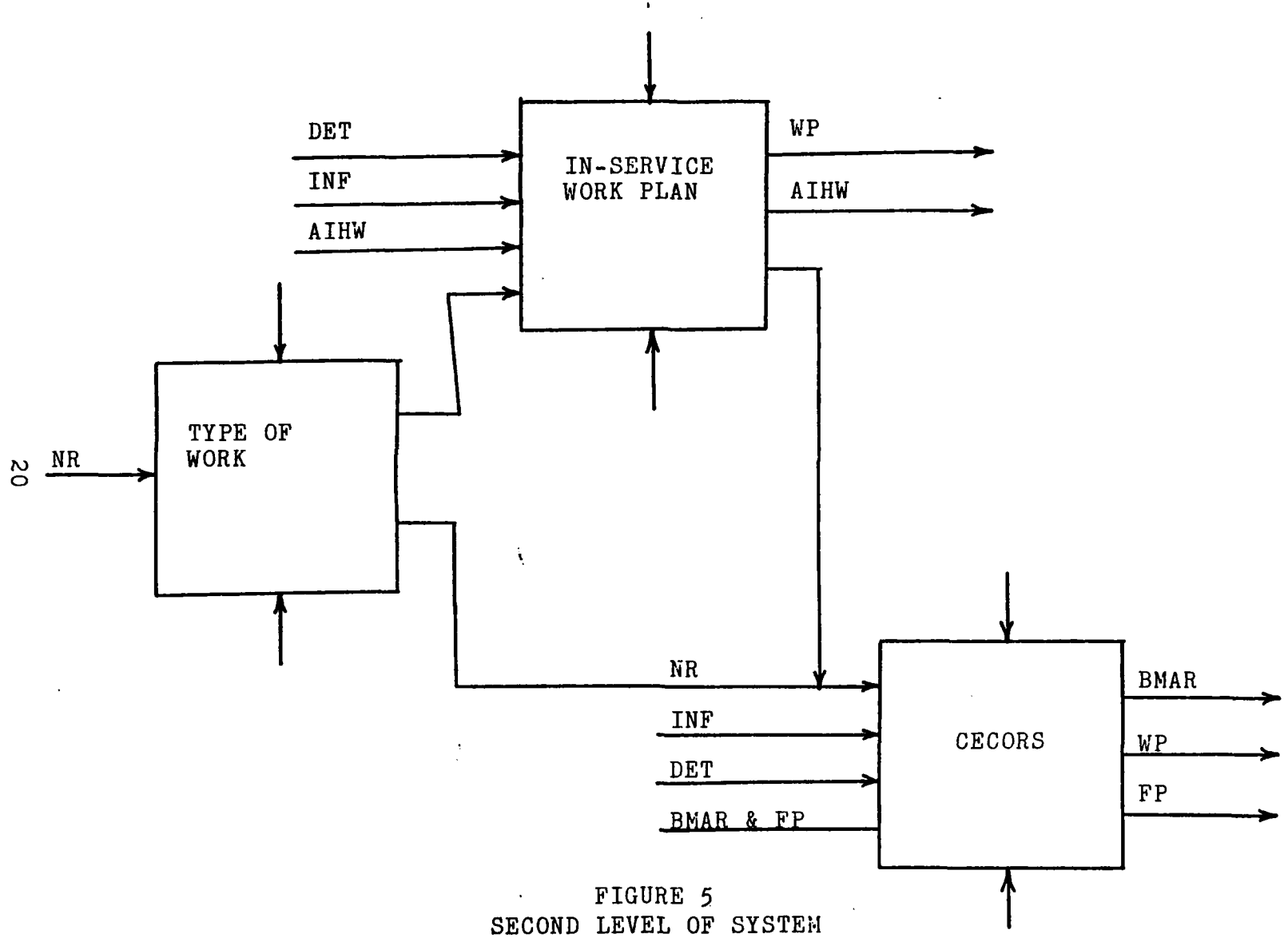


FIGURE 5
SECOND LEVEL OF SYSTEM

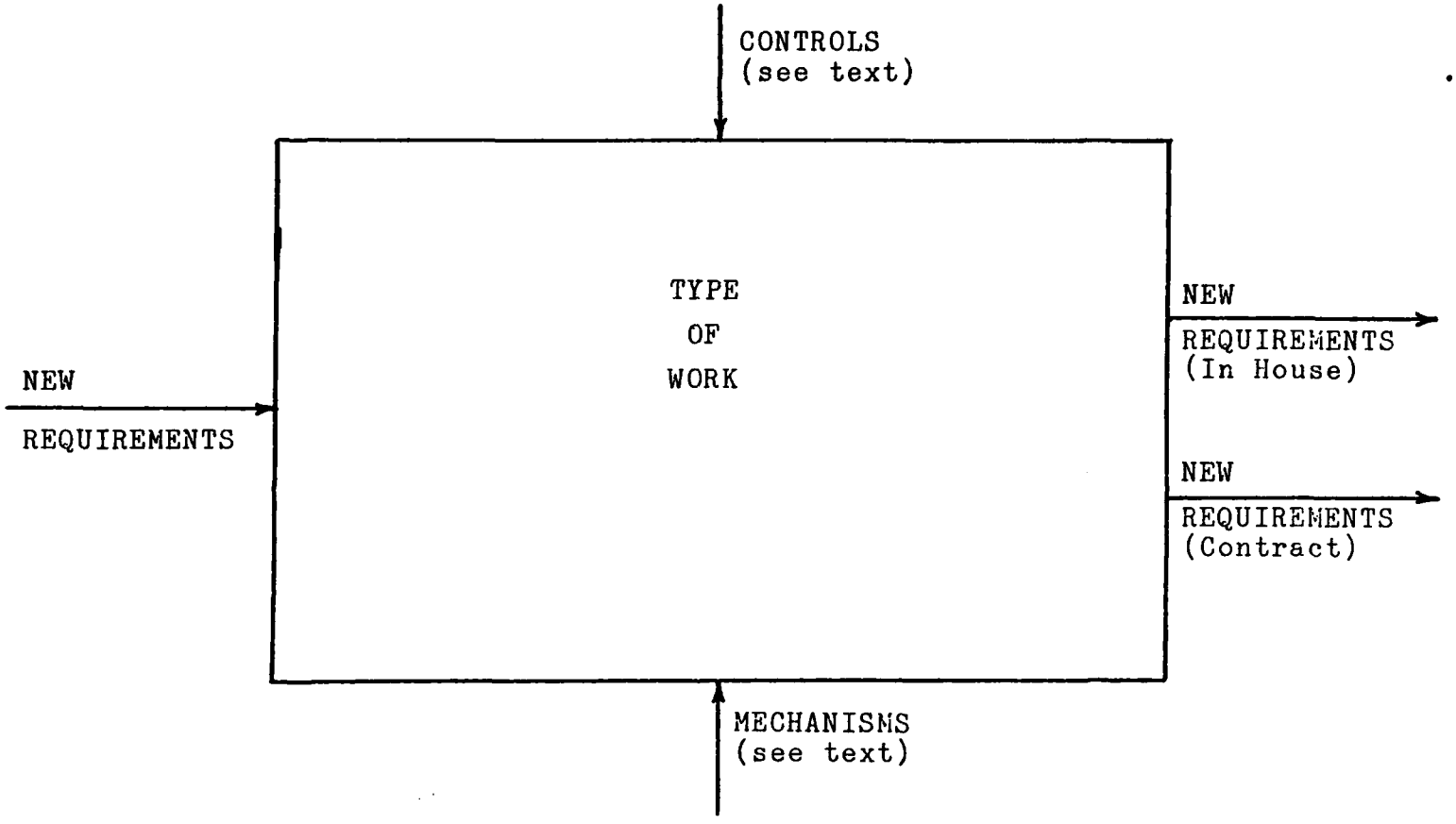


FIGURE 6
TYPE OF WORK

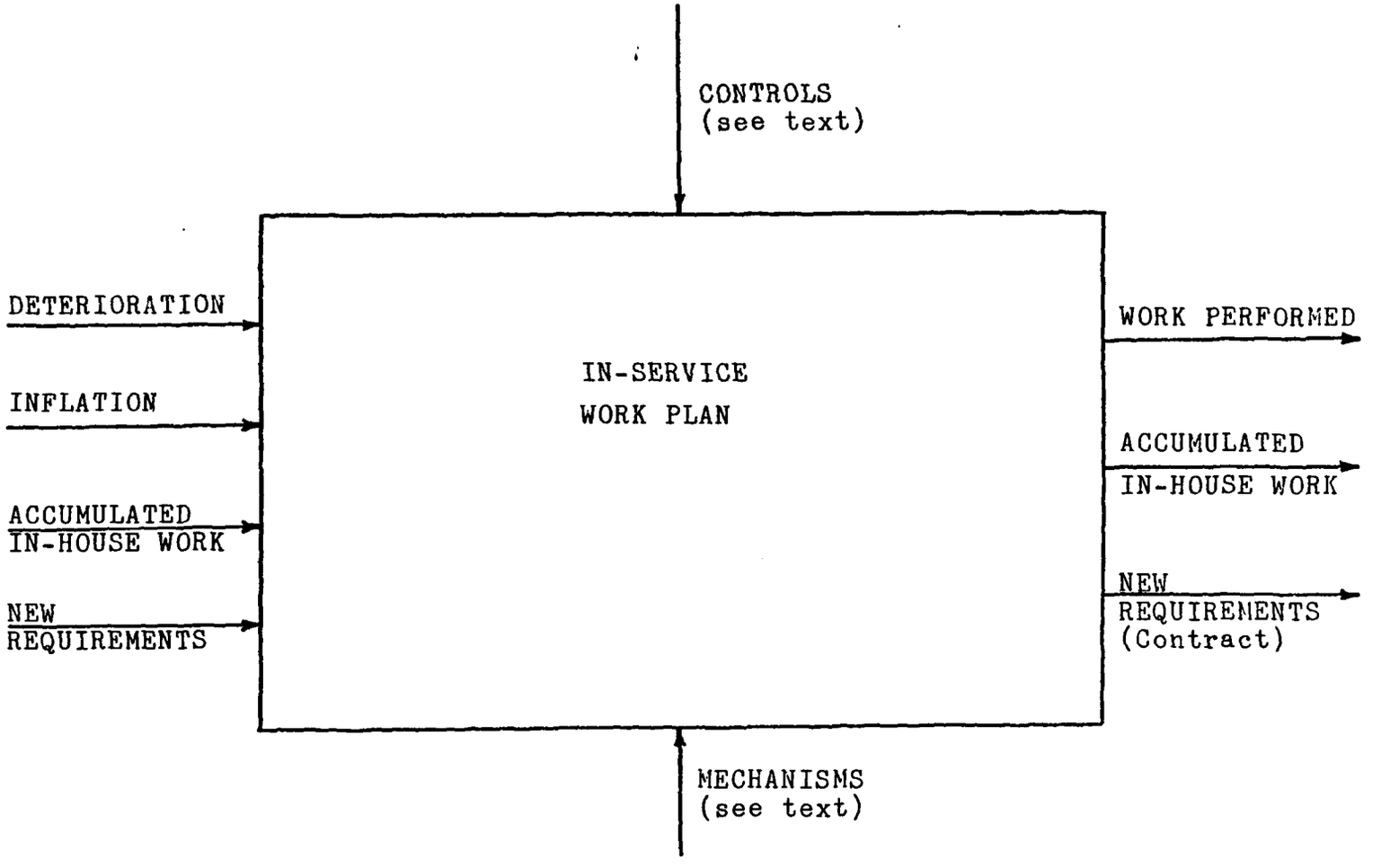


FIGURE 7
IN-SERVICE WORK PLAN

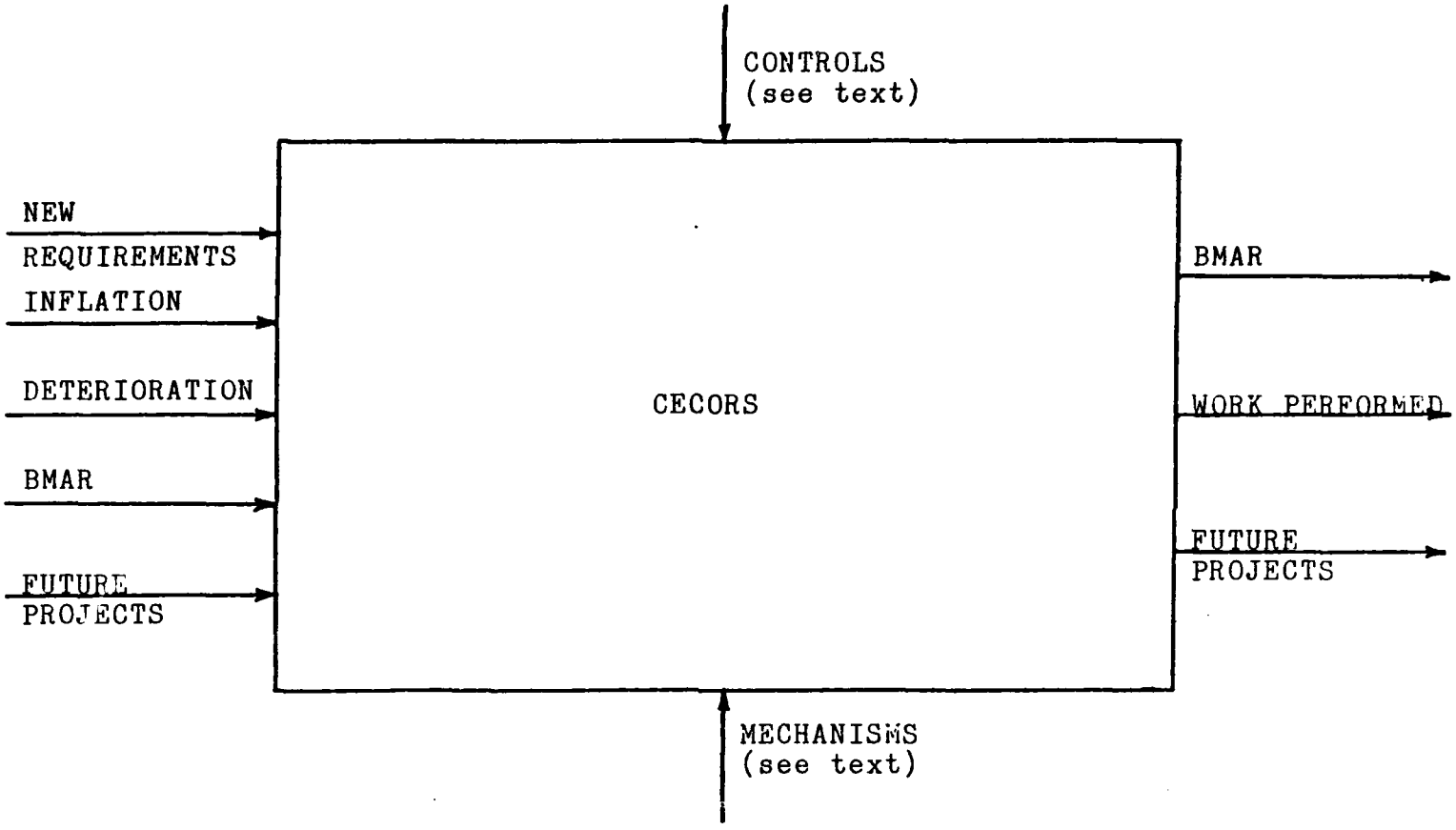


FIGURE 8
CECORS

The process labeled "type of work" stands for the decision making process whether an individual job will be accomplished in-house or by contract. One of the outputs of that box becomes an input for the process called "in-service work plan", which represents the scheduling of the in-house forces. The other output of the "type of work" sub-system becomes an input to the process labeled "CECORS", which represents the programming of projects to be accomplished by contract. The various sub-system parts and interactions will be discussed in detail in the rest of this chapter.

Inputs

All the inputs to the entire model will be discussed in this section rather than trying to list them with separate processes because some overlap and repetition would be involved in breaking the discussion into sub-system sections. Reference should be made to Figures 4 through 8 throughout the description of the model.

New Requirements. Probably the most complex input to the model is the new requirements. It is an input to the "type of work" sub-system and represents all the many ways that a new requirement for work can be made known to the civil engineering function at an installation. These might be service calls, work requests on AF Forms 332 or 1135, SMART inspections, or periodic facility inspections performed by civil engineering personnel.

A large number of these new requirements are either disapproved early or approved as job orders and the work is performed by the CE work forces. Those requirements do not affect the BMAR system being examined here, and therefore do not become a part of the model. The new requirements of most interest here are those that will have to be accomplished eventually by work order or contract. Those would normally be minor construction or larger maintenance and repair jobs.

The new requirements will be input into the "type of work" sub-system for the decision to be made on whether to do the job in-house or by contract. More will be said about this decision in later sections. The inputs to the IWP and CECORS sub-systems are the new requirements that have been approved and need to be programmed, either for in-house or by contract.

Accumulated In-house Work. At the beginning of a fiscal year, a base will have accumulated approved work orders that have not yet been accomplished. Some of these will be on the immediate schedule while others might not be programmed for some time. This accumulated in-house work is being carried over from one year to the next. The accumulated work and the new requirements that occur during the year are the inputs to the in-house work sub-system. The total of both would represent all the operations and maintenance work that the civil engineering forces are eligible to do in the fiscal

year.

Old BMAR. As stated before, the BMAR is the backlog of maintenance and repair, that is, required work that has not been accomplished at the end of the programmed fiscal year. As such, it is still a valid requirement for work to be accomplished in the new fiscal year. It becomes an input to the CECORS process that attempts to program the contract projects during the year.

Programmed Projects. The CECORS data file includes all facility projects-by-contract, validated for accomplishment in the current fiscal year and the following six future fiscal years plus prior fiscal year projects that are still active (13:para.14-4b). The projects that are known and planned for accomplishment in the new fiscal year become an input to the by-contract process. Whether or not they are accomplished in that fiscal year will determine the output with which they are associated. It is also possible that some projects planned for a future year will be accomplished in the current fiscal year instead. That might happen due to excess contracting funds, being designed out-of-sequence and completed prior to planned current year projects, or increasing priority to be accomplished earlier than some others.

For whatever reason, projects carried in the CECORS as programmed projects might enter the by-contract process in the new fiscal year, therefore it is shown as an input to the sub-system labeled CECORS. Even if the projects listed in the CECORS at the start of the year are not accomplished, they would still be inputs to the programming process that might end up as any of the several different outputs of the sub-system.

Inflation. The author chose to show inflation as an input to the programming processes. It could have been depicted as a process occurring at year-end to both the accumulated in-house work and the BMAR. It seemed to keep the model simpler and more understandable to treat it as an input. It represents the effect inflation has on the work that has accumulated from one year to the next. Inflation more often affects the contracting type of work. A project that is listed as a requirement in one year but not accomplished will increase in dollar cost to perform the same work. This becomes a real problem for projects that are designed but not accomplished for several years. The cost estimates that are listed in the project folder and on the CECORS listing have to be updated periodically or stand the risk of underestimating the required funds to perform the work.

Deterioration. Deterioration is very similar to the inflation input described in the previous section. Deterioration is the change in the scope of the required work due to not being done when originally required, but inflation is a change in dollar cost for the same scope of work. Any maintenance and repair work required on structural items of real property is especially prone to deteriorate if not repaired in time. For instance, a roof repair that is postponed from one year to the next will very likely require more work the second year than if it was repaired when first identified as a requirement.

Deterioration and inflation both tend to increase the dollar cost of maintenance and repair work that is backlogged. Both effects might be felt on work order size jobs, but can be very large inputs to the dollar figures associated with backlogged projects of the size usually involved in contracts.

Processes

Type of Work. The type of work sub-system represents the process involved from receipt of a new requirement to submission to the in-service work plan or the CECORS data file. This includes many of the functions of the Customer Service Unit and the Resources and Requirements Section of the civil engineering unit. It also includes the approval processes for all the types of work involved.

The personnel in the Customer Service Unit check each service call, work request (AF Form 332), and maintenance and repair request (AF Form 1135) to insure that the requested work is within the scope of civil engineering work. If the requested work cannot be accomplished for some legal or regulatory reason, it is disapproved and returned to the requestor. In that case, the requested work is never really a new requirement, and therefore does not enter the programming system at all.

If the work can be accomplished, a decision is made at this point whether it will be accomplished by job order, work order, or contract. Usually, a job order is work that requires no planning or a special materials requistion. The job order is sent to the shop (possibly through a scheduler or controller) and is accomplished. Technically, the job never enters the in-service work plan, but it is convenient to treat job orders similarly to the work orders for this model. If the work is to be done by work order, the document (AF Form 327) is prepared and circulated for approval or disapproval. The exact routing for approval varies depending on the type of work and the estimated cost to perform the work. Various personnel (e.g. Base Civil Engineer or Base Commander) have approval levels which they are able to authorize, or the work might require approval of the Base Facilities Board. For this model, it does not make any difference who approves the work order. The only point

of interest here is the fact that it enters the system as an approved new requirement.

In addition to the job orders and work orders, the work might have to be done by contract. If so, it has a different system of tracking the work, approving the requirement as valid, and finally approving and funding the contract for the work. A project folder is prepared, and several forms in the 1392 series are filled out. Generally, the project must be approved by the Facilities Board and, possibly, by the major command responsible for the base. However, the new requirement will be entered into the CECORS data file before approval of the work. In fact, the new requirement is often recognized and entered into the system several years before the work is needed.

In-service Work Plan. The in-service work plan sub-system represents the programming and scheduling of all the work to be accomplished by the civil engineering operations and maintenance personnel. As noted in the last section, some of the work is done by job order, and there is very little programming involved. The job goes almost directly to the craftsmen, and the work is completed very quickly.

Work orders, on the other hand, might be in planning, material procurement, and programming stages for many months. In the planning section, the planner determines the best way to fulfill the new requirement, calculates an estimate of the cost, and provides a list of the required materials to do the

work. The materials are ordered through the Material Control Section and Base Supply. When all the required materials are in the warehouse, the work order is scheduled into the in-service work plan. Often, this scheduling process occurs several months ahead of the time the work is actually performed.

Instead of the work being accomplished by the civil engineering personnel, occasionally, the requirement turns out to be beyond the ability or time limitations of the in-house forces. The work order might then be changed to a project and be programmed through the CECORS sub-system. Another possibility is combining two or more work orders into a project to be performed by contract. This possibility is represented in the model by the output line running from the IWP sub-system box to the new requirements input line for the CECORS sub-system (see Figure 5). It is this capability that Air Force relies upon to insure that the accumulated in-house work does not become a significant factor when trying to track the backlogged maintenance and repair. The fact that the accumulated in-house work did not show up in the BMAR totals was one criticism by the GAO of the Air Force system of tracking and reporting BMAR (10:10). The Air Force response to the GAO hinged on this combining of work orders in projects if the backlog of in-house work grew too large.

CECORS. The CECORS sub-system represents the processes involved with new requirements that will be accomplished by contract. These processes include project validation, project approval, funding, and maintaining the CECORS data file. The CECORS data file might include many requirements that are not of interest in determining the year-end BMAR total. It will include all facility projects-by-contract and all maintenance, repair, and minor construction projects identified to be accomplished by RED HORSE or Prime BEEF forces. It might also include service contracts, in-service work projects, non-appropriated fund projects, military family housing projects, and Military Construction Projects. (13:3)

The new requirement is recognized, and the documents required for validation are prepared. These might be limited to essential information such as work description, cost and scope of the project and basis for the requirement. The Base Facilities Board validates the project, and the full set of project documents are prepared. The information on the project might be included in the CECORS data file before validation, but it must be included after validation.

The base CECORS data file is combined with other bases' files until eventually there is a master list at the Air Force level. This list is a major justification for the annual budget request for the operations and maintenance funds for the Air Force. The funds appropriated by Congress

are then allocated down through the various layers of command to be applied against the requirements. The appropriation does not approve individual projects as line items as the appropriation for the Military Construction Program does.

Each entry in the CECORS data file has a fiscal year data element that identifies the year in which the project is programmed by the Facilities Board to be accomplished. At the end of each fiscal year, all the projects that should have been accomplished but have not (for any reason) are totaled. This total is the reported BMAR figure.

Controls

The controls that regulate all the sub-systems come from many places. The predominant controls are found in AFR 85-1, AFR 86-1, AFR 86-7, policy letters, and budget documents. These controls include the legal and regulatory restrictions on what types of work can be accomplished by civil engineering personnel, the various approval limitations for work orders and projects, and policy guidance from superior levels of command.

Mechanisms

The mechanisms in the systems model are the people and tools that carry out the procedures. In this case, the mechanism for the "type of work" sub-system is primarily the Customer Service Unit of the Operations and Maintenance Branch of the civil engineering unit. It is the people and

standard procedures of the CSU that determine if the new requirement is inputted to the IWP sub-system or the CECORS sub-system. The mechanism for the IWP sub-system is primarily the Chief of Work Control and the schedulers and controllers that maintain control over the CE Operations and Maintenance work force. The primary mechanisms for the CECORS sub-system are the project programmer, the Design Section of the civil engineering unit, and the Base Facilities Board.

Outputs

Work Performed. Work performed is an output of two of the sub-systems. As an output of the IWP sub-system, it represents all the job orders and work orders accomplished throughout the fiscal year. As an output of the CECORS sub-system, work performed is the contracts started in the fiscal year. The two outputs together would constitute all the operations and maintenance work done on the base during the year. In each case, work performed would be the end product that the new requirement input originally set out to accomplish.

Accumulated In-house Work. This output has been mentioned previously, and it represents the amount of operations and maintenance work still somewhere in the IWP sub-system at the end of the fiscal year. This work is not necessarily overdue under the limitations used by civil engineering. It might be

in planning, material control, scheduling, or approval stages. It is work that is a valid requirement and that needed to be done in the fiscal year, but under the Air Force definition of BMAR, it does not count as BMAR since it is planned to be performed by in-house forces rather than by contract. This output becomes an input for the succeeding year's IWP sub-system.

Future Projects. The CECORS data file has the projects for the current fiscal year, all previous fiscal years (BMAR), and projects that are known for the succeeding six fiscal years. The projects for the succeeding years are the output labeled future projects. As an example, in fiscal year 1983, projects that are planned to be accomplished in fiscal years 1984 through 1989 might be listed in the CECORS data file. In 1984, those projects would be the future (or programmed) projects input to the CECORS sub-system. Those projects accomplished during the year become the work performed output. Those planned for 1984 and not accomplished are combined with any BMAR from 1983. Those planned for 1985 through 1989 and not accomplished are added to the new requirements to become the future projects output and, subsequently, the future projects input to the 1985 system.

BMAR. The BMAR output is the topic that has been discussed throughout the thesis. This output is the main purpose behind the entire model. The BMAR output is the

total of those projects planned to be accomplished by contract in the fiscal year just ending or any previous fiscal years and not accomplished by the end of that year. The BMAR, like the accumulated in-house work and future project outputs, become inputs to the system for the succeeding year.

Total System

The total system represents the planning, programming, and scheduling of operations and maintenance work by the civil engineering unit for a fiscal year, both by in-house forces and by contract. The system accepts new requirements from many sources and processes them into job orders, work orders, and projects so they may be accomplished. In addition to the new requirements, there is usually some planned work left over from previous years. The leftover work may need to be adjusted in scope due to deterioration that has happened since the original requirement was recognized, or the cost may need to be adjusted for inflation and change in scope.

The system accepts the inputs and processes them in accordance with several controlling guidelines, the most important being AFR 85-1 and AFR 86-1. The mechanisms of the system represent the personnel involved in accepting, approving, planning, and performing the work. The results of the mechanisms transforming the inputs in accordance with the controls are the output. One of the main goals of civil

engineering is the work performed in support of the base mission (14:2). The other outputs, accumulated in-house work, future projects, and BMAR, are tools used by civil engineering personnel to help effectively accomplish work planning and performing.

The BMAR, considered the indicator of adequate funding of maintenance and repair, is just one output of the entire system. To predict what the year-end BMAR will be for a base or a command involves also knowing or predicting all the other inputs and outputs. Even if one knew exactly how much maintenance and repair would be required for all the facilities on an Air Force base in one year, the BMAR would still depend heavily on how much work is accomplished during the year by in-house and contract, how much work is in the accumulated in-house work sections, and how the inflation and deterioration factors would affect the old BMAR and the old accumulated work.

CHAPTER 4

RESPONSE REVIEW

An example of the letter sent to the Deputy Chief of Staff for Engineering and Services in each of the ten major commands is included as Appendix B. The letter asked in very general terms for any techniques and justifications used to present their annual budgets for contract maintenance and repair. The request was worded generally in order to prompt as many comments as possible from each command. A specific question might have been answered by saying, "BMAR is found by looking in the CECORS report."

Responses were received from eight of the ten commands. Not unexpectedly, the responses ranged from very short to fairly long discussions of the problems that have to be faced in accurately representing the BMAR. The rest of this chapter summarizes the responses and forms part of the background for the conclusions chapter.

A common observation in the command responses was that the funds for maintenance and repair of facilities are often used as the flexible part of the O&M appropriation. Although the funds allocated each year for maintenance and repair of facilities must total at least the amount of the congressionally mandated spending floor, the variability in funds to be actually obligated in the fiscal year would make realistic and accurate planning very difficult. Four of the eight commands mentioned this flexibility aspect in one form

or another.

> Because the only flex in the SAC O&M funding is in the 12 percent/RPMA reserve maintained to cover the command's supplies and faciliy projects, frequently it becomes the source of funds for shortfalls elsewhere in the account. (4:1)

> Anticipated funding- Fitting the largest amount possible into Part I for facility maintenance and repair without degrading other command programs. (15:1)

> In most cases, funds for facility projects are held until all other "must pay" items are funded. Bases benefit at year end if there is a windfall of funds that cannot be obligated. These funds generally go toward facility projects and BMAR. (6:1)

> Ability of MAC bases to have projects designed and ready to use year-end "fall-out" funds migrating from within or outside MAC. (8:1)

This flexibility of funding would not seem to have a great effect on the BMAR since the amount actually spent on maintenance and repair each year exceeded the amount planned to be spent 1965 through at least 1978(9:41). This indicates that the funding is not being shorted due to the flexibility problem since the funding is as large as the expected funding. It just introduces a very large uncertainty into any planning toward when particular projects will be obligated.

Two of the commands mentioned they used teams to help their individual bases. Command teams consisted of personnel from the command going to the bases, validating the planned work, and helping prioritize the projects. This is a management tool used by command to insure that the projects

in the CECORS data base have the proper priority and planned accomplishment years in relation to all other required work.

The response from one command stated that the growth of BMAR is not caused by poor methods of estimating the BMAR but rather, the lack of funding. The next paragraph noted that there has been considerable growth in the BMAR in that command in recent years because the bases have made conscientious efforts to identify and validate requirements. It further said the previous artificial curtailment of BMAR was lifted to allow a more accurate statement of work required.

The response from Headquarters, Pacific Air Forces had two specific recommendations for improving the reporting of BMAR.

> The techniques could be improved by standardizing the definition of BMAR worldwide. BMAR should include only essential maintenance and repair ... Maintenance that can be deferred should not be classified as BMAR.
>
> We require better methods of assuring that funding intended for facility projects in the President's budget is in fact expended on facility projects. Possible ways to accomplish this may be in fencing these funds, raising the real property maintenance floor or providing specific direction against reprogramming these funds. (15:1)

Two commands noted difficulties with tracking, reporting, and funding backlogged maintenance and repair projects that are funded from appropriations other than the operations and maintenance one. The Military Airlift Command stated that Airlift Support Industrial Funds (ASIF) are made available for passenger and freight terminals, select command

posts, and aircraft maintenance facilities. The Air Force Systems Command pointed out that the majority of their bases use RDT&E funds for facility projects. In both cases, the actual backlog for those projects would not be included in the totals from the CECORS reports forwarded to Headquarter, Air Force.

The response from MAC also remarked that MAC methods to manage the BMAR are not independent, fixed procedures. They are affected by several outside factors: HQ USAF, SAF, OSD, OMB, and Congressional budget decisions which limit, reduce, or increase funding regardless of major command budget requests. This is one more point that makes any long range planning for the maintenance and repair projects very difficult to do at any level.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

First Research Question

The first research question was, "What affects the year-end level of the backlog?" The first thing that affects the BMAR level is the BMAR definition. The definitions of BMAR have some problems.

The foremost conclusion is that Air Force (and all the services) must have the same definition and interpretation of BMAR. Under the present system, Air Force totals the maintenance and repair facility projects-by-contract scheduled to be done in a previous year, but deferred because of lack of funds. The DOD takes the BMAR figure and says this is the measurement of maintenance and repair work remaining as a firm requirement of the installation work plans but which lack of resources prohibit accomplishment.

There are breakdowns in communication anytime that the parties involved do not agree on the meaning of the words being used. While the differences that arise from Air Force's constraints concerning contracts and lack of funds might not be large, they still exist. The GAO pointed out the problem in their 1979 report. There has been no solution to the problem by 1983. The author's conclusion was that neither DOD nor Air Force has been effective in solving this basic problem in the BMAR system.

Using the present Air Force system, a requirement for some real property maintenance or repair can be recognized. If the requirement is something that needs to be done but is not time-critical or mission essential, it still will be validated by the Facilities Board, and a year for accomplishment will be selected. For example, if 1985 were selected as the projected year for accomplishment, the project would be given an 85- project number and be entered into CECORS. If, in 1985, there are only enough funds to contract for time-critical and mission essential work, the project will not be done and will become part of the BMAR at the end of 1985. In future years then, the Facilities Board will be faced with decisions on whether to allocate funds to the non-critical project in BMAR or critical projects not in BMAR. This can result in either setting the priority on the non-critical project higher than critical projects, or it can result in the project remaining in BMAR for years.

Until 1973, the DOD definition of BMAR only called for essential maintenance and repair to be included. The Navy still includes only deferrable work (10:7). PACAF recommended that only essential maintenance and repair be included in BMAR. It is the author's conclusion that including deferrable (non-essential) work in the BMAR figure both distorts the figure and applies unrealistic pressure on the decision makers.

The year-end BMAR figure is also affected by the entire system as depicted in Chapter 3. Fixing the definition would require fixing some problems in the system. It must be recognized that the personnel involved will not always work the system exactly as required by regulation. There were comments in the GAO reports and one comment in one of the command responses relating to managerial, administrative curtailment on BMAR levels. There is enough flexibility in the system to allow artificially setting the BMAR total to any desired level. The solution is to keep checks and balances in the system to insure the total is accurate.

Second Research Question

The second research question was, "What is being done at MAJCOM level to control BMAR?" This question is more difficult to answer definitively. Letters were sent to ten MAJCOM DCS for Engineering and Services. Eight responses were received. Out of the eight, four just described the system as it is required be Air Force regulations. The other four gave more insight into techniques and management tools being used that are not required by regulation.

The responses from SAC and MAC mentioned MAJCOM validation assistance. This is a check and balance to insure the BMAR figure is accurate. It helps keep the interpretation of priorities constant across the command. Two responses also mentioned attempting to spend 85% to 90% of the O&M contract funds for the maintenance and repair

projects. Those were the only specific things being done to control the BMAR that were listed in the responses.

General Conclusions

The author's conclusion concerning the system used to identify and report the BMAR is that it is good as it is described in the regulations. There needs to be more standardization in interpretation of BMAR across commands and services. The problem of the accumulated in-house work being separate from BMAR would be fixed by a change in definition. The next biggest hurdle in predicting the BMAR is the flexibility at base level in determining requirements to be documented and validated and flexibility in listing the projected accomplishment year. These flexibilities are undoubtedly required in order to be able to properly manage the O&M funds.

Flexibility to manage effectively can be detrimental to predictability. Less flexible (more deterministic) systems have more predictable outputs. Every point in a system where someone is given the opportunity to affect the output increases the problem of knowing in advance what the total output will be. Some reasonable balance between management flexibility and firm system requirements must be found. The author concluded that DOD, Air Force, and the MAJCOMs have decentralized the MRP management too much to be able to control BMAR.

Recommendations

Again, the strongest recommendation is that DOD, the services, the commands, and the bases must have a consistent definition and consistent interpretation of the definition of BMAR. Without it, there will be no credibility in the BMAR figure.

To try to balance manageability and predictability, there should be two BMAR figures. One would be essential BMAR, and the other would be total BMAR. With the computerization of programmed work (CECORS in the Air Force), breaking the BMAR into categories would entail small changes. The computer programs that extract and combine totals from base level data bases would require minor modification to handle two totals. Each base Facility Board would have to code each backlogged project essential or non-essential, and different codes would have to be used in the data base.

The author's recommended definitions are:

> The backlog of maintenance and repair, essential (BMARE) is the end of fiscal year measurement of essential maintenance and repair work remaining as a past requirement, but which lack of resources prohibited accomplishment in that fiscal year. An item is considered essential when delay for inclusion in a future program will impair the military readiness and capability, or will cause significant deterioration of real property facilities.
>
> The backlog of maintenance and repair, total (BMART) is the end of fiscal year measurement of all maintenance and repair work remaining as a past requirement, but which lack of resources prohibited accomplishment in that fiscal year.

A further recommendation is that anytime a base Facilities Board approves obligating a project that is not BMARE while that base has BMARE, the base should be required to justifiy their decision to command in writing. This would be somewhat similar to the extra justification required for P-341 projects. This policy leaves most of the control at base level, but adds a check.

The two figures BMARE and BMART would then be easily visible brackets to the funding required for MRP at any level. A funding level below BMARE would indicate a willingness to "impair the military readiness and capability." A funding level between BMARE and BMART would imply maintaining readiness and accomplishing some other needed MRP work. The amount of the difference between BMART and BMARE that was funded would determine whether the BMART would grow.

The system (as any system) would still rely on good decisions at base level concerning what needs to be done, when it needs to be done, and whether it is essential. These decisions can be monitored by command and Air Force validation teams to insure consistent interpretation of terms.

Limitations of the Thesis

While the descriptive model using systems analysis techniques was based on Air Force regulations pertaining to the programming of work requirements, it is the author's

interpretation of the system. There was no external validation of the model. If there are any incorrect assumptions, the author does not believe they would affect the overall objective of demonstrating what affects the BMAR total of a base.

There is no way for the author to learn if his recommendations would improve the BMAR system. That could only happen by trial in the field. While the two BMARs could be implemented at any level down to an individual base, it would not be very meaningful until there is standardization across DOD.

Not devising an actual predictive BMAR model might be viewed as a limitation of this thesis, but the author strongly believes that there would be little point to being able to predict a measure that has no credibility and is so flexible as to be able to be set at any desired amount at various levels of command.

Appendix A

BMAR AND EXPENDITURES

	1965	1966	1967	1968	1969	1970	1971
	(millions)						
Air Force:							
Planned expenditures	230.0	258.0	250.0	250.0	250.0	250.0	250.0
Maintenance floor	230.0	258.0	250.0	250.0	250.0	250.0	250.0
Actual expenditures	289.5	264.5	289.6	280.4	296.0	315.3	312.7
Backlog	60.0	112.0	125.0	139.0	158.2	170.3	92.1
Total DOD:							
Planned expenditures	618.7	641.4	673.0	706.2	708.3	645.3	627.9
Maintenance floor	619.0	644.5	677.5	706.2	708.3	644.9	627.9
Actual expenditures	722.3	716.4	781.7	844.6	845.8	862.9	813.1
Backlog	285.0	326.0	368.0	556.5	654.0	721.8	657.5

	1972	1973	1974	1975	1976	1977	1978	1979
	(millions)							
Air Force								
Planned expenditures	276.0	265.1	288.1	356.8	394.5	423.4	547.9	635.3
Maintenance floor	250.0	216.7	215.0	330.0	340.0	380.0	509.0	592.2
Actual expenditures	334.1	374.3	439.3	493.5	535.0	682.8	697.9	730.9
Backlog	82.0	179.3	159.3	150.3	162.0	219.1	299.9	365.5
Total DOD								
Planned expenditures	696.0	764.4	779.2	1097.9	1122.8	1297.0	1455.5	1705.7
Maintenance floor	652.0	612.2	643.7	935.8	995.0	1177.0	1360.7	1660.2
Actual expenditures	910.0	958.7	1078.3	1245.4	1280.1	1632.5	1754.8	1969.7
Backlog	669.3	909.7	1011.1	1213.6	1566.1	1949.5	2183.0	2376.7

Appendix B

SAMPLE LETTER

Budgeting for Maintenance and Repair

SAC/DE

1. I am a graduate student in the AFIT Engineering Management program (used to be Facilities Management). I am doing my thesis on estimating backlog of maintenance and repair (BMAR). There has been interest for several years now up to congressional level concerning the growth of the BMAR. Presently, there does not seem to be a readily available technique for estimating how much maintenance and repair will be required at Air Forces bases and consequently in a MAJCOM.
2. As part of my thesis, I am requesting information from each MAJCOM for any techniques and justifications used to present their annual budget for contract maintenance and repair. The techniques used by various commands will become one chapter of my thesis. I am also doing a literature review of any published techniques in industry and plan to present a theoretical model based on depreciation techniques.
3. Any techniques that your command personnel can provide me will be greatly appreciated and will become part of an increased body of knowledge in this area. The thesis should be completed this summer, and copies will be available this fall.

TROY L. SANDERS
Capt, USAF

SELECTED BIBLIOGRAPHY

A. REFERENCES CITED

1. Chase, Richard B., and Nicholas J. Aquilano. Production and Operations Management. Homewood IL: Richard D. Irwin, Inc., 1981.

2. Descartes, Rene. "Rules for the Direction of the Mind," Great Books of the Western World, volume 31. Chicago: Encyclopaedia Brittanica, Inc., 1971.

3. FitzGerald, Jerry, Ardra A. FitzGerald, and Warren D. Stallings, Jr. Fundamentals of Systems Analysis. New York: John Wiley & Sons, Inc., 1981.

4. Halac, Colonel H. E. Deputy Chief of Staff, Engineering and Services, HQ SAC. Letter, 27 July 1983.

5. Optner, Stanford L. Systems Analysis for Business Management. Englewood Cliffs NJ: Prentice-Hall, Inc., 1963.

6. Penninno, James R. Director of Programs, HQ AFSC. Letter, subject: Budgeting for Maintenance and Repair, to AFIT/LSM (Capt Troy L. Sanders), 31 May 1983.

7. Ross, D. T., J. W. Brackett, R. R. Bravaco, and K. E. Schoman, Jr. "Guide to Understanding Activity Diagrams, $IDEF_0$" Contract F33615-78-C-5158 with ICAM Program Office, AFML, WPAFB. 23 October 1978.

8. Sowers, Colonel John C. Director of Programs, HQ MAC. Letter, no subject, no date.

9. Staats, E. R. DOD's Real Property Maintenance and Repair Backlog. Report by the Comptroller General of the United States. General Accounting Office Report LCD-79-314, August 31, 1979.

10. _____. Congress Cannot Rely on the Military Services' Reported Real Property Maintenance and Repair Backlog Data. Comptroller General's Report to the Committee on Appropriations, United States Senate. General Accounting Office Report LCD-81-19. February 2, 1981.

11. U.S. Department of Defense. DOD Instruction 4165.58 Washington: Government Printing Office. August, 1973.

12. U.S. Department of the Air Force. Financial Management Guide. AFP 85-11. Washington: Government Printing Office, 15 Sep 1980.

13. _____. Programming Civil Engineer Resources. AFR 86-1, Draft Chapter 14, CECORS. Washington: Government Printing Office, 6 August 1976.

14. Wright, Clifton D. "The Engineering and Services Strategic Plan." May 1983.

15. Yancey, Colonel Kenneth E., Jr. Director of Programs, HQ, PACAF. Letter, subject: Budgeting for Maintenance and Repair, to AFIT/LSM (Capt Troy L. Sanders), May 26, 1983.

B. RELATED SOURCES

Hartenstein, Captain T., USMC. "A Review of the Marine Corps Maintenance of Real Property Program in Order to Improve the Marine Corps' BMAR Projection." Unpublished Master's Thesis. Naval Postgraduate School, Monterey CA, June 1980. AD A090 317.

McAuley, Lieutenant Commander Janet Marie, USN. "Backlog of Maintenance and Repair (BMAR): The Navy's Approach to Funding." Unpublished Master's Thesis. Naval Postgraduate School, Monterey CA, June 1980. AD A090 094.

U.S. Department of the Air Force. Facilities Board. AFR 86-7. Wasington: Government Printing Office, 20 Feb 1981.

_____. Resources and Work Force Management. AFR 85-1. Washington: Government Printing Office. 21 May 1982.

END

FILMED

12-83

DTIC