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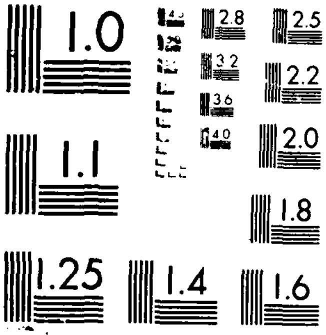
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CORPS OF ENGINEERS RESOURCE AND MILITARY MANPOWER SYSTEM

Report AR603R1

May 1987

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LMI

Executive Summary

CORPS OF ENGINEERS RESOURCE AND MILITARY MANPOWER SYSTEM

The U.S. Army Corps of Engineers (USACE) provides engineering and construction management services for both military and civil works programs. In 1986, the military programs for Army, Air Force, defense agencies, and several nondefense agencies exceeded $6 billion and required a 14,000-person work force. Managers in USACE must continually adjust the work force to accommodate changes in the size, location, and composition of the annual workload.

To make such adjustments, managers need the capability to forecast manpower and funding requirements quickly and accurately and to allocate the available resources to the Divisions and Districts. We have developed the Corps of Engineers Resource and Military Manpower System (CERAMMS) to provide that capability for the military programs.

CERAMMS combines computer models, management policy controls, and Department of the Army resource constraints. It enables managers to forecast manpower requirements, planning and design (P&D) funding requirements, and supervision and administration (S&A) funding requirements for all of USACE and its individual Divisions and Districts. It also enables managers to examine options for allocating manpower resources to the Divisions and Districts.

The forecasting model for total manpower requirements has been validated and was used by USACE to prepare its FY87 and Five Year Defense Plan requirements (Total Army Analysis). The Division and District manpower forecasting models, the P&D and S&A models, and the allocation model are currently prototype models that need to be validated and refined.

To make CERAMMS an effective operational system, we recommend the Director of Engineering and Construction:

- Establish a permanent group to complete the development, validation, and testing of CERAMMS, maintain it, and use it for preparing manpower and funding recommendations.
- Use CERAMMS to establish FY88 target rates for charging P&D and S&A costs to customers.
- Coordinate the development and operation of CERAMMS with the efforts of the Directorate of Resource Management to develop Manpower Staffing Standard Systems (MS3).
- Establish regulations and procedures to incorporate CERAMMS into the existing manpower management process.

We also recommend that the Director of Engineering and Construction develop a capability to quantify the costs and impacts of staffing Divisions and Districts below the forecasted manpower requirement levels.

CONTENTS

FIGURES

CHAPTER 1

INTRODUCTION

The U.S. Army Corps of Engineers (USACE) provides engineering and construction management services for both military and civil works programs. The military programs include Army, Air Force, defense agency, and selected nondefense agency projects. In 1986, the cost of those projects exceeded $6 billion, and their implementation required a 14,000-person work force. To execute programs of that magnitude successfully, USACE managers must forecast manpower and funding requirements and allocate available resources to the Divisions and Districts. (The organization of USACE is shown in Figure 1-1.) USACE needs a method to perform those functions quickly and accurately and to analyze the impact that changes to the military program have on its manpower and funding requirements.

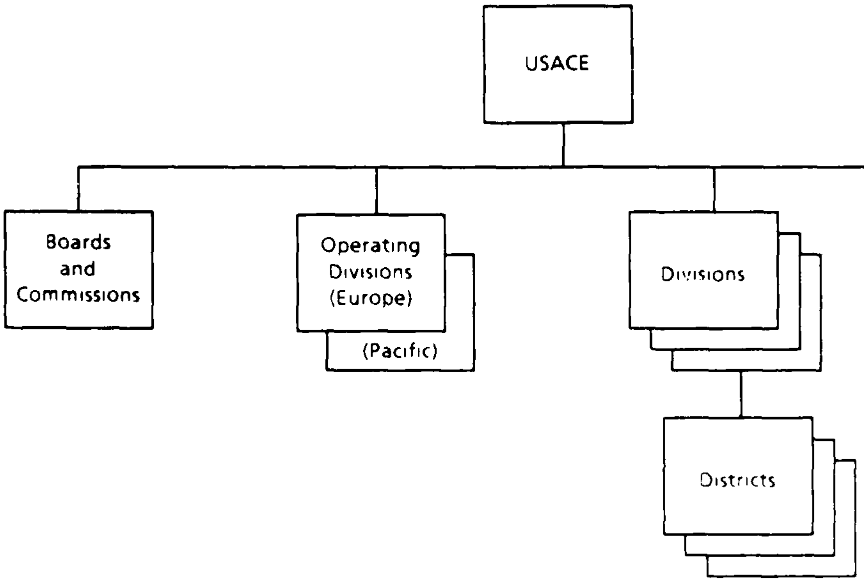

FIG.1-1. THE ORGANIZATION OF USACE

To meet these needs, the USACE Director of Engineering and Construction established a Manpower Task Force (MANTAF) to develop the necessary management tools. The initial charter of MANTAF was to develop the means for providing proper management of manpower associated with the military program. Early investigations revealed that the management of manpower resources was intimately related to the management of funds for planning and design (P&D) and construction supervision and administration (S&A). Consequently, MANTAF developed a program that addresses both manpower management and the interrelationship with P&D and S&A targets as they affect manpower decisions. The USACE Director of Engineering and Construction tasked us to develop appropriate computer models for the three-phase MANTAF program:

- In Phase I, we developed a prototype computer model for forecasting the workyears needed to support the USACE military engineering and construction program and to serve as the basis for further manpower management initiatives.
- In Phase II, we improved the statistical basis and the capabilities of the prototype USACE manpower forecasting model, developed prototype models for forecasting the workyear requirements of Divisions and Districts, developed a prototype allocation model, and developed prototype P&D and S&A models. The models developed in this phase are referred to as the Corps of Engineers Resource and Military Manpower System (CERAMMS).
- In Phase III, we plan to convert the models to an operational system by validating the prototype Division and District manpower forecasting models, enhancing the prototype allocation model and the protoype P&D and S&A models, and developing implementation procedures.

We have completed Phase I and Phase II of the effort, and Phase III is scheduled to be completed in early 1988.

OVERVIEW OF CERAMMS

The multiple information requirements of USACE and the desire to be able to run the model on a microcomputer led to the development of CERAMMS as five interrelated models rather than a single large model (see Figure 1-2). The models address the two primary USACE management needs – forecasting requirements and allocating resources. The two forecasting models and the S&A and P&D models quantify the requirements for manpower and funding, and the allocation model apportions the available manpower and funding resources to USACE Divisions. Consistency among the models is maintained through the use of common input files, which ensures that the same assumptions and policies that drive manpower requirements are used to determine P&D and S&A funding requirements. In the past,

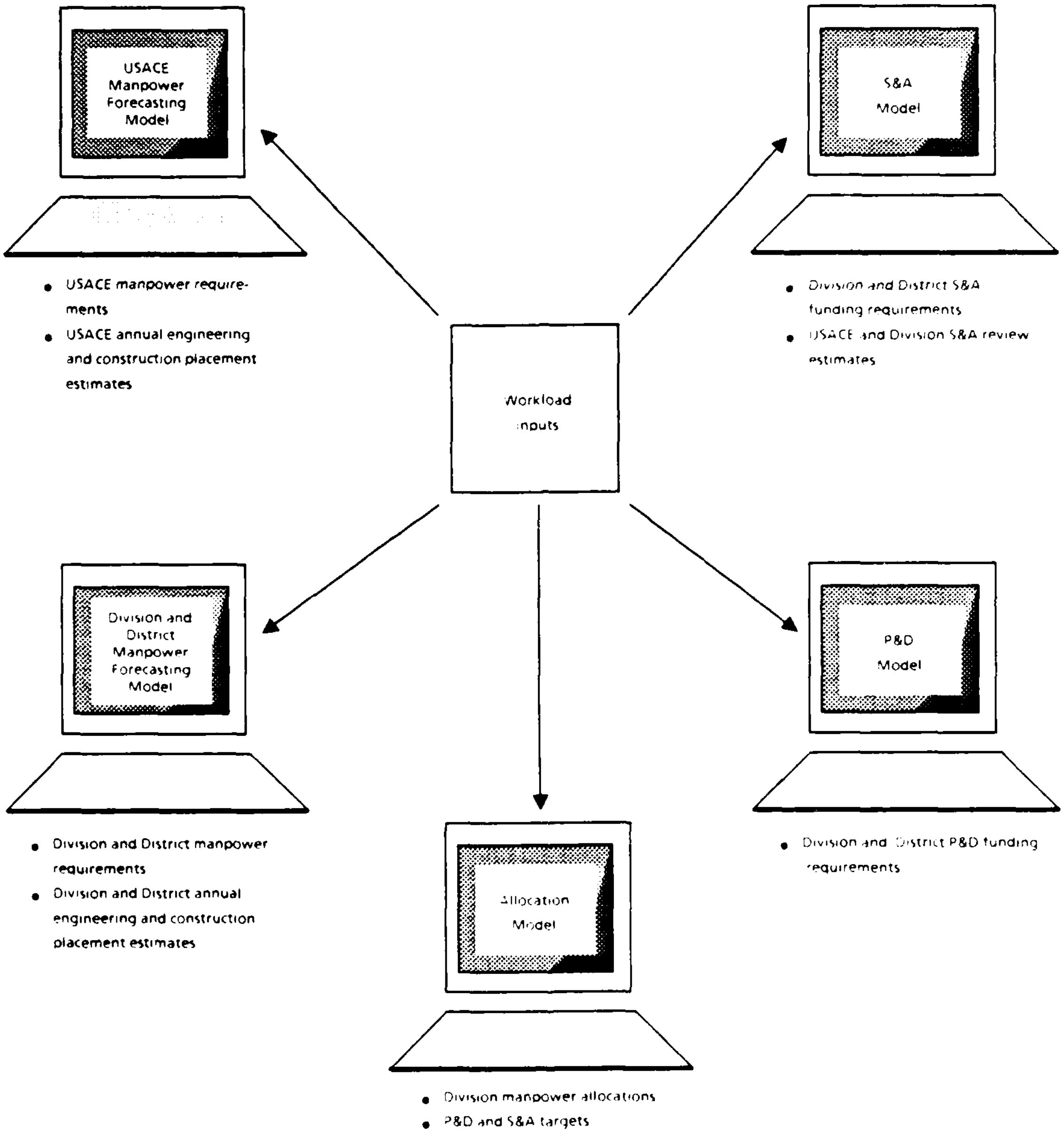

FIG. 1-2. OVERVIEW OF CERAMMS MODELS AND OUTPUTS

because manpower has not been directly linked to P&D and S&A, disconnects have occurred between the manpower allocations and the funding targets established for P&D and S&A. We believe that interrelated models provide an effective mechanism for developing manpower requirements, establishing P&D and S&A targets, and then allocating available resources.

CERAMMS INPUT

Both engineering and construction workload inputs are measured by the estimated cost of construction (ECC). It is calculated by subtracting contingency costs, engineering-during-construction costs, and S&A expenses from the annual program amount (PA). We refer to this workload measure as the "adjusted PA." The more important workload measure is the spread workload, which is a detailed apportionment of the adjusted PA to the year or years in which the engineering and construction services are performed rather than to the year in which the project is appropriated.

HARDWARE AND SOFTWARE

The minimal hardware configuration needed to operate CERAMMS is an IBM-compatible microcomputer with 640 kilobytes of random access memory and a 10-megabyte hard disk drive. However, because of the large secondary storage requirement, we recommend a 20- to 30-megabyte hard disk drive. The model will function with any standard microprocessor; however, the large volume of calculations will result in significant delays (5 to 8 minutes) with slower microprocessors. For faster operation, we recommend using an Intel 80286 microprocessor. The optimum hardware configuration is an IBM-compatible computer with the Intel 80286 microprocessor, 2 megabytes of extended memory, and a 30-megabyte hard disk.

The models use LOTUS 1-2-3™ software, which provides an automated analysis that can be readily modified to reflect changes in underlying assumptions, policies, or inputs. LOTUS 1-2-3™ macros are used to exchange information among files, move information between and within files, generate outputs, and create graphics. Macros are selected from menus displayed on the microcomputer screen and invoked by entering codes consisting of two key strokes. We made every effort to design the model to be as user-friendly as possible; however, as a minimum, users must have a basic understanding of LOTUS 1-2-3™ operation. Use of standard commercial software with minimal hardware requirements should promote maximum dissemination and use of the models.

REPORT ORGANIZATION

The remainder of this report describes development and operation of the various models and presents the recommended next steps. Chapter 2 is a description of the USACE manpower forecasting model and the Division/District manpower forecasting model. Chapter 3 describes the workings of the manpower allocation model, and Chapter 4 describes the P&D and S&A models. Our recommendations for the next steps are presented in Chapter 5. Detailed discussions on the development of the models as well as user information are presented in six appendices. Appendices A and B describe the statistical analyses used to develop the model coefficients. Appendix C describes the USACE-wide conference held in August 1986 to identify the factors that have the potential to influence manpower requirements. Appendix D presents the approach used in the analysis of Engineering Not Related to Construction (ENRC) and project mortality rates, and Appendix E describes the methodology used for workload spreading. Appendix F contains instructions for using CERAMMS and details its structure and calculations. Several of the appendices assume a basic understanding of applied statistics.

CHAPTER 2

THE MANPOWER FORECASTING MODELS

The manpower forecasting models are based upon two primary assumptions: that the USACE mix of project size and complexity for future program years can be related to that for historical program years and that USACE's historical resource requirements for engineering and construction management services are comparable to those found in other government agencies and the private sector.

The initial step in developing the models was the creation of a structure that related the mix of projects in the anticipated workload to historical USACE data. Analysis of historical USACE data showed that the the type of fund used to support a project gives a good indication of project differences and can be used as the basis for structuring the mix of projects to determine manpower requirements. By dividing the military program into fund types[1] and using the historical project mix in those fund types, inputs to the manpower forecasting models can be generated from existing DoD workload forecasts. That method is valid unless major changes in priorities alter the relatively constant historical project mix within fund types.

Models to forecast future manpower and funding requirements must be based upon data that represent a reasonable level of resource expenditure for the work accomplished; factors developed from a data base that contains inefficiently managed projects are of little value. Since USACE's costs for design and construction management services have been shown to be comparable with those of other Federal, state, and local government agencies and large private sector corporations,[2] properly sampled historical USACE data can be used to generate requirements factors that reflect industry standards.

One of the major objectives in developing the models was to minimize the resources needed by maximizing the use of existing data sources for developing and subsequently maintaining the model. USACE currently maintains two large project

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[1] Table A-1 presents a listing of the 13 fund types used.

[2] Paul F. Dienemann, Joseph S. Domin, and Evan R. Harrington, "*Management Costs of DoD Military Construction Projects*," Logistics Management Institute Final Report ML215, April 1983

and cost data bases: the Corps of Engineers Management Information System (COEMIS) and the Automated Management Project Reporting System (AMPRS). Those data bases, however, had to be supplemented with information that was not available from either, and thus a "field data call" (i.e., a request to all USACE field offices for specific data) was issued. Information from that call and from the two data bases formed the combined data base used to develop the algorithms for the forecasting models.

The development of each of the forecasting models followed a similar process. The combined data base was first examined to determine where possible relationships might exist between the dependent variable (man-years or funding) and the potential independent variable(s). These hypothesized relationships were then examined statistically to determine whether a relationship did, in fact, exist and if it did, to quantify it. The relationships that were quantified through the statistical analysis were used to develop algorithms for building forecasting models. Figure 2-1 depicts the model development process, and more details on the model are presented in Appendix A.

The outputs of the forecasting models (forecasts of workyear requirements) were then compared with actual usage to validate the reliability of the models. The manpower requirements for FY85 and FY86 forecast by the USACE model were within 3 percent of the actual usage. A similar validation for the Division forecasting model is currently underway.

THE USACE MANPOWER FORECASTING MODEL

The outputs of the USACE manpower forecasting model are multiyear forecasts of the workyears required to provide engineering and construction services for the ongoing and planned military program. Workyear requirements are calculated by fund type and summarized in three customer categories: Army installation support, other Army support, and non-Army support. This functional display of manpower requirements facilitates the analysis of the impact of changes in specific fund types and readily supports the "what if" scenarios that are an integral part of manpower management.

The manpower requirements generated by the USACE forecasting model serve as an input to the Total Army Analysis (TAA) process, as shown in Figure 2-2. The manpower forecast for the TAA process must cover the budget year under

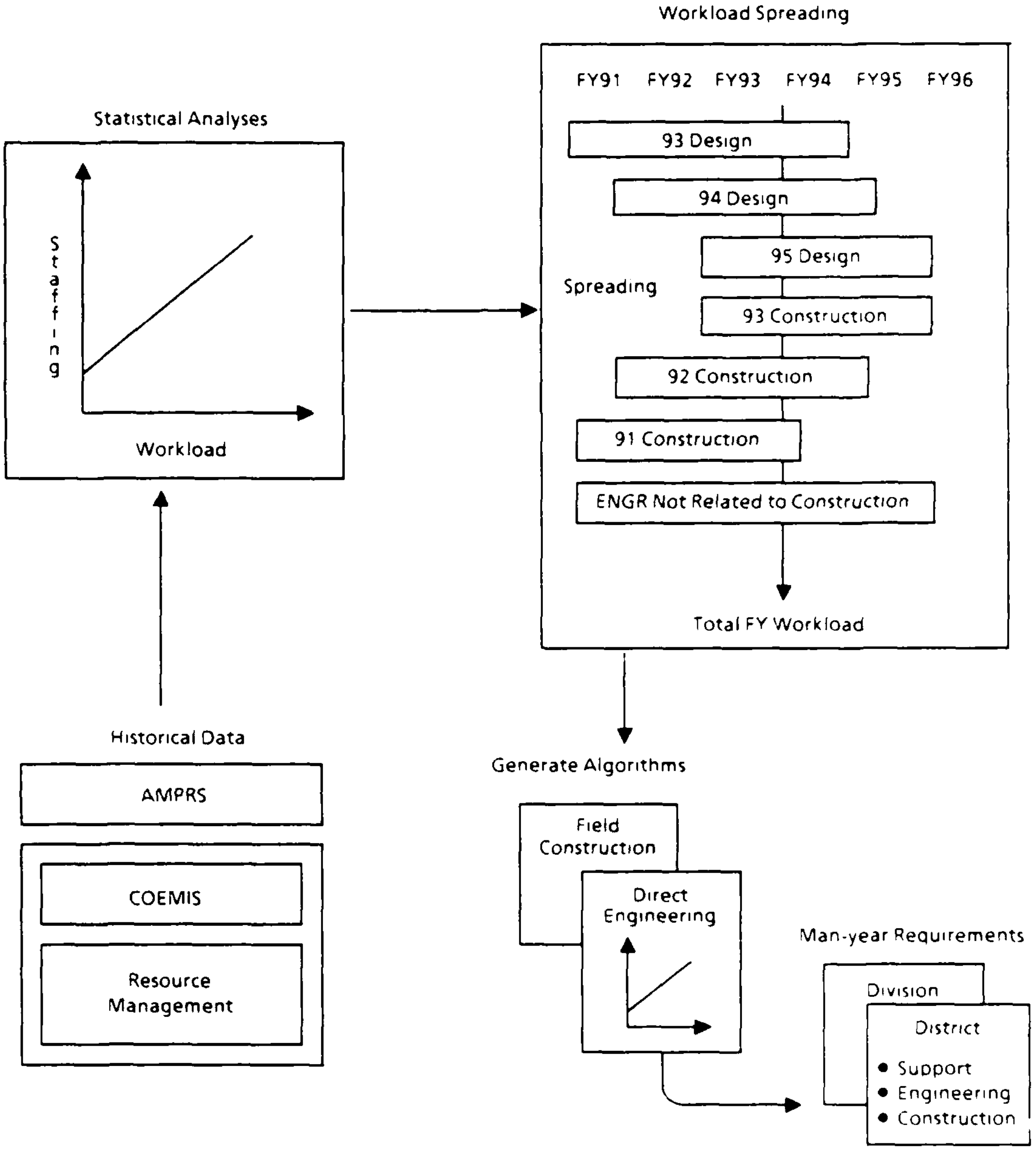


FIG. 2-1. MODEL DEVELOPMENT PROCESS

consideration as well as 6 future years. Through the TAA process, the USACE requirements are evaluated and manpower ceilings for the budget year under consideration are established as well as programming numbers for future year manpower levels.

Historical data were used to develop the USACE manpower forecasting model. A statistical analysis of actual manpower utilization and work accomplished was

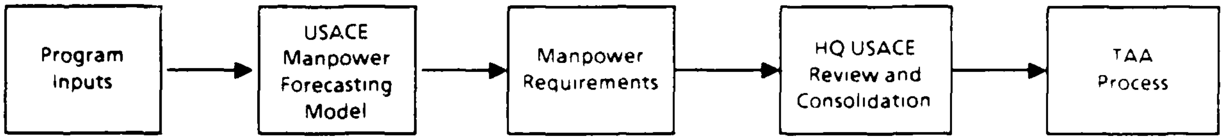


FIG. 2-2. USACE MANPOWER FORECASTING MODEL: INPUT TO TAA

used to derive the predicting equations (algorithms). The data analyzed were selected from a sample of USACE Districts throughout the world. The analysis is based on single variable and multivariate regressions that relate the manpower actually utilized to the dependent variable(s) under consideration. (Detailed descriptions of the sampling techniques and analytic approach are presented in Appendix A.) Although workload was the most significant factor affecting manpower requirements, some other factors such as economies of effort realized on large projects and the number of active construction contracts were also found to be important. Figure 2-3 depicts the major components of the USACE manpower forecasting model.

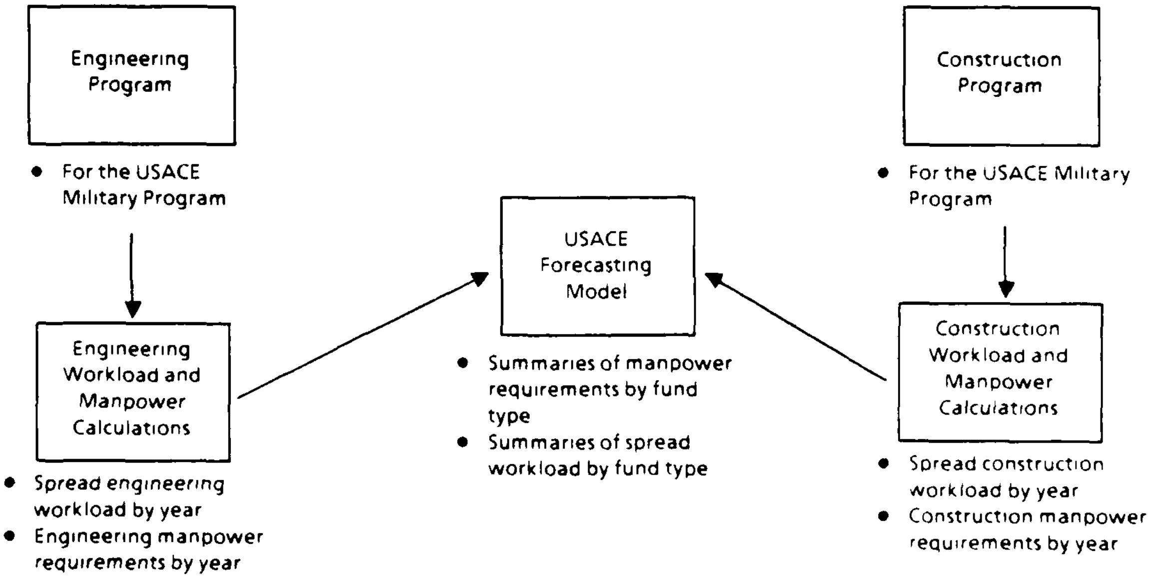


FIG. 2-3. USACE MANPOWER FORECASTING MODEL COMPONENTS

The inputs to the USACE forecasting model are the actual and planned PAs for each of the years under consideration. Those years include the year for which outputs are sought, the 3 years preceding it, and the 2 years following it. Data for this range of years are needed because of the multiyear nature of design and construction program execution. Projects that are programmed for execution in a given year must be designed before that year. Similarly, since completion of construction projects normally requires more than 1 year, construction workload often continues past the execution year. Thus, TAA forecasts require programming information for multiple years. Much of the PA information for future years is based upon "best guesses" and extrapolation of historical trends. Assumptions related to program execution are secondary inputs to the model and are discussed in following sections; later, the input needs of the USACE manpower forecasting model are contrasted with those of the District manpower forecasting model.

The development of manpower forecasts begins with inputs of data and assumptions and ends with a presentation of manpower requirements by fund type. Workload is measured by inflation-adjusted PAs and is obtained from a combination of existing USACE automated data bases and estimates by program managers. The assumptions that the model considers are the number of available man-hours per man-year, the estimated amount of in-house design work that will be done, the number of projects that will not survive the budget review process (mortality rate), the amount of engineering not related to construction (ENRC) to be done in-house, the average number of active construction projects that each District will experience, and the Operation and Maintenance Army (OMA) positions. Once the input data and assumptions are entered, the calculation of manpower requirements begins.

The first step in the calculation is to identify the year or years over which a particular PA will be executed. Workload (inflation-adjusted PA) is spread by factors that have been developed from a detailed analysis of a multiyear sample of historical USACE design and construction data (see Figures 2-4 and 2-5). The factors account for the duration of projects, variances in project start dates, historical patterns of completion, mandated goals (such as 35 percent design completion before submission to Congress), and the historical mix of projects. Separate sets of spreading factors have been developed for in-house design and contracted out architect and engineering (A/E) design and construction.

The factors developed from the analysis of historical manpower usage versus workload are then applied to the spread workload. Factors were developed for six major functional areas: Division Office Staffing, District Support Staffing, District

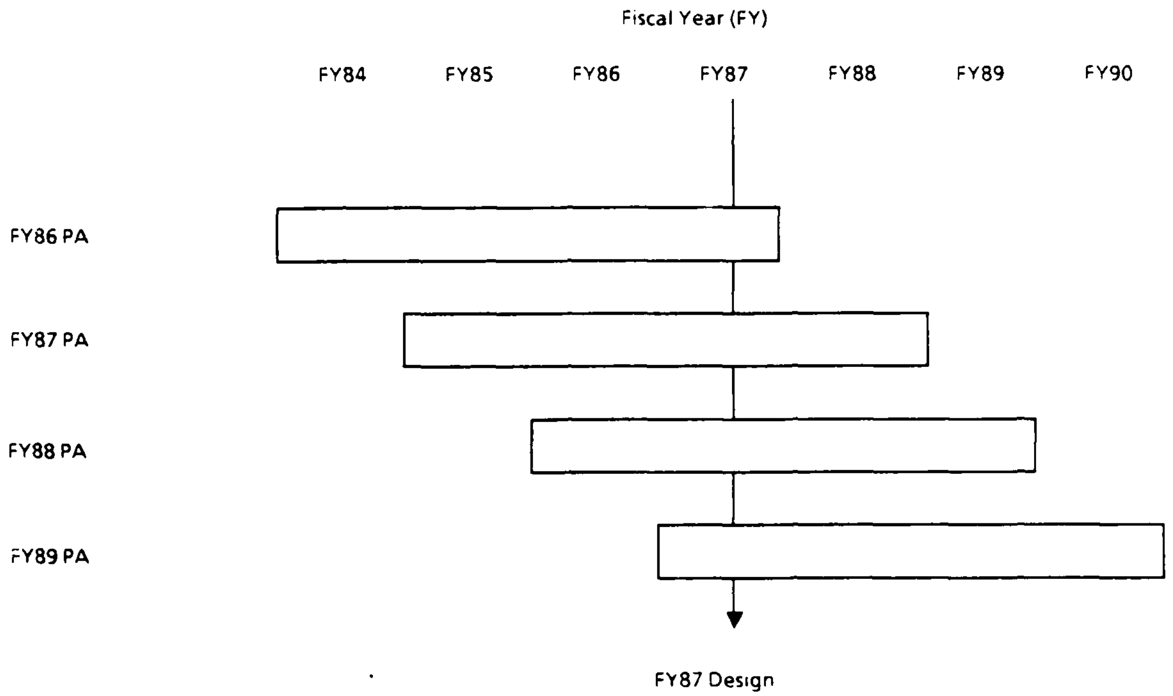


FIG. 2-4. DESIGN WORKLOAD SPREADING

Engineering, District Construction, District Direct Engineering, and District Field Construction Offices. Division Office Staffing represents the Military Construction (MILCON)-driven manpower requirement for USACE Divisions. District Support Staffing is the manpower needed to provide the support functions within a District such as legal, finance and accounting, etc. District Engineering refers to the manpower required to provide technical indirect support for the District's engineering program. District Construction is the construction equivalent to District Engineering (i.e., the construction technical indirect support). District Direct Engineering is the manpower within a District that is directly charged to engineering projects. District Field Construction Offices refers to the manpower associated with staffing field elements such as area and resident offices. The model calculates manpower forecasts for each of these categories.

Some caution must be taken when using the estimates of manpower requirements for any of the functional areas. The factors for each functional area were developed from historical data, and in some cases, data were found to vary significantly among Districts. Although we have a high level of confidence in the total USACE functional breakouts, extrapolating ratios of USACE functional areas

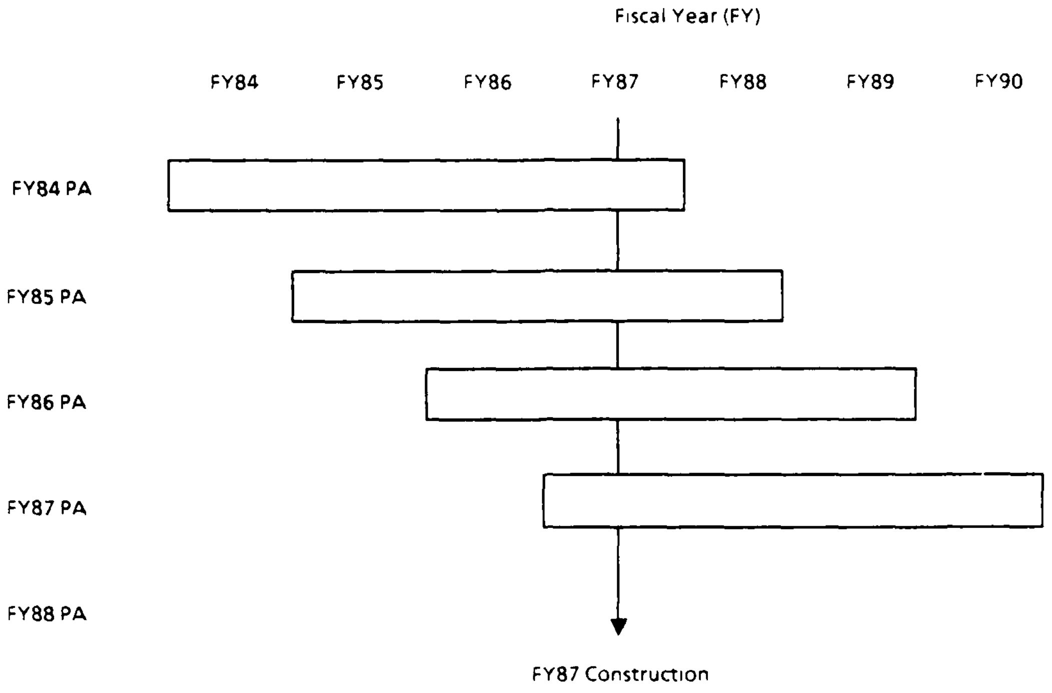


FIG. 2-5. CONSTRUCTION WORKLOAD SPREADING

to the Districts implies a level of precision that does not exist. Such extrapolations should be used only as a guide and not as a suggested functional staffing level.

In addition, the model develops manpower summary tables. These tables display the manpower requirements by fund type for each year. Summary tables are calculated for engineering manpower requirements, construction manpower requirements, and total (engineering, construction, and support) manpower requirements. Additional tables that depict dollar placement summaries by fund type are also developed.

DIVISION AND DISTRICT MANPOWER FORECASTING MODELS

The outputs of the Division and District forecasting models provide a forecast of the workyears required by Divisions and Districts to execute their MILCON engineering and construction programs. As with the USACE model, the requirements are analyzed by fund type. The forecasts generated by the District forecasting model are used as the major input to the manpower allocation process via the manpower allocation model (see Figure 2-6). In contrast to the USACE manpower forecasting model, the Division and District manpower forecasting

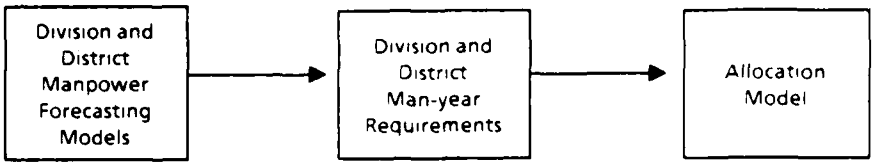


FIG. 2-6. DIVISION AND DISTRICT FORECASTING MODELS: INPUTS TO THE ALLOCATION MODEL

models address only the budget year under consideration and 1 following year. Although the future year engineering and construction programs are either known or can be estimated at the USACE level, the location of those projects (e.g., which District will have responsibility) is not known for more than 2 or 3 years beyond the current year. Thus, the major difference between the USACE manpower forecasting model and the Division and District models is the time horizon that they address, and that horizon is dictated by the level of detail available to describe the workload inputs, as shown in Figure 2-7.

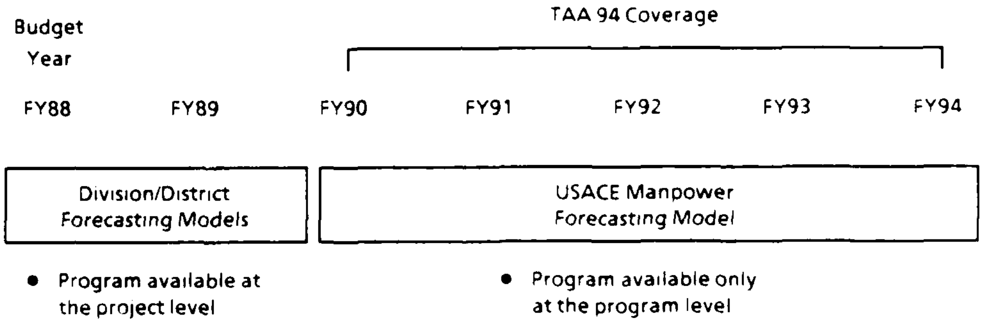


FIG. 2-7. RELATIONSHIPS OF MODEL COVERAGE

Figure 2-8 depicts the major components of the Division and District forecasting models. Both models were developed in the same way as the USACE manpower forecasting model, and the primary inputs to both models are the same as those for the USACE manpower forecasting model except that the Division and District models use only data for the year for which outputs are sought and the 3 years preceding and 2 years following it. Again, the development of manpower forecasts also follows the procedure given for the USACE model.

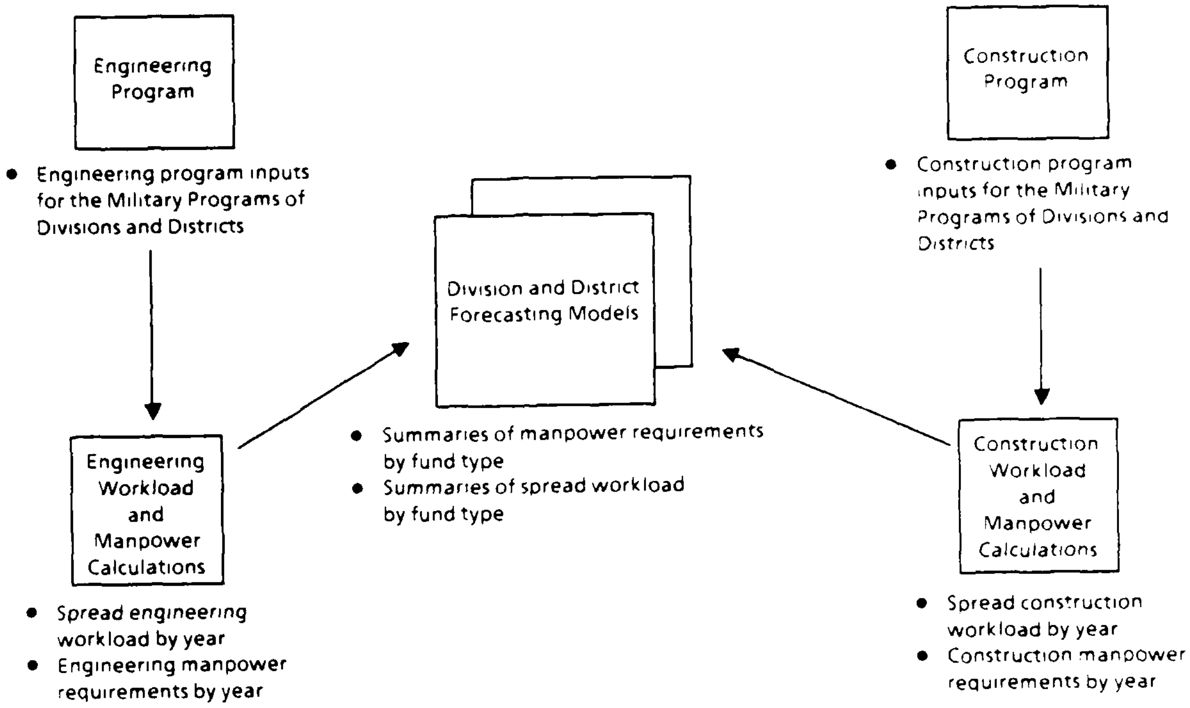


FIG. 2-8. COMPONENTS OF DIVISION AND DISTRICT FORECASTING MODELS

CHAPTER 3

MANPOWER ALLOCATION

Manpower resources are allocated to Divisions based on the requirements developed with the USACE manpower forecasting model, the Division and District manpower forecasting models, and the manpower resources made available through the TAA process. The USACE manpower forecasting model is used to develop the total manpower requirements for the USACE military program. That requirement is the basis for the initial manpower request submitted as part of the TAA process. It represents the unconstrained requirement based on the military program as it is known at the time of the forecast. The TAA process then establishes the constrained manpower available to execute the military program, again based upon the program as it is known at the time of the forecast.

The outputs of the Division and District forecasting models are forecasts of required workyears at the District and Division level for the current year and 1 additional year. These models forecast the required manpower at a point in time closer to the year of execution than does the USACE model, and consequently, they are more reliable. The sum of the manpower forecasts for all of the Divisions and Districts should compare favorably with the USACE model forecast in a year in which the military program is relatively stable. However, the forecasts could be significantly different during a year in which major changes to the military program occur. USACE would then have to decide whether the discrepancy is large enough to pursue a change in the manpower ceiling with the Army staff.

The allocation model matches Division and District requirements with the manpower that is made available through the TAA process, and all requirements are not likely to be satisfied. The allocation model provides a mechanism for the Directorate of Engineering and Construction corporate board to develop a recommended distribution of the available manpower resources to Divisions. (The corporate board consists of senior managers from the Directorate.)

The allocation model uses five sets of inputs to determine how to distribute available manpower: the unconstrained manpower requirement (USACE total) from the USACE manpower forecasting model, the Division and District unconstrained manpower requirements, the authorized manpower ceiling (USACE total) as determined from the TAA process, the previous year's allocation to the Divisions and Districts, and the management variables that will be considered. The interaction of these variables is shown in Figure 3-1.

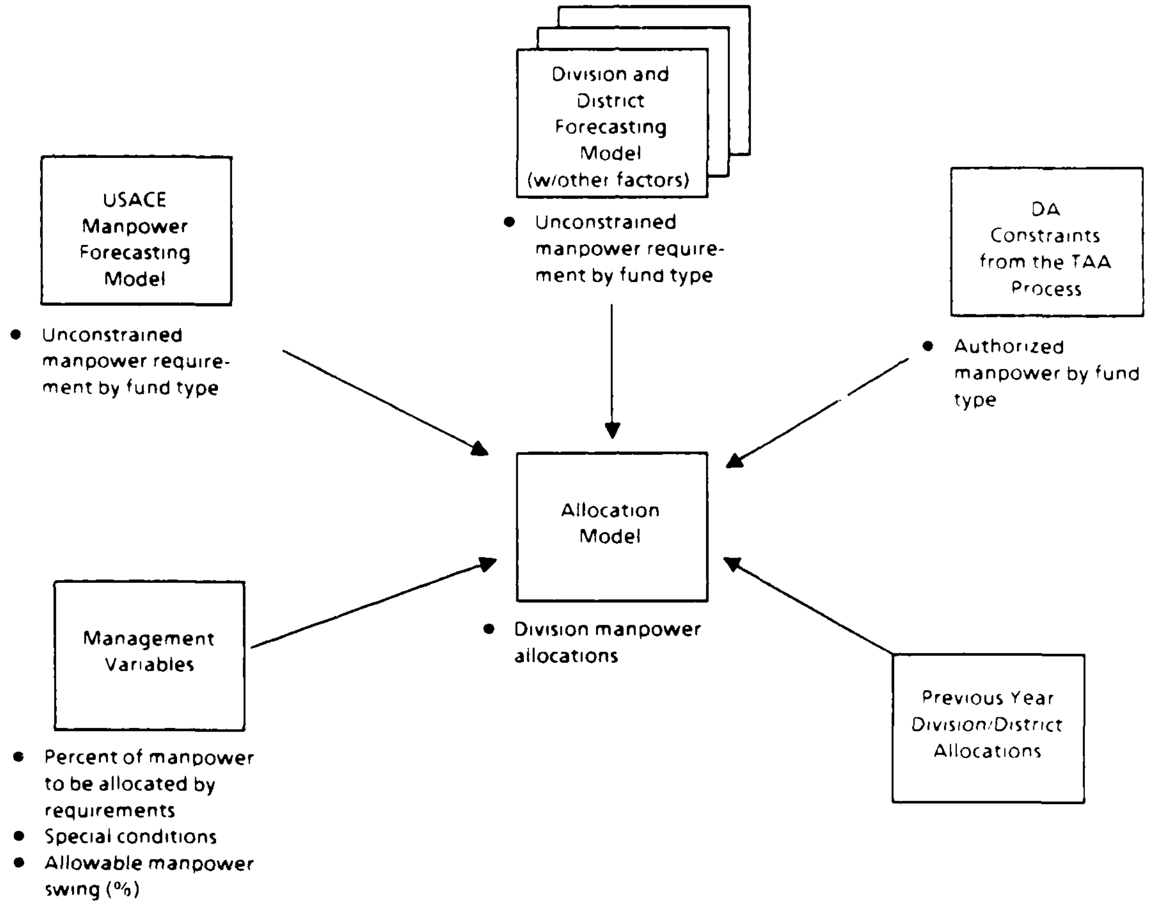


FIG. 3-1. ALLOCATION MODEL INTERACTION

The unconstrained manpower requirement from the USACE model represents the workyears required to execute the military program. This requirement is entered into the TAA process, and the Army uses it to determine the USACE manpower ceiling. The established staffing ceiling may be equal to or less than the unconstrained requirement. The unconstrained staffing requirement and the staffing ceiling must then be compared with the individual Division and District requirements from their respective models. The sum of the requirements from the

Division and District models may not equal the total USACE requirement from the USACE model as mentioned previously for a number of reasons. The Division and District model is run later in the fiscal year than the USACE model, and consequently, more is known about the military program and changes that may have occurred since the USACE model developed total USACE requirements. Items that could affect the required manpower include changes in the size of the program, changes in the program mix, different in-house design goals, etc. The Division and District allocations must simultaneously consider the requirements from the Division and District models and the USACE model as well as the manpower ceiling set by the Army staff.

Two remaining factors – the previous year's Division and District allocations and the management variables – provide the "rules" for establishing manpower allocations. The previous year's allocation is used as a reference point from which changes in manpower can be measured. The allocation model utilizes three types of management variables: the amount of available manpower to be allocated strictly by identified requirements, special conditions that may affect manpower requirements, and the maximum staffing swings (up or down) that are considered acceptable. *All management variables can be readily changed in the model*; in fact, the model is designed to arrive at an allocation through an iterative process that is basically the examination of a number of allocation scenarios in an effort to select the most preferable solution.

The iterative process begins by determining how much of the available manpower should be allocated by identified requirements. An initial reaction is that all available manpower should be allocated by the identified requirements as determined by the USACE and Division and District models. However, other considerations affect allocations such as special projects that require emphasis, unidentified requirements, staffing up in anticipation of a major program, and the desire to avoid large variations in Division and District staffs. Factors such as these cannot be considered if all available manpower is allocated based solely on identified requirements. That portion of the allocation based upon identified requirements is made by prorating the difference between the manpower available for allocation and the sum of the requirements from the Division and District models. We estimate that 90 to 95 percent of the available manpower should be allocated based on identified requirements. The remaining 5 to 10 percent would then be allocated based upon the remaining management variables.

Special conditions are accounted for by a corporate board that directly allocates staff to Divisions and Districts. This procedure permits factors such as previously unidentified requirements, staffing up for major projects, projects with special emphasis, etc., to be accounted for. The allowable staffing variation is a variable that imposes limits on how much a Division or District will be required to increase or decrease its staff from the previous year. Staffing variations are directly related to how much manpower is to be allocated by identified requirements. The smaller the allowable staffing variations, the smaller the amount of available manpower that can be allocated by identified requirements.

Thus, the allocation process becomes a weighing of alternatives with the allocation model providing the capability to analyze the impact of the alternatives both graphically and with tabular displays. We emphasize that the allocation model *does not* allocate manpower resources. The Directorate of Engineering and Construction corporate board recommends the distribution of manpower using the allocation model as a tool to facilitate the process.

CHAPTER 4

THE P&D AND S&A MODELS

A natural linkage exists between the manpower required to execute the engineering and construction program and the planning and design (P&D) and supervision and administration (S&A) requirements. The fiscal resources needed to support the manpower used to execute USACE's military engineering and construction program comes from either P&D or S&A funds. We believe the P&D funds allocated to a District should be directly related to the amount of design effort a District expects to expend. If such a linkage is not made, a District could be placed in the position of being allocated sufficient manpower but not being able to pay salaries and associated costs or, similarly, having sufficient funds but not enough allocated manpower. The S&A funds allocated to a District should also be directly related to its allocated manpower. Again, failure to make this linkage will detrimentally affect execution of the construction program. P&D and S&A are linked to manpower through anticipated workload in CERAMMS.

CERAMMS facilitates making the linkage by using a methodology that employs the same workload data to determine P&D and S&A targets and calculate manpower requirements. Further consistency is achieved by applying the same set of rules for all Districts and Divisions to determine manpower and funding requirements.

The outputs from CERAMMS can be used to establish targets and evaluate past performance. Effective management indicators can be developed by combining the outputs from the P&D and S&A models with those of other available models. As an example, estimates of engineering and construction placement are model outputs; those estimates can then be used in conjunction with the estimates for P&D and S&A funds needed to develop the cost per dollar of project for providing design and construction services. Past performance can also be evaluated by comparing historical expenditures for P&D and S&A to CERAMMS estimates. Such indicators can be used to evaluate and manage the execution of the USACE military design and construction program.

THE P&D MODEL

The P&D model is divided into two parts in CERAMMS. The first part is resident in the engineering module of the manpower forecasting model and calculates the P&D funding that would be required for the forecasted design placement. The funding requirement is determined by applying rates developed from an analysis of historical planning and design costs to the forecasted design placement. The funding requirement is calculated for each fund type and for the total design program. Initial design targets for P&D costs can be established by dividing the total P&D funds required by the forecasted design placement.

The second part of the P&D model is resident in the allocation model. That portion of the model establishes final P&D targets after considering certain management inputs. The management inputs considered are any special conditions that may affect the P&D funding requirement within a District. That process is analogous to the allocation procedure for manpower and S&A. However, since P&D efforts tend to be fully funded, fewer allocation scenarios will be examined for P&D than for either S&A or manpower. The components of the P&D model are depicted in Figure 4-1.

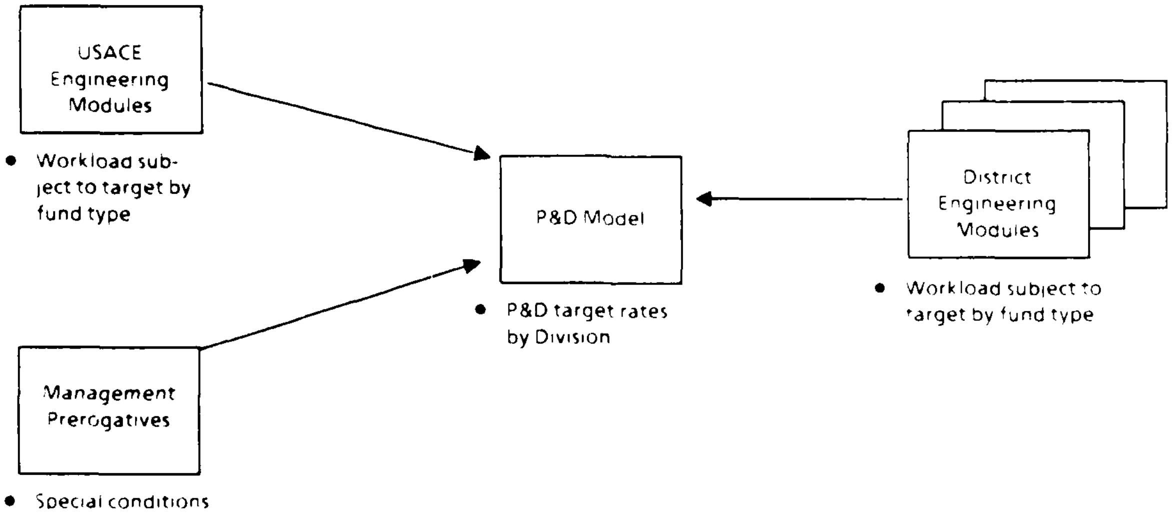
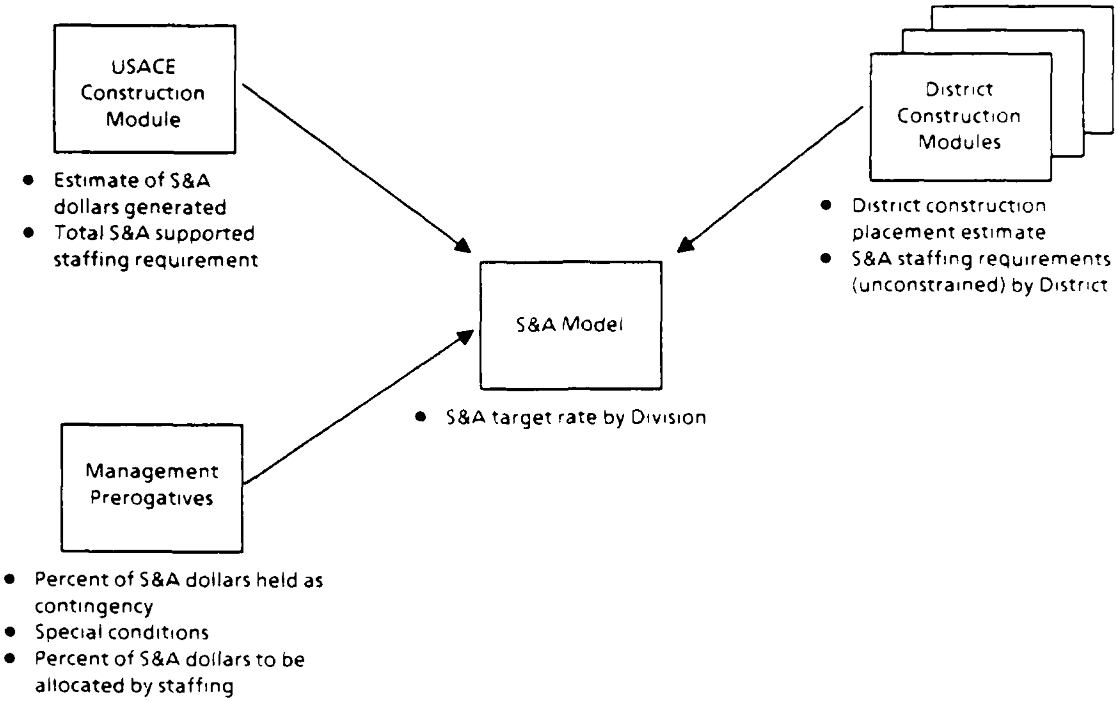


FIG 4-1. COMPONENTS OF THE P&D MODEL

THE S&A MODEL

The S&A model is also divided into two parts in CERAMMS. The first part is resident in the construction module of the manpower forecasting model and calculates the S&A funds expected to be generated by the forecasted construction placement and the S&A funding required to support the unconstrained staffing forecasted by the model. The S&A funds generated by fund type are determined by applying the appropriate S&A rate to the forecast construction placement for the fund type under consideration. The funding required to support the unconstrained staffing requirement is determined by multiplying the number of man-years required by the average cost per man-year, where the cost per man-year includes overhead and technical indirect costs.

The second part of the S&A model is resident in the allocation model. That portion of the S&A model uses management inputs to establish S&A targets in much the same fashion as manpower is allocated. The inputs to the decision process are the unconstrained S&A funding requirement, the percent of S&A funds generated to be held as contingency, the percent of S&A funds to be allocated by staffing requirements, and any special conditions that should be considered. Multiple allocation scenarios are examined by the Directorate of Engineering and Construction corporate board until a preferred solution is selected. The components of the S&A model are depicted in Figure 4-2.



- Estimate of S&A dollars generated
- Total S&A supported staffing requirement

- District construction placement estimate
- S&A staffing requirements (unconstrained) by District

- S&A target rate by Division

- Percent of S&A dollars held as contingency
- Special conditions
- Percent of S&A dollars to be allocated by staffing

FIG 4-2. COMPONENTS OF THE S&A MODEL

CHAPTER 5

NEXT STEPS

The MANTAF has identified problems with the methods that USACE has historically used to manage military engineering and construction resources. CERAMMS resolves many of those problems and provides USACE managers with the tools needed to manage their military design and construction resources effectively. Other directorates in USACE – most notably the Directorate of Resource Management (RM) – are now examining past methods of managing resources, and much of the work done in the development of CERAMMS can and should be incorporated in RM initiatives such as the establishment of manpower staffing standards. All efforts that relate to forecasting and managing resources should be coordinated with the Director of Resource Management. The coordination that occurred during the development of CERAMMS should be followed by a plan for integrating MANTAF and RM initiatives to ensure that they support one another.

The Director of Engineering and Construction needs to establish procedures for the operation and maintenance of CERAMMS. Those procedures should identify the office within the directorate that is to serve as the proponent for engineering and construction issues related to the model. We believe that proponency should be established as shown in Figure 5-1. Engineering divisions within USACE would monitor the engineering inputs and recommend changes to the engineering modules. Construction divisions would monitor the construction inputs and recommend changes to the construction modules. The corporate board of the Directorate of Engineering and Construction would provide management inputs and monitor the allocation model. The procedures should also specify who has the authority for changing input assumptions, specify the timing of submissions to USACE, define the inputs, and describe model proponency clearly and how it is intended to work. The development of these procedures is a critical step in CERAMMS operations and maintenance.

The forecasting model for total manpower requirements has been validated and was used by USACE to defend its FY87 requirements and TAA submission to Army Headquarters. The Division and District manpower forecasting models, the P&D

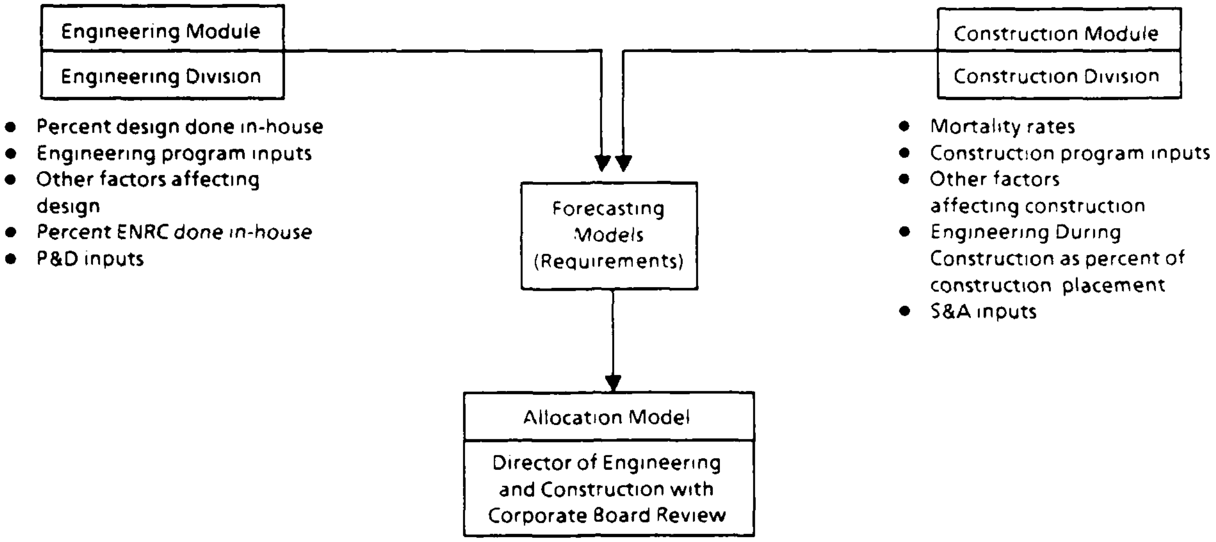


FIG.5-1. MODEL PROPONENCY

and S&A funding models, and the allocation models are currently prototype models and require follow-on actions.

We recommend the Director of Engineering and Construction take the following steps to make CERAMMS an operational system:

- Establish a permanent group within the Directorate to complete the development, validation, testing, and maintenance of CERAMMS and to use the system for preparing manpower allocation recommendations and funding targets.
- Establish FY88 performance targets for P&D and S&A using CERAMMS.
- Coordinate the development and operation of CERAMMS with the efforts of the Directorate of Resource Management to develop manpower staffing standard systems to take maximum advantage of the work done in developing the model.
- Establish regulations and procedures to incorporate CERAMMS into the existing manpower management process. The procedures should address the role of the Directorate corporate board, establish proponency for engineering and construction issues, identify who has authority to make changes, etc.

We also recommend that the Director of Engineering and Construction develop a capability to justify USACE manpower requirements based on the impacts and costs associated with understaffing Division and District requirements.

By completing the CERAMMS development, we believe the Director of Engineering and Construction will greatly improve the efficiency of the Corps of Engineers military manpower system. The benefits will extend throughout USACE and ultimately to all the departments and agencies it serves.

APPENDIX A

STATISTICAL ANALYSIS TO DETERMINE FORECASTING MODEL COEFFICIENTS

INTRODUCTION

Data for each of the following U.S. Army Corps of Engineers (USACE) components were assembled for inclusion in the manpower forecasting model:

- Division Office Staffing
- District Support Staffing
- District Construction
- District Engineering
- District Direct Engineering
- District Field Construction Offices.

For Division Office Staffing, FY 1985 data on design and construction placement and man-years were utilized, supplemented by data on field operating activity (FOA) factors relevant to Division offices (FOA factors and data are discussed in Appendix C). Therefore, each Division's placement, staffing, and FOA factor value represented an observation for analysis: all Division observations were combined into a data file for statistically determining forecasting model coefficients for Division support.

For District Support Staffing, FY 1985 data on design and construction placement and staffing were utilized and were also supplemented by data on FOA factors relevant to District offices. Each District's placement, staffing, and FOA factor value comprised an observation for analysis; all District observations were combined into a data file for statistical derivation of District Support Staffing model coefficients. Analysis of technical indirect staffing (that does not charge directly to specific projects) at the District level was segregated into District Construction and District Engineering.

Individual projects were used as the units of observation for District Direct Engineering staffing requirements. Data were obtained on programmed amount and staff-hours charged for sampled projects within each fund type from "field data calls" conducted in October and November 1986 . Separate data analysis files were created for each fund type (see Table A-1 for a fund type listing), and model coefficients were determined for each group.

Field construction offices were used as the units of observation for District Field Construction Offices. Data on placement and staffing for each fund type, augmented by FOA factor values for each field office, for fiscal years 1984, 1985, and 1986 were obtained through field data calls. Separate data files were created and analyzed for each fund type with each field office's placement, staffing, and relevant FOA factor values included.

TABLE A-1

FUND TYPE LISTING

Fund	Type listing
MCA	Military Construction Army
MCAR	Military Construction Army Reserve
MCAF	Military Construction Air Force
MCNM	Military Construction Navy and Marine Corps
MILCON-OTHER	Other Military Construction
OMA	Operation and Maintenance Army
OMAR	Operation and Maintenance Army Reserve
OMAF	Operation and Maintenance Air Force
FHA	Family Housing Army
FHAF	Family Housing Air Force
PBS	Production Base Support
FMS	Foreign Military Sales
HN	Host Nation

We used multivariate linear regression analysis to derive the relationship between workload, staffing, and relevant FOA factors for each of these model segments. Workload was measured either as programmed amount (adjusted to reflect placement by removing contingencies), engineering during construction

(EDC), or engineering not related to construction (ENRC). In all cases, the dollar values were adjusted to FY 1985 constant dollars to maintain interyear data comparability. The statistical results for individual model segments follow.

The basic multivariate model used in the regressions was:

$$\text{Staffing} = c + a(\text{Wkld}) + b(\text{Wkld}^2) + d(\text{FOA}) + e$$

where:

c = a constant term that reflects the nonvariable portion of staffing in each model,

a = staffing increases with increases in workload (Wkld) above the nonvariable component c,

b = economies of scale achieved with larger workload levels (giving a slightly curved relationship between staffing and workload as shown in Figure A-1),

d = the effect of an FOA factor (e.g., the number of active construction projects as a percentage of placement) on staffing independent of the effect of workload on staffing, and

e = an error term that accounts for random variation in staffing unaccounted for by workload and FOA factors.

DIVISION OFFICE STAFFING

Division Office Staffing (man-years) was regressed against engineering placement, engineering placement squared (i.e., the scale effect), and several FOA factors. None of the FOA factors proved to have a statistically significant effect on staffing <u>independent</u> of workload. In arriving at this conclusion, we followed a careful process to examine the potential impacts of any FOA factors. First, we ran correlations (simple linear regressions) between the FOA factors and staffing to look for potential relationships. Only a few had a statistically significant relationship. Next, we normalized each of the FOA factors by dividing each factor by Division workload [some factors, such as Outside Continental United States (OCONUS), were already normalized on workload and were left intact]. This procedure ensured that the FOA factor measured the effects of staffing that are independent of the size of the workload. Multivariate linear regressions were then run with workload, the scale factor, and the normalized FOA factors in the same equation. In this final step, only

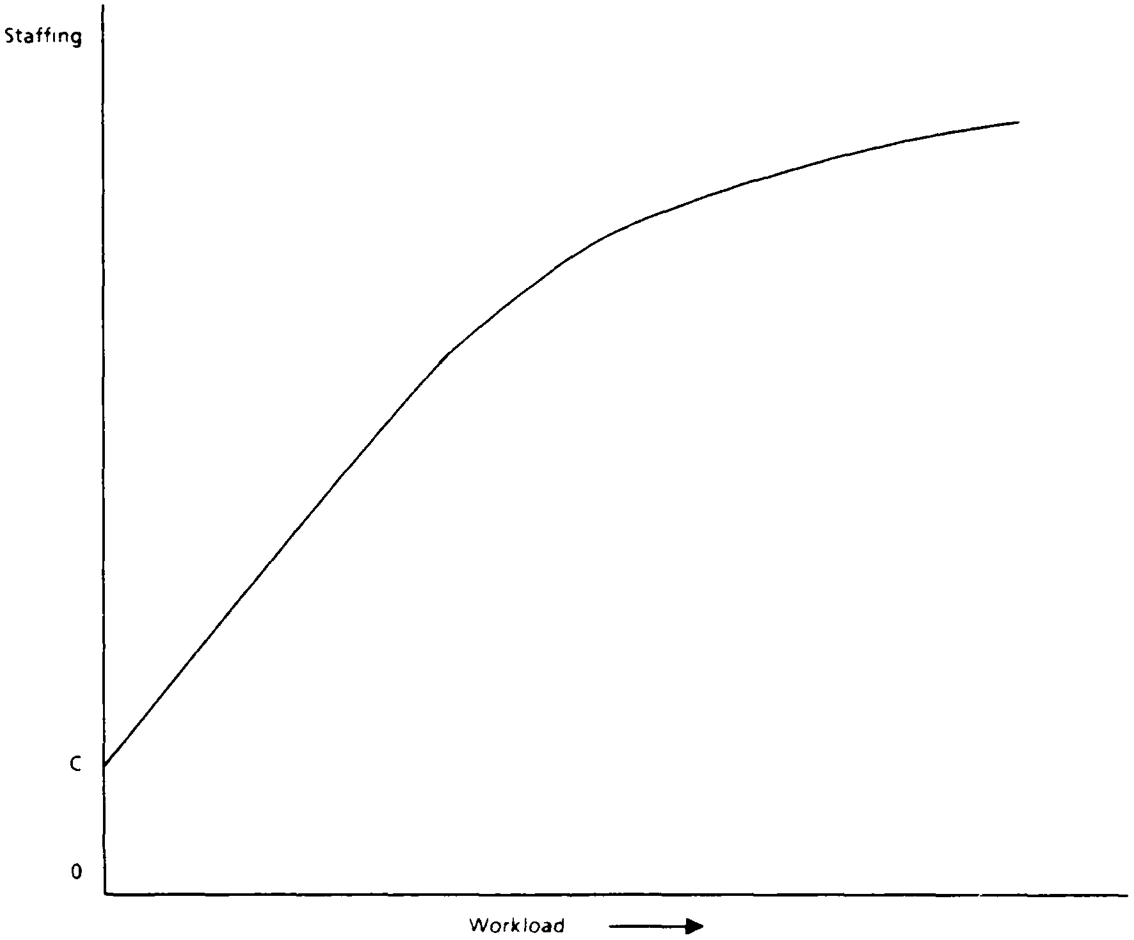


FIG. A-1. ECONOMIES OF SCALE IN STAFF UTILIZATION AS WORKLOAD INCREASES

the workload variable was significantly related to staffing. Neither the scale factor nor the FOA factors was statistically significant.

The constant, c, was determined to be 39.33, and the variable coefficient for workload, a, was determined to be 0.1703. We used those values in the manpower requirements forecasting model for Division Office Staffing. The final regression results for Division Office Staffing are shown in Table A-2.

DISTRICT STAFFING

Analysis at the District level was separated into: District Construction, District Engineering, and District Support Staffing components, and separate regressions were run for each component. Actual 1985 man-years for each

TABLE A-2

DIVISION OFFICE STAFFING REGRESSION RESULTS

Dependent variable – man-years		
Explanatory variable	Coefficient	t-statistic
Constant	39.33	2.695
Design placement (in millions)	0.1703	3.510
Adjusted R-squared (proportion of variation explained by model)		0.654
F-statistic		12.32

component were used as the measures of staffing. Design placement provided the measure of workload. The same process used in the Division analysis to search for statistically significant FOA factors was utilized in the District analysis. In the analysis of District construction, one District FOA factor – the ratio of the number of active construction projects to construction placement ($ millions) – was found to exert a statistically significant influence on staffing independent of the workload effect. This factor is denoted as CONPER in the model. No economies of scale effect was discerned for construction support. The constant (nonvariable) amount of construction support was determined to be zero. The model coefficients for design placement and CONPER were determined to be 0.0789 man-years per million dollars of design placement and 5.37 man-years for each one percentage point increase in the CONPER ratio, respectively. The regression results for District Construction Staffing are shown in Table A-3.

District Engineering Staffing proved to be a function of engineering placement only; the scale effect and FOA factors had no significant relationship with staffing independent of engineering placement. The nonvariable component was also determined to be zero. The coefficient for engineering placement was 0.1183 man-years per million dollars of engineering placement. The regression results for District Engineering staffing are also presented in Table A-3.

District Support Staffing, like District Engineering, had only one statistically significant variable – engineering placement. Neither the scale effect nor any of the FOA factors bore a significant relationship to staffing independent of engineering placement, and the nonvariable component was also determined to be zero. The coefficient for design placement was 0.4666 man-years per million dollars of engineering placement. Table A-3 shows the regression results for District Support Staffing.

TABLE A-3

DISTRICT STAFFING REGRESSION RESULTS

District Construction
(Dependent Variable = Man-years)

Explanatory variable	Coefficient	t-statistic
Engineering placement (in millions)	0.0789	20.53
CONPER	5.37	24.14
Adjusted R-squared	0.76	
F-statistic	19.75	

District Engineering
(Dependent Variable = Man-years)

Explanatory variable	Coefficient	t-statistic
Engineering placement (in millions)	0.1183	4.91
Adjusted R-squared	0.12	
F-statistic	4.91	

District Support Staffing
(Dependent Variable = Man-years)

Explanatory variable	Coefficient	t-statistic
Engineering placement (in millions)	0.4666	8.77
Adjusted R-squared	0.22	
F-statistic	8.77	

DISTRICT DIRECT ENGINEERING

District Direct Engineering was the subject of intensive data collection and analysis efforts focused on a large sample of individual projects from all of the USACE offices. The procedure began by obtaining a computerized data file from the Automated Management Project Reporting System (AMPRS) data base of all design projects that started in FY 1980 or later. That file was first divided into two files, one each for projects designed in-house and the other for projects contracted to architectural and engineering firms. Both of these files were then subdivided into the 13 fund types used by the model. The projects in each fund type were then sorted in ascending order of programmed amount and divided into quartiles, with 25 percent of a fund type's projects in each quartile. Thirty projects from each quartile were randomly selected.

We used the procedure of selecting a stratified random sample based on size of programmed amount for two reasons. First, many fund types have a relatively small number of large projects and simple random sampling would have included very few large projects. Second, and most important, we believe that the relationship between staffing and programmed amount is not a constant linear proportion throughout the entire range of projects; in particular, we wanted to allow for the possibility of economies of scale in staff utilization for large projects. An appropriate sampling scheme under these conditions is a stratified random sample based on the size of programmed amount, thus ensuring appropriate representation of all sizes of projects in the sample.

The Automated Management Progress Reporting System (AMPRS) data base provided information on programmed amount for each sampled project but not direct charged man-hours. We, therefore, sorted the sampled projects for each fund type according to Districts and mailed lists of those sampled project numbers, by fund type, to each District office. Districts were requested to query their Corps of Engineers Management Information System (COEMIS) data base and send in the total direct charged man-hours for each project, and those man-hours were keyed into the data files for analysis. More than 1,000 design projects were analyzed.

In regressions for District Direct Engineering, we used project man-hours as the variable to be explained (i.e., the dependent variable) and the programmed amount of the projects as the explanatory (i.e., independent) variable. Separate regression equations were estimated for each fund type, for both in-house and AE efforts. The regression results for District Direct Engineering showing the non-variable (or constant) amounts, coefficients for programmed amount, and the adjusted R squared (i.e., the proportion of total variation in work-years explained by the regression models) are presented in Tables A-4 and A-5.

TABLE A-4

IN-HOUSE DESIGN STAFFING REGRESSION MODEL RESULTS

Fund type	Dependent variable = man-hours						
	Constant	Prog. amt. coeff.	t statistic	Prog. amt. sqd. coeff.	t statistic	Adj. R squared	F statistic value
MCA	2,511	1,125.80	68.52	N/A	N/A	0.50	68.52
MCAR[a]	2,511	1,125.80	68.52	N/A	N/A	0.50	68.52
MCAF	4,315	727.90	16.20	N/A	N/A	0.19	16.20
OMA	343	885.50	50.19	N/A	N/A	0.54	50.19
OMAF	388	474.50	12.71	N/A	N/A	0.26	12.71
FHA	803	97.90	52.03	N/A	N/A	0.52	25.81
FHAF[b]	803	97.90	52.03	N/A	N/A	0.52	25.81
PBS	243	1197.90	41.92	N/A	N/A	0.57	41.92
FMS	- 1,510	324.60	2.04	N/A	N/A	0.23	2.04
HN[c]	2,511	1,125.80	68.52	N/A	N/A	0.50	68.52
Other	1,007	493.60	33.38	N/A	N/A	0.38	33.38

[a] Regression equation not significant, use MCA results.
[b] Regression equation not significant, use FHA results.
[c] Insufficient data points provided, use MCA results

TABLE A-5

AE DESIGN STAFFING REGRESSION MODEL RESULTS

Fund type	Dependent variable = man-hours						
	Constant	Prog. amt. coeff.	t statistic	Prog. amt. sqd. coeff.	t statistic	Adj. R squared	F statistic value
MCA	1,090	296.70	86.72	N/A	N/A	0.38	86.72
MCAR	602	726.70	19.70	N/A	N/A	0.22	19.70
MCAF	1,222	160.70	34.06	N/A	N/A	0.33	34.06
OMA	195	334.50	85.92	N/A	N/A	0.32	85.92
OMAF	147	99.20	9.30	N/A	N/A	0.12	11.60
FHA[a]	47	409.60	18.80	N/A	N/A	0.30	18.80
FHAF	47	409.60	18.80	N/A	N/A	0.30	18.80
PBS	639	267.90	92.15	N/A	N/A	0.60	92.15
FMS[b]	1,090	296.70	86.72	N/A	N/A	0.38	86.72
HN[c]	1,090	296.70	86.72	N/A	N/A	0.38	86.72
Other	562	191.30	23.75	N/A	N/A	0.22	23.75

[a] Regression equation not significant, use FHAF results.
[b] Regression equation not significant, use MCA results.
[c] Insufficient data points provided, use MCA results.

DISTRICT FIELD CONSTRUCTION OFFICES

All of the data for analyzing District Field Construction Office staffing came from the September 1986 field data call. In that data call, we asked Districts to provide figures on field construction office man-hours charged, total placement, and other FOA factors for each of the twelve fund types for fiscal years 1984–86. Further, these data were requested separately for each Area Office within each District. Average 3-year values for each variable for each office became the observations used in the final analyses.

Regression analyses utilized direct man-hours charged to construction projects in individual Area Offices as the variable to be explained (i.e., the dependent variable), and total placement in individual Area Offices as the primary explanatory (i.e., independent) variable. In addition, total placement squared was introduced to identify any economies of scale in large construction projects and the FOA factors were included for potential effects on man-hours.

The same process for identifying potentially important FOA factors in Division Office and District Support Staffing was also followed in the analyses of District Field Construction Office staffing. None of the FOA factors yielded a statistically significant effect on man-hours independent of the effect of total placement.

The scale variable (total placement squared) was statistically significant for three construction fund types – OMA, OMAR, and MILCON-OTHER. The complete final regression results for each construction fund type are shown in Table A-6. The percentage of variation in man-hours accounted for by the placement and scale factors varies from 55 percent (OMA) to 88 percent (MCA) – relatively high explanatory power for cross-section data.

CONCLUSIONS

The sampling and data analysis techniques utilized to generate the coefficients for the manpower forecasting and prototype allocation models were appropriate for the objectives of the study. The stratified random sampling of design projects from the universe of projects begun since 1980 provided representative data for all types and sizes of projects.

The primary factors for explaining/predicting staffing in District Offices were program mix (i.e., fund type), size of workload (i.e., programmed amount or placement), and economies of scale of larger workloads. In addition, we found one FOA factor – the ratio of active construction projects to total construction placement for District Construction staffing – to have significant effects on staffing independent of workload.

When placed into the USACE manpower forecasting model, the analytical regression results performed extremely well. Using programmed amounts from the applicable years, the prototype model predicted manpower requirements that were within 3 percent of the actual manpower utilized for FY85 and FY86.

TABLE A-6

CONSTRUCTION STAFFING REGRESSION MODEL RESULTS

Fund type	Dependent variable = man-hours						
	Constant	Total plac. coeff.	t statistic	Total plac. sqd. coeff.	t statistic	Adj. R squared	F value
MCA	-79.65	1,700	448.93	N/A	N/A	0.88	448.93
MCAR[b]	-79.65	1,700	448.93	N/A	N/A	0.88	448.93
MCAF	3,846.14	1,900	76.28	-1.78[a]	13.59	0.79	98.57
OMA	4,354.07	2,600	22.05	-0.610	7.37	0.55	29.32
OMAF	444.73	2,700	22.46	-1.726[a]	7.34	0.65	28.01
FHA	481.36	1,400	265.94	N/A	N/A	0.84	265.94
FHAF[c]	481.36	1,400	265.94	N/A	N/A	0.84	265.94
PBS[b]	-79.65	1,700	448.93	N/A	N/A	0.88	448.93
FMS[b]	-79.65	1,700	448.93	N/A	N/A	0.88	448.93
HN	7,474.66	0.20	32.26	N/A	N/A	0.78	32.26
Other	2,956.74	7.0×10^{-4}	3.68	6.155[a]	94.08	0.77	38.74

[a] These values are $\times 10^{-11}$.

[b] Regression equation not significant, use MCA results.

[c] Regression equation not significant, use FHA results.

APPENDIX B

STATISTICAL ANALYSIS TO DETERMINE THE PLANNING AND DESIGN MODEL COEFFICIENTS

The United States Corps of Engineers (USACE) needs the capability to consistently make accurate forecasts of Planning and Design (P&D) funding requirements for multiyear construction plans. The methodology needs to be sensitive to changes in fund-type mix and average project sizes and reflect the multiyear nature of design. The approach to forecasting P&D requirements for the model described in this report meets those needs.

Historical data on programmed amount, appropriated amount, and actual design expenditures were obtained for several fund types from USACE and U.S. Air Force data bases. Each data base provided data records on more than 6,000 construction projects. Those data were used to estimate relationships between programmed amount and actual design expenditures in an attempt to identify significant relationships that could be used to forecast future P&D resource requirements. All amounts were converted to constant FY 1985 dollars for analysis purposes.

The P&D percentages necessary to carry out project design functions were estimated for the 13 major fund type categories used in the rest of the manpower forecasting model. Besides fund type, design funding requirements were expected to be a function of project size, reflecting economies of scale in the design of larger projects. In other words, as project sizes increase, the increase in design resource requirements is expected to be proportionally less than the increase in project size. Therefore, we used a nonlinear technique to estimate P&D requirements. Models for each fund type were estimated using the following regression equation:

$$\ln(\text{Actual Design \$}) = a + b[\ln(\text{Project \$})] + d$$

where:

a = a constant term that reflects the nonvariable portion of the funding,

b = a coefficient that determines the relationship between project size and actual design dollars expended on projects for a particular fund type, and

d = the effect on a Field Operating Activity (FOA) factor on funding independent of the effect of workload on funding.

Regressions were estimated separately using the programmed amount for project dollars and then again using the appropriated amount in an attempt to discover the best prediction relationship. The first derivative of this double-natural logarithm regression equation yields the change in engineering resource requirements expended for each $1,000 change in project dollars. Since the first derivative of a natural log variable is the natural exponential function, the result is a continuous, nonlinear estimated relationship between engineering dollars and project dollars. This model worked well in explaining variations in actual engineering dollars, as shown in Table B-1. The adjustment factors in Table B-1 correct for the fact that the average value of a variable is somewhat higher than the anti-log of the average logarithmic value.

TABLE B-1

ACTUAL PLANNING AND DESIGN CHARGES IN RELATION TO PROJECT DOLLARS: DOUBLE-LOGARITHMIC REGRESSION MODEL RESULTS

Fund type	X-amt. variable	Constant	Coefficient of log amt.	Adjustment factor	R squared	F statistic
MCA[a]	Program amt.	0.4608	0.7717	1.1681	0.71	2,670
MCAF[b]	Program amt.	0.0582	0.6753	1.2107	0.58	238
Minor Const. (less than $1M)	Program amt.	0.1472	0.9377	1.1199	0.32	106
DoD	Program amt.	1.8759	0.5332	1.5680	0.27	12

[a] MCA Military Construction Army

[b] MCAF Military Construction Air Force

By taking anti-logs, we used these coefficients to estimate the <u>average</u> percent of programmed amount (or appropriated amount) that should be requested for design resources for each fund type. Those design percentages, presented in Table B-2, are the design percentages used in the manpower forecasting model described in this report. The coefficients in Table B-1 and the resulting design percentages in Table B-2 were derived from a historical distribution of project sizes for each fund type. If the distribution of average project sizes in any of the fund types changes significantly in the future, the design percentages will also change because of the significant nonlinearity that exists between project size and design resource requirements. The appropriate design percentages for different average fund type project sizes based on evaluating the natural log function at various mean values for each fund type are shown in Table B-3. Those values are presented for information only; the values shown in Table B-2 are the model coefficients.

TABLE B-2

PLANNING AND DESIGN PERCENT OF APPROPRIATED OR PROGRAM AMOUNT: ESTIMATES BASED ON DOUBLE-LOGARITHMIC REGRESSION MODEL

Fund type	X-amt. variable	Design percent
MCA	Program amt.	7.09
MCAR[a]	Program amt.	7.09
MCAF	Program amt.	7.77
Minor Const. (<$1M)	Program amt.	10.99
OMA[b]	Program amt.	10.99
OMAF[b]	Program amt.	10.99
FHA[b]	Program amt.	10.99
FHAF[b]	Program amt.	10.99
PBS[a]	Program amt.	7.09
FMS[a]	Program amt.	7.09
HN[a]	Program amt.	7.09
Other[a]	Program amt.	7.09
DoD	Program amt.	2.75

[a] Use MCA results.

[b] Use minor construction results.

TABLE B-3

PLANNING AND DESIGN PERCENTS FOR ALTERNATIVE MEAN PROGRAMMED OR APPROPRIATED AMOUNT, BY FUND TYPE (000s of FY85 $)

Fund type	$100	$250	$500	$1,000	$2,500	$5,000	$10,000	$25,000	$50,000
MCA	18.81	15.26	13.03	11.12	9.02	7.70	6.57	5.33	4.55
MCAF	28.77	21.37	17.06	13.62	10.12	8.08	6.45	4.79	3.82
Minor Cons.	12.38	11.69	11.19	10.72	10.13	9.70	9.29	8.77	8.40
DoD	34.27	22.35	16.17	11.70	7.63	5.52	3.99	2.60	1.88

APPENDIX C

MANTAF CONFERENCE SUMMARY

Part of the Phase II development effort was to develop a model to forecast the manpower requirements that the military program generates in U.S. Army Corps of Engineers (USACE) Districts and Divisions. To meet this objective, it was necessary to gain the experienced input of those field personnel most familiar with forecasting, allocation, and management of the USACE military manpower. A Manpower Task Force (MANTAF) workshop was scheduled in Arlington, TX, from August 26 through 28, 1986, and members from each USACE Military Division and District were invited to participate. Each Division sent representatives with a variety of functional backgrounds with emphasis in engineering, construction, and resource management.

OBJECTIVES

The MANTAF Conference had the following three objectives:

- Identify field operating activity (FOA) factors that contribute to manpower requirements and should be considered for inclusion in the Division and District forecasting models
- Use FOA inputs to establish priorities and define the FOA factors into measurable model variables
- Explain data call requirements necessary for Phase II activities.

IDENTIFICATION OF FACTORS THAT AFFECT MANPOWER

The workshop concentrated on identifying FOA-specific variables to be considered for inclusion in the Phase II Division/District forecasting model. Working groups were asked to concentrate on at least one of the following six primary functional areas:

- District Support Staffing
- District Engineering
- District Construction

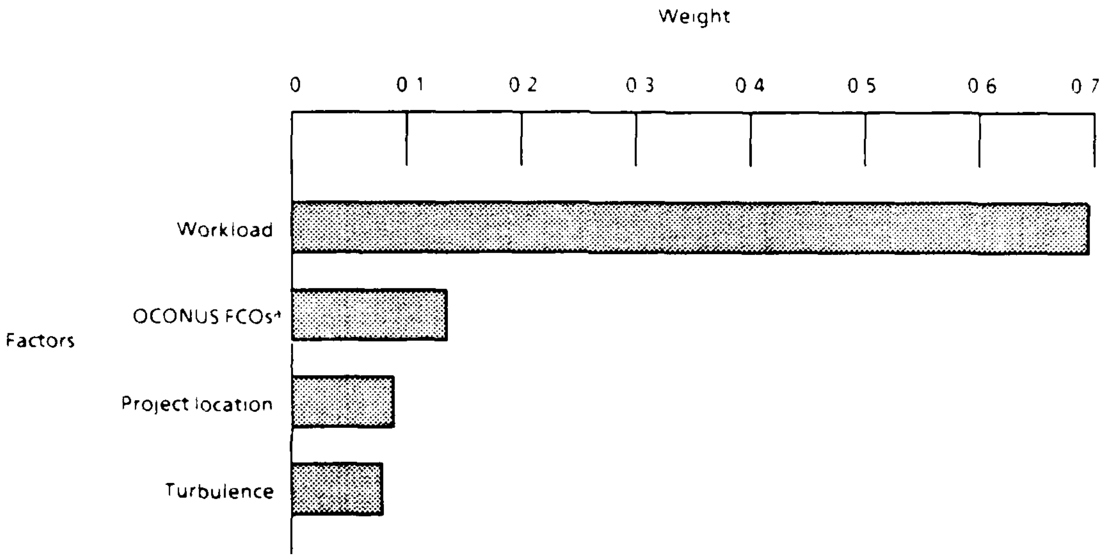
- District Direct Engineering
- District Field Construction Offices
- Division Offices.

As a first step, each group identified all the potential variables in its functional area that it considered to affect manpower staffing requirements. Each group then selected those variables that it felt either could be quantified or were unquantifiable but sufficiently important to be considered.

The next step in the factor-identification process was for each group to establish a priority list of its variables. Using Expert Choice™ software (a structured technique for rank ordering), each group developed a ranked listing of factors that it felt had a significant effect on determining manpower requirements for its primary functional area. A short list of the several most important factors was developed for each primary area.

As a final step, the most significant factors identified by each group were run through a second Expert Choice analysis, this time including workload as a variable. The final rankings for each group were presented in a full conference presentation made by the group leaders. The graphs that follow (Figures C-1 through C-4) show the relative weightings of these factors by functional area. (An "overall inconsistency index" of 0.1 or less indicates that the weightings are based on a consistent rank ordering.)

These relative weights were not used in developing the forecasting model but rather were used to guide our data collection efforts. As a result of the conference, we developed several alternative measures for each FOA factor. Through a field data call, we collected information on those variables from the USACE District Offices and included them in the statistical analysis to determine forecasting model coefficients described in Appendix A. A complete list of the variables used to measure each factor is shown in Table C-1.



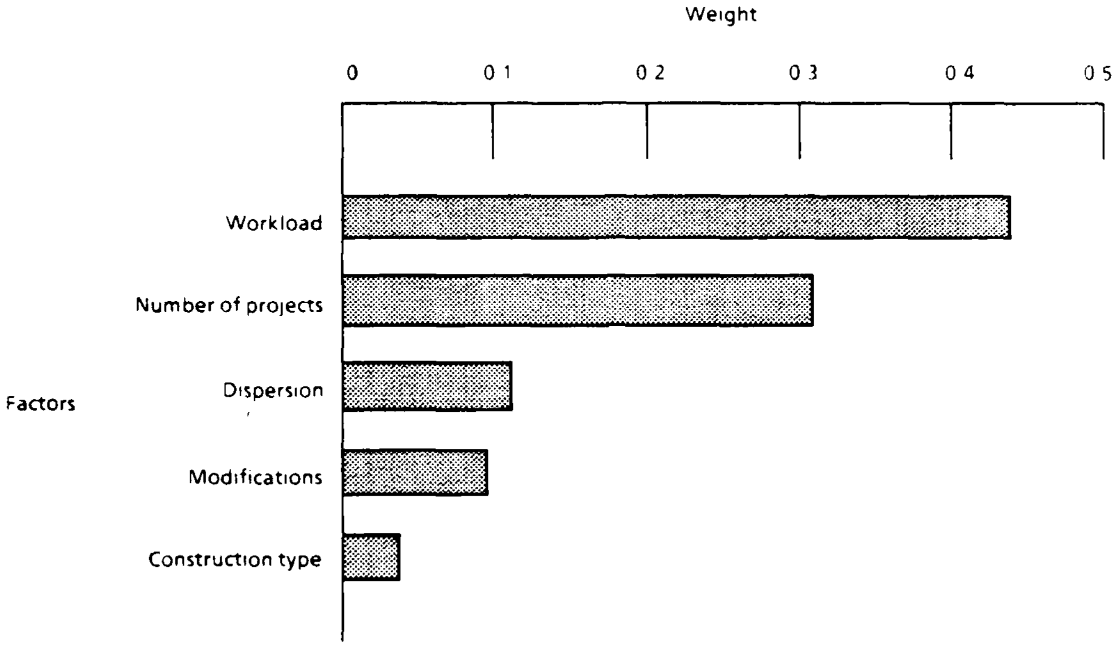
Note: Overall inconsistency index 0.11

[a] OCONUS FCO Outside Continental United States Field Construction Office

FIG. C-1. DISTRICT AND DIVISION FUNCTIONS

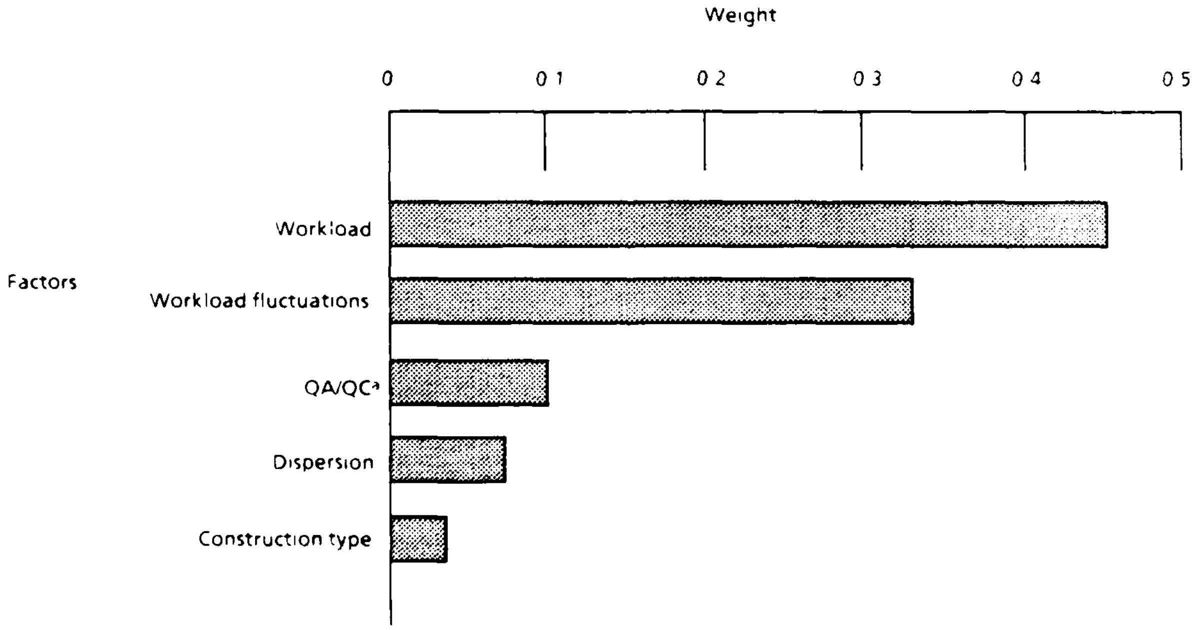
Note. Overall inconsistency index 0.[illegible]5

FIG. C-2. DISTRICT AND DIVISION FUNCTIONS



Note: Overall inconsistency index 0.09

FIG. C-3. DISTRICT CONSTRUCTION



Note: Overall inconsistency index 0.10

[a] QA/QC Quality Assurance/Quality Control

FIG. C-4. DISTRICT FIELD CONSTRUCTION OFFICES

TABLE C-1

FACTORS TESTED FOR SIGNIFICANCE IN FORECASTING MANPOWER WORKLOAD

Centralized functions
OCONUS
Number of claims
Number of reimbursable work orders
Civil/Military workload mix
Number of field offices
Turbulence
Project location
Contract type
Number of projects
Dispersion
Number of contract modifications
Number of active construction contracts
Personnel turnovers
Workload fluctuation
Level of QA/QC
Amount of Government-furnished equipment (GFE)
Amount of Government-furnished equipment (GFE)
Economy of Scale
Program mix

APPENDIX D

ANALYSIS OF ENRC AND PROJECT MORTALITY RATES

ENRC MANPOWER REQUIREMENTS

Engineering not related to construction (ENRC) includes such activities as master planning, preparation of environmental impact statements, and special studies. It is considered a major part of the U.S. Army Corps of Engineers (USACE) total workload. In the Phase I model, ENRC workload for future years was estimated by extrapolating the 1985 workload to 1986 and beyond. Separate manpower factors were developed for ENRC based on the historical experience of Districts performing such work. These factors were then used to forecast the total ENRC manpower requirements. Because ENRC is a significant staffing component, a more precise manner of estimating ENRC was needed for Phase II.

Data for the Phase II model were collected on each USACE Division from Finance and Accounting 3018C data bases for FY 1982 through FY 1985. The historical levels of ENRC spending were analyzed against engineering during construction (EDC) expenditures and construction placement expenditures for Military Construction Army (MCA) and Operations and Maintenance Army (O&MA) workloads, with program amounts adjusted to constant 1985 dollars.

Using ordinary least-squares regression analysis, we found that a strong correlation existed between total construction placement and total ENRC. Based on the correlation coefficient of the regression analysis, ENRC is estimated to be 15 percent of total construction placement. The estimated workload for ENRC activities is then converted to manpower requirements by applying the ENRC factors.

PROJECT MORTALITY RATES

Another enhancement to the Phase II Model is in the precision with which project mortality rates are estimated. Project mortality is the term used to describe the elimination of projects from a given year's construction program as the program passes through the Army, DoD, and Congressional budget reviews.

In the Phase I model, the project mortality rate was estimated to be approximately 15 percent of the Army's total military construction (MILCON) program for a given year. The measure was based on an analyses of Congressional deletions from the MILCON program. It did not attempt to break down rates by fund type and did not allow forecasts to be made for more than 1 year into the future.

In developing the Phase II model, we collected historical budget data and analyzed them to determine the estimated rate of decrement of a program as it passed through several phases of the Military Construction (MILCON) and Program Objectives Memorandum (POM) cycles. A separate analysis was done for three major fund types; MCA, Military Construction Army Reserve (MCAR), and Family Housing Army (FHA). All three fund types exhibited similar project mortality rates, and for that reason, we decided that the Phase II model need include only one mortality rate for all fund types (with the exception of operations and maintenance which have no mortality rate). The Phase II calculation was refined to take into consideration project mortality occurring in the earlier phases of the POM cycle, such as cuts made during Army and DoD budget reviews. Because of this, the model uses different rates for each year in the program cycle, as follows:

PY = 100 percent
PY + 1 = 86 percent
PY + 2 = 80 percent
PY + 3 = 73 percent
PY + 4 (and more) = 60 percent

where PY is the program year and the resulting percentage rate is the estimated percentage of the program surviving to Congressional appropriation (e.g., the estimated level of survival for a program that is 4 years away from Congressional appropriation may be expected to be cut to about 60 percent of its current dollar value by the time it reaches appropriation). The mortality rate becomes less severe as the program moves closer to appropriation. This calculation is used to adjust workload estimates for construction.

APPENDIX E

WORKLOAD SPREADING

A critical aspect in the development of a manpower forecasting model for the U.S. Army Corps of Engineers (USACE) was the development of a methodology to determine factors for spreading workload over time since design and construction program dollars (adjusted for contingencies) do not translate into workload for a single program year only. Design and construction work is spread over a number of years for the majority of USACE projects.

In particular, approximately 35 percent of the design for projects must be completed before a project can be submitted to Congress for inclusion in the appropriations for a particular year. The exception is operations and maintenance (O&M) design work, which begins in the program year. Thus, design work can precede as well as follow the program year. Construction work was assumed to begin in the program year and continue for a number of years.

The spreading algorithm takes three factors into account: project durations, project start dates during the fiscal year, and the relationships between time expended and work completed. The data used to develop the spreading algorithm came from the USACE Automated Management Project Reporting System (AMPRS) data base and included a nearly complete 10,000-record sample of USACE projects from all Districts over a number of years.

Table E-1 displays the spreading factors (i.e., the workload for each of 6 program years) that were developed by the spreading algorithm and used in the forecasting model. Design spreading factors were developed for 11 fund types for both contracted architect and engineering (AE) and in-house design as well as construction. Project efforts did not exceed 4 years for any fund type, and, moreover, the workload carried into the fourth year was very small in all cases (1 percent or less of total adjusted program amount).

We used AMPRS data to develop frequency tables showing the distribution of project durations for each of 11 fund types for AE design, in-house design, and construction. Data on a relatively large number of projects are needed to build such

TABLE E-1

WORKLOAD SPREADING RESULTS

Fund types	Fiscal year (FY) workload spread (%)						Total (%)
	FY-2	FY-1	FY	FY + 1	FY + 2	FY + 3	
Design: AE Firms							
FHA	55.7	41.1	3.1	0.1	-	-	100.0
FHAF	56.5	40.5	3.0	0.0	-	-	100.0
FMS	41.9	47.2	10.6	0.3	-	-	100.0
HN	41.9	47.2	10.6	0.3	-	-	100.0
MCA	41.6	47.6	10.5	0.3	-	-	100.0
MCAF	38.3	50.0	11.4	0.3	-	-	100.0
MCAR	41.3	47.5	11.0	0.2	-	-	100.0
OMA	-	-	61.8	35.0	3.1	0.1	100.0
OMAF	-	-	63.0	35.6	1.3	0.1	100.0
PBS	41.7	47.4	10.6	0.3	-	-	100.0
Other	52.9	41.5	5.4	0.2	-	-	100.0
Design: In-House							
FHA	52.0	44.1	3.8	0.1	-	-	100.0
FHAF	52.7	43.5	3.7	0.1	-	-	100.0
FMS	36.1	49.5	13.9	0.5	-	-	100.0
HN	36.1	49.5	13.9	0.5	-	-	100.0
MCA	34.9	50.4	14.3	0.4	-	-	100.0
MCAF	31.8	52.8	14.8	0.6	-	-	100.0
MCAR	34.4	50.2	15.0	0.4	-	-	100.0
OMA	-	-	58.1	38.0	3.8	0.1	100.0
OMAF	-	-	59.9	38.4	1.7	0.0	100.0
PBS	34.9	50.4	14.2	0.5	-	-	100.0
Other	48.1	44.8	7.0	0.1	-	-	100.0
Construction							
FHA	-	-	29.3	63.9	6.5	0.3	100.0
FHAF	-	-	29.3	63.9	6.5	0.3	100.0
FMS	-	-	20.3	62.7	16.0	1.0	100.0
HN	-	-	20.3	62.7	16.0	1.0	100.0
MCA	-	-	20.6	63.3	15.2	0.9	100.0
MCAF	-	-	21.9	63.2	14.0	0.9	100.0
MCAR	-	-	20.7	63.4	15.1	0.8	100.0
OMA	-	-	25.8	63.7	10.2	0.3	100.0
OMAF	-	-	26.4	63.8	9.5	0.3	100.0
PBS	-	-	26.7	64.7	8.1	0.5	100.0
Other	-	-	26.7	64.5	8.3	0.5	100.0

frequency tables. After we had selected only those projects that were 100 percent complete, we did not have a sufficiently large number of projects for every fund type. In particular, the in-house design data were relatively sparse. Table E-2 shows how we then combined certain fund types to obtain the sample sizes needed for the analysis. For example, AMPRS contained 512 completed Family Housing Army (FHA) projects designated as AE design, but only 63 Family Housing Air Force (FHAF) projects. Five hundred and twelve data points were sufficient to build a frequency table, but 63 were not. Therefore, we added the FHA data to the FHAF data (512 + 63 = 575 data points) to develop a frequency table of FHAF project durations. In-house design duration distributions were developed by combining both AE and in-house projects.

The resulting distributions of project durations are shown in Tables E-3 through E-5. Table E-3, for example, shows that of the FHA projects designed by AE firms, none took 2 months or less to complete, while 6.1 percent were completed in three months, 4.9 percent were completed in 4 months, and so on. Figures E-1 and E-2 show the same results graphically for Military Construction Army (MCA) and Operations and Maintenance Army (OMA). As expected, MCA projects last longer, on average, than OMA projects, for both design and construction.

We also developed distributions of start dates from the AMPRS data. To do this, we eliminated all projects with start dates on or after October 1, 1985 (since FY86 data were incomplete) and built frequency tables of start dates for AE design, in-house design, and construction. The results are displayed in Table E-6. As shown in the table, the data indicated that a large number of construction projects (about 40 percent) have historically been started in the final month of the fiscal year. September has also been the most active month for starting AE design projects as well (about 15 percent).

The final element analyzed to develop spreading factors was the relationship between time expended and work completed. We did not assume a straight-line relationship but again examined the AMPRS project data to develop time-versus-work relationships for AE design, in-house design, and construction. We found that, on average, construction and AE design projects were about 40 percent complete when half the time had elapsed, while in-house design was about 30 percent

TABLE E-2

PROJECT DURATIONS; SAMPLE SIZE

Fund types[a]	Raw data sample size	Combined fund types	Combined sample size
Design: AE Firms			
FHA	512	FHA	512
FHAF	63	FHA/FHAF	575
FMS	80	MCA/FMS/HN	1,391
HN	3	MCA/FMS/HN	1,391
MCA	1,308	MCA	1,308
MCAF	1,195	MCAF	1,195
MCAR	86	MCA/MCAR	1,394
OMA	2,093	OMA	2,093
OMAF	498	OMAF	498
PBS	190	MCA/PBS	1,498
Other	571	Other	571
Total	6,599		
Design: In-House			
FHA	101	AE/FHA[b]	613
FHAF	7	AE/FHA/FHAF	683
FMS	56	AE/MCA/FMS/HN	1,759
HN	3	AE/MCA/FMS/HN	1,759
MCA	309	AE/MCA	1,617
MCAF	249	AE/MCAF	1,444
MCAR	26	AE/MCA/MCAR	1,729
OMA	300	AE/OMA	2,3[illegible]3
OMAF	107	AE/OMAF	605
PBS	42	AE/MCA/PBS	1,849
Other	88	AE/Other	659
Total	1,288		
Construction			
FHA	416	FHA/FHAF	448
FHAF	32	FHA/FHAF	448
FMS	85	MCA/FMS/HN	1,155
HN	14	MCA/FMS/HN	1,155
MCA	1,056	MCA	1,056
MCAF	912	MCAF	912
MCAR	65	MCA/MCAR	1,121
OMA	2,178	OMA	2,178
OMAF	316	OMA/OMAF	2,494
PBS	86	Other/PBS	532
Other	446	Other	446
Total	5,606		

[a] Fund Types are defined in Figure A-1 in Appendix A

[b] AE indicates addition of AE projects of appropriate fund type(s)

TABLE E-3

PROJECT DURATIONS; DESIGN – AE FIRMS

Project length (months)	Distribution of project durations (%) by fund type										
	FHA	FHAF	FMS	HN	MCA	MCAF	MCAR	OMA	OMAF	PBS	Other
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
3	6.1	5.7	1.9	1.9	1.7	0.5	1.6	10.6	7.8	1.6	4.9
4	4.9	7.0	2.9	2.9	2.7	1.2	2.7	11.6	8.6	2.7	7.7
5	10.4	10.8	2.5	2.5	2.4	1.1	2.4	12.4	11.0	2.2	8.2
6	7.4	7.1	3.1	3.1	2.8	0.9	2.8	11.4	13.5	2.6	8.4
7	6.8	6.8	3.0	3.0	3.1	1.6	2.9	8.2	13.7	2.8	5.1
8	9.4	9.7	4.0	4.0	4.1	1.8	3.9	7.6	9.8	5.3	6.3
9	9.8	9.7	2.4	2.4	2.2	2.3	2.2	6.0	8.8	2.7	5.3
10	4.9	4.7	2.8	2.8	2.6	3.6	2.7	5.8	7.2	2.7	5.4
11	4.9	4.9	6.7	6.7	6.8	4.7	6.6	3.7	5.0	6.8	5.3
12	6.6	5.9	4.4	4.4	4.4	6.6	4.6	2.0	3.2	4.4	3.5
13	6.3	5.9	6.1	6.1	6.2	9.2	6.0	3.1	1.6	6.1	6.3
14	2.3	2.1	6.5	6.5	6.9	7.8	6.6	2.2	2.0	6.6	3.5
15	2.5	2.4	4.9	4.9	5.1	8.7	5.0	2.1	1.0	5.1	4.6
16	2.7	2.4	4.7	4.7	4.7	5.9	4.7	1.1	2.0	4.4	2.6
17	2.3	2.1	7.8	7.8	8.3	6.1	7.9	1.9	0.4	7.7	2.6
18	3.1	4.0	5.0	5.0	5.2	5.1	5.2	1.6	0.0	4.7	2.6
19	2.3	2.1	5.0	5.0	5.0	5.0	5.2	1.0	0.2	4.9	3.3
20	2.7	2.4	3.9	3.9	3.7	3.6	3.8	1.1	0.6	4.3	3.3
21	1.6	1.4	3.8	3.8	4.1	4.2	4.3	0.7	1.0	4.0	2.5
22	0.2	0.2	3.0	3.0	2.9	3.4	3.1	0.9	0.0	3.1	2.3
23	0.2	0.3	3.2	3.2	3.1	2.0	3.3	0.8	0.8	3.0	0.9
24	0.8	0.7	2.7	2.7	2.4	2.8	2.6	1.3	0.2	2.1	1.6
25	0.2	0.2	1.5	1.5	1.6	2.7	1.6	0.6	0.0	1.7	0.9
26	0.4	0.3	0.8	0.8	0.8	1.8	0.9	0.1	0.4	1.0	0.9
27	0.8	0.7	2.2	2.2	2.2	1.1	2.4	0.2	0.2	2.3	0.0
28	0.0	0.0	1.7	1.7	1.6	1.5	1.6	0.2	0.4	1.7	0.2
29	0.0	0.0	1.2	1.2	1.2	1.4	1.4	0.7	0.0	1.2	1.1
30	0.0	0.0	0.9	0.9	0.8	1.2	0.8	0.4	0.0	0.7	0.2
31	0.0	0.0	0.4	0.4	0.4	0.8	0.4	0.3	0.2	0.4	0.4
32	0.0	0.0	0.5	0.5	0.4	1.0	0.5	0.1	0.0	0.5	0.4
33	0.4	0.3	0.6	0.6	0.6	0.4	0.6	0.2	0.0	0.7	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE E-4

PROJECT DURATIONS; DESIGN – IN-HOUSE

Project length (months)	Distribution of project durations (%) by fund type										
	FHA	FHAF	FMS	HN	MCA	MCAF	MCAR	OMA	OMAF	PBS	Other
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.3	0.3	0.1	0.1	0.0	0.0	0.0	0.3	0.3	0.0	0.0
3	7.8	7.6	3.1	3.1	2.2	0.9	2.1	11.2	10.2	2.1	5.5
4	6.9	8.3	3.2	3.2	2.9	1.7	2.8	13.3	8.8	2.8	8.5
5	10.6	11.0	3.3	3.3	2.9	1.5	2.8	12.2	14.4	2.7	9.7
6	8.5	8.2	3.3	3.3	2.7	1.2	2.7	10.8	12.4	2.5	7.6
7	6.5	6.6	3.2	3.2	3.0	1.7	2.8	8.1	12.2	2.7	5.0
8	8.0	8.3	3.5	3.5	3.6	2.0	3.5	7.4	8.9	4.6	6.4
9	8.8	8.8	2.4	2.4	2.3	2.6	2.3	6.5	7.9	2.7	4.9
10	4.2	4.2	2.5	2.5	2.3	3.3	2.3	5.3	6.4	2.5	5.0
11	4.6	4.5	5.8	5.8	5.8	4.6	5.6	3.5	4.5	6.0	4.7
12	5.9	5.4	4.0	4.0	4.1	6.1	4.2	1.9	3.0	4.1	3.5
13	5.5	5.3	5.3	5.3	5.5	8.3	5.4	2.8	2.0	5.5	5.5
14	2.4	2.2	6.0	6.0	6.5	6.7	6.2	2.0	2.0	6.5	3.6
15	2.8	2.6	4.7	4.7	4.9	8.4	4.9	1.9	0.8	4.9	4.1
16	3.4	3.1	4.5	4.5	4.7	5.9	4.7	1.0	1.8	4.7	3.2
17	2.4	2.2	7.4	7.4	7.9	6.0	7.5	1.7	0.3	7.4	2.6
18	2.6	3.4	4.7	4.7	5.1	5.1	5.0	1.5	0.2	4.6	2.9
19	2.1	1.9	4.5	4.5	4.7	5.0	4.7	1.0	0.2	4.6	3.0
20	2.3	2.0	5.1	5.1	5.2	4.3	5.3	0.9	0.5	5.5	3.5
21	1.3	1.2	4.0	4.0	4.4	4.1	4.6	0.6	0.8	4.3	2.4
22	0.2	0.1	3.0	3.0	2.9	3.4	3.1	1.0	0.0	3.1	2.1
23	0.2	0.3	2.9	2.9	2.9	2.1	3.1	0.8	0.7	2.9	0.8
24	0.7	0.6	2.9	2.9	2.7	2.6	3.1	1.3	0.2	2.4	1.7
25	0.3	0.3	1.6	1.6	1.8	2.6	1.9	0.5	0.0	1.8	0.9
26	0.3	0.3	1.4	1.4	1.4	1.9	1.7	0.2	0.3	1.5	0.8
27	0.7	0.6	1.9	1.9	2.0	1.2	2.1	0.2	0.7	2.0	0.2
28	0.0	0.0	1.7	1.7	1.7	1.7	1.9	0.3	0.3	1.8	0.2
29	0.0	0.0	1.1	1.1	1.2	1.5	1.4	0.7	0.0	1.2	1.1
30	0.0	0.0	0.9	0.9	0.9	1.2	0.9	0.5	0.0	0.8	0.2
31	0.3	0.3	0.7	0.7	0.7	0.8	0.7	0.3	0.2	0.6	0.3
32	0.0	0.0	0.6	0.6	0.5	1.2	0.6	0.1	0.0	0.5	0.5
33	0.3	0.3	0.5	0.5	0.5	0.4	0.5	0.2	0.0	0.5	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE E-5

PROJECT DURATIONS; CONSTRUCTION

Project length (months)	Distribution of project durations (%) by fund type										
	FHA	FHAF	FMS	HN	MCA	MCAF	MCAR	OMA	OMAF	PBS	Other
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4
3	3.1	3.1	0.1	0.1	0.1	1.3	0.3	2.2	2.3	1.7	1.6
4	8.0	8.0	1.6	1.6	1.7	2.1	1.6	3.4	4.1	3.0	3.1
5	8.0	8.0	1.9	1.9	2.0	2.3	2.0	5.2	5.3	4.1	4.7
6	7.4	7.4	2.1	2.1	2.3	3.4	2.4	6.6	6.8	5.8	5.2
7	4.9	4.9	2.6	2.6	2.7	3.7	2.6	5.7	5.9	5.3	4.7
8	6.9	6.9	3.8	3.8	3.8	4.1	3.7	6.7	6.9	9.0	9.0
9	6.7	6.7	5.0	5.0	5.0	4.5	5.0	7.3	7.5	10.2	11.2
10	7.1	7.1	5.1	5.1	5.4	7.2	5.4	5.2	5.5	10.2	10.1
11	7.1	7.1	5.5	5.5	5.9	4.9	5.8	5.7	5.7	6.4	6.3
12	9.2	9.2	7.4	7.4	7.6	6.3	7.5	5.9	6.4	8.3	9.0
13	6.7	6.7	6.6	6.6	6.9	7.2	7.0	6.5	6.2	4.7	4.0
14	5.1	5.1	7.6	7.6	8.0	8.2	7.9	7.5	6.9	4.1	3.1
15	3.8	3.8	7.5	7.5	7.4	5.8	7.6	3.4	3.3	5.5	5.6
16	1.3	1.3	4.2	4.2	4.1	5.4	4.3	3.2	3.4	3.2	2.7
17	1.8	1.8	4.0	4.0	3.8	4.9	3.8	4.6	4.2	2.1	1.8
18	2.0	2.0	5.7	5.7	5.9	3.6	5.8	3.4	3.4	2.1	2.2
19	0.4	0.4	4.1	4.1	3.8	4.2	3.9	2.5	2.4	2.3	2.5
20	1.1	1.1	4.4	4.4	4.5	3.3	4.4	3.4	3.0	1.5	1.8
21	0.9	0.9	3.3	3.3	3.2	2.1	3.2	1.7	1.7	1.7	2.0
22	0.0	0.0	2.4	2.4	2.5	2.1	2.5	1.3	1.4	1.3	1.6
23	3.1	3.1	2.3	2.3	2.3	2.0	2.2	2.6	2.3	0.4	0.4
24	1.1	1.1	2.2	2.2	2.4	2.3	2.3	2.0	1.8	0.9	0.9
25	0.7	0.7	1.8	1.8	1.8	1.5	1.8	0.5	0.4	0.9	0.7
26	0.0	0.0	1.5	1.5	1.1	1.4	1.2	0.4	0.4	1.3	1.3
27	2.2	2.2	1.4	1.4	1.3	1.5	1.3	1.1	1.0	0.9	0.9
28	0.0	0.0	1.4	1.4	1.2	0.9	1.2	0.5	0.5	0.4	0.4
29	0.7	0.7	1.5	1.5	1.0	1.1	1.0	0.7	0.6	1.1	1.3
30	0.2	0.2	0.9	0.9	0.8	0.9	0.7	0.4	0.4	0.6	0.7
31	0.2	0.2	0.9	0.9	0.6	0.5	0.5	0.0	0.0	0.4	0.4
32	0.0	0.0	1.1	1.1	0.9	0.5	0.8	0.1	0.1	0.4	0.2
33	0.0	0.0	0.3	0.3	0.3	0.7	0.3	0.1	0.1	0.0	0.0
34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

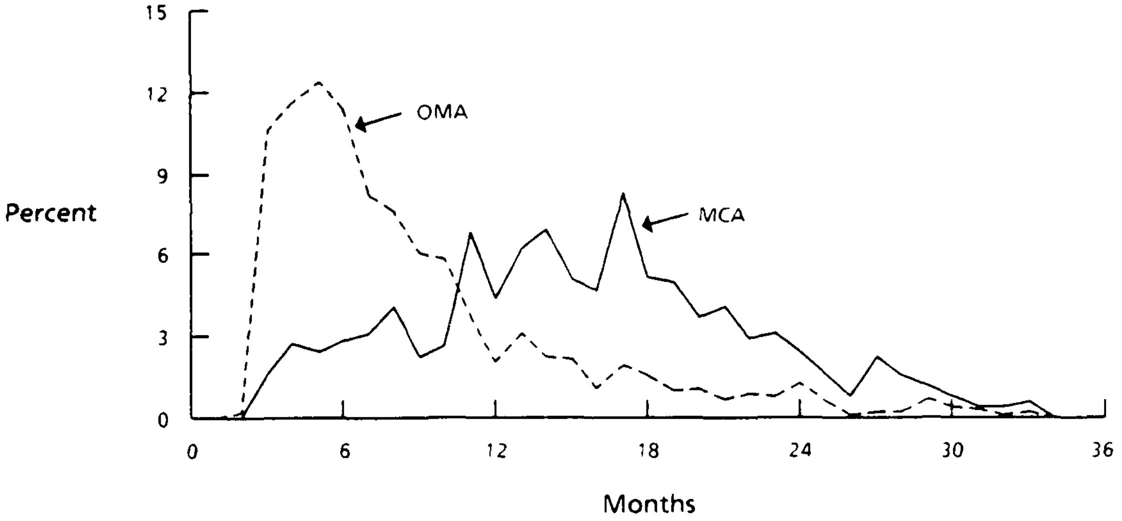


FIG. E-1. PROJECT DURATIONS: DESIGN – AE FIRMS

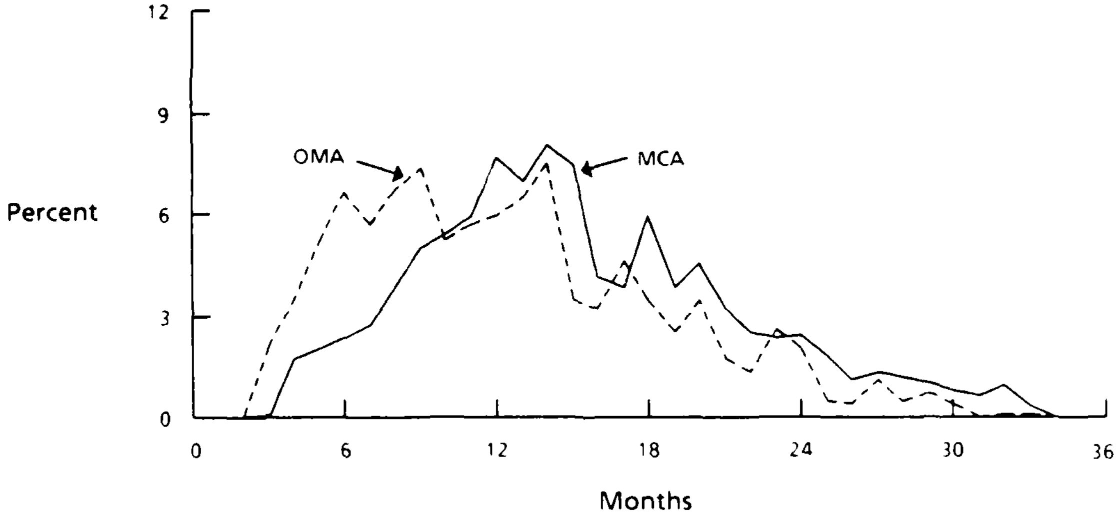


FIG. E-2. PROJECT DURATIONS: CONSTRUCTION

complete at the same point in time. Table E-7 shows the results of our analysis; those results are also shown graphically in Figure E-3.

The methodology used to calculate the spreading factors is illustrated in Tables E-8 and E-9. This algorithm is not part of the forecasting model. It was used

TABLE E-6

START DATE DISTRIBUTIONS

Month	Percent projects started		
	Design AE firms	Design In-house	Construction
October	8.0	6.9	7.0
November	5.6	6.2	1.5
December	6.1	7.7	3.5
January	5.8	10.2	2.8
February	5.9	8.4	3.5
March	8.8	10.0	6.2
April	9.1	8.8	5.2
May	9.8	7.5	7.2
June	8.8	6.6	7.2
July	8.6	8.1	6.0
August	8.6	10.7	9.3
September	14.8	8.8	40.6
Total	100.0	100.0	100.0

to calculate the spreading factors shown in Table E-1, and those factors are imbedded as constants in the forecasting model. As an example, we have shown the calculation of spreading factors for MCA construction. The entire process detailed below was repeated for each of the other 11 fund types for AE design, in-house design, and construction.

The algorithm starts by calculating the spread over time for projects that start in a particular month. As an example, Table E-8 shows the calculations for those projects that began in April. On average, projects beginning in April have 5.5 months remaining in the fiscal year. Unless they take less than 5.5 months to complete, they will carry over into the subsequent year or years; that is, the percent time spent on a particular project in any given year depends upon the length of the project and the start date.

TABLE E-7

TIME EXPENDED VERSUS WORK COMPLETED

Time expended (%)	Work completed (%)		
	Design AE firms	Design In-house	Construction
5.0	9.1	4.9	2.2
10.0	18.3	9.7	3.6
15.0	23.1	14.2	6.0
20.0	29.1	18.2	10.0
25.0	31.0	23.1	14.4
30.0	33.0	26.4	18.3
35.0	33.7	28.7	22.8
40.0	34.2	28.7	27.9
45.0	37.9	28.7	32.9
50.0	41.5	31.2	39.0
55.0	45.1	33.8	43.8
60.0	45.6	36.4	47.1
65.0	50.4	36.9	51.1
70.0	54.7	45.2	56.9
75.0	61.8	53.5	65.7
80.0	68.8	64.5	71.9
85.0	78.5	74.2	78.3
90.0	89.1	84.7	83.1
95.0	95.7	94.4	90.6
100.0	100.0	100.0	100.0

The final calculation shown in Table E-8 is the conversion from time to work, using the time expended versus work completed relationships in Table E-7.

The calculation of spreading factors for projects begun in April is shown in the top half of Table E-9. The algorithm uses matrix multiplication. The first matrix consists of the table of work completed per year by project length. The second matrix is a one-dimensional vector consisting of the distribution of project durations for MCA construction projects. Multiplying these two matrices produces the spreading

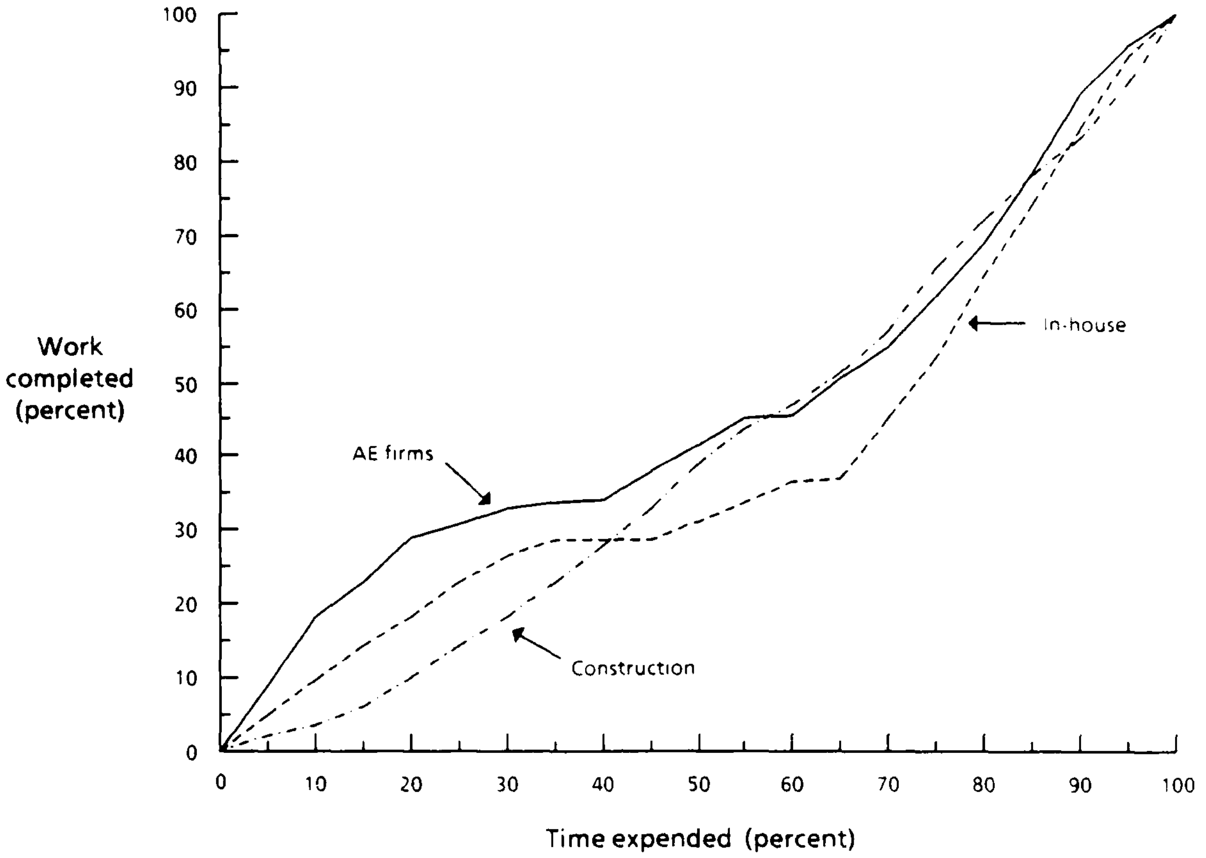


FIG. E-3. TIME EXPENDED VERSUS WORK COMPLETED

factors for projects that start in April. The entire process outlined so far is repeated for each month of the fiscal year, November through September.

The final step of the calculation is shown in the bottom half of Table E-9. Again, matrix multiplication is used. The first matrix consists of the table of spreading factors by start month. That matrix is multiplied by the vector consisting of the distribution of construction start dates. The resulting vector consists of the spreading factors for MCA construction. Only that last line of four numbers is actually used in the forecasting model.

TABLE E-8

SAMPLE SPREADING CALCULATION

Part I

Project duration	Number of months per project year				Cumulative percent time spent			
	N	N + 1	N + 2	N + 3	N	N + 1	N + 2	N + 3
1	0.5	0.0	0.0	0.0	100.0	100.0	100.0	100.0
2	1.5	0.0	0.0	0.0	100.0	100.0	100.0	100.0
3	2.5	0.0	0.0	0.0	100.0	100.0	100.0	100.0
4	3.5	0.0	0.0	0.0	100.0	100.0	100.0	100.0
5	4.5	0.0	0.0	0.0	100.0	100.0	100.0	100.0
6	5.5	0.0	0.0	0.0	100.0	100.0	100.0	100.0
●	●	●	●	●	●	●	●	●
●	●	●	●	●	●	●	●	●
30	5.5	12.0	12.0	0.0	18.6	59.3	100.0	100.0
31	5.5	12.0	12.0	1.0	18.0	57.4	96.7	100.0
32	5.5	12.0	12.0	2.0	17.5	55.6	93.7	100.0
33	5.5	12.0	12.0	3.0	16.9	53.8	90.8	100.0
34	5.5	12.0	12.0	4.0	16.4	52.2	88.1	100.0
35	5.5	12.0	12.0	5.0	15.9	50.7	85.5	100.0
36	5.5	12.0	12.0	6.0	15.5	49.3[a]	83.1	100.0

[a] (5.5 + 12.0) 35.5 = 49.3%

Project duration	Cumulative percent work completed[b]							
	N		N + 1		N + 2		N + 3	
	Time	Work	Time	Work	Time	Work	Time	Work
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
●	●	●	●	●	●	●	●	●
●	●	●	●	●	●	●	●	●
30	18.6	10.0	59.3	47.1	100.0	100.0	100.0	100.0
31	18.0	10.0	57.4	47.1	96.7	100.0	100.0	100.0
32	17.5	10.0	55.6	47.1	93.7	90.6	100.0	100.0
33	16.9	10.0	53.8	43.8	90.8	90.6	100.0	100.0
34	16.4	10.0	52.2	43.8	88.1	83.1	100.0	100.0
35	15.9	10.0	50.7	43.8	85.5	83.1	100.0	100.0
36	15.5	10.0	49.3	39.0	83.1	78.3	100.0	100.0

[b] From time expended versus work completed tables

TABLE E-9

SAMPLE SPREADING CALCULATION

Part II

Months	Percent work completed per year					MCA duration distribution	Percent work times duration distribution				
	N	N + 1	N + 2	N + 3	Total		N	N + 1	N + 2	N + 3	Total
1	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
2	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
3	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
4	100.0	0.0	0.0	0.0	100.0	1.3	1.3	0.0	0.0	0.0	1.3
5	100.0	0.0	0.0	0.0	100.0	2.1	2.1	0.0	0.0	0.0	2.1
6	100.0	0.0	0.0	0.0	100.0	2.3	2.3	0.0	0.0	0.0	2.3
•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•
30	10.0	37.1	52.9	0.0	100.0	0.9	0.1	0.3	0.5	0.0	0.9
31	10.0	37.1	52.9	0.0	100.0	0.5	0.1	0.2	0.3	0.0	0.5
32	10.0	37.1	43.5	9.4	100.0	0.5	0.1	0.2	0.2	0.1	0.5
33	10.0	33.8	46.8	9.4	100.0	0.7	0.1[a]	0.2	0.3	0.1	0.7
34	10.0	33.8	39.3	16.9	100.0	0.0	0.0	0.0	0.0	0.0	0.0
35	10.0	33.8	39.3	16.9	100.0	0.0	0.0	0.0	0.0	0.0	0.0
36	10.0	29.0	39.3	21.7	100.0	0.0	0.0	0.0	0.0	0.0	0.0
						Total:	32.4	58.3	9.2	0.2	100.0

[a] 10.0% * 0.7% = 0.1%

Month	Percent work completed per year when started in October through September					Start date distribution	Percent work times start date distribution				
	N	N + 1	N + 2	N + 3	Total		N	N + 1	N + 2	N + 3	Total
Oct	70.6	27.5	1.9	0.0	100.0	7.0	4.9	1.9	0.1	0.0	7.0
Nov	65.1	32.3	2.6	0.0	100.0	1.5	1.0	0.5	0.0	0.0	1.5
Dec	60.1	36.5	3.3	0.0	100.0	3.5	2.1	1.3	0.1	0.0	3.5
Jan	52.5	43.2	4.3	0.0	100.0	2.8	1.5	1.2	0.1	0.0	2.8
Feb	46.6	48.0	5.4	0.0	100.0	3.5	1.6	1.7	0.2	0.0	3.5
Mar	39.5	53.3	7.1	0.1	100.0	6.2	2.5	3.3	0.4	0.0	6.2
April[b]	32.4	58.3	9.2	0.2	100.0	5.2	1.7	3.0	0.5	0.0	5.2
May	25.3	63.3	11.1	0.3	100.0	7.2	1.8	4.6	0.8	0.0	7.2
Jun	18.2	67.9	13.3	0.5	100.0	7.2	1.3	4.9	1.0	0.0	7.2
Jul	11.5	71.6	16.1	0.8	100.0	6.0	0.7	4.3	1.0	0.1	6.0
Aug	6.0	73.7	19.2	1.1	100.0	9.3	0.6	6.9	1.8	0.1	9.3
Sep	2.5	73.4	22.7	1.4	100.0	40.6	1.0[c]	29.8	9.2	0.6	40.6
						Total	20.6	63.3	15.2	0.9	100.0

[b] From total line above

[c] 2.5% * 40.6% = 1.0%

APPENDIX F

USING THE MODEL

GENERAL

The automated manpower requirements model is a management tool with which USACE decision-makers can forecast staffing requirements and effectively manage their manpower resources. The model is designed so that users can easily update input variables and assumptions and check the effect on manpower levels. The information in this appendix is intended to facilitate model understanding and operation. The subject areas covered and their location in the appendix are shown below.

Equipment Needs

The Manpower Task Force (MANTAF) model requires, at a minimum, an IBM PC™ compatible computer with a hard (fixed) disk and available RAM capacity of at least 640 kilobytes. The model will run more efficiently, however, on a computer with an 80286 microprocessor (i.e., an IBM AT™ compatible computer). The model runs in about 4 to 5 minutes using an 80286 microprocessor.

The model itself is written on Lotus 1-2-3™ (Release 2) software and formatted on the MS DOS™ (Version 2.12 or higher) operating system. The model, therefore, requires that the user have a copy of Lotus 1-2-3 (Release 2) and that the user be familiar with the basic commands of Lotus 1-2-3. Full utilization of the model requires that the user know some additional Lotus 1-2-3 commands such as those which can be used to print sections of the model or to create new output tables.

Cautions

The following notes highlight some features of Lotus 1-2-3 that the model user should be aware of:

NOTE 1. The forecasting model uses formulas that refer to a number of cell locations so that input changes affect the entire model. The model user should be especially aware that data and formulas within the model affect many locations and so should avoid using the insert, delete, and move commands. (If formulas are unintentionally altered, the user should use the back-up diskettes as a reference for corrections. A back-up copy should be made of the original diskettes before using the model.) The model uses the Lotus worksheet protection features to help avoid unintentional changes.

NOTE 2. Because several of the model spreadsheets are very large and include many formulas, an input change may require a minute or so of calculation time. To save time, the user should keep the CALC (or F9) key off until all data changes have been made (recalculation is set to manual).

NOTE 3. Users should refer to the Lotus 1-2-3 Operations Guide on questions regarding Lotus 1-2-3 operations. Questions regarding the assumptions, calculations, and methodologies of the MANTAF model are explained in this final report.

NOTE 4. The model uses a number of very large Lotus 1-2-3 files that consume large amounts of RAM in the computer. If you run into "memory full" problems, check first to see if you have any RAM-resident programs running.

DETAILED INSTRUCTIONS

Model Set-Up

We recommend that the user create a number of directories on the hard disk to hold back-up copies as well as working copies of the model (assuming that sufficient memory is available). Creation of several directories allows the user to make any number of changes in the working directories while maintaining the integrity of the original model in the back-up directory. The instructions below can be used to set up a back-up directory: MODEL, and one working directory: JUN1. MODEL is the archival directory; files are read from that directory only. The working directories are used for changing inputs and running different model scenarios. Each directory uses up about 1.3 megabytes of disk space.

The user is, of course, free to use a different back-up scheme and is also free to change directory names. We recommend, however, that the user create at least one back-up directory. We have used dates to name the working files; you might prefer RUN1, RUN2 . . . , or other names more consistent with your own filing schemes.

First, create the directories on the hard disk using the following MS DOS commands shown in italics (if you prefer other names or fewer directories, simply make the appropriate substitutions or deletions):

```
C>MKDIR C:\MODEL
```

```
C>MKDIR C:\JUN1
```

Now place Disk 1 (from the original set of four model disks) into Drive A: (the floppy drive), and copy all of the files from Disk 1 to the directory MODEL as follows:

```
C>COPY A:*.* C:\MODEL
```

Remove Disk 1 from Drive A:, replace with Disk 2, and repeat the copy command exactly as shown above. (Pressing the *F3* key will cause the last command to reappear.) Repeat for Disks 3 through 4. Keep the original model disks in a safe place, do not remove the write protect tabs, and do not write to those disks.

Next, copy all files from the directory MODEL into your working directory:

```
C>COPY C:\MODEL\*.* C:\JUN1
```

Whenever you create a new working directory, use the above command with the appropriate name. The instructions titled "BACKING UP A WORKING DIRECTORY" below will show you how to back up your working directories and how to delete extraneous directories. Creation of too many working directories poses the danger of filling up your hard disk.

Do not run the model from the directory MODEL; keep that directory as your hard disk archive. You are now ready to input your data.

Input Data and Assumptions

Before detailing the operation of the model, you should be aware of the types of input data and assumptions required. We emphasize strongly that the model can produce useful projections ONLY when it receives valid inputs. Each file is listed below together with a description of the types of data needed by that part of the model. The sections that follow will tell you how to retrieve and operate these files.

CON_IN and DES_IN are the two input files; they receive the major inputs as described below. CONMOD, DESMOD1, DESMOD2, and SUMMARY are the model files; all except DESMOD2 use a few additional inputs, which we refer to as assumptions, also detailed below.

CON_IN. This file requires *construction program amounts* in millions of then-year dollars, NOT placement or current working estimate (CWE). It is extremely important that correct data is placed into the input files, since errors here will yield distorted staffing and placement projections. In particular, DO NOT SPREAD the program amounts over the life of your programs, even for past actuals, since the model does that automatically for all years.

Because the model spreads your program amount inputs over the number of years needed to complete the construction program, it requires you to input more than 1 year's data. Table F-1 shows how many years of data are required for each year to be forecast. For example, to forecast construction staffing in 1987 only, construction data are needed for the years 1984 through 1987 inclusive. If any of those 4 years are omitted, the 1987 forecast will be too low.

TABLE F-1

PROGRAM AMOUNT YEAR REQUIREMENTS

Program	To forecast fiscal year	You MUST input PROGRAM AMOUNTS for the years:
Construction		
All programs	N	N-3 through N
Engineering/Design		
Operations & Maintenance	N	N-3 through N
All others	N	N-1 through N + 2

You should put then-year or actual dollars into CON_IN; that is, the 1986 column should contain the 1986 construction program in 1986 dollars, the 1987 column should contain 1987 dollars, and so on. The model automatically converts the input data into constant year dollars. (Putting constant dollars into CON_IN will distort the output, since the dollars will be deflated twice.)

The input dollar amounts must be in millions of dollars. Put in the best data that you have: do not feel that you have to round to the nearest million. The model uses all of the decimal places that you enter and rounds the numbers for display purposes only.

DES_IN. This file requires *engineering/design program amounts* in millions of then-year dollars; as with CON_IN you must NOT input workload, placement, or CWE. Again, DO NOT SPREAD the program amounts over the life of your programs, even for past actuals, since the model does that automatically for all years.

The model spreads design program amount inputs over the number of years needed to complete the design program. The model therefore requires you to input more than 1 year's data. Design spreading is different from construction spreading in that most design work begins up to 2 years before a project can be submitted to Congress; an exception is operations and maintenance (O&M) work. Table F-1 shows how many years of design data are required for each year to be forecast. For example, to forecast design staffing in 1987 only, design data are needed for the years 1986 through 1989 inclusive (or 1984 through 1987 for O&M work). If any of those years are omitted, the forecast will be too low.

As with CON_IN, you must put then-year or actual dollars into DES_IN. The input dollar amounts must be in millions of dollars, but you do not have to round the figures to the nearest million. The model rounds the numbers for display purposes only.

CONMOD. This file calculates construction placement and area office staffing based on the program amount inputs in CON_IN. CONMOD also uses the following assumptions: (1) effective man-hours per man-year, (2) the percent of program amount that is workload, and (3) the percent of projects surviving to construction per year. If you make no changes to these assumptions the model will use the values that appear on the screen (the default values) when the file is retrieved. You DO NOT have to alter these assumptions and should not do so unless approval has been given by the Directorate of Engineering and Construction.

DESMOD1. This file calculates in-house design placement and direct staffing for in-house design based on the program amount inputs in DES_IN as well as ENRC. DESMOD1 also uses a number of assumptions. They are: (1) the percent of design done in-house, (2) engineering during construction (EDC) as a percent of construction placement, (3) the percent of engineering not related to construction (ENRC) done in-house, (4) the percent of program amount that is workload, and (5) effective man-hours per man-year. The last assumption is brought in from CONMOD and should not be changed in DESMOD1. Just as with the CONMOD file, if you make no changes to these assumptions the model will use the default values. Again, you DO NOT have to alter these assumptions and should not do so unless approval has been given by the Directorate of Engineering and Construction.

DESMOD2. You should not make any changes to this file since all of the neccesary inputs and assumptions are brought in from DESMOD1 and must not be changed. DESMOD2 calculates remaining design placement and direct staffing for contracted architect and engineering (AE) design based on exactly the same program amounts and assumptions used by DESMOD1. EDC is also calculated as a percentage of construction placement.

SUMMARY. The last model file calculates Division and District staffing (i.e., overhead and indirect design and engineering) in addition to summarizing the model results, including direct construction and design staffing and placement. SUMMARY also requires a number of assumptions. They are: (1) the number of divisions, (2) the number of Districts including operating divisions (POD and EUD), (3) the number of active construction contracts, (4) the number of Division office OMA slots, and (5) other staffing requirements. The number of active construction contracts should be a District average. Also, additional staffing should not be added unless there is good reason to believe that the model is overlooking a special category of personnel.

If you explore the spreadsheet files that make up the model, you will see many additional factors and assumptions that are used by the model to calculate staffing and placement. These factors are not variables; they are based on statistical analyses and should not be altered.

Having examined the types of data required to run the model, we can now turn to the operations you need to know in order to input the data and run the model.

Initial Data Input

Start Lotus 1-2-3 (Version 2), and set it up to call the working directory. (If you are unfamiliar with Lotus, pressing the "/" key causes a menu to appear near the top of the screen; you can then move to the appropriate command either by using the right and left arrow keys or by pressing the letter key corresponding to the initial letter of the command, i.e., *F* for FILE.):

/ *F*ILE *D*IRECTORY *C:\JUN1*

Next, retrieve the first input file, DES_IN.WK1. That file receives and processes engineering/design input data:

/ *F*ILE *R*ETRIEVE *DES_IN*

When the spreadsheet appears, it will display instructions plus space for your District or Division name. You are in a regular Lotus file and can move around in it by pressing the *HOME* key and then scrolling down and across using the arrow (cursor) keys. As with all the model files, the Home location (the upper left hand corner of the spreadsheet) gives the name of the file, indicates the version number, and shows the latest run date. Next, move to the program input location by holding down the *ALT* key and pressing *P* (for Program). You are now ready to type the input data into the unprotected cells. Enter program amounts (NOT placement) in millions of then-year (i.e., uninflated) dollars. For example, PY 1984 program amounts should be in 1984 dollars and PY 1987 program amounts should be in 1987 dollars. The numbers you enter do not have to be rounded to the nearest million; the spreadsheet rounds the numbers for display purposes only and uses the decimals in its calculations. (You can return to the initial instruction and assumption input screen at any time by holding down the *ALT* key and pressing *S*.)

Once you have entered all of your data, you can invoke the model's automatic procedures (the "macro") by holding down the *ALT* key and pressing *I* (for Input). The ALT I macro automatically converts then-year dollars into constant dollar amounts across all years of the model and carries out the first step of the data transfer to the DESMOD1.WK1 spreadsheet by placing the updated input values into a temporary file named D_IN_TEM.WK1.

Repeat the same process with CON_IN for the construction data. While still in DES_IN, enter *ALT C* to retrieve CON_IN. Once the file has appeared, type in your District/Division name, enter *ALT P*, type the input data into the unprotected cells, and then invoke the *ALT I* macro to process the revised data. (*ALT S* will get you back to the initial screen.)

The macro, ALT I, will automatically retrieve the CONMOD.WK1 file. Once that file has appeared on the screen, you must enter *ALT I* again in order to complete the transfer of the revised construction data into CONMOD. Do the same with DESMOD1; retrieve DESMOD1 and then enter *ALT I* again. You do not have to update the DESMOD2 and SUMMARY spreadsheets because the model will do that automatically when it is run.

To run the model, follow the instructions below.

Running The Model

Start Lotus 1-2-3 (Version 2) and set it up to call the working directory.

/ *F*ILE *D*IRECTORY *C:\JAN28*

Next, retrieve the first model file, CONMOD.WK1. This file processes the construction data.

/ *F*ILE *R*ETRIEVE *CONMOD*

When the file appears, it will display instructions telling you to make your desired changes. You are in a regular Lotus file and are free to move around the spreadsheet at will (by pressing the *HOME* key, for example, to move to the top leftmost corner). You can change the construction input assumptions without moving from the initial screen. Changes are allowed only in unprotected cells. (The model is very complex; cell protection prevents inadvertent changes in formulas or cell locations that could cause the model to misbehave.) If you have moved away from the initial input screen, you can return to it at any time by invoking the *ALT S* "macro"; hold down the *ALT* key and press *S*.

Once the assumptions are made, hold down the *ALT* key and press *I* to invoke the ALT I macro. (If you have already input the construction placement amounts, you can use *ALT A* instead.) ALT I automatically executes both the ALT I and ALT A macros. The macro will now take over and process the data automatically; the screen will indicate what the macro is doing.

Follow the instructions displayed on the screen. The instructions will tell you to enter *ALT B*. Now hold down the *ALT* key and press *B*. That will, among other things, automatically retrieve the next file, DESMOD1.WK1. DESMOD1 and DESMOD2 process engineering/design data. The screen message will tell you to make your desired changes to the design assumptions. You are again in a regular Lotus spreadsheet and are free to move around it and make engineering input and assumption changes in the unprotected cells. You can return to the initial input screen at any time by entering *ALT S*.

Once the engineering assumptions are made, enter *ALT I* (or *ALT C* if you have already input the design program amounts). Again follow the instructions on the screen. Those instructions will eventually tell you to enter *ALT D*, which retrieves the third file, DESMOD2. You should not need to change any inputs on this file, because the engineering inputs used by DESMOD2 are automatically brought over from DESMOD1. Enter *ALT E*, which completes transfer of the design inputs and assumptions from DESMOD1. Then, when prompted, enter *ALT F*.

ALT F retrieves the SUMMARY file. When that file appears, make whatever assumption changes are necessary and then enter *ALT G* for final processing. When that final macro is finished, it will leave you in the staffing summary section of the model. You can then move around the SUMMARY spreadsheet and study or print out the final results. A series of macros makes moving around this file easier; enter *ALT M* for a menu of these location macros. Again, *ALT S* will return you to the initial input screen.

Backing Up a Working Directory

You can back up a working directory to floppy disks at any time by using the following procedure. Other back-up procedures, such as tape back-up, are also effective.

Exit Lotus into the disk operating system (DOS).

```
/QUIT YES
```

Then make sure you are in the working directory, JUN1, by using the following DOS command:

```
C>CHDIR C:\JUN1
```

Next, place a formatted floppy disk into Drive A: and invoke the "batch file" MODBAK1.BAT. The batch file automatically copies the CONMOD.WK1 and CON_IN.WK1 files onto the first disk:

```
C>MODBAK1
```

Replace the first floppy disk with a second, and type *MODBAK2*. Repeat with three more disks using *MODBAK3* through *MODBAK4* for a total of four disks. Label the four disks and store them in a safe place.

If you have a high density drive, simply copy all files onto one disk using the following copy command:

```
C>COPY C:\JUN1\*.* A:
```

Label the high-density disk, and store it in a safe place.

Once you have copied a working directory onto floppy disks, you may want to remove the directory from your hard disk to avoid overusing memory. First remove all files as follows:

```
C>DEL C:\JUN1\*.*
Are you sure (Y/N)? Y
```

Finally, remove the directory:

```
C>RMDIR C:\JUN1
```

ABBREVIATED INSTRUCTIONS

To run through the complete sequence of input files and model files, follow the instructions below:

Input Files

1. Retrieve DES__IN.
   Type in District or Division name.
   Enter *ALT P* and type input data into the unprotected cells.
   Enter *ALT I.*
   Enter *ALT C* to retrieve CON__IN.

2. Type in District or Division name.
   Enter *ALT P* and type input data into the unprotected cells.
   Enter *ALT I.*

Model Files

3. (CONMOD is retrieved automatically.)
   Type assumptions into the unprotected cells.
   Enter *ALT I* (which automatically executes ALT A as well).
   Enter *ALT B.*

4. (DESMOD1 is retrieved automatically.)
   Type assumptions into the unprotected cells.
   Enter *ALT I* (which automatically executes ALT C as well).
   Enter *ALT D.*

5. (DESMOD2 is retrieved automatically.)
   Enter *ALT E.*
   Enter *ALT F.*

6. (SUMMARY is retrieved automatically.)
   Type assumptions into the unprotected cells.
   Enter *ALT G.*

INPUT AND MODEL FILES

Locations of major worksheet areas by column/row are shown for each of the major files in the models. In many cases, the location indicates the upper left corner of a large area such as program spreading for each fund type, etc.

File: CON_IN

A1	Title, Run date
A7	Documentation
A19	Construction program inputs (then-year $'s)
A89	Inflation factors
A99	Construction program amounts in 1985 $'s (output)

File: DES_IN

A1	Title, Run date
A7	Documentation
A19	Engineering program inputs (then-year $'s)
A89	Inflation factors
A99	Design Program amounts in 1985 $'s (output)

File: CONMOD

A1	Title, Run date
C9	Construction program inputs
A12	Staffing and S&A factors
A127	Construction program assumptions
G130	Spreading factors
A146	District field construction staffing
A1273	Construction staffing requirements - summary
A1313	Inflation factors
A1322	Construction placement by fund type (then-year $'s)
A1360	Construction placement (1985 $'s)
A1363	S&A dollars generated (then-year $'s)

File: DESMOD1

A1	Title, Run date
E9	Engineering/design program inputs
A11	Staffing and P&D factors
A128	Design program assumptions
F129	Spreading factors
A146	District in-house engineering/design staffing
A1214	Inflation factors
A1223	In-house design staffing requirements - summary
A1259	In-house design placement by fund type (then-year $'s)
A1295	In-house design placement (1985 $'s)
A1298	Construction placement (1985 $'s)
A1302	In-house P&D dollars generated (then-year $'s)

File: DESMOD2

A1	Title, Run date
E9	Engineering/design program inputs
A11	Staffing and P&D factors
A128	Design program assumptions
G130	Spreading factors
A146	District AE engineering/design staffing
A1214	In-house design and construction placement (1985 $'s)
A1222	Engineering during construction
A1240	Inflation factors
A1249	AE design staffing requirements - summary
A1285	AE design placement by fund type (then-year $'s)
A1327	AE P&D dollars generated (then-year $'s)
A1364	Total placement (1985 $'s)

File: SUMMARY

A1	Title, Documentation, Run date
A8	District and Division assumptions
A30	District and Division workloads (1985 $'s)
A46	District staffing
A68	Division staffing
A86	Construction staffing by fund type
A124	In-house design staffing by fund type
A163	AE design staffing by fund type
A203	Total design staffing by fund type
A243	Total staffing by fund type
A285	Total staffing summary
A319	Military officer and enlisted staffing
A360	Staffing by customer
A407	Construction placement (then-year $'s)
A444	In-house design placement (then-year $'s)
A481	AE design placement (then-year $'s)
A518	Total design placement (then-year $'s)

TEMPORARY FILES

Figure F-1 shows the relationships between the Lotus files that comprise the MANTAF model. The model consists of 2 input files, 4 model files, and 17 "temporary" data transfer files. The temporary files exist solely to pass data values from one input or model file to another model file; the user never needs to access these temporary files because Lotus instructions imbedded in the "macros" carry out the data transfers automatically. Figure F-1 also illustrates the sequence of macro instructions, showing the files from and to which they transfer data.

All of the temporary (data transfer) files are listed below, together with an indication of their contents. The descriptions also show the name of the originating file from which the data are taken, plus the *range name* (and the worksheet range) associated with the data within the originating file.

C_IN_TEM. Construction program amounts (1985 dollars).
From: CON_IN, *con_pa* (E103.Q215)

D_IN_TEM. Design program amounts (1985 dollars).
From: DES_IN, *des_pa* (E103.Q215)

TEMP1. Total construction placement (1985 dollars), plus effective man-hours per man-year.
From: CONMOD, *conwork* (E1360.R1360)

TEMP2. Construction staffing by fund type.
From: CONMOD, *constaff* (E1282.Q1307)

TEMP3. Construction placement by fund type (then-year dollars).
From: CONMOD, *conplace* (E1331.Q1356)

TEMP4. S&A revenues by fund type (then-year dollars).
From: CONMOD, *s&a* (E1372.R1397)

TEMP5. In-house (IH) design program amounts, including ENRC (1985 dollars).
From: DESMOD1, *des_pa* (G12.s123)

TEMP6. Design input assumptions, including effective man-hours per man-year.
From: DESMOD1, *inputs* (C132.C141)

TEMP7. Total construction and IH design placement (1985 dollars).

From: DESMOD1, *ihwork* (E1295.Q1299)

TEMP8. IH design staffing by fund type.
From: DESMOD1, *ihstaff* (E1229.Q1254)

TEMP9. IH design placement by fund type (then-year dollars).
From: DESMOD1, *ihplace* (E1266.Q1291)

TEMP10. IH design P&D requirements by fund type (then-year dollars).
From: DESMOD1, *ihp&d* (E1309.Q1336)

TEMP11. AE design staffing by fund type.
From: DESMOD2, *aestaff* (E1255.Q1280)

TEMP12. Total construction, design, and EDC placement (1985 dollars).
From: DESMOD2, *totwork* (E1367.Q1371)

TEMP13. Engineering during construction staffing.
From: DESMOD2, *edc* (E1237.Q1237)

TEMP14. AE design placement by fund type (then-year dollars).
From: DESMOD2, *aeplace* (E1292.Q1317)

TEMP15. AE design P&D requirements by fund type (then-year dollars).
From: DESMOD2, *aep&d* (E1334.Q1359)

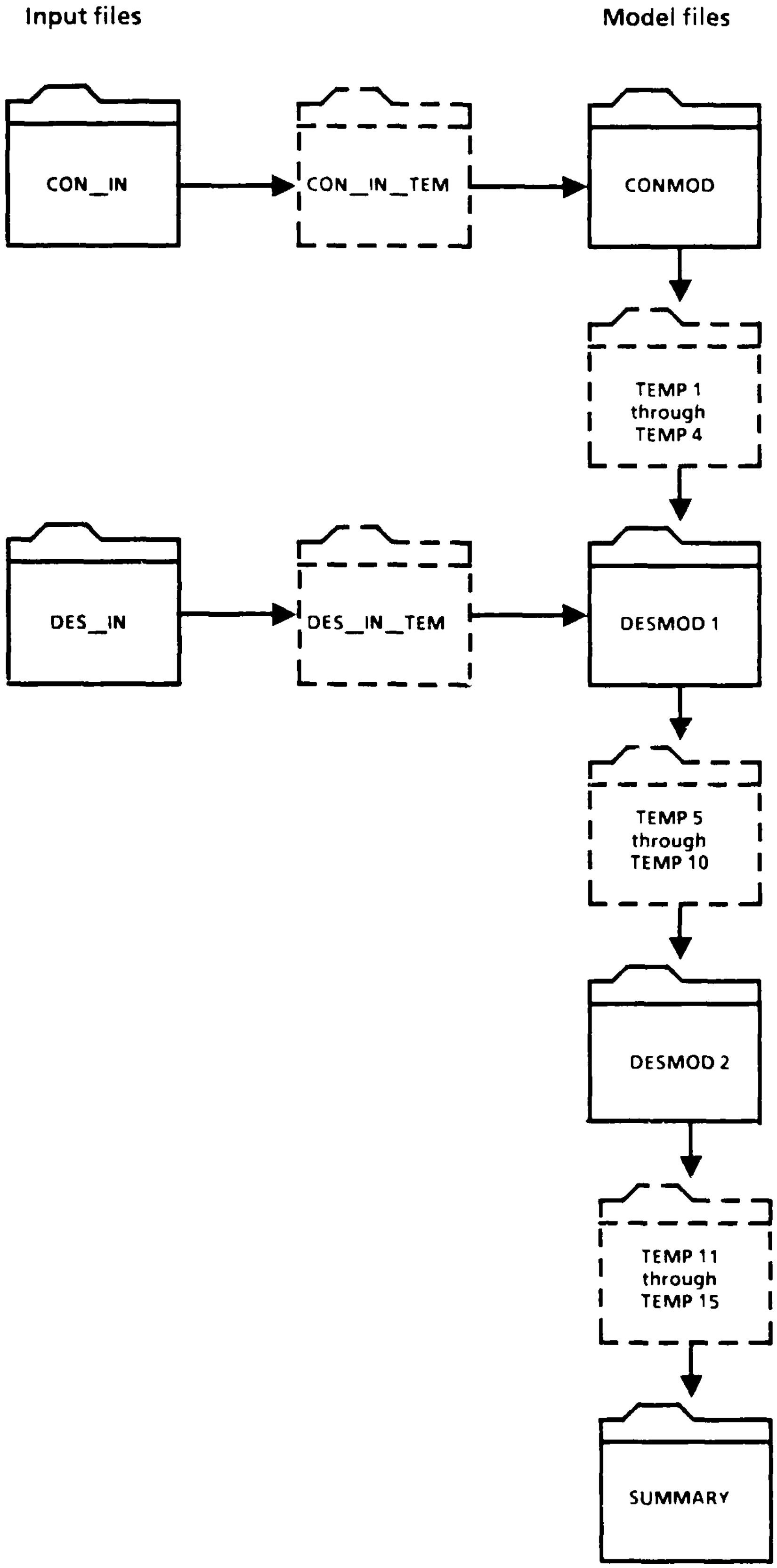


FIG. F-1. HOW THE MODEL OPERATES
(Input files, model files, and data transfer files)

REFERENCE GUIDE TO SPREADSHEET CALCULATIONS

The following sections describe the calculations in each of the models. Included are the *item name*, (the worksheet location), and a description of the calculation. Where there are multiple calculations, only the cell location for the first calculation is given. Table F-2 provides a summary of the relationships between model inputs and model outputs.

CONMOD

District Field Construction Staffing
(Calculated separately for each fund type)

Annual Program Amount, (C159.C171).[1] Program amount multiplied by the percentage of projects surviving to construction.

Annual Workload, (E159.Q171). Annual program amounts multiplied by construction spreading factors for that fund type.

Program Additions and Deletions, (E175.Q175). Input amounts taken as cuts or additions to the program. This is a direct input.

Adjusted Total Workload (E177.Q177). Sum of the annual workload amounts minus program deletions plus program additions, multiplied by the percentage of the program amount that is workload.

Percent Workload > $5 Million, (C179). Percentage of workload consisting of projects larger than $5 million.

Average Area Office (AO) Placement, (C180). Historical placement for that fund type.

Number of Area Offices (AO), (E181.Q181). Adjusted total workload amount divided by average AO placement.

Non-Variable Staffing, (E183.Q183). Non-variable man-hour factor multiplied by adjusted total workload, multiplied by percent workload > $5 million, divided by average AO placement.

Variable Staffing, (E184.Q184). Variable man-hour factor multiplied by adjusted total workload, multiplied by percent workload > $5 million plus the economy of scale factor multiplied by average AO placement squared multiplied by number of area offices.

Total Staffing, (E186.Q186). The sum of non-variable and variable staffing.

---

[1] Cell locations are specific to the first fund type in each module.

S&A, (E199.Q199). The S&A rate for that fund type multiplied by adjusted total workload equals the estimated S&A requirement.

Construction Placement (by fund type), (E1331.Q1356). Adjusted spread workload (in 1985 dollars) divided by 1985 deflation factor (E1319.Q1319).

S&A Dollars Generated (by fund type), (E1372.Q1397). S&A divided by 1985 deflation factor.

DESMOD1

District In-House Engineering/Design Staffing
(Calculated separately for each fund type)

Annual Program Amount, (C159.C170). Program amount multiplied by the percentage of design workload done in-house.

Annual Workload, (C158.G170). Annual program amounts multiplied by in-house workload spreading factors for that fund type.

Program Additions and Deletions, (E172.Q172). Amounts of program cuts or additions taken for design for that year. This is a direct input.

Total Spread PA, (E174.Q174). Sum of workload dollars by fiscal year plus any program additions, minus any program deletions.

Net Total Workload, (E175.Q175). Total workload multiplied by percentage of program amount that is workload.

Percent Workload > $5 Million, (C177) Percentage of workload consisting of projects larger than $5 million.

Average Project Size, (C178). Historical Corps average project size for that fund type design.

Number of Projects, (E179.Q179). Net total workload, multiplied by percent workload > $5 million, divided by average project size.

Non-Variable Staffing, (E181.Q181). Non-variable man-hour factor multiplied by net total workload, multiplied by percent workload > $5 million, divided by average project size.

Variable Staffing, (E182.Q182). Variable man-hour factor multiplied by percent workload > $5 million multiplied by net total workload.

Total Staff, (E184.Q184). The sum of the nonvariable and variable staffing.

Total In-House Staffing, (E195.Q195). Total staffing for in-house design.

P&D, (E197.Q197). The P&D rate for that fund type multiplied by net total workload equals the estimated P&D requirement.

In-House Design Placement, (E1266.Q1291). Net total workload (in 1985 dollars) divided by 1985 deflation factor (E1220.Q1220).

P&D Dollars Generated, (E1309.Q1334). P&D divided by 1985 deflation factor.

Engineering Not Related to Construction (ENRC)

Army Installation (AI) Support Placement, (G121.S121). Construction placement multiplied by 0.015 (percent of placement) multiplied by 0.398 (AI as % of ENRC).

Other Army (OA) Support Placement, (G122.S122). Construction placement multiplied by 0.015 (percent of placement) multiplied by 0.398 (OA as percent of ENRC).

Non-Army (NA) Support Placement, (G123.S123). Construction placement multiplied by 0.015 (percent of placement) multiplied by 0.204 (NA as percent of ENRC).

Total Workload, (E1159.Q1159). AI placement plus OA placement plus NA placement.

In-House Workload, (E1162.Q1162). Total workload multiplied by percent ENRC in-house.

AI Support Staffing, (E1165.Q1165). AI placement multiplied by percent ENRC in-house multiplied by ENRC staffing factor.

OA Support Staffing, (E1166.Q1166). OA placement multiplied by percent ENRC in-house multiplied by ENRC staffing factor.

NA Support Staffing, (E1167.Q1167). NA placement multiplied by percent ENRC in-house multiplied by ENRC staffing factor.

P&D, (E1172.Q1172) in-house ENRC placement multiplied by P&D percent.

DESMOD2

District AE Engineering/Design Staffing
(Calculated separately for each fund type)

AE staffing calculations are identical to the in-house calculations with the substitution of percent AE and AE non-variable and variable staffing factors.

EDC Staffing

EDC Placement, (E1225.Q1225) Constructed placement multiplied by EDC as a percent of placement.

In-House Non-Variable Staff, (E1227.Q1227). EDC placement multiplied by percent in-house (E1226.Q1226, hidden) multiplied by OMA in-house non-variable staffing factor divided by average OMA project size.

In-House Variable Staff, (E1228.Q1228). EDC placement multiplied by percent in-house (E1226.Q1226, hidden) multiplied by OMA in-house variable staffing factor.

Total IH Staffing, (E1230.Q1230). Non-variable staffing plus variable staffing.

Summary

District Staffing

(If number of Districts plus number of operating Divisions is zero, then District staffing is zero, otherwise staffing is calculated as given below.)

District Support Staffing, (E55.Q55). Design placement multiplied by support staffing factor.

District Construction Staffing (E59.Q59). Design placement multiplied by construction staffing factor. Plus (if following amount > 10) number of construction contracts divided by construction placement multiplied by number of Districts multiplied by construction contract factor.

District Engineering Staffing (E63.Q63). Design placement multiplied by the District engineering factor.

Total District Staffing (E65.Q65). Total of above.

Division Office Staffing

(If number of Divisions plus number of operating Divisions is zero, then Division staffing is zero, otherwise staffing is calculated as given below.)

Non-Variable Staffing (E76.Q76). Number of Divisions plus number of operating Divisions multiplied by non-variable staffing factor.

Variable Staffing (E78.Q78). Construction placement multiplied by variable staffing factor.

Total Division Staffing (E81.Q81). The sum of the nonvariable staffing plus the variable staffing.

Total Staffing Summary

District Support Staffing (E294.Q294). From above calculation.

District Construction (E296.Q296). From above calculation.

District Engineering (F298.Q298). From above calculation.

District Direct Engineering (E300.Q300). Design staffing plus EDC staffing.

District Field Office Staffing (E302.Q302). Same as construction staffing.

Division Staffing (E304.Q304). From above calculation.

Total (All fund sources) (E307.Q307). Total of all staffing.

Division Office OMA Staff (E309.Q309). This is a direct input to the model.

Subtotal MCA Funded (E311.Q311). Total staffing minus Division office OMA staff.

Total MCA Funded Requirements (E315.Q315). Subtotal MCA funded plus other requirements.

TABLE F-2

RELATIONSHIP BETWEEN MODEL INPUTS AND MODEL OUTPUTS

Outputs	Inputs													
	Construction PA	Design PA	Manhours per man-year	% PA	% Survival	% IH	EDC % of placement	Other engineering (% IH)	# of divisions	# of operating divisions	# of districts	Active construction contracts	MCA/OMA ratio	Other staffing
Construction:														
Construction staffing	x		x	x	x									
Construction placement	x			x	x									
S&A	x			x	x									
Engineering design:														
Design staffing[a]	x	x	x	x	x	x		x						
Design placement		x		x		x								
P&D		x		x		x								
Other engineering placement	x			x	x			x						
EDC staffing	x		x	x	x	x	x							
Overhead and totals:														
District support staffing		x		x		x				x	x			
District construction	x	x		x	x	x				x	x	x		
District engineering		x		x		x				x	x			
District direct engineering[b]	x	x	x	x	x	x	x	x						
District field office staffing[c]	x		x	x	x									
Division staffing	x			x	x				x	x				
Total staffing (all fund sources)	x	x	x	x	x	x	x	x	x	x	x	x		
Division office OMA staff	x	x	x	x	x	x	x	x	x	x	x	x	x	
Subtotal MCA funded	x	x	x	x	x	x	x	x	x	x	x	x	x	
Total MCA funded requirement	x	x	x	x	x	x	x	x	x	x	x	x	x	x

[a] Includes [illegible]

[b] Includes EDC

[c] Equals construction staffing.

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Logistics Management Institute

6b OFFICE SYMBOL *(If applicable)*

7a NAME OF MONITORING ORGANIZATION

6c. ADDRESS *(City, State, and ZIP Code)*
6400 Goldsboro Road
Bethesda, Maryland 20817-5886

7b ADDRESS *(City, State, and ZIP Code)*

8a NAME OF FUNDING / SPONSORING ORGANIZATION
U.S. Army Corps of Engineers

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20 Massachusetts Ave., N.W.
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19 ABSTRACT *(Continue on reverse if necessary and identify by block number)*

The U.S. Army Corps of Engineers provides design and construction management services for military and civil works programs. In 1986, the military programs for Army, Air Force, defense agencies, and several nondefense agencies exceeded $6 billion and required a 14,000-person work force to execute. Managers in USACE must continually adjust the work force to accommodate changes in the the size, location, and composition of the annual workload. To do this, they need the capability to quickly and accurately forecast manpower and funding requirements and to allocate the available resources to operating Divisions and Districts. We have developed the Corps of Engineers Resource and Manpower Management System (CERAMMS) to provide that capability for Military programs. This system enables managers to forecast manpower requirements, planning and design (P&D) funding requirements, and supervision and administration (S&A) funding requirements for all of USACE and its individual Divisions and Districts. It also enables managers to examine options for allocating manpower resources to the Divisions and Districts.

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83 APR edition may be used until exhausted
All other editions are obsolete

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LMI

Executive Summary

CORPS OF ENGINEERS RESOURCE AND MILITARY MANPOWER SYSTEM

The U.S. Army Corps of Engineers (USACE) provides engineering and construction management services for both military and civil works programs. In 1986, the military programs for Army, Air Force, defense agencies, and several nondefense agencies exceeded $6 billion and required a 14,000-person work force. Managers in USACE must continually adjust the work force to accommodate changes in the size, location, and composition of the annual workload.

To make such adjustments, managers need the capability to forecast manpower and funding requirements quickly and accurately and to allocate the available resources to the Divisions and Districts. We have developed the Corps of Engineers Resource and Military Manpower System (CERAMMS) to provide that capability for the military programs.

CERAMMS combines computer models, management policy controls, and Department of the Army resource constraints. It enables managers to forecast manpower requirements, planning and design (P&D) funding requirements, and supervision and administration (S&A) funding requirements for all of USACE and its individual Divisions and Districts. It also enables managers to examine options for allocating manpower resources to the Divisions and Districts.

The forecasting model for total manpower requirements has been validated and was used by USACE to prepare its FY87 and Five Year Defense Plan requirements (Total Army Analysis). The Division and District manpower forecasting models, the P&D and S&A models, and the allocation model are currently prototype models that need to be validated and refined.

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To make CERAMMS an effective operational system, we recommend the Director of Engineering and Construction:

- Establish a permanent group to complete the development, validation, and testing of CERAMMS, maintain it, and use it for preparing manpower and funding recommendations.
- Use CERAMMS to establish FY88 target rates for charging P&D and S&A costs to customers.
- Coordinate the development and operation of CERAMMS with the efforts of the Directorate of Resource Management to develop Manpower Staffing Standard Systems (MS3).
- Establish regulations and procedures to incorporate CERAMMS into the existing manpower management process.

We also recommend that the Director of Engineering and Construction develop a capability to quantify the costs and impacts of staffing Divisions and Districts below the forecasted manpower requirement levels.

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