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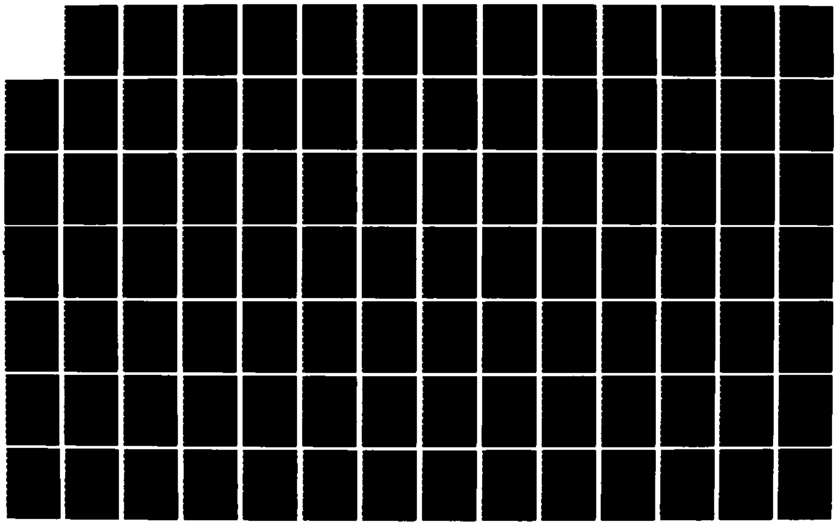

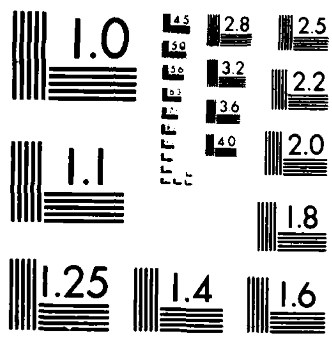

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ANALYSIS OF THE PERCEPTIONS OF
CPM AS A PROJECT MANAGEMENT TOOL ON
BASE LEVEL CIVIL ENGINEERING PROJECTS

THESIS

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AFIT/GEM/DEM/86S-21

ANALYSIS OF THE PERCEPTIONS OF CPM AS A PROJECT MANAGEMENT TOOL ON BASE LEVEL CIVIL ENGINEERING PROJECTS

THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Engineering Management

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Abstract

This study identifies current project management practices and investigates the knowledge and use of the Critical Path Method (CPM) in base level civil engineering contract projects. The increased approval authority for maintenance, repair, and minor construction projects accents the need for good project management. CPM is a widely-used management technique on large construction projects, but its value for these smaller operations and maintenance projects is less publicized. A survey questionnaire was developed to colelct data from senior managers in CONUS base level Engineering and Environmental Planning branches. The survey results indicate these managers are somewhat satisfied with their current methods of managing base-level projects but are dissatisfied in some areas. The perceived knowledge of CPM terms, concepts, and applications is average to below average. Most experience with CPM is with MCP projects. Half of those responding believe that CPM would be effective on base-level projects, and half feel it would be ineffective. Those with the most association with CPM projects tend to be among those who feel it would be effective on base-level projects.

ANALYSIS OF THE PERCEPTIONS OF
CPM AS A PROJECT MANAGEMENT TOOL
ON BASE LEVEL CIVIL ENGINEERING PROJECTS

I. Introduction

Overview

This chapter presents a general background on the increased approval authority for Operations and Maintenance (O & M) civil engineering projects, highlighting the need for good project management. The specific problem statement of this research study is then stated, followed by the research objectives. Finally, the scope of the study and definitions of frequently-used terms are presented.

Background

In recent years, the Air Force has delegated increased authority for approval of projects in maintenance, repair, and minor construction work classifications to lower levels of command (8; 28). Air Force Regulation (AFR) 86-1, Programming Civil Engineering Resouces, dictates approval levels for these O & M projects. Table 1.1 displays this information and shows the difference between the 1980 and 1985 approval authorities. The same regulation allows commanders of major commands to further delegate all or part of their authority as low as installation commanders (8:11). Table 1.2 shows the latest approval authorities which the seven major CONUS commands delegate to their installation commanders.

Table 1.1

Project Approval Levels ($000) (8:14; 17)

Class of Work	MAJCOM	HQ USAF	Sec. of AF
Maintenance (EEIC 521)			
1980	500	Unlimited	NR
1985	Unlimited	NR	NR
Repair (EEIC 522)			
1980	300	400	Unlimited
1985	3000	0	Unlimited
Minor Construction (EEIC 529)			
1980	100	300	400
1985	200	500	1000

Table 1.2

MAJCOM Delegation of Approval Authority ($000)

Command	Maintenance	Repair	Minor Constr.	Source
SAC	1000	1000	150	(2)
MAC	500	300	150	(31)
TAC	1000	500	150	(23)
ATC	750	750	100	(3)
AFLC	750	500	125	(30)
AFSC	Unlim	1000	200	(15)
SPACE	250	200	100	(22)

The significance of these figures lies, not in the comparison among commands, but in the magnitude of the project size which the commands authorize their bases to design, contract, and manage. As these projects grow in scope and complexity, project management becomes an increasingly significant factor. The Air Force must therefore insure that project managers have the best available management tools to effectively handle this increased responsibility.

One of the most widely-used project management tools in the construction industry is the Critical Path Method (CPM) (7:80-83; 20:37). A type of network analysis system used in planning, scheduling, and controlling complex projects through the use of graphical network diagrams, CPM supports many of the features inherent in the project management concept.

The Air Force does not require CPM use in construction, although it does place value in its application. The DOD Federal Aquisition Regulation Supplement (DFARS) authorizes the contracting officer to specify a network analysis system in fixed price construction contracts (12). The Air Force FAR Supplement (AFFARS), in addition, recommends such a system for family housing renovation projects (9). Finally, the School of Civil Engineering of the Air Force Institute of Technology (AFIT) offers lessons in CPM among its continuing education programs.

Although CPM is most commonly used on large, complex projects, some suggest that with the increasing size of base-level O & M projects, CPM could be of great value on these projects as well (7:80; 27). The belief, however, is that CPM is not a common management tool in this area (27).

Statement of the Problem

The School of Civil Engineering strives to maximize the benefits of its CPM instruction to best satisfy the needs of the Air Force civil engineering community. In order to accomplish this goal, the school needs an indication of the existing knowledge, experience, and perceived effectiveness of CPM in project management. This research study determines the current methods of project management used on base-level civil engineering projects and analyzes the perceived effectiveness of CPM by senior managers as it applies to this process.

Research Objectives

The primary objective of this study was to solicit information and opinions from senior managers in base-level engineering regarding the use of CPM as a project management tool on base-level projects. The following specific objectives channeled the research toward meeting this primary goal:

1. Determine if current methods of managing base-level civil engineering projects are perceived as satisfactory.

2. Determine if engineering managers are knowledgable in the terms, concepts, and potential applications of CPM.

3. Determine the experience engineering managers have with CPM.

4. Determine engineering managers' perceptions of CPM's advantages and disadvantages.

5. Determine the criteria that engineering managers consider important in deciding whether or not CPM is

appropriate for a project.

6. Determine if engineering managers believe CPM would be effective for base-level projects.

Scope of Study

This study does not evaluate the current methods for managing base-level civil engineering projects. Neither does this report recommend that CPM be used as a project management tool on base-level projects. This study does, however, collect information on (1) current project management practices, (2) knowledge of and experience with CPM as one of many possible project management tools, and (3) the perceptions, by those with CPM experience, of its value and potential effectiveness on base-level projects.

Definitions

Base-level Civil Engineering Projects. Projects whose design specifications and contract management are accomplished by the base civil engineering organization. For the purposes of this study, these projects include work in the Maintenance, Repair, and Minor Construction classifications. These work classifications fall under the Operations and Maintenance program.

Project Management. Making of decisions concerning the planning, organizing, directing, and controlling of project systems.

II. Literature Review

Overview

The use of CPM as a project management tool has grown since its origination in the late 1950's. With this maturation and diffusion throughout the construction industry, in particular, it has gathered both supporters and dissenters. The following discussion provides a simplified description of the CPM network logic and construction, followed by a broad overview of how CPM works as a project management tool. Finally, this chapter reviews the current literature with regards to the criticisms of CPM in project management.

Description

The basic premise of CPM is that a project consists of well-defined jobs, or activities, having fairly certain time durations, with a logical sequence of performance (7:83; 33:3). Several definitions, conventions, and rules provide the building blocks for the CPM network.

An activity is a portion of the project which consumes time and resources (29). Figure 2.1 shows the graphic representation of an activity as an arrow.

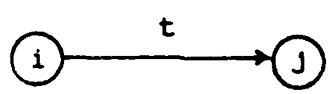


Figure 2.1 Activity and Event Notation

The end points of an activity, called events, signify instantaneous points in time, only indicating the start and end points of an activity (29). Circles, or nodes, are the graphic representations of events, with each event assigned a distinct number. The starting activity event is called the i, and the ending event is the j. Therefore, each activity can be described by its own i-j number.

The activity duration, which conventionally appears as a number above the activity arrow, is an estimate of the time required to accomplish the activity assuming a normal crew (26:59).

Certain rules apply to the network construction (13:3-4; 26:28-30; 29):

1. Activity arrows represent precedence relationships only. There is no significance associated with their length.

2. No two events can have the same number.

3. The j number should be greater than the i number.

4. Before each activity begins, all preceding activities entering the i event must be completed. Figure 2.2 illustrates this situation, called a merge event.

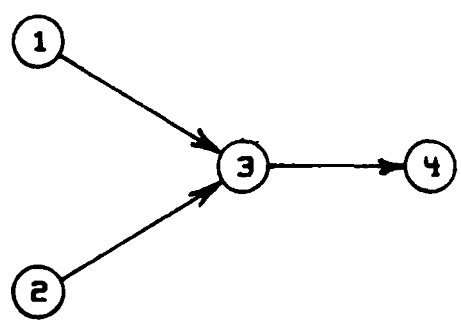


Figure 2.2 Merge Event

5. Each activity must have its own unique i-j number. In cases where more than one activity spans two events, a dummy activity, or restraint, introduces an additional event to maintain the uniqueness of each activity. This restraint, represented by a dashed arrow, consumes no time or resources. It only shows a precedence relationship, or restraint on the start of the next activity.

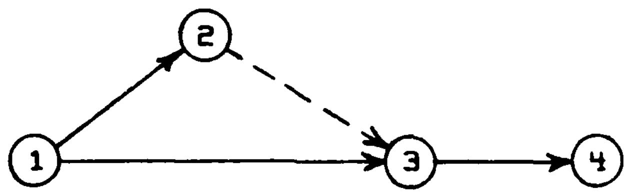


Figure 2.3 Restraint

Figure 2.3 demonstrates this case, in which two activities must precede activity 3-4. As two activities cannot use the same i-j number, 1-3, the restraint, 2-3, supplies the solution.

An analysis of the network diagram then determines the early and late event times. The early event time, TE, is the earliest time an event can occur. TE is calculated by proceeding forward from the origin and adding duration times along each path, remembering that all activities leading into an event must be completed before an event can occur. TE is therefore the maximum time at each event and is enclosed in a square above the event. The late event time, TL, is the latest time to reach an event without delaying the entire project. TL is calculated by working backward from the project completion point and subtracting activity durations. Graphically displayed in a circle above each event, TL is the smallest number of all activities emanating from an event (10:A8-A9; 26:64-71).

Although event times are important, the project advances by completing activities. Therefore, the more useful information pertains to the work activities (10:A9-10; 26:74-75):

1. Early Start (ES) is the earliest time that an activity can start.

$$ES = TE \tag{1}$$

2. Early Finish (EF) is the earliest time that an activity can be completed. It is computed by adding the activity duration (D) to the Early Start.

$$EF = ES + D \tag{2}$$

3. Late Finish (LF) is the latest time that an activity can be completed without delaying the project.

$$LF = TL \tag{3}$$

4. Late Start (LS) is the latest time an activity can start without delaying the project. It is computed by subtracting the activity duration from the Late Finish.

$$LS = LF - D \tag{4}$$

The critical path is the longest path through the network. It connects the critical activities which control the duration of the project. These activities must meet three conditions to be considered critical (10:A9; 13:6; 26:76-77):

1. Equal early and late event times at the start of the activity.

2. Equal early and late event times at the end of the activity.

3. Ending event times minus starting event times must equal the activity duration.

Figure 2.4 displays a very simple CPM diagram with early and late event times and the critical path highlighted.

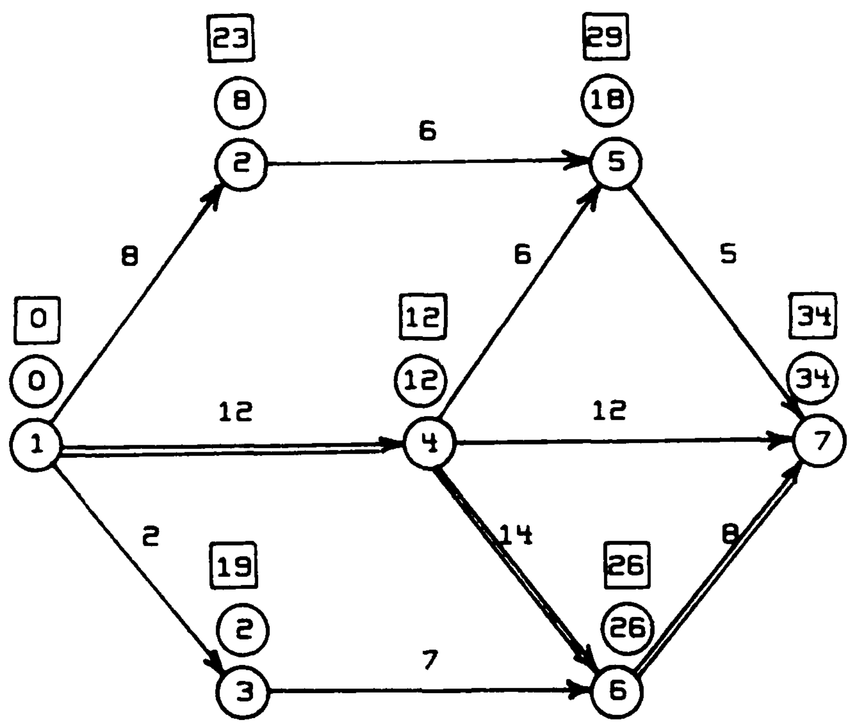


Figure 2.4 The Critical Path (9:10)

Events which meet conditions 1 and 2 have zero slack, or float. Float is the amount of time that the start of an activity can be delayed without extending the final project completion date (10:11). It is the difference between the late start and early start times (LS - ES) or the late finish and early finish times (LF - EF). Events with zero float are also critical events.

This simplified discussion of CPM network construction provides the background for understanding how CPM operates as a project management tool.

CPM as a Project Management Tool

Much of the literature discusses CPM in relation to scheduling and controlling a project's construction activities. However, other sources view CPM as applicable to the project in a larger universe, since the time spent in the administration review and preconstruction design frequently exceeds the amount of construction time (26:248). Weist and Levy describe CPM as a method of "project management useful in the basic managerial functions of planning, scheduling, and control" (33:4). This discussion reviews the current literature with regards to CPM's role in these functions.

Planning. According to O'Brien, "the use of CPM often defines planning factors which were previously vague and unidentified - and sometimes incorrect" (26:108). With a project's conception, an undetailed network allows top management to envision the scope of the project, establish goals, determine the funding source, and assess these planning factors for project feasibility. Following project approval, a more detailed network includes such predesign activities as real estate aquisition, environmental impact statements, budgeting, and engineering studies (11:2; 26:250-251). Since the design is a key ingredient in project planning, a well-coordinated design network saves time not only at the planning level, but also in future stages of the project. The final phase of planning involves a listing of all of the activities required for completion of the project, including their estimated cost and duration, as well as the material, equipment, and manpower requirements (33:4).

Scheduling. The scheduling function involves sequencing the activities in the necessary order of their performance. In this area, many sources promote CPM techniques and other network analysis systems as superior tools, especially in larger, more complex projects (7:80; 17:36-37). Unlike traditional bar charts, networks depict the dependencies of activities upon the completion of others. These interrelationships, in effect, force a logical construction sequence (21:18).

A major advantage of CPM in project scheduling, according to several experts, is its use in reconciling the allocation of resources (7:81; 17:40-41; 26:224; 33:103-112). Whereas a primary assumption in the network development is that manpower and equipment are available as needed for each activity, reality usually dictates otherwise. The completed network aids in resolving this conflict by revealing the resource bottlenecks, or peak requirement periods. Through the processes of resource allocation and resource levelling, the scheduler can adjust the start times of noncritical activities within the float. By doing so, the scheduler can reduce these peak resource requirement periods before they develop.

Controlling. Project control consists of monitoring the project's progress in comparison to the computed schedule. This function is the primary concern of the Air Force civil engineering organization's Contract Management branch. O'Brien declares this area an excellent opportunity for CPM application:

> A prime advantage of CPM is that by means of it a greater amount of work can be managed "by exception" rather than "by direction". In other words, management should focus their attention on actual trouble areas, and CPM can accurately identify these areas for them [26:178-179].

Monitoring project progress with regular updates of the CPM network serves two purposes. First, reality frequently differs from the computed schedule due to the uncertainties associated with estimation. Updating the network at regular intervals displays the project's progress in relation to the original schedule and may even create a new critical path. The very nature of this process highlights the problem areas before they occur and shows the cause and effect of delays (19:64). Secondly, regular updates provide a permanent record of the critical path at any given point in the construction process with regards to its scheduled completion date (32:289-290). The record provides both parties (contractor and owner) documentation of project delays. This documentation is becoming more and more important in judicial proceedings for project delay claims, where "the use of CPM schedules to prove construction contract claims has become the standard, rather than the exception" (32:281).

Another application of CPM as a control is related to progress payments. All fixed-price construction contracts are required to base progress payments to the contractor on percentage of project completion (12). Unless the contract specifies the exact requirements for completion percentages, the owner's and contractor's estimates may conflict, causing delays in payments. If, however, progress payments are tied to activity completion, CPM provides an immediate agreement on project status (20:41; 26:201).

Criticism of CPM

Since the beginnings of CPM, its use as a project management tool has fluctuated, as is the case with many management techniques. Regardless of the stage of its popularity, it has gained a foothold in the construction industry and continues as a widespread management tool for projects of various types and dimensions (26:1-13; 33: 163-165). CPM is not, however, without its critics. The following discussion reviews the current criticisms of CPM in relation to the needs of the construction process, the basic CPM assumptions, and the computerization of CPM.

With regards to the needs of the construction process, Birrell attacks CPM as an inappropriate management tool because it emphasizes minimization of time and project duration with little regard for resource consumption, and hence, cost (4:390-395). According to Birrell, general and subcontractors require the freedom to control their individual resources and workflow. Since their prime objective is profit maximization, these contractors will naturally allocate their manpower and equipment in such a way as to minimize their consumption of these resources. Their internal control will increase efficiency and eliminate unnecessary cost increases. Birrell's complaint is that the resource allocation and levelling processes in CPM assume central control over all resources. He contends that, with contractors each working on more than one project at a time, this situation is not acceptable. "Such action would usurp the individual entrepreneurial contractual role of both the general and subcontractor" (4:394).

Other analysts dispute this claim, however. O'Brien briefly addresses this problem in his discussion on subcontractors (26:112-113). He emphasizes the inclusion of all subcontractors in the early planning stages to state their positions and support their requirements. In fact, Jaafari states that it is precisely this problem of coordination requirements among various groups that makes CPM so effective (18:230). He says that "The only formal method of coordinating such an array of works and services is through an interrelated network of activities". Griffin takes a neutral stand on this topic when he cites several legal cases concerning CPM and subcontractors (16:J-48 - J-50). He found that courts generally support contractors who diligently follow and maintain their CPM schedules , but subcontractors prevail when the contractors are less than committed to their schedules .

The second common criticism of CPM deals with its underlying assumptions. The assumptions that a project can be divided into predictable, independent activities, whose durations can be estimated, and whose interrelationships can be determined and graphically represented, are, in some cases, questionable (33:166-170). Also, Birrell criticizes the assumption of one critical path through a project, asserting again that this concept seeks only minimization of time, with little regard for resource conservation (4:402). Brown reinforces this idea with the contention that the critical path focuses the manager's attention in one direction (5:60). The reduced vigilance on noncritical activities can cause their delay, forcing their criticality, and, hence, reducing the manager's options.

In addressing these claims, both O'Brien and Jaafari admit that activity durations are, indeed, only estimates, but experience has proven the validity of the estimation methods (18:227; 26:58-60). Jaafari further supports CPM's emphasis on project duration as a benefit to the contractor by motivating his workforce, identifying the critical items and external dependencies, forcing orderly operations, and providing possible financial incentives for early completion (18:229). He disputes the critics of a critical path with the contention that planners, whether or not they use CPM, "induce their own critical path through the set of decisions they make at the time of planning, thus the critical path is neither irrelevant nor incidental" (18:227).

The final area of criticism lies in the computerization of CPM. Cori, in his comparison of five project scheduling techniques, declares that CPM's primary weakness in the areas of simulation capabilities, updating status, flexibility, and cost analysis is the requirement for computer capability on all but the smallest projects (7:84-88). He does, however, qualify these comments with a brief discussion of some of the available computer software programs. On the other hand, Birrell sees the "mounds of computer printout" as "Another failure in the use of CPM" (4:404). His position is that the site managers have neither the knowledge to understand these outputs nor the time to spend learning their applications.

Most of the recent literature, however, approaches the computerized CPM from a very positive viewpoint. O'Brien devotes a whole chapter in his book _CPM in Construction Management_ to computer programs, including a summary of a 1982 survey, published in _Project Management Quarterly_, on available CPM software packages (26:279-308). Case studies hail the computerized CPM as a distinct advantage (1; 6). With software packages adaptable to microcomputers, smaller firms now have access to these more sophisticated management tools, giving them a more competitive edge in the construction industry.

Summary

CPM is a project management tool which uses activity sequence diagrams to define a logical job flow for the entire project accomplishment. The critical path highlights the sequence of tasks which determine the project duration. Used initially as a technique for developing the construction schedule, CPM is now also recognized as a process useful in the planning, scheduling, and controlling aspects of project management. Although critics debate its merit, CPM enjoys widespread use as a project management tool in the construction industry.

III. Methodology

Overview

This chapter discusses the methods which this project used to accomplish the research objectives stated in Chapter I. Specifically, the chapter defines the research population, describes the survey instrument used for data collection, and explains the procedures used for processing and analyzing the data to meet these objectives.

Population

The research population of interest included the Chief of Design (DEEE), the Chief of Contract Management (DEEC), and their supervisor, the Chief of Engineering and Environmental Planning (DEE) at all CONUS USAF base-level civil engineering organizations. The DEEE chief supervises the project engineers, who design and/or prepare design specifications for base-level projects. The DEEC chief directs the total construction management effort and oversees the direct users of project management tools. The chief of DEE supervises the organizational branches responsible for all phases of the project, including planning, design, and contract management. This person should therefore be versed in the organization's use (or non-use) of CPM in all or any phase of project management. These three positions are filled primarily by Air Force officers or Department of Defense civilians, depending on each base's manpower authorization. The population was limiited to CONUS installations because of the potential difficulties with overseas mailing times and also the possible differences in contract requirements with local contractors at overseas locations. This limitation restricts the generalization of the results to CONUS members. The total population included 241 positions. This small number of potential respondents allowed for a census of the population.

Survey Instrument

A mailed questionnaire gathered the primary data for accomplishing the research objectives. This method offered several advantages over interviews (14:172). With the wide dispersion of the survey population, the mailed questionnaire provided the most economical instrument in terms of both time and money. The questionnaire also allowed the respondents more time to collect facts and consider their replies. Lastly, this method provided the respondents more anonymity, thereby possibly encouraging more candid responses.

The questionnaire included features to encourage maximum participation from the respondents. The cover letter justified the project in terms of its benefit to the respondent. The questions were worded specifically to avoid potential ambiguities. The questionnaire was kept as brief as possible. Answers were to be marked directly on the questionnaire rather than a separate coded answer sheet.

The questionnaire used four types of questions to gather the primary data: scales, rank-ordering, yes-no, and open-ended. Scaled questions requested information on degrees of knowledge, experience, and satisfaction. Rank-ordered questions requested priority ranking of selected items. Yes-no questions at selective points throughout the questionnaire directed those respondents answering "No" to discontinue answering further. The assumption here was that "Yes" answers to these questions were prerequisites for valid answers to the remainder of the questionnaire. Open-ended questions served two purposes. They first solicited information on current methods and perceptions. Secondly, the open-ended questions gave the opportunity for supplying additional items for the rank-ordering questions.

The proposed questionnaire was administered to 27 students attending the Contract Preparation and Management Course, Mgt 425, at the AFIT School of Civil Engineering for indications of validity and solicitation of comments. These students ranged from E-7 to O-3 and GS-9 to GS-12 and represented several positions within the DEE branch of numerous worldwide base-level and MAJCOM civil engineering organizations. Several minor revisions in both content and format were incorperated from this pretest. A copy of the final questionnaire, which was approved by the Personnel Survey Branch, AFMPC and distributed to the survey population, is located in Appendix A.

Data Processing

Of the 241 surveys distributed, 146 were returned, with 3 unusable. This response represented a 59.3% usable response.

Responses to each question were converted to numerical values and entered into a computer data file. Converting the open-ended responses first required developing categories. The individual responses were then placed in the appropriate category, which was assigned a specific number. Since this subjective categorization was accomplished by the same individual, the results are assumed to be valid.

Data Analysis

After the questionnaire responses were all stored in a data file, they were retrieved and analyzed using the computer program Statistical Package for the Social Sciences (SPSSX). This analysis was a two-step process. Chapter IV presents the tabulated survey results obtained using the FREQUENCIES subprogram. In Chapter V these results are then analyzed using the CROSSTABS subprogram.

FREQUENCIES. Each question was examined using the FREQUENCIES subprogram of SPSSX. This subprogram computed the numbers and percentages for each response category of each question. FREQUENCIES was also used to determine the measure of central tendency for each question. It computed the mode, median, and mean for selected questions, which represented nominal, ordinal, and interval data.

CROSSTABS. The subprogram CROSSTABS was used to examine the possible relationships between responses to different questions. The hypothesized dependent and independent variables were arranged in contingency tables, which displayed numbers and percentages for each cell, as well as the chi-square statistic and its probability value for each relationship.

> The calculated chi-square is compared to the critical points on the theoretical chi-square distribution to produce an estimate of how likely (or unlikely) this calculated value is if the two variables are in fact independent [25:53].

Because of the relatively small number and the disproportionate distribution of responses, many cells in these tables were left blank or had very low expected frequencies. An attempt at collapsing categories produced similar results, and further collapsing was ruled out as obscuring the meaning of the data. These small cell sizes makes the reliability of the chi-square statistic highly questionable. Therefore, the determination of statistical dependency was excluded, and a qualitative analysis was performed based on the results of the FREQUENCIES and CROSSTABS tables.

IV. Results

Overview

This chapter presents the results of the descriptive statistics performed using the data gathered from the survey questionnaires. The subprograms FREQUENCIES and CROSSTABS were employed to compute the statistics, using the methodology described in Chapter III. The results are presented in numerical order and divided into four parts, corresponding to the same pattern as the questionnaire. The first two parts addressed the entire population and the last two parts pertained only to those portions of the respondents who answered affirmatively to milestone questions (12 and 16).

Demographic Data

Survey Question 1. Table 4.1 displays the military rank and civilian grade distribution of the respondents. The table indicates that 84.0% of those responding were civilian, more than half of whom filled GM-13 or higher positions.

Survey Question 2. Table 4.2 shows the respondent distribution by education level.

Survey Question 3. Table 4.3 provides information on the amount of time the respondents have spent in the civil engineering career field. The table suggests a population with a great deal of experience.

TABLE 4.1

Grade of Respondents

Grade	Freq	Percent	Valid Percent
E-9	2	1.4	1.4
O-1	1	0.7	0.7
O-2	10	7.0	7.0
O-3	7	4.9	4.9
O-4	2	1.4	1.4
O-5	1	0.7	0.7
GS-9 or below	1	0.7	0.7
GS-11	17	11.9	11.9
GS-12	40	28.0	28.0
GM-13 or higher	62	43.4	43.4
TOTAL	143	100.0	100.0

TABLE 4.2

Education Level

Education Level	Freq	Percent	Valid Percent
High School	1	0.7	0.7
Associate	4	2.8	2.8
Baccalaureate	104	72.7	72.7
Masters	33	23.1	23.1
Doctorate	1	0.7	0.7
TOTAL	143	100.0	100.0

TABLE 4.3

Time in the CE Career Field

Time (years)	Freq	Percent	Valid Percent
< 2	3	2.1	2.1
2 - 4	12	8.4	8.4
4 - 8	12	9.1	9.1
8 - 10	9	6.3	6.3
> 12	106	74.1	74.1
TOTAL	143	100.0	100.0

Survey Questions 4 and 5. Table 4.4 presents the information on the respondent's position within his civil engineering unit and the length of time in that position.

TABLE 4.4

Position and Time in Position

COUNT COL %	Position in CE Organization				
Time in Position	Chief of DEE	Chief of DEEC	Chief of DEEE	Other	Row Total
< 2 years	22 44.9	24 49.0	22 52.4	1 33.3	69 48.3
2 - 4 years	7 14.3	7 14.3	7 16.7	1 33.3	22 15.4
4 - 8 years	6 12.2	9 18.4	10 23.8	0 0.0	25 17.5
8 - 10 years	3 6.1	4 8.2	1 2.4	1 33.3	9 12.6
> 12 years	11 22.4	5 10.2	2 4.8	0 0.0	18 12.6
COLUMN TOTAL	49 34.3	49 34.3	42 29.4	3 2.1	143 100.0

Survey Question 6. Appendix B provides a display, by base and major command, of the respondent distribution.

Methods of Project Management

Survey questions 7, 8, 9, and 10 were three-part questions regarding aspects of project management in the respondent's organization. Part A of each question solicited information on the method used in performing a certain function. Part B requested the respondent's level of satisfaction with this method, based on the following scale:

Value	Level of Satisfaction
1	Very Dissatisfied
2	Somewhat Dissatisfied
3	Neutral Satisfaction
4	Somewhat Satisfied
5	Very Satisfied

Part C asked for any particular areas of dissatisfaction with the respondent's current method of accomplishing the function. Responses to Parts A and C were categorized as described in Chapter III. Selected responses are listed in Appendix C.

A category common to all parts was the "Invalid/no response" category. Responses were placed in this category when they did not seem to answer the question as asked or were left blank. The one exception for blank responses was for those in Part C of each question. These were considered negative responses to the area of dissatisfaction when the preceding method in Part A was considered valid.

A category of responses common to Part A of all four questions is the "Deferred" category. Responses placed in this category were those in the respondent indicated that some other branch or individual had responsibility for this function. Being unfamiliar with the particular method, however, did not necessarily mean the respondent was unaware of the effect of the method. Therefore, the responses to Parts B and C of these questions were considered valid. The same reasoning was used for Parts B and C following a blank or invalid Part A.

Survey Question 7. Survey question 7 asked respondents to state the method they use for determining a project's planned duration. Table 4.5 displays the responses by category. The table indicates the extensive role of judgement in this function. Several responses mentioned simply judgement or past experience as their method. Others based their judgement or experience on a range of certain factors. Many others merely listed one or more factors. A response listing particular factors and one using judgement based on the factors were considered too similar to distinguish between. Therefore, the "Judgemental Estimate" category included all responses which mentioned judgement or experience, a list of factors, or judgement based on factors. Some of these factors considered included complexity, weather, material delivery time, MEANS manhour estimates, user needs, and location.

The most common deferment for planning the project duration was to the design engineer.

Table 4.5 also shows the levels of satisfaction and particular areas of dissatisfaction with the current methods of determining planned duration. Those areas considered "Estimating Techniques" ranged from the lack of any system to the lack of confidence in the present system to systems which were unable to compensate for natural and supply delays and human shortcomings. The "Organizational Interface" area included those responses concerning inadequate understanding and cooperation among those concerned organizations on the government side of the contract. These organizations included the civil engineering organization, base contracting office, and the using agency. Responses regarding command interest, funding, and priority changes were placed in the "Management Policies" area of dissatisfaction.

TABLE 4.5

Aspects of Determining Planned Duration

Methods	Freq	Percent	Valid Percent
Systematized Estimate	8	5.6	6.1
Judgemental Estimate	93	65.0	70.5
Guess	3	2.1	2.3
Deferred	28	19.6	21.2
Invalid/No Response	11	7.7	MISSING
TOTAL	143	100.0	100.0
Levels of Satisfaction			
(1) Very Dissatisfied	9	6.3	6.6
(2) Somewhat Dissatisfied	10	7.0	7.3
(3) Neutral Satisfaction	32	22.4	23.4
(4) Somewhat Satisfied	48	33.6	35.0
(5) Very Satisfied	38	26.6	27.7
No Response	6	4.2	MISSING
TOTAL	143	100.0	100.0
Mode 4.000 Mean 3.701			
Areas of Dissatisfaction			
None	80	55.9	60.2
Estimating Technique	34	23.8	25.6
Organizational Interface	6	4.2	4.5
Management Policies	8	5.6	6.0
Other	5	3.5	3.8
Invalid/No Response	10	7.0	MISSING
TOTAL	143	100.0	100.0

Survey Question 8. This question asked the respondent to state the method used for estimating project completion percentages for the AF Form 3065, Contract Progress Report. A great many respondents indicated their percentages came from the pre-coordinated schedule submitted by the contractor on the AF Form 3064, Contract Progress Schedule or by comparing work-in-place with this schedule. This category of response was in line with standard procedures used for this function. However, the question was apparently ambiguous because its intention was to solicit actual methods of determining work-in-place for comparison to the AF Form 3064. Those respondents who did indicate a method comprised the other two usable categories: estimating by some sort of system or estimating primarily through judgement and experience. Those who did not indicate a method, however, were not excluded because they still provided valuable information on satisfaction levels and areas of dissatisfaction. Table 4.6 provides the distribution of responses by category as well as the levels of satisfaction with these methods.

Table 4.6 also summarizes the areas of dissatisfaction with the methods of estimating project completion percentages. The most common concern dealt with the inaccuracies of the estimating process, including reliance on the expertise of inspectors who may not have adequate experience. Closely related to this category were those responses which mentioned dependence on a contractor's schedule which was frequently front-loaded, too general, and often inaccurate.

TABLE 4.6

Aspects of Estimating Project Completion Percentages

Methods	Freq	Percent	Valid Percent
Contractor's Schedule	66	46.2	50.8
Systematized Estimate	26	18.2	20.0
Judgemental Estimate	36	25.2	27.7
Deferred	2	1.4	1.5
Invalid/No Response	13	9.1	MISSING
TOTAL	143	100.0	100.0
Levels of Satisfaction			
(1) Very Dissatisfied	7	4.9	5.3
(2) Somewhat Dissatisfied	10	7.0	7.6
(3) Neutral Satisfaction	30	21.0	22.9
(4) Somewhat Satisfied	44	30.8	33.6
(5) Very Satisfied	40	28.0	30.5
No Response	12	8.4	MISSING
TOTAL	143	100.0	100.0
Mode 4.000 Mean 3.763			
Areas of Dissatisfaction			
None	85	59.4	65.9
Contractor Schedule	15	10.5	11.6
Estimating Technique	25	17.5	19.4
Organizational Interface	3	2.1	2.3
Management Policies	1	0.7	0.8
Invalid/No Response	14	9.8	MISSING
TOTAL	143	100.0	100.0

Survey Question 9. This question asked the respondent to state the method used for determining the impact on performance time of contract modifications which add or delete work. The intent of this question was to discern the method used for determining whether added work should actually extend the contract and, if so, by how much. Many respondents deferred the determination to the base contracting office or to the process of negotiation. Of those responses which indicated a method, three general categories prevailed. One group indicated a concern for the project as a whole and how the modification impacted other phases of the project. The second, and most prevalent, type of response mentioned methods of estimating the time required to accomplish the modification, with no mention of its impact on other jobs or the project as a whole. The third category indicated a general acceptance of the contractor's request for additional time. Table 4.11 displays the distribution of these methods among the responses and the levels of satisfaction with these methods.

The areas of dissatisfaction produced similar results as in questions 7 and 8 with two additions. One concerned contractor's taking advantage of extra time on contract modifications to catch up on work which was already behind schedule while the other category was a general lack of faith in the current method.

TABLE 4.7

Aspects of Determining the Impact of Contract Modifications Adding or Deleting Work

Methods	Freq	Percent	Valid Percent
Impact on Whole Project	17	11.9	12.8
Modification Alone	74	51.7	55.6
Contractor Request	3	2.1	2.3
Case-by-case	2	1.4	1.5
Deferred	37	25.9	27.8
Invalid/No Response	10	7.0	MISSING
TOTAL	143	100.0	100.0
Levels of Satisfaction			
(1) Very Dissatisfied	9	6.3	6.5
(2) Somewhat Dissatisfied	17	11.9	12.3
(3) Neutral Satisfaction	35	24.5	25.4
(4) Somewhat Satisfied	47	32.9	34.1
(5) Very Satisfied	30	21.0	21.7
No Response	5	3.5	MISSING
TOTAL	143	100.0	100.0
Mode 4.000 Mean 3.522			
Areas of Dissatisfaction			
None	91	63.6	65.9
Organizational Interface	15	10.5	10.9
Contractor Misuse	8	5.6	5.8
Estimating Technique	12	8.4	8.7
Management Policies	7	4.9	5.1
General Dissatisfaction	5	3.5	3.6
Invalid/No Response	5	3.5	MISSING
TOTAL	143	100.0	100.0

Survey Question 10. This question asked the respondent to state the method used for determining the impact on project completion time of delaying activities, such as unusually severe weather, acts of God, or strikes. The intent of this question was to learn how the respondent determines if and how much a delaying activity actually delays the entire project completion time, not strictly the work in progress at the time of the activity. Several respondents interpreted the question as asking how the delay would affect the user's necessity for a particular completion date. Many others consulted hard evidence, such as weather records, inspector's log, and contractor's documentation. These responses were all declared invalid because they were inconsistent with the intent of the question, which was to discern how they verified, not that the delaying activity existed, but that it did, in fact, delay the project as a whole. Since very few respondents answered in this manner, responses were included which stated any method of accounting for delays. These responses were then categorized according to whether they were based upon some sort of system or primarily upon judgement and experience. Table 4.8 shows the distribution of responses by method, the levels of satisfaction, and areas of dissatisfaction.

Survey Question 11. Table 4.9 displays the results of the respondents' approximations of the percent of maintenance, repair, and minor construction projects at their base which experience construction delays.

TABLE 4.8

Aspects of Determining the Impact of
Delaying Activities on Project Completion Time

Methods	Freq	Percent	Valid Percent
Systematized Method	29	20.3	42.6
Judgemental Method	15	10.5	22.1
Case-by-case	8	5.6	11.8
Deferred	16	11.2	11.8
Invalid/No Response	75	52.4	MISSING
TOTAL	143	100.0	100.0
Levels of Satisfaction			
(1) Very Dissatisfied	7	4.9	5.4
(2) Somewhat Dissatisfied	12	8.4	9.3
(3) Neutral Satisfaction	37	25.9	28.7
(4) Somewhat Satisfied	43	30.1	33.3
(5) Very Satisfied	30	21.0	23.3
No Response	14	9.8	MISSING
TOTAL	143	100.0	100.0
Mode 4.000 Mean 3.597			
Areas of Dissatisfaction			
None	106	74.1	80.9
Organizational Interface	11	7.7	8.4
Contractor Misuse	3	2.1	2.3
Estimating Technique	9	6.3	6.9
Mannning	2	1.4	1.5
Invalid/No Response	12	8.4	MISSING
TOTAL	143	100.0	100.0

CPM Knowledge

Survey Question 12. This question asked the respondents to indicate whether or not they had heard of CPM or any other form of network analysis. Table 4.10 displays the results. The "No Response" category in subsequent tables includes the 11 who answered "No" to question 12.

TABLE 4.9

Frequencies of Delays on Base-level Projects

Percent Which Experience Delays	Freq	Percent	Valid Percent
Maintenance Projects			
< 20%	56	39.2	41.8
20 - 40%	44	30.8	32.8
40 - 60%	23	16.1	17.2
60 - 80%	6	4.2	4.5
> 80%	5	3.5	3.7
No Response	9	6.3	MISSING
TOTAL	143	100.0	100.0
Repair Projects			
< 20%	41	28.7	30.8
20 - 40%	42	29.4	31.6
40 - 60%	29	20.3	21.8
60 - 80%	15	10.5	11.3
> 80%	6	4.2	4.5
No Response	10	7.0	MISSING
TOTAL	143	100.0	100.0
Minor Construction Projects			
< 20%	56	39.2	42.1
20 - 40%	34	23.8	25.6
40 - 60%	21	14.7	15.8
60 - 80%	16	11.2	12.0
> 80%	6	4.2	4.5
No Response	10	7.0	MISSING
TOTAL	143	100.0	100.0

TABLE 4.10

Awareness of CPM or Other Forms of Network Analysis

Heard of CPM?	Freq	Percent	Valid Percent
Yes, heard of CPM	132	92.3	92.3
No, not heard of CPM	11	7.7	7.7
TOTAL	143	100.0	100.0

Survey Questions 13, 14, and 15. These questions asked the respondents to indicate their familiarity with terms, concepts, applications, and other aspects of CPM. Question 13 began with terms used in building a network: merge and burst events and dummy activity. Next were terms associated with network analysis: slack time, early start and finish times, and late start and finish times. These terms were presented in Chapter II. The last three terms of question 13 dealt with concepts used in applying CPM. The concept of crash refers to expediting an activity (33:62). Resource levelling smooths the utilization of resources to a relatively constant rate throughout the project duration, while resource allocation refers to scheduling activities for minimum project duration, subject to a fixed pool of resources (24:81). Question 14 addressed areas to which CPM has been applied in practice: controlling the impact of added work and delaying activities and monitoring the project's progress. Question 15 touched other aspects regarding knowledge of network analysis guidance DFARS and AFFARS and familiarity with any type of computerized CPM. Table 4.11 displays the results of responses which are based on the following scale:

Value	Level of Knowledge
1	No knowledge
2	Below average knowledge
3	Average knowledge
4	Above average knowledge
5	Very knowledgeable

The final part of question 15 asked whether the respondent was familiar with any particular CPM software. Seven respondents named computers and commercial software programs with which they were familiar.

CPM Experience

Survey Question 16. This question asked the respondents whether or not they had ever used CPM or been associated with projects on which it was used. Table 4.12 displays the results. The "No Response" category in subsequent tables includes the 61 who answered "No" to questions 12 and 16

Survey Question 17. Table 4.13 displays the respondent's approximation of the frequency of CPM use by project.

Survey Question 18. This question asked for the respondents' approximation of the percentages of projects upon which they perceived that CPM had a positive effect on project management. Table 4.14 displays the results.

Survey Questions 19 and 20. Survey questions 19 and 20 listed four suggested reasons for and against, respectively, using CPM. The fifth option in each question gave the respondent an opportunity to provide another reason. The respondent rank ordered the reasons according to their relative strength. The strongest reason was ranked 1, and the weakest reason, 5. A blank was interpretted as meaning the reason held no importance to the respondent. Tables 4.15 and 4.16 present the results of questions 19 and 20, respectively. Appendices D & E contain the list of added reasons for both questions and the relative strength given to each.

TABLE 4.11

Respondent Familiarity with Terms, Concepts, Applications, and Other Aspects of CPM

FREQUENCY VALID ROW %	Level of Knowledge 1	2	3	4	5	No Resp	TOTAL	MEAN
Merge and Burst Events	56 43.1	29 22.3	30 23.1	6 4.6	9 6.9	13 MISS	143 100.0	2.10
Dummy Activity	24 18.6	25 19.4	39 30.2	15 11.6	26 20.2	14 MISS	143 100.0	2.95
Slack Time	9 6.9	14 10.8	48 36.9	30 23.1	29 22.3	13 MISS	143 100.0	3.43
Early Start/ Finish Times	9 6.9	16 12.3	47 36.2	25 19.2	33 25.4	13 MISS	143 100.0	3.44
Late Start/ Finish Times	10 7.6	15 11.5	47 35.9	26 19.8	33 25.2	12 MISS	143 100.0	3.44
Crash	57 44.2	28 21.7	27 20.9	10 7.8	7 5.4	14 MISS	143 100.0	2.09
Resource Levelling	56 43.1	34 26.2	25 19.2	6 4.6	9 6.9	13 MISS	143 100.0	2.06
Resource Allocation	45 34.6	31 23.8	31 23.8	11 8.5	12 9.2	13 MISS	143 100.0	2.34
Controlling Impact of Added Work	25 19.5	25 19.5	42 32.8	24 18.8	12 9.4	15 MISS	143 100.0	2.79
Controlling Impact of Delays	24 18.8	23 18.0	43 33.6	23 18.0	15 11.7	15 MISS	143 100.0	2.86
Monitoring Contractor Progress	16 12.2	12 9.2	43 32.8	37 28.2	23 17.6	12 MISS	143 100.0	3.30
NA Policy in DFARS and AFFARS	63 48.8	34 26.4	20 15.5	6 4.7	6 4.7	14 MISS	143 100.0	1.90
CPM Software	72 55.8	34 26.4	16 12.4	4 3.1	3 2.3	14 MISS	143 100.0	1.70

TABLE 4.12

Association with Projects Using CPM

Associated with Projects Using CPM?	Freq	Percent	Valid Percent
Yes	71	49.7	53.8
No	61	42.7	46.2
No Response	11	7.7	MISSING
TOTAL	143	100.0	100.0

Survey Questions 21 and 22. Survey question 21 asked the respondents to indicate the factors they perceived important for determining whether or not to use CPM on a project and to quantify these factors, if possible. Appendix F provides a list of these specified quantities, as well as the additional factors solicited in question 21e. Question 22 then asked the respondents to rank order the factors they selected according to their relative importance. The most important factor was ranked 1, and the least important was ranked 5. Table 4.17 displays the results of question 22.

Survey question 23. This question asked the respondents for their perceptions of CPM's effectiveness on base-level projects if they had a computerized CPM capability. Table 4.18 presents the results.

Survey Question 24. This question presented the respondents with a list of topics concerning CPM. The respondents were asked to mark the areas in which they felt they would require additional knowledge should they be required to use CPM. Table 4.19 displays the results.

TABLE 4.13

Respondent Approximation of CPM Use on Projects

Amount of MCP Projects Using CPM	Freq	Percent	Valid Percent
< 20%	27	18.9	41.5
20 - 40%	9	6.3	13.8
40 - 60%	6	4.2	9.2
60 - 80%	6	4.2	9.2
> 80%	12	8.4	18.5
Don't Know	5	3.5	7.7
No Response	78	54.5	MISSING
TOTAL	143	100.0	100.0
Amount of MC Projects Using CPM			
< 20%	55	38.5	83.3
20 - 40%	3	2.1	4.5
40 - 60%	1	0.7	1.5
60 - 80%	1	0.7	1.5
> 80%	0	0.0	0.0
Don't Know	6	4.2	9.1
No Response	77	53.8	MISSING
TOTAL	143	100.0	100.0
Amount of Maintenance Projects Using CPM			
< 20%	53	37.1	80.3
20 - 40%	5	3.5	7.6
40 - 60%, 60 - 80%, > 80%	0	0.0	0.0
Don't Know	8	5.6	12.1
No Response	77	53.8	MISSING
TOTAL	143	100.0	100.0
Amount of Repair Projects Using CPM			
< 20%	56	39.2	84.8
20 - 40%	4	2.8	6.1
40 - 60%, 60 - 80%, > 80%	0	0.0	0.0
Don't Know	6	4.2	9.1
No Response	77	53.8	MISSING
TOTAL	143	100.0	100.0

TABLE 4.14

Respondent Approximation of Percent of Projects Upon Which CPM had a Positive Effect on Project Management

% of MCP Projects	Freq	Percent	Valid Percent
< 20%	18	12.6	27.3
20 - 40%	3	2.1	4.5
40 - 60%	8	5.6	12.1
60 - 80%	4	2.8	6.1
> 80%	16	11.2	24.2
Don't Know	11	7.7	16.7
N/A	6	4.2	9.1
No Response	77	57.3	MISSING
TOTAL	143	100.0	100.0
% of MC Projects			
< 20%	23	16.1	35.4
20 - 40%	6	4.2	9.2
40 - 60%	2	1.4	3.1
60 - 80%	2	1.4	3.1
> 80%	7	4.9	10.8
Don't Know	6	4.2	9.2
N/A	19	13.3	29.2
No Response	78	58.8	MISSING
TOTAL	143	100.0	100.0
% of Maintenance Projects			
< 20%	27	18.9	41.5
20 - 40%	3	2.1	4.6
40 - 60%	2	1.4	3.1
60 - 80%	0	0.0	0.0
> 80%	4	2.8	6.2
Don't Know	7	4.9	10.8
N/A	22	15.4	33.8
No Response	78	58.8	MISSING
TOTAL	143	100.0	100.0
% of Repair Projects			
< 20%	26	18.2	40.0
20 - 40%	6	4.2	9.2
40 - 60%	1	0.7	1.5
60 - 80%	1	0.7	1.5
> 80%	4	2.8	6.2
Don't Know	7	4.9	10.8
N/A	20	14.0	30.8
No Response	78	58.8	MISSING
TOTAL	143	100.0	100.0

TABLE 4.15
Perceived Strength of Reasons FOR Using CPM

Ranking of Reason	Freq	Percent	Valid Percent
Provides Information on Contractor Progress			
Strongest (1)	12	8.4	16.9
(2)	10	7.0	14.1
(3)	13	9.1	18.3
(4)	30	21.0	42.3
Weakest (5)	3	2.1	4.2
Not Important	3	2.1	4.2
No Response	72	50.3	MISSING
TOTAL	143	100.0	100.0
Knowing Interrelationships Helps Forecast Effects of Delays and Modifications			
Strongest (1)	18	12.6	25.4
(2)	14	9.8	19.7
(3)	23	16.1	32.4
(4)	11	7.7	15.5
Weakest (5)	3	2.1	4.2
Not Important	2	0.7	1.4
No Response	72	50.3	MISSING
TOTAL	143	100.0	100.0
Focuses Attention on Most Time-critical Activities			
Strongest (1)	34	23.8	47.9
(2)	19	13.3	26.8
(3)	12	8.4	16.9
(4)	3	2.1	4.2
Weakest (5)	1	0.7	1.4
Not Important	2	1.4	2.8
No Response	72	50.3	MISSING
TOTAL	143	100.0	100.0
Preplanning Shows Potential Resource Conflicts			
Strongest (1)	12	8.4	16.9
(2)	20	14.0	28.2
(3)	15	10.5	21.1
(4)	16	11.2	22.5
Weakest (5)	6	4.2	8.5
Not Important	2	1.4	2.8
No Response	72	50.3	MISSING
TOTAL	143	100.0	100.0

TABLE 4.16
Perceived Strength of Reasons AGAINST Using CPM

Ranking of Reason	Freq	Percent	Valid Percent
Emphasis on Time With Little Concern for Resources & Cost			
Strongest (1)	7	4.9	9.9
(2)	11	7.7	15.5
(3)	19	13.3	26.8
(4)	23	16.1	32.4
Weakest (5)	5	3.5	7.0
Not Important	6	4.2	8.5
No Response	72	50.3	MISSING
TOTAL	143	100.0	100.0
Time and Cost for Network Development and Analysis			
Strongest (1)	20	14.0	28.2
(2)	19	13.3	26.8
(3)	11	7.7	15.5
(4)	12	6.4	16.9
Weakest (5)	5	3.5	7.0
Not Important	6	4.2	8.5
No Response	72	50.3	MISSING
TOTAL	143	100.0	100.0
Complexity in Development and Understanding			
Strongest (1)	19	13.3	26.8
(2)	18	12.6	25.4
(3)	10	7.0	14.1
(4)	14	9.8	19.7
Weakest (5)	5	3.5	7.0
Not Important	5	3.5	7.0
No Response	72	50.3	MISSING
TOTAL	143	100.0	100.0
CPM is Only as Good as the Activity Time Estimates			
Strongest (1)	17	11.9	23.9
(2)	15	10.5	21.1
(3)	24	16.8	33.8
(4)	10	74.1	14.1
Weakest (5)	2	1.4	2.8
Not Important	3	2.2	4.2
No Response	72	50.3	MISSING
TOTAL	143	100.0	100.0

TABLE 4.17

Perceived Importance of
Factors Considered in Decision to Use CPM

Ranking of Factor		Freq	Percent	Valid Percent
Project Cost				
Most Important	(1)	10	7.0	14.4
	(2)	11	7.7	15.5
	(3)	14	9.8	19.7
	(4)	6	4.2	8.5
Least Important	(5)	1	0.7	1.4
Not Important		29	20.3	40.8
No Response		72	50.3	MISSING
	TOTAL	143	100.0	100.0
Project Complexity				
Most Important	(1)	32	22.4	45.1
	(2)	13	9.1	18.3
	(3)	3	2.1	4.2
	(4)	2	1.4	2.8
Least Important	(5)	0	0.0	0.0
Not Important		21	14.7	29.6
No Response		72	50.3	MISSING
	TOTAL	143	100.0	100.0
Project Duration				
Most Important	(1)	4	2.8	5.6
	(2)	13	9.1	18.3
	(3)	11	7.7	15.5
	(4)	8	5.6	11.3
Least Important	(5)	0	0.0	0.0
Not Important		35	24.5	49.3
No Response		72	50.3	MISSING
	TOTAL	143	100.0	100.0
Project Type				
Most Important	(1)	6	4.2	8.5
	(2)	15	10.5	21.1
	(3)	8	5.6	11.3
	(4)	4	2.8	5.6
Least Important	(5)	1	0.7	1.4
Not Important		37	25.9	52.1
No Response		72	50.3	MISSING
	TOTAL	143	100.0	100.0

TABLE 4.18

Perceived Effectiveness of CPM on Base-level Projects

Level of Effectiveness	Freq	Percent	Valid Percent
Very Ineffective	19	13.3	27.9
Somewhat Ineffective	15	10.5	22.1
No Opinion	0	0.0	0.0
Somewhat Effective	29	20.3	42.6
Very Effective	5	3.5	7.4
No Response	75	52.4	MISSING
TOTAL	143	100.0	100.0

TABLE 4.19
Areas of CPM About Which More Knowledge is Needed

Need More Knowledge?	Freq	Percent	Valid Percent
Basic Concepts			
Yes, Need to Know More	23	16.1	33.3
No, Sufficient Knowledge	46	32.2	66.7
No Response	74	51.7	MISSING
TOTAL	143	100.0	100.0
Network Interpretation			
Yes, Need to Know More	26	18.2	37.7
No, Sufficient Knowledge	43	30.1	62.3
No Response	74	51.7	MISSING
TOTAL	143	100.0	100.0
Contract Specifications			
Yes, Need to Know More	42	29.4	60.9
No, Sufficient Knowledge	27	18.9	39.1
No Response	74	51.7	MISSING
TOTAL	143	100.0	100.0
Monitoring Contractor Progress			
Yes, Need to Know More	24	16.8	34.8
No, Sufficient Knowledge	45	31.5	65.2
No Response	74	51.7	MISSING
TOTAL	143	100.0	100.0
Forecasting Effects of Delays and Work Modifications			
Yes, Need to Know More	24	16.8	34.8
No, Sufficient Knowledge	45	31.5	65.2
No Response	74	51.7	MISSING
TOTAL	143	100.0	100.0
Permanent Progress Report			
Yes, Need to Know More	31	21.7	44.9
No, Sufficient Knowledge	38	26.6	55.1
No Response	74	51.7	MISSING
TOTAL	143	100.0	100.0
Implementation of CPM Software			
Yes, Need to Know More	61	42.7	88.4
No, Sufficient Knowledge	8	5.6	11.6
No Response	74	51.7	MISSING
TOTAL	143	100.0	100.0

Analysis and Discussion

Overview

This chapter analyzes the data gathered by the survey questionnaires. Each research objective is analyzed separately by examining the results of the specific survey questions designed to support that objective.

Research Objective #1

> Determine if current methods of managing base-level civil engineering projects are perceived as satisfactory.

This research objective is supported by survey questions 7 through 10, which addressed four selected areas related to project management:

1. Determining a project's planned duration;
2. Estimating project completion percentages;
3. Determining the impact on performance time of contract modifications which add or delete work;
4. Determining the impact on performance time of delaying activities.

Part B of each question specifically requested the respondent's level of satisfaction with the current methods of handling each of these areas. The potential problem with this question is that respondents could be reluctant to admit they are dissatisfied with the way they do business. Nevertheless, one variable which could be expected to influence the respondent's satisfaction is the method itself. In othe~ words, some methods of accomplishing a task may be perceived as more satisfactory than others. A second variable with possible influence on satisfaction is the respondent's experience in the career field (Table 4.3) The assumption here is that the experienced managers may be more set in their ways, suspicious of change, and generally satisfied with the current methods. Subprogram CROSSTABS was used to examine individually the relationship of these two variables with the respondents' levels of satisfaction (Tables 4.5 through 4.8). The tabulated results are displayed in Contingency Tables 1 through 8 in Appendix G. As discussed in Chapter III, an examination of the dependence of these variables is unreliable, but a qualitative analysis of the data reveals some insights and potential patterns of response.

<u>Determining Planned Duration</u>. The level of satisfaction with the current methods of determining a project's planned duration (Table 4.5) is one of general satisfaction (mode = 4.000, mean = 3.701). Those respondents indicating some method of estimating, whether systematized or judgemental, reflect the highest levels of satisfaction (Contingency Table 1). Those who depend on guessing are all very dissatisfied with the method. The group who deferred responsibility contains the largest frequency of dissatisfied respondents (those responding very dissatisfied or somewhat dissatisfied = 22.2%). Their primary area of dissatisfaction is in the estimating techniques. They feel the system is unrealistic, based on experience rather than sound scheduling methods, and

unable to adequately adjust for the inherent inaccuracies of estimating. This sentiment prevails throughout the range of dissatisfied respondents. Although 60.2% of the repondents indicate no areas of dissatisfaction (Table 4.5), 34 of the 53 who do, identify an area related to estimating techniques.

The distribution of satisfaction by experience level (Contingency Table 2) is so disproportionate toward the most experienced group (74.1% have more than 12 years in the civil engineering career field) that generalizations can only be made on this group. 63.4% of these respondents indicate they are satisfied with their current methods of determining project duration. The other four categories vary somewhat either side of the mean, however the mode of these groups is all somewhat satisfied.

Estimating Project Completion Percentages. Engineering managers are generally satisfied with their methods of estimating project completion percentages (mode = 4.000, mean = 3.763 from Table 4.6). The three major categories of methods reflect this indication fairly evenly, as do the categories of experience level (Contingency Tables 3 and 4). Although 65.9% of the respondents indicate no areas of dissatisfaction, 40 of the 44 who do, address one of two interrelated areas: the contractor's schedule and the estimating method. A major concern is the basing of completion percentages on the contractor's progress schedule. Contractors tend to front-load the schedule with high percentages, including the amount and cost of delivered materials as disproportionately high percentages of project completion. The fact that this procedure occurs is a function of the estimating technique itself, which reflects cash flow rather than work accomplished. Complicating this fact is the low experience level of the inspectors, who do the estimating. According to one respondent, inspectors are frequently inexperienced because "low inspector grades GS 7/8 preclude hiring quality poeple able to make accurate, logical, project completion percentages". With nothing but the progress schedule to go by, these inexperienced inspectors are sometimes pressured by the contractors to inflate the percentages.

Determining Impact of Contract Modifications. Managers are generally satisfied with their current methods in this area (Table 4.7), although the level of satisfaction is the lowest of the four areas of project management in the survey (mode = 4.000, mean = 3.522) The group who consider the modification impact on the whole project are the most satisfied (Contingency Table 5). Those who determine the effects of the modification alone are also satisfied, although the results are skewed more toward the lower spectrum of satisfaction. The results of those who accept the contractor's proposals and those who analyzed each case separately are too sparse to generalize upon. However, the significant number of respondents who defer responsibility for this task are almost evenly distributed throughout the range of satisfaction (except "Very Dissatisfied"). The areas of dissatisfaction for this "Deferred" group are not so much with the techniques used for calculating the impact but with the bureaucratic process and results of negotiation (Table 4.7) They feel they do not have adequate control in this area of project management, and the base contracting office grants contractor extensions without sufficient documentation and technical support.

Regarding the influence of experience on level of satisfaction, the five categories are again similarly distributed about the mean, with the most experienced group making the only significant contribution (Contingency Table 6). Although the mode for this group is somewhat satisfied, for the first time, more respondents in this category report neutral (28) than very satisfied (23). In addition, almost as many report dissatisfied (21).

Overall, this area of project management reports the highest percentage of dissatisfied managers (18.8%) compared with 55.8% satisfied (Table 4.7). As with the other areas, however, most respondents (65.9%) report no areas of dissatisfaction. Of the 52 who do, the other major category, in addition to the interface with the base contracting office, is the techniques used for calculating the impact. The concerns here are with the inherent inaccuracies of estimating, inexperience of the estimators, and also with the estimating method itself. Two respondents state that their use of bar charts is inadequate for determining the imact of the contract modification on the project duration because they cannot see how the modification interrelates with other activities and affects the project's critical path.

Determining Impact of Delaying Activities. Engineering managers are somewhat satisfied in this area (mode = 4.000, mean = 3.597), although the distribution is again skewed somewhat lower, with more respondents indicating neutral (37) than very satisfied (30) (Table 4.8). Although more than half of the respondents' methods are declared invalid, their levels of satisfaction center very close to the overall mean, as do the small group who report case-by-case determinations. Those with a systematized method are generally much more satisfied and those using judgement somewhat less satisfied than the mean level (Contingency Table 7). Again, as with the other areas of project management, those who defer responsibility for this task are the least satisfied category. In fact, in this area, almost half of this group are dissatisfied with their current method. Their primary concerns essentially echo those of the preceding task. They feel the base contracting office is too liberal, and the technical expertise within civil engineering should play a larger role. As with the other areas of project management, these views represent only a small portion of the respondents, 80.9% of whom report no areas of dissatisfaction.

Regarding the influence of experience level on satisfaction, all categories tend to cluster about the overall mean (Contingency Table 8).

Summary of Responses to Research Objective #1. When viewed against the original research objective, the responses show that engineering managers tend to be satisfied with their current methods of managing base-level civil engineering projects.

The first two areas of project management, determining planned duration and project completion percentages, being mostly "in-house" functions, show the highest level of satisfaction. Those methods which reflect systematized techniques generally score higher than those based primarily on judgement. The most widely-mentioned topics of dissatisfaction in these two areas deal with the estimating techniques: their foundation, their inaccuracies, and the inexperience of the estimators.

The other two areas of project management, determining the impact on project duration of contract modifications and delaying activities, show more dispersed responses and slightly lower levels of satisfaction. As these areas require more interface with other base organizations, such as the user and the base contracting office, this interface becomes the most prevalent topic of dissatisfaction. Engineering managers feel they have too little control in these areas.

In total, however, the results show satisfaction with the current methods, with the majority of respondents indicating no areas of dissatisfaction.

Research Objective #2

> Determine if engineering managers are knowledgable in the terms, concepts and potential applications of CPM.

Survey questions 13, 14, and 15 were specifically designed to meet this objective. The results of Table 4.11 are analyzed by group to determine knowledgable areas.

The first group of terms, used in network construction, show mean knowledge levels of below average to average (2.10 to 2.95), with 56 respondents having no knowledge of merge and burst events. However, 23 of them proceded to answer "Yes" to question 16 as having been associated with CPM. A possible explanation is that the respondents are familiar with the concepts but not the particular terms. Although the knowledge level for dummy activity is higher, the general knowledge in this area is slightly below average. One explanation for this result is that the respondents are in supervisory positions and have probably forgotten the terms from lack of recent use.

The next group of terms, associated with network analysis, show almost identical results among the terms. The knowledge level of average to above average is the highest of all the surveyed areas of knowledge (modes = 3.00, means = 3.43 to 3.44). In practical applications of CPM, these terms are commonplace and would therefore be more familiar to project managers than would the network development terms in the first area. Also, those respondents who have taken the Contract Management course at the AFIT School of Civil

Engineering would remember these terms from the Project Management lesson. Interestingly, the most experienced group of respondents (from question 3) have the highest disproportionate percentage of low knowledge in the area. With 75% of those responding to questions 13, 14, and 15 having greater than twelve years of civil engineering experience, 89% with below average or no knowledge of this group of three terms are in this most experienced category.

The third category of terms are concepts used in direct application of the CPM network schedule. These concepts would likely be more familiar to the contractor working with the CPM schedule than the Air Force project manager inspecting the work and monitoring conformance to the contract. The respondents' levels of knowledge are generally below average in this area (modes = 1.000, means = 2.06 to 2.34). "Resource Allocation" scores somewhat higher possibly because this phrase is also frequently used outside the context of CPM.

Question 14 lists three areas of project management in which CPM has been used. The knowledge level centers around average (modes = 3.000, means = 2.79 to 3.30). These areas would likely be the most familiar to those in the management of the actual construction contract. In fact, the Chiefs of DEEC respond with slightly higher levels of familiarity (means = 3.00 to 3.61) than the other respondents. The overall higher level of familiarity with monitoring contractor progress is attributed to the fact that this task is the primary function of DEEC. Whether or not these respondents are using CPM now, this area would likely be where they would have encountered its use.

Finally, the results of question 15 show little knowledge in two unrelated areas. As mentioned in Chapter I, both the DOD and Air Force supplements to the Federal Acquistion Regulation offer options for specifying CPM. Of those responding to familiarity in this area, almost half report no knowledge, with a mean of 1.90, or below average knowledge. As those who write the specifications, the design engineers would likely be the most knowledgable in this area. Somewhat disturbing, however, is that 64.9% of the Chiefs of DEEE have no knowledge of these options. Their mean level of knowledge (1.84) is the lowest of the organizational position categories from question 4. The last topic deals with knowledge of computerized CPM applications. More than half of the respondents have no knowledge in this area, with the mean level being 1.70, or well below average. With the Work Information Management System (WIMS) entering the civil engineering organizations very soon, this system could prove very receptive to CPM software.

Summary of Responses to Research Objective #2. Analysis of this objective is based on the results in Table 4.11. The below average knowledge of the basic terms of CPM network construction is attributed to the respondents' supervisory positions, which prevents actual "hands-on" work in this area. Their above average familiarity with the analysis terms may result from common use of these terms throughtout the construction industry or from attendance at AFIT courses. Below average knowledge of network application concepts results again from the respondents' supervisory positions being outside the direct management of CPM networks. The group of terms associated with using CPM in project management would most likely show the highest level of knowledge if CPM were being used frequently. The grouping about the average indicates awareness of CPM's application in these areas but not a high frequency of use. Regarding the last two aspects of CPM, the low level of familiarity with CPM software was expected, but the same low level of knowledge of contract specification clauses and policy is somewhat disturbing.

Research Objective #3

Determine the experience engineering managers have with CPM

Survey questions 16 an 17 were used to accomplish this objective. Those respondents who have never heard of CPM did not answer these questions, and those who have never been associated with projects using CPM did not answer question 17.

Contingency Table 9 in Appendix G breaks down the question 16 results by position within the civil engineering organization (question 4). With approximately half of the respondents having been associated with projects using CPM, slightly more than half of the DEE and DEEC chiefs and slightly less than half of the DEEE chiefs are included.

Contingency Table 10 in Appendix G breaks down the question 16 results by years of experience (question 3). Although the experience level is heavily weighted toward the most experienced category, a fairly proportional number from each category contribute to the 71 respondents who have been associated with projects using CPM. Slightly more than half of the most experienced respondents appear in this group, with slightly less than half of the other experience categories, although the numbers in these latter categories are too few to generalize upon.

The results of question 17 (Table 4.13) show that the respondents more often encounter CPM in use on Military Construction Program (MCP) projects than on minor construction, maintenance, or repair projects. Whereas 41.5% report CPM in use on less than 20% of all MCP projects, almost as many (36.9%) say it is used on more than 40% of such projects. In contrast, more than 80% of the respondents indicate less than 20% of all minor construction, maintenance, and repair projects use CPM, and less than 10% say CPM is used on more than 40% of these projects. As CPM has most often been associated with large, complex projects, these results show that AF civil engineering still follows that policy.

Based on their association with projects using CPM, the respondents were then asked in question 18 to approximate the percentage of those projects upon which CPM had a positive effect on project management. Contingency Table 11 in

Appendix G shows the crosstabulation of question 18 with question 17 for MCP projects. Interestingly, the table indicates that those experiencing greater percentages of projects using CPM also perceive CPM to be helpful at a higher rate, with opposite being the case for those associated with a lesser percentage of CPM on MCP projects. Because the high response rate (greater than 90%) in the "Don't Know" and " < 20%" categories for minor construction, maintenance, and repair projects, such crosstabulations were unable to produce meaningful results for these projects. An interesting note, however, is that, of the 6 respondents who experience CPM on greater than 20% of these projects, their perceptions of CPM's effectiveness range from less than 20% to greater than 80%.

Summary of Responses to Research Objective #3. Question 16 split the respondents in half between those who have been associated with projects using CPM and those who have not. Those with CPM experience include slightly more than half of the DEE and DEEC groups and the group with greater than 12 years of civil engineering experience. Slightly less than half of the DEEE and lesser experienced groups are also among those who have been associated with CPM projects. From their experience, these respondents indicate that a greater percentage of MCP projects use CPM than do minor construction, maintenance, and repair projects. Although it seems that increased experience with CPM on MCP projects increases the perceptions of CPM's effectiveness, similar associations cannot be determined from the responses for minor construction, maintenance, and repair projects.

Research Objective #4

> Determine engineering managers' perceptions of CPM's advantages and disadvantages.

Survey questions 19 and 20 were used to meet this objective. Results from Tables 4.15 and 4.16 are arranged in rank order by median in Tables 5.1 and 5.2. The modes are also presented for comparison.

TABLE 5.1

Comparison of Suggested Reasons FOR Using CPM

Rank	Reason	Median	Mode
1	Focuses manager's attention on most time-critical activities	2	1
2	Preplanning requirements show potential resource conflicts	3	2
3	Knowing interrelationsips of activities helps forecast impact of delays and contract modifications	3	3
4	Provides specific information on contractor progress	4	4
**	Other	5	5

** See Appendix D for respondent-generated reasons.

Table 5.1 shows that focusing the manager's attention on time-critical activities is clearly perceived as the strongest advantage, with almost half of the respondents ranking it first and three-fourths ranking it among the top two (Table 4.15). These results are logical since, on the surface, the primary goal of CPM is keeping the critical activities on track. It is interesting to note, however, that 45.1% of the respondents can see beyond the face value of CPM and rank its potentials for forecasting resource conflicts and the impacts of delays and modifications among the top two reasons for using CPM. A comparison with knowledge levels of these same CPM applications in question 14 shows no apparent association between the level of knowledge in these areas and their rank given in question 19.

TABLE 5.2

Comparison of Suggested Reasons AGAINST Using CPM

Rank	Reason	Median	Mode
1	Time and cost for network development and analysis	2	1
2	Compexity in development and understanding	2	1
3	Excessive emphasis on time with little concern for minimizing resources and cost	3	4
4	CPM is only as good as the activity estimates	3	3
**	Other	1	1

** See Appendix E for respondent-generated reasons.

Table 5.2 indicates that engineering managers believe the additional time and cost for CPM, as well as its complexity, are its biggest disadvantages. The open-ended responses to question 20e expand on these same ideas. Some state that CPM is not applicable to small projects because of the additional cost to small businesses, who do not have capabilities for CPM development. Their additional costs for subcontracting the CPM would increase the cost of the contract. Others mention the lack of knowledge and time within the civil engineering organizations for properly monitoring and updating the CPM network.

Summary of Responses to Research Objective #4. The most prevalent advantage of CPM among engineering managers is the fact that it focuses the manager's attention on the most time-critical activities. In contrast, they feel that the additional time, cost, and complexity are its primary disadvantages.

Research Objective #5

> Determine the criteria engineering managers consider important in deciding whether or not CPM is appropriaate for a project.

This research objective required first determining the factors that managers consider important (question 21) and then rank ordering them (question 22). Table 5.3 displays the ranking by median of the factors which the respondents consider important. The modes are also presented for comparison. Open-ended responses for question 21e are tabulated in Appendix F.

Table 5.3 indicates that engineering managers feel that the highest priority when determining whether or not to use CPM is the complexity of the project. Of those who quantified this complexity, Appendix F shows almost three-fourths suggest that 3 to 5 trades/disciplines should be involved in a project before they consider using CPM.

TABLE 5.3

Comparison of Factors Considered in Using CPM

Priority	Factor	Median	Mode
1	Complexity	1	1
2	Type	2	2
3	Cost	2.5	3
4	Duration	3	2
**	Other	1	1

** See Appendix F for respondent-generated reasons.

With project type being the second priority, predictably Appendix F shows the most frequently-reported type is MCP projects, including multi-story, new construction, mission beddown, and major renovation. Minor construction and repair projects are suggested infrequently, and maintenance is mentioned by only two respondents. These results again highlight the perceptions of CPM's primary usefulness on larger, more complex projects.

The distribution of cost cutoffs for the third priority are listed in Appendix F. The results show three similar sized groupings: those between $50,000 and $200,000 (10), those over $1 million (7), and those indicating $multi-million (10). Those in the higher two groups overwhelming believe that CPM would be ineffective on base-level projects (question 23), and those in the lower cost group feel that CPM would be effective.

The factor given the lowest priority is project duration. The minimum time, from those who quantified this factor, range from two weeks to 2-3 years, as seen in Appendix F. However, the largest group appear from those who believe the minimum project duration for CPM application should be either six months or one year.

Those respondents providing another factor in question 21e generally ranked that factor first in question 22. These added factors, shown in Appendix F, most frequently deal with mission essentiality. No mention is made, however, as to whether highly mission-essential projects are or are not candidates for using CPM.

Summary of Responses to Research Objective #5. Analysis of the respondents' priorities when determining whether or not to use CPM developed the rank ordering shown in Table 5.3. It should be noted, however, that, except for project duration, at least half of the respondents who selected a factor, ranked it either first or second. Since respondents were asked to rank only those factors they selected in question 21, many did not indicate a third, fourth, or fifth priority. Had they been asked to do so, the lower-ranked factors might have faired differently.

Research Objective #6

Determine if engineering managers believe CPM would be effective for base-level projects.

Question 23 specifically addressd this topic. Table 4.18 shows that, of those responding to this question, exactly half report very or somewhat ineffective and half indicated very or somewhat effective (mode = 4.000, mean = 2.794). A comparison among categories from questions 3 and 4 (years of civil engineering experience and organization position). reveals that all subgroups are similarly divided. The fact that none of the respondents report "No Opinion" suggests a highly-opinionated population on the topic. Also, more respondents indicate CPM would be very ineffective (19) than those indicating very effective (5). These results suggest that the population half who feel that CPM would be ineffective on base-level projects are more adamant in their beliefs than the other half who believe CPM would be effective.

Crosstabulations with question 17 (see Contingency Table 12 in Appendix G) show a possible association with the percentage of projects, from the respondent's experience, which used CPM. Of those experiencing greater than 40% of all MCP projects using CPM, three times as many believe that CPM would be effective (17) on base-level projects than believed CPM would be ineffective (6). Those who experienced CPM on less than 40% of MCP projects are more likely to believe CPM would be ineffective (24) than effective (15). As discussed in Research Objective #3, the number of respondents experiencing greater than 20% of minor construction, maintenance, and repair projects using CPM is so small that no generalizations can be made. However, of the six respondents in these categories, five indicate that CPM would be effective on base-level projects.

Summary of Responses to Research Objective #6. Exactly half of those responding to question 23 believe CPM would be effective on base-level projects and half feel it would be ineffective. Distribution of the responses suggests that the latter group are more highly opinionated. Although years of civil engineering experience and organizational position play no part in these perceptions, those with experience on a higher percentage of projects using CPM tend to believe CPM would be effective on base-level projects.

VI. Conclusions and Recommendations

Overview

This chapter summarizes the conclusions which can be drawn from this study on Air Force civil engineering project management methods and the perceptions of the applications of CPM to these methods. Also presented are recommendations for improving base-level project management and recommendations for further study.

Conclusions

Conclusions with supporting empirical data were discussed for each research objective in detail in Chapter V. Following is a unification of these conclusions:

1. Engineering managers are somewhat satisfied with their current methods of managing the following aspects of base-level civil engineering projects: determining planned duration, estimating completion percentages, determining impact of contract modifications which add or delete work, and determining impact of delaying activities. This level of satisfaction indicates a low demand for different techniques but definite room for improvement.

Even with the higher levels of satisfaction associated with the methods of determining planned duration and estimating project completion percentages, the most frequent area of dissatisfaction in these two functions is with the estimating techniques. Managers are dissatisfied with the basis for these estimates, their inherent inaccuracies, and the low experience level of the estimators. Since they were most satisfied with the systematized methods in both of these functions, indications are that CPM could be of value by providing a sound basis for planning the project's duration and outlining specific activities upon which to base completion percentages.

With slightly lower and more dispersed levels of satisfaction with current methods of determining the impacts of contract modifications and delaying activities, managers express dissatisfaction mostly in the area of interface among the base organizations. The concern in this area is that base contracting does not rely enough on the technical expertise of civil engineering in the decisions on granting extensions for contract modifications and delays. With the vast majority of respondents showing little consideration for the impact of modifications on related activities and the project as a whole, the results indicate that a properly-maintained CPM network could substantiate civil engineering's input and fortify its position in the decision-making process.

2. The results show that, while engineeering managers have slightly above average knowledge of the network interpretation concepts and application of CPM to monitoring contractor progress, their knowledge of basic terms and other concepts and applications is average to below average. These results suggest that managers understand the potential uses

of CPM but have little depth of understanding that comes from "hands-on" experience.

This lack of experience can be seen in the responses to survey question 17 (Table 4.13) The respondents' most frequent association with CPM has been on MCP projects. However, base level association with MCP projects is limited to surveillance. Actual management of base-level projects occurs on maintenance, repair, and minor construction projects. However, more than 80% of the responses indicate minimal use of CPM on such projects.

The results suggest two possible reasons for this low frequency of CPM use. First, managers do not know how to specify CPM in civil engineering contracts. Their below average knowledge of the network analysis policies in the DFARS and AFFARS is a significant indication of this possibility. Second, managers consider CPM too time-consuming, costly, and complex to warrant its use on base-level projects (Table 5.2). This conclusion is the more probable reason, especially when combined with the well-below average knowledge of CPM computer software, indicated in Table 4.11. One weakness of CPM is its requirement for computer support on all but the very small projects (7:87). Therefore, with base-level projects growing in size and complexity, the lack of computerized CPM support is indeed a deterrent to the use of CPM on such projects.

3. Managers who have been associated with a higher percentage of MCP projects using CPM have a higher frequency

of belief in its effectiveness than those experiencing a lower percentage of MCP projects using CPM. The more experienced group also places greater confidence in CPM's effectiveness on base-level projects than the less experienced group. The number of respondents with experience on base-level CPM projects is too small to generalize upon; however, the tendency is for those with CPM experience on a higher percentage of base-level projects to believe that CPM is effective in this area.

Recommendations

While the results of this study show that engineering managers are generally satisfied with their current methods of managing base-level civil engineering projects, they also reveal some areas of dissatisfaction. These areas, coupled with the growing complexity of such projects, suggest that improvement in the following areas could raise the levels of satisfaction and improve the effectiveness of base-level project management:

1. Emphasize the DFARS and AFFARS policy which allows specification of network analysis on fixed-price construction contracts and family housing renovation projects. Development and distribution of standard guidelines to follow in specifying network analysis would increase awareness of the availability of this management tool and ease the workload of those writing the specifications.

2. Develop a block of instruction on CPM and network

analysis for the Contract Construction Inspection Course at Sheppard AFB TX. Specifying network analysis alone is not enough if those required to monitor the contract are not familiar with the management technique being used. Inspectors must have some exposure to network analysis prior to encountering it in the field; otherwise the purpose for its specification is defeated.

3. Provide workshops for project managers to learn applications and develop in-depth understanding of CPM and other project management tools. The 3-hour block of instruction in AFIT School of Civil Engineering's Mgt 425 course is, by necessity, introductory. Workshops at MAJCOM levels can be made accessible to more project managers and allow them to further develop their introductory skills.

4. Acquire and implement CPM software which is compatible with WIMS. Since WIMS will soon be in use at all civil engineering organizations, this system is the logical home for a readily-accessible, user-friendly network analysis program. This program could aid the Design section significantly in the planning of projects.

Recommendations for Further Study

1. A follow-up study should be made to investigate the effectiveness of CPM on base-level civil engineering projects. Although very infrequent, some respondents in this study indicated 20 - 80% of base-level projects use CPM. A study of these projects to determine the benefits and

pitfalls encountered could assist project managers in their application of CPM on such projects.

2. A study should be undertaken to investigate other project management techniques suitable for base-level projects. With the expansion of base-level projects, current methods of managing them, though satisfactory, may be outmoded. Further research may find more suitable techniques throughout the growing construction industry.

Appendix A: Cover Letter and Survey Questionnaire

DEPARTMENT OF THE AIR FORCE
AIR FORCE INSTITUTE OF TECHNOLOGY (AU)
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433

9 APR 1986

REPLY TO ATTN OF: LS (Capt Roderick D. Reay, AV 785-5435)

SUBJECT: Project Management Survey Package

TO: CES/Chief of DEE

1. Project management is a vital component of the construction industry, and the School of Civil Engineering at AFIT offers lessons in this area to assist the Air Force civil engineering community. We are asking your help in determining the current field practices in this area to guide the content and quality of these lessons.

2. Recently, the Air Force has delegated increased authority for approval of Operations and Maintenance projects to lower levels of command. With this authority comes the opportunity for projects of increased scope and complexity. These projects increase the importance of the project management function.

3. You, as a project manager or management supervisor, can provide valuable guidance by answering the brief questionnaire (10 - 15 minutes) attached to this letter. Your answers will provide both the methods of project management currently in use at our bases and the existing knowledge and experience with a particular technique. Your information will become part of an AFIT research project and may help the School of Civil Engineering design course content that will best fit your needs.

4. Your responses will be combined with others, and no individuals or organizations will be identified in any use of this material. Your participation is completely voluntary, but we would certainly appreciate your help.

5. Please return your responses in the enclosed pre-addressed envelope within one week of receipt. Thank you for your help.

Larry L. Smith

LARRY L. SMITH, Colonel, USAF
Dean
School of Systems and Logistics

2 Atch
1. Questionnaire
2. Return Envelope

ASSESSMENT OF PROJECT MANAGEMENT STRATEGIES

PART I

Please circle the appropriate answer.

1. What is your rank or grade?

a. 0-1	f. GS-9 or below	k. E-7 or below
b. 0-2	g. GS-10	l. E-8
c. 0-3	h. GS-11	m. E-9
d. 0-4	i. GS-12	
e. 0-5	j. GS-13 or higher	

2. What is your highest academic degree?

   a. High school
   b. Associate's degree
   c. Bachelor's degree
   d. Master's degree
   e. Doctorate

3. How long have you been in the civil engineering career field?

   a. Less than 2 years
   b. Between 2 and 4 years
   c. Between 4 and 8 years
   d. Between 8 and 10 years
   e. More than 12 years

4. What position do you hold?

   a. Chief of Engineering and Environmental Planning
   b. Chief of Contract Management
   c. Chief of Design
   d. Other (please specify) ______________________

5. How long have you held this position?

   a. Less than 2 years
   b. Between 2 and 4 years
   c. Between 4 and 8 years
   d. Between 8 and 10 years
   e. More than 12 years

6. To which Air Force Base are you assigned? ______________________

PART II

For the following questions, please use this scale to indicate your degree of satisfaction:

1 - Very dissatisfied
2 - Somewhat dissatisfied
3 - Neutral satisfaction
4 - Somewhat satisfied
5 - Very satisfied

7. State briefly the predominant method your organization uses to determine a project's **planned duration.** ____________________

____

Circle the number that indicates your satisfaction with this method. (-) 1 2 3 4 5 (+)

Is there any particular area of dissatisfaction? ____________

____

____

8. State briefly the predominant method your contract inspectors use in estimating **project completion percentages** for the AF Form 3065.

____

____

Circle the number that indicates your satisfaction with this method. (-) 1 2 3 4 5 (+)

Is there any particular area of dissatisfaction? ____________

____

____

9. State briefly the predominant method your organization uses in determining the impact on performance time of **contract modifications which add or delete work.** ____________________

____

Circle the number that indicates your satisfaction with this method. (-) 1 2 3 4 5 (+)

Is there any particular area of dissatisfaction? ____________

____

10. State briefly the predominant methods your organization uses for determining the impact of **delaying activities** (ie. unusually severe weather, acts of God, strikes, etc.) on project completion time.

____

____

Circle the number that indicates your satisfaction with this method. (-) 1 2 3 4 5 (+)

Is there any particular area of dissatisfaction? ____________

____

____

11. Place a check in the space which approximates the frequency at which the following **base level projects** experience construction delays at your base.

	<20%	20-40%	40-60%	60-80%	> 80%
Maintenance	___	___	___	___	___
Repair	___	___	___	___	___
Minor construction	___	___	___	___	___

PART III

The Critical Path Method (CPM) is one type of network analysis system used in planning, scheduling, and controlling projects through the use of graphical network diagrams. Analysis of these diagrams yields the longest--or critical--path through a project's jobs sequence and determines the project duration. Calculation of the critical path also reveals the float--or slack time--allowed for the jobs not located along the critical path.

12. Have you ever heard of CPM or any other form of network analysis used as a project management tool?

___ Yes ___ No

*****

If you answered "No" to Question 12, please skip the remainder of the questionnaire. Thank you for your extremely valuable contribution to this research effort.

*****

Please use the following scale in answering Questions 13-15.

1 - No knowledge
2 - Below average knowledge
3 - Average knowledge
4 - Above average knowledge
5 - Very knowledgeable

13. Circle the number which best indicates your familiarity with the following terms and concepts associated with CPM.

Merge and burst events	(-)	1	2	3	4	5	(+)
Dummy activity (or restraint)		1	2	3	4	5	
Slack (or float time)		1	2	3	4	5	
Early start and finish times		1	2	3	4	5	
Late start and finish times		1	2	3	4	5	
Crash		1	2	3	4	5	
Resource levelling		1	2	3	4	5	
Resource allocation		1	2	3	4	5	

14. Circle the answer which best indicates your familiarity with the applications of CPM in:

Controlling time impact of contract modifications which add or delete work	(-)	1	2	3	4	5	(+)
Controlling time impact of delays		1	2	3	4	5	
Monitoring contractor progress		1	2	3	4	5	

15. Circle the number which best indicates your familiarity with:

Network analysis contract clauses or policy authorized in the DOD and AF supplements to the Federal Acquisition Regulations	(-)	1	2	3	4	5	(+)
Computerized CPM software		1	2	3	4	5	

Any particular software? _________________________

PART IV

16. Have you personally ever used CPM or been associated in any capacity with projects on which CPM was used?

___ Yes ___ No

*****

If you answered "No" to Question 16, please skip the remainder of the questionnaire. Thank you for your extremely valuable contribution to this research effort.

*****

The following abbreviations are used in Questions 17-18:

DN = Don't know
NA = Not applicable

17. From your association with the following types of projects, check the space which indicates the approximate percentage of each project type which used CPM.

	< 20%	20-40%	40-60%	60-80%	> 80%	DN
MCP projects	___	___	___	___	___	___
Minor construction projects	___	___	___	___	___	___
Maintenance projects	___	___	___	___	___	___
Repair projects	___	___	___	___	___	___

18. Of those projects using CPM, check the space which approximates the percentage upon which CPM had a positive effect on project management.

	< 20%	20-40%	40-60%	60-80%	> 80%	DN	NA
MCP projects	___	___	___	___	___	___	___
Minor construction projects	___	___	___	___	___	___	___
Maintenance projects	___	___	___	___	___	___	___
Repair projects	___	___	___	___	___	___	___

19. The following is a list of suggested reasons **FOR** using CPM. In the spaces in front of each letter, rank order them from 1 to 5 (1 = strongest reason) to indicate your opinion of their relative strength (use each number only once).

___ a. Provides specific information on contractor progress
___ b. Knowing interrelationships of project activities helps forecast effects of delays and work modifications
___ c. Focuses manager's attention on the most time-critical activities
___ d. Preplanning requirements show potential resource conflicts
___ e. Other (please specify) ______________________________

20. Following is a list of suggested reasons **AGAINST** using CPM. In the spaces in front of each letter, rank order them from 1 to 5 (1 = strongest reason) to indicate your opinion of their relative strength (use each number only once).

___ a. Excessive emphasis on minimizing time with little concern for minimizing resources and cost
___ b. Additional time and cost for network development and analysis
___ c. Complexity in development and understanding
___ d. Activity estimates are simply that - estimates. CPM is only as good as the estimates
___ e. Other (please specify) ______________________________

21. Put a check before each of the following areas that you consider important when determining whether or not to use CPM in a project. If you have a cut-off point **for the items you checked**, quantify in the spaces to the right.

___ a. Project cost (What minimum $ amount?) ____________

___ b. Project complexity
(What minimum # of trades/disciplines) ____________

___ c. Project duration (What minimum time?) ____________

___ d. Project type (eg. questions 17 & 18)
(Are some more suitable than others?) ____________

___ e. Other (If quantity, please specify) ____________

22. Please indicate the relative importance of the items **you checked above** by placing the item letter next to its corresponding rank.

Item letter	Rank (1=highest)
___	1
___	2
___	3
___	4
___	5

23. If you had computerized CPM capability available to you at your squadron, how effective do you think it would be **for base-level projects** (circle one).

a. Very ineffective
b. Somewhat ineffective
c. No opinion
d. Somewhat effective
e. Very effective

24. If you were required to use CPM on a project tomorrow, check the following areas where you feel you would need additional knowledge. (Check all that apply.)

___ a. Basic concepts of CPM regarding interrelationships of project activities

___ b. Interpretation of a CPM network

___ c. Contract specification of CPM analysis

___ d. Use of CPM in monitoring contractor progress

___ e. Use of CPM in forecasting effects of delays and work modifications

___ f. Use of CPM as a permanent progress report

___ g. Implementation of available CPM computer software

THANK YOU FOR THE VALUABLE INFORMATION YOU HAVE CONTRIBUTED TO THIS STUDY. Please return the completed questionnaire in the enclosed envelope to: AFIT/LSG (Capt Reay), WPAFB, OH 45433.

Appendix B: Questionnaire Response Distribution

MAJCOM	Base	# of Responses
ATC	Columbus AFB MS	2
	Keesler AFB MS	2
	Laughlin AFB TX	3
	Lowry AFB CO	2
	Mather AFB CA	2
	Reese AFB TX	1
	Sheppard AFB TX	1
	Williams AFB AZ	2
AU	Maxwell AFB AL	1
AFLC	Hill AFB UT	3
	McClellan AFB CA	3
	Newark AFS OH	1
	Robbins AFB GA	2
	Tinker AFB OK	1
	Wright-Patterson AFB OH	3
MAC	Altus AFB OK	1
	Andrews AFB MD	1
	Bolling AFB	2
	Charleston AFB SC	2
	Dover AFB DL	1
	Hurlburt Field FL	3
	Kirtland AFB NM	1
	Little Rock AFB AR	3
	McCord AFB WA	1

MAJCOM	Base	# of Responses
	McGuire AFB NJ	2
	Norton AFB CA	1
	Pope AFB NC	2
	Scott AFB IL	2
	Travis AFB CA	3
SAC	Barksdale AFB LA	1
	Beale AFB CA	3
	Carswell AFB TX	2
	Dyess AFB TX	2
	Ellsworth AFB SD	1
	F E Warren AFB WY	1
	Grand Forks AFB ND	1
	Griffiss AFB NY	1
	Grissom AFB IN	2
	K I Sawyer AFB MI	3
	Loring AFB ME	3
	Malmstrom AFB MT	2
	March AFB CA	2
	McConnell AFB KS	1
	Minot AFB ND	3
	Offutt AFB NE	3
	Pease AFB NH	3
	Plattsburgh AFB NY	2
	Whiteman AFB MO	2
	Wurtsmith AFB MI	2

MAJCOM	Base	# of Responses
SPACE	Cheyenne Mt Complex CO	1
	Peterson AFB CO	2
AFSC	Edwards AFB CA	1
	Eglin AFB FL	2
	Hanscom Field MA	2
	Wright-Patterson AFB OH (ASD)	1
TAC	Bergstrom AFB TX	3
	Davis Monthan AFB AZ	3
	England AFB LA	2
	George AFB CA	2
	Holloman AFB NM	2
	Homestead AFB FL	3
	Langley AFB VA	1
	Luke AFB AZ	3
	MacDill AFB FL	2
	Moody AFB GA	3
	Mt Home AFB ID	1
	Myrtle Beach AFB SC	2
	Nellis AFB NV	2
	Seymour Johnson AFB NC	1
	Shaw AFB SC	3
	Tyndall AFB FL	2
USAFA	USAF Academy CO	3
Unknown		3

Appendix C: Representative Responses to Survey

Questions 7 Through 10

Question 7a: State briefly the predominant method your organization uses to determine a project's planned duration.

SYSTEMATIZED ESTIMATE

-- Critical Path Method and "MEANS" manhour standards

-- Engineering and construction analysis

-- 5-Year plan so that a project can be designed and constructed in one year

-- 1. Administrative requirements 30 days 2. Procurement of materials 30 days 3. Physical performance 30 days

JUDGEMENTAL ESTIMATE

-- Engineering judgement

-- We use experience with past similar projects, time of year, and lead time for critical items.

-- Historical averages

-- Consultation with user, and higher levels of authority

DEFERRED

-- Project engineer's suggestion

-- Project duration is established by designers prior to IFB

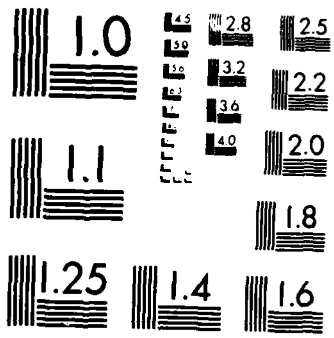
GUESS

-- Guesswork

-- SWAG

AD-A174 593 ANALYSIS OF THE PERCEPTIONS OF CPM (CRITICAL PATH METHOD) AS A PROJECT MA (U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYST R D REAY 2/2

UNCLASSIFIED SEP 86 AFIT/GEM/DEM/86S-21 F/G 15/5 NL



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

Question 7c: Is there any particular area of dissatisfaction?

ESTIMATING TECHNIQUE

-- Approval of submittals and material lead time does not seem to be considered

-- The design engineers do not have a formal scheduling method to ascertain the planned duration, such as: bar chart, CPM, or PERT.

-- When number of days is based on need rather than a realistic time

-- Experience level of engineers providing estimates is not high enough for good estimates.

OGANIZATIONAL INTERFACE

-- Unrealistic restraints imposed on project management by LGC personnel

-- More positive attitude towards modifications to correct a proven deficiency

-- Problems develop when user wants facility too quick and influences performance time.

MANAGEMENT POLICIES

-- Things don't stay stable because of command interest which is usually political.

-- Priority of a project can change quickly as there are 5 strong tenant commanders which seem to be able to dictate a priority for their projects without regard to other base priorities.

-- Once estimated, it becomes bible. It should be used as it was intended, as a guideline.

OTHER

-- Intervening factors beyond my control and authority

-- The contractor is permitted to perform work during unit's exclusion periods. This time is not counted as performance time.

-- Extremely heavy workload results in many projects for each engineer.

Question 8a: State briefly the predomominant method your contract inspectors use in esimating project completion percentages for the AF Form 3064.

CONTRACTOR'S SCHEDULE

-- They compare actual contruction to the contractor's progress schedule.

-- Work in place

-- Progress schedules submitted by the contractor at the start of the project identify specific tasks to be completed by certain dates and assign a percentage completion for that/those task(s). Inspectors simply determine task(s) are completed.

SYSTEMATIZED ESTIMATE

-- Physical materials and equipment intallation

-- Line percentages are based on dollar costs.

-- Constuction analysis

-- Materials and labor utilized to estimate what percentage has been accomplished

JUDGEMENTAL ESTIMATE

-- Estimation based on inspector experience

-- Site visits and estimating

-- Look a jobsite and determine approximate percentage of work - coordinate with contractor

-- Inspectors use project schedule items and use individual judgement to determine percentage of each item completely installed and totals these item percentages for percent complete.

Question 8c: Is there any particular area of dissatisfaction?

CONTRACTOR'S SCHEDULE

-- Contractors often front-load a schedule with more $ than actual expenditures.

-- Frequently contractors will not submit a schedule that accurately reflects the actual progress.

-- Difference between DEEC and contractor on what a work item is worth

ESTIMATING TECHNIQUE

-- Not accurate enough. Percentages reported sometimes too high

-- Estimate of percentage completed is subjective for items not easily measured.

-- Yes, stored materials often get included as being part of a completion percentage!

-- Low inspector grades GS 7/8 preclude hiring quality people able to make accurate, logical, project completion percentages. Dissatisfied with grades.

OGANIZATIONAL INTERFACE

-- Need to justify method and results to LGC in each instance

-- Sometimes we specify more detailed progress charts. The contractors and LGC seem unwilling to use.

-- Too often the cost of materials inflates the progress schedule hence it does not reflect actual work but merely cash flow.

MANAGEMENT POLICIES

-- Sometimes the wing commanders have their own opinion of the percentages which don't match ours

Question 9a: State briefly the predominant method your organization uses in determining the impact on performance time of contract modifications which add or delete work.

IMPACT ON WHOLE PROJECT

-- Estimate amount of work added or deleted and what time frame in contract is mod being made - How does it affect the rest of the work?

-- Review the need with consideration of initial project completion

-- Normally review of bar charts - sometimes CPM

-- Analyze the work to be performed, the crafts and impact on other work, ie. delays caused by new work

MODIFICATION ALONE

-- Estimating amount of work involved

-- Availability of material, weather, type of work

-- An estimate of number of days required for contract mod to be completed are added or deleted.

-- Time for add work mod to secure funds

-- Pure time to perform mod without regard to minor critical path increases

CONTRACTOR REQUEST

-- No set method - usually documented delays by the contractor prevails

-- Contractor's estimate of work time/material time required

-- Contractor estimate of time are normally used by contracting.

DEFERRED

-- Determination by project engineer, negotiated by contracting

-- Specifically assigned a general engineer to construction management to handle all addendum

-- Contracting determines the time extensions

-- Committee assessment

Question 9c: Is there any particular area of dissatisfaction?

OGANIZATIONAL INTERFACE

-- Contracting appears to be biased towards contractor's proposal.

-- Engineering loses control of the contract.

-- Better teamwork among Design Engineering, Base Civil Engineer, Contracting Officer, and Contract Management

-- There is little understanding of the total construction process by the user.

-- Contracting office lenient on granting time extensions when change has little impact on total project performance time.

CONTRACTOR MISUSE

-- Contractors don't think along the lines of efficiency.

-- The contractors usually try to use change orders to get more time on work that they are behind on - usually works.

ESTIMATING TECHNIQUE

-- Improper/incomplete daily reports on all actions by contractor and government office

-- Without using CPM showing elements interrelationship you cannot disprove contractor's claim for time. (3064 does not provide adequate interrelation, it's a bar chart)

-- Because excess time given in planned duration, modification time doesn't matter.

-- Yes, experience level is generally low

MANAGEMENT POLICIES

-- Delay in getting funds approval from HQ

-- Contractors and government don't concern themselves with time until after price is settled.

-- A revised schedule should be written up to show the overall impact that mod will have on overall project.

GENERAL DISSATISFACTION

-- Process takes too long

-- Subjective

-- Would prefer a more realistic governmental approach

Question 10a: State briefly the predominant method your organization uses for determining the impact of delaying activities (ie. unusually severe weather, acts of God, strikes, etc.) on project completion time.

SYSTEMATIZED METHOD

-- Days lost due to exceptional bad weather above and beyond seasonal weather, plus time for repairs due to weather

-- Mission analysis

-- Time lost by unforeseen circumstances is added to the end of the contract.

-- Usually CPM

JUDGEMENTAL ESTIMATE

-- Construction experience, practical knowledge

-- Try to estimate the delay. Keep record of delaying activities like Hurricane Gloria.

-- Judgement

-- Common sense

DEFERRED

-- Each case is evaluated by DEEC, DEEE, Contracting, and Legal (when deemed necessary).

-- The CM and inspector decide how much compensation should be given fcr bad weather

-- Base contracting officer and buyer deal with these items.

Question 10c: Is there any particular area of dissatisfaction?

OGANIZATIONAL INTERFACE

-- We should be included as a more active participant.

-- Too often contracting does not have time for a thorough review and gives contractor extra time too readily.

-- There is little understanding of the total construction process by the user.

CONTRACTOR MISUSE

-- Contractor likes to stretch delay to his favor

-- Works only with honest contractor

-- Some contractor claims are not practical and obviously inflated.

ESTIMATING TECHNIQUE

-- A problem is created when the designer does not specify sufficient performance time, or does not allow for weekends, holidays, or normal bad weather.

-- Inadequate study of events that led to change of site conditions

MANNING

-- Requires a level of expertise not found in the staffing level for Constr. Mgt (CM)

-- We are overloaded - more and more requirements are levelled on us and more cuts in manpower mandated.

Appendix D: Responses to Survey Question 19e: Other Reasons FOR Using CPM

Rank	Reason
2	Defends government position in claims situation
3	Esimate completion date
4	Brief the customer
5	Forces contractor to plan, organize coordinate, etc.
	Provides a check on total days allotted for contract
	Material acquistion requirements
	Negotiate contract modifications
	Can be used for ordering long-lead materials

Appendix E: Responses to Survey Question 20e:

Other Reasons AGAINST Using CPM

Rank	Reason
1	Excessive time required to monitor, keep current and make changes
	Lack of timely, competent up-dating and lack of training of people who need to see it and use it
	Haven't seen a small business contractor who knew how to use and maintain it correctly. Since the burden is on the CM to ensure correctness, I would not reccomend CPM for these projects...a detailed progress schedule/time is about their speed. Currenc project/inspector ratio is 8:1, inspectors would have an extreme amount of extra work if they had to set up and maintain a CPM for each job! Cutting into time on the site and quality inspection
4	Litigation support
	Small contractors - small projects - little or no knowledge - no means to train - will impose <u>additional</u> costs with little return on small business set-aside
5	Shouldn t be used for smaller simple jobs
	Most construction superintendents don't know how to use CPM for its full value
	Jobs too small to warrant the effort

Appendix F: Responses to Survey Question 21: Quantification of CPM Considerations

a. Minimum Cost

Cost ($000)	5	10	50	100	200	250	400	500	1M	2M	3M	>3M
# of Responses	1	1	3	4	4	1	1	3	7	3	3	4

b. Minimum # of Trades/disciplines

# of Trades	2	3	4	4-5	5	6	5-7	10	3-12	20	30
# of Responses	1	6	4	2	3	1	1	2	1	1	1

c. Minimum Time

Time (Months)	1/2	1	2	3	4	5	6	9	12	18	24	24-36
# of Responses	1	1	1	2	1	1	9	1	6	2	1	1

d. Project Type

Type	# of Responses
Military Construction Program	9
Repair	7
Minor Construction	5
Maintenance	2
Renovation/alteration	5
Mission Beddown	2
New Costruction	2
Multistory construction	2
Medical and industrial buildings	2

e. Other Considerations

Rank	Factor
1	Mission essentiality
	Mission impact
	Mission essential and/or command interest
	CPM should only be used for projects that are time constrained (ie. runways, dormitories, bowling alleys, etc.)
	Where completion time is critical
	Criticality of time and cost
	High command interest or mission related
	Only use CPM on "have it now projects"
	Ability to implement and manpower to make it work effectively. Not possible in government work at base level.
4	FAST TRACK design/build

Appendix G: Contingency Tables

The following scale is used for levels of satisfaction in Contingency Table 1 through 8:

1	Very Dissatisfied
2	Somewhat Dissatisfied
3	Neutral Satisfaction
4	Somewhat Satisfied
5	Very Satisfied
0	No Response

Contingency Table 1

Crosstabulation of Methods of Determining Planned Duration With Level of Satisfaction

COUNT ROW % COL %	1	2	3	4	5	0	ROW TOTAL	MEAN
System. Estimate	0 0.0 0.0	1 12.5 12.5	1 12.5 3.3	3 37.7 6.5	3 37.5 7.9	0 N/A N/A	8 5.6	4.00
Judge. Estimate	1 1.1 11.1	6 6.5 75.0	23 24.7 76.7	31 33.3 67.4	32 34.4 84.2	0 N/A N/A	93 70.5	3.94
Guess	3 100.0 33.3	0 0.0 0.0	0 0.0 0.0	0 0.0 0.0	0 0.0 0.0	0 N/A N/A	3 2.1	1.00
Deferred	5 18.5 55.6	1 3.7 12.5	6 22.2 20.0	12 44.4 26.1	3 11.1 7.9	1 N/A N/A	28 21.2	3.26
Invalid/ No Resp.	0 0.0 N/A	2 33.3 N/A	2 33.3 N/A	2 33.3 N/A	0 0.0 N/A	5 N/A N/A	11 N/A	
COLUMN TOTAL	9 6.6	10 7.3	32 23.4	48 35.0	38 27.7	6 N/A	143 100.0	3.70

Contingency Table 2

Crosstabulation of Years in the CE Career Field With Level of Satisfaction with Current Methods of Determining Planned Duration

COUNT / ROW % / COL %	1	2	3	4	5	0	ROW TOTAL	MEAN
< 2 yrs	0	0	1	1	1	0	3	4.00
	0.0	0.0	33.3	33.3	33.3	N/A	2.1	
	0.0	0.0	3.1	2.1	2.6	N/A		
2-4 yrs	2	1	2	6	0	1	12	3.01
	18.2	9.1	18.2	54.5	0.0	N/A	8.4	
	22.2	10.0	6.3	12.5	0.0	N/A		
4-8 yrs	1	0	4	5	0	3	13	3.30
	10.0	0.0	40.0	50.0	0.0	N/A	9.1	
	11.1	0.0	12.5	10.4	0.0	N/A		
8-10 yrs	1	0	1	6	1	0	9	3.67
	11.1	0.0	11.1	66.7	11.1	N/A	6.3	
	11.1	0.0	3.1	12.5	2.6	N/A		
> 12 yrs	5	9	24	30	36	2	106	3.80
	4.8	8.7	23.1	28.8	34.6	N/A	74.1	
	55.6	90.0	75.0	62.5	94.7	N/A		
COLUMN TOTAL	9	10	32	48	38	6	143	3.70
	6.6	7.3	23.4	35.0	27.7	N/A	100.0	

Contingency Table 3

Crosstabulation of Methods of Estimating Project Completion Percentages With Level of Satisfaction

COUNT ROW % COL %	1	2	3	4	5	0	ROW TOTAL	MEAN
Contract. Schedule	2 3.1 28.6	4 6.2 40.0	19 29.2 63.3	22 33.8 51.2	18 27.7 46.2	1 N/A N/A	66 50.8	3.77
System. Estimate	0 0.0 0.0	3 11.5 30.0	4 15.4 13.3	9 34.6 20.9	10 38.5 25.6	0 N/A N/A	26 20.0	4.00
Judge. Estimate	4 11.1 57.1	3 8.3 30.0	7 19.4 23.3	12 33.3 27.9	10 27.8 25.6	0 N/A N/A	36 27.7	3.58
Deferred	1 50.0 14.3	0 0.0 0.0	0 0.0 0.0	0 0.0 0.0	1 50.0 2.6	0 N/A N/A	2 1.5	3.00
Invalid/ No Resp.	0 0.0 N/A	0 0.0 N/A	0 0.0 N/A	1 50.0 N/A	1 50.0 N/A	11 N/A N/A	13 N/A	
COLUMN TOTAL	7 5.3	10 7.6	30 22.9	44 33.6	40 30.5	12 N/A	143 100.0	3.76

Contingency Table 4

Crosstabulation of Years in the CE Career Field With Level of Satisfaction with Current Methods of Estimating Project Completion Percentages

COUNT ROW % COL %	1	2	3	4	5	0	ROW TOTAL	MEAN
< 2 yrs	0 0.0 0.0	0 0.0 0.0	0 0.0 0.0	2 100.0 4.5	0 0.0 0.0	1 N/A N/A	3 2.1	4.00
2-4 yrs	1 9.1 14.3	0 0.0 0.0	1 9.1 3.3	5 45.5 11.4	4 36.4 10.0	1 N/A N/A	12 8.4	4.00
4-8 yrs	1 8.3 14.3	1 8.3 10.0	3 25.1 10.0	5 41.7 11.4	2 16.7 5.0	1 N/A N/A	13 9.1	3.50
8-10 yrs	1 11.1 14.3	1 11.1 10.0	1 11.1 3.3	2 22.2 4.5	4 44.4 10.0	0 N/A N/A	9 6.3	3.78
> 12 yrs	4 4.1 57.1	8 8.2 80.0	25 25.8 83.3	30 30.9 68.2	30 30.9 75.0	9 N/A N/A	106 74.1	3.76
COLUMN TOTAL	7 5.3	10 7.6	30 22.9	44 33.6	40 30.5	12 N/A	143 100.0	3.76

Contingency Table 5

Crosstabulation of Methods of Determining Impact of Contract Modifications With Level of Satisfaction

COUNT ROW % COL %	1	2	3	4	5	0	ROW TOTAL	MEAN
Project Impact	0 0.0 0.0	1 5.9 5.9	4 23.5 12.1	6 35.3 13.6	6 35.3 20.7	0 N/A N/A	17 12.8	4.00
Mod. Alone	5 6.8 55.6	6 8.2 35.3	19 26.0 57.6	28 38.4 63.6	15 20.5 51.7	1 N/A N/A	74 55.6	3.58
Contract. Request	1 33.3 11.1	0 0.0 0.0	1 33.3 3.0	1 33.3 2.3	0 0.0 0.0	0 N/A N/A	3 2.3	2.67
Case-by -case	0 0.0 0.0	2 100.0 11.8	0 0.0 0.0	0 0.0 0.0	0 0.0 0.0	0 N/A N/A	2 1.5	2.00
Invalid/ No Resp.	0 0.0 N/A	0 0.0 N/A	2 33.3 N/A	3 50.0 N/A	1 16.7 N/A	4 N/A N/A	10 N/A	
COLUMN TOTAL	9 6.5	17 12.3	35 25.4	47 34.1	30 21.7	5 N/A	143 100.0	3.52

Contingency Table 6

Crosstabulation of Years in the CE Career Field With Level of Satisfaction with Current Methods of Determining Impact of Contract Modifications

COUNT ROW % COL %	1	2	3	4	5	0	ROW TOTAL	MEAN
< 2 yrs	0 0.0 0.0	0 0.0 0.0	0 0.0 0.0	2 100.0 4.3	0 0.0 0.0	1 N/A N/A	3 2.1	4.00
2-4 yrs	1 8.3 11.1	2 16.7 11.8	2 16.7 5.7	2 16.7 4.3	5 41.7 16.7	0 N/A N/A	12 8.4	3.50
4-8 yrs	0 0.0 0.0	0 0.0 0.0	4 36.4 11.4	6 54.5 12.8	1 9.1 3.3	2 N/A N/A	13 9.1	3.50
8-10 yrs	1 11.1 11.1	1 11.1 5.9	1 11.1 2.9	5 55.6 10.6	1 11.1 3.3	0 N/A N/A	9 6.3	3.44
> 12 yrs	7 6.7 77.8	14 13.5 82.4	28 26.9 80.0	32 30.8 68.1	23 22.1 76.7	2 N/A N/A	106 74.1	3.48
COLUMN TOTAL	9 6.5	17 12.3	35 25.4	47 34.1	30 21.7	5 N/A	143 100.0	3.52

Contingency Table 7

Crosstabulation of Methods of Determining Impact of Delaying Activities With Level of Satisfaction

COUNT ROW % COL %	1	2	3	4	5	0	ROW TOTAL	MEAN
System. Estimate	0 0.0 0.0	0 0.0 0.0	9 31.0 60.0	12 41.4 54.5	8 27.6 53.3	0 N/A N/A	29 42.6	3.97
Judge. Estimate	2 14.3 28.6	3 21.4 50.0	2 14.3 13.3	4 28.6 18.2	3 21.4 20.0	1 N/A N/A	15 22.1	3.21
Case-by -case	0 0.0 0.0	1 14.3 16.7	2 28.6 13.3	2 28.6 9.1	2 28.6 13.3	1 N/A N/A	8 11.8	3.71
Deferred	5 33.3 71.4	2 13.3 33.3	2 13.3 13.3	4 26.7 18.2	2 13.3 13.3	1 N/A N/A	16 23.5	2.73
Invalid/ No Resp.	0 0.0 N/A	6 9.4 N/A	22 34.4 N/A	21 32.8 N/A	15 23.4 N/A	11 N/A N/A	75 N/A	
COLUMN TOTAL	7 5.4	12 9.3	37 28.7	43 33.3	30 27.3	14 N/A	143 100.0	3.52

Contingency Table 8

Crosstabulation of Years in the CE Career Field <u>With</u> Level of Satisfaction with Current Methods of Determining Impact of Delaying Activities

COUNT ROW % COL %	1	2	3	4	5	0	ROW TOTAL	MEAN
< 2 yrs	0 0.0 0.0	0 0.0 0.0	2 66.7 5.4	0 0.0 0.0	1 33.3 3.3	0 N/A N/A	3 2.1	3.67
2-4 yrs	2 16.7 28.6	0 0.0 0.0	3 25.0 8.1	3 25.0 7.0	4 33.3 13.3	0 N/A N/A	12 8.4	3.58
4-8 yrs	0 0.0 0.0	0 0.0 0.0	5 41.7 13.5	6 50.0 14.0	1 8.3 3.3	1 N/A N/A	13 9.1	3.50
8-10 yrs	1 11.1 14.3	0 0.0 0.0	3 33.3 8.1	5 55.6 11.6	0 0.0 0.0	0 N/A N/A	9 6.3	3.33
> 12 yrs	4 4.3 57.1	12 12.9 100.0	24 25.8 64.9	29 31.2 67.4	24 25.8 80.0	13 N/A N/A	106 74.1	3.61
COLUMN TOTAL	7 5.4	12 9.3	37 28.7	43 33.3	30 27.3	14 N/A	143 100.0	3.52

Contingency Table 9

Crosstabulation of Association with Projects Using CPM
With Position in the CE Organization

COUNT ROW % COL %	DEE	DEEC	DEEE	Other	ROW TOTAL
No	21 34.4 44.7	19 31.1 43.2	21 34.4 55.3	0 0.0 0.0	61 46.2
Yes	26 36.6 55.3	25 35.2 56.8	17 23.9 44.7	3 4.2 100.0	61 53.8
No Resp.	2 18.2 N/A	5 45.4 N/A	4 36.4 N/A	0 0.0 N/A	11 N/A
COLUMN TOTAL	49 34.3	49 34.3	42 29.4	3 2.1	143 100.0

Contingency Table 10

Crosstabulation of Association with Projects Using CPM
With Years in the CE Career Field

COUNT ROW % COL %	< 2 Yrs	2-4 Yrs	4-8 Yrs	8-10 Yrs	> 12 Yrs	ROW TOTAL
No	1 1.6 33.3	5 8.2 55.6	7 11.5 63.6	5 8.2 55.6	43 70.5 43.0	61 46.2
Yes	2 2.8 66.7	4 5.6 44.4	4 5.6 36.4	4 5.6 44.4	57 80.3 57.0	71 53.8
No Resp.	0 0.0 N/A	3 27.3 N/A	2 18.2 N/A	0 0.0 N/A	6 54.5	11 N/A
COLUMN TOTAL	3 2.1	12 8.4	13 9.1	9 6.3	106 74.1	143 100.0

Contingency Table 11

Crosstabulation of Percent of MCP Projects Using CPM With Percent of These Projects Upon Which CPM had a Positive Effect on Project Management

COUNT ROW % COL %	< 20%	20- 40%	40- 60%	60- 80%	> 80%	Dont Know	N/A	ROW TOTAL
Dont Know	0 0.0 0.0	0 0.0 0.0	0 0.0 0.0	0 0.0 0.0	0 0.0 0.0	4 80.0 36.4	1 20.0 16.7	5 7.7
< 20%	14 51.9 77.8	1 3.7 33.3	3 11.1 37.5	1 3.7 25.0	2 7.4 13.3	1 3.7 9.1	5 18.5 83.3	27 41.5
20-40%	3 33.3 16.7	2 22.2 66.7	2 22.2 25.0	1 11.1 25.0	0 0.0 0.0	1 11.1 9.1	0 0.0 0.0	9 13.8
40-60%	0 0.0 0.0	0 0.0 0.0	1 16.7 12.5	0 0.0 0.0	3 50.0 20.0	2 33.3 18.2	0 0.0 0.0	6 9.2
60-80%	0 0.0 0.0	0 0.0 0.0	1 16.7 12.5	1 16.7 25.0	3 50.0 20.0	1 16.7 9.1	0 0.0 0.0	6 9.2
> 80%	1 8.3 5.6	0 0.0 0.0	1 8.3 12.5	1 8.3 25.0	7 58.3 46.7	2 16.7 18.2	0 0.0 0.0	12 18.5
COLUMN TOTAL	18 27.7	3 4.6	8 12.3	4 6.2	15 23.1	11 16.9	6 9.2	65 100.0

Contingency Table 12

Crosstabulation of Percent of MCP Projects Using CPM With Opinions of CPM's Effectiveness on Base-level Civil Engineering Projects

COUNT ROW % COL %	Very Ineff	Some Ineff	No Opin	Some Eff	Very Eff	ROW TOTAL
Dont Know	2 40.0 11.8	1 20.0 7.7	0 0.0 0.0	1 20.0 3.7	1 20.0 20.0	5 8.1
< 20%	11 42.3 64.7	5 19.2 38.5	0 0.0 0.0	9 34.6 33.3	1 3.8 20.0	26 41.9
20-40%	1 12.5 5.9	4 50.0 30.8	0 0.0 0.0	3 37.5 11.1	0 0.0 0.0	8 12.9
40-60%	0 0.0 0.0	0 0.0 0.0	0 0.0 0.0	4 80.0 14.8	1 20.0 20.0	5 8.1
60-80%	0 0.0 0.0	2 33.3 15.4	0 0.0 0.0	3 50.0 11.1	1 16.7 20.0	6 9.7
> 80%	3 25.0 17.6	1 8.3 7.7	0 0.0 0.0	7 58.3 25.9	1 8.3 20.0	12 19.4
COLUMN TOTAL	17 27.4	13 21.0	0 0.0	27 43.5	5 8.1	62 100.0

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This study identifies current project management practices and investigates the knowledge and use of the Critical Path Method (CPM) in base level civil engineering contract projects. The increased approval authority for maintenance, repair, and minor construction projects accents the need for good project management. CPM is a widely-used management technique on large construction projects, but its value for these smaller operations and maintenance projects is less publicized. A survey questionnaire was developed to collect data from senior managers in CONUS base level Engineering and Environmental Planning branches. The survey results indicate these managers are somewhat satisfied with their current methods of managing base-level projects but are dissatisfied in some areas. The perceived knowledge of CPM terms, concepts, and applications is average to below average. Most experience with CPM is with MCP projects. Half of those responding believe that CPM would be effective on base-level projects, and half feel it would be ineffective. Those with the most association with CPM projects tend to be among those who feel it would be effective on base-level projects.

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