✓Done

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
SYNTHESIS OF HIGHWAY PRACTICE

168

CONTRACT MANAGEMENT SYSTEMS

TRANSPORTATION RESEARCH BOARD
National Research Council

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
SYNTHESIS OF HIGHWAY PRACTICE 168

CONTRACT MANAGEMENT SYSTEMS

JACK STERNBACH
Albany, N.Y.

Topic Panel

VERDI ADAM, *Gulf Engineers & Consultants*
KEITH BORKENHAGEN, *Federal Highway Administration*
KENNETH E. COOK, *Transportation Research Board*
W. MAL HILLIARD, *Florida Department of Transportation*
THOMAS H. MAY, *Pennsylvania Department of Transportation*
JIM SIEBELS, *Colorado Department of Highways*
JAMES M. WELSH, *Maryland State Highway Administration*

RESEARCH SPONSORED BY THE AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS IN COOPERATION WITH THE FEDERAL HIGHWAY ADMINISTRATION

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
WASHINGTON, D.C. DECEMBER 1990

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as: it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to the National Research Council is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

NOTE: The Transportation Research Board, the National Research Council, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and the individual states participating in the National Cooperative Highway Research Program do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

NCHRP SYNTHESIS 168

Project 20-5 FY 1986 (Topic 18-10)
ISSN 0547-5570
ISBN 0-309-04916-4
Library of Congress Catalog Card No. 90-71668

Price $10.00

Subject Area
Administration

Mode
Highway Transportation

NOTICE

The project that is the subject of this report was a part of the National Cooperative Highway Research Program conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council. Such approval reflects the Governing Board's judgment that the program concerned is of national importance and appropriate with respect to both the purposes and resources of the National Research Council.

The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation Officials, or the Federal Highway Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical committee according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

The National Research Council was established by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and of advising the Federal Government. The Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in the conduct of their services to the government, the public, and the scientific and engineering communities. It is administered jointly by both Academies and the Institute of Medicine. The National Academy of Engineering and the Institute of Medicine were established in 1964 and 1970, respectively, under the charter of the National Academy of Sciences.

The Transportation Research Board evolved in 1974 from the Highway Research Board, which was established in 1920. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society.

Published reports of the

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Transportation Research Board
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

Printed in the United States of America

PREFACE

A vast storehouse of information exists on nearly every subject of concern to highway administrators and engineers. Much of this information has resulted from both research and the successful application of solutions to the problems faced by practitioners in their daily work. Because previously there has been no systematic means for compiling such useful information and making it available to the entire highway community, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing project to search out and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in the subject areas of concern.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD

By Staff
Transportation
Research Board

This synthesis will be of interest to administrators, contract officers, and others interested in using consulting firms to manage a transportation agency's work activities—ranging from a single project to a complete spectrum of work. Information is provided on various aspects of contract management systems, including examples of use of each aspect in several agencies.

Administrators, engineers, and researchers are continually faced with highway problems on which much information exists, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and unevaluated, and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to available practices for solving or alleviating the problem. In an effort to correct this situation, a continuing NCHRP project, carried out by the Transportation Research Board as the research agency, has the objective of reporting on common highway problems and synthesizing available information. The synthesis reports from this endeavor constitute an NCHRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to specific highway problems or sets of closely related problems.

An increasing workload coupled with reduced staff size have caused state highway agencies to turn to private enterprise to accomplish work that has traditionally been done in-house. This report of the Transportation Research Board describes various aspects of the use of consultants to manage a highway agency's work and gives specific examples of use of each aspect in several agencies.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, the Board analyzed available information assembled from numerous sources, including a large number of state highway and transportation departments. A topic panel of experts in the subject area was established to guide the researcher in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

CONTENTS

1 SUMMARY

4 CHAPTER ONE INTRODUCTION
- Variations of Construction Management, 4
- Trends, 5
- Scope of Synthesis and Approach, 5

8 CHAPTER TWO CONTRACT MANAGEMENT PROJECTS
- Introductory Examples, 8
- State Projects, 9
- Overview, 14

15 CHAPTER THREE SELECTION OF A CONTRACT MANAGEMENT CONSULTANT
- Reasons for the CMC Approach, 16
- Selection of CMC, 18
- Overview, 20

22 CHAPTER FOUR SCOPE AND COST OF MANAGEMENT CONTRACTS
- General, 22
- Scope of Work on State Projects, 23
- Scope Preparation and Cost Estimating, 27
- Selected Contract Features, 29
- Overview, 30

32 CHAPTER FIVE ORGANIZATION AND INTERRELATIONSHIPS
- General Background, 32
- State Projects, 33
- Federal Requirements, 42
- Overview, 45

46 CHAPTER SIX CONTROL OF PROGRESS AND COST
- Monitoring and Reporting Systems, 46
- Corrective Actions, 52
- Overview, 54

55 CHAPTER SEVEN LEGAL RESPONSIBILITIES AND LIABILITY
- Liability and Claims, 57
- Indemnification and Insurance, 58
- Overview, 59

61 REFERENCES

62 APPENDIX A DELINEATION OF RELATIVE RESPONSIBILITIES IN THE MANAGEMENT OF FDOT'S I-595 PROGRAM

67 APPENDIX B SAMPLES OF OUTPUT FROM FDOT'S I-595 COMPUTERIZED MANAGEMENT SYSTEM FOR MONTHLY PROGRESS REPORTS

70 APPENDIX C SAMPLES OF OUTPUT FROM WSDOT'S I-90 COMPUTERIZED MANAGEMENT SYSTEM FOR MONTHLY PROGRESS REPORTS

ACKNOWLEDGMENTS

This synthesis was completed by the Transportation Research Board under the supervision of Robert E. Skinner, Jr., Director for Special Projects. The Principal Investigators responsible for conduct of the synthesis was Herbert A. Pennock, Special Projects Engineer. This synthesis was edited by Judith Klein.

Special appreciation is expressed to Jack Sternbach, Albany, N.Y., who was responsible for the collection of the data and the preparation of the report.

Valuable assistance in the preparation of this synthesis was provided by the Topic Panel, consisting of Verdi Adam, President, Gulf Engineers & Consultants; Keith Borkenhagen, Highway Engineer, Office of Engineering, Federal Highway Administration; W. Mal Hilliard, Research Coordinator, Florida Department of Transportation; Thomas H. May, Design Services Engineer, Pennsylvania Department of Transportation; Jim Siebels, Director of Central Engineering, Colorado Department of Highways; and James M. Welsh, Deputy Chief Engineer—Construction, Maryland State Highway Administration.

Kenneth E. Cook, Transportation Economist, Transportation Research Board, assisted the NCHRP Project 20-5 Staff and the Topic Panel.

Information on current practice was provided by many highway and transportation agencies. Their cooperation and assistance were most helpful.

CONTRACT MANAGEMENT SYSTEMS

SUMMARY

This summary is a synopsis of the subject matter of this synthesis. Those readers who need somewhat greater detail may find it worthwhile to read the overviews at the end of Chapters 2 through 7. Each overview gives a summary and analysis of the contents of the chapter.

The burgeoning need to rehabilitate the nation's aging infrastructure has required increasingly greater capital expenditures at the federal and state levels over the past few decades. Because of the prevailing policy to limit the growth of governmental bureaucracies, states had to find alternatives to increasing their permanent staffs in order to accommodate their growing transportation programs. Although the alternative of supplementing the states' manpower resources with production consultants for design and construction supervision has been successful, a growing shortage of experienced engineering managers within the states' organizations is limiting their ability to control and manage their programs. An emerging solution is the states' use of contract management consultants (CMCs), a variation of the construction manager concept used by private industry. This practice is expected to increase over time to meet projected shortfalls.

The appeal of this concept is enhanced by its adaptability to any type or amount of work desired by an agency and by its flexibility in augmenting personnel shortages in any number of functional disciplines. Management consultants are being assigned to projects varying in size from a few million dollars to multi-billion-dollar megaprojects, and from the management of a single work activity to the management of the complete spectrum of work from the conceptual stage through the completion and operation of the facility.

Many state agencies prefer using management consultants to increasing their permanent staff for temporary increases in program workload, thereby avoiding the trauma of subsequent personnel layoffs, the delays associated with hiring and training new staff, and reducing the critical time allowed to meet funding deadlines or demands by the public. Other reasons cited for selecting the consultant manager alternative, apart from legislative restrictions on increases in permanent staff, include the ready availability of computerized management systems and the potential savings that may result from constructibility reviews by experienced or specialized firms.

The considerations and methods for selecting management consultants are generally similar to those for production consultants, but with a somewhat different emphasis. The most important asset of a contract management consultant is perceived to be its multidisciplinary staff with a broad spectrum of experience in managing all types of projects, including the specific experience required for the project at hand. The procedure recommended by most agencies includes oral interviews with the principals and key staff of the firm to evaluate their qualifications, their knowledge of the project and its potential problems, and their ingenuity in resolving the potential problems.

Contract management consultants generally need to assume leadership in reviewing designs by others; in selecting the most economical construction methods; in establishing project design schedules, construction schedules, and mileposts; in monitoring the work to assure that the progress, cost, and quality objectives are met; and in discharging any other responsibilities delegated by the owner. Such responsibilities are tailored by the owner to the specific project needs and may be considerably less or greater than indicated above. In order for the CMC to adequately represent the owner's interests, the owner should not require the CMC to do any significant construction or design work on the project with its own forces. This will reduce the potential of adversary relationships and assure the CMC's objectivity and impartiality, important assets to the owner in the adjudication of disputes and in constructibility reviews.

State agencies have had varying degrees of difficulty in developing the scope of work required of their management consultants and in estimating their costs. When capable and experienced engineers were available, such difficulties were manageable. Most states develop their initial scope and cost by comparing the man-hour estimates and the technical proposals submitted by shortlisted firms. Oral interviews and negotiations provided additional insight. Also, by committing the CMC sequentially to successive stages of the project, rather than to the entire project initially, errors in estimating over the long term were reduced.

The cost of a CMC varies sharply with the size and scope of the project, but the data available are insufficient for the development of averages. Such costs vary considerably and inconsistently from about 1 to 8 percent of the total construction cost of the project. When the construction phase is not managed, such cost percentages are less.

There is no prototype organization for the management of large projects. The relationships among the owner, the management consultant, the designers, the contractors, and others involved in the project are extremely important, because people, not structure, make concepts work. Prevailing opinion cites the three-party team of owner, manager, and designer as the best nonadversarial approach to the management of large projects. The delegation of authority to appropriate lower levels is deemed to be preferable to the retention of centralized decision making, which can result in excessive and costly delays. Control and communications at these lower levels are simplified via the matrix concept of interrelationships between counterparts of the owner's and the manager's staffs.

The control systems used by the management firms consist of critical path method networks and computerized management information systems to simplify the continual updating of data and timely reporting. Their basic objectives are to compare actual progress and expenditures to mileposts and budgeted amounts respectively and to report on deficiencies for timely correction. Functional managers prefer using personal computers rather than a centralized mainframe run by computer specialists because they are able to adjust the output and level of detail to their individual needs and because the system is readily available.

The contract management consultants are basically advisers to the state agency and are authorized only to recommend appropriate action in the event production consultants are deficient in meeting the program objectives. The corrective actions available to the state are limited to the assessment of liquidated damages, restrictions on future contracts with the firm, or termination. Bonuses to expedite work are occasionally offered to reduce conflicts or delays in emergencies, but are not the general practice.

Incentive or penalty provisions to motivate the manager are notably absent from state agency contracts because of the prevalent attitude that the CMC is more than

sufficiently motivated by its own concern for its reputation. The actions available to the state in the event of faulty performance by the CMC are limited to dismissal of specific employees or termination of the contract.

Liability claims and suits have doubled within the national transportation program over a recent three-year period. Their potential is even greater because of the size and complexity of the projects that are usually assigned to CMCs. This higher potential for claims is caused by the interferences and delays caused by the friction of numerous entities working within the confines of limited space and time.

Inserting another entity between the state agency and its agents further adds to the liability problem by blurring communications and delaying approvals. These factors increase the potential for contractual claims, third party claims by abutting property owners and businesses, and claims generated by a need to accelerate the work to meet mileposts. It is not considered appropriate for a state agency to transfer the risks of such claims to the CMC because that firm has no control over the incidence of such claims nor is it compensated for such risk. To do so would violate the desirable relationship between the state and its manager for effective management without conflict of interest.

For similar reasons, insurance requirements in consultant management contracts are limited to general liability and indemnification provisions to protect the agency, with only modest requirements for professional liability coverage. The general practice is to avoid placing responsibility upon the CMC for liability other than for its own negligence or malfeasance. It is important to delineate the manager's responsibilities clearly and to cast his role in an advisory capacity in order to reduce the manager's liability risk and resultant insurance costs, which the state ultimately pays indirectly. However, in the final analysis, the best approach to reducing liability and risk is deemed to be in the implementation of a risk management program to reduce the potential for claims. This is accomplished in some states by expediting reviews and approvals, promptly settling disputes during the course of the work, and delegating approvals to local levels to expedite all communications and decisions.

CHAPTER ONE

INTRODUCTION

The rapidly escalating needs over the past decade for transportation improvements and for rehabilitating the nation's infrastructure have placed enormous demands on the manpower and financial resources at all levels of government. Although sharp increases in funding were made available via the Surface Transportation and Assistance Act of 1982 and various state bond issues, the prevailing national concern over the growth of government bureaucracy generated strong budgetary resistance to the hiring of the additional staff needed to manage the enlarged program.

Initially, the states looked toward improvements in engineering productivity and the increased use of consultants for design and construction engineering and inspection to fill the gap between their existing personnel and the numbers needed to handle their ever-increasing workload. However, the states' inability over many years to infuse their aging professional engineering staff with younger professionals and to provide the new hires with the experience needed to fill the vacancies eventually created by a wave of retirements among the most experienced personnel created a serious shortfall in the states' engineering management capacity.

Continuing legislative resistance to increasing state agency staff has required the consideration of ways to reduce the states' need for managers. For example, the traditional approach used by public agencies requires a high degree of management and control. It involves design by the owner or its consultant, competitive bids for construction, and a contract between the owner and the lowest responsible bidder. The construction work may be supervised by the owner, its consultant contracted for that purpose, or by the design consultant. This approach is favored by government because it provides the ability to control cost and quality and meets well-established legal and contractual precedents. Its disadvantages include the need for high involvement by the owner, general adversary relationships with the contractor, and high overall project time from the planning phase through construction completion. The last factor is particularly critical in situations where completion time is more important than project cost.

The design-construct approach sparked interest in the industrial field because of the high and escalating costs of delay. In this approach, all phases of a project from conceptual through design and construction are handled by the same organization. This unified approach permits a phased construction program, even while design is in progress, to minimize project duration. Savings in overall time over competitors could spell the difference between economic survival, increased market penetration, and profits versus bankruptcy.

However, public agencies became disenchanted with the design-construct approach because of its inability to set a firm cost until the project is well under way, the lack of motivation to emphasize quality versus profit, and the lack of detailed control beyond broad major cost objectives and individual milestones, with quantity and cost variations of more than 100 percent a usual occurrence.

Barrie and Paulson (*1*) relate that, with the new critical path method (CPM) scheduling ability and simultaneous staging of design and construction, pressures began to build for increasingly greater work accelerations. These pressures began to cause labor shortages and ever-increasing costs, including numerous claims for the cost of accelerating work because of delays to one contractor caused by interference or delays by another. This situation caused some owners to return to the traditional cost-effective method and others to turn to construction management.

VARIATIONS OF CONSTRUCTION MANAGEMENT

Construction management (CM) is generally considered to be a generic term encompassing many variations, including professional construction management and program management. Its many definitions are attributable to the specific interests of the various organizations from which they emanate. The term CM may apply to any or all phases in the life cycle of a construction project, from concept and feasibility studies through implementation and operation.

The American Society of Civil Engineers (ASCE) Committee on Construction Management (*2*) cites CM as a unique alternative that competes with both the traditional general contracting approach and the design-construct system. Construction management provides a menu of services from which the owner may select when engaging a construction manager. It is this very flexibility that causes both the confusion regarding the true nature of CM and the many variations in its definition.

Barrie (*3*) describes professional construction management (PCM) as a contract arrangement tying the owner, the professional manager, and the design organization into a management team that handles the project planning, design, and construction phases as integrated tasks. The team may also include members from a prime construction contractor or a funding agency or both. The team's objectives include serving the owner's interests and minimizing adversary relationships in the management of a phased construction project. Tatum et al. (*4*) recommend, however, that the basic design responsibility in such an arrangement must be retained by the designer.

The management firm does not usually do any design or construction work with its own forces nor does it guarantee the overall cost of the work, but may do both if required by the owner. The manager must work with the owner and designer from the inception of the project through to its completion; propose alternatives and analyze their effects on cost and schedule; monitor the work to assure meeting quality, cost, and schedule objectives; and advise and coordinate in the procurement of

materials and in the selection and performance of construction contractors.

The advantages of PCM include the ability to apply construction expertise in design, coordinate full time between design and construction, make decisions in the best interest of the owner, reduce duration time to a minimum, assure competition by contractors, and provide for value engineering (VE) opportunities. On the other hand, there is a risk with the phased construction approach that the value of time saved may not be commensurate with the cost, and that it lacks any guarantees regarding the project cost or quality.

Another variation is program management (PM), which is described by Barrie (*3*) as an emerging concept whereby the program manager may manage a number of design firms, construction contractors, materials and equipment suppliers, or others without retaining any actual design or direct construction responsibilities. The concept has been used on some very large projects, with the owner's top management staff participating heavily in an integrated program management team alongside specialized consultant personnel.

TRENDS

The use of CM in one form or another has grown rapidly, primarily in private industry. The magazine *ENR* (*5*) reports that "an active public construction market helped boost construction management billings by The Top 500 by 14% in 1987" and that A/E firms are very active in this field, accounting for more than two-thirds of the total CM billings. A list of the top 50 CM market leaders shows that CM work represents from 30 percent to 100 percent of the total work of a majority of the firms.

However, although high inflation, interest rates, and demand for the finished product sparked a surge in CM to reduce the critical length of time from concept to reality, the risk of budget overruns and delays imposed by increased governmental regulation served to counter the trend. Barrie (*3*) cites owner dissatisfaction with cost and time overruns as the cause of increased owner involvement.

Naoum and Langford (*6*) report similar findings on the use of management contracting (MC) in the United Kingdom, which is the equivalent of PCM in the United States except that the client has a more muted role. The objective of this system is also to minimize the overall project duration for large complex projects, with the cost of construction considered to be of secondary importance. A survey of clients after their use of this system indicated that MC is more costly to clients and more profitable to contractors than the traditional approach, results in the same number of claims, can produce earlier starts, is more reliable in predicting time for construction, and provides more control over operations and subcontractors; it does, however, yield a worse building design.

SCOPE OF SYNTHESIS AND APPROACH

This is the fourth synthesis that relates to the use of consultants by state transportation agencies in the administration and management of their programs:

- *Synthesis 145: Staffing Considerations in Construction Engineering Management* (*7*) summarizes and analyzes the state of the art in staffing highway construction projects from the points of view of both the contractor and the agency. It addresses the adequacy of such staff relative to the construction quality, attrition, training, and incentives.
- *Synthesis 146: Use of Consultants for Construction Engineering and Inspection* (*8*) covers determination of the need for consultants, definition of the scope of services and the type of contract, consultant selection and negotiation, the responsibility and accountability of construction engineering and inspection (CEI) consultants, and administration and monitoring.
- *Synthesis 137: Negotiating and Contracting for Professional Engineering Services* (*9*) examines the entire process from the determination of the need for consultants; preselection policies and procedures, including an examination of the value of price competition from historical federal, state, professional, and public viewpoints; consultant selection; negotiation; risk assignment; and selected contract features.

This synthesis centers on the management systems and related procedures adopted by the various states to fill the gaps in their engineering management staffs. The states seem to be more involved and exert greater controls than private industry over the consultant managers. This may reflect a resistance to change, but is generally attributed to the federal requirements for adequate state organizations and controls to manage the states' federal-aid programs, and to restrictions within the state bureaucracies and their responsibilities to the general public.

The management system addressed in this synthesis is another variation of construction management that may be particularly suited to public agencies. To avoid confusion it appears advisable to address it by a generic term, contract management system (CMS). At the risk of adding another definition to the world of management, the CMS is described as an agency's use of a contract management consultant (CMC) to assist it in managing multiple contracts between the agency and other consultants or firms engaged for services on a large project or system. The CMC should do little or no production work with its own forces.

Such services by other consultants or firms may include any or all functions from planning and project definition through environmental design, land acquisition, procurement, and quality control of materials, construction supervision, maintenance, or other operations. The CMC's assistance must be in the form of taking over some aspect of management normally handled by the owner or agency. The foregoing definition of a CMC does not apply to consultant supervision of a large project with the assistance of multiple subcontractors.

A literature search was made of studies, journal articles, publications, and other works relating to this subject. In addition, a two-part survey questionnaire was sent to all state highway and transportation departments and to a sample of state authorities. The responses were highly variable in degree of detail, largely because the personnel who were familiar with their state's use of a CMC were either not available or no longer employed by the state, or could not take the time for a comprehensive reply. Follow-up communications to clarify some aspects were only partially successful for similar reasons.

Table 1 lists the 42 states that responded to the survey, the size of their annual construction programs, and their annual payments to consultants. A linear expansion of consultant payments yields a national annual expenditure of well over $1 billion

TABLE 1
STATES RESPONDING TO SURVEY

State	Annual Construction Contract Awards ($ millions)[a]	Total Annual Consultant Payments (All Type) ($ millions)[a]
Alaska	141	3
Arizona[b]	342	76
Arkansas	160	2
California	1000	105
Colorado	240	15
Connecticut[b]	661	n.a.
Delaware	62	10
District of Columbia	90	4
Florida[b]	550	150
Georgia	575	3
Illinois	807	65
Indiana	400	13
Iowa[b]	210	6
Kansas	210	3
Louisiana[b]	391	14
Maine	60	3
Maryland[b]	468	32
Massachusetts[b]	380	42
Michigan	417	2
Minnesota	450	16
Missouri	350	2
Nebraska	165	1
Nevada	180	3
New Hampshire	n.a.	7
New Jersey[b]	490	44
New York[b]	1000	147
North Carolina[b]	370	19
North Dakota	97	0
Ohio[b]	658	27
Oklahoma	300	9
Oregon	250	2
Pennsylvania	780	n.a.
Rhode Island	85	10
South Carolina	200	13
South Dakota	125	1
Texas	1846	31
Utah	175	6
Vermont	75	5
Washington[b]	243	12
West Virginia	175	n.a.
Wisconsin	n.a.	29
Wyoming	149	1

[a]The dollar amount shown represents the total of state and federal-aid matching funds.
[b] a contract management consultant.

in state and federal-aid matching funds to supplement the states' engineering staffs with consultant forces.

The following summarizes other relevant trends reported by the states:

- *Program Size* Eighty percent of the states report an average increase of 42 percent in their annual construction contract awards in the last five years; 87 percent project a 27 percent increase in contract awards in the next five years.
- *State Staff* Eighty percent of the states report average increases in both total and professional staffs of about 8 percent over the past five years and project an additional 8 percent increase over the next five years. Such increases are far less than needed to manage either the current or projected programs,

a deficiency that is exacerbated by continual long-term hiring freezes.

- *Consultant Payments* Eighty-two percent of the states report a 216 percent average increase in the use of consultants over the past five years. This probably reflects the increased use of production consultants by states with shortages in engineering personnel, but may not necessarily address similar shortages in their engineering management staffs.
- *Use of a CMC* Thirty-three percent of the states report their previous or current use of a CMC, but only 24 percent project such use in the future. Although this appears to contradict the projected greater need for CMCs, it should be recognized that such projections are flavored by the highly variable uncertainties of budget, program, and management objectives.

Nevertheless, the above responses by the states indicate continued disparities between the larger increases in program and the much smaller increases in state engineering and management personnel. Such discrepancies in the relative increases in program and staff will require the continued use of CMCs for the management of substantial portions of the states' transportation programs.

CHAPTER TWO

CONTRACT MANAGEMENT PROJECTS

This chapter describes a number of private and public projects managed by variations of the construction management approach. It illustrates the variety of work that may be handled using this concept and provides a basis for subsequent discussions in this synthesis.

INTRODUCTORY EXAMPLES

Megaprojects requiring special methods of management include large nuclear plants, large coal gasification plants, metropolitan rapid-transit projects, the Alaska Pipeline, and the Corps of Engineers' $5 billion project in Saudi Arabia for the construction of an entire city for 70,000 people. Illustrations of large projects involving a form of construction management follow.

Metropolitan Atlanta Rapid Transit Authority (MARTA)

The Metropolitan Atlanta Rapid Transit Authority is using a joint venture of general engineering consultants as CMC.

Lammie and Shah (*10*) describe MARTA as a 53-mile system with 39 stations planned at a cost of more than $3 billion. The East and West Lines, totaling about 12 miles in length, opened in 1979. The scheduling of future extensions depends on the availability of 80 percent Urban Mass Transportation Administration (UMTA) funding.

Lammie and Shah assert that a critical early decision was the selection of a single consultant for design and construction services rather than the "alternatives of multiple prime consultants as was done on the Washington Metro, or of expanding in-house capability as normally done by the larger, more mature transit systems with continuing expansion and upgrading programs." A joint venture of two prominent engineering consultants served as manager for the project. The Metropolitan Atlanta Rapid Transit Authority elected to delegate day-to-day technical management to the consultant but to retain authority for all policy, cost, and scheduling decisions.

Bay Area Region Transit (BART)

Bay Area Region Transit is using a joint venture of different engineering specialties consultants as CMC.

Hammond (*11*) reports that California legislation established a commission to study the feasibility of a transit system for the entire nine counties in the San Francisco Bay Area region. In 1962, three counties remained as participants. The BART board of directors decided on the use of consultants for planning, design, and management of construction rather than building up a large and diversified staff for a relatively short term. However, it felt the need for strong representation on the management team by its own forces of qualified engineers to coordinate the work and to ensure that commitments to the 33 communities involved were reflected in design decisions.

A joint venture of three consultants with different specialties was hired to manage the project. Direct contacts between opposite members on the BART and consultant's staffs were encouraged. The BART board approved matters of policy, public controversy, and funding. The BART personnel were involved with problem identification and solving, decision making, community meetings, contacts with governmental bodies, public relations, finance, and consultation with BART operations personnel. Hammond feels that the keys to success were the freedom by the general manager and the chief engineer of BART to act on their own authority, the use of a single joint venture to provide overall coordination and management, and the availability of a strong engineering group within BART to provide direction, coordination, and advice to the consultant, as well as to BART management.

New York City Transit Authority (NYCTA)

At NYCTA a single consultant with two subcontractors is acting as CMC.

The New York City Transit Authority is engaged in a $6.4 billion five-year capital revitalization program, Tillman (*12*) reports, involving the purchase of rapid-transit cars and new buses and the improvement of all the rail and bus transit facilities. One consultant, in association with two subcontractors, is responsible for a $900 million portion of this program: the modernizing of car barns and shops, the bus depot, and other facilities.

The consultant manager is responsible for surveying the needs for improvements and rehabilitation and for developing the scopes of work for the individual design consultants, who are selected and contracted by the NYCTA. The CMC is also responsible for administering their design efforts and managing some of the consultants retained for the technical inspection of the work. Three security barns were handled under a turnkey contract, which the CMC prepared for bidding, administered the final design, and inspected the construction after award.

Miami International Airport

At Miami International Airport, consultants were used as CMCs for specific tasks.

This $1.5 billion project described by Bitner (*13*) includes increasing the number of aircraft gates and tripling the size of the terminal area. The Dade County Aviation Department assigned an assistant director to oversee both design and con-

struction, with the heads of the separate design and construction management groups reporting to him. Outside scheduling consultants, equivalent to CMCs, are used for phasing studies and schedules, contract document reviews, estimates at various stages of design, and claims analysis.

Pre-bid schedules use simple, time-scaled CPM, which is referenced to the designers' phasing and safety plans and contractual milestones, some of which are tied to liquidated damages. Bitner states that the key element of success is the in-house staff of seasoned design and construction personnel coupled with a team of outside scheduling and estimating consultants. He recommends that one consultant be used for overall coordination of the project, that computerization of the construction CPM reports should be used for more accurate and timely reporting, and that each scheduling consultant should be assigned a specific area of the project work in the field or terminal.

Montreal International Airport

A three-firm consortium was used as CMC for Montreal International Airport.

Sebastyan (*14*) reports that the new airport, which encompasses 88,000 acres of land, six runways, six passenger terminals, and 150 aircraft gates, was estimated at a total capital cost of $300 million. To manage and coordinate design and field construction, a consortium of three engineering and architectural firms was designated as CMC. The Ministry of Transport retained review and approval authority.

The CMC produced predesigns and estimates for each of the design packages that, after approval by the ministry, were the basis for designs by the individual design consultants. The design contracts were with the ministry but were reviewed and coordinated by the CMC. The field construction was supervised by the CMC and by quality control consultants. It is interesting to note that the terminal building was constructed by the design-construct method to reduce design lead time and costs.

Sebastyan considers the project to be successful in terms of achieving the end product at a reasonable cost and time despite an unreasonably tight schedule, a tense labor situation, inflation and material shortages, and numerous other problems.

James Bay

At James Bay a purpose-specific construction management company was used as CMC.

Behr (*15*) states that the 135,000-square-mile James Bay Territory was created by the province of Quebec, Canada, in 1971 to centralize the development of all resources including water, mineral, timber, and tourism. The hydroelectric resources were developed separately by Hydro-Quebec (H-Q), the provincial utility. The engineering and construction of the hydroelectric facilities was managed by a construction management company, the James Bay Energy Corporation (JBEC). This work involved major projects for merging watersheds and creating reservoirs, dams, powerhouses, and the infrastructure needed for access to the work. The total cost, including transmission line work by H-Q, was estimated at $16.2 billion for completion in 1985.

The top management of JBEC was a board of directors that included commissioners of H-Q. The corporation's staff came from H-Q and two consulting firms who were represented on the management committee. All personnel assigned to the corporation became integrated with its employees for the objectives of the project, without separate identification of their origin. The construction management organization initiated contracts, provided input into design, and monitored construction work. However, because of the public nature of the project, even small changes that resulted in increases in contract cost were recommended to top management for approval.

STATE PROJECTS

The remainder of this chapter briefly describes the projects cited by the various state agencies in their responses to the national survey. Additional information on each of these projects is given in each section of Chapters 3 through 7.

Florida's I-595 Program

The Interstate 595 Port Everglades Expressway is an urban Interstate route in Broward County, approximately 12.5 miles long, from Routes U.S.1/State Routes (SRs) 5 and A1A on the east to I-75 on the west. Its alignment is generally along the corridor of SR 84, with major interchanges at U.S. 441 and I-95, proceeding along the northern boundary of the Fort Lauderdale-Hollywood International Airport to an interchange with relocated routes 5 and A1A and a terminus into the Port Everglades Terminal. Also involved is a major modification and upgrading of existing I-95 in the vicinity of the project requiring the relocation of major railroad facilities.

The project includes two three-level interchanges, 10 other multi-level crossings, and 93 bridges, and requires coordination with many agencies, i.e.:

- With the airport to avoid infringement of the high-level ramps into the airport glide slopes and possible pilot confusion by any highway lighting,
- With the railroads involved in the state's purchase and relocation of facilities, and
- With a number of environmental agencies because of the substantial wetlands in the area and involvement with the habitat of the endangered manatee.

The total cost of the I-595 program, including design, construction, right of way (ROW), administration, and related activities, is estimated at $1.2 billion. The program was designed by eight different section design consultants into 20 separate construction segments totaling $600 million. More than $450 million was programmed for the purchase of nearly 500 ROW parcels and the relocation of owners and utilities. The construction phase was initially projected at seven years from the award of the first contract to the completion of the last.

Because of the sheer magnitude of the I-595 program, thrust upon an already large statewide program, and the need for its completion within a relatively short time schedule, the state engaged a CMC: Kaiser Engineers, with Howard Needles Tammen & Bergendoff (HNTB) as principal subcontractor. The CMC has been working since 1983 doing the three phases of the I-595 program:

- Pre-Final Design,
- Final Design and Bid Packaging, Utility Relocation, ROW Acquisition, and Relocation Assistance Services,
- Construction Management Services.

The design and ROW acquisition were well under way at the time the CMC came on board. Engineering design was done by multiple engineering firms and by the Florida Department of Transportation (FDOT). Construction began in mid 1984, with ultimate completion currently scheduled for 1993. Construction is done by unit bid contracts let and awarded by the state. Construction engineering and inspection services are provided by FDOT staff on some projects and the remainder by state contract with professional firms.

The state has a high-level manager with key staff in responsible charge of the I-595 program. The CMC provides support in the management of design, construction, ROW services, utility relocation, and in the administration of the CEI consultants who administer the construction contracts and direct the construction contractors for FDOT.

Florida's Bridge Repair and Replacement Program

The state originally identified the need for widening and rehabilitating 433 bridges and culverts at an estimated cost of $125 million and for the replacement of 70 bridges at an estimated cost of $280 million. Because of the lengthy lead times inherent in the preconstruction process and its limited production staff to meet program targets, FDOT entered into an agreement at the end of 1987 with Sverdrup Corporation as a CMC. Subsequent funding limitations virtually eliminated all of the bridge-widening projects and resulted in a reduced program of $159 million construction cost for replacing 61 bridges and rehabilitating 11, for a total of 72 bridges. The contract with the CMC has been extended to December 1990, with provisions for extension by supplement.

The CMC is responsible for bringing all the projects in the program to a production-ready status per prescribed schedule. The CMC must manage, schedule, coordinate, review, and report on the activities of the section consultants under contract with FDOT who are performing project development and environmental (PDE) services and design on each of the projects in the program. In addition, the contract contains an option to add CEI management services by supplemental agreement, though there are no current plans to do so.

Washington's I-90 Program

This program involves the design and construction of a 7.5-mile section of eight-lane urban Interstate freeway extending from central Seattle across Lake Washington and Mercer Island to the Factoria Interchange in South Bellevue. Major features of the section include extensive cut-and-cover lidded portions, a soft-ground bored tunnel, a high-level water crossing, a floating pontoon bridge, a significant length of depressed roadway with city street separations, transit access facilities, and architectural and landscaping features.

This section of I-90 is being constructed in phases using multiple heavy-construction contracts. The construction is being accomplished while existing I-90 traffic volumes of more than 65,000 vehicles per day are maintained, adding greatly to the management problems. The complexity of the program, whose total cost is estimated at $1.5 billion, is reflected by a limited work area and construction access, insufficient flexibility for traffic management, and the need for multiple stages to orchestrate the traffic flow.

The state had already accomplished significant planning, design, contract packaging, construction sequencing, and scheduling on the project. The state, however, decided on the use of a CMC because of its lack of sufficient qualified engineering personnel to handle a program of this magnitude within a critical deadline without severe impact on its overall program. In May 1984 the joint venture of Morrison-Knudsen Company, Inc. and H.W. Lochner, Inc. was engaged to assist the state in delivering the completed program by the funding termination date of September 30, 1990.

The Washington State Department of Transportation (WSDOT) is maintaining direct control of all design and construction activities, with the CMC providing project and construction management services to assist and support the department in the management of the program. The CMC is assigned a phased effort to provide recommendations to the state in Phase I and assist in their implementation during Phases II and III, as authorized by the state.

In Phase I, the CMC was required to review the current schedule and completed ongoing engineering work performed by the WSDOT and its consultants, and provide recommendations regarding construction sequencing, contract packaging, constructibility, maintenance of traffic on existing I-90, and improvements to the state's plan for the management of the project. As a result of the CMC's work in this phase, the CMC was assigned additional tasks by supplemental agreements that included contract packaging, schedule monitoring, construction change order review, shop drawing review, contractor CPM review, and individual construction project management.

Because the design is almost complete, a new agreement has retained the CMC for project and construction management services through September 1992. The services include:

- Project management assistance: recommendations on policies, organization, procedures, and operations;
- Operations center: assistance and advice regarding program level scheduling, cost tracking, and reporting;
- Construction management assistance: monitoring of progress, costs, and cash flow; evaluation of changes, disputes, delays and problems; constructibility and technical reviews of PS&E;
- Special study services; and
- Administration.

Arizona's Statewide Design Program

The Arizona Department of Transportation (ADOT) currently has nine management and general consultants under contract who are serving as an extension of the department's forces in the management of the state's design and construction programs. Six of these are assigned primarily to management responsibilities, whereas the remaining three, who are called general consultants, are permitted to perform design work with their own forces in addition to managing work by others.

The state initiated the use of CMCs in 1981 at the request of the Federal Highway Administration (FHWA) because of the unavailability of sufficient staff to manage the design of the final leg of its Interstate program. Howard Needles Tammen & Bergendoff was selected as CMC for the I-10 Papago Inner Loop, which is now in the final stages of completion.

Because of the rapidly escalating program without commensurate increases in either management or engineering personnel, the need for such consultants increased. Not only are the CMCs currently under contract involved with the management of major systems but two of them assume the state's role, under ADOT's supervision and control, in the management of the design and construction of numerous projects within its statewide program.

HDR Engineering, Inc., as an example, is the CMC for the management of a 34-mile section of Loop 101, which is a controlled-access circumferential loop roadway encompassing the Phoenix metropolitan area and includes segments of the Price Expressway, Santan Freeway, and the South Mountain Freeway. Its January 1989 contract requires the CMC to assist ADOT in the selection, negotiation, coordination, and administration of the design consultants and to prepare the construction plans for the project, the construction cost of which is estimated at $325 million.

The CMC has the responsibility for major predesign functions, such as coordinating and resolving significant issues with the affected communities and developing a general plan, as well as responsibility for monitoring the quality, progress, and costs of designs produced by the design consultants. However, this CMC is also required to do production work in addition to management, namely, preparing final plans for lighting, signing, and other features and assimilating them into the final PS&E and construction packages along with the plans by the individual design consultants.

Another example is the CMC June 1986 contract with Sverdrup Corporation to establish from ADOT's five-year program an inventory of construction plans, specifications, and estimates to be ready for contract letting by June 30, 1987. To accomplish this task, the CMC was required to direct and manage the services of a number of project design and functional consultants. The CMC served as an extension of the state's Highway Development Group and was delegated the responsibility for functions that are normally administered by ADOT, including responsibility for location, materials, design, right-of-way, utilities, structures, and local government coordination, as delegated by ADOT.

The projects to be developed were statewide, and varied from pavement rehabilitation and safety improvements to major new highway construction. Initially, 88 projects were identified for development, totaling $272 million. The CMC was required to finalize design concepts and develop the general plan for the design work, to assist ADOT in the selection process, to finalize scopes of work, to aid in negotiations and preparation of contract documents, to coordinate between the design consultants and affected agencies and utility companies, and to monitor the performance and progress of the designers.

During construction, the CMC was responsible for maintaining schedules, interpreting the plans, and having the designers correct any errors or omissions. Such construction support services were to be implemented by supplemental agreement. The ADOT retained the responsibility for managing the construction phase with its own staff or with the use of CEI consultants as needed.

The above contract is near completion, but a similar responsibility for advancing ADOT's statewide design program is being continued by a CMC contract initiated in September 1989 with Parsons, Brinckerhoff, Quade & Douglas. The latter contract includes requirements for an orientation program, with the goal of developing written guidelines and training to ensure an effective transition from CMC management to ADOT management of the statewide program.

New Jersey's Railroad Electrification Program

The New Jersey DOT has been administering an agreement with the firm of Gannett Fleming Corddry and Carpenter from 1980 to date for construction engineering, surveillance, and management services for its North Jersey Coast Line Electrification project and its Erie-Lackawanna Re-Electrification project. The agreement allows the consultant the use of four designated subconsultants because of their special expertise. This program is financed with two UMTA grants, and therefore follows UMTA rather than FHWA requirements.

In general, the program involves the improvement of station and electrification facilities for commuter rail services over the lines of the former Erie Lackawanna Railway Company, including the upgrading of the traction power system to 25 KV 60 Hz AC, the rehabilitation and reconstruction of several sections of the catenary system, and making the signal and communications systems compatible with AC traction power.

The program is implemented by 12 construction contracts and 24 prepurchase contracts involving 67 route miles of railroad facilities and 156 track miles. The total estimated cost of the program, including related railroad force account work, is approximately $200 million.

The 12 construction contracts cover the following:

- The construction of 15 electrical, autotransformer, signal, and supply substations and related equipment, access roads, structures, and work under utilities agreements.
- Modification and construction of new catenary support structures, including concrete and pile foundations, and related utilities agreements with Conrail and others for crossover and trackwork to maintain railroad operations.
- The replacement of the entire signal plant, including circuits, cable, signals, and switches.
- The furnishing, installation, and testing of the required communication system, including the establishment of communication facilities at 26 locations.
- A run-in-track facility to familiarize operating personnel with the operation of the department's 180 new multiple-unit cars on the rehabilitated system.

The 24 prepurchase contracts include the design, fabrication, testing, and delivery of frequency-conversion equipment and transformers, and numerous electrical materials and equipment.

The New Jersey DOT advertises and awards all contracts and provides the CMC with plans, specifications, and a signed contractor for each contract. The CMC provides a program manager, engineering support personnel, and surveillance staff to coordinate and oversee the individual contracts, contractors,

utilities firms, the railroad operator, and New Jersey DOT efforts.

Connecticut's Bridge Infrastructure Program

The serious condition of Connecticut's bridges was revealed by the tragic collapse of the Mianus River Bridge. An emergency declaration provided the impetus for the immediate hiring of the consultant firms necessary to expedite the massive Infrastructure Renewal Program, which is now in its sixth year and has been expanded to include designs for the rehabilitation of about 960 bridges statewide.

The Connecticut DOT is currently using two consultant firms to manage the program that uses 46 engineering consultants, each working on multiple bridge rehabilitation design projects. Each of these two CMCs is assigned approximately 23 firms. Each CMC is considered an arm of the state, is responsible for all facets of program development and administration, and has sufficient staff to provide proper liaison service to cover the various engineering disciplines relative to traffic and bridges and environmental and other concerns.

Louisiana's I-49 Program

Louisiana cites four examples of its use of the CMC approach in its management of large projects, the most notable being the I-49 program from Lafayette to Shreveport.

The management of this program was implemented by separate engineering agreements with the same CMC, Howard Needles Tammen & Bergendoff, covering five successive sections of I-49. This approximately 200-mile Interstate highway was estimated at a $1.5 billion construction cost. The scope of the overall management contract primarily involved the coordination of the activities of the various design consultants engaged by Louisiana's Department of Transportation and Development (DOTD). The initial CMC agreement was entered into in March 1979 and the initial completion dates for the I-49 agreements were later extended to September 1984.

Massachusetts's Central Artery Program

The existing elevated central artery structure through Boston is cited as one of the most congested and dangerous sections of Interstate highway nationwide, and threatened to cripple the regional economy. In 1985, the FHWA approved a plan to overcome the bottleneck by:

- Replacing the 6-lane elevated I-93 artery with an 8- to 10-lane roadway, largely underground, between the Southeast Expressway and Charlestown.
- Extending the I-90 Massachusetts Turnpike via a Seaport Access Road and a four-lane tunnel across Boston Harbor.

This project is estimated to cost $3.1 billion, including federal Interstate funding, and to be completed in 1998. Its complexity is heightened by the need to maintain all lanes of the existing central artery structure open until traffic can be diverted to underground sections. The total project is being managed in several segments by the use of separate CMCs and state management groups for each segment.

The Central Artery-Third Harbor Tunnel project is the most ambitious of the segments, with the CMC involved in both the complex design and construction under difficult traffic conditions. However, the remainder of this synthesis discusses only the section that was addressed in the state's response, namely, the Central Artery-North Area project in the vicinity of Charlestown.

The state engaged the services of HNTB in May 1984 to manage, coordinate, schedule, direct, and review work to be performed by other consultants under contract with the state for the design of the project. The CMC's contract extended through the 30-month design period to ensure that the design work is completed within the approved time schedules and within the established budgets. It encompassed three phases: organization and project planning, preliminary design, and final design, including construction bidding and awards.

Although the state's Department of Public Works retained the responsibility to manage the construction phase, the same CMC received a contract in October 1987 for construction services. This was limited to reviewing the design revisions and invoices of the designers, whose services were also extended for such purpose, and coordinating between the department and other public and private entities concerned with the construction.

Maryland's Open-End Agreements

Maryland resorted to the use of consultant managers for services that were beyond the capacity of its limited management staff during a peak program workload. The state cites a number of open-end agreements with CMCs to manage design consultants under contract with the state performing different kinds of projects and functions, such as:

- A $3 million, four-year-term agreement with Greiner Inc. for the implementation of the state's truck weigh and inspection safety program. This contract includes managing the design of specific newly identified truck weigh and inspection stations, as well as expanding and renovating existing stations. Three design consultants are currently on board, but the CMC contract is open to accommodate others as needed in the future.
- A $3 million, four-year-term agreement with Johnson, Mirmiran, and Thompson for the identification, delineation, impact determination, and mitigation of wetlands areas within proposed highway construction. Such highways currently include Interstate Highways 270, 370, 97, and 68, U.S. 50, and MD Route 100.

Both agreements are state funded without federal-aid participation and involve both federal-aid and nonfederal-aid projects. The latter agreement requires the CMC's services to manage other consultants performing project planning activities and engineering services and to perform such planning activities and engineering services as required by the state.

New York's West Side Highway Project

The West Side Highway project, commonly known as the Westway, was established in late 1971 by a memorandum of

understanding signed by the governor of New York State and the mayor of the city of New York. The federal government designated the route of this project from the Battery to 42nd Street in the borough of Manhattan as Interstate Route 478. The final environmental impact statement was completed and hearings were held. In mid 1977, the FHWA issued a design approval for a modified location alternative extending outward and along the east bank of the Hudson River.

The next phase of the work consisted of preparing the final plans, specifications, and estimates for letting contracts for the construction of the various segments of the project. The state contracted with Parsons, Brinckerhoff, Quade & Douglas, Inc. to manage the engineering work and related services, as follows:

- Manage the work of the section design consultants, develop and maintain a computerized project control system to monitor schedules and costs, review billings, and coordinate various communications between the state and its consultants.
- Perform technical management, which requires the CMC to monitor survey work; collect, maintain, and distribute data; assist in the development of a soils program; review the system for monitoring tunnel movement; coordinate with all interested agencies; prepare base plans for the project; and make economic evaluations of alternative designs.
- Develop system-wide criteria, standards, and specifications for various transportation, sewer, ventilation, structural, electrical, environmental, and other elements of the system.
- Monitor the technical progress of the section design consultants and review and coordinate their work.

This relatively short in length but ambitious project had an estimated cost of more than $2 billion. Though the agreement detailed a schedule of the work from 1979 through the end of 1988, the initial scope of work for the CMC was limited to a two-year portion of the total work effort.

The project faced continual problems to meet various public and environmental concerns during its preliminary planning and design. In 1985, the lengthy environmental litigation and potential loss of $1.7 billion in federal funds led the city and the state to abandon the Westway plan and to allocate the funds to mass transit and to a more modest solution to the replacement of the current roadway, which is in a deteriorated and collapsed condition. The evaluation of alternatives is currently under way, but the process involved does not fit the CMC concept and is not included in this synthesis.

Other Examples

The examples in this section are not further expanded in the ensuing chapters.

Ohio's Bridge Replacement Program

Ohio uses two management consultants to assist the state with its bridge replacement program, which handles more than 400 bridge projects. One firm reviews proposals and prepares contracts for the various bridge design consultants. The second firm reviews the preliminary and detailed bridge plans prepared by the same bridge design consultants. Both are lump-sum contracts and financed with 100 percent state funds.

The CMCs work closely with state personnel on the same projects and are limited to defined tasks developed jointly with the state before the contract stage. The defined tasks are broken down into five parts, each representing different stages, from preliminary location through construction. The tasks include various types of reviews, coordination with the state and other agencies, processing and other administrative activities, and recommendations for problem solving. The routine and repetitive nature of the tasks requires little need for management and control by the state. Each part provides for a lump-sum payment per bridge and a maximum lump sum payable for each contract.

North Carolina's Planning and Environmental Studies

The use of CMCs by the state's transportation department is very recent and limited to its Planning and Research Branch. The department is anticipating a three-fold increase in its highway-improvement program, with current favorable consideration by the state legislature of the needed funding. Because the responsibilities of the Planning and Research Branch are at the front end of the greatly enlarged highway program, the branch was forced, because of its limited staff, into a greatly expanded use not only of project consultants but also to the use of two contract management consultants to coordinate the work of other private firms on 18 study projects and others as may be assigned.

Though the CMC contracts have been approved, work has not yet begun. The CMC's responsibilities primarily include those guidance and coordination tasks that would ordinarily be provided by the state staff, such as:

- Developing scope of study,
- Conducting contract negotiations with project consultants,
- Reviewing and refining study alternatives,
- Coordinating with review agencies,
- Evaluating impacts and mitigation measures,
- Controlling costs and schedules,
- Monitoring quality control,
- Coordinating review of completed studies, and
- Reviewing billings and change order requests.

The CMC will report directly to the department's Assistant Manager for Project Planning. Each contract is on a cost-plus-fee basis with a maximum limiting amount payable of less than $2 million.

Iowa's U.S. 61 Bridge Designs

In order to meet the critical deadlines for the construction of an urban expressway project, U.S. 61 through Dubuque, the state engaged the services of a CMC to provide management and technical monitoring of five consultants engaged in the preparation of final bridge designs for the facility. The CMC's scope of work includes assisting the state in:

- Preparing scope and design parameters for each design contract,
- Preparing master and project schedules, monitoring the work and taking corrective action as needed,
- Reporting on progress and changes in scope and cost,
- Maintaining records of all decisions and information flow,
- Coordinating roadway and bridge designs and design changes,
- Conducting and coordinating meetings related to project initiation, progress review, and other subjects, and
- Reviewing alternate designs and progress drawings.

The CMC reports directly to the director-chief engineer of the State Highway Division or his authorized representative, and is subject to the state's control and approval process. The contract is on a cost-plus-fee basis with a maximum amount payable of less than $200,000, subject to supplementation. The agreement recognizes the difficulty of arriving at an accurate cost estimate and provides a contingency amount in the event of verified increases beyond the estimated cost.

Pennsylvania Turnpike Commission

The Commission is currently in the process of engaging Slick Corporation as CMC for the management of design and construction contracts between various firms and the Commission for the Beaver Valley Expressway Turnpike extension. This 17-mile route extends from an interchange with U.S. Route 51 in Beaver northerly to an interchange with U.S. Route 422 in Lawrence County.

The five-year contract, which is not financed with any federal funds, requires the CMC to review and monitor the design work by other firms and to augment the commission staff for construction management. The CMC may not participate in either the design or construction phase of the project. The CMC's responsibilities include:

- Review the design drawings, provisions, specifications, and estimates prepared by other firms.
- Perform constructibility reviews.
- Prepare master design and construction timetables and schedules for all significant related activities.
- Review VE efforts by others for all elements of design and construction to ensure cost savings, such as by mass purchasing methods and standardized design details.
- Coordinate all traffic control plans.
- Monitor design and construction work progress and costs relative to schedules and budget.
- Provide claims-avoidance guidance.
- Provide numerous other services relative to coordination, meetings with utilities and other agencies, permit and other applications, and prepare drawings, conduct surveys, and other work.

The CMC was engaged primarily because of the lack of commission staff to manage the project. In effect, the CMC works on behalf of the commission and is subject only to its general reviews and approvals. The commission retains the right to approve all change orders for cost increases and all claims submitted by construction contractors.

The primary factors considered in the selection process included experience in management of highway projects, past performance in the control of quality, schedule and costs of similar projects, and availability of management staff and of computer services for management and scheduling.

OVERVIEW

The projects cited in this chapter reflect the large variations in the nature, scope, and magnitude of work that is being delegated by the states and other governmental or private entities for management by contract management consultants. Mega-projects managed by CMCs for large private or governmental agencies include large nuclear plants, metropolitan rapid-transit systems, a $5 billion city in Saudi Arabia, and a $16 billion development project in Quebec, Canada. Projects managed for state transportation agencies vary in cost from a few million dollars for functional services to $2 billion to $3 billion in overall project costs.

In addition to the project size variation, there is also a large menu of functions, activities, and responsibilities normally handled by the agency from which selections may be made for management by a CMC. These may vary from simply monitoring progress and costs of projects being designed by design consultants to carrying overall responsibility for the entire gamut of management activities required to advance a large project or program of projects from the conceptual and planning stages through design and construction completion.

The dollar value of the CMC contracts varies from a few hundred thousand dollars for management support services to hundreds of millions for the management of multi-billion-dollar projects.

With the continuing drain of experienced professional engineers, and the flexibility available to supplement the agency's shortages in experienced staff with consultant management forces, it appears likely that the states will at least continue, if not increase, the use of CMCs in the management of their growing programs. Previous users of such services, however, stress the importance of an adequate and capable corps of qualified engineers within the agency to retain control over policy, cost, and scheduling decisions.

CHAPTER THREE

SELECTION OF A CONTRACT MANAGEMENT CONSULTANT

An agency's reasons for using a CMC generally include the need for a specific expertise or capability; insufficient number of professional managers; lack of agency experience with the type of work; criticality of time, which precludes the hiring and training of in-house staff; or the temporary nature of the work, which does not justify increasing the permanent work force.

There are numerous forms of contract management systems, depending on the extent of owner involvement in managing the project, the nature of the work, the type and extent of management desired, and the degree of risk delegated to the CMC. Determining desired system objectives is a necessary precedent to determining the factors to be considered in the selection of the CMC.

Hammond (*11*) states that BART selected the option of choosing outside management of overall engineering, design, and construction rather than staffing up with a large and diversified staff for a relatively short term. He supports BART's selection of a single joint venture to accomplish such an objective as the "best, most appropriate, and successful option for BART."

Tillman (*12*) finds it preferable for owners to minimize a long learning curve by using experienced consultants rather than staffing up for new systems. From his background of familiarity with other major transit projects, Tillman observes that the Metro was constructed in Baltimore by a variation of the multiple-contract policy, whereby different consultants are hired for different functions. At BART in San Francisco, on the other hand, a single consultant was used for the overall project. Although both projects were successful, Tillman believes that "the single consultant philosophy produces better results. It appears that the interests of the client are better served by having the same consultant responsible for managing both design and construction."

Sebastyan (*14*) lists three objectives that were considered by the task force for the development of the new Montreal International Airport:

- To minimize increasing the public service permanent staff,
- To disseminate in-house knowledge and expertise in the design and construction of airport facilities, and
- To streamline decision making by providing the general manager with financial authority equivalent to that of the Deputy Minister.

The common thread in the above examples of reasons for hiring a CMC and the use of a single firm or joint venture will also be observed subsequently for the projects cited in the responses to the national survey.

Although there appears to be a general consensus regarding many of the factors to be considered in the selection of a CMC and the methods used, there are variations in their relative weights that are considered to be appropriate. Barrie and Paulson (*1*) list overall experience, financial status, depth of organization, suitable specialized experience, references, understanding of the project requirements, plans for implementation, and proposed cost as appropriate factors to consider.

They also cite guidelines by the Associated General Contractors of America that provide for selection on the basis of professional and general contracting qualifications. Such guidelines include success on projects with similar size and complexity, financial strength, capability of in-house staff managers and staff, record for completing work on time and within budget, demonstrated cooperation with owner and designer, leadership, and initiative on the management team.

The ASCE Committee on Construction Management (*2*) lists some key considerations in the standard consultant selection process and analyzes their relative importance when applied to the selection of a CMC. Such considerations include:

- *Financial Strength* This factor is particularly important when the CMC also performs services as a contractor. Because such services rarely apply to government work, the factor is of no greater importance than for the selection of design professionals on projects of equivalent magnitude.
- *Performance* A good performance record as a professional designer does not necessarily indicate potential proficiency as a CMC. A CMC must have a multidisciplinary organization with the expertise required for the project.
- *Geographic Mobility* Contract management consultants must have mobility and be able to perform capably regardless of location relative to their home office. "Familiarity with local conditions and contractors may mitigate the objectivity" of the CMC, whereas its performance in a new location could be enhanced as a result of inquisitive investigations (*2*). Because objectivity and an inquisitive approach are important management qualities, agencies should not overvalue the importance of a local firm in the selection of a CMC.
- *Varied Experience* A CMC with extensive experience in the management of a variety of projects may be a better choice than one whose experience is limited to the specific type of work involved in the project at hand. When the technical expertise is available from the owner and the designers, the primary contribution needed from the CMC becomes the ability to manage. Such management ability is enhanced by experience with a broader spectrum of work types.

The ASCE (*2*) further recommends the selection of a CMC as early in the project as is possible, preferably at the same time as the hiring of the designer, to ensure their respective compatibility with the team and the early use of the CMC's experience in conceptual estimating.

Based on a survey of approximately 100 CMCs and clients using such services, Murray et al. (*16*) report a considerable

discrepancy between the perspectives of CMCs and those of their clients concerning the selection factors deemed to be most important. The clients consider the most important factor to be an interview with the proposed project manager to ascertain his/her experience with similar projects, record of cooperation with the client, and ability to perform. Equally important from the clients' viewpoint is the size of the pool of qualified staff from which project assignments can be made. The CMCs ranked this factor only third.

Other factors ranked high by clients include:

- The quality rather than quantity of the CMC's experience,
- A discussion in the technical proposal of proposed alternative solutions to the client's problems to demonstrate knowledge and ability to handle the proposed project, and
- A presentation of problems or failures on similar projects and how they were resolved.

Barrie and Paulson (*1*) and the ASCE (*2*) recommend similar guidelines for selecting a CMC. The key features of the process include obtaining a list of qualified and interested firms, determining the ability of each of the firms on the list, and evaluating the proposed cost. (It should be noted that the recommendations relative to the cost factor predated the qualifications-based procurement provisions of the 1987 Surface Transportation and Uniform Relocation Assistance Act.) Except for the factors to be considered, the process is very similar to the standard consultant selection process.

Both of the above references consider cost to be a relatively minor consideration that should not prematurely influence the orientation of the selection efforts toward the scope and quality of the services to be provided. The list of qualified firms may be obtained by invitation or advertising for an expression of interest. The ASCE recommends a screening process to obtain a long list of 5 to 10 of the most qualified firms, which should receive both an initial and subsequent Request for Proposal (RFP). This list is considered to be the most important screening device in determining a short list for oral interviews and selection.

Barrie and Paulson (*1*) recommend that the CMC's proposal should provide a suggested work plan describing the firm's overall approach to the project, the services to be provided at the home and field offices, the proposed contract package, a preliminary procurement schedule, proposed VE program, preliminary construction schedule, description of the cost and progress control systems, construction cost estimates, estimated fee and reimbursable costs, proposed project organization, and résumés of the project manager and other key personnel.

Technical evaluation of the proposals and the evaluation of the oral interviews complete the selection process. For a fuller discussion of the standard selection process for production consultants, interested readers are referred to Synthesis 137 (*9*).

The remainder of this chapter examines both the reasons for contracting with CMCs and the methods used in their selection beyond those discussed in Synthesis 137 for design and construction engineering firms.

REASONS FOR THE CMC APPROACH

Florida's I-595 Program

The size and complexity of the program and the need to advance it within a limited time schedule exceeded the capacity of the existing FDOT staff. The sheer magnitude of the review process alone for I-595 was equivalent to an average department program. To do the work in-house would have absorbed all of FDOT's professional staff from the statewide program.

The design plans had been well in hand, and the state initially considered managing the construction phase with its own forces. Delays in implementation, however, subsequently necessitated the need for major design changes. The initial use of the CMC for design and constructibility reviews resulted in numerous redesigns with savings of $12 million. This experience led the state to realize the limitations of its staff capacity and subsequently engage the CMC to manage the entire project.

Florida's Bridge Repair and Replacement Program

Because of the limited number of qualified professional bridge engineers, the state could not effectively implement its bridge widening and replacement program to meet programmed letting targets. The CMC approach was taken primarily to resolve this problem, particularly in anticipation of additional revenue and an avalanche of unmet production demands.

The anticipated benefits cited thereby included:

- Enhanced production capability to meet targets,
- Relief from the labor-intensive activities required by this program, which would allow the FDOT staff to give greater emphasis to other programs and projects of critical concern,
- Single, centralized management provided by a CMC, which is suited to a statewide program with substantial similarity among individual projects, and
- Enhanced production capability, which will realize a significant number of projects in a production-ready status to ensure that targets are met in the future.

Basically, all of the above objectives relate to the need for additional qualified manpower resources to handle a sudden surge of work. The need to handle such a workload within near-term target dates did not allow the alternative of hiring and training additional professional state forces.

Washington's I-90 Program

The state's initial reasons for using a CMC also centered on insufficient staff, time constraints, and the need for additional expertise. Its continued use of the CMC also included the benefit of large financial savings.

The WSDOT estimated that it had accrued savings of $69.8 million in Phase I of the program because of its use of the CMC, and projected additional savings of $13.3 million in Phase II. The following summarizes such savings by categories and does not include savings in managerial and organizational aspects or through the use of project control systems and procedures that could not be readily estimated:

Phase I:	
Planning/sequencing changes	$ 49.0 million
Delay avoidance	
Resulting from PS&E reviews	$ 2.6 million
During construction	$ 3.6 million

Claims avoidance	
Resulting from PS&E reviews	$ 6.6 million
During construction	$ 1.8 million
Disputes management	$ 6.2 million
PHASE TOTAL	$ 69.8 million

Phase II:

Delay avoidance	
Resulting from remaining PS&E reviews	$ 0.3 million
During construction	$ 4.2 million
Claims avoidance	
Resulting from remaining PS&E reviews	$ 0.5 million
During construction	$ 3.5 million
Disputes management	$ 4.8 million
PHASE TOTAL	$ 13.3 million

In requesting budgetary approval for the continued use of a CMC on Phase II, the WSDOT stressed its primary objective of maintaining the program schedule and budget within mandated limits, a task that would otherwise be very difficult because of the complexity of the work.

To further support its request, the department projected an expanded use of consultant personnel over the subsequent four years to meet the forecasted peak work force requirements of its statewide program. The alternative to using a CMC on the I-90 program would have been the use of personnel who:

- Were not readily available because of their assignment to other critical projects in the state program;
- Were not familiar with the complex details of the program;
- Were subject to promotion, and therefore could not remain on the program until its completion; and/or
- Did not have the contractor and "big picture" perspective.

Furthermore, the WSDOT stated, if state personnel were used for the program management positions, consultant personnel would still be required elsewhere to offset the work force peak. Consequently, there would be no savings in labor cost. It was stressed that the continued use of the CMC in Phase II would provide the most cost-effective use of consultants with significant estimated savings in overall costs through the early identification, evaluation, and solutions for delays and claims. These were in addition to the larger savings accrued in Phase I by the adoption of the CMC's recommendations following its program review.

Arizona's Statewide Design Program

The primary reason for Arizona's use of a CMC initially was its lack of engineering and management staff to complete its Interstate program in a timely fashion. The state expanded its use of management consultants in step with its rapidly escalating construction program and concurrent inability to increase its personnel to the level required for such additional workload.

Additional reasons cited for the expanded use of CMCs included the need for technical expertise on some projects that was not available in-house and the ability to mobilize and demobilize quickly by using consultants instead of hiring additional state personnel.

The state points out that training problems associated with the hiring of new state personnel are not fully mitigated by using consultants who may not be fully familiar with ADOT's design criteria, procedures, and policies. Other problems cited are similar to those involved with the use of production consultants by state agencies with capable in-house organizations:

- Internal expertise may be lost. This was mitigated by allowing the department's operational groups to have a voice in the retention of projects and services to be performed by the ADOT rather than by consultants. In this way, the state's staff could continue to gain experience and a variety of skills.
- The public image of ADOT's capability may deteriorate by the perception that it requires extensive outside help.
- Consultants may be reluctant to make decisions in matters that place them in danger of liability, such as those involving policy, safety, and certain design criteria.

Nevertheless, the pros and cons must be weighed for each specific situation when determining the use of consultants versus the expansion of in-house capability.

New Jersey's Railroad Electrification Program

New Jersey asserts that it elected to use a CMC to manage this program for the following reasons:

- It did not want to increase its staff with personnel having the specialized talents that this program required.
- The program schedule required personnel who were already trained and experienced in the disciplines needed.
- The New Jersey DOT did not want ultimately to absorb staff selected and trained for specialized functions that the department did not normally perform.

The New Jersey DOT states that it achieved these objectives for selecting a CMC because additional permanent state staff were not hired, knowledgeable personnel were immediately available, and the work was effectively managed by a single prime CMC.

Connecticut's Bridge Infrastructure Program

Connecticut's reasons for selecting CMCs to manage this program relate primarily to the emergency generated by the collapse of one of its major structures, which highlighted the serious need to rehabilitate its remaining structures promptly. The huge workload thrust on a limited state staff, further complicated by the short response time required, required additional services by both production consultants and CMCs.

The state's initial objectives in hiring CMCs have been realized to the extent that the emergency situation has been alleviated effectively and in a timely fashion.

Louisiana's I-49 Program

The primary reason cited by the Louisiana DOTD for electing to use a CMC was the inability of its limited professional staff

to manage the sudden upsurge in the size of its normal design program. During a five-year span, the state's design workload was doubled by the addition of the I-49 program and the Greater New Orleans Mississippi River Bridge and Approaches, which together amounted to an estimated construction cost of $2.1 billion.

The state did not consider it practical to service this sudden peak workload by doubling its design staff temporarily. Because the completion time of these projects was critical from both a funding and public relations perspective, it was not reasonable to increase the state staff in an orderly manner and provide the training necessary for the program. Furthermore, the state would not have been able to absorb such a large increase in permanent staff at the completion of the program, and the use of temporary staff for such purpose was considered ineffective.

Maryland's Open-End Agreements

The state reports that it initiated CMC-managed open-end agreements as a contingency solution to an unanticipated heavy workload of responsibilities beyond its capacity to administer. In 1988, the State Highway Administration (SHA) awarded more than $400 million in highway construction projects. This sudden increase in workload strained the resources of the SHA's management staff, particularly at the project engineer level. Construction management consultants were selected rather than increasing the number of permanent state staff for reasons cited previously by other states.

Maryland asserts that the CMCs fulfilled the technical objectives capably, but, in hindsight, the state would have preferred the assignment of greater direct authority to the CMCs. Requiring the CMC to manage through the state liaison officer caused delays in the design process and some management deficiencies.

New York's West Side Highway Project

This project was a major addition to the state's planning, design, and construction programs, which were already well beyond the existing state personnel capacity. Furthermore, the project required special technical expertise and intensive coordination with numerous political, public, and environmental groups. Because of these reasons and the need to complete this Interstate project before the expiration of federal Interstate funding, it was deemed advisable to seek the services of a management consultant.

Though the initial concept was later abandoned, the original objectives for hiring a CMC were achieved because it was possible to develop and evaluate all alternatives with minimal impact on the state's staff and the advancement of other statewide programs.

SELECTION OF CMC

The following discussions cover methods or factors used in the selection of the CMC beyond those presented in Synthesis 137 (*9*) that are applicable to production consultants.

Florida's I-595 Program

A short list of five top engineering firms with key personnel who had expertise in all of the major aspects of the program was compiled. The state prepared clear and complete scope statements and a cost estimate for the CMC services. The short-listed firms were requested to submit technical and man-hour requirement proposals, as well as résumés of the key staff to be assigned to the project. A review of these submissions plus oral interviews allowed the state to determine the most qualified firm, with whom price negotiations were initiated. Additional details on this process are provided in the following discussion of the FDOT's Statewide Bridge Program.

Florida's Bridge Repair and Replacement Program

The principal factors evaluated in the CMC selection included the knowledge and experience of the firm's key personnel in management and organizational concepts; their strengths in CPM techniques for program management, in scheduling and control, and in reporting; the caliber of their proposed community involvement plan; and the degree of commitment of the key personnel to the project relative to other portions of the firm's current or future workload.

In the selection process, five short-listed firms simultaneously attend a meeting with FDOT to discuss the scope of services. They then submit technical proposals and man-hour estimates, followed by individual oral interviews. The technical proposals have to include the firm's approach, staffing plan, subconsultants, schedule, location of project offices, and coordination plan. The technical proposals are reviewed by a technical review committee (which includes the district director, district project manager, and appropriate staff), whose comments are provided to a selection committee (containing the secretary, deputy secretary, and the appropriate division director). The selection committee holds the oral interviews and makes its selection based on comments from the technical review committee and its own perceptions, developed during the oral interviews, of the capabilities and experience of each firm's key personnel in management and technical abilities, their innovative approaches, and other factors considered in the standard consultant selection process.

Florida requires that each key staff member identified in the technical proposal have at least a two-year commitment to the project, and that additional staff needed not come from other firms or agencies in the state of Florida. Also, the CMC is not allowed to subcontract any work other than such specialized services as geotechnical, aerial photography, field surveys, and ROW appraisal and acquisition services.

The major selection factors are the experience of the key staff in management concepts and computer-generated scheduling and reporting. The commitment and subcontracting requirements cited above are intended to ensure that such functions be performed by the key personnel upon whom the selection of the firm was based.

The state had the following recommendations relative to the selection and use of a CMC:

- The CMC should be engaged at the earliest possible time to permit the firm to become fully aware of the program's ramifications and to use the CMC's expertise fully.

- The program manager and the second-level key technical staff should have extensive experience and capabilities in the management of large projects.
- The selection procedure should require the program manager and the second-level key staff to be at the oral interview to present the firm's experience and capabilities.
- The CMC should be given a free hand to manage the program, with reviews and controls by the state limited to the minimum necessary to assure itself that the CMC is effectively controlling the quality, cost, and performance time.

Washington's I-90 Program

The state's public notice solicited interest from engineering firms wishing to perform management services for the I-90 program. The major features of the design and construction of the project were defined, as well as the consultant's responsibilities. The public notice also listed the major selection criteria and required interested firms to comply with the following conditions:

- The consultant's team shall be able to exhibit proof of having successfully managed projects of a similar scope and complexity.
- The consultant's team shall be composed of personnel having experience in project construction management, highway design, structural design, traffic engineering, highway-heavy construction contracting, and construction estimating.
- The consultant shall have access to a proven computer-scheduling program capable of developing and monitoring design and construction activities, and have a capacity of handling a program of this magnitude.
- The successful consultant shall maintain an office in the local area satisfactory to the WSDOT.
- Members of the consultant's team shall not have had significant previous I-90 involvement, the firm will be precluded from seeking future I-90 engineering work, and construction contractors affiliated with the firm will be precluded from bidding on any future I-90 contracts.

The engineering agreement required, in addition to the above, that key personnel designated in the selection and negotiation processes for this program should be committed to the project for its duration unless a change was approved by the state. The agreement also required that terminals to the consultant's computer, if the state approved the hardware and software, be located in the state's office.

Ten factors were considered by the state in the evaluation of proposals and oral interviews, as follows:

- *Management Plan* The adequacy of the organization, the project manager, and procedural plan for communications, monitoring and control, review, work assignments, and the resolution of problems.
- *Project Approach* The capability of the firm to work as a team with the state, affirmatively cooperate in training state staff while that staff is working under their control, and learn as much about the program as possible independently of state guidance.
- *Key Personnel* Capabilities relevant to the specific needs of the program and expertise required.
- *Relevant Experience* The experience of the management team in programs of equivalent nature, size, and complexity.
- *Ability to Meet Schedule*
- *Minority Business Enterprise/Women-Owned Business Enterprise Approach*
- *Computer Scheduling Capability* The caliber of the firm's computer-scheduling program, the firm's experience therewith on equivalent projects, and the program's compatibility with the state's mainframe computer.
- *Constructibility Reviews* The expertise of the firm's team in constructibility reviews, contract packaging, cost estimates, PS&E, scheduling, traffic plans, change orders, and shop drawings.
- *Claim Defense* Experience of the firm's team as expert witness and in the formulation of records for claim defense and in claims-avoidance reviews.
- *Project Management Recommendations* The firm's approach, initiative, and capability in helping the state to manage the program effectively.

Arizona's Statewide Design Program

The state's CMC selection methods primarily emphasize the firm's experience in managing multiple contracts and in any specific design work it may be required to perform with its own personnel. The public notice describes the services required for the specific project and requires submission of a statement of interest in a prescribed format. Two or more firms are selected for the submission of technical proposals for consideration in the final selection.

The public notice specifically precludes consideration of partnerships and joint ventures. This provision resulted from problems experienced by the state caused by the breakup of a joint venture previously under contract with ADOT. Not only were there contractual problems in dealing with an entity that no longer existed, but there were legal problems associated with the state's claims against the consultant for errors and omissions. In addition, the state cites various administrative problems with multiple primes relating to audits, establishing overhead rates, and obtaining reasonable insurance coverage. However, the above requirement does not preclude the use of a prime consultant in association with another firm as principal subcontractor. In such an instance, each firm stands on its own rather than as a combined single entity.

New Jersey's Railroad Electrification Program

After interviewing approximately 20 consultant firms, the New Jersey DOT solicited proposals by special letter to each of five short-listed firms. The letter stated the DOT's intention of negotiating an agreement with the organization whose proposal best served the state on the basis of the experience of its qualified personnel and whose proposed job performance related to the specific tasks described in the scope of work. Price was not considered as a factor in selection but, rather, a matter for negotiation.

The department's technical evaluation committee stressed that its primary concern in the evaluation of candidates as a CMC lay in the candidates' ability to handle the complexity of the

project, provide service to the public, and coordinate all activities to achieve the best end product. The following selection criteria were recommended to the selection committee, with emphasis on experience in construction management and in the field of railroad signal and electrification work:

- Qualifications of Firm
  Presentation (Understanding of project)
  Experience and technical competence
  Management experience on railroad projects
  Past Performance (cooperation, motivation, safety record)
  Knowledge (Regulations, standards, labor disputes)
- Qualifications of Individuals
  Key personnel
  Subconsultants
  Availability of staff
- Miscellaneous
  Conflict of interest
- Proposed Organization
  Innovation ingenuity
  Safety—cognizance

The engineering agreement with the CMC requires that the program manager and five assistant program managers designated by the CMC and approved by the state will not be removed for the duration of the program except with the consent of the state. It further requires that professional personnel who have been employed by the U.S. Department of Transportation or of the state shall not be employed on this program without the consent of the public employer of such person.

Based on its experience with this program, the state provides the following observations and recommendations:

- The selection of a CMC should be based on oral interviews with each of the candidate firms' principals and key staff and those of their proposed subconsultants. The candidate firms should present their proposal in person, and their cohesiveness and ability to field questions effectively and responsively should be observed. The department staff should not hesitate in challenging each of the candidate firms with questions regarding their presentation and method of handling various difficult or delicate matters. In this way, the state can determine whether the team will be able to coordinate the implementation of its responsibilities effectively.
- The most important special factors for selection include the quality of the firm's experience in construction management and in the specialized areas of the program.
- The selection committee should be established specifically for the program and should include representatives from the various disciplines in the department that are pertinent to the program.
- A point system should be used to rate each of the prospective candidates.

Connecticut's Bridge Infrastructure Program

The special factors considered in the selection of the CMCs include adequate size of the firm and sufficient staff with expertise in the fields of structure design, highway design, and soils and foundations. A legal notice was published requesting letters of interest from qualified firms. Selection was by standard state procedures.

Louisiana's I-49 Program

Although the specific procedures used in the selection of the CMC are not available, the state asserts that the major factors considered in such selection should be experience in highway design, experience in management of large projects, availability of specialized staff in the disciplines required for the program, number of qualified personnel, reputation of the firm, and familiarity with the state's policies and procedures.

The state stresses the importance of the consultant's familiarity with the department's policies and procedures in the selection process. It also recommends that the CMC be primarily an engineering rather than a management firm, though a joint venture of both might be acceptable.

Maryland's Open-End Agreements

The state's selection procedures for a CMC are standard for all consultants. The short-listed firms are requested to attend a meeting to discuss the scope of the project and related matters before they submit technical proposals. The consultant with the highest-ranked technical proposal may be requested to submit a price proposal, along with an affirmative action package and financial statement.

The technical proposal addresses the methodology, techniques, and processes that the CMC proposes to use, highlighting any special innovations or concepts and the use of computer services. The key staff to be used on the project must be identified with résumés of their experience pertinent to the project requirements. Estimates of the total man-hours estimated and the percentage of such effort by major activity are required. Such estimates are also used to verify the firm's comprehension of the scope of work required.

Price negotiation with the highest technically ranked firm is standard. Consultants are advised, however, that if a precontract audit investigation determines the need for substantial adjustments to their price proposals, a consultant's price proposal may be rejected and the revised price may be considered in selection.

New York's West Side Highway Project

New York emphasized oral interviews with each of the short-listed firms and their key personnel in order to arrive at a CMC that had the best management and technical experience in the disciplines required for this project.

OVERVIEW

The decision by governmental agencies to use the services of CMCs is generally based on either the agency's inability to manage a specific program function or large project in-house or on the agency's lack of a specialized capability needed for a specific task.

The agency's inability is usually caused by a sudden imposition of a large workload on agency staff already fully occupied with the agency's continuing programs. When such a workload is of limited duration, the agency is not willing to hire additional permanent staff only to discharge them eventually or absorb them ineffectively. When the added workload is associated with critical time limitations for its completion, the time required for hiring and training additional personnel precludes such an option. In some instances, the temporary or urgent need for specialized expertise or for a computerized system becomes the mandate for the selection of a CMC.

Such reasons were cited by all the states. Florida and Washington cited as additional reasons the large savings resulting from design and constructibility reviews and the administration of disputes and claims by their CMCs.

Before selecting a CMC, the agency must decide what it expects the CMC to do and the level of authority to be delegated to the firm. A single CMC (whether or not it is associated organizationally with other firms) responsible for overall coordination is preferable to the use of separate consultants for each of several functional responsibilities.

Informal negative comments have been expressed by some state personnel in Florida and Arizona about the use of joint ventures because of administrative problems associated with audits, overhead rates, and insurance coverage. Arizona does not consider the use of multiple primes, specifically joint ventures or partnerships, because of legal and contractual problems experienced as a result of a breakup by a previous joint venture. Arizona, however, does not preclude the use of a prime in association with another firm as principal subcontractor, which was also found satisfactory by Florida for the CMC on the I-595 program. On the other hand, Washington formally expressed full satisfaction with the performance of the joint venture CMC on its I-90 program, and specifically responded that it did not experience any of the cited administrative problems.

The factors considered in the selection of CMCs are similar to those used for design or CEI consultants except that emphasis is placed on different qualifications. The most important assets of a CMC include a multidisciplinary staff with the specific expertise required for the project and with a broad spectrum of experience in managing projects of all types. The firm's familiarity with local conditions, which is generally stressed in the selection of design or CEI consultants, may be considered more of a liability than an asset in some circumstances.

An important feature in the selection procedure is an oral interview with the principals and key managers of the firm, who should be challenged to demonstrate their knowledge of the project, their awareness of specific problems, their ability and their cohesiveness, and any innovative approaches they may have to managing the project and its problems. This feature was stressed by most of the states.

Other selection factors or methods considered important by the states include the following:

- A proven computerized scheduling system should be available.
- The key staff of the CMC should be committed to the project for its full duration, except when transfer is approved by the state.
- The CMC should be experienced in constructibility reviews and as an expert witness in the defense of claims.
- The CMC should be hired early in the project to use its expertise in conceptual stage estimating and to allow for early familiarization with all aspects of the project.

CHAPTER FOUR

SCOPE AND COST OF MANAGEMENT CONTRACTS

This chapter examines the nature and extent of the responsibilities generally assigned to a CMC. It discusses some of the difficulties in defining the scope of work for the CMC's contract and in determining the contract's cost, because the CMC concept is a relatively new approach to state agency contract management. The chapter also contains general comments from several states addressing provisions for changes to CMC contracts and VE.

GENERAL

The scope of work assigned to a CMC varies widely by the type and nature of the project for which such services are required. The work managed by a CMC may include one or more different phases, such as predesign evaluations and studies, design, construction, operations, or any other responsibility of the project owner.

Barrie and Paulson (*1*) cite some key responsibilities of a CMC as follows:

- Leadership in all aspects of the project, including making recommendations for design improvements, construction methods and economies, and scheduling.
- Monitoring the project to ensure that cost and schedule targets are not exceeded without the owner's knowledge.
- Coordinating the procurement of material and equipment (to assure adequate lead time when such procurement is on the critical path) and the work of all construction contractors, monitoring payments to contractors, reviewing changes and claims, and inspecting the work for design conformance.

It should be noted that the CMC rarely performs any significant amount of design or construction work with its own forces. This is important in order to avoid an adversary relationship between the CMC and any other members of the project's management team.

The ASCE's (*2*) descriptions of the general management functions of a construction manager are paraphrased for application to a CMC as follows:

- *Cost Management* Repetitive cycles of cost estimates during all phases from concept through design and construction are necessary to ensure the viability of the project. The CMC must be a proficient estimator of all types of expenditures, including those beyond construction costs.
- *Value Management* The CMC is responsible for reviewing and recommending alternatives to the project management team. The costing and evaluation of the alternatives by the CMC permit the inclusion of the time value of money in the decision-making process.
- *Decision Management* The management team structure provides for group decision making using the collective expertise of the CMC, the designer, and the owner. The success of the system of checks and balances provided thereby depends on the ability of the CMC to maintain a peer relationship among all members of the team.
- *Schedule Management* The CMC is required to schedule all project elements in significant detail using a computerized system in order to have the capability for frequent updating.
- *Information Management* The CMC must develop and maintain a computerized management information system (MIS) that is compatible with the owner's needs and existing computerized systems to provide documentation of the project and related reporting.
- *Risk Management* This is discussed in Chapter 7 and relates to the need to minimize the owner's exposure to liability.
- *Contract Management* The CMC needs to be empowered as an agent of the owner to bring together the various consultants, contractors, fabricators, suppliers, and other elements required for the delivery of the project in accord with all schedule and other requirements.
- *Quality Management* This must be an integral part of the project delivery process and relates to specifying materials and equipment and monitoring the work to deliver the quality desired by the owner.

The ASCE (*2*) classifies the activities of the CMC into the generic classifications of "administrating, advising, budgeting, checking consulting, coordinating, documenting, estimating, evaluating, expediting, managing, planning, recording, reporting, and scheduling."

The Business Roundtable (*17*) cites constructibility reviews as an important service by a construction manager. Very often, designers with little field experience may not be up to date about methods of construction or how to design the product so that it may be constructed or erected in the most efficient and cost-effective manner. To avoid such pitfalls, the CMC is sometimes required to combine its experience with that of the designer in periodic constructibility reviews.

Stukhart (*18*) defines the role of the construction manager, a CMC equivalent, as including constructibility recommendations, contract packaging, cost estimating, budget and control, and the planning and coordination of all work. Such coordination includes design, site layout, and on-site engineering, including changes, payments, quality control, procurement and control of soils and materials, review of contractor proposals and drawings, VE, and safety. He states that the constructibility recommendations by the CMC should be made early in the design phase to improve the contracting strategy and to customize design packages to fit the subcontracting plan, construction needs, and overall project schedule integration. He further asserts that, despite these potential benefits, constructibility reviews are not practiced widely.

Barrie and Paulson (*1*) cite quality assurance as another important service by a CMC by providing the objectivity of a

third party to an area of conflicting motivations. The designer is concerned with a level of quality that ensures satisfactory performance and is a credit to his professional reputation. The contractor on a fixed-price contract may be motivated to minimize nonreimbursable costs. External special-interest agencies may demand quality standards for features not directly related to the project objectives regardless of the cost. The CMC's mission is to provide the objectivity needed to ensure the proper level of trade-off between the value of quality and the cost of obtaining it.

Barrie and Paulson (*1*), in discussing VE as a management service, recall its emergence during World War II when critical shortages necessitated the evaluation of alternative methods, materials, and designs, which resulted in superior performance at lower cost. The VE concept became a mandatory requirement of the Armed Services Procurement Regulations and was subsequently embraced by the larger governmental construction agencies. Although the growth of VE was fostered at the federal level by legislation and regulation, relatively mild interest was stirred in the private sector. The reasons for such slow growth may be attributed to the reluctance by the owner to pay for changes in design, feeling that it should have been done right the first time, and the resistance by the designer, who may feel professionally and financially threatened by the alleged corrections to the design work.

Barrie and Paulson (*1*) recommend that the three-party management team approach can avoid such pitfalls and ensure the success of the VE program if sufficient care is devoted to maintaining a nonadversary relationship among all those involved. This can be accomplished as follows:

- The owner, designer, and CMC should instruct all their personnel to be alert to potential savings and submit their proposals to the CMC, who has the responsibility for overall coordination.
- The designer should retain the responsibility for ruling on the suitability of alternative proposals. Those approved should be forwarded by the CMC to the owner. If approved by the owner, extra design costs should be reimbursable and deducted from the projected savings.
- Each team member should get equal credit in the eyes of the owner for any savings.
- During the construction phase, bid packages should contain several equally acceptable alternatives to pull bidders in to the VE program. Bidders should be encouraged to develop their own alternatives, with a bid evaluation system that credits the ingenious bidder who is allowed to receive the contract without initially being the low bidder.

Value engineering, if used at all, is generally practiced (*1*) in one or more of the following phases:

- Conceptual Phase, in which alternatives are considered during the preliminary design by the designer and/or CMC.
- Detailed Design Phase, in which opportunities exist for cost- and construction-oriented advice by the CMC.
- Procurement Phase, in which bidders may be requested to price alternatives in a phased-construction program.

Barrie and Mulch (*19*) cite sample savings resulting from VE programs of 1 to 6 percent of the building costs, with an overall average of 3.5 percent. They find, however, that the VE concept is not generally favored in the traditional contract approach, which is used for most state transportation construction projects.

After having reviewed the diverse and extensive responsibilities that may be delegated to a CMC, an agency considering such an approach may be interested in the type of contract that is most often entered into with the CMC and its cost.

Barrie and Paulson (*1*) find that CMC contracts have been performed successfully under lump sum or several varieties of reimbursable contracts:

- Reimbursement for both home and field office costs plus a fixed fee,
- Fixed fee for home office costs, overhead and profit, plus cost reimbursement for all field costs, and
- A guaranteed maximum cost for CMC services under a cost-reimbursable-plus-fixed-fee type of contract.

The ASCE (*2*) cites the use of various types of contracts and fee arrangements with construction managers. Those suitable for state transportation department contracts with CMCs include lump-sum and reimbursable contracts. Lump-sum contracts, in which the responsibilities of all parties are clearly predictable, generally include a contingency clause to provide reimbursement and/or extension of time for delays beyond the CMC's control. When relative responsibilities are not predictable, reimbursable provisions are more complex and need to be clearly defined in the contract. The reimbursable contract, such as the cost-plus-fee arrangement, has total flexibility and may be used on any project. Any of these contract forms may contain incentive provisions, which are discussed in Chapter 6.

As noted by Barrie (*20*), field and home office responsibilities and related costs vary sharply by the nature and scope of the project and by the degree of risk which the CMC is expected to assume. Because the fees are generally low, Barrie does not consider it reasonable to hold the CMC to any large degree of risk. Because he finds field costs to be too variable to develop averages, he cites a curve based on a survey of 50 projects expressing only the home office cost plus overhead and profit portion of the total CMC costs as a percentage of the total project value. The curve ranges from about 1.4 to 2.2 percent for a $40 million total project cost to 4.2 to 6.0 percent for $2.5 million projects.

The remainder of this chapter examines several aspects of CMC agreements on various state projects: the variation in their scopes of work, the difficulties encountered in preparing the scope of work and in estimating its cost, and several key requirements in the CMC contracts.

SCOPE OF WORK ON STATE PROJECTS

Florida's I-595 Program

Responsibilities for the management of this program were sequentially assigned to the CMC during three successive phases as the program matured, as follows:

- *Phase I* During this phase, the CMC was required to coordinate with the FDOT, FHWA, and consultant designers in reviewing designs that had already been completed for their constructibility; to review the overall compatibility among the designs; to develop the necessary schedules and reports; to moni-

tor the completion of the designs, land acquisition, utility relocation and adjustment, and permits; and to develop a public-information system. An overall project implementation plan also had to be developed consistent with the project's technical aspects and funding capabilities. The plan treated costs, schedules, and physical progress as interrelated components to facilitate comparisons of actual to planned or budgeted performance at any stage.

- *Phase II* The development of the various individual construction packages started in this phase upon the adoption of the construction implementation plan. Final design proceeded, and the CPM schedules and reporting systems developed in Phase I were implemented to monitor, control, and direct the acquisition of ROW, relocation of residences and businesses, adjustment and relocation of utilities, and securing the final permits. Development of the public-information system and other activities were continued, and the scheduling and control systems needed to monitor the construction work were developed for later use.
- *Phase III* The CMC was not permitted to start on this phase, which began with the award of the first construction contract, until authorized. The agreement provided the FDOT the alternatives of authorizing the CMC to directly perform CEI services or to manage other consultants under CEI service contracts with FDOT. The latter was ultimately selected, and the CMC adapted the computerized scheduling and reporting system and monitored the overall quality, cost, and progress of the construction projects. The CMC also evaluated change-order requests and contractor claims; served as liaison between designers and CEI consultants; coordinated the overall maintenance of traffic, safety, and materials plans; provided training manuals and sessions; and performed other administrative and management activities on behalf of FDOT, subject to the latter's review and approval.

The engineering agreement with the CMC delineates the relative responsibilities of the CMC, FDOT, FHWA, and the design and CEI consultants by detailed activity within the scope of work, indicating which has the prime, input, or review responsibility. A sample of such detail is included in Appendix A.

Florida's Bridge Repair and Replacement Program

The initial contract with the CMC for this program was also phased and provided for at least two annual renewals. The Phase II design phase services were not allowed to start until the completion and approval of the Phase I study recommendations. Subsequent funding limitations resulted in a sharp reduction in the scope of work and a time extension.

The CMC is required to minimize the need for FDOT's resources in discharging its responsibilities to manage, schedule, coordinate, review, and report on activities of section consultants performing PDE and design services for each of the individual projects in the program. Such program management services include:

- Development of section consultant contracts, which involves preparing scopes of services and advertisements for each of the consultant contracts required, evaluating the proposals, and monitoring the scope of work performed.
- Management of section consultants, which requires the CMC to develop and maintain fully computerized and integrated scheduling systems for the various study and design contracts and the utility, ROW, and permit activities and to prepare related reports for different management levels.
- Quality assurance, which involves developing and implementing a quality assurance program for the approval of the FDOT.
- Other, which includes development by the CMC of reporting procedures and monitoring of the progress of each project, review of project invoices, development and maintanence of a document control system, and participation in technical and informational meetings and forums.

Additional services required of the CMC include:

- Technical services. The CMC performs these services under the direction of the FDOT project manager, who, with guidance from an FDOT technical support team, reviews and approves alternatives and recommendations by the CMC. The alternatives and recommendations include technical reviews of submissions by the section consultants, technical investigations, analyses, reports and guidance, technical meetings, application for environmental permits, utility agreements, acquisition of ROW, and PDE services.
- Optional CEI management services. At the option of FDOT, the CMC may be requested to perform management services during the construction phase by administering and managing the CEI consultants for FDOT. However, there are no current plans to implement such an option.

Washington's I-90 Program

The state had done a considerable amount of planning and work on this program before it determined that a CMC was necessary to assure that the funding deadline was met. The CMC was given responsibility for advising and supporting the state, with the WSDOT remaining in full and direct control of all design and construction activities. The CMC agreement was defined for the entire program as summarized below, though the CMC was initially given a contract for Phase I only. Morris-Knudsen later received a new contract for the remaining responsibilities through the construction phase.

Phase I—Project Management Analysis and Recommendations

In this phase, the WSDOT sought an independent evaluation of the management aspects of the project to check on the work it had done. It required completion of the following within 4½ months because the timing of the program depended heavily on the resulting recommendations by the CMC:

- Project familiarization and data collection involved briefing by the state and independent action by the CMC to become completely familiar with all technical, financial, administrative, and political aspects of the program. The CMC was required to determine and evaluate all program-related commitments, procedures, and requirements and to recommend systematic pro-

cedures for monitoring the submittals from the various design consultants and construction contractors in the program.

- Construction sequence and contract packaging required the CMC to review the state's master construction sequence plan and schedule; the existing contract packaging; and the constructibility from technical, traffic, and financial perspectives and to provide its findings and recommendations.
- Computer scheduling required the CMC to evaluate, refine, or replace the state's system with a previously proven CPM computer-scheduling system that could interrelate all the projects through design and construction.
- Project management recommendations included the CMC's proposals to improve the management plans and procedures and the state's specifications in order to reduce costs, time, disputes, and claims.

Phase II—Project Management Recommendation Implementation

This phase involved the implementation of the CMC's recommendations developed in the previous phase. The contract states that any tasks for which the state does not have sufficient qualified personnel may be assigned to the CMC.

The responsibilities in this phase include projecting needs for additional manpower and/or consultants; training state personnel in management and computer-scheduling techniques; and assisting and advising the state in reviewing change orders, scheduling, developing reporting procedures and formats, and running the program's operations center.

Phase III—Construction Management Assistance

In this phase, the CMC needs to use its expertise in construction, design, and scheduling to assist the state:

- In the review of the PS&E for each contract relative to completeness, constructibility, schedule, and estimated cost. Special reviews include tunnel ventilation, electrical, mechanical, and drainage systems.
- In determining whether the CPM schedule for each project is an accurate representation of how it should be built, taking into account the scheduling of resources, the timing of other projects, and the maintenance of traffic.
- In the review of change orders selected by the state that may have program effects.
- In the projection of peak-load staffing requirements for the reviews of shop drawings, approvals of materials, and other activities.
- As an expert witness in the defense of claims.
- In special studies requested by the state, such as the potential benefits of fast-tracking certain projects and determining the need for VE studies.

New Jersey's Railroad Electrification Program

This program is under UMTA financing and regulations, which are similar to FHWA requirements for the retention of responsibility and control by the state agencies. However, UMTA appears to be a bit more flexible in allowing direct action by the CMC. For example, field decisions were made directly by the CMC, though the state's field representative was often, but not always, at hand.

The CMC served as consultant to the department in the management, supervision, and inspection of all phases and aspects of the program to assure compliance with the plans and specifications. The CMC provided a program manager and full-time resident staff to control costs and progress schedules and to perform site inspection, quality control, and associated administrative functions. The scope of work assigned to the CMC included the following:

- Develop a CPM master schedule for the program, which must be updated monthly to reflect all changes in construction and prepurchase contracts. Implement courses of action to be taken in the event any contract or railroad force account construction falls behind schedule. Establish a system to monitor cost control and provide monthly reports.
- Establish close liaison among all the program participants, including the resident engineer, contractor, supplier, railroad, New Jersey DOT, and others, and organize and assign staff to effectuate program control, coordination, and expediting.
- Provide on-site supervision and continuous inspection of all materials incorporated in the work, and review and recommend for approval the contractors' monthly progress vouchers. Document all utility and railroad operations and certify all payment vouchers.
- Conduct construction and utility meetings; establish administrative procedures; review shop drawings; maintain job diaries; and prepare and recommend for approval all change orders, plan changes, and supplementary agreements.
- Provide resident engineers and staff in the required numbers and disciplines to observe and measure the work and to take samples and conduct field tests to control the quality of the work. The New Jersey DOT provides all off-site testing. The CMC must also perform all administrative functions for each contract, including those associated with affirmative action, labor disputes, maintenance of traffic, response to public complaints and inquiries, and preparation of federal reports.
- Inspect, test, and control the fabrication at the plant of all materials in prepurchase contracts. Develop an operational and start-up test plan for all components, supervise any needed corrective actions, and develop training programs for personnel required to operate and maintain the facilities.
- Document and prepare recommendations on all contractual liability claims and assist the state in the termination of any contracts in the event of default.

Connecticut's Bridge Infrastructure Program

The CMC provided liaison and engineering services, technical overview of designs, accounting services, and project schedule control, including:

- Supervision of other consultants under agreement with the state for bridge design and related work.
- Review of the work performed for conformance to standard state practices and to the terms of the contract between the state and the design firm.

- Administrative activities including reviewing and processing work directives and invoices by other firms, developing and updating project schedules and costs, reporting on project status, and coordinating with outside agencies and others as required.
- Responsibility for all technical and safety aspects, including geometry, maintenance of traffic, hydrology, and drainage.
- Responsibility for the timely submission of plans, specifications, estimates, and related materials prepared by the consultant designers for bid advertising in accordance with the approved schedule.
- Responsibility for the timely submission of applications for required environmental permits.
- Overseeing the preparation and issuance of construction change orders.

Louisiana's I-49 Program

Because there were four separate agreements with the CMC covering different sections of this program, a typical scope of services will be described briefly.

Predesign functions of the CMC included breaking down the program into usable sections, preparing design packages for each design consultant, and participating in predesign meetings.

Design functions included monitoring progress; coordinating work between consultants; reviewing plans; coordinating with the state, utility companies, and railroads; performing environmental work; and assembling plans for construction contracts.

The state retained responsibility for review and control, geotechnical information, ROW appraisals and negotiations, negotiating design consultant contracts, preparing bidding documents, and reviewing and processing all invoices from design consultants.

Massachusetts's Central Artery Program

Chapter 2 describes the overall project, which is being managed with the use of several CMCs. Although the overall completion of this large project was estimated for 1998, the initial CMC contracts were of limited duration, followed by other contracts or supplementation for subsequent stages. The CMC contract for the Third Harbor Tunnel, for example, was limited to only a three-year period, with recognition in the agreement that the services to be provided would not complete the full effort; i.e., not all designs would progress to contract plans.

The Central Artery-North Area project was assigned to the CMC, HNTB, through two separate agreements, one in May 1984 for management during the design phase and a subsequent one in October 1987 for construction phase services. The services are described below very briefly because of their similarity to those previously described for other states.

The design phase contract included the review of all designs and estimates; coordination with other consultants, governmental agencies, and private groups; scheduling and monitoring of cost and progress; review of extra work claims; and several administrative functions including communications, document maintenance, and community participation. These tasks were implemented during three separate subphases:

- Organization and Project Planning, including project orientation, mapping and control surveys, tentative project scheduling, establishing administrative procedures, and project monitoring and control.
- Preliminary Design, covering coordination and direction, project control plans and technical criteria, reviewing survey programs and construction segments, refining project schedule and costs, and project monitoring and control.
- Final Design, including alignment, coordination with designers, reviews, scheduling, funding and cost analysis, construction bids and awards, community participation, and monitoring and control.

The Phase II construction services contract required the CMC to review various invoices and force account documentation; attend preconstruction conferences; coordinate inquiries with the designers; review design adjustments to field conditions; assist in mitigation issues; and coordinate with the state, designers, utilities, municipalities, and private groups.

Maryland's Open-End Agreements

The following discussion deals with the second example cited in Chapter 2: the determination of the impact of the proposed highway construction along various routes and the mitigation of its effect on wetlands within its bounds. The scope of work required of the CMC includes the management of other consultants and production services as described below.

Project Management

The CMC manages other consultants performing any or all phases of project planning activities, preliminary and final engineering design, public involvement support, traffic engineering, landscaping, and checking of shop and working drawings. Because the agreement is open-ended, the CMC needs to provide a proposed work plan, including scope, manpower, scheduling, and price for each project added to the agreement, subject to approval by the state.

Production Services

In lieu of engaging a consultant, the state may require the CMC to perform with its own forces any or all of the above identified services for any specific projects it may assign.

New York's West Side Highway Project

The agreement contains extensive detail for the scope of work, which is very briefly summarized as follows:

- Managing and coordinating the work by all consultants involved in the project, including meetings, reviews, and the development and maintenance of a CPM network schedule and reporting system.
- Performing engineering work, which includes coordinating surveys and mapping; data handling; coordinating with the gen-

eral soils consultant and the department relative to geotechnical explorations, criteria, and standards; reviewing and coordinating the tunnel-monitoring system; preparing the base plans, system-wide elements, and preliminary design concepts and geometric controls; and coordinating, reviewing, or monitoring the structural, roadway, ventilation, electrical and mechanical elements, environmental and architectural items, and park design.

- Evaluating the cost-effectiveness of each system-wide element by a multidisciplinary team, acting as technical manager of all of the section-design consultants, and reviewing their work.

SCOPE PREPARATION AND COST ESTIMATING

The objective of this section is to present problems reported by the states in preparing the scope of services or in estimating the costs of a CMC contract and the means taken to overcome them. Some actual costs of CMC contracts are also presented to the extent reported, which may provide helpful information to those considering the use of a CMC for the first time.

Florida's I-595 Program

The total cost of the I-595 program, including design, utility relocation, construction, CEI, and administration by FDOT, was estimated at $1.2 billion, approximately $600 million of which was estimated for construction costs.

Although the cost estimates for the construction remained relatively stable, considering the project's size and type, the initial $3.4 million contract with the CMC was increased 15 times by supplemental agreement during the subsequent six years. This was caused in large part by the sequential phasing of the work and the identification by FDOT of additions to the original scope, requiring additional subcontracting or direct effort by the CMC. At the time of the survey for this synthesis, the total amount payable, though not a final figure, was about $46 million. Thus, in this instance, the CMC cost represents approximately 7 to 8 percent of the cost of the construction, or less than 4 percent of the total project cost.

The Florida Department of Transportation did not report any difficulty in estimating the costs or the scope of work for three probable reasons:

- The department has capable design professionals, though their number is insufficient relative to the sudden increase in work load.
- The selection system, which was subsequently changed, provided for the submission of technical proposals and man-hour estimates from the short-listed consultants. This provided the department staff with comparative information against which they could measure their own estimates of scope and costs.
- The use of phased supplementals to the contract continually increases the state staff experience with its needs for management and consequently its capability for more accurate estimates of the required work activities and their costs.

Florida's Bridge Repair and Replacement Program

The total construction cost of this program was estimated at about $400 million. The original contract with the CMC provided for a maximum limiting compensation of $10.6 million for managing this program. This amount was based on actual allowable salary costs; administrative overhead and payroll burden; actual direct operating expenses including subconsultants, mobilization, and relocation (lump sum); and a fixed fee. Such initial estimates represent a CMC cost of about 3 percent of the construction cost. This does not include any optional CEI management services. The subsequent reduction of the program to $159 million in construction cost and the CMC contract to $9.24 million over a 15-month-longer time period represents a cost factor of almost 6 percent.

The department did not report any difficulty in estimating the costs or the scope of work for this program. It should be noted that, although the level of total effort proposed by the short-listed firms varied considerably, the percentages of the total man-hours assigned to the particular tasks were generally similar in three of the five submittals. Such information provided a good basis for arriving at average costs and evaluating the selected CMC's cost proposal in the negotiation process.

Washington's I-90 Program

The state reports that the initial preparation of the scope of services was very difficult because this was the WSDOT's first effort at hiring a CMC. Because the state did not have an experienced staff to define the scope of work fully and accurately, an evolutionary process was used, based on its best judgment of what was required to meet the objectives. It borrowed heavily from the experience gained on Florida's I-595 program, using that state's materials and advice. Once the CMC was selected, that firm aided in the development of scope tasks, particularly during negotiations.

Similarly, the state had great difficulty in arriving at an accurate cost estimate of the CMC contract and had to seek guidance from Florida's I-595 experience. The Washington State DOT's estimate for all three phases of the six-year program was initially $12.5 million, whereas the consultant's was $18.3 million. The major reason for this large cost difference was the differing perspectives of the state and the CMC regarding the number of man-months required for the various aspects of the scope of work. Subsequent negotiations resulted in reaching a compromise and arriving at a total cost of approximately $13.2 million.

However, the WSDOT used Florida's approach of learning from experience and committed itself only to an initial phase of the work. In this way, it could arrive at more accurate estimates of work and costs for the subsequent phases that were initiated via sequential supplemental agreements.

The engineering agreement states that it was not practical to identify precisely what the work activities and relevant costs were for the subsequent Phases II and III and that the contract would be supplemented biennially when the work in such phases could be defined more accurately.

The maximum amount payable for the initial Phase I was specified at approximately $4.3 million. There were six supplemental agreements up to the time of this synthesis, which added the various responsibilities envisioned for Phases II and III and resulted in an extension of time to June 30, 1989 and a total maximum amount payable of $13.3 million.

Though the latest supplemental agreement has not fully accounted for all of the remaining work, the CMC's costs for the

work delineated in the foregoing scope represents about 1 percent of the total $1.4 billion construction cost for this program. However, Morrison-Knudsen has been retained under a new agreement to provide project and construction management services from July 1989 through September 1992 for a maximum amount payable of $5.4 million, which increases the total CMC percentage to 1.4.

New Jersey's Railroad Electrification Program

New Jersey reports that it did not experience any problem preparing the scope of work for the CMC on this program primarily because it had experienced personnel in-house. Furthermore, the selection interviews with the prospective candidates would occasionally highlight features that would be incorporated in the scope if deemed desirable by the state.

Based on its experience with this program, the state recommends the following:

- Great care should be exercised in the preparation of the scope of work, because the entire relationship between the state and the CMC is built thereon.
- The method by which the consultant's pay raises are to be determined and their frequency should be defined in advance.
- As-builts and job records must be maintained during the progress of the work, because it is not cost-effective to have the consultant on board near the end of the program and during job closeout.
- Provisions that protect the CMC as an agent of the state should be investigated in order to reduce liability insurance costs. However, the consultant must remain responsible for any negligence by the firm's personnel.

The original cost estimate was prepared by the New Jersey DOT more than 10 years ago, but the department asserts that there were no major deviations other than justifiable increases in the rates to be paid to the consultant personnel.

The engineering agreement provides for an incremental work program for the purposes of schedule and cost control. Such annual spreading of the CMC's responsibilities over a three-year period also allows the state to gain experience with the needed activities by the CMC and the costs thereof. Furthermore, the agreement includes a section of extra work items that covers areas in which distinct scope provisions could not be determined initially.

The percentage of CMC management cost relative to this $264 million program is not pertinent because it is not strictly a CMC-managed operation but also includes responsibilities of CEI consultants.

Arizona's Statewide Design Program

Arizona acknowledges great difficulty in developing the scope of work and preparing the cost estimate for its initial CMC contract because of the lack of staff with sufficient experience in major projects. This initial effort and its work with subsequent CMC contracts served as building blocks in the upgrading of ADOT's capability in this area. Its abilities were greatly enhanced by using the resources of one of its CMCs in developing comprehensive scopes of work for both CMC and design consultant contracts. Its initial problems with estimating costs are attributed to the fact that the state considered the earlier scopes as moving targets, subject to change even after execution of the contract. Such changes occurred to accommodate ADOT's cash flow or fluctuations in its priorities or available staff resources.

The problems of cost estimation were simplified by the mechanism of change orders. The use of major change orders is a deliberate process imposed by management to control the expenditure of funds. ADOT's CMC contracts span several years and, although the total amount of the contract is approved at the start, expenditures in subsequent years are controlled by the need for authorization by change order.

The department finds that the total cost of its CMC contracts averages from 1½ to 3 percent of the total construction cost of the projects or program managed. Such percentages vary by the number and size of projects managed and by the scope of services. The three CMC projects described in Chapter 2, with total construction costs varying from $250 million to $325 million, fall within this percentage range.

Connecticut's Bridge Infrastructure Program

The state reports no difficulties in arriving at the scope and costs of work. The CMC is paid on an hourly basis for its personnel, to which is added a multiplier that includes payroll burden, fringe benefits, overhead, and profit, plus all approved direct costs.

Louisiana's I-49 Program

The state asserts that there were difficulties in estimating the scope of work and cost for the CMC contract. Because this was among the first consultant management contracts negotiated by the department, the CMC played an important role in defining the scope and cost of the work.

The CMC was assigned the management of this program by five separate agreements covering different sections of the highway and successive operations. In this way, the state was relieved of committing itself to work and costs for a long-range program that it could not adequately define up front.

However, each of these separate agreements required five to seven supplementary agreements for additional work and time extensions for completion of the work for several years, increasing the maximum amounts payable from two to six fold. The type of work supplemented included the addition of new sections of highway design for management, evaluation of alternative interchanges or design details, additional services not originally contemplated, extended services required because of late or faulty designs, and additional compensation for increased consultant employee pay rates.

Nevertheless, the total cost of the CMC's management effort represents less than ½ of 1 percent of the total $1.5 billion program construction cost.

Maryland's Open-End Agreements

The state reports that there were very few problems with the development of the scope of services for the management

contracts, which it attributes to the close coordination between the department's senior management personnel in the development, implementation, and control of the contracts.

Estimating cost was also no problem. A maximum amount payable was specified under each of the state's open-end agreements. Negotiations of the work to be included in each contract tailored the effort to the funds available, though there have been instances in which it was necessary to increase the maximum amount payable to accommodate additional work desired by the state.

The Maryland State Highway Administration's provisions include an acknowledgment of salary escalations and assert that any rate increase up to 8 percent per year is considered reasonable. However, another provision states that if a contract is performed within the required time frame and conditions, increases in salary costs and overhead would not be sole justification for an increase in the maximum amount payable. The consultant is responsible for staying within the maximum stated limits in the absence of justification for an extension of time.

SELECTED CONTRACT FEATURES

This section discusses two provisions generally included in CMC contracts that are deemed to be of general interest. Provisions for changes to CMC contracts are examined because they may be an indication of the difficulty agencies unfamiliar with such contracts have initially in determining the scope of work. Value engineering has been discussed earlier in this chapter as a valuable management function that has not grown much outside the federal bureaucracy. It may be of interest to view the extent to which it is delegated by the states to the CMC in contract management.

Other provisions, such as termination, liability, and insurance, are discussed in subsequent chapters because of their relevance to the subject matter therein.

Changes

The following selected examples of the the states' provisions for changes in CMC contracts indicate their great similarity with those used in contracts with production consultants on design or CEI contracts.

Florida

When changes are required to the scope of services defined in the agreement, a supplemental agreement is processed as follows:

- The department issues written instructions to the CMC for changes in the defined scope of services.
- The CMC proposes appropriate revisions thereto.
- Upon concurrence therewith by FDOT, the CMC proposes additional staffing requirements and wage rates for FDOT's consideration.
- Upon successful negotiation, a supplemental agreement is prepared.
- The maximum limiting compensation is equitably adjusted to account for any increase or decrease in the estimated cost of performance. If FDOT cannot agree with the CMC regarding the amount of such increase in compensation, the state retains the right to terminate all further services with respect to such change.

Washington

Washington provides that any changes or revisions to previously completed work that are desired and directed by the state shall be paid for as extra work. Also, if the state directs the consultant to perform work or render services in addition to the work provided for by the expressed intent of the scope of work or the magnitude or complexity of work contemplated by the agreement, it shall be considered extra work and paid by supplement.

New Jersey

The standard provisions allow payment as extra work, including an additional, prorated fixed fee, for any additional work resulting from an extension of time required because of delays beyond the control of the CMC or for work ordered by the state that represents a change in the original character or extent of work or requires the revision of work already completed.

Special provisions also set forth specific items of work that may be ordered by the state and paid as extra work. These include assisting the state in negotiations and court testimony in the institution of any default actions against contractors, certain additional special services, design or VE services, or specialized field or laboratory testing of products and materials.

Connecticut

The agreement simply reserves the right of the state to add or withdraw work and the right to process supplemental agreements if deemed necessary by the state.

Louisiana

The agreement provides that minor changes will not be cause for additional compensation as the work progresses. Major changes that do not involve a change in the original scope will justify additional compensation as provided in the agreement. In such instances, payment will be made at specific hourly rates specified in the agreement. These hourly rates include all direct and indirect costs and profit.

Any extra work or major change outside the original scope or in excess of 10 percent of the cost of the contract requires a fully executed supplemental agreement.

Maryland

Extra or additional work is authorized when there is a change in the scope, magnitude, or complexity of the project. The consultant must support its request for additional payment as well

as the amount therefor. The state makes a distinction between extra and additional work, as follows:

- Extra work includes services beyond the original scope, including those beyond the project limits or those defined in the contract, or tasks specifically deleted from the scope of work. A fee adjustment is usually allowed for extra work.
- Additional work includes services that are quantitatively more of the same tasks defined in the scope, and does not justify an additional fee.

Additional discussion of these standard provisions and recommendations thereon may be found in Synthesis 137 (*9*).

Value Engineering

Florida

For its Statewide Bridge Program, FDOT reserves the right to conduct VE analyses for projects whose construction costs are estimated to exceed $1 million, as well as for lesser projects that are deemed to warrant such evaluation. The VE analyses are not required unless specifically included in the contract.

The department's instructions provide for VE reviews at four phases in the development of the project: (a) at the draft preliminary engineering (PE) report, (b) the final PE report, (c) the final engineering report, and (d) the preliminary bridge plans phase. It stresses the importance of reviews early in the project development to identify any concepts that need further investigation in order to eliminate time and efficiency loss later in the project.

Value engineering is generally conducted by a multidisciplinary team of FDOT personnel who require a significant amount of support services from the section consultants. Key personnel from the section consultant must appear at the FDOT central or district office to advise the VE team regarding the initial concepts of the project, traffic projections supplied by the CMC, aerial and other surveys, and a decision matrix of alternatives considered. These include construction cost, ROW cost, life-cycle costs, environmental impacts, safety, operation, relocations, and public acceptance. Such written evaluations are passed through the CMC for review and comments to the VE team, which may include an additional concept, upon review with the CMC, for inclusion in the evaluation of alternatives by the section consultant. The potential for adversary relationships is reduced in the above procedure because of the adoption by FDOT of a central role in the review and approval of VE alternatives and analyses.

Washington

The state does not require the CMC to perform VE on its I-90 program. Its contract requires only that the CMC review the need for further VE studies and, if requested by the state, furnish candidates as members of a VE team if another study is to be done.

Arizona

Value engineering is included as a major requirement in contracts with design consultants. The CMC is expected only to cooperate in the administration of the program and in the review of VE recommendations. The VE program encompasses only preconstruction activities, and there is no sharing of any savings by the state with any of the consultants.

New Jersey

The state does not require the CMC to perform VE services but retains the right to do so through an engineering agreement provision that such services, if required, be paid under the extra work provisions in the contract.

Maryland

The state retained other consultants for value engineering services at the preliminary investigation and semifinal review stages. The CMC only had the general responsibility of ensuring that the state was getting the best value for its dollar.

New York

The contract required the CMC to undertake an economic evaluation of each system-wide element initially and during the final design of the project by the section design consultants. The CMC was required to organize a team to provide a multidisciplinary analysis and evaluation of the major components of the project, including the following:

- Evaluating the functional and environmental requirements.
- Evaluating the costs of various structural configurations, alignments, design criteria, and feasibility of construction.
- Identifying more cost-effective alternatives.
- Preparing reports detailing the analyses and recommended modifications for submittal to the department and other interested agencies for approval.

Other

Neither Connecticut nor Louisiana requires the CMC to perform or review any VE services.

OVERVIEW

Management contracts generally require the CMC to assume a leadership role in reviewing the designs; selecting economical construction methods; establishing reasonable schedules; monitoring the work to assure that its progress, cost, and quality conform to the owner's and designer's desires and intent; and other responsibilities required by the owner. In order to avoid adversary relationships, the CMC should not do design or construction work with its own forces.

A computerized scheduling system is an essential feature of such contracts in order to provide the capability for continual

updating of progress and cost information and for frequent reporting to various management levels. Such systems are required by almost all of the states' CMC contracts.

Additional features generally reported by the states include constructibility reviews and assistance in the review of disputes and claims. Periodic constructibility reviews by the CMC are helpful when the designers may not be up to date on the best and most economical construction methods. The objectivity of the CMC is useful in reconciling differing perspectives by the contractor, designer, and public or political groups who may request additional features regardless of cost or effect on other concerns.

The scope of the states' CMC projects varies from the management of a single functional activity for a number of projects to the complete management of the planning, predesign, design, and construction operations for a large Interstate facility. In effect, any agency desiring to supplement its capability to manage a program may select from a menu that provides a wide variety of expertise and experience in any number of disciplines. However, once such selections are made, it is important for the owner to delineate the scope of the work carefully so that all members of the management team are aware of their responsibilities and the chain of command in order to avoid adversarial relationships.

Many of the states had problems of varying degrees in developing the initial scope of work for the relatively new CMC approach to the management of their programs and in estimating its costs. When the states had a corps of capable professionals that could be assigned the task of developing the scope and cost estimates of the work, the problems were more manageable. These problems were generally ameliorated in the following ways:

- By staging the overall project and committing the CMC and the state to it sequentially by phase, the state managers gained insight from their experience into the activities needed and their costs. This resulted in better estimating in the subsequent preparation of supplemental agreements.
- Most of the states availed themselves of both the man-hour estimates in the technical proposals submitted by the short-listed candidates and their interviews with the selected CMC during the negotiation processes to help them develop both the scope and cost of the CMC contract.
- All of the CMC contracts were on a reimbursable-cost or unit-price-plus-fee basis, which provided more flexibility in managing work in an uncertain environment. The extra work provisions in such contracts provided additional acceptable means to pay for unaccounted activities. One state listed specific activities in the agreement that could not be estimated at the time, and provided for its future payment as extra work.

Several states cited the difficulty in negotiating pay rates for the CMC's personnel in the event of significant extensions to the contract completion date. Although some states include a salary schedule in an agreement that covers the entire period of the contract, such inclusion does not address time extensions. It is not reasonable to subject either party to the contract to the risk of guessing the necessity of a contract extension or the prevailing wage rates at that later date. One solution is to include the method of arriving at new or escalated rates directly in the agreement as a negotiable item.

The costs of CMC contracts vary sharply with the scope of the CMC's responsibilities, the size and scope of the project managed, and the degree of risk assigned to the CMC. Some sources cite CMC costs, excluding the highly variable field costs, as a percentage of the total cost of the project managed by a curve that varies from 5 percent for small projects to about 2 percent for projects of $40 million in total cost. The projects cited by the states, however, are of a much larger magnitude. The highest management percentages, which include the CMC's field costs, are on Florida's I-595 project: 4 percent of the total $1.2 billion cost, which includes management and administration of the design and construction projects, or 7 to 8 percent of the total estimated project construction cost. However, management of this project included complex construction and extensive coordination in a heavily urbanized area.

The other state projects, which varied in construction cost from several hundred million dollars to considerably more than $1 billion, required CMC management percentages that varied from less than 1 percent to 4 percent of the total cost of construction.

An analysis of all the variables affecting the cost of management is not feasible with the limited data available. However, the data cited from Barrie and Paulson's work (*1*) in the introductory pages of this chapter, along with the isolated examples cited above, may provide a generalized envelope of management costs for states interested in initiating the CMC concept.

The survey answers cited herein included the manner and extent in which provisions for change order and VE appear in CMC contracts. Change orders can reflect upon the degree of a state's uncertainty in defining the CMC's scope of work, and VE is considered to be particularly effective with the CMC approach.

Change order provisions were no different from those included in contracts with design or CEI consultants. Most states simply allowed for reimbursement for extra work beyond the original scope. A smaller number took the trouble to define the difference between extra work and additional work, to provide the circumstances under which an additional fee was warranted and its amount, and/or to acknowledge that a significant reduction in the scope of work required an appropriate adjustment in fee.

Value engineering, fostered by legislation and regulation at the federal level, has never taken hold. This may reflect the owner's reluctance to pay for changes in design that should have been done correctly in the first place and resistance by the designer, who may feel threatened by the owner's attitude. The concept of the nonadversary three-party team approach of the CMC, designer, and owner is intended to resolve this problem.

Florida stressed VE reviews at four stages of the development of a large project by a multidisciplinary team of state personnel, with support by the design consultants and recommendations thereon by the CMC. Adversarial relations are reduced by the state's, rather than the CMC's, assumption of the central role. However, this is possible only when the state has sufficient staff.

New York required the CMC to set up a multidisciplinary team to evaluate the project's functional and environmental requirements; the costs of alternative structural designs, alignments, and criteria; and cost-effective alternatives. Four other states did not require VE reviews, and one state required other consultants to perform VE at the preliminary investigation and semifinal review stages.

Thus, even at the state agency level, VE is required of the CMC far less frequently than might be anticipated.

CHAPTER FIVE

ORGANIZATION AND INTERRELATIONSHIPS

This chapter explores the ways in which state agencies and CMCs are organized to manage large programs or projects and how such organizations interact with each other and with other groups in the delegation of authority and exercise of responsibility. It also examines the compatibility of such methods and procedures with the federal requirements for direct control and responsibility by the state and with the need for efficient management to meet program and public objectives.

GENERAL BACKGROUND

There are several organizational structures that may be used regardless of the way a project is managed contractually. Barrie (*3*) describes these and their shortfalls as follows:

- *The Functional Organization* features direct lines of control from the owner through the project manager to the heads of separate design and construction divisions and other functional groups. This is the traditional approach in the construction industry, and features stability, professionalism, and an excellent corporate memory. Its weaknesses include low adaptability and lack of appreciation of project objectives. Such organizations succeed when the top managers are skillful and able to avoid internal jurisdictional conflicts among the separate groups involved in the project.
- *The Autonomous Task Force* works best when a self-sufficient organization is needed. Its strengths include adaptability and understanding of the task at hand and a high team spirit. Its pitfalls include lack of a backup of expertise and corporate memory, no functional checks and balances, and poor stability.
- *The Line and Staff Organization* used by General Motors combines functional strengths with the expertise of the project-oriented task force. It also can develop project managers by giving them diverse assignments. Its weaknesses include greater costs, conflicts between the functional staff and the operating organization, and problems with dual accountability to functional and project supervisors. It requires capable managers and a clear delineation of project management versus functional authority.
- *The Matrix Organization* is intended to solve the conflict between operational and functional authority by opening up lines of communication and providing dual responsibilities at all levels. There is a difference of opinion among managers in the construction industry about the effectiveness of this type of organization, which has yet to be proved.

Managing very large projects with time spans of eight or more years has proved troublesome to the construction industry. The theoretical economies of scale do not seem to apply to superprojects, perhaps because of the greater separation between the top management and the operational level. Although medium-sized projects permit close supervision of operations by top management, the large projects depend chiefly on interactions among middle managers, resulting in increasingly longer times for problem solving and decisions.

The ASCE (*2*) asserts that there is no prototype CMC organization, that it can be any organization that has the resources to execute the owner's management requirements proficiently.

Closely intertwined within any management organization are the interrelationships among the owner, the CMC, and the designer, as well as those with the contractor and other interested groups. These are of equal or greater importance than the type of organization. Barrie and Paulson (*1*) cite the potential of the three-party management team to avoid the adversarial relationships inherent in the traditional approach by state transportation construction agencies. Adversarial positions may be avoided by the following relationships:

- *Manager to Owner* Faithful professional representation and advice within the responsibilities delegated by the owner, keeping the owner fully informed.
- *Manager to Designer* Professional approach to securing full cooperation by designer in reducing costs, sharing credit for benefits achieved with the designer.
- *Manager to Contractor* Accurate interpretation of plans and specifications, impartial adjudication of disputes, and professional approach to responsibilities.

Tatum et al. (*4*) also extol the value of the three-member project organization team of the owner, CMC, and design organization. They recommend varying interrelationships among the team members during different phases of the project:

- *Conceptual and planning phase* The owner should have the prime authority, with input and assistance by the CMC and designer.
- *Design phase* The designer should have prime authority but should seek out and be responsive to the CMC.
- *Construction phase* The designer should retain responsibility for adjusting the design to changed conditions.

There is generally a disparity of objectives among the members of the team, such as between the CMC and the designer. The CMC may want to consider other alternatives to achieve lower total costs for the owner. The designer may tend to discourage continual proposals because of their effect on time and cost of design. Therefore, their division of responsibility should be defined clearly at the inception of the project.

Tillman (*12*), in analyzing the New York City transit program, stresses the importance of a careful delineation of the CMC's responsibilities and duties in the contract documents. He recom-

mends that the public construction agency should retain only the minimum amount of control of financial aspects and other major concerns that cannot be legally delegated.

Behr (*15*) reports that the public nature of the James Bay program requires formal recommendations for approval to top management for even small changes that involve cost increases. Such an approach appears unnecessarily stringent.

Hammond (*11*) cites the importance to San Francisco's BART program of its decision to have a strong, highly qualified engineering group of its own to provide direction, technical assistance, and advice and to ensure that its public commitments to the affected communities were met. Although the BART board approved major matters involving policy, public interest, or funding, the BART staff was encouraged to maintain general control by means of the matrix approach of direct contacts between opposite members of the BART and CMC staffs. Contacts included those involved in problem solving, decision making, public relations, consultations with governmental bodies, and financial matters.

Lammie and Shah (*10*) state that MARTA selected the CMC on the basis of the firm's experience with the BART project. Although the initial organization and procedures were patterned after those of BART, they evolved rapidly because of different operating policies by MARTA, more restricted delegation of authority, and strong technical capabilities of MARTA's staff. For example, at the inception of the project, MARTA elected to delegate day-to-day technical management to the CMC but to retain authority for all policy, cost, and schedule decisions. This required a substantial number of capable MARTA staff members. The rapid transit authority implemented this concept with a staff of 140, compared with the CMC's average staff strength of 550.

As the project shifted from design to construction, the CMC's organization changed further, to one with more responsive lines of communication. The organization for the management of the construction phase illustrates the system of checks and balances between MARTA and the CMC and the use of designated equivalent points of contact between the two organizations.

The responsibility and approval authority is delineated for each level of contact. For example, the CMC's resident engineer reports through an area manager to a manager of construction, and is the contact point with MARTA's project engineer. The latter reports to the director of construction, who, in turn, is the contact point with the CMC's manager of construction. Change orders up to $5000 may be approved at the contact level of MARTA's director of construction, but all contract modifications require approval at the contracting officer level.

An equivalent system is used in design. Lammie and Shah (*10*) state that, though each design change is reviewed three times (one time for need, one for concept, and one for detail), the apparently cumbersome cycle can be completed in a matter of hours for critical items and in one week for less urgent processing, because of the matrix relationships.

STATE PROJECTS

Florida's I-595 Program

Organization

The state's initial management procedures were cited by the FHWA for excessive delegation of authority to the CMC and for inadequate review and approval by state representatives. The Florida Department of Transportation's corrective action was the imposition of more stringent controls, which resulted in excessive turnaround times because of lengthy reviews by the central office. A matrix approach between a task force and the CMC staff subsequently evolved, which merged and expedited direction and control by the state with the exercise of responsibilities by all involved entities.

An I-595 task force headed by a district director was established to manage the program in order to consolidate and expedite the decision-making process. Timely, well-informed decisions on major issues are made by appropriate department administrators within the task force, and informational copies of each issue and its resolution are sent to the appropriate division director.

Figure 1 shows a schematic organization of the task force into its distinct functional groupings and its location within FDOT during the course of the I-595 program. Each of the six district offices and three central office divisions is headed by a deputy assistant secretary (DAS). The elevation of the FDOT manager of the I-595 program to a district director reporting to the District 4 DAS provided him with greater clout in his relationships within the state. (Such an organization subsequently evolved into another deemed to be more suitable for the later stages.)

Figure 2 shows the position of the CMC's project director and staff relative to FDOT and its task force, as well as the two umbrella groups over the task force: the I-595 Overview Committee and the Major Projects Steering Committee.

For the construction phase, seven entities came into play, one superimposed on the other in a hierarchical sense:

- FDOT Major Projects Steering Committee
- I-595 Overview Committee
- FDOT DAS, District Four
- I-595 task force
- CMC organization
- CEI consultant organizations
- construction contractors

The composition and responsibilities of some of the above components of the I-595 organization were as follows:

- *Major Projects Steering Committee* The three DASs in the central office serve on this committee, providing policy guidance at monthly meetings with FDOT and CMC managers relative to political ramifications, community relations, finances, program status, and major changes in scope or cost.
- *Overview Committee* This three-member committee serves as a knowledgeable resource for the task force by means of an overall review of the program at its monthly meetings with the steering committee.
- *I-595 Task Force* Figure 1 shows three FDOT functional managers within the task force with responsibilities for design, construction, and ROW, respectively. With staff assistance by the CMC, they manage and coordinate production within their function, and resolve issues through coordination with FDOT components, FHWA, and outside organizations. Major issues are brought to the attention of the task force director, who informs the overview and steering committees.
- *I-595 Project Management Team* The construction phase provides an example of how the program is managed by the

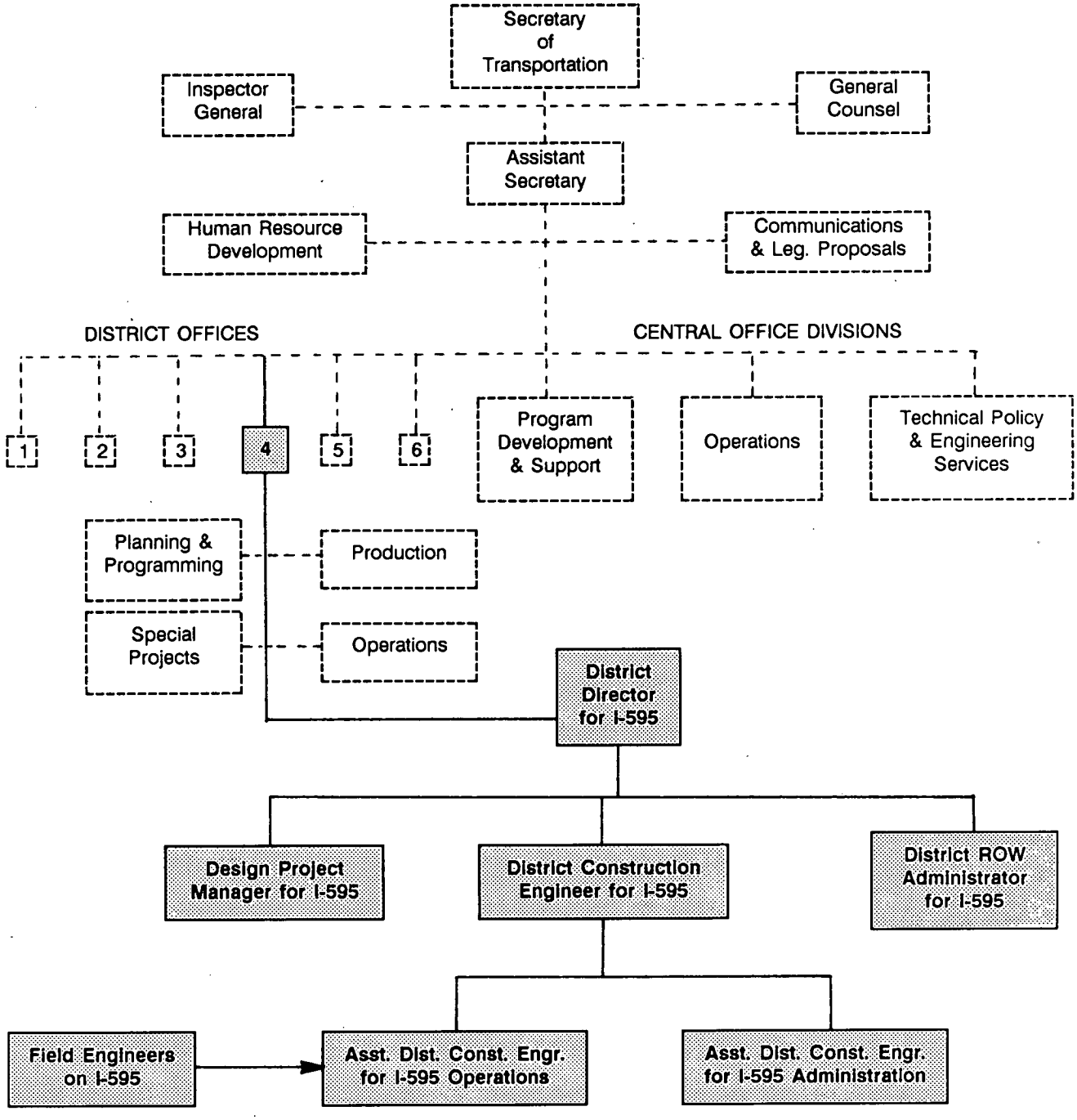


FIGURE 1 Organization of the I-595 task force within FDOT.

management team by means of a matrix of the combined staff of the task force (FDOT) and the CMC.

As shown in Figure 1, the district construction engineer for I-595 manages the program with two assistants and staff. Support is provided by the CMC and the CEI consultants. The assistants provide direction to the CMC managers, verify contract compliance by the CEI consultants and by the CMC, review and decide upon recommendations by the CMC on major issues, as well as on change orders, time extensions, claims, and payments. These assistant district construction engineers (ADCEs) are at the lowest level at which FDOT policies are interpreted and direction given.

Figure 2 shows the general positioning of the CMC organization relative to FDOT for the purposes of carrying forth the responsibilities of the management team. The CMC's board of control comprises top executives of the CMC and acts similarly to FDOT's steering committee. The CMC's project director not

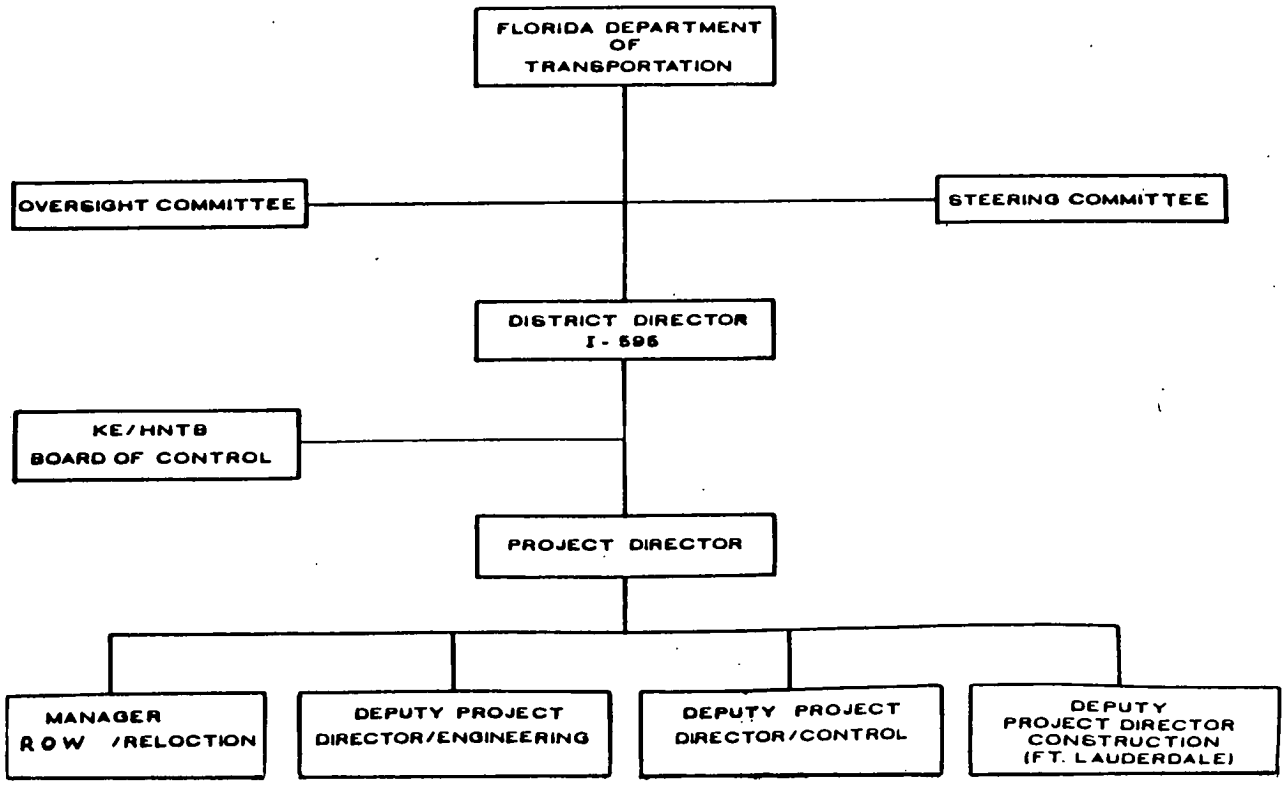


FIGURE 2 Organization of FDOT/CMC management team for I-595.

only provides the principal linkage to the CMC's board but also reports to FDOT's district director for I-595.

State/CMC Interrelationships

Because the I-595 organization and interrelationships were subject to periodic evolution, the following discussion applies only to the situation existing at the time of the survey for this synthesis.

Figure 3 shows the matrix organization of the management team and the decision chain during the construction phase. As can be seen, the primary decision-making authority rests with the state. Nevertheless, the delays inherent in the funneling of decision making to a centralized authority are avoided by delegating the responsibility for real-time decisions to field officials. The support work to aid in the decision-making process is provided by the CEI consultants and the CMC.

Figure 3 also shows the principal responsibilities of the CMC (shown in the figure as KE/HNTB) and FDOT, and their counterpart levels for communications, review, and decision making.

For example, the CMC's area production manager keeps FDOT's ADCE for operations informed of all important issues as they come up, as well as at weekly meetings with the CEI consultant and other FDOT and CMC managers. He also serves as the central clearing house for providing staff and timely responses to complaints by local officials and the public. All proposed corrective measures must be coordinated with FDOT and approved at the appropriate FDOT level.

Florida's Bridge Repair and Replacement Program

Organization

The department benefited from the lessons learned from its I-595 program in the organization of its bridge program. Its overall management goal was to minimize the need for FDOT staffing resources consistent with proper management and with the federal requirements for state control. This program, however, is far less complex than I-595, with less need for day-to-day management decisions.

Basically, management liaison is accomplished by an FDOT central office project manager assisted by one staff person from each of a number of central functional groups. This team coordinates various matters between the CMC and FDOT, whereas the districts remain responsible for the projects falling within their bounds.

A management and staffing plan identifies the key personnel of the CMC, FDOT project manager and support team, and district offices, delineating their individual disciplines, responsibilities, their counterparts, and their channels of communication. The plan includes narrative details of the management, control, coordination, review, and guidance functions among FDOT, the CMC, and the section consultants.

Figure 4 shows the general management organization of FDOT and the CMC (Sverdrup) for this program. The key entities shown are further described below:

- The FDOT project manager reports to the director of preconstruction and design (P&D) in the central office. He is sup-

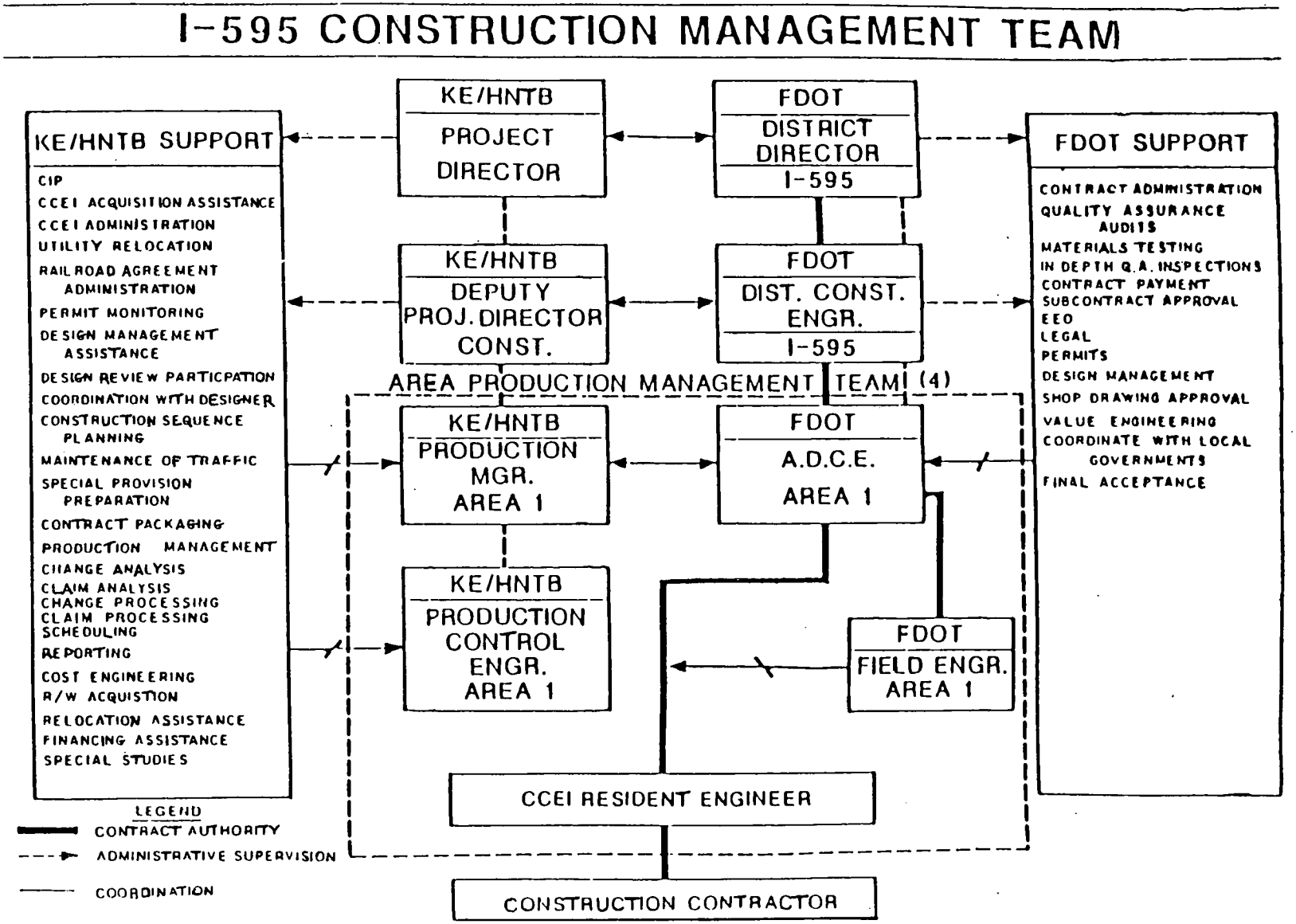


FIGURE 3 Matrix relationships on I-595 management team.

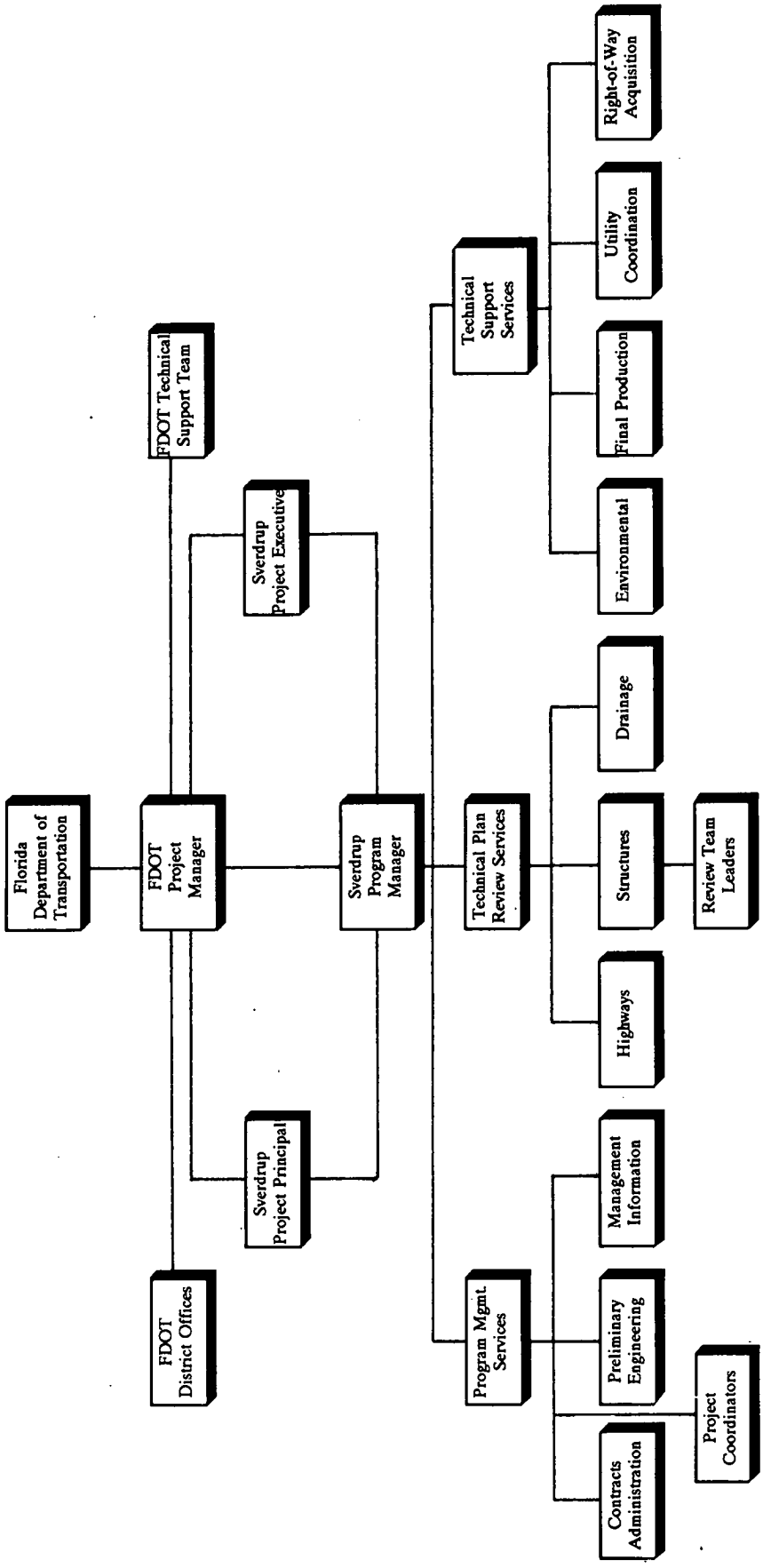


FIGURE 4 Organizational structure of FDOT's bridge program.

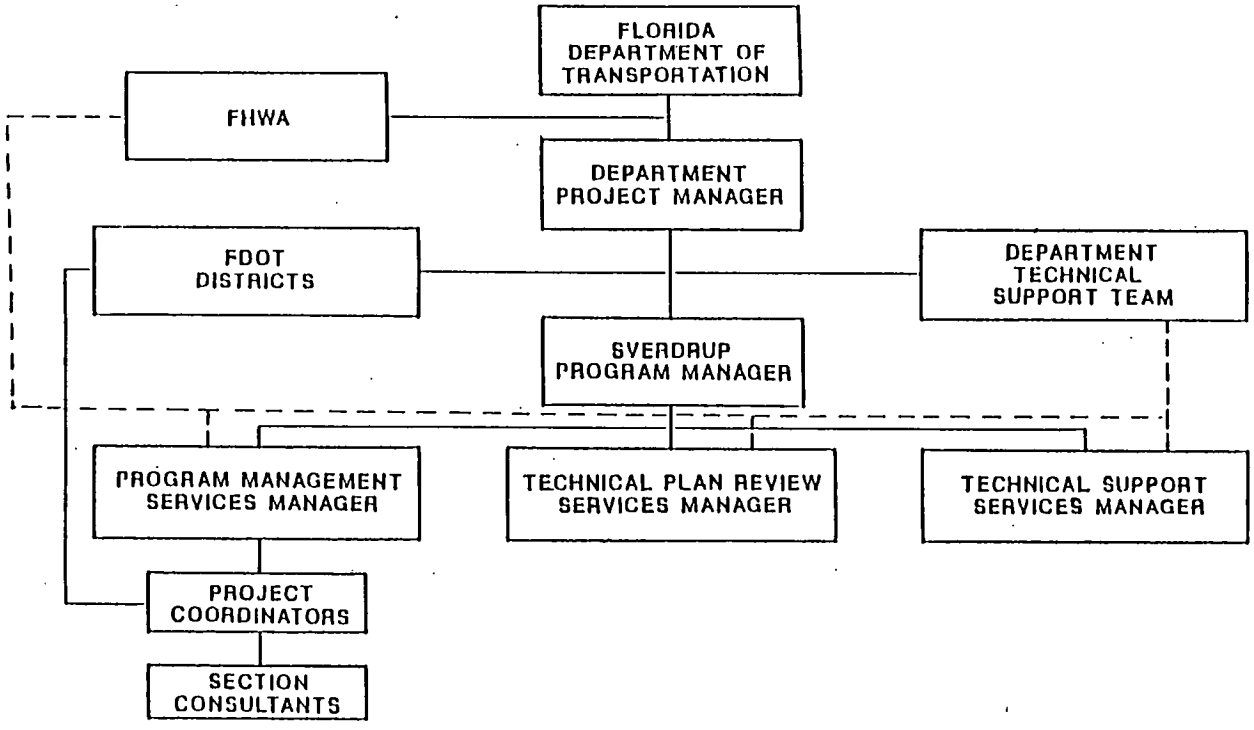


FIGURE 5 Communications plan for FDOT's bridge program.

ported by two full-time professional engineer assistants and by an FDOT technical support team.

- The FDOT technical support team contains 14 or more key individuals from the P&D division. The team operates on a part-time, as-needed basis. It communicates directly with the CMC's section leaders and deputy program managers, providing support, direction, and guidance in the management of section consultants and in the CMC's own preliminary engineering, design, and environmental activities.
- The FDOT districts report to the FDOT project manager on program matters, but provide direction and information on project specific issues to the CMC's project coordinators. For the development of individual projects, the department is decentralized, with decisions made within the districts. The state indicates that each district's administration over its projects in this program requires only a few personnel working part time.
- The CMC project executive is its senior representative. He communicates with the CMC program manager and ensures that sufficient resources and personnel are made available to meet the program objectives, and reviews any related concerns with the FDOT project manager.
- The CMC project principal sets criteria for program control and guidelines and guides their implementation.
- The CMC program manager reports to the FDOT project manager and is the person primarily responsible for the successful accomplishment of the program. He ensures that the projects are completed on time, within budget, and in conformance with project requirements. Figure 5 shows three major functional areas administered by the program manager: (a) services in program management, (b) technical plan review, and (c) technical support. The key responsibilities of these areas are self-evident from the figure, except for those of the project coordinators.
- The CMC project coordinators monitor and administer each section consultant contract. As shown in Figure 5, they are the contacts for interaction between the CMC and the section consultants, dealing directly with FDOT district personnel and with CMC functional groups relative to project scope, schedule, progress, cost, and quality.

State/CMC Interrelationships

Florida indicates that management of this program minimizes the use of FDOT staff by giving the CMC a freer hand than was done for I-595. However, comparison is difficult because of the vast differences in the nature and complexity of the work.

The CMC directly administers the selection of design consultants and reviews their subsequent price proposals, whereas FDOT retains responsibility for the preparation of long and short lists and for approval of the price and final consultant selection. The CMC administers the section design contracts, including the review of all documents and support services to complete the project development, environmental studies, and design packages. The state retains final review and approval authority based on the CMC's comments and recommendations.

Figure 5 shows the organization for the program into a three-level hierarchy established for efficient processing and communication of information between the department and the CMC and between the CMC and the section consultants. The CMC's responsibility and authority are clearly defined in manuals and

guidelines issued by FDOT to section design consultants with a mandate that, in the performance of their services, the section consultants will report directly to the CMC on all contractual and technical matters.

The CMC's project coordinator monitors the progress of the section consultants; reviews their invoices, extension of time request and supplemental agreements; and evaluates their performance. Major reviews are conducted by the appropriate CMC disciplines pursuant to the flow chart of the review process as shown in Figure 6. Consolidated review comments are sent to FDOT and to FHWA for review and comments. When these are received, they are incorporated into the CMC's comments.

Right-of-way acquisition is handled directly by the CMC, with appraisals and other important matters reviewed by the FDOT's ROW section.

The section consultants prepare the construction cost estimates and summaries of pay items, and the CMC prepares the construction contract packages for bidding.

Washington's I-90 Program

Organization

The WSDOT, having learned from the experience gained by Florida, designed the overall organization and requirements for this program similarly to those for FDOT's I-595. As in Florida, WSDOT retained approval authority of all design and construction activities, with the CMC primarily assisting and advising the state in managing the program.

The state's I-90 program table of organization is similar to that of Florida's I-595. The WSDOT's program manager reports to the district administrator and, with the guidance of a management review board, manages the program by means of a program construction engineer, operations manager, and location engineer, with CMC support. The management review board consists of key personnel from WSDOT headquarters, FHWA, and the project and has responsibility and authority for major program decisions.

The CMC provides support staff to each of the above three organizational units on a regular and on an as-needed basis.

State/CMC Interrelationships

The state has retained overall management and control of the project, with the CMC providing support and advice. The CMC staff members works side by side with WSDOT personnel in the same offices under state supervisors as if they also were state employees. This simplifies and expedites both the exercise of decision making by FDOT staff and communications between state and consultant personnel.

For example, the CMC provides cost and scheduling staff to each of the state's project engineers. These staff members report to the project engineers as if they were state employees yet feed data to the CMC for the overall program master schedule. The only exceptions to such a near merger of FDOT and CMC personnel are in the review of the CMC's billings and in the state's audit procedure. With the exception of the operations center and the field cost schedulers, the CMC staff members are supervised by CMC managers for their regular tasks. Many tasks, however, are generated by lower-level staff members of WSDOT and the CMC and are performed and reported informally at such levels.

Although the WSDOT retains total decision-making authority, whether performing PS&E reviews, scheduling, special reports, change order analysis, or other work, such decisions consider formal and informal input from CMC staff members, with the CMC remaining in an advisory capacity. The state reports that the flexibility in communications and teamwork between the state and the CMC has produced excellent results in terms of efficiency and in meeting critical schedules.

New Jersey's Railroad Electrification Program

Organization

Figure 7 shows the relative organization plan of the New Jersey DOT and the CMC for this program (Gannett, Fleming, Corddry, & Carpenter), which was developed by the combined efforts of the DOT and the CMC and its affiliates during a review of the initial proposal. One of the benefits from such review was a streamlining of the office and field operations under the CMC's assistant project manager for construction to enhance point responsibility, fast decisions, internal communications, and coordination with outside agencies. The staffing for the engineering manager was revised to provide the in-house capabilities commensurate with the scope of services and to provide immediate response to field forces.

The New Jersey DOT Rail Systems Unit (RSU), which managed this program, has the standing of a division and reports directly to the assistant commissioner. It is organized into two sections: a design section with a staff of 9 and a construction section with a staff of 18. Each section employs professional electrical and structural engineers at the senior and principal engineer levels and provided the project engineers for coordination with the CMC.

State/CMC Interrelationships

The CMC had a peak staff of about 100, with state control coming from the RSU's permanent staff of 27, who were also involved with other statewide program matters. This project was financed with UMTA funds and administered by the New Jersey DOT under UMTA's certification-acceptance procedures.

Communication between the CMC and the department was through the RSU staff, who tracked state responses and forwarded them to the CMC. The RSU staff closely monitored CMC activities, attending meetings and visiting active job sites. The CMC's resident engineers held weekly meetings with contractors to discuss problem areas. The meetings were also attended by the RSU's project engineer or a principal engineer, as appropriate. Though all actions with contractors were through the CMC, the state was knowledgeable about such actions and retained ultimate approval power.

New Jersey Department of Transportation staff countersigned construction change orders and controlled the addition and removal of CMC personnel. Final approvals of designs and design changes rested with the design consultants and the New Jersey DOT. The New Jersey Department of Transportation retained

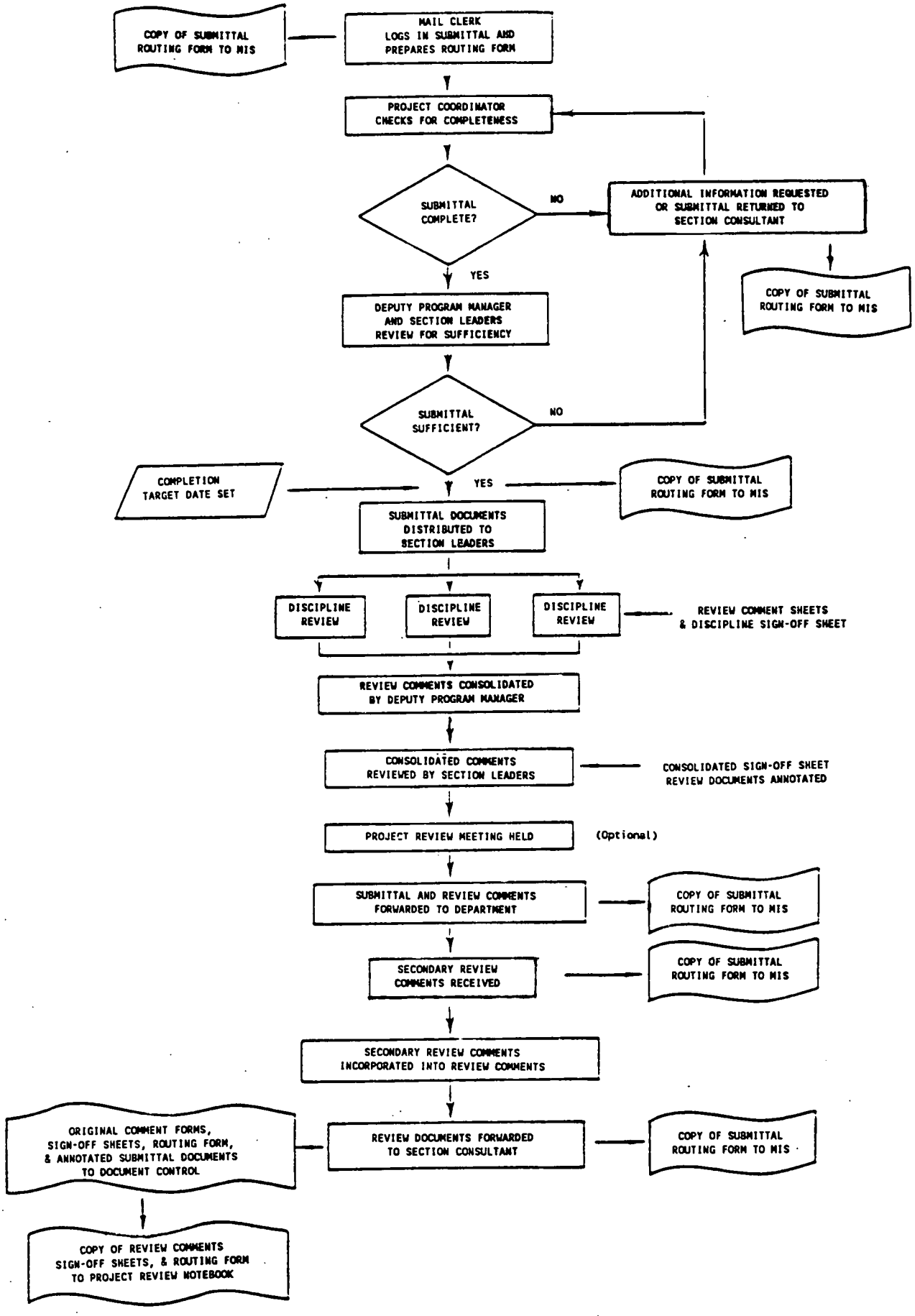


FIGURE 6 Review process flowchart for FDOT's bridge program.

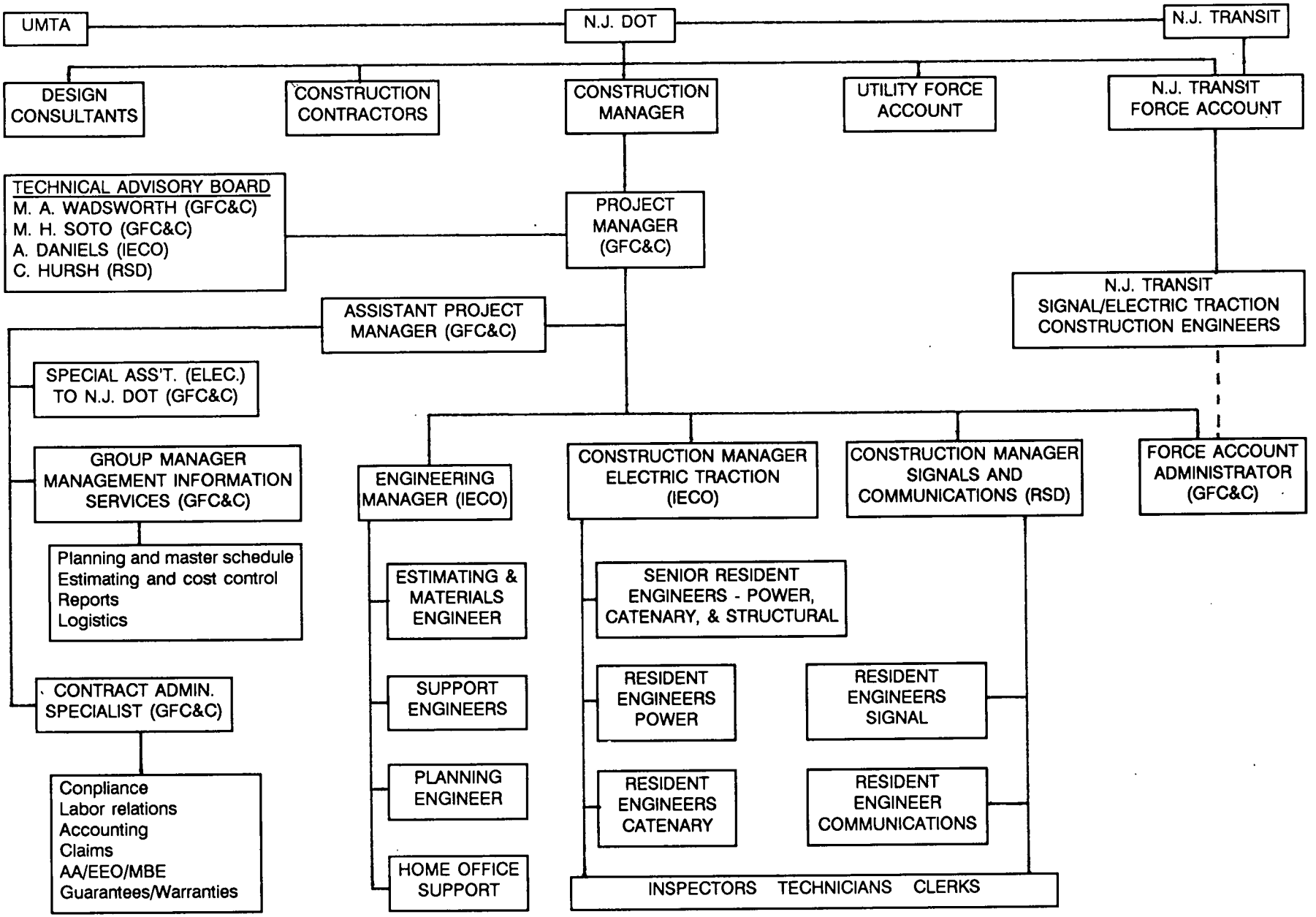


FIGURE 7 Organization of New Jersey DOT's railroad program.

NOTES: (GFC&C) = Gannett Fleming Cordry & Carpenter, Inc. (IECO) = International Engineering Comapany, Inc. (RSD) = Railway Systems Design, Inc.

final approval authority over major decisions, such as those relative to plan errors and significant changes in site conditions and others involving increases in cost. The CMC had direct contact with the railroad and other agencies and authority to proceed independently, subject to general reviews and approvals by the state.

The relationship between the respective staffs of the RSU and the CMC is shown below:

Consultant	*Relationship*	*State (RSU)*
Project Manager	one to one	Construction Supervisor
Construction Managers	one to one	Project Engineers
Resident Engineers	three to one	Principal Engineers

Connecticut's Bridge Infrastructure Program

Organization and CMC/State Relationships

Apart from its key central personnel, the CMC has a full-time staff of 11 persons managing the program, including a project manager and assistant, three structural engineers, four engineers in various specialties, an accountant, and a clerk typist. The primary direct liaison by ConnDot with the CMC is through the CMC's project manager or his assistant. A third CMC engineer is designated as direct liaison solely for coordinating the maintenance of the CPM networks for the management information system.

A ConnDOT liaison engineer has office space in the same area as the CMC's staff. He has no state staff, and his primary mission is to facilitate coordination between the CMC and the appropriate ConnDOT staff or others to expedite any required reviews and approvals. Such approvals by the state and FHWA are by and through ConnDOT's chief engineer.

Louisiana's I-49 Program

Organization

The state reports that the program was administered by two department coordinating squads of 6 to 10 engineers assigned full time to the program, using the resources of other department units as needed. In addition, a steering committee consisting of 10 top-level administrators provided major policy and procedure decisions.

State/CMC Interrelationships

In addition to the above activities by the coordinating squads, monthly status and scheduling meetings were attended by approximately 20 department personnel of the pertinent disciplines, FHWA, and representatives of the CMC. At the peak of the program, the CMC used a staff of about 25 personnel, with 20 devoting full or nearly full time to the program.

Maryland's Open-End Agreements

Organization and State/CMC Interrelationships

Although organizational details are not available, the state retained full control over changes, costs, time for performance, and other major aspects of the work. The CMC monitored the work of each production consultant through office inspections; on-board reviews; periodic meetings; and reviews of plans, invoices, and progress reports. The ultimate approval authority remained with the State Highway Administration.

The state reports a degree of dissatisfaction with its use of CMCs. Although the consultants were able to provide capable assistance in the technical aspects of the work, their ability to manage was not deemed equal to that of a state representative because the state withheld total authority to the CMC, as follows:

- The CMC did not have fiscal authority over production consultants and could not even impose a threat to withhold payments in the event of unsatisfactory performance.
- The CMC had insufficient freedom to manage the project properly, being required to go through the state's liaison officer to request soil exploration and ground surveys, ROW acquisition, and the submission of various reports.
- The CMC was not located at the state offices, and therefore relied on the state representative to research and locate needed information upon request. This slowed the design process.

The above is cited here simply to caution the readers of the importance of advance planning to streamline the approval and communications processes. Also, although the state needs to retain control over major decisions, such control should not inhibit the delegation of authority inordinately.

FEDERAL REQUIREMENTS

This section reviews the federal requirements and their influence on the level of delegation of authority by state agencies to CMCs or on their channels of communication.

Although there is considerable federal coverage governing the traditional state-consultant relationships on design and CEI contracts, nationwide guidelines applicable to contract management services by consultants are notably limited. The *Federal-Aid Highway Program Manual* (FHPM) 1-7-2 set forth FHWA's policy regarding the administration of negotiated contracts but did not cover the imposition of a management consultant between the state and its production consultants. With the pronounced increase in the use of consultants by the states in the early 1980s, national guidelines were issued by FHWA (*21*) on an interim basis but were limited to CEI consultants.

The FHPM 1-7-2 was superseded by the Office of Management and Budget's (OMB) Common Rule, effective on October 1, 1988. In February 1990, OMB signed off on a revised version of FHWA's consultant regulation, 23 CFR 172, which addresses the qualifications-based procurement provisions of the 1987 Surface Transportation and Uniform Relocation Assistance Act. The new regulation was written specifically for engineering and design related service contracts and was published in the *Federal Register* on March 5, 1990.

Two sections in the Code of Federal Regulations (23 CFR) are considered to relate indirectly to contract management, though such terminology is absent. Extracts of the pertinent provisions are shown in Figure 8.

Section 1.11 addresses engineering services and provides generalized limitations on federal participation in the use by the states of private consultants or engineering organizations of other

FIGURE 8 Abstracts from Code of Federal Regulations.

§ 1.11 Engineering services.

(a) *Federal participation.* Costs of engineering services performed by the State highway department or any instrumentality or entity referred to in paragraphs (b) and (c) of this section may be eligible for Federal participation only to the extent that such costs are directly attributable and properly allocable to specific projects. Expenditures for the establishment, maintenance, general administration, supervision, and other overhead of the State highway department, or other instrumentality or entity referred to in paragraphs (b) and (c) of this section shall not be eligible for Federal participation.

(b) *Governmental engineering organizations.* The State highway department may utilize, under its supervision, the services of well-qualified and suitably equipped engineering organizations of other governmental instrumentalities for making surveys, preparing plans, specifications and estimates, and for supervising the construction of any project.

(c) *Railroad and utility engineering organizations.* The State highway department may utilize, under its supervision, the services of well-qualified and suitably equipped engineering organizations of the affected railroad companies for railway-highway crossing projects and of the affected utility companies for projects involving utility installations.

(d) *Private engineering organizations.* Private engineering organizations may be utilized on projects in accordance with requirements prescribed by the Administrator.

(e) *Responsibility of the State highway department.* The State highway department is not relieved of its responsibilities under Federal law and the regulations in this part in the event it utilizes the services of any engineering organization under paragraphs (b), (c) or (d) of this section.

§ 635.105 Supervising agency.

(a) The State highway agency has responsibility for the construction of all Federal-aid projects, and is not relieved of such responsibility by authorizing performance of the work by or under the supervision of a county, city, or other local public agency. The State highway agency will be responsible for insuring that such projects receive the same degree of supervision and inspection as a project constructed under a contract let and directly supervised by that agency and that the project is completed in conformity with approved plans and specifications.

(b) When a project is not located on a highway system over which the State highway agency has legal jurisdiction, or when other special conditions warrant, the State highway agency may arrange for a local public agency having jurisdiction over such streets or highways to perform the work with its own forces, or to let a contract therefor, provided the division administrator approves such proposed arrangements in advance and provided all the following conditions are met:

(1) There is an agreement between the State highway agency and the local public agency setting forth the conditions under which the project will be constructed. The agreement shall provide that construction work performed by or under the supervision of a local public agency will be subject to inspection at all times by the State highway agency and the FHWA.

(2) The State highway agency certifies that the work performed by the local public agency is cost effective.

(3) The local public agency is paying part of the cost of the work or has other special interest therein.

(4) The local public agency is adequately staffed and suitably equipped to undertake and satisfactorily complete the work.

(5) In the case of force account work, there is full compliance with Subpart B of this part.

(c) When the work is to be performed under a contract awarded by a local public agency, all Federal requirements including those prescribed in this subpart shall be met.

(d) Although the State highway agency may employ a consultant to provide construction engineering services, such as inspection or survey work on a project, the State highway agency shall provide a full-time State-employed engineer to be in responsible charge and direct control of the project at all times. In those instances where a city or county can justify the use of consultants for these services, the city or county shall have a similar duty. The State highway agency and any such city or county shall not be relieved of its responsibilities under Federal law and the regulations in the event it utilizes the services of an engineering organization.

(e) When construction operations are performed on Federal-aid highway projects by any Federal agency by Federal contract and under such agency's procedures and operations on behalf of a State highway agency or other public agency, such construction operations shall be performed under the direct supervision of the State highway agency except that such supervision may be exercised through the contracting Federal agency where it is so provided by agreement between the State highway agency and the Federal agency. The right of inspection of the work under these contracts shall be extended to all agencies involved in the project.

[39 FR 35152, Sept. 30, 1974, as amended at 48 FR 22912, May 23, 1983]

governmental instrumentalities or of railroad or utility companies. The section does not relieve the state of its responsibilities under federal law and regulations in the event it uses such services.

Section 635.105 defines in general terms the state's responsibility in employing consultants for construction engineering services on state and local federal-aid systems. Basically it requires a "full-time State-employed engineer to be in responsible charge and direct control of the project at all times."

Some projects cited in this synthesis are financed with UMTA grants and are subject to UMTA regulations, which have provisions similar to the 23 CFR requirements for supervision and control by the public agency. Neither FHWA nor UMTA, however, have any centralized guidelines to the extent of state control that is required by the regulations or the degree of authority that may be delegated to CMCs. Interpretation of the general provisions is left by both agencies to the judgment of their local office directly responsible for the project.

Although responses by the states on this subject are very sparse both in number and in content, the following sections give a qualitative look at the federal influence.

Florida

Initial procedures in the management of Florida's I-595 program were cited by the FHWA district office for violating Federal Regulation 23-635.105 because the CMC was given too much authority in the approval of change orders and other matters. As a result, FDOT had to modify its initial approach to require that all significant decisions be made by state personnel. A continual state presence was required, which necessitated more state staff than was originally envisioned.

Examples of federal citations on certain aspects of the state/CMC arrangement include several requesting FDOT to limit the CMC's involvement "in any construction project matters except when requested in writing to resolve problems with their expertise in a specific area" (*22*). The federal position was that FDOT should not allow the CMC to assume responsibilities that belonged to the CEI consultant without written authorization by the state. Another citation (*23*) related to inadequate FDOT control of CMC staff activities, finding a significant amount of CMC construction services as administrative functions and, therefore, not eligible for federal participation.

Florida indicates that its bridge repair and replacement program required much less effort by state personnel for its management, and attributes it to greater freedom given to the CMC than on I-595. This may be true, but it is more likely to be attributable to significant differences between the two projects rather than to the federal influence on I-595.

I-595 is a complex Interstate system that required extensive coordination of sensitive and intricate matters with numerous groups and agencies. Its scope included all aspects of development through the completion of construction within a critically limited time frame. The project required continual coordination with FHWA for approvals and for funding authorizations and careful management by the CMC and the state.

The bridge program does not use federal funds for the contracts with the CMC or the section consultants, and half of the bridges in the program are not financed with federal funds, reducing the delays usually encountered with the involvement of another agency. It is a much simpler program, with repetitive types of activities that can be accomplished by the districts and managed centrally; thus the complex construction and coordination problems of I-595 are nonexistent.

The Florida Department of Transportation cites only one federal citation on the bridge repair program. The FHWA division required all formal written and verbal communication on project matters to be from FDOT personnel to FHWA. Apparently this was based on its interpretation of 635.105(d): that the use of a management consultant does not relieve the state from its obligation to be in responsible charge and direct control of the project at all times.

Washington

Washington indicates that there were federal citations and a report by the Office of the Inspector General (OIG) that resulted in some changes in its procedures for the I-90 program. The most significant finding in the report was that the I-90 agreement should have been administered under a section of the Federal Procurement Regulations that requires separate field and home office overhead rates.

The FHWA division office in Washington says that it did not receive any major federal audit findings regarding the extent of delegated authority on the I-90 project. Regarding the extent of authority that may be delegated to a CMC, it referred to Section 302 of Title 23 USC, which requires a state to "have a State highway department which shall have adequate powers, and be suitably equipped and organized to discharge to the satisfaction of the Secretary the duties required by this title." This applies even when the state engages the services of private engineering firms. The FHWA office also cited 23CFR 635.105(d), which requires that a full-time state-employed engineer be in responsible charge and direct control of the project and concluded that "a State may not delegate its authority and control."

The FHWA division provided a copy of general guidance regarding the use of management consultants that was issued by the headquarters office in 1985. However, such guidance adds little to the generalized statements in the regulations.

Others

New Jersey, Louisiana, and Maryland are not aware of any federal citations by FHWA or by UMTA regarding the extent of delegation of authority to the CMC or any deficiencies in control by the state over its projects or programs. None of the other responding states addressed this subject.

Urban Mass Transportation Administration projects are also governed by similar requirements for adequate control by the state agency over a project. Though New Jersey apparently had no difficulty with UMTA requirements, Lammie and Shah (*10*) cite the impact on MARTA of the requirement for UMTA's approval of the selection of each architect/engineer team and initial form of the design subcontract. This caused extensive delays in issuing the notice to proceed and required crash schedules during design in order to meet construction contract target dates. Although this example does not relate to the delegation of the state's authority to the CMC, it highlights the delays associated with centralized control.

The foregoing federal citations are presented only to illustrate the need for a clear and carefully considered delineation of the extent of authority that may be delegated to a CMC and a definition of what constitutes being in responsible charge and in direct control. It is in the federal, state, and public interest to avoid the costs and delays of false starts and the inefficiencies of excessive controls.

OVERVIEW

Any of four different organizational structures may be used for the management of large projects by a CMC: functional, autonomous task force, line and staff, and the matrix organization. The line and staff organization combines the strengths of the functional organization and the project-oriented task force. The matrix organization is intended to solve the conflicts between operational and functional staffs that are inherent with line and staff organizations. The latter holds much promise but remains to be proved.

The extent of central control by public agencies varies considerably. Managers associated with public projects, other than state transportation projects, cite the inefficiencies of excessive control by the owner and recommend limiting such control to financial and other major concerns that cannot be delegated. Others point to the advantages of the matrix system in the delegation of decision making to lower levels.

Rutherford (*24*) cites the advantage of delegating authority in his comparison of the I-595 program with Georgia's MARTA project. The CMC on the latter project initially was organized in a manner similar to that of a CEI consultant, with a resident engineer reporting up the line to successive levels. This was changed very quickly to a joint MARTA/CMC management team, with MARTA supervisors retaining approval authority though located in joint field offices. This approach also proved to be too cumbersome and, after two additional changes, Rutherford reports that there developed a "de facto delegation of authority on many items beyond that specified in approved procedures." He further asserts that this was similar to the phase entered into by the I-595 organization in order to address an effective challenge by the program to problems.

Rutherford (*24*) says that, despite the commonly held negative opinions about a matrix management organization as being ineffective, restrictive, and nonproductive, it can be made to work. "The individuals who share the decision-making responsibility must be *willing* and *able* to negotiate the ultimate direction to be taken." He says that all staff must understand and acknowledge their responsibilities and roles without regard to any loyalties, personal aspirations, or other factors that may conflict with the basic goals of the project organization. What is needed is the proper environment for effective negotiation among the parties involved, with decisions at lower levels monitored by senior management. He maintains that this was accomplished by the organization for Florida's I-595 program and cites the following factors that enhanced the effectiveness of the matrix approach:

- The Florida DOT's program manager was elevated to the level of deputy director, which gave him greater status in his negotiations with functional managers.
- The CMC was structured to provide staff services to FDOT as needed.
- The CMC and other consultants were motivated by their recognition that their personal growth depended on the successful completion of the long-term objectives of the program.
- The direct line supervision channels guaranteed one boss per worker, avoiding conflicts.

Lammie and Shah (*10*) also cite the advantages of the matrix approach of parallel organizational structures for the MARTA and CMC staffs, which was dictated by the decision for a comprehensive check-and-balance system. They say that the success of such a relationship is largely dependent on the people involved and their personalities.

There is no prototype organization for management by a CMC. Of equal or greater importance are the relationships among the owner, the CMC, the designers, the contractors, and others involved with the project. Prevailing opinion cites the three-party team of owner, CMC, and design organization as the best nonadversarial approach to the management of large projects. The exercise of authority and control to fulfill the owner's responsibilities seems to be best accomplished by means of the matrix concept of interrelationships between counterparts of the owner's and CMC's staffs. Such a delegation of authority and coordination to lower levels appears to be superior to the centralized retention of all decision making, which can generate excessive delays and costs in terms of manpower, operational inefficiencies, and claims.

The avoidance of adversarial relationships is essential to the success of the management team approach. It is important that the owner clearly and completely delineate the authority and responsibilities of each member of the team to reduce any conflict. It is also generally recommended that the public agency have a strong, highly qualified engineering in-house group to provide proper guidance and assistance in the management of the project and to protect its interests.

Because of the potential problems associated with excessive centralized control, it is recommended that federal guidelines be issued after a careful consideration of the extent of control required by the regulations or needed to protect the federal, state, and public interests.

CHAPTER SIX

CONTROL OF PROGRESS AND COST

This chapter addresses the methods used by CMCs to control the progress and costs of the total project within the milestones and budgets defined by the public agency. Incidental subjects include the agency's review of the CMC's performance, the nature of any corrective actions available to the CMC in the event of deficiencies by the production consultants, and the kinds of incentives available or being used to motivate the CMC.

With the increasing availability of computers to all levels of management, a more sophisticated approach to the management and control of large projects has evolved. Yet Barrie (*3*) asserts that many construction managers find that the overall management and control of projects has not improved. This is attributable to the separation of planning, scheduling, estimating, and cost control disciplines in many organizations, with only an integrated computer program to coordinate their separate concerns. As a result, computer output has grown so cumbersome and detailed that many managers have returned to precomputer fundamentals.

Barrie further states that, although centralized data banks and management information systems have been used effectively in manufacturing industries, their effective application in construction has not been demonstrated consistently. The key is a simplification of reporting for ready use by individual managers. Preferable application of controls includes monthly progress reports and computer-based cost controls to measure continual estimates against budgeted amounts. Computer technology is not necessary on every project and should be used only when required to provide the level of detail desired by the manager.

Similarly, the Business Roundtable (*17*) finds that up-to-date, cost-effective management systems are not being used by the construction industry to the extent that they should. A case in point is the critical path method (CPM) of scheduling, which has been used for three decades but is not being used to its full potential. Opportunities to cut costs and schedule time are lost because "construction operates as a production process separated by a chasm from financial planning, scheduling, and engineering or architectural design." Nevertheless, the general application of CPM and computerized control systems will be found in subsequent illustrations of the states' requirements of their CMCs.

The use of incentives in the construction industry to motivate performance or to achieve certain goals has not generally been effective. This may be because of the myriad goals by both the owner and the contractor that are not all attainable on any specific project, making compromise a necessity. Stukhart (*25*) says that incentives are better understood by focusing on only a few of the many owner and contractor goals; such as the owner's interest in reducing cost and maintaining a timely progress schedule and the contractor's motivation for profit.

Stukhart finds that incentives for efficient management and for achieving some of the owner's specific objectives are generally associated with the assignment of "some portion of the owner's risk to the contractor with a reward for accomplishing the objectives effectively." In this context, risk is defined as the exposure to possible economic loss or gain. The allocation of risk should reflect its motivational effect on performance, potential economic returns, the degree of control by the party assuming the risk, and the ability of such party to protect against the risk. Although incentive-type contracts are frequently found in the private sector of the construction industry, incentives are not generally applied in public construction contracts.

For cost-reimbursable contracts (the type that is generally used by state agencies), Stukhart (*25*) describes two categories of incentive provisions:

- *Cost and Schedule Incentives* include the sharing of any overruns and underruns of target project and/or man-hour costs, and bonus/penalty awards related to direct labor costs or the scheduled completion date.
- *Performance Incentives* include bonuses or penalties that are added to or subtracted from the contractor's fee based on the owner's subjective performance evaluations relative to safety, quality, and other measures.

Although the sharing feature of incentives provides a common goal for the owner and the contractor to achieve targets and cost-effectiveness, Stukhart points out a number of problems. These include the difficulty in arriving at equitable targets, additional administrative costs, the need for continual negotiation to adjust cost targets for changes and escalation, and the difficulty in measuring performance by subjective judgments of nebulous criteria.

The ASCE (*2*), in discussing similar fee-enhancement provisions in contracts with CMCs, raises several concerns. Because the CMC is directly involved in the development of both the budget and schedule for the project, the owner should be alert to the potential of unwarranted economic returns being "inadvertently or strategically included in either the budget or the schedule." An ethical question is also raised by "the dual level of performance inferred by this fee arrangement." Because a CMC is required under its agreement to provide its best professional performance, an incentive payment for some additional increment above its best is of questionable value.

MONITORING AND REPORTING SYSTEMS

Florida's I-595 Program

Rutherford (*24*), in his unpublished report on the I-95 project, says that "the absence of a tracking system to measure progress against the work plan is an invitation to lose control." He cites

the need for project control systems to achieve quality standards within time, budget, and resource constraints. Although such systems apply equally to both large and small projects, the larger-scale projects require computerized systems, which have grown more effective but require close attention. It was realized at the outset that this project needed a work plan to which all staff was committed, a monitoring system, and a mechanism to correct deficiencies. Because time mandated the planning cycle concurrently with familiarization with the project requirements, specialized experienced personnel were needed.

The CMC's staff included area production managers who were experienced in planning and execution of megaprojects and experienced cost/schedule production control engineers. Such a resource was very useful in designing organization and staff requirements. The CMC had the responsibility, subject to review and input by FDOT designers, to set milestone dates for preconstruction, and to:

- Provide a mainframe and install terminals in central and local offices,
- Provide training in CPM and computerized systems, and
- Review contractors' CPM schedules and incorporate them into the master schedule, which coordinated all major program work and responsibilities, including funding, ROW activities, and utilities.

Rutherford finds that some packaged systems are too comprehensive and costly, limiting their use to projects that may justify such a level of detail. Furthermore, although there are fine systems for handling large amounts of detail on a mainframe, Florida found that network programming did not accommodate some activities. Accordingly, "the decentralized control responsibilities and the multifaceted nature of this construction management project made it logical to select microcomputers over a mainframe for tracking information" (*24*).

Adopting a microcomputer-based system was far better than using a full mainframe system because it could be used by functional managers rather than computer specialists. Because a major feature of the required system was the ability to correct any deviations from the program objectives promptly, the system was decentralized to those responsible for major features of the work. Microcomputers were particularly suited to such decentralization.

The output of this system was tailored to the user and included bar charts, progress curves and reports, cost reports, manpower curves, computerized reports of various types and level of detail, network diagrams, and exception and management action reports. Examples of some of these are shown in Appendix B.

Florida's Bridge Repair and Replacement Program

The CMC has the responsibility for maintaining project control within the areas of project administration, design review and coordination, scheduling, design and estimated construction cost reporting, and technical support.

Figure 9 shows the general flow of information in the comprehensive, computerized Management Information System (MIS), whose major tasks are management, scheduling, and reporting. The MIS input includes:

- Data sheets containing general project information and milestones; section consultant schedules, costs, supplemental agreements, and projected construction costs; and information relative to bridges, utilities, and permits.
- Computerized schedules showing early or late starts and finishes and float times developed for preaward, PDE, and design activities, which are updated frequently from reports received from section consultants.

The output of the MIS includes various reports, such as program summaries, program status by discipline (preaward, design, environmental, ROW), program cost, and various miscellaneous reports. These are all tied in to the original milestone dates and are in tabular and chart format for ready reading. Because the reports are computer generated, they can be sorted with any combination of available information to serve the individual needs of any user.

Figure 10 shows an example of a typical project schedule report. The computer's scheduling program calculates dates for early and late starts and finishes and total float time. Early dates are the earliest point in the project at which the activity can start or finish. Late dates are the latest points consistent with meeting program objectives as defined in the original schedule. Total float in this report is used as a measure of schedule status. If the value shown is negative, the activity is behind schedule. Positive or "0" days float represents work ahead or on schedule.

Reporting is an essential feature of the MIS, so that the FDOT may verify that the goals and objectives of the program are being accomplished. In addition to numerous computerized reports designed to serve various disciplines and levels of management and weekly meetings among the CMC, the FDOT project manager, and key staff, a monthly progress report is distributed to the central and district offices.

The Monthly Progress Report includes a summary of the activities by the CMC, districts, section consultants, the status of ROW, permits, and utilities, the contract status, and an executive summary. Figure 11 is a sample page from a recent progress report.

The CMC also maintains a document-control system, as illustrated in Figure 12. In line with FDOT's desire to minimize the need for its own personnel on the program, the system features easy retrieval by categorizing, coding, and storing all documents through the use of a comprehensive computerized records management system.

Washington's I-90 Program

The CMC was required to evaluate the WSDOT's existing scheduling system and either modify such a system or implement another proven CPM computer-scheduling system capable of interrelating all projects from design through construction.

The state had a three-person scheduling section equipped with personal computers interconnected with a mainframe in the central office in Olympia and printing capability in the Seattle district office.

The CMC selected a PC-based CPM system using the AMS Time Machine software, which is a precedence-based network scheduling package with the capability of providing multiple calendar scheduling. The individual projects are monitored using scheduling software provided by the construction contractors.

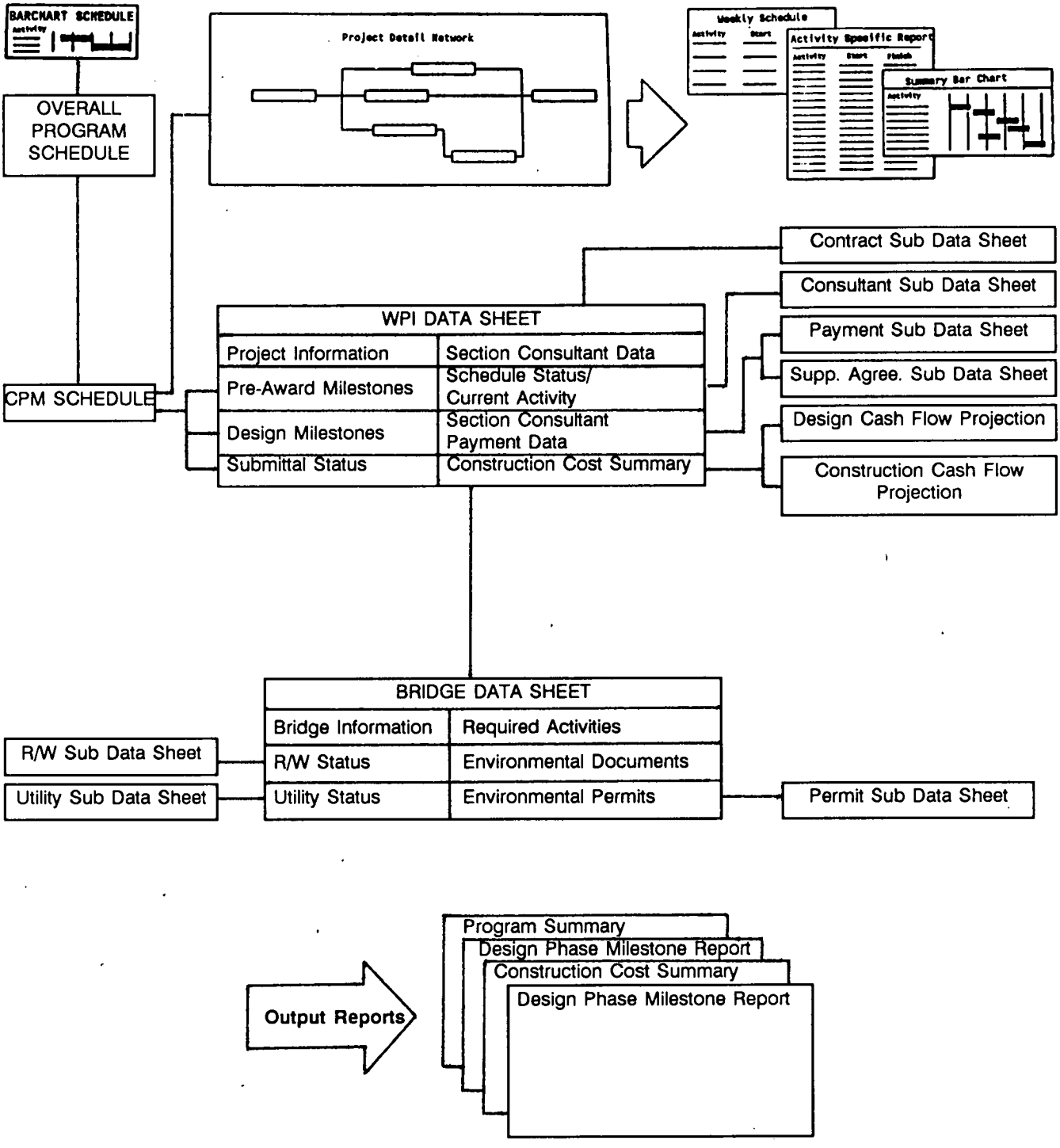


FIGURE 9 Flow diagram for FDOT bridge program's MIS.

SVERDRUP CORPORATION
MAGNOLIA CENTRE, SUITE 300
TALLAHASSEE, FL 32301
(904) 877-8500

ORIGINAL SCHEDULE REPORT

ALDERGRAF CPR440-3.2

REPORT J
SORTED BY EARLY FINISH
SEQUENCE :1824

BRIDGE PROGRAM
UPDATE # 1
RUN # 196

UPDATE DATE: 01JUL88
REPORT DATE: 12AUG88

PROJECT ID: WIDENING

ACT ID	ACTIVITY #	ORG DUR	ACTIVITY DESCRIPTION	EARLY START	EARLY FINISH	LATE START	LATE FINISH	TOTAL FLOAT
ORGAN. 1-4	0540							
MS05	54100	1	NTP PHASE I **1115385 - MANATEE CO-SR 45 BRDGS	25JUL88	25JUL88	25JUL88	25JUL88	0
PE05	54150	30	DATA COLLECTION & CONDITION EVAL. REPORT	26JUL88	06SEP88	26JUL88	06SEP88	0
PE07	54160	15	BPGC/FDOT REVIEW COND. EVAL. REPT.	07SEP88	27SEP88	07SEP88	27SEP88	0
MS10	54200	1	NTP PHASE II ** 1115385 **	28SEP88	28SEP88	28SEP88	28SEP88	0
EN15	54310	20	ENVIRONMENTAL SUPPORT DOCUMENTATION	29SEP88	26OCT88	10NOV88	08DEC88	30
EN25	54325	10	PRELIMINARY ENVIRONMENTAL DETERMINATION FORM	27OCT88	09NOV88	09DEC88	22DEC88	30
MS20	54210	30	SURVEYS AND MAPPING	29SEP88	09NOV88	09DEC88	19JAN89	50
PE10	54215	25	BRIDGE LOC. & HYDRAULIC STUDY	20OCT88	23NOV88	16DEC88	19JAN89	40
EN50	54350	20	CATEGORICAL EXCLUSION SUBMITTAL	10NOV88	08DEC88	23DEC88	19JAN89	30
PE25	54240	15	BPGC REVIEW BR. LOC. HYD. STUDY	25NOV88	15DEC88	20JAN89	09FEB89	40
MS15	54205	75	GEOTECH INVEST. & REPORT	29SEP88	12JAN89	06OCT88	19JAN89	5
PE45	54285	65	BRIDGE CONCEPT STUDIES & FINAL ENG REPORT	20OCT88	19JAN89	20OCT88	19JAN89	0
PE50	54290	15	BPGC/FDOT REVIEW FINAL ENGINEERING REPORT	20JAN89	09FEB89	20JAN89	09FEB89	0
BD10	54410	50	PRELIM. BR. PLANS & 60% RDWY PLANS	10FEB89	20APR89	10FEB89	20APR89	0
SB10	54420	15	BPGC/FDOT REVIEW PRELIM.BR./60% RDWY.PLANS	21APR89	11MAY89	21APR89	11MAY89	0
PT10	54700	20	PERMIT APPLICATION FORMS	12MAY89	09JUN89	07AUG89	01SEP89	59
UT10	54600	40	UTILITY RELOCATION PLANS	12MAY89	10JUL89	24JUL89	18SEP89	49
UT20	54610	10	BPGC UTILITY REVIEW	11JUL89	24JUL89	19SEP89	02OCT89	49
UT30	54620	20	FDOT AND UTILITY COMPANY REVIEW	25JUL89	21AUG89	03OCT89	30OCT89	49
UT40	54635	20	REFINE RELOCATION PLAN	22AUG89	19SEP89	31OCT89	29NOV89	49
BD20	54425	90	90% BRDG PLANS, SPEC. & EST./90% RDWY. PLANS	12MAY89	19SEP89	12MAY89	19SEP89	0
PT20	54710	5	STORM WATER PERMIT SUBMITTAL	20SEP89	26SEP89	24OCT89	30OCT89	24
SB20	54445	15	BPGC/FDOT REVIEW 90% BR. & RDWY. PLANS	20SEP89	10OCT89	20SEP89	10OCT89	0
PT30	54720	100	AGENCY REVIEW & APPROVAL	12JUN89	31OCT89	05SEP89	25JAN90	59
UT50	54640	40	UTILITY RELOCATION AGREEMENT	20SEP89	14NOV89	29NOV89	25JAN90	49
BD30	54455	44	100% BRIDGE/100% RDWY PLANS	11OCT89	12DEC89	11OCT89	12DEC89	0
PT40	54730	60	AGENCY REVIEW & APPROVAL	27SEP89	20DEC89	31OCT89	25JAN90	24
SB30	54465	15	100% BPGC REVIEW	13DEC89	04JAN90	13DEC89	04JAN90	0
SB40	54480	15	PLANS TO TALLAHASSEE	05JAN90	25JAN90	05JAN90	25JAN90	0
PS10	54800	30	BPGC PS&E PREPARATION	26JAN90	08MAR90	26JAN90	08MAR90	0
PS20	54850	10	FDOT FINAL REVIEW	09MAR90	22MAR90	09MAR90	22MAR90	0

FIGURE 10 Project schedule report—FDOT bridge program.

The CMC assigned some of its personnel to assist in the scheduling process by feeding data to the CMC for the I-90 master schedule. The contract requires the scheduling system to be able to track individual projects and their relationship to the master schedule from design through construction completion relative to the: (a) design approval milestones, (b) PS&E preparation milestones, (c) construction milestones, (d) ROW milestones, and (e) utility relocation milestones. The scheduling system should also keep track of permit requirements; master schedule bar chart, including milestones; and total program and individual project costs.

In addition, the schedule should be (a) updatable monthly and able to produce schedule reports, (b) capable of incorporating consultants' and contractors' schedules and making revisions to the master schedule as necessary, (c) able to present cash flow by quarter for each project and be able to adjust the schedule to reflect the availability of federal funds, and (d) capable of assessing the effect of strikes, acts of God, changes in working hours, or other factors or occurrences affecting time or cash flow.

Appendix C contains illustrations from the March 1989 I-90 progress report that illustrate the reporting abilities of the computerized scheduling system.

New Jersey's Railroad Electrification Program

The CMC's responsibilities included the following:

- Develop a CPM master schedule for the overall project, incorporating the required time frame for each significant feature of the project and all significant milestone dates.

BRIDGE PROGRAM GENERAL CONSULTANT
DESIGN PHASE MILESTONE REPORT

UPDATED THROUGH: August 31, 1989

SORTED BY WPI NUMBER

BPGC CONTROL NUMBER	FDOT CONTRACT NUMBER	WPI NUMBER	BRIDGE NUMBER	SR NUMBER	BRIDGE NAME (CROSSING)	ISSUE NTP		PDE COMPLETE LOC/DES APPROVAL	FINAL R/W MAPS APPROVAL	DESIGN COMPLETE	R/W CLEAR	PERMITS CLEAR	UTILITIES CLEAR	PRODUCTION LIST DATE	EARLIEST POSSIBLE LETTING	FLOAT TO AUD (CAL DAYS)
103	C-2982	1110463	040941	SR 35	Thornton Branch (D)	9/06/88	ORIG	5/25/89	9/12/89	12/27/89	11/10/92	11/10/92	11/10/92	11/16/92	2/16/93	0
						9/06/88A	A/F	8/25/89A	12/07/89F	3/29/90F	11/10/92F	11/10/92F	11/10/92F	11/16/92F	2/16/93F	
104	C-2953	1110867	050007	78	Lakeport Dr. Canal (D)	8/15/88	ORIG	8/08/89		6/18/90	7/11/90	7/11/90	7/11/90	7/17/90	10/15/90	-171
			050008	78	Fisheating Bay Creek	8/15/88A	A/F	1/26/90F		12/05/90F	12/28/90F	12/28/90F	12/28/90F	1/04/91F	4/03/91F	
			050015	78	Shell Fish Canal											
			050009	78	Caluse Drain. Canal (W)	8/15/88	ORIG	10/25/89		9/05/90	9/27/90	9/27/90	9/27/90	10/03/90	1/03/91	0
			050012	78	Little Sarasota Canal (W)	8/15/88A	A/F	10/25/89F		9/05/90F	9/27/90F	9/27/90F	9/27/90F	10/03/90F	1/03/91F	
			050013	78	Big Bear Beach Canal (W)											
			050014	78	Big Bear Canal (W)											
			050016	78	Cat Tail Canal (W)											
			050017	78	Black Snake Canal (W)											
103	C-2982	1111268	060002	SR 35	Charlie Creek Overflow (D) (W)	9/06/88	ORIG	8/03/89		2/13/90	3/28/90	3/28/90	3/28/90	4/03/90	7/02/90	4
						9/06/88A	A/F	9/06/89F		2/09/90F	3/26/90F	3/26/90F	3/26/90F	3/30/90F	6/28/90F	
104	C-2953	1112515	090012	78	Brighton Canal (D) (W)	8/15/88	ORIG	10/25/89	3/26/90	9/05/90	10/13/92	10/13/92	10/13/92	10/19/92	1/19/93	0
						8/15/88A	A/F	10/25/89F	3/26/90F	9/05/90F	10/13/92F	10/13/92F	10/13/92F	10/19/92F	1/19/93F	
109	C-3101	1114554	120062	82	Tri-County Creek (D-F)	1/16/89	ORIG	2/14/90		11/02/90	11/19/90	11/19/90	11/19/90	11/26/90	2/25/91	-88
						1/16/89A	A/F	5/11/90F		2/01/91F	2/18/91F	2/18/91F	2/18/91F	2/22/91F	5/22/91F	
103	C-2982	1114567	120044	78	Stroud Creek (D-F)	9/06/88	ORIG	6/09/89	9/26/89	2/20/90	6/04/91	6/04/91	6/04/91	6/10/91	9/09/91	-18
						9/06/88A	A/F	10/10/89F	1/26/90F	6/20/90F	6/24/91F	6/24/91F	6/24/91F	6/28/91F	9/27/91F	
109	C-3101	1114568	120059	82	Buck Creek (D-F)	1/16/89	ORIG	2/14/90		11/02/90	11/19/90	11/19/90	11/19/90	11/26/90	2/25/91	-88
						1/16/89A	A/F	5/11/90F		2/01/91F	2/18/91F	2/18/91F	2/18/91F	2/22/91F	5/22/91F	
109	C-3101	1114569	120060	82	Halfway Slough (D)	1/16/89	ORIG	2/14/90		11/02/90	11/19/90	11/19/90	11/19/90	11/26/90	2/25/91	-88
			120061	82	Corkscrew Creek	1/16/89A	A/F	5/11/90F		2/01/91F	2/18/91F	2/18/91F	2/18/91F	2/22/91F	5/22/91F	
109	C-3101	1114595	120031	884	Sailfish Canal (D-F)	1/16/89	ORIG	1/10/90	4/25/90	9/28/90	10/06/92	10/06/92	10/06/92	10/12/92	1/12/93	0
						1/16/89A	A/F	3/06/90F	6/20/90F	11/23/90F	10/06/92F	10/06/92F	10/06/92F	10/12/92F	1/12/93F	
102	C-2847	1115346	130049	64	Manatee River - SR 64 (D-F)	6/30/88	ORIG	2/22/89		12/28/89	12/29/89	12/29/89	12/29/89	1/05/90	4/04/90	-144
						6/30/88A	A/F	9/06/89F		5/21/90F	5/22/90F	5/22/90F	5/22/90F	5/29/90F	8/27/90F	
114	C-2953	1115357	130054	64	Anna Maria Island Bridge (P-F)	8/15/88	ORIG	7/31/89	11/14/89	7/02/90	10/06/92	10/06/92	10/06/92	10/12/92	1/12/93	-71
						8/15/88A	A/F	2/19/90F	6/05/90F	1/22/91F	12/16/92F	12/16/92F	12/16/92F	12/22/92F	3/23/93F	

KEY

(D) = Design
(D-F) = Design w/Fed Aid
(P) = PD&E
(P-F) = PD&E w/Fed Aid
(W) = Widening

FIGURE 11 Progress report—FDOT bridge program.

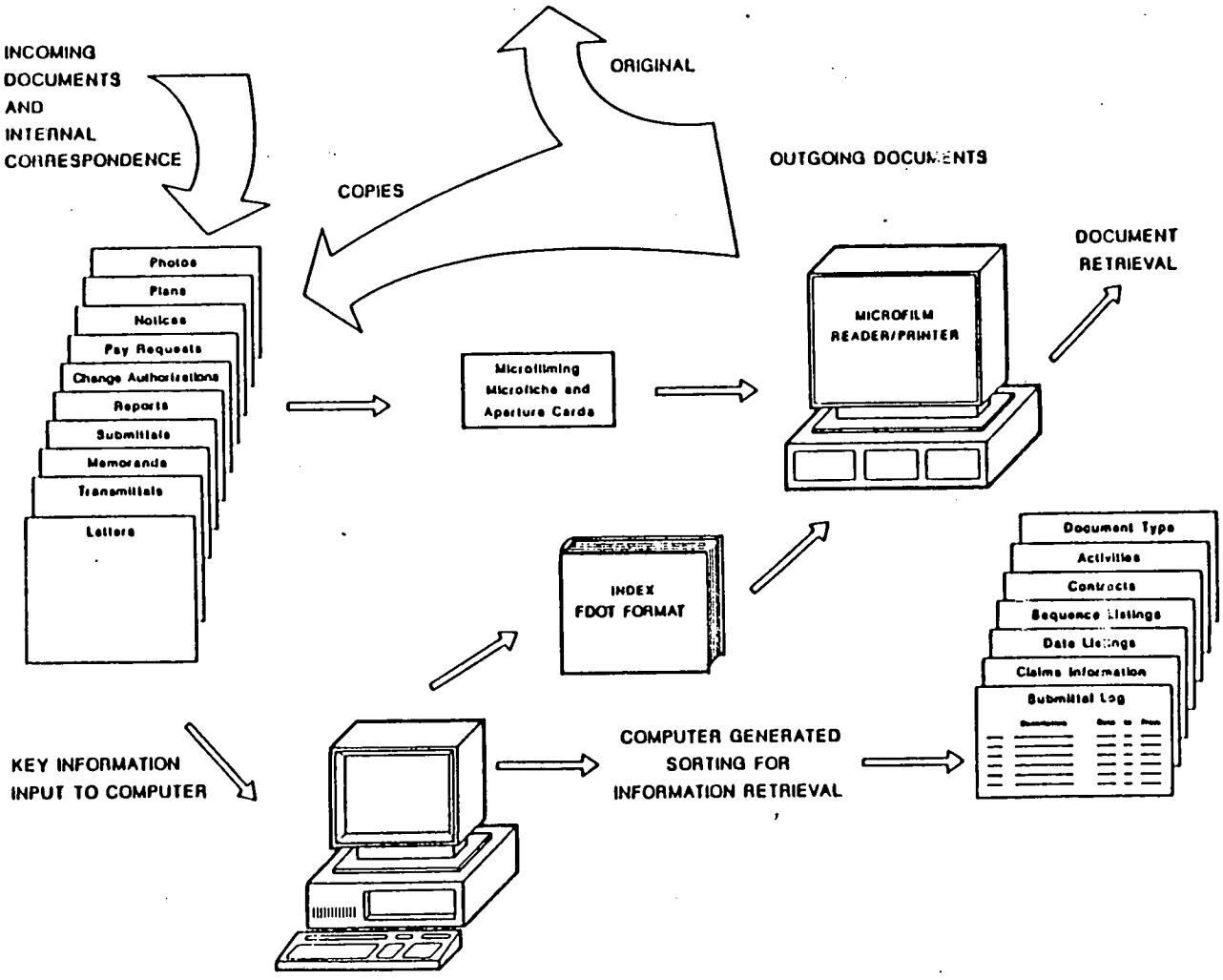


FIGURE 12 Document-control system—FDOT bridge program.

- Update the master schedule on a monthly basis to reflect all changes in construction and prepurchase contracts.
- Review, for compliance with the contract plans and specifications, the construction schedules prepared and submitted by the various contractors and recommend them for acceptance or corrective action.
- Implement courses of action to be taken for any contract or railroad force account construction falling behind schedule.

The CMC was also required to establish a system to monitor cost control. Monthly cost control reports were issued indicating the cost of work constructed to date, additional work to be performed, projections of the cost of partially completed work, and comparisons of the project cost with the original estimated cost.

The program and cost control system was implemented with a joint department-CMC monthly report advising of the program status and expenditures to all levels of management. It included an executive summary, a detailed contract and schedule status report for each contract and force account work, status of key personnel, and an affirmative action report.

Connecticut's Bridge Infrastructure Program

The CMC developed a computerized MIS, some aspects of which were available from previous use on other projects. The MIS consists of a series of interrelated computer programs to establish and control progress scheduling, cost accounting, and budgetary control. It uses three data bases (one consisting of man/job/hour, a second based on job/activity/duration, and a third based on job/budget). All other data required for report output are computed by the appropriate computer programs.

The CPM was used to develop a network for scheduling purposes. The CMC assigned durations to all activities from the state's work directives and in coordination with each consultant firm relative to the availability of manpower. The schedule includes durations of all reviews and approvals by the state and other parties, which is ultimately subject to approval by ConnDOT.

The CMC distributes monthly reports to all interested parties indicating the progress and costs of each project relative to approved milestones and budgeted amounts, respectively. The CMC and design consultants are jointly responsible for main-

taining communication to anticipate delays and other problems in order to ensure the earliest possible implementation of corrective measures, particularly when the activity lies in the critical path.

The detailed reports of all activities of networks are only distributed to the technical analysts, with summary and exception reports sent to management staff. Cost reports compare the progress of work and amounts billed with projections and serve to alert the consultant designer and ConnDOT when progress is unsatisfactory.

Also, for more effective scheduling control, there is a special reporting system on activities involving third parties, such as local and state wetlands interests and utilities. Such reports list, separately by third party, those activities under CMC and ConnDOT control requiring their attention by specified dates and those that are delinquent.

Louisiana's I-49 Program

The engineering agreement required the CMC to develop a master schedule to compare submittals from each design consultant with milestones so that the overall project could be completed in the proper time frame. Progress was monitored by monthly comparisons of actual progress with the master schedule. Such checking by the CMC also provided the basis for verifying and recommending payment of design consultant invoices.

Maryland's Open-End Agreements

The CMC is required to establish a management system capable of producing reports and listings that allow both the state and the CMC to readily determine the status of any particular task, project, or the program as a whole. The CMC is required to submit with the monthly invoice a narrative report of the status of the project, any delays and reasons therefor, and other factors pertinent to the prosecution of the work. The CMC must also report promptly any schedule problems, scope changes, or discrepancies between the percent of work completed and the percent budgeted therefor.

New York's Westway Project

The CMC was required to develop and maintain a computerized system to serve as a monitoring, reporting, and controlling mechanism over the schedule, progress, and cost factors associated with the various participants in the project, including:

- An overall project schedule in timescale format that includes milestone dates for each participant's work effort.
- A work breakdown structure (WBS) that defines significant work activities for each participant.
- A CPM network schedule based on the project schedule and the WBS, including milestones, durations, and cost factors.

The system was also supposed to monitor and report on a monthly basis:

- Current versus original schedule for each item of work,
- Current versus original schedule for each participant,
- Projected costs versus budget for each item of work,
- Projected costs versus budget for each participant,
- Exception reports showing the effect of slippages and early completions of activities on other activities and costs, and
- Narrative of monthly progress reports, with recommendations for corrective actions or modifications to the project schedules. Finally, the CMC was required to monitor the corrective actions taken by project participants, and assist in periodic technical informational briefing meetings.

CORRECTIVE ACTIONS

It should not be expected that the expertise of an experienced CMC and comprehensive computerized control systems will in all instances ensure the achievement of program progress and costs within the defined goals and objectives. The various contractual, environmental, political, project-related, and other conditions that normally plague a large project or program may defy original expectations. However, an organized approach should help in minimizing the incidence of such situations by providing the ability to take appropriate and timely actions.

Beyond reliance on the production consultant's or the contractor's interest in completing the product both in a timely fashion and efficiently from an economic perspective, the additional motivation provided by the state agencies or their CMCs to encourage the consultant or contractor meeting project milestones and cost targets is generally limited to performance ratings and contract provisions for liquidated damages and termination.

As Stukhart (*25*) noted, incentive provisions are rarely found in public contracts; this is substantiated by the survey of the states. The survey found only one instance of a direct incentive provision within an initial public contract, that cited by Sebastyan (*14*) for the Montreal International Airport in which part of the CMC's fee was related to its success "in producing the completed works within the approved target cost." The target cost was established upon approval of the 100 percent preliminary design.

The discussion in this section covers the corrective actions that are available to both the CMC and the state. For reasons previously discussed, incentive provisions to motivate the CMC are notably absent.

Florida

Corrective Actions by CMC

Although the CMC reviews the work and provides assistance and guidance, it has no authority to impose corrective action on section design or CEI consultants unilaterally. The CMC has the responsibility to monitor performance, to alert FDOT regarding deficiencies, and to make recommendations for overcoming any problems in quality, progress, or costs. The Florida Department of Transportation retains such authority not only because it is a federal requirement but also because it is perceived to be a proper management practice in the exercise of its public responsibility.

The corrective actions available to FDOT for faulty performance by design or CEI consultants are limited to:

- Warning that such deficiencies may be reflected in performance ratings and limit future contracts to the firm.
- Withholding payments for unsatisfactory performance.
- Terminating the contract.

State Monitoring of CMC

The Florida Department of Transportation's contracts with the CMC on both the I-595 and the bridge replacement programs require close control by the state over the CMC but contain no provisions for bonuses, penalties, or performance bonds. There has been a general feeling that the CMC, having been selected on the basis of its broad experience and capability, should not present any problem in performance or require motivation beyond its own concern for its reputation.

The I-595 agreement contains termination provisions that reimburse the CMC for all costs incurred but do not address the situation wherein termination is caused by the CMC's failure to perform adequately. The later contract for the statewide bridge program contains broader termination provisions that cover such possibilities as:

- If the department determines that the CMC's performance is not satisfactory, it shall have the option of: (a) terminating the agreement immediately or (b) requiring the correction of the deficiency or prompt termination by a specified date.
- If the department requires the termination of the contract for reasons other than for unsatisfactory performance, it shall notify the CMC of the effective date of termination or the stage of work at which it is to be effective.
- If the agreement is terminated before performance is completed, the CMC is to be paid for all work satisfactorily performed, based on substantiated costs, not to exceed an amount that is the same percentage of the contract price as the amount of work satisfactorily completed is a percentage of the total work called for by the agreement.

These termination provisions make no distinction in the amount reimbursable between termination for cause or for the state's benefit. A discussion of provisions adopted by a number of states that limit the reimbursable amount in the event of termination for cause may be found in Synthesis 137 (*9*).

Washington

Corrective Actions by CMC

The CMC is not authorized to impose any corrective actions over other consultants or contractors, being largely in an advisory and assisting role, with all final authority resting with the state.

State Monitoring of CMC

The state does not provide for any penalties, bonuses, or performance bonds to motivate the CMC, nor does it consider such provisions to be necessary in view of the advisory nature of the contract. Because the state and CMC personnel work side by side in the same office, monitoring of the CMC is a continual operation. If the CMC's performance is considered to be unsatisfactory, termination is the only available action.

The contract's termination provisions provide that:

- In the event of termination by the state for its own benefit, the CMC shall be paid the total of actual costs plus the same percentage of the fixed fee that the total of actual costs bears to the contract amount. In addition, the CMC shall be paid for all extra work and for costs that cannot be cancelled and that are incurred as a result of this program, such as leases, long-term maintenance agreements, demobilization, and others.
- If the state finds it necessary to terminate the agreement because of faulty performance by the CMC, the amount to be paid shall be less than the amount computed by the above method, with consideration given to the actual costs incurred to the point of termination, the amount of work originally required that was completed at the termination point, whether such work was in a form or type usable to the state, the cost to the state of employing another firm to complete the work and the time required to do so, and any other factors that affect the value to the state of the work performed by the termination date.

New Jersey

Corrective Actions by CMC

The CMC had the responsibility to monitor performance and recommend corrective actions it deemed to be appropriate. In addition to the usual motivation provided by the penalties cited for the previous states, there was one instance in which the contractor was offered a bonus to accelerate the work in order to lessen the effect of delay on an adjacent contract. The amount of the bonus to be paid was reduced incrementally for each day beyond the goal date.

State Monitoring of CMC

The state says that it had a very close working relationship with the CMC and that it was not necessary to impose any motivation provisions. The CMC was self-motivated and very interested in performing well in its assignment. The state advises, however, that a state work closely with the CMC to ensure that its performance reflects the style desired by the state, and to remove and replace any CMC personnel deemed not to be effective.

The termination provisions in the contract provide for payment of all costs in accordance with Federal Procurement Regulations 1-8, regardless of whether the termination was caused by the CMC's performance, including those that could not be stopped despite all reasonable efforts by the CMC.

Other States

Corrective Actions by CMC

Arizona, Connecticut, Louisiana, and Maryland report that their CMCs have only the authority to monitor progress and

costs and other aspects of their projects and to recommend to the state any corrective actions needed.

State Monitoring of CMC

Arizona, Connecticut, Louisiana, and Maryland find no need to impose any motivation measures other than those provided by the standard provisions already discussed. The provisions in Connecticut and Louisiana contracts make no distinction in payment between termination for cause or for the convenience of the state.

However, both Arizona's and Maryland's provisions hold the CMC liable for damages or additional construction costs resulting from a failure to perform its required services satisfactorily. The contract provisions cover both termination for default and for convenience of the state. In the event of termination for failure to perform satisfactorily, the CMC becomes liable for damages caused by its breach. Such damages shall be deducted from its final payment.

OVERVIEW

The control systems used by the states are generally similar in objectives, methods, and level of detail. All are designed to set progress mileposts and cost targets, to monitor the performance of the work relative to such targets, and to report deficiencies for their timely correction. All use computerization and CPM networks for ease in data management, but the level of detail is limited to that required by the managers.

The use of personal computers is preferred by functional managers over a centralized mainframe run by computer specialists because of the ability to adjust the output to their individual needs and the ready availability of the system. Because of the continuing vast advances in the capability of small computers, specific recommendations in this synthesis are not appropriate.

Corrective actions by CMCs on deficient progress or excessive costs by production consultants are generally restricted to recommendations to the state. The recourse by the state, in turn, is limited to reliance upon its power to restrict the future use of the consultant, terminate the contract, or assess liquidated damages. Although bonuses are occasionally offered in emergency situations or to reduce delay to other contractors and related claims, the types of incentives used in private industry are rarely seen in public contracts.

Incentive provisions to motivate the CMC are notably absent because of both ethical and practical considerations. The states consider the CMC more than adequately motivated by its own concern for its reputation, and feel that penalties are not applicable because of the advisory nature of the CMC's responsibility. The corrective action available to the state includes dismissal of specific employees or the termination of the CMC contract. The states should consider the adoption of termination provisions that reflect lesser payments in the event of termination for cause.

CHAPTER SEVEN

LEGAL RESPONSIBILITIES AND LIABILITY

The rapidly increasing number of liability lawsuits and the amounts of penalties imposed by the liberalization of judicial decisions affecting the national transportation program has been well documented. This has caused the states, their contractors, consultants, and other agents to incur an onerous financial burden in terms of the cost of adjudicated payments and liability insurance, and has even exposed their respective employees to personal liability.

The Transportation Research Board (*26*) reports that the pending tort liability claims reported by 40 states in a 1983 American Association of State Highway and Transportation Officials (AASHTO) survey total more than $6.4 billion, which is nearly double the amount reported in a 1980 survey by AASHTO. The states are no longer under the protection of sovereign immunity from tort liability. Although seven states still had such protection in 1983, one lost its immunity after 1984 and the remaining six were required by a tort claims act to create a board or commission for litigating claims against the state.

The private sector has the option of using alternative contract types and provisions to minimize the owner's risks. The Business Roundtable (*27*) states that the "changing and increasingly costly legal and insurance environment are major reasons for owners to consider whether better contractual arrangements are possible." The challenge to both the owner and the contractor is to provide for the uncertainties and the risks while still gaining improved productivity and innovation. Such a challenge involves the allocation of risk commensurate with the degree of control over the incidence of a cost liability, the potential economic return from risk management, and the relative ability to protect against the risks. Although incentive provisions associated with fixed-price contracts provide a mechanism for the assignment of greater risk to the contractor, they require trade-offs between cost and time or quality that public owners are generally not able or willing to accept.

Barrie (*3*) cites the trend in the allocation of risk toward placing the liability burdens "on those best able to bear them and to distribute them evenly to the general populace." The long-standing doctrine of privity of contract has been replaced by the generally accepted principle of placing responsibility upon the architect, engineer, or contractor for damages caused by them to parties with whom they have no contractual relationship. The courts have adopted the viewpoint that a professional has a larger responsibility beyond the interests of the client. This places the engineer in the position of a conflict of interest between a larger responsibility to the public and a contractual responsibility to the owner, increasing risk and liability to both.

With this trend, the previous common-law tradition, that contributory negligence in the slightest degree denies any recovery of damages, has been replaced by the doctrine of comparative negligence, which allocates damage in proportion to the degree of fault of the parties involved.

Synthesis 137 (*9*) discusses the potential of liability, the doctrine of joint and several liability that has exacerbated the "deep pockets syndrome," the limitations of insurance coverage, and the steps being considered at the state and national levels to reduce such liability to more equitable proportions.

This chapter addresses only the additional liability that may be imposed upon a CMC by its exercise of a state's authority in the review and monitoring of numerous entities under contract with the state who are all working within the confines of a relatively limited amount of time and space, such as:

- Delay incurred to one entity caused by an alleged failure by the CMC to prevent interference or delays by another.
- Delay incurred by failure of the CMC to provide timely direction or approval.

(The above and other delays may generate claims for sizable additional costs associated with alleged reductions in the efficiency of the operation or by the need to accelerate the work to meet critical mileposts.)

- Claims by the general public relative to disruptions to businesses, accidents, and other consequences of alleged faulty design, construction or schedule approved by the CMC.

Hope (*28*) illustrates the liability and extra costs associated with the construction of a Louisiana power plant. Beyond the potential claims associated with the disposal of hazardous chemicals, pollution of the groundwater, muddy runoff, and the use of herbicides, there was a potential delay claim. The subsequent need to accelerate the construction schedule of the plant required a 33 percent increase in work force, which overtaxed the site's packaged sanitary wastewater treatment plant and required an additional $75,000 facility.

Acceleration of work can cause claims by the involved contractors for extra costs, by the general public and the business community for damages by heavier construction operations, and by the design and supervisory engineers for extra costs and increases in their fees. A 1986 court decision found that an additional fee, beyond incurred costs, is warranted for fast tracking design work (*29*).

Barrie (*3*) cites the Federal Procurement Regulations, which recognize acceleration of work, and its ripple effect as a result of changes, to be a compensable item in fixed-price government contracts. However, it can be abused on large projects, and the exculpatory clauses generally used by owners to protect against such abuses may not stand up in the courts.

The above risks are similar to those normally assumed by the states and their agents, but the extent and types of programs managed by a CMC provide more opportunities for friction, with the CMC adding its own "deep pockets" to help pay for the consequences.

The ASCE (*2*) states that "the complex interaction of numerous independent contractors generates an unusually high potential for liability among them, which must be mitigated as a means of minimizing owner exposure to liability." The risks are primarily operational—related to the delivery of the project. It is the CMC's responsibility to define such risks, to place a value on the owner's exposure and extent of liability to each risk, and to dispose of them appropriately in the best interests of the owner.

The ASCE (*2*) compares the services by a CMC with those by a lump-sum contractor to illustrate the conflicts of interest in the project-delivery system. A construction contractor may be able to assume the economic risk of a lump-sum payment because of its ability to limit the amount of effort to a level of acceptability that remains possible after first having ensured an acceptable profit. The contractor has a potential conflict of interest between a concern for profit and a desire to do a good job. The CMC, on the other hand, particularly one under a reimbursable-plus-fee contract, does not have such a financial conflict of interest because of the lack of opportunity for personal gain and because of the CMC's fiduciary relationship with the owner, as its agent and under its guidance and control.

This distinction lends support to the concept that the CMC should not be asked to assume economic risks on behalf of the owner. The CMC should not be placed in a position to assume liability for matters beyond its ability to control or protect against because it would inhibit the nature of his relationship with the owner required by the management system. Stukhart (*25*) recommends that the allocation of risk should be based on the relative degree of control over the risk by the parties involved to prevent its occurrence and their relative ability to protect themselves against the risk.

Stukhart (*18*) cautions that liability may be associated with various activities, including design review, costs and schedule estimates, and field design adjustments. The contract should state clearly whether the CMC has the lead role in discharging such responsibilities or is only required to make recommendations. In the former instance, the fee should reflect the risk. Similarly, Graef (*30*) finds that the CMC is frequently asked to be responsible for areas, such as project costs, completion and fabrication times, and equipment delivery, that are beyond its control. Contracting for such responsibilities is very dangerous and should not be contemplated. It imposes huge liabilities for direct and indirect costs, such as lost revenue, and even third-party user costs or losses.

Gans (*31*) discusses the enormous vulnerability of the CMC to liability in the safety area, depending on the degree to which it exercises control or direction. Such risks include:

- Occupational Safety and Health Administration (OSHA) citations,
- Litigation in the event of injury or property damage,
- Claims by the owner for the CMC's performance deficiency,
- Increases in workers' compensation rates,
- Criminal negligence, and
- Claims by on-site contractors because of failure to prevent interference to their operations by others.

The CMC may avoid such liability by acting solely as the owner's agent or representative. On the other hand, one may question the degree to which the owner and the CMC should assume responsibility for project safety regardless of the associated liability exposure. The selection of the level of responsibility to be delegated to the CMC needs to consider the degree to which the CMC is protected or compensated for risks over which it has no control.

Barrie and Paulson (*1*) say that the CMC should assume a lesser risk than contractors do because of its lower profit potential, and cite the following acceptable risks by CMCs:

- Responsibility for actions of its key personnel including the prudent exercise of skill and judgment. The amount of such liability should be stipulated in the contract.
- Responsibility to its own employees for accidents, property damage, and other hazards that are insurable.
- Responsibility by law for OSHA requirements, though project contractors must also assume responsibility therefor.

Although general-liability insurance is essential for the protection of the various parties involved in the contract, Barrie (*3*) reports that engineers have great difficulty in securing adequate coverage, because of high premium rates and limited availability, and tend to self-insure for all but potentially catastrophic losses. Because the owner ultimately pays the costs of such insurance indirectly through bid or quoted prices, there is an advantage to the owner to minimize the cost or need for insurance. Barrie suggests that owners reduce costs by directly purchasing "wrap-up" insurance for a specific project.

Gans (*31*) describes wrap-up insurance as a single umbrella policy purchased by the owner to cover all risks by all parties to a construction project, including workers' compensation, public liability, property damage liability, and automobile liability, and covering the owner, the CMC, and all primes and subcontractors, who then need not carry any insurance. Although there may not be any savings with this approach, the owner may perceive other benefits, such as the involvement of the insurance underwriter along with the CMC in overall risk management for the project.

Lammie and Shah (*10*) found the use of wrap-up insurance on all MARTA contracts to be beneficial. It covered general liability; workers' compensation; property insurance, including builder's all-risk; errors and omissions; business interruptions; and safety program supervision. They cite advantages to the use of such insurance, including:

- Possible cost savings (which, however, is difficult to prove),
- Coordinated safety program,
- Uniform handling of claims, and
- Availability of insurance coverage to all parties to the contract, even in a tight insurance market.

Disadvantages include:

- Possible failure of bid prices to reflect savings in insurance costs,
- Reduction of contractor incentive to minimize claims, unless a special incentive plan is included, and
- Coverage of marginal contractors without their being screened.

Sebastyan (*14*) reports that the ministry, in constructing the Montreal Airport, saved insurance costs by making available

directly, through a consortium of insurance brokers, a package of liability and builder's risk insurance covering the total value of the project over the total work area.

On the other hand, Synthesis 106 (*32*) suggests that, in the long run, an effective risk management program may be the best method of reducing liability. In this context, it cites the benefits of self-insurance in reducing costs and in retaining within the agency the experience on which to base future risk management activities. This option, however, may not be available to any but the larger agencies, which have sufficient capital and qualified staff for a risk management program.

The following sections present the responses by the states regarding their approach to the additional liability caused by the CMC's role as an agent of the state. Their responses, unfortunately, were limited generally to procedures in handling claims, to indemnification provisions, and to insurance requirements.

LIABILITY AND CLAIMS

Florida

The Florida Department of Transportation indirectly protects the CMC against liability exposure based on the perspective that the CMC acts as an agent of the state and is subject to its reviews and controls.

No claims experience was reported by the state to allow analysis of the extent of the CMC's exposure to liability risk. It is interesting to note, however, that the CMC requires its review staff to be cautious in the wording of review comments and related correspondence to avoid the perception that the CMC is directing the work, thereby assuming responsibility for the design. This caution is based on a rule by the Florida board of professional engineers that the professional engineer who makes a decision to override documents prepared by another must bear full responsibility for that action. If a consultant voluntarily modifies its design to conform to review comments, however, he or she retains the responsibility. Such caution is shared by many state agencies that have been educated by claims resulting from zealous assumption by their personnel of the responsibilities of their contractors or agents.

Rutherford (*24*) reports that the state's policy on the I-595 program was to settle claims during the course of the work to the extent possible. Learning its lessons from their early claims experience, the state later adopted specifications for subsequent contracts that required production rates for specific roadway and bridge activities and updates when critical activities fell behind schedule. He further states that the specifications provided for the withholding of payments until the submission and approval of the revised schedule, increasing the ability to settle delay claims as the work progressed.

Washington

The CMC is protected against liability exposure through the state's assumption of all authority and control, with the CMC assuming only an advisory and assistance role. In such a capacity, the CMC is required to assist the state in claims analysis and evaluation, including cost justification, and as an expert witness in the defense of claims.

Based on recommendations by the CMC, procedures were implemented by the state to reduce the overall exposure to delays and claims, including:

- Availability of WSDOT bridge personnel to project engineers to review problems and approve changes.
- Availability of design consultants on call to review and approve shop drawings, changes, and other matters within their expertise. Only state designs and falsework drawings are reviewed and approved through the normal state process.
- To reduce delay, increased authority at the district level to approve change orders.
- Authority by the management review board, consisting of central and project state staff and FHWA personnel, to render decisions on major packages, reducing delay and extra costs.

New Jersey

The state believes that it should protect the CMC against all liability except for its own negligence. It recommends that contract provisions should be designed to protect the CMC as an agent of the state against liability exposure in order to reduce the overall insurance cost for the project.

In the New Jersey DOT's rail program, every contract overlapped with at least one other contract, and delay claims have ranged up to $17 million in magnitude. Because these claims are still being adjudicated within the department or are in court, the state is prevented from providing any details on them at this time.

Delay claims are reviewed by the CMC's resident engineer in concert with the New Jersey DOT field representative. If the contractor disagrees with their determination, the dispute proceeds upward through the CMC's chain of command with parallel department guidance. Time extensions and extra payments for approved claims are handled through the standard change order system.

In order to reduce the incidence of delay claims, the state insists upon timely approvals by the CMC and state personnel. It stresses the importance of having all members of the team, including design and top management, be aware that their active decisions affect construction schedules.

Louisiana

Without citing any specifics, the state reports that the incidence of claims has been greater when CMCs are involved and attributes this to conflicts among various consultants involved with overlapping contracts or to the presence of a CMC between them and the state. The state stresses the importance of clarity in communications and in delineating the chain of command both for approvals and for communication.

There have been no claims for payment adjustments resulting from accelerated schedules primarily because the need for acceleration has been rare. Although the contract language does not address such a situation, the state agrees that such adjustments may be warranted in certain situations.

The state says that it does not specify the time required for reviews by the department and its CMC because sufficient time is included in the contract for such reviews. Also, a break in

contract time of an indefinite length is specified for both the preliminary and final plan phases.

The department has a consultant claims committee that reviews all claims and makes recommendations through the chief engineer. The claims encountered relate primarily to the complexity of large design contracts and the unfamiliarity by newer design consultants with the department's procedures and specifications. This has resulted in some firms proceeding with work before receiving state approval and guidance relative to design intent in certain ambiguous situations.

Other States

Connecticut did not report any legal problems generated by the use of its CMCs. The CMC is required to assist the state in its risk management program by appearing in court on behalf of the state and furnishing expert testimony regarding any matters relating to the work performed. Maryland reports that it has not experienced any delay claims or legal problems either with the CMCs or contractors associated with management contracts.

INDEMNIFICATION AND INSURANCE

The following provisions are found to be similar to those used by the states in contracts with production consultants. For additional information, the reader is referred to Synthesis 137 (*9*).

Florida

On the I-595 program, the CMC was required to maintain coverage and limits that were equivalent to those already being maintained by the CMC for its protection, including:

- Comprehensive public-liability insurance with a limit of $200 million, with FDOT named as an additional insured with respect to the CMC's operations, as well as
- Professional indemnity insurance in the amount of $1 million, which was required to be maintained for four years following the completion of the work.

The contract also carried a hold harmless provision that covered two contingencies, as follows:

- An indemnification clause wherein the CMC agreed for four years after completion of the work to save and hold the state harmless against liability to third parties because of actions by the CMC or any of its employees or agents.
- Liability of the CMC for damage or loss sustained by FDOT directly, as distinguished from the derivative liability covered in the preceding provision. Such liability does not include consequential damages. The amount of such liability may not exceed the CMC's insurance coverage by more than 10 percent of the amount of profit payable under the contract.

The Florida Department of Transportation's contract for its bridge repair and rehabilitation program contains a standard indemnification clause and also requires professional liability insurance coverage in the amount of $1 million to be maintained for three years following completion of the CMC's services.

Washington

The engineering agreement contains an indemnification clause in which the CMC agrees to indemnify and hold the state and its officers and employees harmless from, and shall process and defend at its own expense, all claims, demands, or suits at law or equity attributable to the negligence of the consultant and arising out of bodily injury to persons or damage to property other than the state's. The total liability with respect to this clause is limited to $1 million.

In addition, the CMC is required to secure the following insurance coverage:

- Regular public-liability and property damage insurance coverage in the minimum amount of $50,000 for death or injury to any one person and $200,000 for death or injury to two or more persons in any one occurrence, and property damage coverage of $100,000 for each occurrence.
- Professional liability insurance coverage to protect the CMC from damages resulting from the performance of its professional services.

The engineering agreement does not specify the amount of professional liability insurance required. The limit of professional liability insurance and its cost became an initial issue in determining the appropriate amount to approve for the program. The standard limit used by the CMC on its own initiative for the I-90 type of work had been $30 million. This limit and its cost was perceived initially by the state as being too high, but attempts to arrive at some changed language in the legal-relations section of the agreement to lower both the CMC's risk and premiums did not meet with any significant success.

The state subsequently investigated the insurance coverage of many of its major consultants and found that their coverage and premiums were generally equivalent to those experienced by the CMC. Although the consultants were reluctant to expose such details, it was found that basic coverages averaged $5 million, with $25,000 to $100,000 deductibles, and that premiums ranged from $50,000 to $200,000 per year. Coverages of $25 million to $50 million were not unusual. Accordingly, the CMC's coverage of $30 million with an annual premium of $59,000 was found to be consistent with general practice.

New Jersey

The engineering agreement has a standard indemnification clause whereby the CMC indemnifies, and holds and saves the state and its officers and employees harmless from, all claims, actions, suits, proceedings, costs, judgments, damages, and liabilities attributable to any negligent act or error and omission in the performance of the contract services by the CMC or its subconsultants.

The provisions also state that neither the CMC nor its officers, employees, or agents shall be responsible for any administrative or operational actions of the state's contractors, subcontractors, or their officers or agents, nor for any safety precautions or

methods. Furthermore, the CMC does not guarantee performance by the state's contractors or subcontractors, does not assume any financial responsibility for them, shall not be under any obligation to defend or protect the state from liability arising from their work, and that neither the CMC nor its employees, officers, or agents shall be liable for any claims or liability arising from any omission or commission by the state's contractors or subcontractors.

The above limitation of the CMC's responsibility for the actions of others appears to be an attempt by the state to reduce the CMC's risk and insurance premiums. However, the New Jersey DOT asserts that no such protection was provided by the provisions because the CMC is involved in a claims action and the cost of liability insurance was not reduced.

Other insurance provisions in the agreement include:

- Errors and omissions, professional malpractice and/or professional liability insurance in the amount of $5 million for the CMC and a major subconsultant and $2 million for each of two other subconsultants to be in force for three years beyond the completion and acceptance of the program.
- Comprehensive general liability insurance in the amount of $15 million protecting the CMC and the state and their agents, subcontractors, and employees, but not the agents, subcontractors, and employees of the state's contractors, against all claims arising out of the work of the program.
- Special provisions within the comprehensive general liability requirements to the effect that the state and the CMC agree that each party shall remain responsible for the negligent acts of its own employees and agents and any uninsured amounts beyond insurance limits, and that the state shall not assert any claim against the CMC for consequential damages suffered by the state.

Connecticut

The agreement prescribes a standard indemnification clause and liability insurance coverage plus professional-services liability insurance for errors and omissions in the amount of $4 million. The CMC is allowed to obtain such a policy with a maximum $50,000 deductible clause provided the CMC recognizes that it becomes liable to the extent of the deductible amount.

Other States

Louisiana's agreement simply contains provisions that require the CMC to indemnify and hold the state harmless against all claims of any kind resulting from any negligence or omission or operation of work by the CMC, and from any liens for labor, services, or material used in the program. There are no direct requirements for professional-liability coverage.

Maryland requires the consultant to have an adequate financial capability to provide the required services and standard insurance coverage, including professional liability in the amount of $2 million.

New York has a standard indemnification clause and requires the various types of insurance coverage applicable to all consultants, including a $10 million limit on professional-liability insurance.

Massachusetts specifies a limit of only $300,000 for professional-liability insurance.

OVERVIEW

The sharp increase in liability claims and suits, which have doubled in the space of only three years, has subjected the national transportation program to a geometrically increasing financial burden. Such a surge in the number and dollar amount of adjudicated claims is attributable to factors other than the rapid increase in the size of the program.

The trend started with the replacement of the previous doctrine of privity of contract with one that supplements the professional's commitment to the client's interests with a larger responsibility to the public. This evolved into an association with the doctrine of comparative negligence and the "deep pockets" syndrome, which placed an onerous burden of financial responsibility on the public agencies and their agents for events to which their contribution was relatively minor.

The size and complexity of projects that are usually assigned to management by CMCs normally result in a high incidence of claims because of interferences and delays caused by the friction of numerous entities working within limited confines of space and time. The insertion of another link, the CMC, in the chain of authority between the owner and its agents and contractors compounds such problems because of delays and the blurring of clarity caused by an additional step in the review, approval, and communication processes. These may generate contractual claims, third-party claims by the general public and the business community, and a consequent need to accelerate the work to meet mileposts. The latter risks are associated with potentially large financial liabilities caused by the trend in the liberal adjudication of claims.

The general practice by owners to delegate construction risks to their contractors and agents is not appropriate for application to CMCs because the latter are not able to control the outcome of such risks or compensated for assuming them. To ignore these considerations would violate the desirable CMC/owner relationship necessary for effective management without conflict of interest.

Requirements for indemnification clauses and insurance in CMC contracts are equivalent to those specified by owners for protection against the risks generated by construction contractors and production consultants, with adjustments to project scale. All of the states incorporate in their CMC agreements standard indemnification clauses and general-liability insurance requirements. Professional liability insurance requirements vary from specifying limits of $1 million to $10 million to simply specifying the need for such coverage and leaving it up to the CMC to provide the coverage it deems to be appropriate. Deductible amounts to reduce premiums are permitted by some states, but the CMC remains responsible for such an amount.

Wrap-up insurance is recommended by some, not only as a possible cost-saving measure but also for the advantages associated with involving insurance experts in the project's risk management program. However, it is not used by state transportation agencies because of perceived disadvantages and questionable cost savings. In the long run, it appears that the best approach to risk management by the owner/CMC management team may

be to reduce or manage the risk of liability rather than insure against it or delegate it to others.

General practice by the state transportation agencies and others is to avoid placing responsibility on the CMC for any liability other than for its own negligence or malfeasance. Such protection of the CMC includes a clear delineation of the CMC's responsibilities and duties. By casting the CMC in an advisory rather than a lead role, the CMC's liability and risk may be reduced sharply.

Overall liability of the owner and the CMC is reduced in some states by expediting reviews and approvals of solutions to problems, change orders, and shop drawings; by settling disputes and claims promptly during the course of the work; by delegating increased authority to the local or district level; and by clarifying communications and chains of command in all processes.

Because great care is exerted in selecting a capable and responsible CMC to manage a complex operation in the best interests and under the general control of the public agency, it appears best to avoid the conflict-of-interest and adversary relationship that may be generated by delegating liability risk to the CMC that it cannot control or assume. The resulting reduction in the CMC's motivation to serve the agency and protect its interests would destroy the CMC/owner relationship that is essential to the management concept.

REFERENCES

1. Barrie D.S. and B.C. Paulson, Jr., *Professional Construction Management,* Second Edition, McGraw-Hill Book Co., New York, N.Y. (1978, 1983).
2. ASCE Committee on Construction Management, "Qualification and Selection of Construction Managers with Suggested Guidelines for Selection Process," *Journal of Construction Engineering and Management,* Vol. 113, No. 1 (March 1987).
3. Barrie, D.S., *Directions in Managing Construction,* John Wiley & Sons, Inc., New York, N.Y. (1981).
4. Tatum, C.B., G.M. Gans, and G.T. Harper, "Professional CM: The Architect-Engineer's Viewpoint," *Proc.,* ASCE, Vol. 106, No. CO2 (June 1980).
5. "CM Work Tagged as Growth Market," *ENR* (May 19, 1988) p. 41.
6. Naoum, S.G. and D. Langford, "Management Contracting—The Client's View," *Journal of Construction Engineering and Management,* Vol. 113, No. 3 (September 1987) pp. 369–384.
7. Newman, R.B., *NCHRP Synthesis of Highway Practice 145: Staffing Considerations in Construction Engineering Management,* Transportation Research Board, National Research Council, Washington, D.C. (May 1989) 42 pp.
8. Newman R.B., *NCHRP Synthesis of Highway Practice 146: Use of Consultants for Construction Engineering and Inspection,* Transportation Research Board, National Research Council, Washington, D.C. (June 1989) 64 pp.
9. Sternbach, J., *NCHRP Synthesis of Highway Practice 137: Negotiating and Contracting for Professional Engineering Services,* Transportation Research Board, National Research Council, Washington, D.C. (July 1988) 75 pp.
10. Lammie, J.L. and D.P. Shah, "Managing Joint Ventures in Large Public Projects," *Proc.,* ASCE, Vol. 107, No. EI1 (January 1981) pp. 25–39.
11. Hammond, D.G., "Management of a Large Project—BART," *Proc.,* ASCE, Vol. 104, No. EI3 (July 1978) pp. 181–191.
12. Tillman, E.A., "Control of Construction Quality on Public Construction Managed by Consultants," in *Transportation Research Record 986: Construction: Quality Control and Specifications,* Transportation Research Board, National Research Council, Washington, D.C. (1984) pp. 47–50.
13. Bitner, M.E., "Total Project Management at the Miami International Airport," *Cost Engineering,* Vol. 27, No. 8 (August 1985) pp. 13–17.
14. Sebastyan, G.Y. "The New Montreal International Airport," *Proc.,* ASCE, Vol. 101, No. CO2 (June 1975) pp. 317–334.
15. Behr, P.G., "James Bay Design and Construction Management," *Proc.,* ASCE, Vol. 104, No. E12 (April 1978) pp. 133–146.
16. Murray, L.W., R. Woywitka, E.R. Gallardo, and S. Aggarwal, "Marketing Construction Management Services," *Proc.,* ASCE, Vol. 107, No. CO4 (December 1981) pp. 665–677.
17. The Business Roundtable, "More Construction for the Money," *Summary Report of the Construction Industry Cost Effectiveness Project,* New York (January 1983) pp. 21–30, 81–88.
18. Stukhart, G., "Construction Management Responsibilities During Design", *Journal of Construction Engineering and Management,* Vol. 113, No. 1 (March 1987).
19. Barrie, D.S. and G.L. Mulch, "The Professional CM Team Discovers Value Engineering," *Proc.,* ASCE, Vol. 103, No. CO3 (September 1977) pp. 423–435.
20. Barrie, D.S., "Guidelines for Successful Construction Management," *Proc.,* ASCE, Vol. 106, No. CO3 (September 1980) pp. 237–245.
21. Leathers, R.C., "Employment of Consultants" and "Engineering and Operations—Interim Guidelines on Employment of Consultants for Construction Engineering and Inspection" (attachment), internal memorandum, Federal Highway Administration, Washington, D.C. (April 10, 1985).
22. Carpenter, P.E., "Florida—I 595, Construction Management," correspondence to W.K. Fowler (July 8, 1986).
23. Skinner, J.R., correspondence to W.K. Fowler (May 20, 1987).
24. Rutherford, W.A., "Organizational Evolution, I-595 Port Everglades Expressway," unpublished report.
25. Stukhart, G., "Contractual Incentives," *Journal of Construction Engineering and Management,* Vol. 110, No. 1 (March 1984).
26. TRB, *Transportation Research Circular No. 308: Tort Claims Involving Roadside Safety,* Transportation Research Board, National Research Council, Washington, D.C. (September 1986) 31 pp.
27. The Business Roundtable, "Contractual Arrangements," *Report A-7,* New York (October 1982, 1986).
28. Hope, S.J., "Constructing a Better Environment," *Civil Engineering,* Vol. 56, No. 10 (October 1986) pp. 66–68.
29. "Court Decisions," *Civil Engineering,* Vol. 56, No. 10 (October 1986) p. 22.
30. Graef, L.W., "New Challenges—New Liabilities," *Proc.,* ASCE, Vol. 104, No. EI4 (October 1978) pp. 245–250.
31. Gans, G.M., Jr., "The Construction Manager and Safety," *Proc.,* ASCE, Vol. 107, CO2 (June 1981) pp. 219–226.
32. Lewis, R.L., *NCHRP Synthesis of Highway Practice 106: Practical Guidelines for Minimizing Tort Liablity,* Transportation Research Board, National Research Council, Washington, D.C. (December 1983) 40 pp.

APPENDIX A

DELINEATION OF RELATIVE RESPONSIBILITIES IN THE MANAGEMENT OF FDOT'S I-595 PROGRAM

Engineering Support Services

I. Engineering
II. Maintenance of Traffic
III. Utility Relocation
IV. Right-of-Way/Relocation Support Services
V. Permitting Support
VI. Final Environmental Impact Statement and Reevaluation if Required

I. ENGINEERING

	Phase I Prefinal Design				Phase II Final Design and Contract				Phase III Construction			
	RKE/ HNTB	FHWA	FDOT	Design	RKE/ HNTB	FHWA	FDOT	Design	RKE/ HNTB	FHWA	FDOT	Construct
A. Collect and Review Data	▲	●	●	●	▲							
1. Preliminary Engineering Reports.												
2. Existing Drawings.												
3. Agreements.												
4. Transcripts.												
5. FEIS.												
6. Aerial Photographs.												
B. Prepare Master Plan	▲	●	●	●								
Plot the following:												
1. Right-of-ways.												
2. Base line.												
3. Roadways and structures.												
4. Limits of work.												
5. Railroads.												
6. Major utilities.												
C. Assist and Advise in Matters of Engineering Policy in Administration of the Project	▲	●	●	●	▲	●	●	●	▲	●	●	●
D. Assist in Development of Construction Implementation Plan	▲	●	●	●	▲	●	●	●				
1. Sequence as to phases.												
2. Construction contracts.												
3. Limits of contracts.												
4. Priority of contracts.												

◆ Optional Service Under FDOT Supplement

▲ Prime Responsibility
● Input and/or Review

	Phase I Prefinal Design				Phase II Final Design and Contract				Phase III Construction			
	RKE/ HNTB	FHWA	FDOT	Design	RKE/ HNTB	FHWA	FDOT	Design	RKE/ HNTB	FHWA	FDOT	Construct
E. Review and Assist in the Preparation of Maintenance of Traffic Plan	▲	●	●	●	▲	●	●	●				
1. Analysis of existing traffic data.												
2. Evaluation of existing movements and access requirements.												
3. Development of plans as necessary.												
F. Confer/Coordinate with Utility Companies Regarding Crossings, Closings and/or Relocation of Their Facilities and Assist in the Negotiation of Utility Agreements and Handling of Utility Permits	▲	●	●	●	▲	●	●	●	▲	●	●	●
G. Confer/Coordinate with State, County, Municipal and Other Legal Authorities Having Jurisdiction Regarding the Crossing, Closing and/or Relocation of Highways, Roads and Streets, and participate in Negotiation of Agreements Covering Such Crossings, Closings and/or Relocations	▲	●	●	●	▲	●	●		▲		●	●
H. Assist in Right-of-Way Acquisition	▲	●	●	●	▲	●	●		▲	●	●	
I. Assist in Obtaining Necessary Easements	▲	●	●	●	▲	●	●	●	▲	●	●	●
J. Check (Cursory) Project Base Control Surveys	▲	●	●	●	▲		●	●	▲		●	
◆ K. Review and Assist in Coordination of Sub-Surface Exploration Contracts	▲	●	●	●	▲	●	●	●	▲	●	●	
L. Review and Assist in Arranging for the Laboratory Testing of Soils Samples	▲	●	●	●	▲	●	●	●	▲	●	●	
M. Review and Assist in Development of All Necessary Supplemental Agreements	▲	●	●	●	▲	●	●	●				
N. Check for Use of Proper Project Design Criteria	▲	●	●	●	▲	●	●	●				
1. FDOT Standards.												
2. FHWA Requirements.												
3. FEIS Requirements.												
◆ O. Verify that Standard Plans and Details Have Been Used to Prepare Construction Documents	▲	●	●	●	▲	●	●					
1. Right-of-way plans.												
2. Utility relocations.												

◆ Optional Service Under FDOT Supplement

▲ Prime Responsibility
● Input and/or Review

	Phase I Prefinal Design				Phase II Final Design and Contract				Phase III Construction			
	RKE/ HNTB	FHWA	FDOT	Design	RKE/ HNTB	FHWA	FDOT	Design	RKE/ HNTB	FHWA	FDOT	Construct
3. Preliminary plans.												
4. Final design and contract plans.												
5. Specifications.												
6. Project manual for special provisions.												
P. Review/Coordinate and Assist in Directing the Work of the Design Section Engineers	▲		●	●	▲		●	●				
Q. Develop and Assist in Reporting on Monthly Progress by Design Consultants	▲	●	●	●	▲	●	●	●				
◆ R. Review Design Compliance and Coordinate Section Engineers to Ensure Compliance with Project Criteria	▲		●		▲		●					
1. Geometry.												
2. Drainage.												
3. Pavement section.												
4. Structures.												
5. Alternatives.												
S. Review and Comment on the Design Consultant Plans at the 60%, 90% and 100% Stages of Completion as Applicable	▲	●	●	●	▲	●	●	●				
T. Review Structural Systems and Types	▲	●	●	●	▲	●	●	●				
◆ U. Receive All Final Plans and Specifications from Design Consultants and Assist FDOT in Arranging Printing for Bidding Construction Packages					▲	●	●	●				
◆ V. Prepare Additional Design Plans, Specifications and Cost Estimates as Required	▲	●	●	●	▲	●	●	●				
W. Assist in Development of Construction Cost Estimates for Each Construction Project	▲	●	●	●	▲	●	●	●	▲	●	●	
X. Assist in Procuring All Necessary Permits, and Other Authorizations Required for the Construction of the Project	▲	●	●	●	▲	●	●	●	▲	●	●	●
Y. Assist in Review of Final Environmental Impact Statement and in Preparation on Any Necessary Updates or Supplements.	▲	●	●		▲	●	●	●				
◆ Optional Service Under FDOT Supplement ▲ Prime Responsibility ● Input and/or Review												

	Phase I Prefinal Design				Phase II Final Design and Contract				Phase III Construction			
	RKE/ HNTB	FHWA	FDOT	Design	RKE/ HNTB	FHWA	FDOT	Design	RKE/ HNTB	FHWA	FDOT	Construct
◆ Z. Advise and Consult on Questions of Engineering with Respect to the Construction of the Project, the Preparation and Advertising of Bids, Review of Bids, and Award of Contracts					▲	●	●	●				
◆ AA. Assist FDOT in Assembling Final Contract Documents Including All Addendums					▲	●	●	●				
◆ BB. Assist in Review and Determination of Standard FDOT Construction Forms and Reports to be Used for Inspection, Testing, Change Order, Extra Work, Supplemental Agreements, etc.					▲	●	●					
CC. Review Mill and Shop Inspection and Testing Reports and Monitor Approval by the Design Section Engineers of Shop and Erection Drawings					▲	●	●	●	▲	●	●	●
DD. Review/Coordinate and/or Prepare Revised Contract Drawings During the Construction Period									▲	●	●	●
EE. Review and Assist in Preparation of Record Drawings									▲	●	●	●
FF. Prepare Final Engineering Report on the Construction of the Project									▲		●	●
GG. Assist in the Analysis of Claims Submitted by Construction Contractors and Others, Provide Support as Required to Effect the Settlement of Such Claims, and Provide Assistance in Hearings, Condemnation Proceedings and Other Litigation Including the Preparation of Trial Exhibits					▲		●		▲	●	●	
◆ HH. Provide any Other Special Engineering Services Including Additional Studies	▲	●	●	●	▲	●	●	●	▲	●	●	●
1. Trust indenture services for portions financed by tolls.												
2. Special evaluations.												
3. Environmental monitoring and control.												
4. Design studies relating to unforeseen conditions.												
5. Specialized inspections, reports, load testing, etc.												
II. Provide Data to Assist with Determination of Design Consultant Compensation	▲	●	●	●	▲	●	●	●				

◆ Optional Service Under FDOT Supplement

▲ Prime Responsibility
● Input and/or Review

APPENDIX B

SAMPLES OF OUTPUT FROM FDOT'S I-595 COMPUTERIZED MANAGEMENT SYSTEM FOR MONTHLY PROGRESS REPORTS

DTA DATE:31-Aug-87
RPT DATE:04-Sep-87
FILE : MILESTON.WR1

I-595 PORT EVERGLADES EXPRESSWAY PROGRAM
PROGRAM MILESTONE DATES

SCH - Scheduled dates reflect FY 87/88 Work Plan Update.
A/F - Actual or Forecast dates as of the Data Date

CONTR. PKG.	PROJECT NUMBER	CONSTRUCTION PACKAGE DESCRIPTION		DESIGN COMPLETE (PTT)	PERMITS APPROVED/ RECEIVED	UTILITY AGREEMENTS CLEAR	RIGHT-OF-WAY CLEAR WITH EXCEPTIONS	SEND PLANS TO TALLAHASSEE DATE (PTT)	PRODUCTION READY (PRD DATE)	LETTING DATE	CONSTRUCTION START DATE	CONSTRUCTION COMPLETION DATE	CONSTRUCTION DURATION (CAL DAYS)
A	3408	US-1 RELOCATION	SCH	20-Feb-84	16-Dec-83	12-Mar-84	26-Apr-84	21-Feb-84	26-Apr-84	30-May-84	27-Jul-84	27-Mar-87	973
			A/F	20-Feb-84	16-Dec-83	12-Mar-84	26-Apr-84	21-Feb-84	26-Apr-84	30-May-84	27-Jul-84	27-Mar-87	973
			FLOAT										
A-1	3439	US-1 RELOCATION -AIRPORT BRIDGES	SCH	30-May-84	16-Dec-83	12-Mar-84	N/A	31-May-84	26-Jul-84	29-Aug-84	31-Oct-84	20-Aug-87	1031
			A/F	30-May-84	16-Dec-83	12-Mar-84	N/A	31-May-84	26-Jul-84	29-Aug-84	31-Oct-84	01-Oct-87	1065
			FLOAT										
B	3406	I-595 - VIADUCT SECTION	SCH	05-Apr-85	25-Apr-85	03-May-85	16-May-85	11-Mar-85	16-May-85	26-Jun-85	30-Sep-85	07-Oct-87	737
			A/F	05-Apr-85	25-Apr-85	03-May-85	16-May-85	11-Mar-85	16-May-85	26-Jun-85	30-Sep-85	07-Oct-87	737
			FLOAT										
C	3422	RAVENSWOOD ROAD RELOCATION	SCH	31-Jul-85	29-Nov-84	18-Oct-85	12-Dec-85	14-Oct-85	12-Dec-85	22-Jan-86	25-Apr-86	06-Mar-87	315
			A/F	31-Jul-85	29-Nov-84	18-Oct-85	12-Dec-85	14-Oct-85	12-Dec-85	22-Jan-86	25-Apr-86	06-Mar-87	315
			FLOAT										
D/F, E & V	3453, 3454 & 3467	I-595/I-95 INTERCHANGE & RAMPS, SR-84 BRIDGES & RAMPS AND CFR BRIDGE	SCH	16-Feb-87	11-Dec-86	24-Feb-87	16-Jan-87	19-Jan-87	12-Mar-87	29-Apr-87	13-Jul-87	13-Nov-90	1219
			A/F	16-Feb-87	11-Dec-86	24-Feb-87	16-Jan-87	19-Jan-87	12-Mar-87	29-Apr-87	13-Jul-87	13-Nov-90	1219
			FLOAT										
G	3463	I-95 AT DAVIE BOULEVARD	SCH	15-Jan-89	17-May-88	11-Apr-89	19-Aug-89	15-May-89	20-Jul-89	27-Sep-89	26-Dec-89	20-Jan-92	755
			A/F	13-Feb-89	16-Oct-88	15-May-89	29-Oct-89	15-May-89	20-Jul-89	27-Sep-89	26-Dec-89	20-Jan-92	755
			FLOAT	91	277	66	-101						
H	3441	I-95 BRIDGES OVER SOUTH FORK NEW RIVER	SCH	20-Feb-84	02-May-85	10-Feb-84	17-May-84	20-Feb-84	17-May-84	27-Jun-84	16-Oct-84	11-Jul-88	1364
			A/F	20-Feb-84	02-May-85	10-Feb-84	17-May-84	20-Feb-84	17-May-84	27-Jun-84	16-Oct-84	11-Jul-88	1364
			FLOAT										
J	3404	I-595 BRIDGES OVER SOUTH FORK NEW RIVER	SCH	20-Feb-84	10-Feb-84	10-Feb-84	17-May-84	20-Feb-84	17-May-84	20-Jun-84	25-Oct-84	14-Sep-87	1054
			A/F	20-Feb-84	10-Feb-84	10-Feb-84	17-May-84	20-Feb-84	17-May-84	20-Jun-84	25-Oct-84	20-Oct-87	1090
			FLOAT										
K	3301	TURNPIKE AND BRIDGES OVER I-595	SCH	22-Oct-86	17-Dec-86	07-Jan-87	14-Nov-86	15-Dec-86	16-Feb-87	25-Mar-87	07-Jul-87	25-Aug-89	780
			A/F	22-Oct-86	17-Dec-86	07-Jan-87	14-Nov-86	15-Dec-86	16-Feb-87	25-Mar-87	07-Jul-87	25-Aug-89	780
			FLOAT										
L	3457	TURNPIKE/I-595 INTERCHANGE	SCH	29-Sep-87	05-Feb-87	19-Oct-87	07-Aug-87	29-Sep-87	19-Nov-87	27-Jan-88	26-Apr-88	26-Apr-90	730
			A/F	29-Sep-87	05-Feb-87	09-Nov-87	07-Sep-87	29-Sep-87	19-Nov-87	27-Jan-88	26-Apr-88	26-Apr-90	730
			FLOAT	0	287	10	73						
M	3458	I-595/US-441 INTERCHANGE	SCH	07-Mar-86	24-Jun-86	02-May-86	29-May-86	10-Mar-86	08-Jul-86	27-Aug-86	06-Oct-86	20-Apr-90	1300
			A/F	07-Mar-86	24-Jun-86	02-May-86	29-May-86	10-Mar-86	08-Jul-86	27-Aug-86	06-Oct-86	20-Apr-90	1300
			FLOAT										
N	3401	I-595 - TURNPIKE TO UNIVERSITY DRIVE	SCH	14-Sep-87	09-Sep-87	14-Sep-87	02-Sep-87	24-Aug-87	22-Oct-87	02-Dec-87	15-Feb-88	09-Feb-90	725
			A/F	14-Sep-87	30-Sep-87	12-Oct-87	25-Sep-87	24-Aug-87	22-Oct-87	02-Dec-87	15-Feb-88	09-Feb-90	725
			FLOAT	-21	22	10	27	59					

(OOP70)

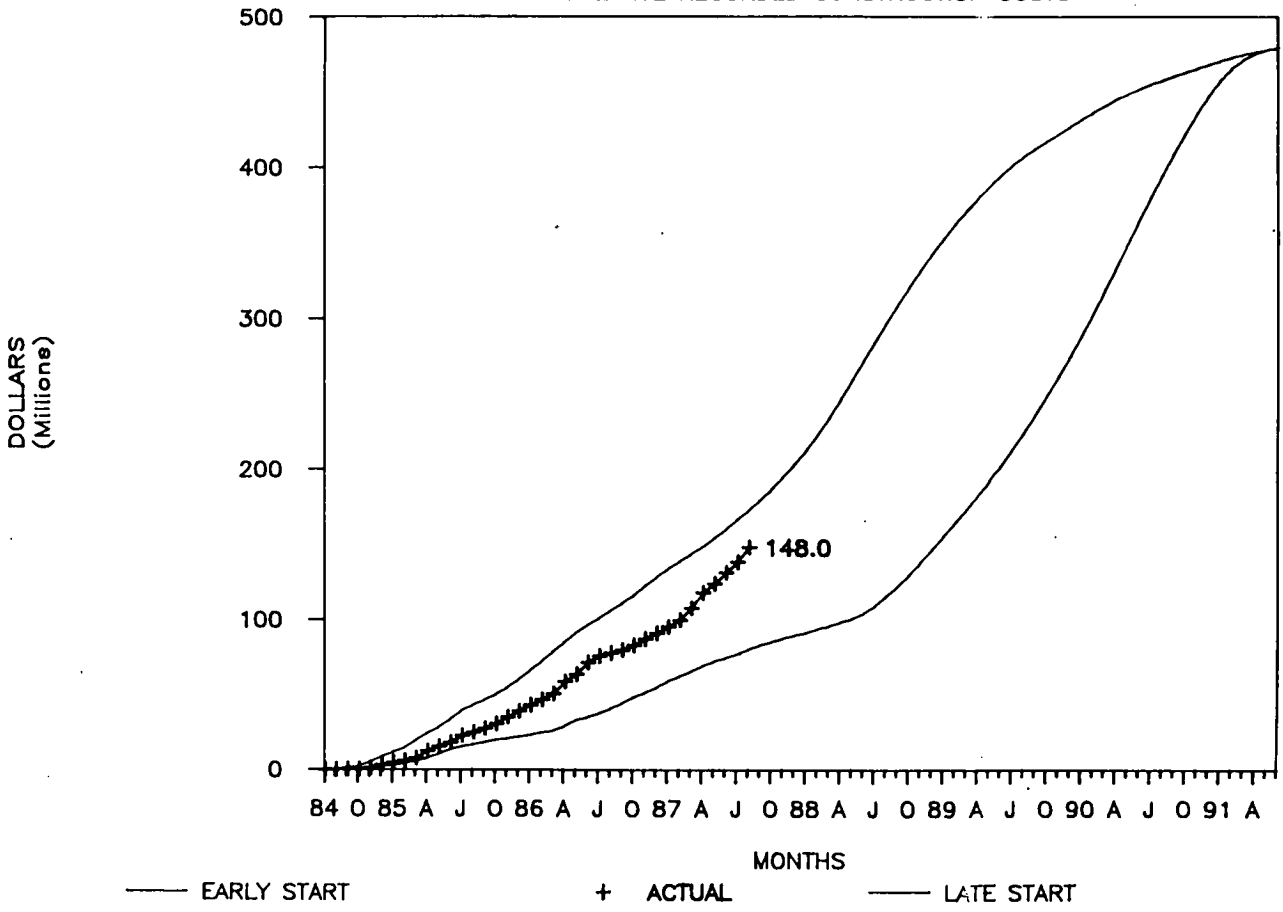
I-595 PORT EVERGLADES EXPRESSWAY
SUMMARY CONSTRUCTION SCHEDULE/PROGRESS TABLE
AUGUST 23, 1987

PACKAGE		SCHEDULED PERCENT			PERCENT COMPLETE			FORECAST FLOAT			
NUMBER	DESCRIPTION	EARLY START	TARGET CURVE	LATE START	PHYSICAL PROGRESS	TIME	COST	THIS MONTH	LAST MONTH	CHANGE	CALCULATED COMPLETION DATE
A	US-1 RELOCATION	N/A	100.0	N/A	100.0	ACTUAL COMPLETION ==========					27-Mar-87
A-1	US-1/AIRPORT BRIDGES	100.0	100.0	100.0	N/A	175.6	101.9	-455	-421	-34	01-Oct-87
B	I-595 SE 14TH TO I-95	99.4	98.8 *	98.1	93.9	91.8	93.9	8	0	8	15-Oct-87
C	RAVENSWOOD RD RELOCA'N	100.0	100.0	100.0	100.0	ACTUAL COMPLETION ==========					06-Mar-87
D/F	I-95/I-595/SR-84 INTERC	N/A	N/A	N/A	1.7	3.4	1.7	0	0	0	09-Nov-90
H	I-95 BRIDGES OVER SFNR	N/A	74.0 **	N/A	71.1	86.8	68.3	-221	-226	5	04-Sep-88
J	I-595 BRIDGES OVER SFNR	97.5	95.0 **	92.0	98.0	114.7	98.8	-189	-160	-29	20-Oct-87
K	TPK BRIDGES & I-595 M/L	N/A	1.8	N/A	5.0	6.2	6.2	0	0	0	25-Aug-89
M	I-595/SR-7 INTERCHANGE	27.2	27.2	7.8	30.0	24.8	30.0	33	33	0	14-Mar-90
P	I-595 HIATUS TO PINE IS	42.2	28.3 *	14.3	35.5	29.7	38.5	13	41	-28	09-Feb-89
Q	I-595 136TH TO HIATUS	62.4	56.8 *	51.2	71.7	62.2	73.5	45	38	7	04-Mar-88
R	GRIFFIN ROAD DETOUR	N/A	100.0	N/A	100.0	ACTUAL COMPLETION ==========					22-Jun-87
T	I-595 OVER SW 136TH	100.0	100.0	100.0	99.1	96.6 ***	102.9	-25	-40	15	09-Oct-87

* AVERAGE OF EARLY AND LATE START CPM CONTRACT CURVE FOR PACKAGES B, P, Q & T.
** PROGRESS BASE REVISED TO CONFORM TO FDOT APPROVED REVISED WORKING SCHEDULE WHICH EXCEEDS CONTRACT DURATION.
*** A 75 DAY TIME EXTENSION HAS BEEN APPROVED AND INCORPORATED HERE.

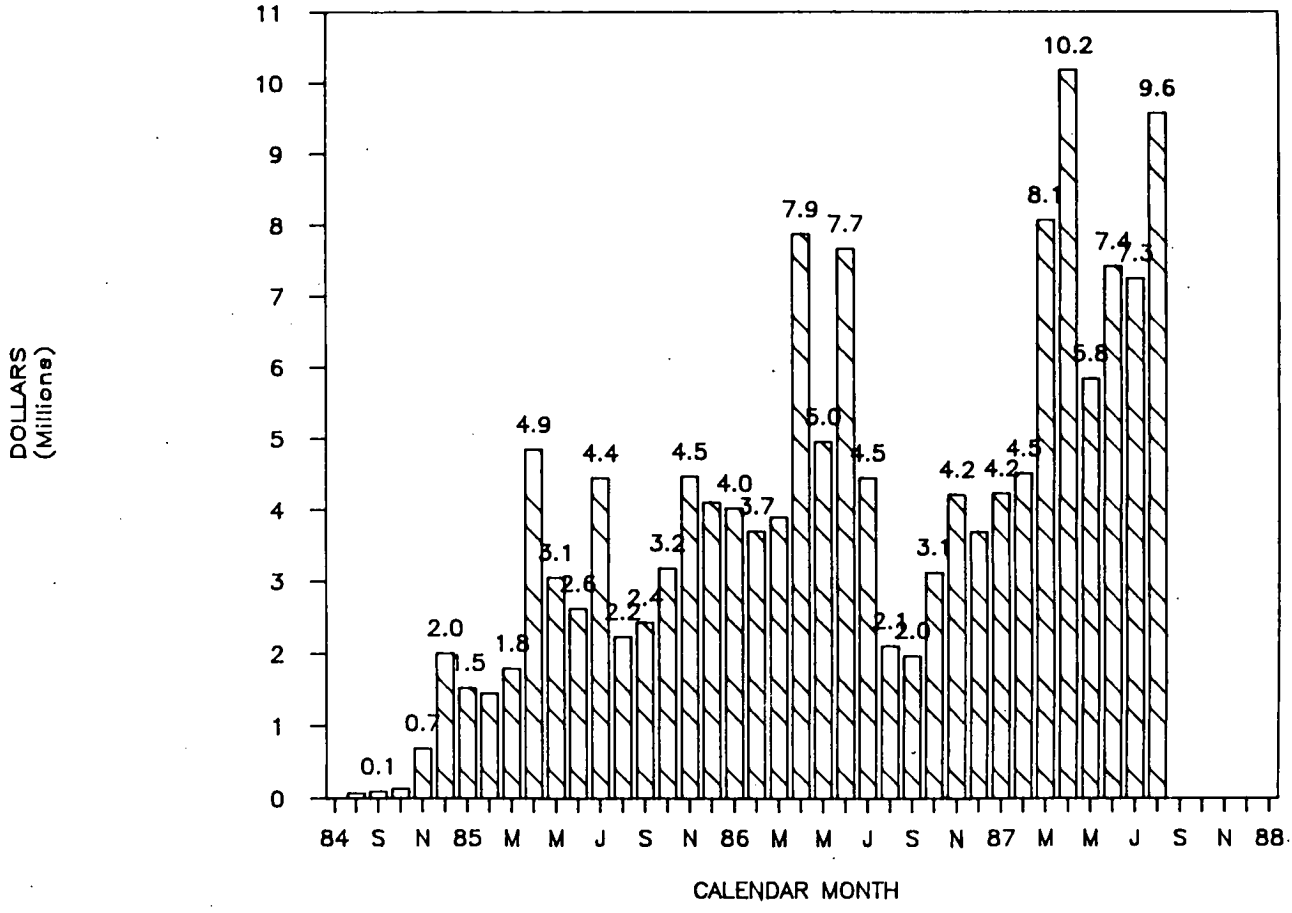
I-595 PORT EVERGLADES EXPRESSWAY

CUMULATIVE RECORDED CONSTRUCTION COSTS



I-595 PORT EVERGLADES EXPRESSWAY

CONSTRUCTION – MONTHLY RECORDED COSTS



APPENDIX C

SAMPLES OF OUTPUT FROM WSDOT'S I-90 COMPUTERIZED MANAGEMENT SYSTEM FOR MONTHLY PROGRESS REPORTS

DATE :09-Sep-87
AS OF :23-Aug-87

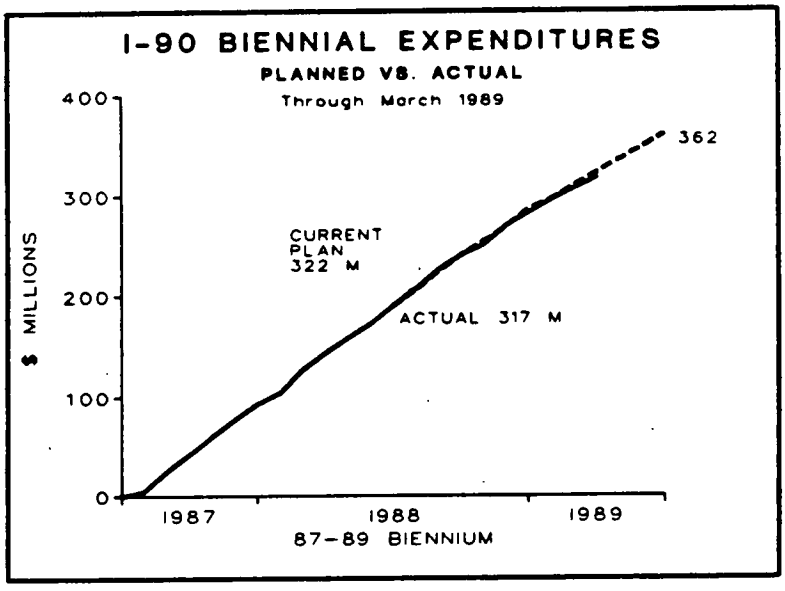
I-595 PORT EVERGLADES EXPRESSWAY - COST AND COMPARISON TO ESTIMATE REPORT : CONSTRUCTION
PERIOD ENDING: AUGUST 23, 1987

COSTS ARE IN $ THOUSANDS (000'S)
FILE : EACCOST.WR1

CONTR PKG	WPA NUMBER	PROJECT NUMBER	DESCRIPTION	RECORDED COSTS: PREV. MONTH TO DATE (1)	RECORDED COSTS: THIS MONTH (2)	RECORDED COSTS: TO DATE (1+2) (3)	ORIGINAL CONTRACT (4)	EXECUTED CHANGES (5)	TOTAL CONTRACTED (4+5) (6)	PENDING CHANGES (7)	WORK NOT YET CONTRACTED (8)	ESTIMATE AT COMPLETION: CURRENT (6+7+8) (9)	ESTIMATE AT COMPLETION: LAST REPORT (10)	ESTIMATE AT COMPLETION: INCR/(DECR) (9-10) (11)	BUDGET: BASELINE OCTOBER 1984 (12)	BUDGET: OVER/(UNDR) (9-12) (13)
A	4140814	3400	US-1 RELOCATION	12,914	0	12,914	10,857	2,358	13,215	150	0	13,36[illegible]	13,365	0	20,554	(7,189)
A-1	4140893	3459	US-1 RELOCATION, AIRPORT BRIDGES	8,858	2	8,860	7,794	1,004	8,798	294	0	9,09[illegible]	9,092	0	6,962	2,130
B	4140813	3406	I-595 - VIADUCT SECTION	29,174	820	29,994	31,453	697	32,150	744	0	32,894	32,894	0	52,532	(19,638)
C	4140834	3422	RAVENSWOOD ROAD RELOCATION	1,334	0	1,334	1,296	66	1,362	63	0	1,425	1,425	0	3,430	(2,005)
D/F E V	4140886 4140887 4140900	3453 3454 3467	I-595/I-95 INTERCHANGE & RAMPS \\ I-95/SR-84 INTERCHANGE)) CARSH/FIRE RESCUE BRIDGE //	869	1,198	2,067	119,195	0	119,195	0	0	119,195	119,191	4	161,282	(42,087)
G	4140872	3463	I-95 AT DAVIE BOULEVARD	0	0	0	0	0	0	0	33,420	33,420	33,420	0	55,673	(22,253)
H	4140862	3441	I-95 BRIDGES OVER SF NEW RIVER	19,621	211	19,832	28,584	495	29,079	709	0	29,788	29,773	15	32,286	(2,498)
J	4140885	3404	I-595 BRIDGES OVER SF NEW RIVER	18,610	428	19,038	19,210	62	19,272	708	0	19,980	19,978	2	30,783	(10,803)
K	4140889	3456	TURNPIKE & BRIDGES OVER I-595	37	799	836	13,409	0	13,409	218	0	13,627	13,409	218	15,709	(2,082)
L	4140890	3457	TURNPIKE/I-595 INTERCHANGE	0	0	0	0	0	0	0	20,600	20,600	20,600	0	14,135	6,465
M	4140891	3458	I-595/US-441 INTERCHANGE	13,784	4,608	18,392	60,244	1,175	61,419	139	0	61,558	60,417	1,141	70,422	(8,864)
N	4140771	3401	I-595-TURNPIKE TO UNIVERSITY DR	0	0	0	0	0	0	0	30,900	30,900	30,900	0	34,860	(3,960)
P	4140821	3421	I-595-UNIVERSITY DR TO HIATUS RD	7,402	811	8,213	21,286	0	21,286	186	0	21,472	21,472	0	25,049	(3,577)
Q	4140823	3462	I-595-HIATUS RD TO SW 136TH AVE	11,230	613	11,843	16,085	22	16,107	(197)	0	15,910	15,910	0	20,133	(4,223)
R	4140875	3449	GRIFFIN ROAD IMPROVEMENTS	7,107	0	7,107	6,558	308	6,866	999	0	7,865	7,865	0	7,018	847
S	4140876	3450	SR-7 IMPROVEMENTS SOUTH OF I-595	0	0	0	3,029	0	3,029	0	0	3,029	3,029	0	2,171	858
S-1	4140927	3485	SR-7 IMPROVEMENTS NORTH OF I-595	0	0	0	0	0	0	0	1,071	1,071	1,071	0	0	1,071
T	4140892	3464	I-595 - I-75 TO SW 136TH AVE	7,523	77	7,600	6,646	903	7,549	373	0	7,922	7,863	59	7,689	233
U	4140860	3443	I-595/I-75 INTERCHANGE				MANAGED DIRECTLY BY FDOT DISTRICT IV									
X	4151612	3350	GRIFFIN RD/TURNPIKE INTERCHANGE	0	0	0	0	0	0	0	5,210	5,21[illegible]	5,210	0	0	5,210
Y	4140924	3422	I-95/GRIFFIN ROAD INTERCHANGE	0	0	0	0	0	0	0	8,300	8,30[illegible]	8,300	0	0	8,300
			CONSTRUCTION SUBTOTAL	138,463	9,567	148,030	345,646	7,090	352,736	4,386	99,501	456,62[illegible]	455,184	1,439	560,608	(103,985)
			CONSTRUCTION RESERVE				0	0	0	0	24,985	24,985	26,424	(1,439)	0	24,985
			CONSTRUCTION TOTAL	138,463	9,567	148,030	1	7,090	352,736	4,386	124,486	481,6[illegible]	481,608	0	560,608	(79,000)

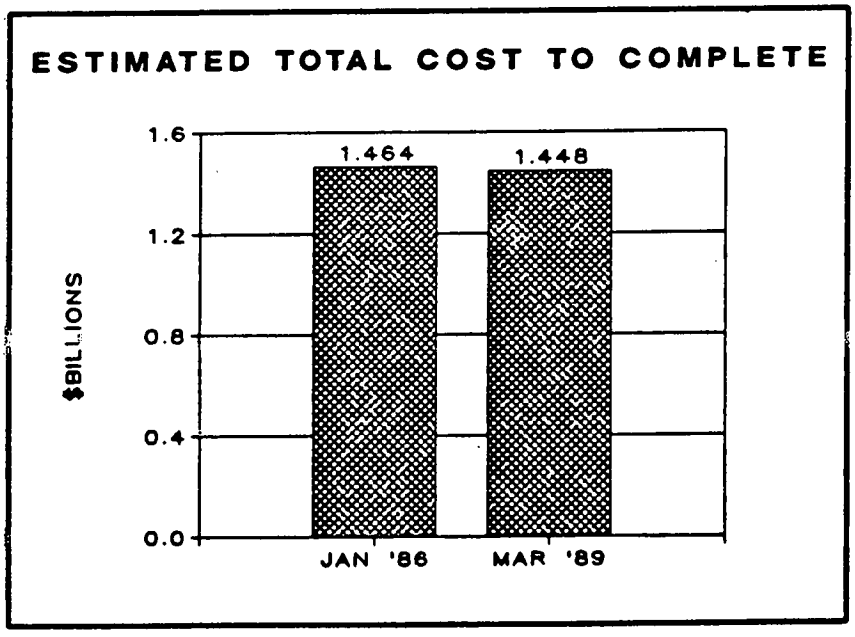
PROGRAM EXPENDITURES

The actual expenditure of $317 million is $5 million below the current I-90 plan, through March.



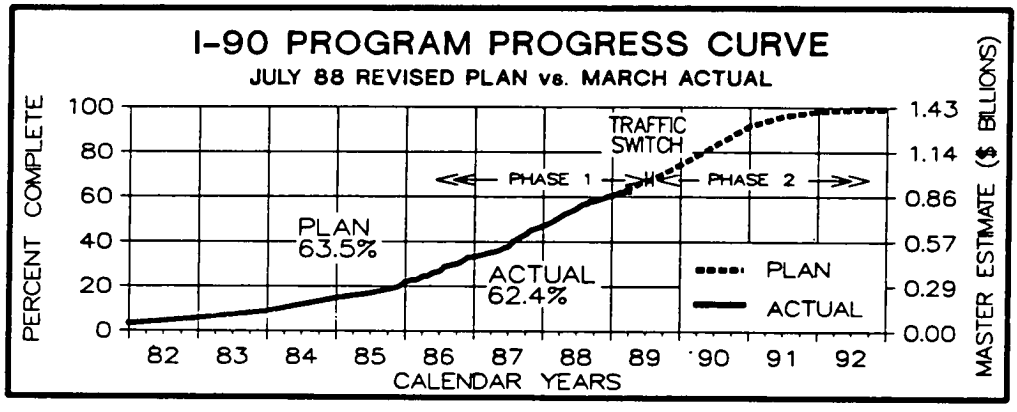
ESTIMATED TOTAL COST TO COMPLETE

The total estimated cost to complete I-90 is now $1.448 billion.



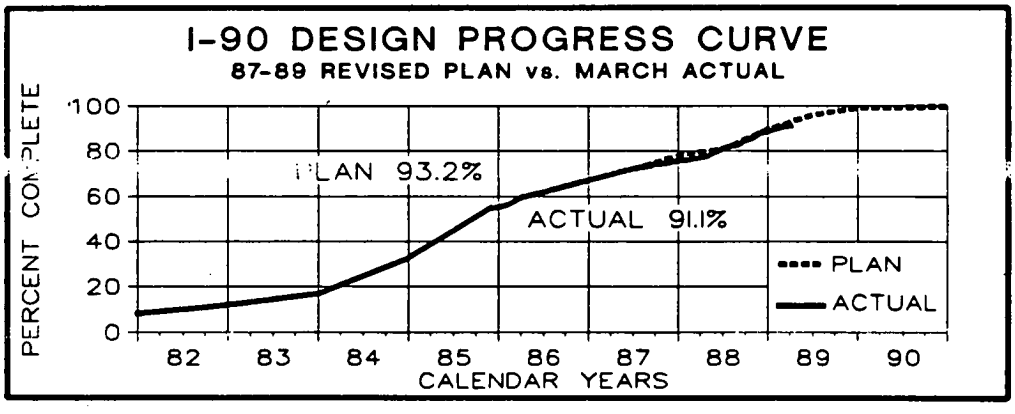
I-90 PROGRAM PROGRESS CURVE

Overall progress for the month was 0.4% compared to a planned progress of 0.9%. To date, actual progress is 62.4% compared to planned progress of 63.5%.



DESIGN PROGRESS CURVE

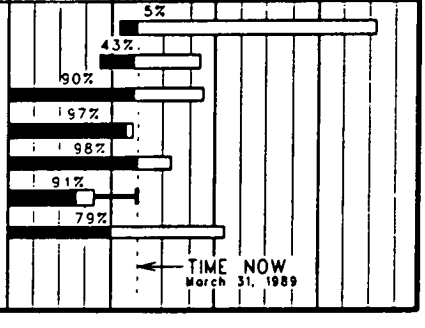
The Design Progress Curve shows that progress for the month was 0.4% compared to a planned progress of 1.0% to date, actual progress is 91.1% compared to planned progress of 93.2%.



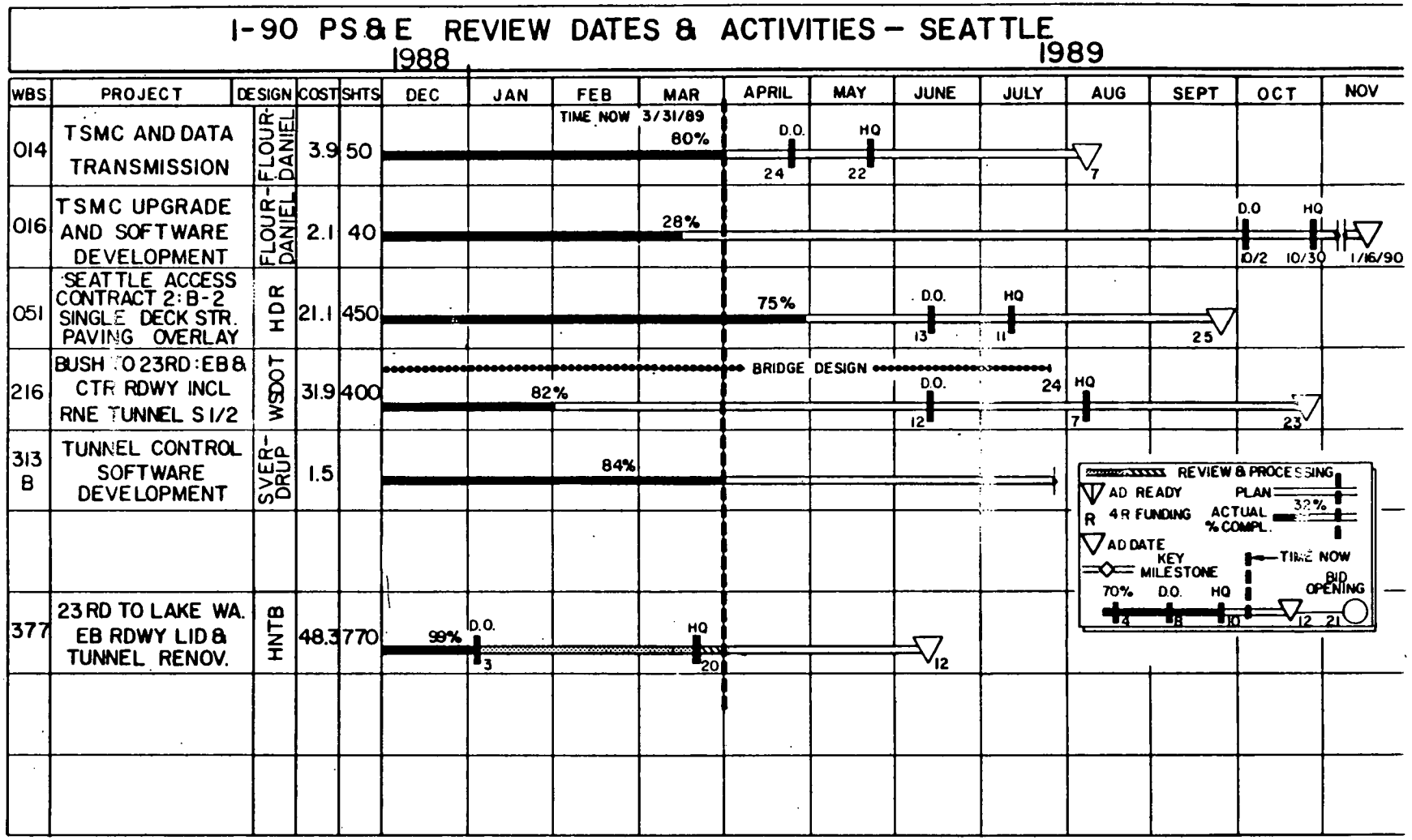
The status of construction projects of special interest is shown below.

CONSTRUCTION PROJECTS OF SPECIAL INTEREST

PROJECT	CONTRACTOR	Original Amount $ Mil.	Current Amount $ Mil.
Seattle Transit Access #1	Kiewit	58.7	58.7
EB & CTR Embankment Preload	Rivera & Green	4.9	5.0
23rd to Lake Washington	Kiewit/Atkinson	70.4	71.7
Bridge Paving & Systems	Mowat	9.5	9.7
First Hill Covered Structure	Paschen	66.8	67.8
L.B. Lid to East Mercer	Led Cor/Sea	8.8	8.8
E. Mercer I/C Stage II	Groves & Sons	32.5	32.8



I-90 PS&E REVIEW DATES & ACTIVITIES – SEATTLE



DESIGN PROJECT PROGRESS REPORT
FOR PERIOD ENDING MARCH 31, 1989

WBS No.: 812	PROJECT: LB LID TO N.M.UXING EB PAVING	ORIG. AGR'T AMT.: $_897,109	TEAM LDR: D. OLSON
PIN No.:109037A	CONSULTANT: TUDOR	CUR'T AGR'T AMT.: $1,448,461	REP'T BY: D. OLSON
AGR No.: Y-3770	No. OF EMPLOYEES: 24(2)	THRU SUPPL NO.: TWO	TEL. No.: 562-4081
AREA: L-8685	WEEKS AHEAD/<BEHIND> SCHEDULE:	% INV'D TO DATE: 99.8 (1)	REVIEWED: P. J.

NARRATIVE REPORT

A. ACCOMPLISHED THIS PERIOD

- DISTRICT PEOPLE MADE REVISIONS TO MYLARS AFTER HQ REVIEW.
- DELIVERED REVISIONS TO SPECIAL PROVISIONS TO HQ 7:00 AM 3-27-89.
- DELIVERED MYLARS AND RED & GREEN REVISIONS MADE TO MYLARS 7:00 AM 3-28-89.

B. PROJECT STATUS TO DATE

- HDQTRS PREPARING PS&E FOR UPCOMING OFFICE COPY REVIEW.

C. PLANNED FOR NEXT PERIOD (* = Action Items)

- RESPOND TO OFFICE COPY REVIEW.

D. PROBLEMS AND SOLUTIONS

- RECEIVED LATE REVIEW COMMENTS FROM I-90 TRAFFIC SECTION (ILLUMINATION & ELECTRICAL) AFTER PS&E WAS TURNED INTO HDQTRS.
- CITY OF MERCER ISLAND & THEIR CONSULTANT UNABLE TO RESPOND TO HDQTRS REVIEW COMMENTS CONCERNING BUILDING/ARCHITECH. UNTIL 4-7-89.
- NEED TO ADD PROJECT ACCESS PLAN SHEET TO PS&E.
- ABOVE ITEMS TO BE RESOLVED DURING OFFICE COPY.
- TUDOR AND TAMS AGREEMENTS OUT OF FUNDS. SUPPLEMENTS NEGOTIATED, SIGNED AND SENT TO HDQTRS FOR EXECUTION.

STATUS OF KEY MILESTONES

	PLANNED	ACT(FCST)
1. PRELIM. PLANS	16MAR87	
2. 70% REVIEW	31AUG87	31AUG87
3. BRIDGE SITE DATA		
4. D.O. REVIEW	02FEB88	09MAR88
5. H.Q. REVIEW	13FEB89	13FEB89
6.		
7. AD DATE	01MAY89	(15MAY89)
PROJECT % COMPLETE:	99%	99%

E. ANTICIPATED CHANGES

F. COMMENTS & FOOTNOTES

(1) BILLING THRU JANUARY 27, 1989.

THE TRANSPORTATION RESEARCH BOARD is a unit of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering. It evolved in 1974 from the Highway Research Board, which was established in 1920. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society. The Board's purpose is to stimulate research concerning the nature and performance of transportation systems, to disseminate information that the research produces, and to encourage the application of appropriate research findings. The Board's program is carried out by more than 270 committees, task forces, and panels composed of more than 3,300 administrators, engineers, social scientists, attorneys, educators, and others concerned with transportation; they serve without compensation. The program is supported by state transportation and highway departments, the modal administrations of the U.S. Department of Transportation, the Association of American Railroads, the National Highway Traffic Safety Administration, and other organizations and individuals interested in the development of transportation.

The National Academy of Sciences is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Frank Press is president of the National Academy of Sciences.

The National Academy of Engineering was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Robert M. White is president of the National Academy of Engineering.

The Institute of Medicine was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Samuel O. Thier is president of the Institute of Medicine.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Frank Press and Dr. Robert M. White are chairman and vice chairman, respectively, of the National Research Council.

TRANSPORTATION RESEARCH BOARD
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

ADDRESS CORRECTION REQUESTED

000015M006
ROBERT M SMITH
RESEARCH & ASST MATLS SUPVR

IDAHO DEPT OF TRANSPORTATION
P O BOX 7129
BOISE ID 83707