CONSTRUCTION MANAGEMENT OVERSIGHT OPTIONS FOR UMTA

Prepared for:

Urban Mass Transportation Administration
U.S. Department of Transportation

Prepared by:

U.S. Department of Transportation
Transportation Systems Center
Cambridge, Massachusetts

November 1, 1983

FOREWORD

This report presents the findings and recommendations of the Task Force formed at the request of the Urban Mass Transportation Administration (UMTA) to conduct an assessment of UMTA construction management oversight practices compared to other funding agencies. The report is based on interviews with UMTA headquarters and regional staff, UMTA grantees and project managers in other organizations with financing responsibility similar to UMTA's.

The authors of this report wish to express their sincere appreciation to the many individuals and their organizations who contributed their advice and effort in this study. Thanks are given to the individuals interviewed in the UMTA regional offices, transit agencies and other agencies listed in Appendix C. Special contributions were made by Dr. Peter Benjamin, Associate Administrator of the Office of Technical Assistance, Mr. Robert McManus, Associate Administrator of the Office of Grants Management, and their staff who provided the original study design, many useful comments and suggestions, and contributed significantly to the structure and content of the final report.

We are also grateful to Ruby Boyd and Joanne Semenza for their many efforts in support of this study.

TASK FORCE MEMBERS

Dr. Frank F. C. Tung
Associate Director
Office of Systems Assessment
Transportation Systems Center (TSC)
(Task Force Manager)

Santo J. Gozzo
Maintenance and Productivity
Division, TSC

Dr. Lawrence L. Vance
Plans Office, TSC

Gary T. Ritter
Plans Office, TSC

Christina O. Yu
Operations Assistance Division, TSC

Lawrence P. Silva
Maintenance and Productivity
Division, TSC

The Task Force was assisted in the interview process by Philip A. Mattson and Stephen N. Bobo of TSC.

CONSTRUCTION MANAGEMENT OVERSIGHT OPTIONS FOR UMTA

for the

URBAN MASS TRANSPORTATION ADMINISTRATION

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

INTRODUCTION

Since 1964, when it was initially established, the Urban Mass Transportation Administration's (UMTA) financial and technical assistance programs have expanded significantly. A major part of this expansion has been a dramatic increase in construction grants for new rail transit systems during the last decade to a current level of $500 million per year. In this period, UMTA has undergone a substantial reorganization to a regional structure for the management of its programs. UMTA has identified a strong need to make its own construction management oversight activities more deliberate and comprehensive. UMTA's challenge is to provide adequate oversight of its expanding construction program with its diminishing resources.

At the request of UMTA, a study team was formed on July 29, 1983 at the Transportation Systems Center (TSC) to conduct a review of the project management and grant monitoring procedures employed by the UMTA Regional Offices in projects involving large construction. The purpose of this review was to document the current construction management oversight practices within UMTA and other agencies, and to provide a list of construction management options for additional oversight actions.

At UMTA's direction, the study team focused its review on new rail system construction. UMTA's construction management oversight practices on transit construction projects were compared with those of the Environmental Protection Agency (EPA), the Federal Highway Administration (FHWA), the Federal Aviation Administration (FAA) and the International Bank for Reconstruction and Development (World Bank). Interviews were also held with the technical staff of these funding agencies and several UMTA regional offices. Those interviews were supplemented by substantial input and review by UMTA senior staff. The study team also interviewed UMTA grantees as well as some of their consultants. These include: MBTA/Boston, MARTA/Atlanta, DCTA/Miami, NFTA/Buffalo, WMATA/Washington, and MTA/Baltimore.

BACKGROUND

Major construction projects generally involve three organizational roles:

1. The owner - prepares plans and specifications to define the project, sets time constraints for project initiation and completion, and monitors project progress to ensure that construction meets specifications, is on schedule and within budget.

2. The builder - contracts with the owner to construct the project.

3. The financier - provides the capital resources to finance the project's construction, and places management controls on the owner to protect their invested capital.

Construction Management is a complex process directed by the owner involving multiple organizations performing management functions to control, monitor, inspect, test and coordinate numerous construction activities. Construction Management Oversight consists of the management review and audit functions performed by funding or granting institutions (the financier) over loan recipients/grantees (the owner). Responsible oversight insures that the construction management process is properly implemented.

FINDINGS

The study team found that:

- As financiers, all the funding agencies surveyed conduct construction management oversight functions and rely on more than one approach. The role, level of involvement, and degree of emphasis varies.

- All the federal agencies surveyed, except UMTA, have in-house training programs for their engineers regarding construction management oversight procedures.

- UMTA project engineers monitor a significantly higher amount of construction work in progress than engineers in the other agencies surveyed.

- o UMTA internal project management guidelines provide broad administrative guidance, but lack technical and procedural details regarding construction management oversight. A construction management oversight aproach that can be administered with limited resources by UMTA is presently not available.

- o Because of limited engineering staff, UMTA oversight emphasis has been placed on cost and schedule issues, rather than reviews of grantee construction management plans, quality assurance reports and periodic on-site inspections.

- o Despite the limited UMTA involvement in construction management oversight, there have been few major problems with construction quality.

CONCLUSIONS

Based on the techniques and procedures employed by other grant agencies, the study team identified three broad categories of possible oversight actions for UMTA's consideration. The action categories range from "hands-off" through "eyes-on" to "hands-on" and are characterized by increasing federal involvement with increased resource requirements. The hands-off category is a minimal UMTA involvement approach providing only technical support or requiring certification. The eyes-on category involves detailed project record reviews whereas the hands-on category requires actual on-site visits or prolonged residency by UMTA staff.

The list of alternative actions that can be adopted by UMTA include:

A. Technical Support

- o Establish a full scale construction management training and orientation program for UMTA and grantee technical staff, including grantee-hired consultants.
- o Provide technical support by developing technical construction management manuals for use by grantees, and their consultants.

B. Certification

- o Require the grantee or an independent consultant to certify that structures are built in accordance with project plans and specifications.

C. Project Record Review

- o Establish guidelines for construction management and evaluate the adequacy of grantee-proposed construction management plans.

D. On-Site Inspection

- o Conduct periodic spot checks of the construction management plan implementation by the grantee.
- o Establish a full-time resident inspector to conduct more intensive on-site examinations of construction management performance and construction quality.

The above actions could be the basic components of a recommended construction management oversight option. Combinations of several of these potential actions may provide the best balance between the execution of a sound set of construction management activities and limited UMTA resources.

Additional skilled, construction management engineering resources must be applied to implement these actions. Implementation can be accomplished through a direct increase of UMTA staff, redeployment of existing UMTA staff or through a contract with a third party such as a private consultant.

1. INTRODUCTION

1.1 General

The Transportation Systems Center (TSC) assembled a special study team in response to the request of the Urban Mass Transportation Administration (UMTA) to review UMTA and other grant agencies' Construction Management Oversight (CMO) practices. Construction management oversight is the term widely used to describe the construction management review and audit functions performed by funding or granting institutions over loan recipients or grantees. In UMTA, the construction management oversight function is a part of the project management responsibilities of their regional offices. Within UMTA, the broader term "project management" is often used when referring to construction management oversight. Construction management oversight is used here to mean a special review and audit function performed during construction and excludes preconstruction activities such as planning, design, and constructability or bidability reviews.

The purpose and approach to the study is described in this chapter. The second chapter provides a general review of construction management practices. Chapter Three provides a description of a range of potential construction actions. Chapter Four describes the present UMTA practices in construction management oversight and compares them to those of other granting and funding agencies. Chapter Five provides estimates of the various resource requirements and discusses funding needed to implement the range of actions presented.

1.2 Purpose

Since 1964, when it was initially established, the Urban Mass Transportation Administration's (UMTA) financial and technical assistance programs have expanded significantly. A major part of this expansion has been a dramatic increase in construction grants for new rail transit

systems during the last decade to a current level of $500 million per year. During this period, UMTA has undergone a substantial reorganization to a regional structure for the management of its programs. UMTA has identified a strong need to make its own construction management oversight activities more deliberate and comprehensive. UMTA's challenge is to provide adequate oversight of its expanding construction programs with its diminishing resources.

This report is designed to assist UMTA in preparing a CMO policy and a program which would guide UMTA and grantee activities to reasonably assure the completion of high quality transit construction projects on time and within budget. In particular, the report is intended to:

1. Inform UMTA of a wide array of actions that might be taken to oversee and positively effect the quality of construction management on its projects.

2. Organize this array of options in such a way as to facilitate their selection and inclusion in a comprehensive and consistent CMO program.

3. Provide UMTA with an overview of the environment within which its CMO program must operate including the strategies of other similar funding agencies.

4. Serve to educate all those involved in establishing and implementing UMTA's CMO Program by providing background and context for the specific actions included in the program.

5. Serve as a baseline against which subsequent reviews and updates of UMTA's CMO Program can be accomplished.

1.3 Approach

The study team reviewed UMTA's construction management oversight practices and compared them to those of similar funding agencies. The implications

for UMTA of increased construction management oversight also were examined. At UMTA's request, the study team focused its review on "new start" rail transit system construction and comparable construction projects in other agencies. Construction management practices on major rail modernization projects were not studied.

The report is based on a series of interviews with UMTA regional personnel responsible for construction management oversight, with urban transit agencies which have large rail transit construction projects underway, and with officials from other organizations which administer comparable construction grant or finance programs. Although the study is based on a limited sample, the results should be representative of institutions responsible for construction management oversight. However, there are undoubtedly detailed variations in construction management oversight practices which could not be observed during the limited time of this study.

2. CONSTRUCTION MANAGEMENT PRACTICES

2.1 Introduction

This chapter broadly describes the major elements of construction management and provides a common framework for discussing UMTA and other agencies' construction management oversight practices. Construction management is a complex process involving multiple organizations performing management functions to control and coordinate numerous construction activities.

A major construction project may have many diverse characteristics. It may involve complex inter-related civil, environmental, electrical/power, electronic, mechanical, and structural features. Typical project costs range from tens of millions to hundreds of millions of dollars. In general, major projects are constructed in coordinated phases over a substantial time period. They are divided into contracts of manageable size, typically in the one to fifty million dollar range. To satisfy a major project's overall functional requirement, component sections must be integrated.

2.2 Construction Process Participants

Major construction projects generally involve three organizational roles. These are: the owner, the builder, and the financier. Typical owners, builders, and financiers for the construction programs surveyed are identified in Table 1.

The owner prepares plans and specifications to define the project, sets time constraints for project initiation and completion; and monitors project progress to ensure that construction is as specified, on schedule, and within budget. The owner's responsibilities often are carried out through architectural, design engineering, and construction management consultants, rather than by the owner's employees.

The builder contracts with the owner to construct the project according to owners plans and specifications. The builder role is often carried out by several independent, private construction and system equipment contractors; each responsible for a specific project section or system-wide installation.

TABLE 1. PARTICIPANTS IN VARIOUS GRANTS PROGRAMS

FINANCIER	OWNER	BUILDER
UMTA	TRANSIT AUTHORITY	PRIVATE CONST. FIRM
FHWA	STATE HIGHWAY AGENCY	PRIVATE CONST. FIRM
FAA	AIRPORT AUTHORITY	PRIVATE CONST. FIRM
EPA	LOCAL COMMUNITY	PRIVATE CONST. FIRM
WORLD BANK	FOREIGN NATION	PRIVATE CONST. FIRM

The financier provides the capital resources to finance project construction, and places management controls on the owner to protect invested capital. Private financiers protect their investment so they may eventually recover their capital. Government financiers, on the other hand, have the responsibility to protect the taxpayer's investment, and assure cost effective accomplishments of their legislative mandate. They must provide sufficient oversight and control of public expenditures to minimize vulnerability to waste and mismanagement by the grant recipients.

2.3 Construction Management

Construction Management (CM) defines the broad process by which a major construction project is undertaken. It involves Quality Control (QC) and Quality Assurance (QA) activities such as monitoring, inspecting, testing, and reporting. Its purpose is to complete the project on-time, within budget, and in accordance with plans and specifications.

To ensure that the project is being constructed according to the owner's requirements, both the owner and the builder use Quality Control techniques and may employ Quality Assurance procedures. The owner employs QC/QA

procedures as part of overall project acceptance and payment procedures. The builder also uses similar procedures to control construction operations and to assure that completed work will be acceptable to the owner.

Quality Control is an inspecting, testing and reporting process performed continuously throughout construction by full time, on-site resident engineers and inspectors. Resident engineers represent the owner, supervise the inspection staff, report project progress and document as-built project conditions. Inspectors observe construction, sample and test materials and document their activities in the form of daily reports and nonconformance reports. The resident engineer and inspectors perform some tests on site; other non-subjective tests may be sent to labs or conducted by the builder/contractor as appropriate.

Quality Assurance is a management review and audit function conducted to confirm that quality control process is being performed properly. It can be implemented in many different ways. In some cases a separate, full-time quality assurance staff is established within the construction management organization. In other situations, the quality assurance function is an ancillary activity of appropriate construction management staff members. It may include builder participation.

The owner, not the financier, has primary responsibility for CM including QC/QA. The owner uses QC to verify that the project is progressing as specified, before making progress payments to the builder for completed work in place. Owners generally employ QA to confirm that the QC process is functioning properly and the construction records are properly maintained, since they are the basis for contractor payment and for preparing as-built project drawings.

The financier oversees the management performance of the owner in terms of schedules, cost and technical performance. Financiers have the responsibility of overseeing that the owner's CM process is properly implemented.

For major rail construction projects, most transit agencies use CM consultants. Generally, transit agencies do not want to maintain large construction staffs because construction activity fluctuates in relation to available funding, and eventually decreases to a moderately low level of continuing construction activity. The use of CM consultants by surveyed transit agencies is shown in Figure 1.

Normally, ten to twelve percent of total construction cost is for construction management. This CM cost generally includes all of the owners activities related to control of the construction process. They begin when the construction is initiated. Initial design and procurement activities, which take place before construction, are not included in construction management. Forty percent of CM cost is for the owner's QA/QC function (4-5% of the total construction cost), whereas the remaining 60% is for other activities including administration, design support and contract monitoring. This is depicted in Figure 2. The financier's construction management oversight function generally amounts to less than one half of one percent of the project funding.

Construction management cost varies depending on project type, complexity and scheduling. For example, the QC/QA requirements for a right-of-way clearing, grading and drainage project are far less than those for constructing a nuclear power plant. Also, if many construction operations are carried out simultaneously at various widely separated sites, both the owner's construction management, including QC and QA, and the financier's oversight labor requirements can be expected to increase.

2.4 Failure Mechanisms

As construction projects become large and increasingly complex, the probability of construction difficulties occurring increases. These difficulties involve items which physically cannot be constructed according to the project plans and specifications, and items which through negligence are not constructed in accordance with the approved plans and specifications.

CONSTRUCTION MANAGEMENT STAFF IN-HOUSE VS. CONSULTANTS

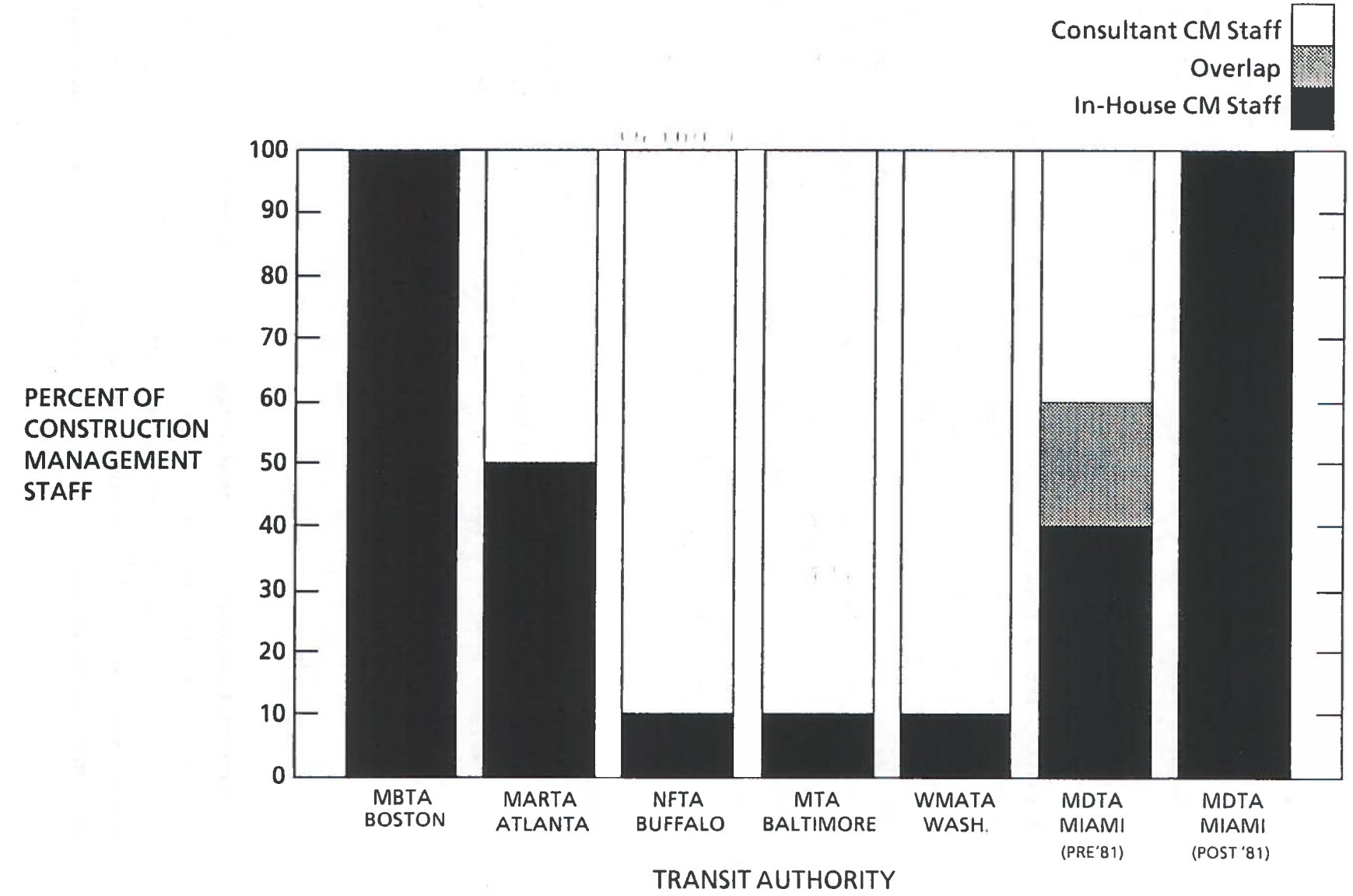

FIGURE 1

CONSTRUCTION MANAGEMENT COST AS A PERCENT OF TOTAL CONSTRUCTION COST

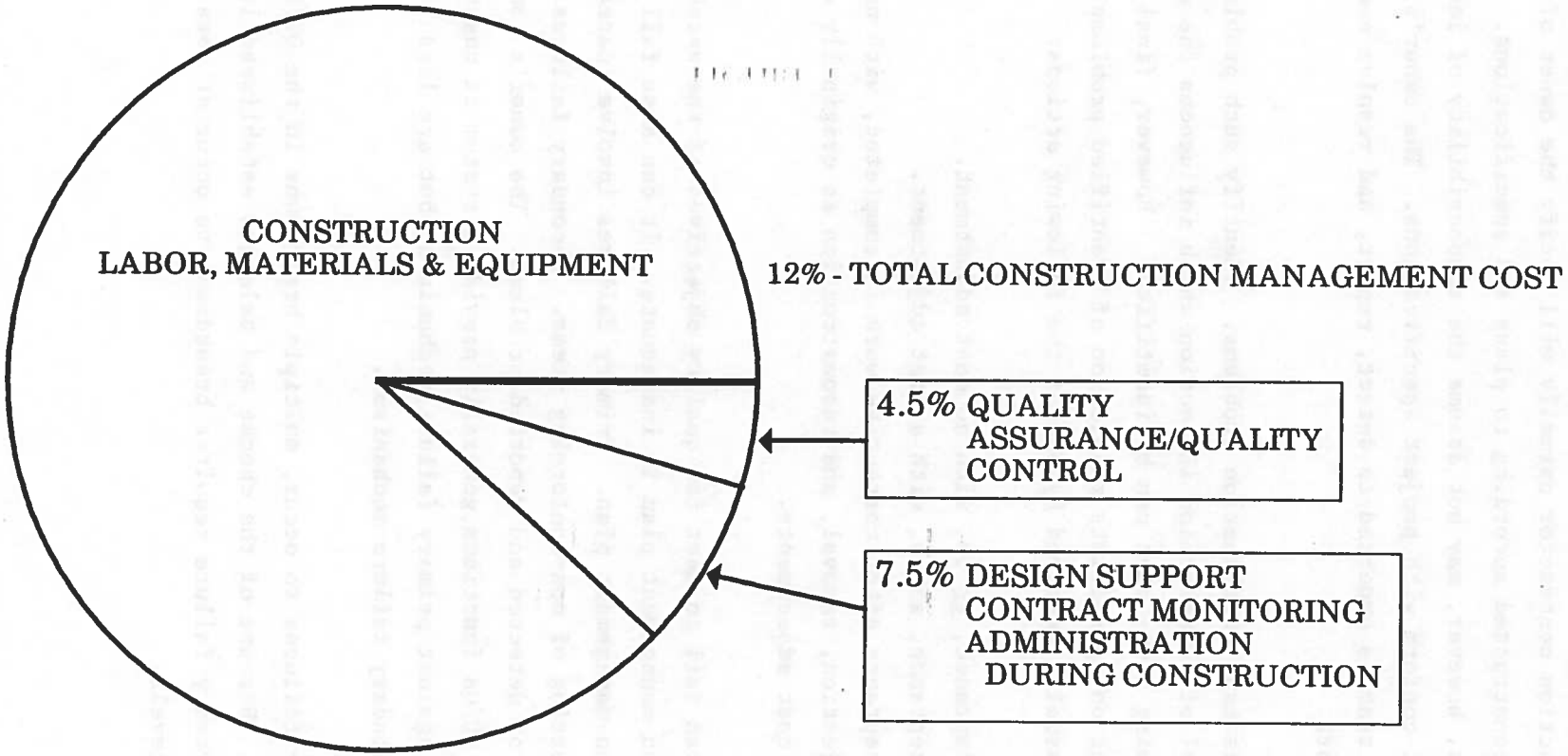

FIGURE 2

The construction contractor normally will notify the owner of items which cannot be constructed according to plans and specifications. Construction contractors, however, may not assume the responsibility of identifying items that do not conform with project specifications. The owner's construction management team is expected to detect, report, and resolve non-conforming items of work.

All projects have construction problems. Identify such problems is a function of the level of construction inspection which influences the number of non-conforming items that can be identified. However, final project quality is dependent on appropriate resolution of identified problems. Non-conforming items are usually resolved by one of the following actions:

1. Acceptance, as is, with no cost adjustment.
2. Acceptance, as is, with a cost adjustment.
3. Acceptance after corrective work is completed, with no cost adjustment.
4. Rejection, removal, and reconstruction as originally specified, with no cost adjustments.

A project can fail to meet its quality objectives if the established construction management plan is inadequate. It can also fail with an adequate construction management plan. Primary failures involve inadequate detection and/or reporting of non-conforming items. Secondary failures involve improper resolution of detected and reported problems. The owner's construction management QC/QA functions generally provide a system of checks and balances to protect against primary failure mechanisms, but are less likely to protect against secondary failure mechanisms.

For primary failures to occur, multiple breakdowns in the QC/QA system have to take place. Because of the checks and balances established in the QC/QA process, primary failure requires breakdowns to occur at more than one of the following levels.

1. Inspector Level

   - failure to observe a construction quality problem
   - failure to take authorized action
   - failure to report discrepancies and non-conforming constructions to resident engineer

2. Resident Engineer Level

   - failure to discover inadequate inspection
   - failure to take authorized action to resolve discrepancies

3. Construction Management Quality Assurance Staff

   - failure to detect or report quality control process breakdown

Secondary failures, on the other hand, can occur by a single action. They generally occur at the owner's top level of management. For example, secondary failure can occur if management accepts work based on faulty QC inspecting, testing and reporting, or accepts work without properly resolving known deficiencies. Another example would be top level management failure to take appropriate actions based on quality assurance audits which identify deficiencies.

The financier's oversight role provide an important check for secondary failures, which generally are associated with imprudent owner actions or inactions. It also provides back-up against a combination of primary and secondary failures; a situation which indicates serious construction management deficiencies.

3. CONSTRUCTION MANAGEMENT OVERSIGHT PRACTICES

3.1 Introduction

There are several approaches that a financier (in this case, the federal agencies) can adopt in the management of construction projects. Generically, the federal role can be grouped into three categories: 1) no further federal oversight involvement after funding; 2) direct federal involvement in construction management; and 3) oversight of the grantee's construction management process.

The Federal role in the first category is similar to the concept of revenue sharing where total responsibility would reside with the grantee. For example, a revenue sharing approach could be used to fund local construction projects with no direct federal involvement. Abandoning the oversight function, however, is inconsistent with current OMB Circular A-102 guidelines which require grantor technical oversight. It is also inconsistent with the practices of other federal grant agencies which provide construction project oversight.

The Federal role in the second category is on the other extreme. In this case the federal agencies would assume the responsibility for performing the quality assurance function on major construction projects with either its own forces or supplemental staff from another federal agency or a private consulting firm. Assumption of this role would result in a shared responsibility with the grantee for construction quality and would conflict with current OMB guidelines which are intended to reduce Federal intrusion into local responsibilities.

As financiers, the appropriate construction management role for federal agencies is the oversight of grantee construction management processes. A list of potential oversight actions is described in the next section.

3.2 Potential Oversight Actions

There are many CMO actions that a federal agency can adopt to carry out its oversight responsibilities. Conceptually, these actions can be divided into three categories: HANDS-OFF, HANDS-ON, AND EYES-ON. These categories are characterized by increasing federal involvement with increased resource requirements. HANDS-OFF is minimal federal involvement with only technical support provided and/or certification. EYES-ON involves detail project record reviews whereas HANDS-ON means the actual on-site visits or residency by the financier's staff.

3.2.1 Hands-off Actions

The hands-off CMO action category includes technical support and certification. Certification is considered a hands off action for the purposes of this study because it involves only limited regulatory actions on the part of the financier. Certification may, however, be a significant cost to the owner. The hands-off actions are shown in Table 2 and described below.

3.2.1.1 Technical Support

The objectives of technical support are to aid in deploying the latest methods, procedures and equipment and to develop and aid in deploying new concepts. Funding agencies normally provide some or all of the following types of technical support:

- o New concept development, test evaluation and deployment
- o Technology transfer
- o Training
- o Direct technical assistance

Only training and technology transfer are considered here since new concept development is usually focused on cost reduction and direct technical assistance is generally directed toward design and safety problems.

TABLE 2. HANDS-OFF CMO ACTIONS

	CM TECHNICAL SUPPORT		CERTIFICATION	
CMO Action / Level of Effort	TRAINING	Technical Development & Transfer	Construction Management Plan	Constructed to Plans & Specifications
LOW	• Limited Use of Existing Training at Outside Teaching Institutions	• Technology Transfers of State-of-the-Art CM Practices • Informal Staff Contacts	• Requires Grantee to Certify Completion of CM Plan	• Require Grantee to Certify that Project is Constructed to Plans & Specifications
MED	• Training for all Staff Tailored for Specific Agency's Needs	• Modify Existing Guideline Specifications & Procedures for CM, QA/QC	• Require Grantee to certify Completion of CM Plan and Its Implementation	Same as Low Option
HIGH	• Establish Internal Training Institute & Specialized courses • Provide Training for Internal Staff and Grantees or Loan Recepients	• Develop New concepts in CM Methods & Practices	• Certification of CM Plan by Owner • Incremental Federal Funding Contingent on Periodic Receritification that CM Plan is Being Followed	• Requires Grantee to Provide Independent Certification that Construction Conforms to Plans & Specifications

A. Training

Training for construction professionals is necessary to maintain the skills of existing staff and to develop new staff. Inadequately trained staff can directly impact the quality of construction through inaction or inappropriate actions.

Formal training courses are used throughout the construction industry. Large organizations often develop their own internal training programs, while smaller organizations typically utilize outside training provided by universities or professional groups. Courses in construction management are widely available to construction professionals. Construction management oversight training, although less available, is currently provided by some of the larger government agencies (e.g., Corps. of Engineers, FHWA). There are, however, few CM and CMO courses applicable to transit applications.

Depending on the availability of resources, the training program can be divided into three levels of effort. This is also shown in Table 2. The low level provides limited training through outside teaching institutions. Such course offerings are useful, but not specifically tailored a specialized field of work. The medium level provides training for all staff tailored for specific agency's needs whereas the high level requires the establishment of an internal training institute and specialized courses, and training would be provided for internal staff and grantees or loan recipients. The pros and cons of training as a CMO action are:

Pros:

- Improve financier and owner's staff effectiveness
- Provides mechanism for teaching good practices
- Encourages use of state-of-the-art methods
- No burden on recipients

Cons:

- o Does not establish an oversight link to individual projects
- o Requires allocation of staff time for training
- o Does not have an immediate impact on project quality

B. Technical Development and Transfer

Although the specifications and procedures used for construction management by various agencies are similar, it is difficult to identify the most effective. Specifications and typical procedures for narrower segments of the industry such as transit construction are only available through past project documentation.

Significant documents in CM and CMO include:

- o Construction Management Plans
- o Specifications for procuring Construction Management Services
- o Procedures manuals for resident engineers
- o Procedures manuals for inspectors
- o Procedures manuals for inspection testing
- o Quality Assurance Plans
- o CMO procedures manuals

To improve the stewardship of the funds they invest in large construction projects, large financiers often schedule conferences and workshops to encourage CM and CMO state-of-the-art information exchange. Guideline specifications and procedures manuals also are prepared and widely distributed.

The low level of effort in technical development and transfer involves technology transfer of state-of-the-art CM practices whereas the high level of effort includes the development of guidelines, specifications and procedures for CM, QA and QC. The pros and cons of technical development and transfer as a CMO action are:

Pros:

- o Good procedures would be assured if adopted
- o Costs are relatively low
- o Federal role is appropriate

Cons:

- o Does not provide an oversight link to individual projects
- o Provides no assurance that good specifications and procedures will be adopted and implemented

3.2.1.2 Certification

Certification of a construction project can take a variety of forms and can be provided by the builder, the owner or, an independent consultant reporting to the financier or the owner. In all cases, the desire is to assure the financier that the construction process and/or construction quality are as specified.

In general, there are:

- o Design certifications to assure that facilities have been designed in accordance with certain nationally recognized standards and practices.
- o Material certifications to assure that the materials used for construction are as specified and meet certain nationally accepted standards.
- o Construction certifications to assure that a construction project has been constructed in strict accordance with the contract plans and specifications.
- o CM plan and implementation certifications to assure that a CM process is operating properly.
- o Safety certification to assure the the facility is safe for use by the public.

Although design certifications affect the project which is ultimately constructed, they relate only to design and are normally completed prior to the onset of construction. Safety certification varies from state to state and the certifying body also varies between Public Utilities Commissions, Public Safety Commissions, State Transportation Departments and others. Both design and safety certifications are not normally related to CM and, therefore, are not addressed in the remainder of this report.

Material Certification

Certification regarding materials used during construction is a very important part of the construction process. It is the construction manager's responsibility to collect certifications from material and equipment suppliers when the materials are delivered to the project and to maintain records that indicate compliance with specifications. This function is normally conducted at the construction site or material supplier's plant. The certifications become part of the official construction records.

Construction Certification

Formal certification indicating that a project has been constructed in accordance with plans and specifications is relatively novel. There is no known requirement other than a recent one at EPA (currently being implemented) that requires the builder or the owner to formally certify that the facility has been built to conform to all of the requirements of the contract plans and specifications. On the other hand, there is often wording built into the payment procedures that payment can only be made for work built in accordance with the plans and specifications. In effect, the builder or the owner, by submitting a payment request, is saying that the construction conforms to the plans and specifications even though a separate certificate stating this is not required.

CM Plan Certification

CM plan certifications assure that a construction management plan has been prepared and may assure that it is being implemented as intended. At the low level of effort, only the completion of the CM plan is certified by the grantee. At the medium level, the plan and its implementation are certified. At the high level, federal incremental funding is made contingent on receipt of the certification.

The pros and cons of requiring certification as a CMO action are:

PRO's

- Provides clear statement of owner's responsibility for providing and implementing a construction management plan
- Enhances owner's incentive to emphasize quality construction

CON's

- Places increased paper work burden on owner/recipient
- No independent review is provided

3.2.2 Eyes-on Actions

Eyes-on oversight is characterized by successive levels of project record reviews. It is the first step into the realm of active construction project management oversight but does not necessarily require site visits.

The reviews can be grouped into three broad categories as shown in Table 3. The three categories are: Construction Progress Report Reviews, Construction Management Program Reviews, and Physical Construction Record Reviews.

TABLE 3. EYES-ON CMO ACTIONS

	PROJECT RECORD REVIEWS		
PROJECT RECORD / LEVEL OF EFFORT	**Construction Progress Reports**	**CM Plan/Implementation**	**Physical Construction Records**
LOW	• Semi-Annual to Annual Review • % Work Completed vs. % Funds Expended Reviewed	• CM Plan Required • CM Plan Reviewed	• Infrequent Review • Only Major Cost Items Reviewed • Selected Plan and Specification Requirements Checked
MED	• Quarterly Review • % Work Completed vs. % Funds Expended Reviewed • Construction Difficulties Noted • Next Quarter Progress Projected	• CM Plan Required • CM Plan Evaluated • CM Implementation Reviewed	• Periodic Review Schedule • Systematic Review Plan Developed • Major Cost and Critical Construction Items Covered • Critical Plan and Specification Requirements Evaluated • Project Change Orders Reviewed
HIGH	• Monthly Review • % Work Compeleted vs. % Funds Expended Reviewed • Construction Difficulties Checked for Resolution • Anticipated Project Issues Reviewed • Significant CM Activities Noted	• Formal CM Plan Required • CM Plan Evaluated • CM Implementation Reviewed • CM Program Evaluated	• Systematic Review Plan • All Construction Items Covered. All Plan and Specification Requirements Reported Under the CM Plan Checked • Project Documentation Reviewed in Detail

3.2.2.1 Construction Progress Report Reviews

Construction progress report (CPR) review is a very common and widespread project management mechanism. It is used by most agencies surveyed for this report as the primary basis for making project progress payments.

Typically, construction progress reports correspond to progress billing periods. Progress reports generally are in a narrative format, but may include photographs and/or drawings to convey complex or detail information. Construction progress reports quantify progress in terms of time elapsed, funds expended, and physical construction completed. In addition, they address the following project issues:

- Major construction activities accomplished during the reporting period.
- Status of critical construction elements.
- Major construction activities planned for the next reporting period.
- Construction difficulties that have occurred during the reporting period.
- Resolution of past construction difficulties during the reporting period.
- Unresolved construction difficulties carried into the next reporting period.
- Factors which may impact the project during the next reporting period such as anticipated contract claims, proposed project change orders, and proposed project time extensions.

Construction progress reports are reviewed against specific criteria for progress payment and/or continued project funding. The review criteria is often established to answer the following questions:

- Are project activities within the approved project scope?
- Are project objectives being met?
- Are project cost overruns likely?
- Are critical project elements being completed on time?

At a low level of effort, major construction projects receive semi-annual or annual review. Review periods in excess of one year are inconsistent with OMB A-102 and therefore, virtually non-existent. Typical low level reviews evaluate:

- o % work completed vs. % funds expended
- o A summary of completed work
- o Identified construction difficulties

A medium level of effort includes quarterly progress report reviews similar to the low level, but in more depth. Medium level review, in addition, generally evaluate projected project progress for the next quarter.

A high level of effort provides a similar review to the medium level but more frequent, generally monthly. It may include review of charge orders, time extensions and contract claims. This level exceeds the OMB A-102 recommended progress reporting guidelines.

The pros and cons of adopting construction progress report reviews as a CMO action are:

PRO's

- o Establishes a routine communication link to the project.
- o Provides a basis for making project progress payments.
- o Projects project outcomes in time for intervention.
- o Limits financier's liability by conducting after-the-fact review.

CONS:

- o Places increased paperwork burden on owner.
- o Provides incentive to report only enough information to obtain progress payments.
- o Recorded information is at least 60 to 90 days old.

3.2.2.2 Construction Management Plan/Implementation Reviews

Construction management program reviews are more intrusive than construction progress report reviews. The reviews here focus on what is being done to assure that acceptable project progress and quality are being obtained at a fair and reasonable cost.

A construction management program can be related to two broad categories, the CM plan and its implementation. The CM plan can be formal or informal. In the more formal format, a lengthy document is prepared. It, at the least, addresses the quality and quantity of construction management labor required in the context of a proposed construction management organization. Many construction management plans also lay out inspection, testing, and reporting procedures and schedules. Formal construction management plans include:

- o An assessment of construction management skills required.
- o Estimated staffing levels throughout the project construction.
- o Quality control procedures and quality assurance functions.
- o Materials sampling and testing policies, procedures and guidelines.
- o Construction management plan implementation reporting requirements.

Construction management plan implementation records are generated based on construction management plan requirements related to staffing, inspection, testing and reporting. These records generally are summary in nature. As an example, if the construction management plan calls for a resident engineer to witness 10% of all concrete slump tests, the implementation record would contain the total number of slump tests required during a given period, the number of tests actually taken, the number of tests witnessed by the resident engineer, and perhaps, the percentage of tests that passed; but not individual test results.

Construction management plan/implementation reviews can be carried out at different levels of effort. At the low end, a construction management plan review evaluates:

- o Is a formal or informal CM plan required?
- o If required, does a CM plan exist?
- o Do existing CM plans satisfy basic requirements relating to content?

At a medium level of effort, the construction management plan is reviewed against more stringent standards and some degree of implementation review is employed. For example:

- o Does a CM plan exist?
- o Does it meet applicable standards for content?
  - Is the staffing plan reasonable?
  - Are the QA/QC procedures reasonable?
  - Is the CM plan implemented?

At the highest level, the construction management plan is reviewed in detail, its implementation is reviewed, and its effectiveness is evaluated against expected results for completed construction. Summary construction management plan implementation reports, including QA audit reports, would be reviewed.

The pros and cons of adopting CM plan/implementation review as a CMO action are:

PROS:

- o Formalizes owner's total responsibility for construction mangement
- o Demonstrates financier's interest in quality without physical construction or on-site field reviews
- o May avert field construction difficulties through good CM planning/implementation
- o Establishes project acceptance criteria and procedures

CONS:

- o Increases paperwork burden
- o May result in implied liability if financier reviews a CM plan and

then deficiencies in the plan allow construction problems to go undetected

3.2.2.3 Physical Construction Record Reviews

Physical construction record reviews consist of evaluation of physical construction records to determine if physical construction conforms to contract plans and specifications. Whereas construction progress report reviews and construction management program reviews may involve summary reports of construction quality and condition, the physical construction record review involves detailed source documents relating to physical construction conditions.

Physical construction records contain information regarding project qualities as well as quantities. Qualitative physical construction records include observation reports of specified events, such as concrete vibration, while quantitative information records include project records such as invoices and material control records which document the amount of material incorporated into a project, or physical tests and measurements regarding construction/material attributes such as concrete strength and dimension measurements.

The key feature that separates physical construction record reviews from the previously discussed construction progress and management record reviews is that it evaluates construction product results, rather than focusing on progress or process matters. Whereas the construction management program review looks to see if procedures are implemented to identify and appropriately resolve construction difficulties, physical construction record reviews evaluate resulting construction quality, regardless of what process was used to produce it; and, that appropriate quantities of acceptable material have been incorporated into the work. Physical construction record reviews generally are conducted on a statistically based sample of construction records. Sometimes, a specific physical construction record type, such as the non-conformance report (NCR), is selected for review on a routine basis.

At a low level of effort, physical construction record reviews involve:

- o Infrequent record reviews of major cost items
- o Selected contract plan and specification requirements

At a medium level of effort, physical construction record reviews involve:

- o Periodic reviews based on a systematic plan
- o Major cost and critical path construction items
- o Critical contract plan and specification requirements only
- o Project/contract technical change orders (PCO's) in addition to normal PCO reviews regarding changes in project scope or cost

At the highest level of effort, physical construction record reviews involve:

- o Frequent reviews based on a systematic plan
- o Major cost and critical construction items
- o All CM program plan and specification reports
- o An assessment of non-major construction items
- o Detailed review of physical construction source documentation

The pro's and con's of physical construction record reviews are:

PROS:

- o Evaluates quality control of materials and workmanship
- o Demonstrates strong interest in construction product quality
- o Provides highest level of assurance regarding construction quality, without a site visit
- o Limits the financier's liability through the use of after-the-fact review techniques

CONS:

- o Costs more than other off-site review techniques
- o Provides only a second hand evaluation, limited by the quality and quantity of records produced
- o Does not convey extenuating factors
- o Imposes a large paperwork burden as level of effort increases

3.2.3 Hands-On

Hands-on oversight actions are characterized by on-site project inspections whose primary function is to verify, first-hand, project status by attending briefings, and reviewing reports and construction records. In addition, inspection and testing to ascertain the quality of construction may be included to increase confidence in the owner's CM performance. On site project inspection is grouped into three major categories; Periodic Progress Meeting, CM Progress Review and Construction Inspection and Testing as shown in Table 4.

3.2.3.1 Periodic Progress Meeting

The least intrusive type of site visit is the periodic progress meeting. Such meetings generally are held at project headquarters and may include a visit to an active construction site. The review is conducted at an upper management level in a briefing format. The material covered is analogous to that covered by a written construction progress report. However, the site visit facilitates discussion among principal project participants for resolving crucial project issues in a timely fashion.

The primary function of the overall project review is to determine whether or not indivdual project elements are properly integrated and that critical elements are progressing as scheduled. Construction management and construction quality issues may be reviewed, but generally this occurs on an overall project summary level. Significant project change orders often are topics for discussion during periodic progress meetings.

TABLE 4. HANDS-ON CMO ACTIONS

	ON-SITE VISITS		
CMO Actions / Level of Effort	**Periodic Progress Meeting**	**CM Program Assessment**	**Construction Inspection & Testing**
LOW	• Infrequent Monitoring of Construction Progress • Focus on Cost & Schedules • "Windshield" Inspection Only	• Limited Sample (5%) of Construction Records • Infrequent	• Final Acceptance Inspection Only • No Active Construction Review • Visual Inspection
MED	• Quarterly Monitoring of Construction Progress • Focus on Cost & Schedule • "Windshield" Inspection Only	• Significant Sample (50%) of Construction Records • Quarterly	• Periodic Visual Inspection of Construction Progress • Witness Major System Inspection Testing • Non-Destructive and Physical Testing may be Included
HIGH	• Frequent Monitoring of Construction Progress • Focus on cost & Schedule • "Windshield" Inspection Only	• Comprehensive Review of All Construction Records • Continuous	• Continuous Presence of Financier Represenatatives • Ranges from a Single On-Site Representative to Monitor Activities, To Financiers Field Force to Certify Construction Quality • Inspection and Testing Witnessed • Non-Destructive and Physical Testing Included • Minimal Final Acceptance Inspection Required

The level of effort associated with periodic progress meetings is determined by the level of detail of the review, the amount of material to be reviewed, and the frequency of the review. Generally, such reviews include four hours of briefing and discussions, with the remainder of the day being available for construction "windshield" inspection. A low level of effort on a major project would consist of semi-annual reviews. A medium level would consist of quarterly reviews, while a high level of effort should consist of monthly reviews.

3.2.3.2 CM Program Assessment

The on-site CM program assessment verifies that the project's CM plan is being implemented and evaluates CM plan effectiveness. Visits to construction sites are made to determine:

- If the field inspection and testing corresponds to the CM plan;
- If the CM organization is adequately staffed and qualified;
- If CM records are complete, accurate, and up-to-date.

At a low level of effort, on-site CM process reviews are conducted infrequently and cover a limited sample construction records. At a medium level of effort, reviews are conducted quarterly and cover larger sample of construction records. At a highest level of effort, all construction records are audited on a continuing basis.

3.2.3.3 Construction Inspection and Testing

Construction inspection and testing is used to assess the performance of the grantee and its contractors by observing operations and assessing completed construction for conformance to plans and specifications. Inspections generally consist of visual inspection and nondestructive testing to determine if construction records accurately reflect physical conditions.

At the lowest level of effort, the inspection is usually visual without testing, and is conducted when the project is substantially complete. At

the medium level, more frequent (e.g. quarterly) checks on randomly sampled major construction items are accomplished. Testing, either nondestructive or physical may be accomplished when visual construction inspections are inconclusive or verification of recorded measurements is desired. Inspections may include the witnessing of scheduled tests on major system components. At the highest level, on-site inspection provides continuous monitoring of construction activities. A significant amount of independent testing may be conducted.

The pros and cons for on-site inspections are as follows:

PRO's:

- Allows CM deficiencies to be detected early
- Provides increased confidence regarding construction quality
- Demonstrates strong financier interest in construction quality
- On-site visits provide first hand information

CON's

- Requires significant resource committment
- May encourage grantee to inappropriately rely on the federal inspector to control the CM process
- May diminish oversight objectivity and effectiveness by continuous and "intimate" involvement
- May increase financiers' liability for construction quality

4. CONSTRUCTION MANAGEMENT OVERSIGHT PRACTICES

4.1 Introduction

Five funding agencies were surveyed for this study. They are: The Urban Mass Transportation Administration (UMTA), The Federal Highway Administration (FHWA), The Federal Aviation Administration (FAA), The Environmental Protection Agency (EPA), and The International Bank for Reconstruction and Development (World Bank). All perform some construction management oversight as a part of their overall grants/funding management. In all cases, however, the responsibility for CM rests with the grantee/loan recipient. Although all of the granting/funding agencies surveyed follow similar approaches to construction management oversight, there are significant differences in the level of reliance each puts on various oversight actions.

A measure selected by the study team for comparing the level of construction management oversight effort is the ratio of estimated active construction dollars to the annual professional labor used for oversight. Figure 3 gives such a comparison for the agencies surveyed. In the case of UMTA, $5 billion was used as the amount of construction in progress per year based on the assumption of an outlay of $1 billion per year and a 5-7 years duration per construction project. Although the comparison does not imply that similar CM activities are used by all agencies, it does give a gross ranking of each agency's oversight effort. The two tone bar for the EPA reflect its use of outside CMO support from other agencies described in detail in Section 4.5.

The construction management oversight activities of UMTA and the other agencies surveyed are summarized as follows.

4.2 Urban Mass Transportation Adminitration

Agency profile

The UMTA funded construction includes rail transit system, maintenance facility and other miscellaneous construction projects. The overwhelming

CONSTRUCTION MANAGEMENT OVERSIGHT WORKLOAD BY SELECTED AGENCIES

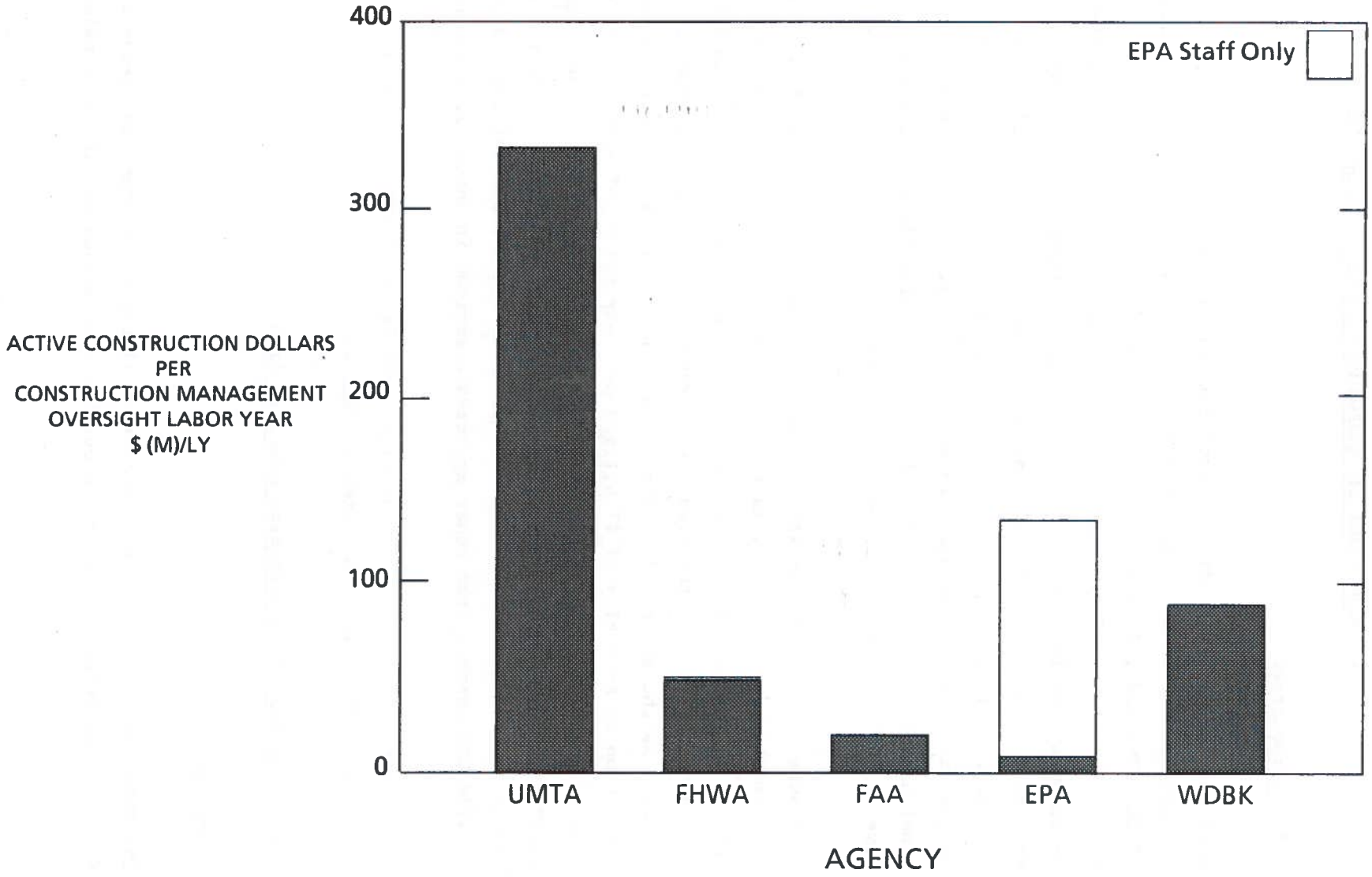

FIGURE 3.

majority of construction funds go to rail construction projects. Therefore, those projects and associated UMTA CMO activities are profiled below.

UMTA grants about $1 billion per year for major rail contruction projects. This program involves about 15 of UMTA's regional project managers. A typical project's total cost is about $750 million. It requires five to seven years to complete and involves ten to twenty contracts. The average project work load is $340 million dollars per project manager. It is important to note that none of these engineers are assigned to CMO on a full time basis.

Construction Management Oversight Philosophy

The UMTA philosophy on construction mangement oversight has been one of minimum involvement and effort. The engineers charged with CMO have little time to carry out their responsibility. The UMTA engineers surveyed indicated that only 10% - 20% of their time is spent on CMO. The majority of their time is spent on other project management activities such as grantee proposal evaluations, third party contracts issues, and audit resolution, that are not directly related to construction.

The construction management oversight provided by the UMTA regional offices varies considerably depending on regional priorities, staff availability, grantee capabilities (including consultant support) and national priorities. Each office must determine its priority for a number of competing objectives:

- Financial control and oversight.
- Technical and administrative aid to authorities.
- Project schedule adherence and technical oversight.
- Prompt delivery of grant funding.
- Minimal federal intrusions.

The study team found that UMTA construction management oversight staff uses its limited resources to place priority on front end evaluation of transit agency capabilities and the review of the plans and specifications. The review of plans and specifications is an examination of project scope and

eligibility issues, and not an in depth technical review. Rapid review and approval is emphasized to avoid project delays. Financial control and schedule adherence is monitored during construction.

The UMTA CMO program, summarized by action, is discussed below and depicted in Table 5.

Technical Support

The UMTA provides limited technical support directed at construction technology development, with little emphasis at construction management issues. No UMTA CM or CMO training exists.

Certifications

Certifications and standard assurances are used by UMTA in the grant management process but none are not construction related.

Project Record Reviews

Quarterly construction progress reports are reviewed by UMTA to a limited extent. Construction management plans sometimes are reviewed, but physical construction records are seldom reviewed due to staff limitations.

On-Site Visits

Quarterly progress meetings are held when possible. On-site CM program reviews generally are not conducted. However, marginal assessments may be made, if time permits, in conjunction with quarterly progress review meetings. Construction inspections are required as part of the UMTA project acceptance procedure. The inspections focused more on project scope considerations than detailed construction quality.

TABLE 5. UMTA & OTHER AGENCIES' CONSTRUCTION MANAGEMENT OVERSIGHT ACTIONS

CMO Action / Level of Effort	HANDS-OFF				EYES-ON			HANDS-ON		
	CM Technical Support		Certification		Project Record Reviews			On-Site Visits		
	Training	Technical Dev. & Transfer	CM Plan	Const. to Plan & Spec.	Const. Progress Reports	CM Plan/ Implementation	Physical Construction Records	Periodic Progress Meeting	CM Program Assessment	Const. Inspection &Testing
LOW		UMTA (limited)	FHWA (optional) FAA	World Bank (Some Loans) EPA (current legislation) FAA (Pre Const.)		UMTA (partial)	World Bank	FAA World Bank UMTA	EPA FHWA	UMTA (limited) World Bank
MED	EPA				FAA UMTA World Bank	FAA (Recommended)	FHWA	EPA (Plus State)	FAA World Bank	EPA FAA FHWA
HIGH	FAA FHWA	FAA FHWA EPA	World Bank (Some Loans)		EPA (Through States) FHWA (Through States)	World Bank FHWA (Statewide)				

The regions place relatively low priority on direct construction oversight. In most cases, an occasional site visit is the only mechanism employed. Unlike the other agencies interviewed, UMTA does not perform routine, in-depth site inspections or CM audits.

In summary, the study team found that UMTA does not perform the depth of construction management oversight performed by the other agencies surveyed. UMTA staff do review and evaluate the financial and schedule performance of the grantees to some depth. Occasionally, they also evaluate construction management plans and personnel. Unlike some other agencies surveyed, UMTA personnel rarely review quality control records or perform in-depth site inspections. UMTA internal project management guidelines recommend more construction management oversight than is possible to accomplish under current staffing limitations.

4.3 Federal Highway Administration

Agency Profile

The Federal Highway Administration administers a wide range of highway related programs. By far, the largest is the Federal-aid Highway Program which provides funds for highway construction including the interstate highway system. All Federal aid highways are constructed, owned, and maintained by the individual states.

The FHWA annual construction budget during the past few years has been about $10-12 billion. The field CMO staff is about 525 engineers. Typical projects are in the $1 million range, have a two to three year life, and generally involve only one contract. There are about 25,000 active projects. This translates into a workload of 50 projects (or $50 million) per CMO engineer.

Construction Management Oversight Philosophy

The FHWA concept of project management is that of a Federal-State partnership based on long standing working relationships. Before a State may participate in the program, FHWA first must determine that the State has an adequately

staffed and equipped highway agency capable of carrying out the proposed construction projects. This "up-front" philosophy is found throughout FHWA CMO procedures. Agreement is reached between FHWA and a State before critical project actions are taken by the State. The FHWA's involvement in a project depends on the project's size and type.

The FHWA employs a wide assortment of CMO actions as shown in Table 5. Various actions are applied to projects based on FHWA's desired level of involvement. The FHWA overall CMO strategy is presented below by CMO action categories.

Technical Support

The FHWA conducts substantial CM training, technology transfer, and research and development. The CM training programs range from six CMO-specific training courses for FHWA engineers to numerous workshops and seminars conducted by FHWA's National Highway Institute for highway engineers throughout the country. The FHWA has an extensive CM technology transfer program for construction management. In its research and development program, FHWA is developing improved highway construction management practices and procedures.

Certification

The FHWA has a broad optional certification program called the Certification Acceptance (CA) program. It covers a broad range of project activities, including construction management. Proposal for the CA program must demonstrate that the State has sufficient controls to assure quality and economy of construction. When this is accepted by FHWA, then they only conduct final project acceptance inspections. This program is not available for Interstate highway projects.

In addition, a mandatory certification is required by FHWA. As part of the FHWA project acceptance procedures, a materials certification is required indicating that materials incorporated in the construction work are in reasonably close conformity with the plans and specifications.

Project Record Reviews

The FHWA generally negotiates progress reporting mechanisms with individual state highway agencies. Rather than require a separate progress report, FHWA tries to identify state required reports that will serve FHWA needs. Most states produce a monthly computer generated, status report containing one line of project status information for each active project. The information includes: % work complete, % time elapsed, and % funds expended.

Construction management program and QA audit reviews form the major portion of FHWA's current CMO strategy. This strategy represents a change from FHWA's past emphasis on physical construction inspection. This philosophy is based on the theory that a satisfactory CM process will produce satisfactory construction. Final acceptance inspections are still carried out for individual projects.

Detailed physical construction record reviews are associated with statewide "inspection-in-depth" programs conducted by FHWA regarding selected construction issues. FHWA also reviews substantial project change orders. Test records are sampled on an annual basis to verify material certifications.

On-Site Visits

Periodic on-site progress reviews like UMTA's are generally not held by FHWA. On-site visits are made by FHWA which combine progress review, CM program assessment and construction inspection. The construction inspection is the primary justification for on-site visits. For other than certification acceptance projects, an initial CM focused, and a final construction focused, inspection are conducted. Intermediate and other inspections are also conducted as specified by each FHWA division's annual construction inspection program, which establishes detailed inspection priorities and strategies.

4.4 Federal Aviation Administration

Agency Profile

The FAA Airport Development Aid Program (ADAP) is a grant program which provides funding for airport facilities and for the purchase of land for airport expansion. The facilities constructed under this program include terminals, control towers, runways, and landing aids. ADAP grants provide 50% to 90% of project funding. The FAA awards about $800 million each year of which 60% is for construction. The average construction project is about $1 million and spans less than 2 years. Each project manager is responsible for about $20 million in projects. Roughly one quarter of the FAA grants staff (approximately 100 people) is actively engaged in construction management oversight.

Construction Management Oversight Philosophy

The FAA has established extensive standards, regulations and design criteria for the air transportation system. Its CMO process is oriented to assure that all airport construction complies with its requirements. The FAA is deeply involved in all project phases from planning through construction and final acceptance as shown in Table 5.

Technical Support

The FAA has a large technical assistance program. FAA provides training for its own employees as well as airport personnel. The training program specifically includes CM and CMO. The majority of the courses are given at its training facility, Mike Monroney Aeronautical Center, Oklahoma City, OK.

The FAA provides technical specifications and procedures manuals for most aspects of airport planning and construction. The manuals are developed by the FAA with review and critique by interested parties including the airport operators. The FAA manuals are used world wide and distributed through the FAA technology transfer program.

Certification

FAA does not require formal certification of CM plans or construction to plans and specifications. FAA does certify airport operators. The operator requests this certification in which compliance with all statuatory and administrative requirements is attested. If authorized by the FAA the effect of the certification is to reduce FAA review and reporting requirements on the airport operator. The FAA requires airport operators to furnish the FAA with a written assurance that: 1, engineering inspection and supervision has been arranged to ensure that construction will conform to the plans and specifications; and 2, the qualifications of the personnel who will be performing inspection and supervision have been reviewed and found satisfactory.

Project Record Reviews

The FAA requires quarterly progress reports from the airport operators on grant projects. CM plan and plan implementation reviews are not performed by the FAA because most ADAP construction projects are too small to justify a formal CM plan. FAA does review the construction management capabilities of the airport operators as a part of the grants process and reviews specific QC records directly.

On-site Visits

The FAA conducts extensive on-site visits which combine technical assistance, project reviews and performance testing of navigation aids and air traffic control equipment. Because several grant projects are often underway at a large airport simultaneously, the FAA has an almost continuous presence at large airports. The FAA procedures require a minimum of three site visits; preconstruction, during construction and completion survey for each grant project. Site visits require examination of the resident engineers records to determine that required records are being kept. The FAA may specify test procedures but does not perform construction inspection tests.

4.5 Environmental Protection Agency

Agency Profile

The EPA Construction Grants Program was started in 1956 to assist communities and sewer districts in financing the design and construction of waste water treatment facilities, pumping stations and sewer systems. It grew steadily hitting its peak in 1977. The program has been trimmed back with the FY'1983 and FY'1984 figures more or less stabilizing at a level about 1/2 of the peak years. The federal program of funding assistance averages about 75% of the total cost.

The total federal program is now running at about $2.1 billion for FY'83 and $2.4 billion for FY'84. It is expected it will stabilize at about $2 billion per year for the next few years. About 5% of these funds are for planning and design in connection with the program leaving 95% for the grants and for the contracted effort to provide construction management oversight through the states (see subsequent discussions).

The total Regional office staff for the Municipal Facilities Branches (including secretaries, clerks, etc.) is 484 persons as of mid 1983. The total headquarters office staff for the Construction Grants Program is 112 persons. EPA estimates that not more than 40 labor years are spent nationwide by EPA personnel in making site visits or in personally inspecting construction activity and progress at the construction site.

The average EPA grant is about $2 million. Although there are a few much larger grants for treatment facilities, the vast majority are for much smaller sewer and pump station projects. EPA was not able to furnish the exact number of grants made in one year across the nation but it is probably amount to about 1200. Most of these grants are on projects with one contract, although the larger projects may be multi-contract undertakings. In general, the grants are made on projects that run from one to five years with most being in the two to three year range.

Construction Management Oversight Philosophy

The EPA has always tried to conduct a CMO operation that would enable them to make periodic visits to the construction sites and to observe field conditions first hand. However, the trememdous growth of EPA's construction grant program has made it difficult to accomplish this. EPA has maintained its up front philosophy, rather than an after-the-fact approach, through a unique arrangement which involves state environmental agencies and the U.S. Army Corps of Engineers.

From the start of the construction grant program in 1956, EPA has attempted to conduct both process and product reviews of their grant construction projects. EPA's engineers are well trained in construction and in sanitary engineering. They are involved in both CMO and design review. EPA engineers typically advise design changes in the field if necessary to assure proper waste treatment. This eventually led to a separate group in each regional office that offers technical assistance in design maintenance and operation of the treatment plants.

Because of the tremendous growth of the EPA program, it became impossible for EPA to perform the functions described above with their own staff. EPA was forced to consider other means of providing additional CMO. As a result, EPA chose to delegate some responsibilities to the state environmental agencies. EPA established procedures for certifying the state capabilities in sanitary and construction engineering prior to transfer of responsiblities to the states. State Management Assistance Grants (SMAG's) under Section 205G of the Clean Water Act were established by EPA to provide separate funding to the states for these services. EPA authorized each state 4% of the federal state allotment to provide the desired assistance.

A few years ago, EPA initiated a refinement to this program. States may obtain the assistance of Corps of Engineers staff to conduct some of the CMO functions. The funding for the Corps of Engineers' assistance was to be provided directly by EPA at no cost to the state. An agreement was negotiated with Corps of Engineers to provide 600 labor years of effort for FY'83 to assist the states to carry out their responsibilities.

The states, with Corps of Engineers' assistance, now carry out virtually all the functions associated with an environmental project from planning, through design, public hearings, preparation of Environmental Impact Statements, construction, and maintenance and operating assistance. As can be seen from the scope of activities, only a portion are related to CMO. EPA still retains ultimate authority over the projects by virtue of its being the funding agency. It can and has stopped payment when EPA requirements have not been met.

The Environmental Protection Agency CMO program, summarized by action is discussed below and depicted in Table 5.

Technical Support

In technical support, EPA provides considerable effort to furnishing complete and very detailed process information. It conducts training courses for its own staff, state and the communities. It provides assistance in correcting plants with operating problems and advises on operational procedures and maintenance. In the construction area, efforts are considerably reduced. However, EPA does provide training for its own staff to maintain construction expertise as necessary for its functions.

Certification

In 1981, EPA established a Certification Requirement that requires the grantee to certify to EPA one year after the project becomes operational that the facility was built in accordance with plans and specifications and that the plant is operating properly. This requirement is currently being implemented. As of September 1983, EPA did not yet have the first certification in hand.

Project Record Review

EPA is no longer involved in the review of construction records having transferred these responsibilities to the states over the last ten years. Other than the collecton of financial data and progress data from state quarterly progress reviews, all record reviews are conducted during site visits.

On-Site Visits

Site visits are made to all EPA projects by the states under the terms of their agreement with EPA. Usually the state (or Corps of Engineers) will make a site visit one or two times a month. Occasionally (about once a year), the EPA staff member will make a site visit in the role of a quality assurance representative checking not only the contractor, but the grantee, the state and the Corps of Engineers as well. EPA has furnished a check list to the states for their use in making site visits. This list has proven to be rather limited in coverage and is currently being improved by EPA in cooperation with the states.

4.6 International Bank for Reconstruction and Development

Agency Profile

The World Bank makes loans to finance public works projects, including major transit systems throughout the world. The bank evaluates the risk of each loan on the basis of many factors, including such considerations as the nations political stability, its level of management effectiveness and its past experience in large projects. Typical World Bank projects are about $10 million in size. The Bank currently uses about 230 staff years of effort per year in its project management oversight of 1860 projects. Each Bank project manager has the responsibility to oversee an average of about $90 million of construction work in progress.

Construction Management Oversight Philosophy

The Bank establishes its construction management oversight approach for each loan based on its evaluation of the overall investment risk involved. The CMO requirements are incorporated, up-front, in the loan agreement. Because of this wide range of risk among Bank loans, it uses a wide range of CMO approaches and tailors the CMO approach to individual projects. The loan generally requires that a major CM consulting firm be hired for each large project to provide "supervision". The Bank must concur in the CM consulting firm contracts, as well as all other contract awards under the project.

The Bank's level of involvement with a project is a function of its risk and may range from hands-off to hands-on involvement. The risk-dictated construction management oversight strategies include the full range of possible actions described in this report with one exception. The World Bank does not have a technical assistance program. Since technical assistance is not considered an appropriate bank function.

The Bank establish a variety of project certifications depending on its perceived risk. In a few cases, the Bank requires certification of every major step in the project including all construction stages, whereas in other cases certification is not required at all. The World Bank performs project record reviews both at its headquarters and on-site. It nominally makes four site visits to each project per year. Although on low risk projects, this may be reduced to one or two visits per year. Quarterly progress reports including financial and schedule status, problems encountered and remedial actions are required. For low risk projects, project CM records review is the primary CMO action employed by the Bank. On higher risk projects, more site visits are required, and project CM records review is performed on-site. The Bank primarily reviews the records of the owner and the supervisory consultant, and rarely reviews physical construction records.

5. IMPLEMENTATION CONSIDERATIONS BY UMTA

5.1 Introduction

Implementation considerations involve answers to the following questions.

A. Which of the oversight actions should UMTA adopt?
B. What are the additional resources required for the various actions?
C. Who should have the responsibility of actually carrying out the actions decided by UMTA, and
D. What funding mechanisms should be used by UMTA for these oversight actions?

The answer to question A is often project specific and, moreover, is interwoven with such policy issues as the desired extent of federal intrusion, exceptable level of vulnerability and other factors. No attempt is made in this section to provide the answer to question A. These decisions can only be made by UMTA.

Questions B, C and D are considered in this chapter. An estimate of the resources required for each action is given in the next section. This is followed by a discussion of deployment alternatives and potential means for obtaining the required resources.

5.2 Resource Requirements

The estimated resources required by UMTA to implement the oversight actions discussed in Chapter 3 are summarized in Table 6. With the exception of the resources for technology development and transfer, all other costs are annualized and based upon a $100K labor year. It is assumed that there are eight major rail projects in active construction in any year. Furthermore an annual UMTA rail construction budget of $1 billion (1982) was assumed.

If options are developed using multiple actions, care must be taken to differentiate between those actions which are independent and others which are dependent. Construction management technical development and transfer actions

TABLE 6. ESTIMATED UMTA RESOURCE REQUIREMENTS FOR CMO ACTIONS

CMO Action / Level of Effort	HANDS-OFF				EYES-ON			HANDS-ON		
	CM Technical Support		Certification		Project Record Reviews			On-Site Visits		
	Training	CM Technical Dev. & Transfer	CM Plan	Const. to Plan & Spec.	Const. Progress Reports	CM Plan/ Implementation	Physical Construction Records	Periodic Progress Meeting	CM Program Assessment	Const. Inspection &Testing
LOW	Limited Training $20K/YR	Technical Transfer Only $100K Per document	Plan Only By Grantee $10K/YR	By Grantee $10K/YR	Annually $15K/YR	CM PLan Required $10K/YR	Sproadic $25K/YR	Infrequent $25K/YR	Limited Sample $10K/YR	Final Only $100K/YR
MED	Training All UMTA CMO Staff $150K/ YR	Manual Development $175K per document	Plan & Implementation By Grantee $30K/YR	By Grantee $10K/YR	Quarterly $30K/YR	CM Plan Implementation Review $50K/YR	Periodic $200K/YR	Moderate $75K/YR	Significant Sample $100K/YR	Systematic $400K/YR to $500K/YR
HIGH	Training Institute $1M/YR	Concept Development $250K Per document	Independent $100K/ YR	Independent $5M/YR	Monthly $90K/YR	CM Plan Evaluation $200K/YR	Systematic $400K/YR	Frequent $250K/YR	Comprehensive Review $200K/YR	Continuous $1M/YR to ≤ $5M/YR

are independent of all other actions so that the cost are additive. Certification actions, however, usually substitute for hands-on or eyes-on actions so that they are not additive. There is overlap between eyes-on actions and hands-on actions so that inclusion of each type in an option implies a cost less than the sum of the two.

Technical Support

The low training action assumes that five UMTA construction management oversight staff members take a three day course in CMO or CM each year. It is assumed that the courses are selected from those available at outside agencies (a $20K effort). The medium option assumes twenty UMTA construction management oversight staff members will attend one seminar/course per year specifically tailored by an outside agency to UMTA's construction management oversight training needs (a $150K effort). The high action involves the establishment of an UMTA transit training institute similar to the National Highway Institute. This high action level also assumes UMTA will assign four staff members an intergovernmental personnel assignment with industry to increase their experience (a $1M effort).

Construction management technical development and transfer at the low level includes defining the state-of-the-art in transit CMO, QA/QC or CM through workshops attended by invited experts. The results of the workshops are published and distributed to the technical community under UMTA sponsorship (a $100K per document effort). The high action level requires UMTA to develop more indepth technical manuals drawing on broader sources (a $250K per document effort).

Certification

Certification of the Construction Management Plan can vary from a simple bookkeeping effort involving filing certificates sent in by the owners (a $10K effort) to a more involved undertaking where the CM Plans are carefully reviewed by an UMTA staff for adequacy with directives issued to the owner for adjustments (a $100K effort).

The UMTA requirement for certification that construction conforms to plans and specifications vary considerably. UMTA efforts could be as little as a bookkeeping task for filing certifications furnished by the owner without any checking to see if it is actually correct. This limited effort may, however, fill a legal requirement which would permit the government to recover a portion of the federal funds if construction deficiencies are found at a later time. On the other extreme, UMTA can retain one or more independent consultants to review an entire project(s) either periodically as the project progresses and/or upon completion. Following this extensive review the independent agency would issue a certification that construction was as specified or indicate the corrective work required before such a certificate could be issued. It is assumed that the certifying consultant will provide four labor years effort per year and that a substantial insurance policy will be taken out by the consultant (a $5M effort).

Project Record Reviews

The eyes-on project record reviews take place in UMTA (or consultant) offices and include examination of records supplied by the grantees. For the three types of records reviewed (progress, construction management and physical construction), the variation between low and high effort is increasing frequency and depth of review. The annual costs varies from $10K to $400K per year.

On-site Visits

The costs for on-site visits are labor and travel. The costs shown in Table 6 include travel expenses. The variations between low and high levels of effort are a function of the frequency of visits and the duration of each visit. The resident federal inspection staff is the most expensive alternative, approaching $5 million per year.

5.3 Funding Mechanisms

Depending on the CMO strategy adopted by UMTA different level of additional human resources will be required. Once the level of required human resources

has been determined, alternatives for providing required labor can be evaluated so as to optimize the deployment of UMTA staff and any required outside support staff. To the degree UMTA staff cannot be redeployed and duties cannot be reassigned to accommodate an enhanced CMO effort, funding for augmenting present UMTA staff needs to be considered.

There are at least two options that can be adopted to implement the CMO actions.

UMTA-Procured CMO Support

Staffing:

- o CMO support from other Federal agencies
- o CMO support from other governmental agencies
- o CMO support from private CM consultants

Funding:

- o UMTA levy on capital grant programs
- o UMTA Section 6 program
- o Revised UMTA Section 3 program authorization

Grantee Procured CMO Support for UMTA

Staffing:

- o CMO support from private CM consultants

Funding:

- o UMTA construction grants at normal matching ratio (80-85%)
- o UMTA construction grants (100%)
- o UMTA Section 6 program (100%)

APPENDIX A: SELECTED TRANSIT CONSTRUCTION MANAGEMENT PRACTICES

This appendix summarizes the construction management methods used by the transit authorities surveyed for this report. The construction management oversight performed on the construction projects by the responsible UMTA regional office is also summarized.

A.1 Atlanta - Metropolitan Atlanta Rapid Transit Authority (MARTA)

The MARTA is constructing a thirty-five mile, area wide, rapid rail transit system in the greater Atlanta metropolitan area. Total estimated cost for the system is $2.7 billion.

Project construction is managed by the MARTA Construction Division with support from a construction management consultant. Project quality control is carried out primarily through consultant-provided resident engineers and inspectors. Quality Assurance, although not formally organized, is carried out by about twenty MARTA Construction Division core professionals in conjunction with their other duties. As construction activity decreases, the consultant effort will be phased-out, leaving the MARTA core staff to perform both QC and QA functions for a limited, on-going construction program.

MARTA officials emphasize that QC/QA functions are fully implemented and working, even though formal organization charts do not contain separate QC/QA units. They consider QC/QA concepts to pervade the organization because MARTA's broad public responsibility to provide high quality transportation facilities extends beyond UMTA, to the community served.

The UMTA project management oversight of MARTA is provided by three regional office professionals. The UMTA regional project managers (engineers) have limited technical involvement with projects. Generally, project plans and specifications are reviewed, however, site visits are infrequent. Greater attention is given to project cost and schedule matters.

The UMTA Region IV project management group in Atlanta is responsible for two major rail construction programs (Atlanta and Miami), the Miami downtown people mover, a half dozen bus maintenance facility construction projects, as well as numerous vehicle procurements each year.

A.2 Baltimore - Mass Transit Administration (MTA)

The MTA's fourteen mile rapid transit system funded by UMTA, is currently underway in Baltimore. This project has been divided into sections, A and B. Section A costs about $800M and is 8 miles long (6 miles tunnel and 2 miles aerial). Section B is 6 miles long, entirely at-grade, and is estimated to cost $200M.

For Section A, MTA performs CM with both in-house staff and consultant forces. The MTA staff includes a construction engineer and seven area engineers who are responsible for quality assurance in addition to their other duties.

The consultant staff includes two construction managers, three area managers and a resident engineer and inspectors. They are all responsible for assuring construction quality by overseeing the contractors who promise quality control. Within the consultant's CM team, a separate staff is set up to perform internal audits and inspector checks. A phase out of the consultant is taking place as the construction of Section A nears completion.

UMTA oversight of MTA is performed by UMTA Region III personnel in Philadelphia. Their staff is comprised of two engineers, two project management specialists and one program management specialist. Their activities cover project design reviews, procurement (including construction bidding) reviews, and construction reviews. During construction, the UMTA regional program engineer responsible for the MTA project makes site visits about once every two months. Half of the visit is held at the grantee's office while the other half is held in the field. Construction problems are addressed in quarterly progress reports and quarterly project management reviews. Both program engineers review and monitor the grantee's proposed project management team, its organization, schedule, finance, projects controls and proposed QC/QA plans.

UMTA Region III personnel are implementing the UMTA Project Management Guidelines (C5010.1A), within staffing limitations, and continue to use the old External Operating Manual for guidance regarding required contract clauses, force account work procedures, etc. In addition, based on the program engineer's engineering background and past experiences, regional policy memos on various issues are distributed to enhance staff performance.

A.3 Boston - Massachusetts Bay Transportation Authority (MBTA)

The MBTA has two major rapid-rail transit projects under construction. One is a $550M, three mile extension of its Red Line. The other is a $750M, five mile, relocation of its Orange Line.

The MBTA employs slightly over two hundred technical people to manage its ongoing construction program; a program that is dominated by the Red Line and Orange Line activity. Little to no consultant support is used for construction management activities. The MBTA also has a materials testing laboratory in addition to its construction and quality management personnel.

The primary Quality Control function is carried out by thirty-two resident engineers, and one hundred and forty field inspectors. The Quality Assurance function is accomplished by two technical specialists and a documentation auditor, who report outside the project management chain of authority.

UMTA oversight of the MBTA primarily is performed by two UMTA Region I engineers in Cambridge, MA. Due to the MBTA's extensive construction background and experience, UMTA Region I only makes occasional site visits. More attention is focused on plans and specifications review, and procurement issues. Construction schedules and financial matters are monitored.

A.4 Buffalo - Niagara Frontier Transportation Authority (NFTA)

The NFTA is constructing a six mile, light-rail system in Buffalo, New York at an estimated cost of $500 million. The NFTA performs the quality assurance function with in-house personnel (Metro Construction Division) and uses a consultant to conduct most quality control functions. The NFTA staff includes seven area engineers who are responsible for quality assurance in addition to their other duties. The NFTA internal staff includes one field team of a resident engineer, supporting staff and inspectors which soon will be assigned to the downtown mall (the last construction element). System construction is about 70% complete. As the construction elements are completed, the consultant's quality control staff is phased out.

Quality assurance is the direct responsibility of the seven NFTA area engineers. In addition, the manager of construction and eight other NFTA engineers perform quality assurance checks in addition to their other duties. The NFTA requires that all quality assurance and control positions be filled with experienced individuals. As a result, NFTA does not have a formal training program for such personnel.

A.5 Miami - Dade County Transportation Administration (DCTA)

The DCTA is nearing completion on the first stage of the METRORAIL system. Stage I has 20 stations and 20.5 miles of elevated guideway, extending north and south through the center of Miami, Florida. The estimated cost of the Stage I system is about $1.1 billion. Initially, DCTA delegated all field inspection responsibilities to their consultants, Kaiser Transit Group (KTG), a composite of five individual firms, but maintained a near duplicate construction management staff for positions of Area Engineer upward to the Chief of Construction. Responsibility for Quality Control (QC) was that of KTG while the function of Quality Assurance (QA) was being performed jointly by KTG and DCTA. The only exception to this was that the girder manufacturer, R. T. Joint Venture, was contracted to perform QC on the precast girders with KTG providing continuous QA inspection.

As construction progressed, DCTA assumed greater responsibility for field inspection and eventually took over all construction management functions and responsibilities. Before the transition, an organization separate from the field inspection forces was responsible for QA. After the transition, the authority/responsibility for QA of completed structures was transferred to the Construction Division and therefore was no longer independent of production.

UMTA oversight of the METRORAIL project is performed by UMTA Region IV personnel in Atlanta. The UMTA regional program manager responsible for the DCTA project attends quarterly review meetings and is concerned primarily with cost and schedule performance of the grantee. Cursory inspection of construction progress is all that is possible with the current staff limitations.

A.6 Washington - Washington Metropolitan Area Transit Authority (WMATA)

The WMATA's rapid transit system consists of seventy-five revenue service miles. The WMATA performs construction management with in-house personnel and a consultant contract administration team. A consultant phase-out is scheduled to take place between 1981 and 1985 as construction winds down.

The WMATA in-house staff includes two contracting officers and a construction engineer for each line. The construction engineer performs the QA function in addition to other duties. Periodically, a WMATA management team consisting of about ten persons visits each project site to conduct an intensive construction management inspection/review. The consultant has a construction manager who oversees three area managers, who have close contact with their resident engineers. Field office staff consists of a resident engineer, one or two office engineers, and a number of inspectors which varies with the size and complexity of the construction element. The resident engineer performs the Quality Control (QC) function on the contractor, can conduct spot inspections and has a right to reject any construction materials not conforming to specifications.

The WMATA's construction management organization provides QA/QC at all levels, including internal auditing procedures. WMATA believes that their organization also provides each resident engineer the accessibility to top-level management and that the management is responsive enough to avoid unnecessary project delays.

Each year, WMATA completes about $200M worth of construction. Approximately 12% of this $200M is for construction management. The 12% covers substantially more support activities than "supervision and inspection (S&I)" which commonly and runs about 5% to 5-1/2%.

APPENDIX B: BIBLIOGRAPHY

1. Airport Development Aid Program (ADAP) Handbook, Department of Transportation, Federal Aviation Agency Order 5100.36

2. Better Administration of Capital Grants Could Reduce Unnecessary Expenditures, UMTA Draft Report 1981, U.S. General Accounting Office

3. Better Contracting for Underground Construction, National Research Council, National Academy of Sciences - National Academy of Engineering, 1974

4. Better Procedure Needed for Inspections at Sewage Treatment Construction Projects, Report from the Environmental Protection Agency, U.S. General Accounting Office, RCEP-83-73, January 26, 1983

5. Construction Grants Program Delegation to States, 40 CFR Part 35, Subpart J, SAR 1846, Environmental Protection Agency, Office of Water Program Operations, May 6, 1983

6. Construction Inspection, Clyde, James E. 1979, John Wiley & Sons, New York, N.Y.

7. Construction Management for the General Contractor, Multi-Authors (Brady, DeMas, Kitchel, McNeil, Scheele, & Wilkemming), Assoc. General Contractors of America, Inc., 1974

8. Construction Quality Control Baltimore Region Rapid Transit Project, The Ralph M. Parsons Company - Engineer/Contractor, Undated

9. Construction Quality Control Section, Massachusetts Bay Transportation Authority, (MBTA), Boston, MA, Resident Engineer Manual, MBTA, Boston, MA 1978

10. Control & Management of Capital Projects, Hackney, John W., 1965, John Wiley & Sons, New York, N.Y.

11 Direct Federal Program Highlights, FY'1982 - Federal Highway Administration (FHWA)

12. Federal Highway Administration Organization Manual, FHWA Order 1-1, Chg. 137, 5/19/83

13. Generalist Highway Engineer Technical Training Needs Review, Memorandum from Executive Director of FHWA, HPT-30 to Associate Administrators, Staff Office Directors, Regional FHWA Administrators, November 12, 1982

14. Guidelines for Developing a Project Management Plan, Vol I, Management of Urban Construction Programs, Report No. UMTA-MA-06-0100-81-2, December, 1980

15. Interagency Agreement between the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency, November, 1982

16. Interim & Final Inspection Checklist - Plans and Specification Checklist, Environmental Protection Agency, May 31, 1983

17. Internal Project Management Guidelines, U.S. DOT Circular, UMTA C5000.1A, 3/12/80

18. MARTA Resident Engineer Manual, Parson, Brinckerhoff, Quade & Douglas, Inc./Tudor Engineering Company, for Metropolitan Atlanta Rapid Transit Authority 1977

19. NFTA Resident Engineer Manual - Niagara Frontier Transportation Authority Buffalo, N.Y.

20. Noncompliance Report Procedure for Baltimore Region Rapid Transit Project, The Ralph M. Parsons Company - Engineer/Contractor, Undated

21. Project Management, Melvin Silverman, John Wiley and Sons, New York, N.Y., 1976

22. Project Supervision Procedures Ministry of Transportation, Empresa Brasileira DOS Transportes Urbanos (EBTU), Brazil, January 1981

23. Quality Problems Get Hard Look, Engineering News Record, Page 11, July 28, 1983

24. Responsibilities of Project Sponsors in Capital Grant Management UMTA memorandum from Regional Engineer, UMTA III to Regional Director, UMTA III, June 21, 1976

25. Role of the Engineering Division in the Region III Mission UMTA Memorandum from Chief, Engineering Division, Philadelphia to Regional Director, Philadelphia; November 22, 1978

26. Serious Understaffing of Engineering Division UMTA Memorandum from Chief, Engineering Division, Philadelphia to Regional Director, Philadelphia; March 7, 1979

27. Simplified Guide to Construction Management, James E. Gorman, P.E., Cahnners Books, Inc., Boston, MA 1976

28. Synthesis of Highway Practice 51: Construction Contract Staffing, National Cooperative Highway Research Program, Transportation Research Board, National Research Council

29. Systematic Construction Inspection, Liebing, Ralph W., 1982, John Wiley & Sons, New York, N.Y.

30. Third Party Contracting Guidelines, U.S. DOT UMTA Circular, UMTA C4220.1A, 6/8/82

31. UMTA Project Management Guidelines for Grantees, U.S. DOT Circular, UMTA C5010.1, 3/17/83

32. Understanding between FHWA and FRA relating to the Design and Construction of the NE Corridor Program, DOT 1100.23A, Chg. June 1976

33. Uniform Administrative Requirements for Grants and Other Agreements with Institutions of High Education, Hospitals and other Non-Profit Organizations", Office of Management & Budget (OMB) Circular A-110, 7/1/76

34. Uniform Requirements for Assistance to State and Local Governments, Office of Management & Budget (OMB) Circular A-102 (Revised) 1/81

35. Urban Mass Transportation Act of 1964, as amended through December 1978, and related laws, U. S. Department of Transportation, Urban Mass Transportation Administration, Washington, D.C.

36. Water Management Division Vulnerability Assessment Memorandum from Acting Director, Water Management Division to Grants and Contracts Administration Section (Environmental Protection Agency) August 12, 1982

37. WMATA Guidelines for Construction Inspection Bechtel Associates Professional Corporation for WMATA, Washington Metro Project

38. WMATA Quality Assurance Program, Bechtel Associates Professional Corporation for Metro Project for WMATA, October 1981

39. WMATA Resident Engineer(s) Manual, Bechtel Associates Professional Corporation for Washington Metropolitan Area Transit Authority, May 13, 1977

APPENDIX C: LIST OF PERSONS CONTACTED

F. Moehle, Chief of the Construction Division, U.S. Army Corps of Engineers New England District, Waltham, MA

M. Beaudoin, Civil Engineer, U.S. Army Corps of Engineers, New England District, Waltham, MA

R. Caruso, Sanitary Engineer, Environmental Protection Agency, Boston, MA

J. Sekman, Chief of Grants Division, Federal Aviation Agency, Washington, DC

B. Castellano, Chief of Office of Airports Planning and Prog., Federal Aviation Agency, Washington, DC

C. K. Dunkley, District Engineer, Mass. Division, Federal Highway Administration, Cambridge, MA

Al Morrison, Director of Project Management, UMTA Region I, Cambridge, MA

F. Keville, Director of Construction, Massachusetts Bay Transit Authority, Boston, MA

J. Toomey, Assistant Director of Construction for Administration, Massachusetts Bay Transit Authority, Boston, MA

J. Dunne, Assistant Director of Construction Control, Massachusetts Bay Transit Authority, Boston, MA

J. Camallonga, Project Manager, UMTA Region II, New York, NY

T. Beck, General Manager of Metro Construction Division, Niagara Frontier Transportation Authority, Buffalo, NY

B. Spencer, Manager for Facilities and Equipment, Niagara Frontier Transportation Authority, Buffalo, NY

G. D. Ingverson, Director of Construction Division, Metropolitan Atlanta Rapid Transit Authority, Atlanta, GA

C. T. Earnest, Construction Service Manager, Parsons, Brinkerhoff/Tudor, Atlanta, GA

Gene Carroll, Director of Project Management, UMTA Region IV, Atlanta, GA

E. Wadell, Director of Office of Construction, Washington Metropolitan Area Transit Authority, Washington, DC

B. Pauling, Construction Manager, Washington Metropolitan Area Transit Authority, Washington, DC

D. Sveigot, Washington Metropolitan Area Transit Authority, Washington, DC

N. Fillip, Project Manager, Washington Metropolitan Area Transit Authority, Washington, DC

J. Mayer, Director of Project Management, UMTA Region III, Philadelphia, PA

D. Soni, Project Manager, UMTA Region III, Philadelphia, PA

F. Hoppe, Director of Construction, Mass Transit Administration, Baltimore, MD

J. Von Briesen, Administrative Assistant Project Manager, Mass Transit Administration, Baltimore, MD

B. Visy, Construction Manager of Ralph M. Parson Company, Mass Transit Administration, Baltimore, MD

C. Lutman, Construction Manager of Ralph M. Parson Company, Mass Transit Administration, Baltimore, MD

P. L. Watson, Senior Financial Analyst, International Bank for Reconstruction and Development, Washington, DC

D. Phillips, Director of Engineering, Federal Highway Administration, Washington, DC

G. Moore, Director of Management Systems, Federal Highway Administration, Washington, DC

R. Benacquista, Direct Federal Program Office, Federal Highway Administration, Washington, DC

T. Myers, Construction and Maintenance Division, Federal Highway Administration, Washington, DC