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**Urban Mass
Transportation
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Project and Construction Management Guidelines

EG&G Dynatrend Inc.
21 Cabot Road
Woburn, MA 01801

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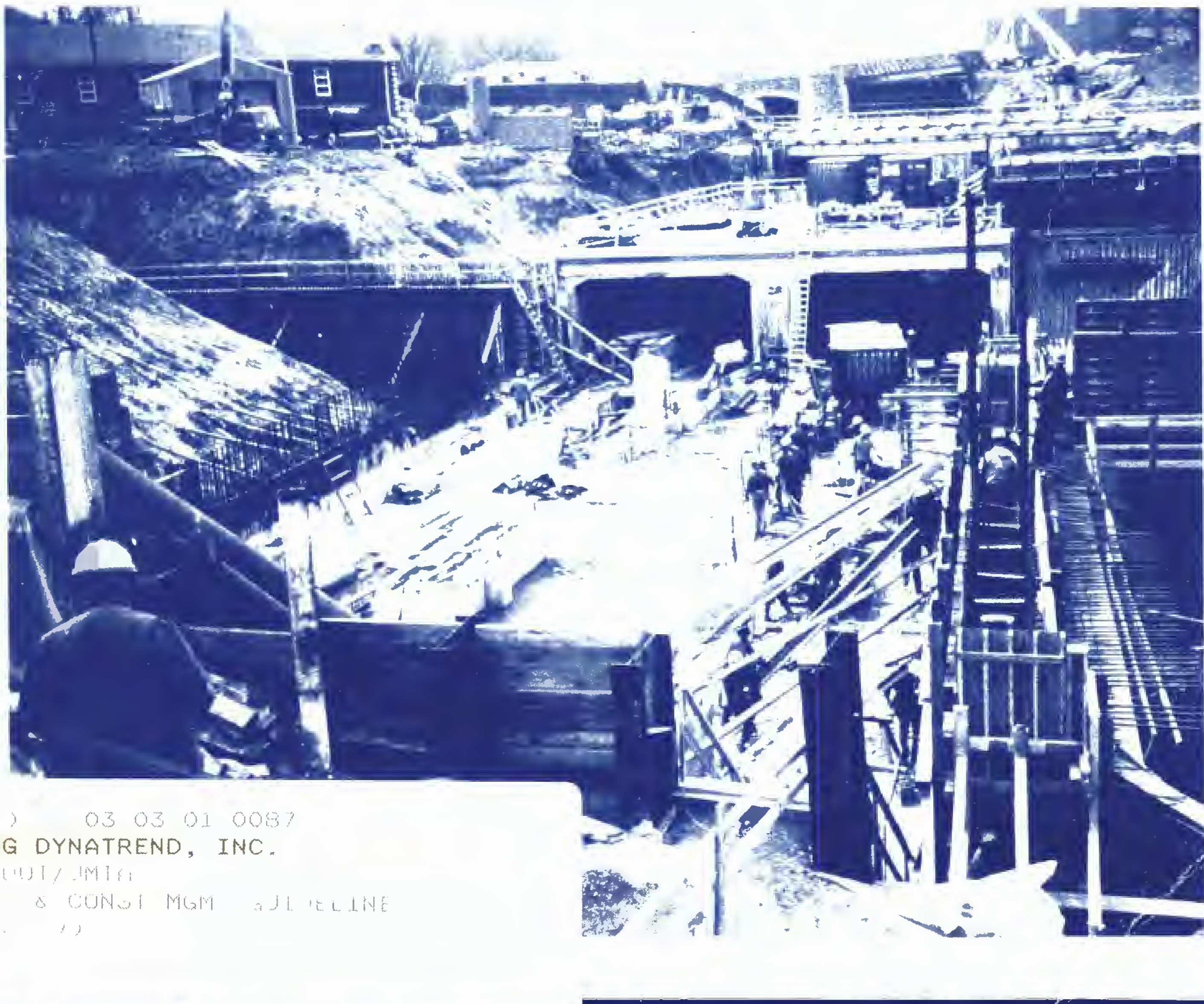
Final Report



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16. Abstract

The Urban Mass Transportation Administration (UMTA) sponsored the development of the Project and Construction Management Guidelines to provide a resource for local transit authorities and others concerned with the effective implementation of transit capital projects. The objective of effective project management is to accomplish the scope of work within defined limits of time, cost and quality. The Guidelines have been structured to describe the phases of project planning and development through construction to completion, including revenue service. Fundamental management principles are stressed, and are applied throughout the various project phases. The Guidelines will be useful to planners, engineers, administrators and managers involved with projects related to both rail and bus modes, including the development of new systems and the modernization or expansion of existing systems.

Chapter 2 describes the project development process through seven phases: System Planning, Project Planning, Preliminary Engineering, Final Design, Construction, Testing and Start-up and Revenue Service. Chapter 3 presents general principles for managing the project development process organized in seven broad categories: Legal/Institutional Authority, Management and Organization; System Definition/ Configuration/Performance; Financial Requirements/Resources; Management Control Systems; Procurement, Contracts, Disputes and Claims; Safety, Risk Management and Insurance; and Communications. Chapters 4 to 10 apply the management principles, by category, to the specific requirements of each project development phase. Several appendices provide additional detail and examples for the management topics addressed in the body of the Guidelines and include a list of references and a comprehensive bibliography.

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DeLeuw Cather & Company was a subcontractor under the direction of Peter Graziano of the Engineering Management Services Division. Joseph Banks and James Keys provided the initial input to Chapters 6, 7 and 8 of the Draft report. Jan Coester, assisted by Bruce Brong, Raymond Hughes, Robert Shipley and Ronald Kleppinger, directed the development and implementation of a two-day workshop program in which the Draft Guidelines were presented to, and discussed by, over 300 representatives of UMTA Regional Offices, UMTA Project Management Oversight Contractors, grantees and consultants in eight separate sessions held nationwide.

Thomas Luglio was aided by Lois Bossman in workshop logistics. The following UMTA Regional Office staff assisted in identifying attendees and speakers on a project of significance in their Region:

- Region I - Allan Morrison
- Region II - Brian Sterman and Letitia Thompson
- Region III - Michael McCollum
- Region IV - Gene Carroll and Donald Alford
- Region V - Peter Slominski
- Region VI - Blas Uribe
- Region VII - Richard Jarrold
- Region VIII - Charles Dolby
- Region IX - Robert Hom
- Region X - Ricardo Ramon

The following workshop guest speakers each made an stimulating presentation on a project which exhibited successful project and construction management:

- Edward Dwyer - Transit Manager, Connecticut DOT, on a New Bus Facility in Hartford
- Glenn Ridsdale - Director of Facilities Engineering, New Jersey Transit, on the Renovation and Expansion of a Bus Maintenance Facility
- Peter Schmidt - Assistant General Manager - Development, Maryland Mass Transit Administration, on a Baltimore Rapid Rail Line Extension and a Bus Garage Rehabilitation

- o Allan Smith - Director of Project Control, MARTA, on the Project Control Approach Utilized for the Implementation of the Rail System

- o Richard Hankett - Deputy Commissioner, Chicago Department of Public Works, on the Southwest Corridor Transit Project

- o John Sedlak - Director of Transitway Projects, Metro, on Houston's Transitway and Mobility Programs

- o Richard Sandaas - Director Technical Services Department, Metro, on the Downtown Seattle Tunnel Project

- o Jane Neilson and Kathy Mayo - O'Brien-Kreitzberg, on the San Francisco Cable Car Project

Review of the Draft Guidelines and valuable input was provided by Brian Sterman (UMTA), Tom Lewis (Fluor), Steven Friedlander (Stone and Webster) and representative of UMTA's Office of Grants Management -- Douglas Kerr, Frank McCarron, Ray Lopez and Robert Stout. In addition, a Task Force of the Transportation Research Board (TRB) provided review and comment on the Draft Guidelines. The process was coordinated by William Gunderman of TRB and included the following industry representatives:

- o Delon Hampton - Delon Hampton & Associates (Chairman)
- o James Freeman - James Freeman Industries
- o Bill Gabig - Consultant to The Business Roundtable
- o Carl Goepfert - Bechtel Civil
- o David Hammond - Consulting Engineer
- o Donn Hancher - Texas A&M University
- o Glenn Ingwersen - Retired from MARTA
- o John Mc Elhenny - Washington Metro. Area Transit Authority
- o William Sim - Potomic Electric Power Company
- o James Strosnider - Southern California Rapid Transit District
- o George Ziegler - Morrison-Knudsen
- o James Condron - Liaison Representative (FHWA)
- o Jeffrey Mora - Liaison Representative (UMTA)

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LIST OF ACRONYMS

AA	Alternatives Analysis
AE	Annual Element
ANSI	American National Standards Institute
APTA	American Public Transit Association
ASCE	American Society of Civil Engineers
ATO	Automatic Train Operation
BART	Bay Area Rapid Transit
BRT	Business Roundtable
CAD	Computer Aided Design
CE	Categorical Exclusion
CEQ	Council of Environmental Quality
CICE	Construction Industry Cost-Effectiveness Program
CII	Construction Industry Institute
CIP	Coordinated Insurance Program
CM	Construction Manager
CMAA	Construction Management Association of America
CMO	Construction Management Organization
CPM	Critical Path Method
CSG	Cost and Schedule Group
DBE	Disadvantaged Business Enterprise
DEIS	Draft Environmental Impact Statement
DOT	Department of Transportation
EA	Environmental Assessment
EIS	Environmental Impact Statement
EEO	Equal Employment Opportunity
FEIS	Final Environmental Impact Statement
FHWA	Federal Highway Administration
GC	General Consultant
IEEE	Institute of Electrical and Electronic Engineers
IR	Inspection Report
LUC	Local User Councils
MARTA	Metropolitan Atlanta Rapid Transit Authority
MOS	Minimum Operable Segment
MPO	Metropolitan Planning Organization
NDE	Non-destructive Examination
NEPA	National Environmental Policy Act
NOR	Notice of Rejection
NRC	National Research Council
NSF	National Science Foundation
NYCTA	New York City Transit Authority
O&M	Operating (ion) and Maintenance
OSHA	Occupational Safety and Health Administration
PDCD	Parsons, DeLeuw, Cather, Dillingham
PE	Preliminary Engineering
PERT	Program Evaluation and Review
PM	Project Manager
PMI	Project Management Institute
PMO	Project Management Oversight
PMP	Project Management Plan

LIST OF ACRONYMS (Concluded)

PRD	Prerequisite Deficiencies
PUC	Public Utility Commission
QA	Quality Assurance
QC	Quality Control
RE	Resident Engineer
RFP	Request for Proposal
RFS	Release for Shipment
RIP	Reliability Improvement Program
ROI	Return-On-Investment
R/W	Right-of-Way
S&I	Supervision and Inspection
SCRTD	Southern California Rapid Transit District
SEPTA	Southeastern Pennsylvania Transportation Authority
TIP	Transportation Improvement Program
TPP	Testing Program Plan
TRB	Transportation Research Board
TSC	Transportation Systems Center
TSG	Technical Services Group
TSM	Transportation System Management
UMTA	Urban Mass Transportation Administration
USDOT	United States Department of Transportation
VE	Value Engineering
WMATA	Washington Metropolitan Area Transit Authority
WBS	Work Breakdown Structure
3-C	Continuous, Comprehensive and Cooperative

CHAPTER 1

INTRODUCTION

PROJECT AND CONSTRUCTION MANAGEMENT GUIDELINES

CHAPTER 1

INTRODUCTION

This Project and Construction Management Guidelines document has been developed under UMTA sponsorship to assist local transit agencies in developing management structures and work programs to effectively plan and implement the various phases of UMTA-funded transit capital improvement projects. UMTA maintains oversight for the grants which it awards, but assigns the grant administration and management responsibility to the grantees. UMTA's Office of Grants Management delegates the responsibility for oversight of nearly all capital grants to the appropriate UMTA Regional Office. The Guidelines, therefore, will also be a resource for UMTA staff to utilize in assessing a grantee's approach to, and performance in, managing the capital grant projects.

Because a sound management and control plan should be implemented early in the life of a project, the Guidelines encompass the planning phases in addition to the design and construction phases where the greatest level of effort is devoted. For completeness, the operational phase is also addressed to encourage a comprehensive management approach which systematically assesses the relationship between the constructed transit capital improvement and operational objectives to determine future system needs, both modernization and expansion.

The Guidelines address the full range of issues and present management principles applicable to all UMTA-funded capital improvement projects. These include projects which could encompass a variety of modes (rail, bus, etc.), improvement type (equipment, facility, etc.), system status (newly developed or modernization of existing), and grantee size, capability and maturity (small, large, newly constituted or established with experienced staff). Whether with an in-house professional staff or by hiring consultants, a grantee should apply the management principles and guidance embodied in this document to their unique project environment through the development of Project Management Plans (PMP). Procedures manuals provide an even greater degree of management guidance/

requirements for the Design and/or Construction Phases of capital projects and should be referenced in the PMP.

Chapter 2 of the Guidelines addresses transit capital project development with emphasis on UMTA's funding process and grant requirements. For each development phase, the major work program elements which influence effective project management are reviewed, noting significant milestones and decision points and their inputs and outputs. The development phases addressed include the following:

- o System Planning
- o Project Planning
- o Preliminary Engineering
- o Final Design
- o Construction
- o Testing and Start-up
- o Revenue Service

This chapter expands on the concept that the existing UMTA requirements should be recognized as the basis for effective project management. For example, UMTA requirements during the planning and analysis phases and prior to capital grant funding commitment are designed to provide assurances that issues of project definition, cost estimation and local funding commitments have been properly resolved. This is to create a realistic project baseline for successfully managing the project, should it advance to subsequent phases. Incentives are another tool UMTA utilizes to encourage effective grantee project management. For major capital investments (new starts and some large-scale modernization projects), the "full funding" agreement concept makes the grantee financially responsible for cost overruns, except for narrowly defined causes which are beyond the control of the grantee. Thus, grantees have the incentive to establish a realistic project baseline and to maintain strong project management control.

General principles for managing the transit capital development process applicable throughout the various phases of planning, design, construction and operation are presented in Chapter 3. These are grouped into the following functional categories:

- o Legal/Institutional Authority, Management and Organization
- o System Definition/Configuration/Performance
- o Financial Requirements/Resources
- o Management Control Systems
- o Procurement, Contracts, Dispute and Claims
- o Safety, Risk Management and Insurance
- o Communications

The project management principles are purposely presented in a general manner in Chapter 3 and applied, more specifically, to each of the capital project development phases in Chapters 4 - 10. The objective in relating the general project management principles to each project phase is to give practical and useful advice for addressing the unique requirements of each phase within the overall context of sound management practices. Therefore, the approach to project management for any given phase should encompass adherence to the general principles presented in Chapter 3, in addition to the more specific guidance provided in the subsequent chapters related to that phase. Figure 1-1 depicts the relationship among the chapters of the Guidelines to accommodate the seven project phases and the seven broad categories of management principles. For example, Section 2.5 relates to the Transit Capital Development Process in the Final Design Phase, Section 3.4 relates to general Project Management Principles of Management Control Systems, and Section 7.4 relates to the application of Management Control Systems in the Final Design Phase. The figure is also used on the title page of each chapter with the chapter contents highlighted.

The Guidelines, rather than dictating precise procedures, present management objectives and positive and negative features associated with alternative approaches. The implementing agencies will have the responsibility to select the approach which is most appropriate to their specific project management situation which, as a minimum, assures the achievement of the related management objective. UMTA and its Project Management Oversight (PMO) contractors, who serve as an independent source of advice on the effectiveness of alternative approaches,

FIGURE 1-1. CHAPTER FORMAT OF GUIDELINES DOCUMENT

Chapter 2 - Transit Capital Devel. Proc. / Chapter 3 - Proj. Management Principles	2.2 System Planning	2.3 Project Planning	2.4 Prel. Engineering	2.5 Final Design	2.6 Construction	2.7 Testing/Start-up	2.8 Revenue Service
3.1 AUTHORITY, MANAGEMENT 3.1.1 Legal Authority 3.1.2 Mgmt/Organization 3.1.3 Human/Labor Issues 3.1.4 Agreements/Approvals	4.1	5.1	6.1	7.1	8.1	9.1	10.1
3.2 SYSTEM DEFINITION 3.2.1 Project Definition 3.2.2 Configuration 3.2.3 Imposed Requirements 3.2.4 Real Estate	4.2	5.2	6.2	7.2	8.2	9.2	10.2
3.3 FINANCIAL ISSUES 3.3.1 Cost Estimates 3.3.2 Funding	4.3	5.3	6.3	7.3	8.3	9.3	10.3
3.4 MGMT. CONTROL SYSTEMS 3.4.1 Work Breakdown 3.4.2 Configuration Contrl 3.4.3 Quality Assurance 3.4.4 Schedule Control 3.4.5 Cost Control 3.4.6 Tools and Techniques	4.4	5.4	6.4	7.4	8.4	9.4	10.4
3.5 PROCUREMENT/CONTRACTS 3.5.1 Procurement Issues 3.5.2 Contract Administrtn 3.5.3 Dispute Resolution 3.5.4 Claims Management	4.5	5.5	6.5	7.5	8.5	9.5	10.5
3.6 SAFETY/RISKS/INSURANCE 3.6.1 Operational Safety 3.6.2 Construction Safety 3.6.3 Risk Mgmt/Insurance	4.6	5.6	6.6	7.6	8.6	9.6	10.6
3.7 COMMUNICATIONS 3.7.1 Program Development 3.7.2 Audience 3.7.3 Responsibility 3.7.4 Reporting Systems 3.7.5 Interface Management	4.7	5.7	6.7	7.7	8.7	9.7	10.7

monitor the project management process of grantees to assure that the management objectives are being achieved.

Thus, these Project and Construction Management Guidelines are intended to be firm in their definition of management principles and objectives, flexible in their application of alternative approaches and techniques, and dynamic in their ability to consider new approaches and techniques in the future.

The process of developing the Guidelines document involved the production of a draft version which was the focus of a nationwide series of workshops. The workshops provided a broad cross section of over 300 representatives of grantees, consultants, PMOs and UMTA Regional Office staff the opportunity to comment on the concept and details of the Guidelines. In addition, a subcommittee of the Transportation Research Board's (TRB) Construction Committee reviewed the Guidelines in detail and provided their comments to UMTA and EG&G Dynatrend. This final Guidelines report incorporates the comments received. A special attempt was made to broaden the application of the Guidelines to better relate to rail modernization and bus facility projects in addition to those defined as "major capital investments" -- new fixed guideway projects and major extensions.

CHAPTER 2

TRANSIT CAPITAL PROJECT

DEVELOPMENT PROCESS

Chapter 3 - Proj. Management Principles \ Chapter 2 - Transit Capital Devel. Proc.	2.2 System Planning	2.3 Project Planning	2.4 Prel. Engineering	2.5 Final Design	2.6 Construction	2.7 Testing/Start-up	2.8 Revenue Service
3.1 AUTHORITY, MANAGEMENT 3.1.1 Legal Authority 3.1.2 Mgmt/Organization 3.1.3 Human/Labor Issues 3.1.4 Agreements/Approvals	4.1	5.1	6.1	7.1	8.1	9.1	10.1
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CHAPTER 2

TRANSIT CAPITAL PROJECT DEVELOPMENT PROCESS

2.1 INTRODUCTION

A lengthy and rigorous process is involved in planning, programming and implementing transit capital improvement projects. This process includes the following:

- Analysis of the existing transportation system in order to determine the need for improvements.
- Evaluation of alternatives that will achieve the desired results.
- Estimation of costs and benefits to justify the required expenditure.
- Financial planning designed to identify funding requirements and possible sources to construct and operate the improvement.
- Preparation of necessary environmental documents.
- Engineering and design necessary to achieve the desired performance in concert with environmental and financial constraints.
- Construction of the improvement in accordance with the plans and specifications.
- Testing and start-up to assure safe and proper integration and operations.
- Continual monitoring during operations to assess system performance and requirements for additional improvements such as modernization or expansion.

The timeframe and specific requirements vary greatly, depending on the type of improvement being considered. In regard to financing, for example, most projects will involve advanced programming and competition for a limited amount of public agency funds. UMTA requires minimum justification for the more routine replacement-type projects funded through formula grants, but requires a very rigorous process for major capital investments funded through discretionary grants.

The degree of environmental impact of a project also affects the implementation process. A new fixed guideway project, for instance, has numerous positive and negative impacts related to route alignment, station locations, relocations, land use implications, construction, traffic generation/diversion, etc. Effectively dealing with the potential impacts of a project requires a process of public involvement to achieve support, even if funding and resource allocation are not a problem, which they usually are. On the other hand, improvements to existing transit systems can often be made with little public scrutiny, since the system's existence is a given and the improvement's external impacts are mostly positive. In this case, attention should be focused on minimizing the negative effects of construction on the system's existing patrons.

This section defines the major elements of the transit capital project development process which affects most projects. While these elements are often precipitated by public planning and funding agency requirements, they also represent appropriate evolutionary steps typical to any major development project.

Associated with each of the transit capital project development phases discussed in the following sections is a set of typical definitions, requirements, inputs, outputs, major milestones and decision points. While these aspects may vary depending on the nature of the project, it is important for a grantee to determine the specific requirements associated with their project as a means of establishing a basis for effective project management. Since the phases of project development are interrelated, proper attention to the management principles and external requirements at the earliest stage can eliminate problems which typically beset management in subsequent phases, resulting in schedule slippages and cost overruns. UMTA, as a major funding source for public transportation, in concert with Congressional direction, is committed to a process of project management which results in successful implementation of the desired project at the lowest cost. This requires a management process which controls quality, cost and schedule.

Two similar but slightly different procedures are used to develop transit capital projects, depending on whether they are major new capital projects, or modifications to existing systems. Both procedures utilize the seven development phases which were previously listed and are the subject of separate discussion in Sections 2.2 - 2.8, respectively. UMTA provides funding and technical assistance during each phase. As projects advance through the phases, their scope, cost, benefits and impacts become more clearly defined.

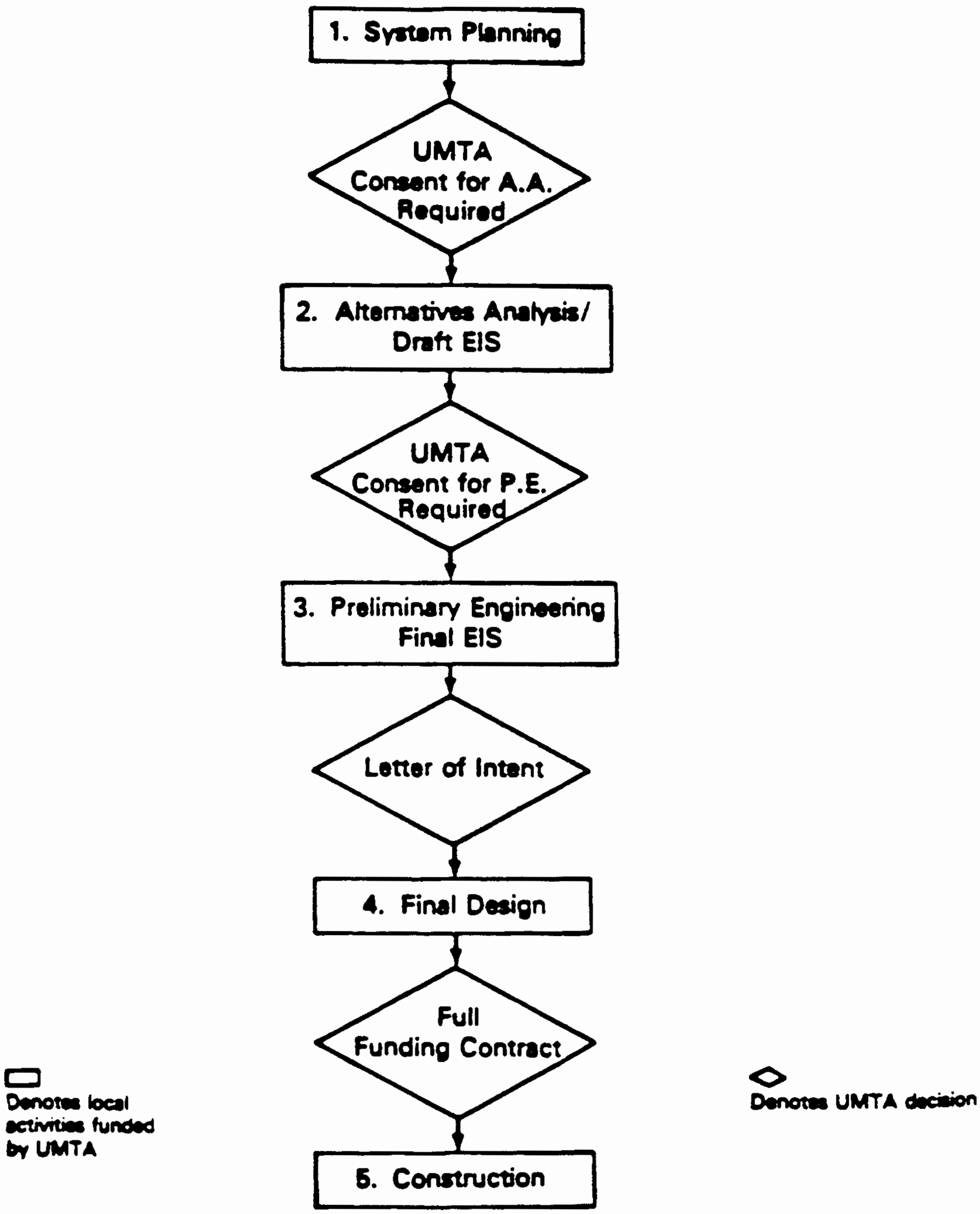
2.1.1 Major Capital Investments

UMTA has in place a well-defined process for planning related to "major capital investments," or "new starts," which includes new rail systems, extensions to existing rail systems, busways, and other types of fixed guideway transit facilities. The development process for these projects contains five distinct phases leading from project conception to construction: (1) System Planning, (2) Alternatives Analysis (AA), (3) Preliminary Engineering (PE), (4) Final Design, and (5) Construction. Figure 2-1 depicts the planning and development phases required by UMTA for new start projects and the related UMTA decision points. Special guidance for the planning phases is provided by UMTA in Procedures and Technical Methods for Transit Project Planning [Ref. 1]. Due to the nature of new start projects, the preparation of Environmental Impact Statements (EIS) is a necessary part of the project development process.

2.1.2 Rail Modernization and Bus Maintenance Facilities

Capital projects consisting of modifications to existing transit systems primarily involve rail modernization and construction of bus maintenance facilities. Unlike new starts, these projects are closely related to an existing transit system, the continuing operation of which must be carefully considered during planning and design. During construction, attention must focus on implementing the improvement in a manner which assures the safety of system operating employees, construction workers, transit riders and the public while minimizing disruption to normal operations and inconvenience to existing patrons.

FIGURE 2-1. UMTA PROJECT DEVELOPMENT PROCESS FOR MAJOR CAPITAL INVESTMENTS [REF. 1]



The related project development process is depicted in Figure 2-2 and differs from the process for new starts in several ways including:

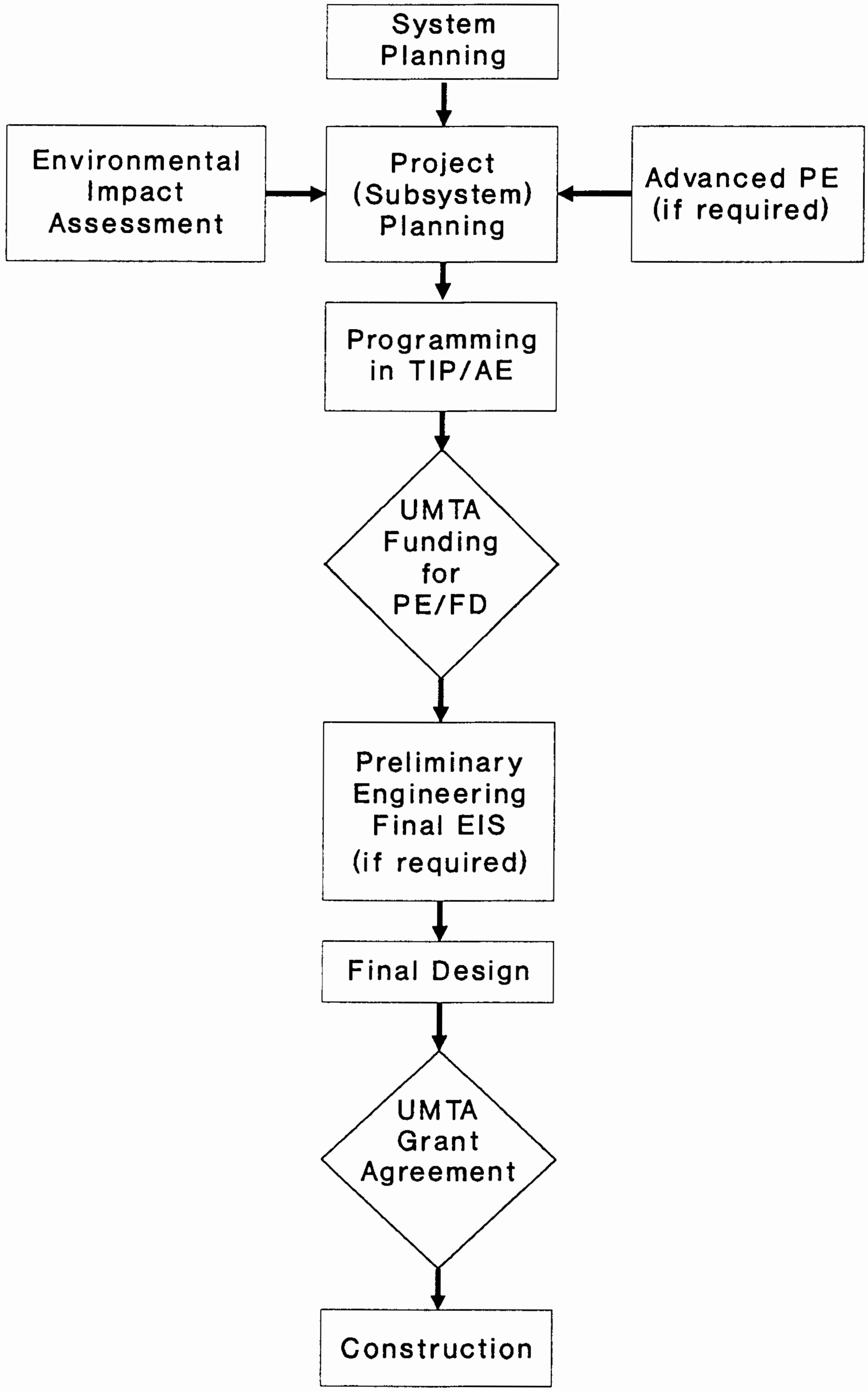
- o During System Planning, the viability of all segments of the existing fixed guideway network should be considered.
- o Rail subsystem planning with some advanced PE should occur during Project Planning.
- o Environmental assessment and historic preservation considerations are only required on a case-by-case basis (see separate discussion in Section 2.3.4).
- o Involves a complex process for determining project priorities.
- o No standard differentiation exists between PE and Final Design.
- o UMTA is less involved in the overall process.

Despite these differences, the management principles governing sound project development and implementation are essentially the same.

2.2 SYSTEM PLANNING

Metropolitan planning organizations (MPO) receive UMTA Section 8 planning grants, supplemented with Section 9 funds as necessary, in addition to funds from the Federal Highway Administration to carry out a continuous, comprehensive and cooperative (3-C) transportation planning process in each urbanized area. During this phase, local officials examine long-range urban development trends, collect travel data, forecast needs, and evaluate regionwide transportation policies and investment options. Based on preliminary assessments of travel patterns and problems, local officials select corridors exhibiting severe transportation problems and rank competing corridors in order of improvement priority. A small set of potentially cost-effective alternatives for the highest priority corridor is identified for detailed study in subsequent project development phases. In the case of existing rail systems, the cost-effectiveness methodology developed as part of UMTA's Rail Modernization Study by LTI Consultants, Inc. [Ref. 2] can be useful in prioritizing rail modernization improvements.

FIGURE 2-2. DEVELOPMENT PROCESS FOR RAIL MODERNIZATION AND BUS FACILITY PROJECTS



The System Planning Phase should not result in selection of a particular transit technology for the region or a corridor for which new starts are being considered. Under the National Environmental Policy Act (NEPA-1969), Federal decisions on project funding cannot be made until a full range of alternatives have been considered, impacts have been examined, public input has been solicited, and necessary environmental documents have been completed. The AA process is designed to produce the types of information normally needed to choose mode and alignment. In most cases, selection of technology on the basis of systems level information is premature.

In conducting system planning studies, attention to the following issues will help develop a strong foundation for subsequent project phases:

- Goals and objectives
- Selection of priority corridor
- Generation of alternatives
- Analysis of alternatives
- Private sector involvement
- Documentation
- UMTA involvement

While UMTA does not prescribe a formal system planning process for rail modernization and bus facility projects, certain considerations by the local transit operator are appropriate in the interest of effective planning, programming and resource allocation. These include the ability to justify major rail modernization expenditures on marginal rail lines or obsolete bus facilities and a region's financial capacity to modernize, operate and maintain its existing transit system. These considerations are obviously interrelated and become significant in those regions which have inadequate levels of local financing for modernization of their existing transit infrastructure. System planning studies that address long-term modernization needs can result in the establishment of enhanced local funding resources or recommendations to reduce the magnitude of the existing system.

The System Planning Phase also defines future demands on the public transit system as a function of regional growth and competing modes. This information is important to determine performance and capacity requirements of the future transit system in the Project Planning Phase. For bus systems, future service requirements would be needed to determine the number, size and location of maintenance and storage facilities. For rail modernization, future demand would be needed to size all of the subsystems, such as the system headway requirements used to design control and communications.

2.3 PROJECT PLANNING

For major capital investments, the Project Planning Phase consists of the AA process as prescribed by UMTA. The planning process for rail modernization and bus facility projects is less rigorous. The following sections describe the project planning process for each of these three types of projects.

2.3.1 Alternatives Analysis

Following the System Planning Phase, any metropolitan area which intends to apply for UMTA assistance for a major transit capital investment must next perform a corridor-wide analysis of transportation alternatives in its priority corridor. Approval by the UMTA Administrator is required before such an AA may be undertaken. UMTA support is generally dependent on promising results of System Planning. Criteria for UMTA support are that the priority corridor have at least 15,000 existing daily transit trips and that fixed guideway alternatives have attractive cost-effectiveness potential.

During AA, the priority corridor identified in system planning is studied in detail, looking at alternative solutions to the corridor's transportation problems. Information on the costs, benefits, and impacts of each alternative is collected to provide a sound technical basis for project decision-making. The AA also includes the preparation of the Draft EIS (DEIS) initiating the environmental process required by the NEPA. At the conclusion of this phase, local officials select a preferred mode and general alignment, adopt a plan for financing the project's capital and operating costs, and request UMTA's approval to begin PE and prepare a Final EIS (FEIS).

The AA process consists of six major steps as follows:

- o Initiation of AA
- o Scoping process
- o Development of alternatives and analysis methodologies
- o Analysis and refinement of alternatives
- o DEIS preparation
- o Selection of locally preferred alternatives

AA typically includes certain technical elements consisting of: development of alternatives; travel demand forecasting; estimation of capital and operating costs; analysis of social, economic and environmental impacts; financial analysis; public involvement; and evaluation. Work is performed on all of these elements during each step in the AA as data is collected, methods are developed, analyses are performed and documented, and the results are presented for public review and local decision-making.

In structuring the approach to AA, careful attention should be devoted to defining agency roles and responsibilities. The vast amount of work conducted in an AA is usually performed locally by the transit operator, MPO, or agency of municipal government. A local lead agency must be defined and the roles and responsibilities of other agencies and consultants clearly established. While participating local and state agencies are responsible for ensuring that the study is conducted in a technically sound manner, UMTA also oversees the work and signs off at key points. The DEIS is considered a Federal document and must be approved by UMTA before it is circulated for public comment. In addition to its role of technical and procedural oversight, UMTA is also available to provide technical assistance, thus sharing the expertise its staff has gained on similar projects throughout the country.

2.3.2 Bus Maintenance Facility Planning

While more narrowly defined in scope and impact, bus maintenance facilities, nevertheless, require adequate planning to achieve their objectives in a cost-effective manner. UMTA sponsored the development of Bus Maintenance Facility Planning Guidelines which should be utilized in this regard [Ref. 3].

Recognizing that planning for a new bus maintenance facility or a set of facilities requires engineering and economic analyses to support effective decision-making, a ten-step process has been recommended. Figure 2-3 relates these steps and depicts an overall bus maintenance facility planning process.

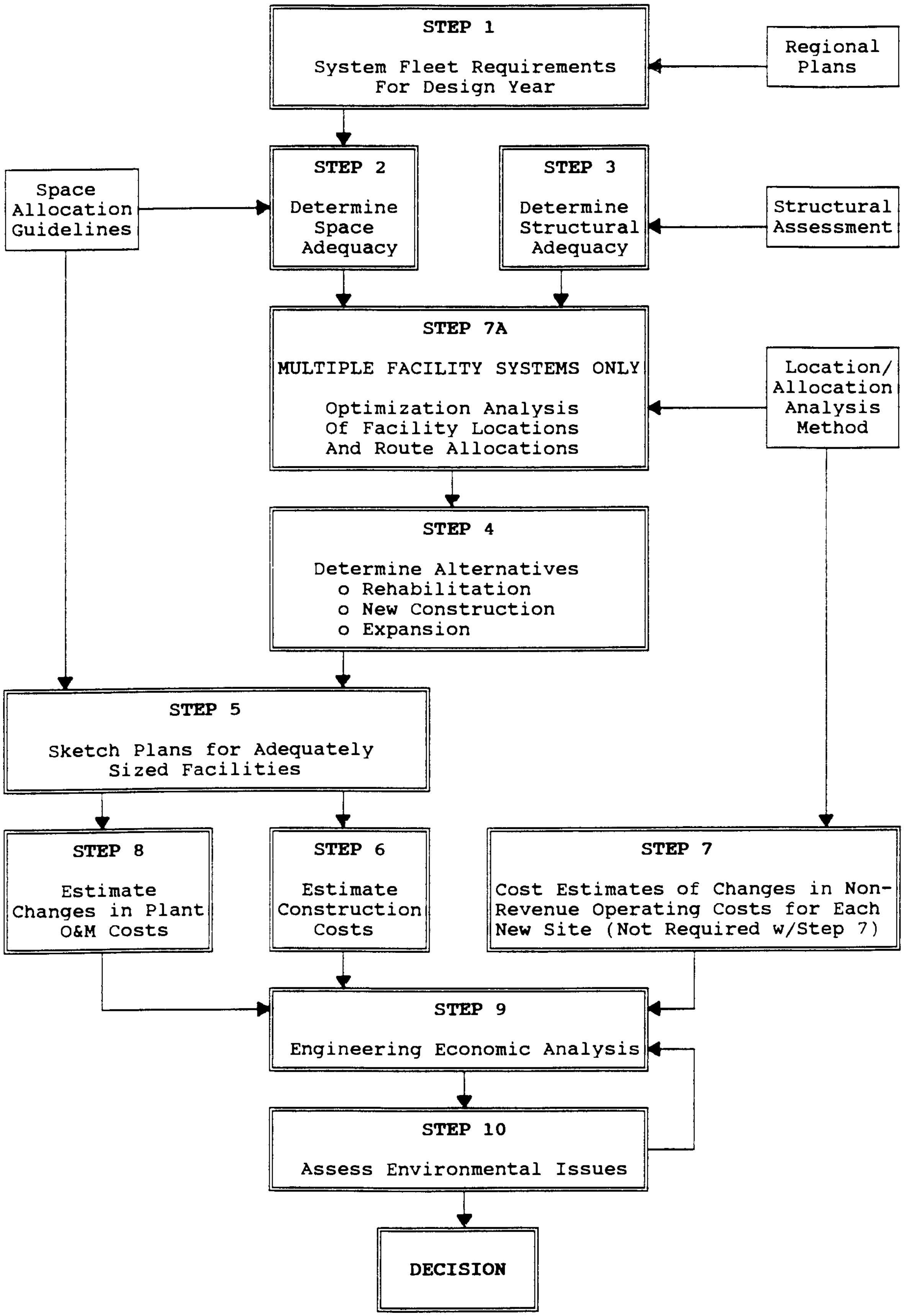
An assessment of environmental impacts may also be required. See Section 2.3.4 for a discussion of environmental issues. Following a local decision to implement a specific bus maintenance facility, PE can advance with UMTA's concurrence and funding support.

2.3.3 Rail Modernization Planning

No single set of requirements or guidelines exists for the planning and prioritization of projects aimed at modernizing existing rail transit systems. Rehabilitation and modernization projects are specifically precluded from the requirements associated with UMTA's major investments policy, including the formal AA process. Recognizing the need for technical assistance, UMTA sponsored a study which resulted in the report entitled: Rail Modernization Planning: Review of Current Practice [Ref. 4]. The study involved investigation of the processes and techniques being utilized by most of the nation's largest rail transit systems. This study documented components of the rail modernization planning process which are utilized, in varying degrees, by the transit planning and operating agencies to prioritize projects for advancement to subsequent phases. They include:

- Prescribe planning/programming requirements
- Establish centralized planning organization/process
- Establish goals/objectives
- Establish quantitative performance goals
- Define performance measures
- Assess long-term modernization requirements
- Consider elimination of existing rail lines
- Plan new route(s) to complement existing system
- Establish life cycle replacement policy

FIGURE 2-3. BUS MAINTENANCE FACILITY PLANNING PROCESS [REF. 3]



- Define long-term financing requirements
- Estimate system-wide ridership and capacity requirements
- Develop subsystem plans and implementation priorities
- Perform systems engineering and analysis of alternatives
- Perform economic analysis of projects
- Predict impact of project on performance measures
- Utilize a project rating system
- Use a senior management review committee

Recognizing that these planning components apply to both the System Planning and Project Planning Phases, each rail transit operator should establish a planning process suited to the specific needs of their system and institutional environment to guide the modernization of existing facilities in a sound and cost-effective manner.

Project planning of rail system modernization projects is best accomplished at the subsystem level for which the following categories are typical:

- Civil structures
- Track structures
- Stations
- Railcars
- Power
- Control and communication
- Maintenance and storage facilities

Subsystem planning involves assessment of condition, establishing modernization goals and performance specifications, performing economic trade-off analyses involving life cycle costing principles, and developing implementation priorities. Associated with this process may be the need to perform some advanced engineering to support subsystem development. For example, this could involve analysis to determine capacity requirements of individual electrical substations and to verify the economic benefits of replacing remotely supervised electro-mechanical substations with centrally controlled solid state equipment.

Depending on the degree to which the rail modernization project extends beyond the bounds of the existing system, environmental assessment may be required. See the following section for a discussion of environmental issues.

2.3.4 Environmental Planning

Environmental planning is an integral part of the 3-C planning process. Final rules for "Environmental Impact and Related Procedures" were published in the Federal Register [Ref. 5]. Closely related, are procedures for historic preservation and protection of public lands. Early in the planning process, it should be determined if there are any environmental or historic preservation issues. UMTA has three classes of action which require different levels of environmental analysis and documentation as follows:

- o Class 1 actions normally have a significant impact on the environment and thus require an EIS. New start projects fall into this category.
- o Class 2 actions normally do not entail significant impact on the environment and therefore do not require an EIS or an Environmental Assessment (EA). These projects are known as categorical exclusions (CE) and typically include rail or bus modernization projects constructed within the bounds of the existing right-of-way, or new bus facilities constructed in industrially zoned areas without major impacts on traffic.
- o Class 3 actions are those in which the significance of the impacts on the environment are not clearly established and for which an EA is prepared to determine the probable impacts. If significant impacts are uncovered, an EIS will then be required, otherwise a "Finding of No Significant Impact" will suffice.

Before a capital project is approved for programming in the annual or biennial element of the Transportation Improvement Program (TIP), evidence should be provided separately that all historic preservation and protection of public land issues related to the project have been raised.

2.4 PRELIMINARY ENGINEERING

2.4.1 General

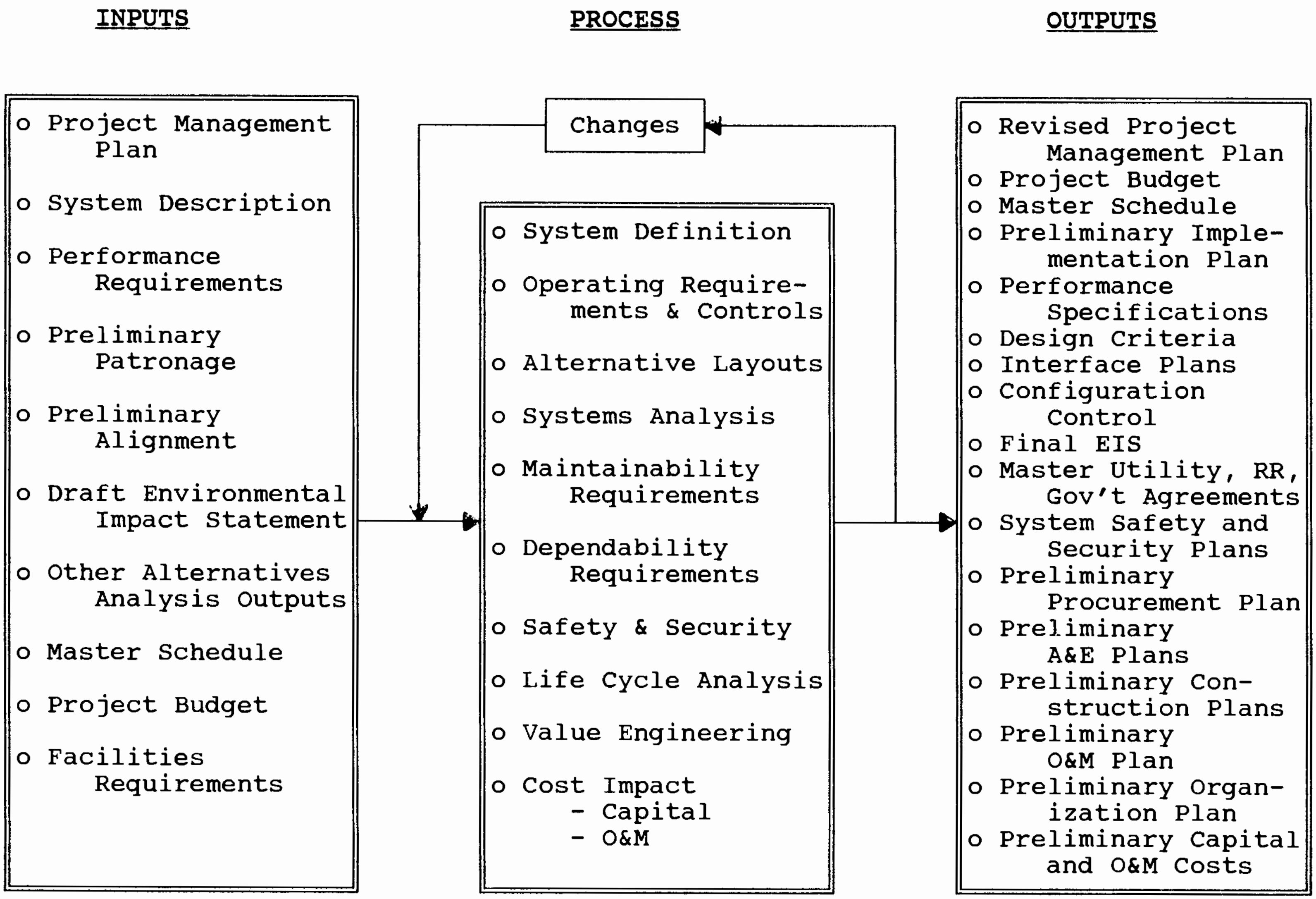
Preliminary Engineering (PE) takes the project from a planning state to a level of design that allows a more accurate estimate of project costs and impacts. The resultant technical and financial information will be a basis for subsequent funding and implementation decisions. A major objective of PE is to investigate the merits of all sound configurations and designs. These investigations require in-depth analysis of all components, their interrelationships, and their costs. In addition, environmental requirements are completed, involving preparation of a FEIS, and in some cases, a supplemental DEIS.

The PE portion of the total design effort, when properly conducted, will permit the project to move rapidly through final design with a minimum of design changes, disruptions and delays. Figure 2-4 depicts the process of PE including the typical inputs and outputs. While the figure establishes the requirements for new start type projects, the general process is applicable to rail modernization and bus facility projects. The inputs are the direct result of Project Planning and the outputs become the basis for the next phase -- Final Design. A major aspect, and most significant in assuring the future success of the project development process, is the Project Management Plan (PMP). The PMP, which is required by UMTA, is discussed in the following section.

Most PE requirements apply to new start type projects as well as to bus maintenance facilities and rail modernization projects. Some differences may exist, however, such as the ability to be excluded from the preparation of an EIS or the need to consider continuity of operations during construction.

If local officials select a major investment, after completion of project planning, UMTA will evaluate the local financing effort, assess the cost-effectiveness of the locally preferred alternative, and consider advancing the locally preferred alternative into PE. Written approval by the UMTA Administrator is required before fixed guideway projects may be advanced into PE.

FIGURE 2-4. PRELIMINARY ENGINEERING PHASE [REF. 6]



This decision is dependent on achievement of certain threshold criteria related to costs and benefits. Approval to initiate PE is not a commitment to fund either final design or construction.

Some rail modernization subsystem projects can be packaged by corridor, rail line or line segment to facilitate coordination in design and construction. The subsystems for which this is most beneficial are civil structures, track structures, control and communications, and power. This permits work on four different subsystems to be accomplished during a single track outage, minimizing operational conflicts. Coordination is also required between the railcar and maintenance/storage facility elements, especially when new railcars are acquired. Stations tend to be somewhat isolated from other subsystems in their modernization, except for assuring physical interfaces such as between the railcar and the platform, and between station security systems and the control center.

Projects to modernize an existing transit system may consider the utilization of agency staff for roles including design, design reviews and construction. Design reviews should encompass compatibility from both an operating and maintenance perspective and constructibility, especially while maintaining operations. Force account labor may also be utilized for certain track, signal and electrical work in addition to providing for the safe working environment of contractors. The utilization of force account resources to support project design and implementation should be planned during the PE phase, but must be justified in accordance with UMTA Circular 5010.1A [Ref. 7].

2.4.2 Project Management Plan

Project management concepts are developed initially during Project Planning and are documented in the PMP. UMTA requirements for the PMP are defined in the Regulation on Project Management Oversight [Ref. 8]. The PMP defines the scope of project implementation during PE in addition to the Final Design, Construction, Testing and Start-Up, and Revenue Services Phases, including the establishment of policies for activities such as project control, quality assurance (QA), quality control (QC), and safety. Also, agreements are made on the allocation of existing financial resources, required new taxes are set in place, and private financing commitments are obtained.

UMTA requires that its grantees undertaking a major capital project must submit a PMP for UMTA's review and approval, both initially and as changes are made throughout the project. As a general rule, the PMP must be submitted during the grant review process and as part of UMTA's grant application review. Although UMTA has some discretion in determining which capital projects are considered major, they generally include: construction of a new fixed guideway segment or extension of an existing fixed guideway, or modernization of existing fixed guideway systems pursuant to a full funding contract. UMTA requires that the grantee's PMP shall include:

- Adequate recipient staff organization, complete with well-defined reporting relationships, statement of functional relationships, job descriptions, and job qualifications.
- A budget covering the project management organization, appropriate consultants, property acquisition, utility relocation, systems demonstration staff, audits, and such miscellaneous payments as the recipient may be prepared to justify.
- A construction schedule.
- A document control procedure and record-keeping system.
- A change order procedure which includes a documented, systematic approach to the handling of construction change orders.
- Organizational structures, management skills, and staffing levels required throughout the construction phase.
- QC and QA functions, procedures, and responsibilities for construction and for system installation and integration of system components.
- Materials testing policies and procedures.
- Internal plan implementation and reporting requirements, including cost and schedule control procedures.
- Criteria and procedures to be used for testing the operational system or its major components.

- The recipient's commitment to make monthly submission of project budget and project schedule to the Administrator.

The PMP should demonstrate that all phases have been thoroughly considered, giving thought to the methods to be used to execute the project, and the interfaces that will be created between various participants. It defines the objectives of the project, the methods and resources proposed to be used in meeting those objectives, the overall management strategy, the responsibilities, authorities and measures of performance for all parties involved.

<u>The PMP, while established initially in the PE Phase, is intended to be a dynamic document which will be updated as required, throughout project implementation.</u> Such updates shall include, but not be limited to, project budget, project schedule, financing, ridership estimates and, where applicable, the status of local efforts to enhance ridership when estimates are contingent, in part, upon the success of such efforts.

Even if a PMP is not formally required by UMTA, it can be a very useful project management tool for rail modernization and bus facility projects. In addition to the eleven aspects previously discussed, the PMP should address coordination and control of force account labor and agency-provided materials for modifications to an existing transit system. The guiding principle in this regard is that force account work should be planned, costed, scheduled and monitored in the same manner as work performed by outside contractors. While the development of PMPs, and indeed the entire QA function, is a discrete activity for one-time capital projects, for on-going modifications to existing systems the project management function is continuous. The transit agency should have an independent staff of professionals skilled in project control functions, such as QA/QC, cost estimation and scheduling. UMTA may review this capability periodically through its Triennial Review process.

2.5 FINAL DESIGN

Final Design is the last phase of project development prior to construction, and is typically financed with the same source of Federal funds utilized for construction (Sections 3, 9 or Interstate Transfer). Upon receipt of the Letter of Intent (for new start projects), local agencies normally proceed with right-of-way acquisition, utility relocation, and the preparation of final construction plans, including construction management plans, detailed specifications, estimates and bid documents, as required. Figure 2-5 depicts the process of Final Design, including the typical inputs and outputs. While the figure establishes the requirements for new start type projects, the general process is applicable to rail modernization and bus facility projects. The inputs are the direct results of PE and the outputs become the foundation for the subsequent phases -- Construction, Testing and Start-up, and Revenue Service. Final Design can extend well into the Construction Phase in that portions can be designed while other portions are being built and/or operated.

UMTA rates projects which are performing or have completed the PE phase to facilitate decisions on the allocation of discretionary (Section 3) program funds for new start projects. The primary criteria include cost-effectiveness and local financial commitment, with additional consideration given to the results of AA analysis, local government support, private sector support, community support and the participation of disadvantaged business enterprises (DBE). Ultimately, funding commitments by UMTA for new starts will be extended to those highest rated projects that have completed PE and can be funded to the completion of an operable segment within available program authorization. When a project has been selected for funding with Section 3 funds, UMTA will typically issue a Letter of Intent and approve funding for Final Design following the completion of PE. The Letter of Intent is a formal pledge which documents UMTA's intention to obligate funds for a particular project, but is not a Federal obligation or administrative commitment. UMTA's decision process is more flexible for rail modernization and bus facility projects. At a particular time in the design stage, when costs are sufficiently defined, final funding commitments can be made.

FIGURE 2-5. FINAL DESIGN PHASE [REF. 6]

<u>INPUTS</u>	<u>PROCESS</u>	<u>OUTPUTS</u>
o Project Management Plan o Project Budget o Master Schedule o Preliminary Implementation Plan o Final EIS o Master Utility, RR, Gov't Agreements o System Safety and Security Plans o Preliminary Procurement Plan o Preliminary A&E Plans o Preliminary Construction Plans o Preliminary O&M Plan o Preliminary Organization Plan o Preliminary Capital and O&M Costs	Changes o Design o Simulation o Analyses o Testing o Operating Req'ts and Constraints o Budget Controls o Schedule Controls o Value Engineering o Design Reviews o Peer Review o Constructibility o Maintainability o Reliability o Safety and Security o Cost Impact - Capital - O&M o Configuration Control	o Revised Project Management Plan o Project Budget o Master Schedule o Implementation Plan o Mitigation Plan o Final Design Documents o Construction Plan o QA/QC Plans o Detailed Utility, RR, Government Agreements o System Safety and Security Plans o Procurement Plan o Bid Documents o Joint Development o Test Plan o O&M Plan o Organization Plan o Capital and O&M Cost Estimates

To avoid delays and substantial added costs that are likely to accompany changes in the detailed Final Design, the project scope should be decided by the completion of the PE and frozen at the initiation of Final Design. Changes should be permitted only for compelling reasons, i.e., substantial economies achieved through value engineering, accommodation of changed conditions in construction, reduction in funds or changes in funding agency criteria, and other reasons for which the consequences of not changing are substantially more adverse than the risk of delay and the increase in design cost.

The purpose of the Final Design Phase is to prepare final drawings, technical specifications, and contract documents required to obtain construction contract bids. This includes clear statements of testing requirements and acceptance criteria for the safety and functionality of all subsystems. Typically, this phase also includes the preparation of the engineer's estimate and schedule, analysis of the construction bids, and award or recommendation for award.

Prior to the award of each construction contract, all real estate necessary to the contract work should be acquired, including land that may be leased for construction plant and access. During the Construction Phase, revisions of the design or even redesign may be necessary to accommodate unanticipated site conditions, accepted value engineering proposals, final manufacturer's drawings, errors, and other factors.

While the definitions for the Final Design and Construction Phases presented here are typical for transit projects, there may be a situation where a "fast track" approach is desirable, such as an emergency situation or in conjunction with a private sector joint development project. In such a case, design and construction tasks would be integrated and the overall implementation time frame would be compressed.

2.6 CONSTRUCTION

During Final Design of a fixed guideway project, UMTA and the grantee will negotiate a construction grant contract (i.e., a full funding agreement) with a fixed ceiling on the Federal contribution, subject to a defined method of adjustment for inflation. Localities will be required to complete construction of the project, as defined, to the point of initiation of revenue operations, and to absorb any additional cost incurred, except under certain specific, extraordinary circumstances. The full funding agreement may also include a mutually agreeable schedule for anticipating Federal contributions during the construction period. Specific annual contributions under the Letter of Intent and full funding agreement will be subject to the availability of budget authority and the ability of the grant recipient to effectively use the funds. An UMTA grant contract is required for modernization projects, but is not typically a "full funding" grant.

The Construction Phase includes the physical building of all structures of the transportation improvement, and the fabrication or manufacturing of the components and subsystems which will be installed with the fixed facilities to form the system, and the testing of all subsystems and components. Construction bid packages are prepared during Final Design and bid upon by contractors for various aspects of work. Construction management performed by the grantee or its consultant involves oversight of the work in progress, both contractor and force account; maintenance of budgetary, cost and schedule control; inspection and testing; and documentation of as-built configurations, QC inspection records, deficiency lists, etc.

Figure 2-6 depicts the process of accomplishing the Construction Phase, including the typical inputs and outputs. While the figure establishes the requirements for new start type projects, the general process is applicable to rail modernization and bus facility projects. The inputs are the direct results of the Final Design Phase and the outputs are the fixed facilities, equipment, plans and procedures required for the Testing Phase. To facilitate implementation of the Construction Phase, a construction management plan must be developed to assure implementation of the proposed transit improvements in accordance with the designs, specifications and resources established in the previous phases. Special attention must be devoted to construction activities adjacent to an operating system to assure the safety of transit riders, operating employees, and

FIGURE 2-6. CONSTRUCTION PHASE [REF. 6]

INPUTS

- o Project Management Plan
- o Project Budget
- o Master Schedule
- o Implementation Plan
- o Mitigation Plan
- o Final Design Documents
- o Construction Plan
- o QA/QC Plan
- o Detailed Utility, RR, Government Agreements
- o System Safety and Security Plans
- o Procurement Plan
- o Bid Documents
- o Joint Development
- o Test Plan
- o O&M Plan
- o Organization Plan
- o Capital and O&M Cost Estimate

PROCESS

Changes

- o Management
- o Engineering
- o Supervision
- o Inspection
- o Construction Contracts
- o Budget Controls
- o Schedule Controls
- o Value Engineering
- o Shop Drawings
- o Vendor Submittals
- o QA/QC
- o Safety
- o Claims
- o As-Built Plans
- o Configuration Control
- o Records Management

OUTPUTS

- o Revised Project Management Plan
- o Mitigation Measures
- o Utility Relocations
- o Ways and Structures
- o Guideways
- o Busways
- o Stations
- o Park and Ride Lots
- o Multimodal Transit Centers
- o Central Control
- o Trackwork
- o Traction Power
- o Train Control
- o Communications
- o Fare Collection
- o Yards and Shops
- o Bus Garages
- o Administration Buildings
- o Completion Documentation

construction workers during modifications to existing transit facilities.

2.7 TESTING AND START-UP

The Testing Phase culminates with the acceptance of an operating transportation system improvement in accordance with predetermined criteria, based on the satisfactory completion of the construction of fixed facilities, the installation and test of all subsystems and components, and their integration into a system. Tests include plant and on-site performance testing of major systems, and integration testing of the entire system in its operating environment. Acceptance of the system by the grantee implies that all design levels and specifications have been met, related to both safety and functionality. Figure 2-7 depicts the process of testing, showing the inputs in terms of plans, procedures and resources which were defined during Final Design, and the output -- the final test report.

Start-up involves operation of the accepted transportation improvement in a test and training mode by the grantee's personnel prior to its initial use in revenue service. Figure 2-8 shows the key inputs to the Start-up Phase in terms of the plans, procedures and resources defined in the previous phases and the resulting plans and reports which create a baseline for the initiation of Revenue Service. While Figures 2-7 and 2-8 establish requirements for new start type projects, the general processes are applicable to rail modernization and bus facility projects.

The testing and start-up process may be much less demanding for modernization projects than for new starts, depending on the degree of complexity and magnitude of the modifications being made.

2.8 REVENUE SERVICE

The Revenue Service Phase is the period of normal system operations which occurs after the previously discussed improvement project(s) have been completed. From the perspective of effective transit project management, during the Revenue Service Phase, attention should be focused on the maintenance of the facility.

FIGURE 2-7. TESTING PHASE [REF. 6]

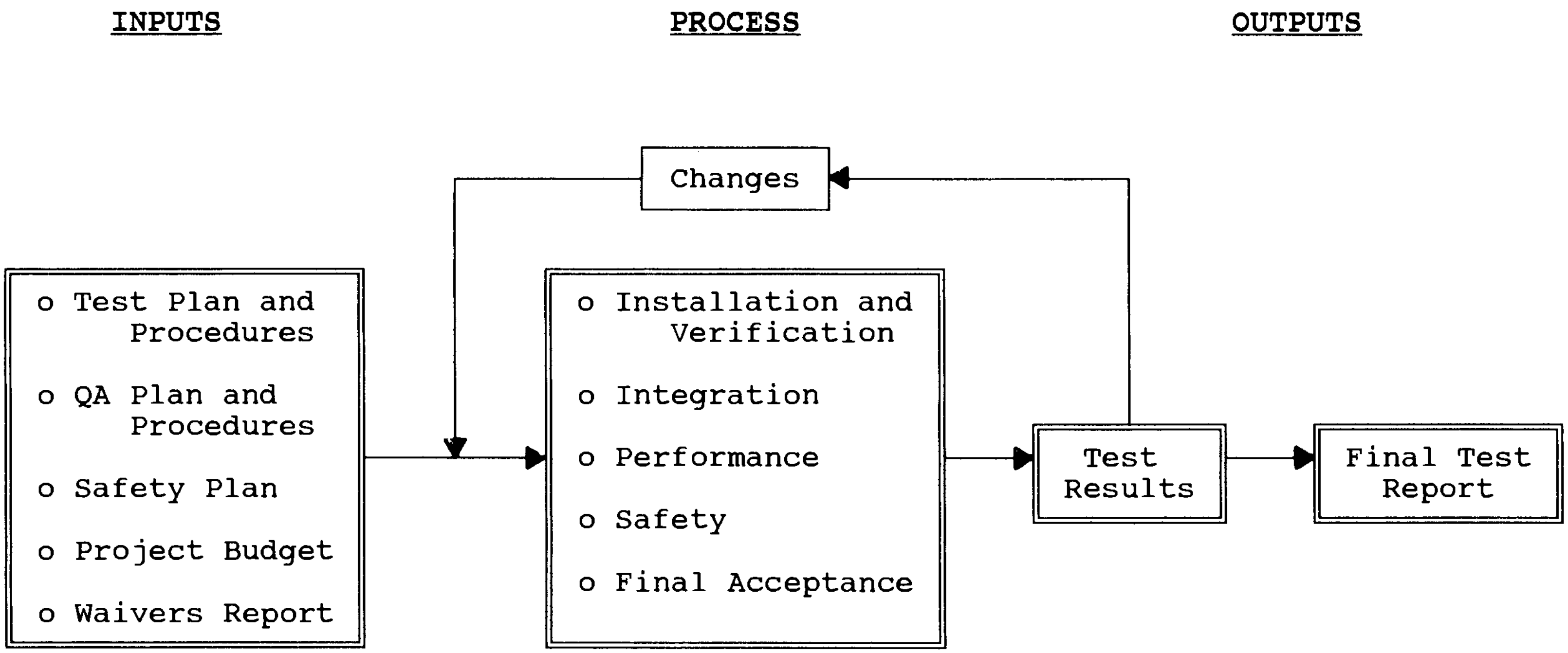
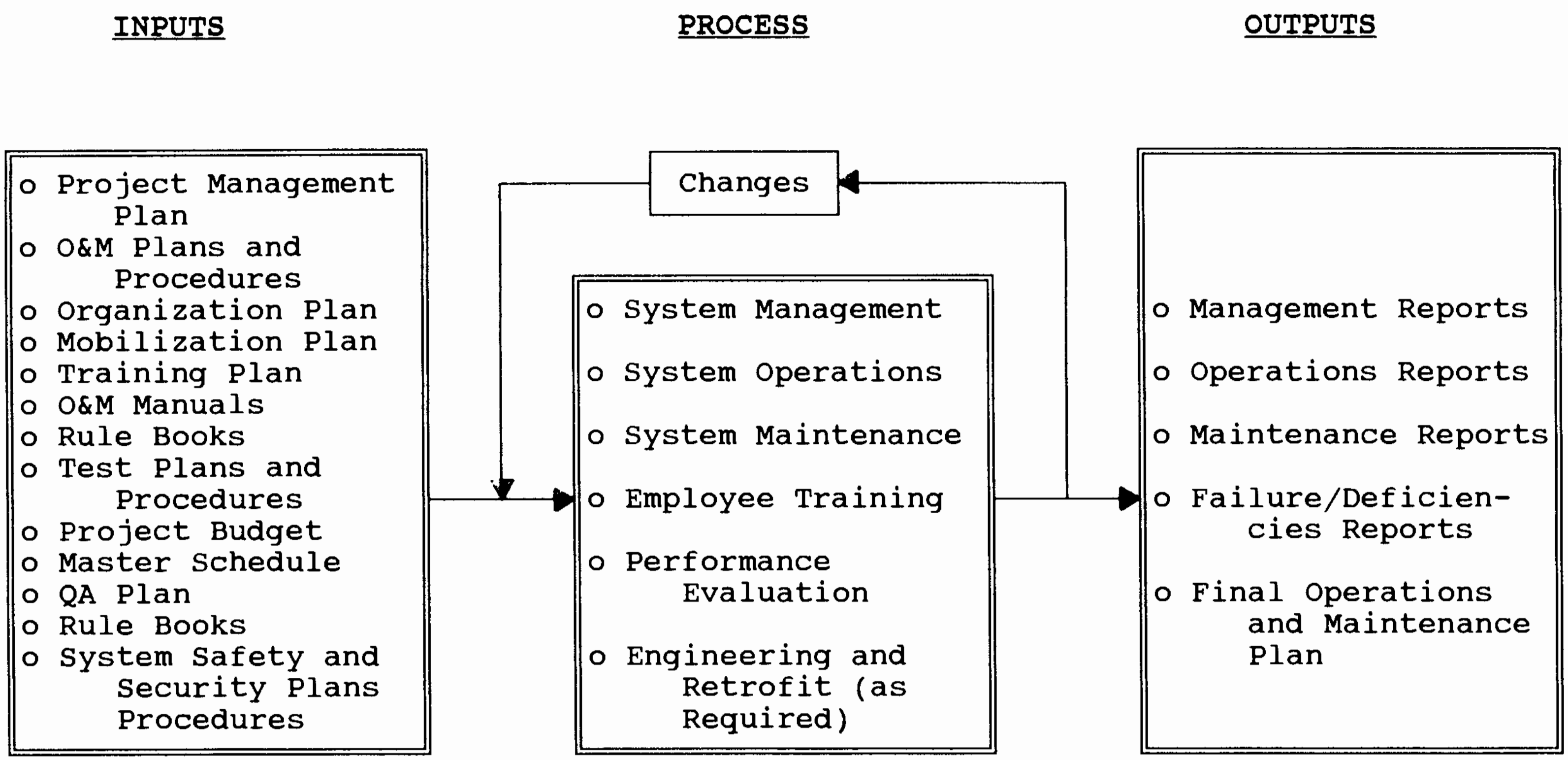


FIGURE 2-8. START-UP PHASE [REF. 6]



An ongoing process of planning and analysis of performance statistics should be structured to define the need for future projects to modernize or supplement the operating transit system.

CHAPTER 3

GENERAL PRINCIPLES FOR MANAGING THE PROJECT DEVELOPMENT PROCESS

Chapter 3 - Proj. Management Principles \ Chapter 2 - Transit Capital Devel. Proc.	2.2 System Planning	2.3 Project Planning	2.4 Prel. Engineering	2.5 Final Design	2.6 Construction	2.7 Testing/Start-up	2.8 Revenue Service
3.1 AUTHORITY, MANAGEMENT 3.1.1 Legal Authority 3.1.2 Mgmt/Organization 3.1.3 Human/Labor Issues 3.1.4 Agreements/Approvals	4.1	5.1	6.1	7.1	8.1	9.1	10.1
3.2 SYSTEM DEFINITION 3.2.1 Project Definition 3.2.2 Configuration 3.2.3 Imposed Requirements 3.2.4 Real Estate	4.2	5.2	6.2	7.2	8.2	9.2	10.2
3.3 FINANCIAL ISSUES 3.3.1 Cost Estimates 3.3.2 Funding	4.3	5.3	6.3	7.3	8.3	9.3	10.3
3.4 MGMT. CONTROL SYSTEMS 3.4.1 Work Breakdown 3.4.2 Configuration Mgmt. 3.4.3 Quality Assurance 3.4.4 Schedule Control 3.4.5 Cost Control 3.4.6 Tools and Techniques	4.4	5.4	6.4	7.4	8.4	9.4	10.4
3.5 PROCUREMENT/CONTRACTS 3.5.1 Procurement Issues 3.5.2 Contract Administrtn 3.5.3 Dispute Resolution 3.5.4 Claims Management	4.5	5.5	6.5	7.5	8.5	9.5	10.5
3.6 SAFETY/RISKS/INSURANCE 3.6.1 Operational Safety 3.6.2 Construction Safety 3.6.3 Risk Mgmt/Insurance	4.6	5.6	6.6	7.6	8.6	9.6	10.6
3.7 COMMUNICATIONS 3.7.1 Develop Program 3.7.2 Audience 3.7.3 Responsibility 3.7.4 Reporting Systems 3.7.5 Interface Management	4.7	5.7	6.7	7.7	8.7	9.7	10.7

CHAPTER 3
GENERAL PRINCIPLES FOR MANAGING THE CAPITAL PROJECT DEVELOPMENT PROCESS

The general principles for managing the transit capital project development process are presented in this chapter. Emphasis is given to those aspects which are not phase-dependent, and thus can be applied throughout the project development process. The principles are intended to establish a framework for the more detailed guidelines presented in Chapters 4 through 10, respectively, which are related to the specific project phases. Extensive use has been made of the report entitled: Management of Urban Construction Programs Volume I: Guidelines for Developing a Project Management Plan and Volume II: Supplemental Information [Ref. 9]. This report was completed in June 1981 by the Building Research Advisory Board of the National Research Council. It was sponsored by UMTA, and is a primary reference document for grantees developing PMPs which guide major transit capital investments.

3.1 LEGAL/INSTITUTIONAL AUTHORITY, MANAGEMENT AND ORGANIZATION

3.1.1 Legal/Institutional Authority of the Project Sponsor/Grantee

Before embarking on any transit capital development project, the public agency(ies) which will be responsible for the various phases must possess the legal authority to carry out all the requirements designed to effectively plan and implement the improvement. Statutory authority may be required to perform functions such as:

- Planning, design, construction, ownership, operation and maintenance of public transit facilities.
- Local financing, including use of public funds, taxation, and issuing bonds.
- Receipt of Federal and state grants.
- Procurements and awarding contracts.
- Real estate acquisition and condemnation.

Where transit organizations are well established for the planning, development and operation of fixed guideway systems and other fixed facilities, a review of existing statutes should, nevertheless, be made to gain a full understanding of the authority of the lead organization and any legal constraints that may affect the project. The purpose of reviewing existing statutes is to identify requirements and constraints in an orderly and timely manner to be able to deal with them in the normal course of project advancement. Failure to recognize and accommodate legal requirements will jeopardize subsequent approval processes and severely impact the project schedule. The project sponsor must be diligent in maintaining an awareness of changes in the legislative/regulatory environment which may impose future constraints on a project. The ability to deal with those potential issues in the planning/design phase may save considerable time and effort during construction. In addition to state and local requirements, specific Federal statutes, rules, regulations and circular listings, include, but are not limited to, the following topics:

- Buy America
- Cargo Preferences
- Copeland Anti-Kickback Act
- Flood Insurance
- Disadvantaged Business Enterprise (DBE)
- Land Acquisition and Relocation
- Procurement
- Equal Employment Opportunity (EEO)
- National Environmental Policy Act
- Davis-Bacon Act (wage rates and labor provisions)
- Rehabilitation Act (elderly and handicapped accommodations)
- Equal Employment Opportunity for Grantee Staff
- 13(c) (labor protection)
- Safety and Health Regulations for Construction

UMTA Circular 5010.1A, Urban Mass Transportation Project Management Guidelines for Grantees, September 18, 1987 [Ref. 7], provides detailed programmatic requirements related to project administration and management, financial management and payment procedures.

3.1.2 Management/Organization

Major transit capital improvement projects are complex undertakings that require a formal management approach in order to achieve completion in a successful manner. In order to better understand the processes involved in management, it is worthwhile to review some definitions. A "project" can be considered to be any series of activities and tasks carrying a specific objective that must be accomplished within certain specifications; have defined start and end dates; have funding limits; and consume resources such as money, labor, materials, etc. "Project management," on the other hand, involves project planning and project monitoring. "Project planning" encompasses the definition of work requirements, quantity of work, and resource requirements. "Project monitoring" involves tracking process, comparing actual to predicted, analyzing impacts and making adjustments. "Successful project management" is defined as having achieved the project objectives within budget and schedule and at the desired performance level, while using the assigned resources effectively and efficiently.

The project management form of organization has found increasing application in engineering and construction activities. Project management is generally defined as an organizational form using the dual reporting relationship of a matrix structure. Figure 3-1 depicts a matrix organization in which line departments with functional responsibilities are shown vertically and project organizations with project responsibilities are shown horizontally. Thus, a staff person has dual reporting responsibilities to the line manager and to the project manager. Figure 3-2 further develops this concept to define the project office into which staff can be assigned on a temporary basis while remaining functionally affiliated. A matrix organization is utilized on finite duration projects, such as transit capital improvements, where dual focal points of equal importance are required -- technical and cost/schedule. Personnel assigned to the project report to the project manager regarding work priorities, and to a functional manager in the firm or agency for the technical adequacy of the work. The matrix form of organization permits the integration of technical specialists and firms who may participate on several individual projects to effectively contribute,

FIGURE 3-1. MATRIX ORGANIZATION

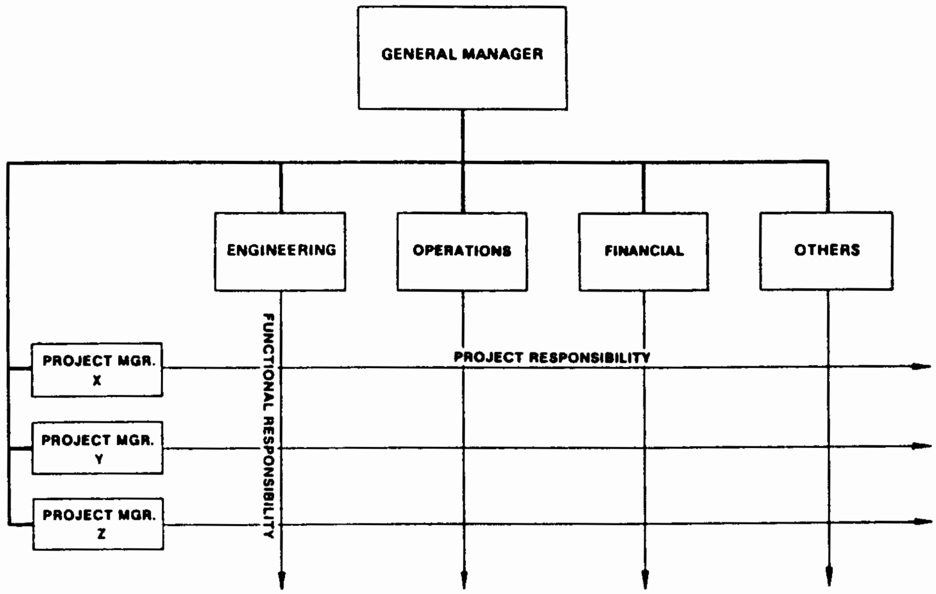
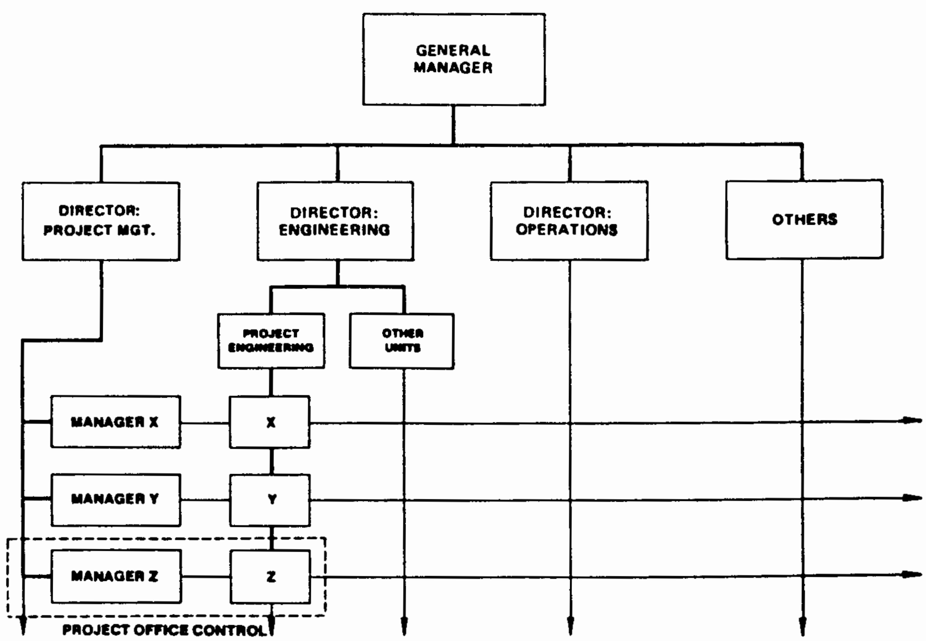


FIGURE 3-2. MATRIX ORGANIZATION WITH A PROJECT OFFICE



along with others, to the accomplishment of the project objectives for which the organization is responsible.

As an urban transit project evolves throughout its phases, from planning to implementation, the objectives will become refined and the organizational participation will vary greatly, depending on the specific requirements of each phase. Thus, the overall project management framework must be flexible to accommodate the needs of each phase. The goal of the organization at any given time should be the effective and efficient accomplishment of the project objectives for that phase. This may necessitate the involvement of different personnel and contractors from phase to phase and may even require different lead public agencies and project managers. As a project evolves, however, there is a need for continuity to assure the achievement of the overall objectives.

Critical in the structuring of any organization is the flow of authority and responsibility from the sponsoring agency through the project manager, functional area managers, and contractor managers, to each assigned project participant. Variations in the size and complexity of a transit capital project and the capability of the sponsoring agency will influence the use of outside contractors and the project organizational structure. The size, qualifications and availability of existing staff resources must be considered in relation to the human resource requirements and duration of the project. For the small bus operator planning a new maintenance facility or the system developing a single fixed guideway segment, it may prove to be prudent to contract for technical studies, design and project management services, rather than hiring an entire staff. In the case of a large fixed guideway system development, consultants may be utilized initially, with staff capabilities developed gradually to replace the consultants. Owners also have the option to give greater responsibility to contractors by utilizing turnkey and build-operate concepts.

The obvious benefit of utilizing contracted support services is the ability to immediately terminate their involvement and associated expense when the need is fulfilled. Even when an outside organization is used, the sponsor or owner must have in place an organization to maintain overall control of the project, it must provide for timely decision-making, and it must maintain appropriate communication channels with all participants. Clearly, any organizational arrangement that would result in duplication of effort or that would tend to undermine authority should be avoided. The organizational structure and work scopes for both agency staff and outside contractors must clearly define their respective responsibilities. Organizational and staffing considerations during each of the project development phases should adhere to the following guidelines:

- o Charts showing the complete organization should be developed for each phase and should cover all project functions and all project personnel, regardless of affiliation. Staffing levels should be indicated.
- o Key personnel in all organizations should be identified and their principle duties, reporting relationships, assigned responsibilities, and delegated authority should be defined.
- o Interface points within and outside the project organization should be identified.
- o Agency and company organization charts showing the organizational placement of personnel assigned to the project and the interface points should be required for all major project participants.
- o A staff mobilization plan that incorporates a schedule of milestone events should be developed.
- o The philosophy governing the development of the project organization should be stated, and the decision to contract for or use in-house services should be explained.

It should be recognized that for large multi-segment fixed guideway projects (new construction or modernization), a grantee may simultaneously be in several project development phases (such as Project Planning, PE, Final Design, Construction, Testing and Startup, and Revenue Service) of individual system segments. Detailed project organization charts should be prepared for each phase to show all of the actors and their reporting relationships. Similarly, when transit operating authorities undertake a capital improvement project, the relationship of the project organization to the operating organization must be defined and the interface points between the two clearly established. In summary, the owner, through its governing board, must be responsible for performing the following functions:

- o Establishing policy
- o Assuring financing of the project
- o Approving budgets and expenditures
- o Approving contract documents
- o Approving award of contracts
- o Acquiring land
- o Executing the project

A typical owner's organization will have a general manager or executive director who will implement board policies through the day-to-day operations of the authority. This individual is assisted by heads of such departments as engineering, construction, real estate, finance, procurement, legal, personnel, operations, and public affairs. Given the characteristics of the existing owner's organization, the project to be implemented, and the owner's future role and responsibilities, organizational approaches available with respect to staffing for the new project include:

- o Develop an in-house staff to undertake the entire project.
- o Delegate responsibility to a general consultant for planning, designing, constructing the facility or to delegate the management of design and construction to separate consultants.
- o Utilize contractors for turnkey or build-operate implementation.
- o Combinations of the above approaches.

There are successful examples of each of these approaches. Whatever the organizational pattern, it is imperative that the owner make certain that the necessary mechanisms exist to permit prompt and final decision-making on all significant questions and that the various elements work in unison.

While the concept of "project management" encompasses the entire capital development process from system and project planning through operations and maintenance, "construction management" can be defined as activities and management principles that have as their objectives, the control of time, cost and quality in the design and construction of a new facility. These guidelines are intended to define sound management of the entire process of transit capital project development, encompassing both traditional project and construction management functions. No attempt will be made to differentiate these functions although an owner may find it convenient to establish the role of a "construction manager" to oversee the construction phase as well as the aspects of the design phase that will affect the success of the construction phase. Separate professional organizations have been created to promote development and practice of these two disciplines and include:

The Project Management Institute (PMI)
P.O. Box 43
Drexel Hill, PA 19026
(215) 622-1796

The Construction Management Association of America (CMAA)
12355 Sunrise Valley Drive
Reston, VA 22091
(703) 391-1200

PMI addresses project management topics in a generic manner not necessarily related to capital improvement projects, while CMAA focuses on issues affecting the construction of capital improvement projects. Both of these organizations have professional development activities and documentation resources that can be used to enhance the capabilities of management personnel involved in implementing transit projects.

Several initiatives of the Business Roundtable (BRT), a national association of about 200 chief executive officers of American companies, reinforce the objectives of the Guidelines. The BRT has sponsored the Construction Industry Cost-effectiveness project (CICE), a wide-ranging study seeking ways of making construction more efficient. CICE found that management shortcomings were responsible for much of the cost overruns and delays commonly occurring on construction projects. The findings of the study are summarized in a report "More Construction for the Money," and its sequel "CICE - The Next Five Years and Beyond." Copies of these reports and of the study's 23 detailed reports are available on request from:

The Business Roundtable
200 Park Avenue
New York, New York 10166
(212) 682-6370

Local User Councils (LUCs) now exist in most metropolitan areas. They gather data on local construction activities and problems, provide a forum for information exchange among owners and contractors, and sponsor educational programs for project and construction managers. Membership and participation by the grantee in the nearest LUC is highly desirable. A list of LUCs and their local contacts is available from BRT at the above address.

The Construction Industry Institute (CII) was founded in 1983 to improve cost-effectiveness in construction by identifying research needs, conducting research, and publicizing remedies to construction problems. A list of CII publications can be obtained from:

The Construction Industry Institute
The University of Texas
ECJ 5.2
Austin, Texas 78712

In addition to the mechanics of organizing and managing projects, the management philosophy, project team attitude and application of project resources are critical to the success of the endeavor. They are established and fostered by the owner/project manager and, if effective, permeate the entire project team. An example of the management philosophy and project requirements attributed to the success of a major urban transportation project (The Center City Commuter Connection in Philadelphia) is as follows:

Management Philosophy

- Management by Objectives
- Control by Exception
- Administer by K.I.S. (Keep it Simple)
- Expedite by Leadership

Project Requirement

- Leadership - Right People in the Right Slots
- Communication - Team Problem Solving
- Participation - Owner and Consultant
- Cooperation - Establish a Common Goal
- Authority - Centralized Management
- Control - Management System

- o Resources - Available as Needed
- o Knowledge - Prior Experience
- o Funding - Adjust to Needs of the Project

The remaining sections of this chapter address the multitude of management functions required to successfully implement a capital improvement project. Effective planning will permit the project manager to control each of these elements. UMTA's requirement for the preparation and submission of a PMP encourages sound management practice. Guidance has been provided by UMTA on the content and structure of the PMP (see Reference 8 and Section 6.1.2) and the two Management of Urban Construction Programs volumes [Ref. 9]. These Project and Construction Management Guidelines are intended to be a further resource for a grantee's reference and consideration throughout the transit capital project development process, including management planning, to be documented in the PMP.

The PMP should be prepared at the beginning of the PE Phase and updated as required, but as a minimum, at the beginning of the Final Design and Construction Phases. It is suggested that for large multi-segment projects, an overall PMP be developed, with supplements for each phase of each segment. A supplement would reflect the unique characteristics of each segment/phase, such as the exact scope of work and specific contractors and personnel involved.

3.1.3 Human Resources and Labor Relations

It is essential that human resource factors be considered in both initial project development and in project execution. Human resource considerations include all elements that are related to the recruitment, selection, utilization and training of all levels of personnel under a coordinated, planned administrative procedure.

Federal, state and local statutory requirements should be identified and incorporated into administrative procedures. Consideration should be given and reference should be made to wage and hour requirements and compliance with state and local regulations and equal employment opportunity regulations. In addition, Federal, state and local labor legislation, (e.g., Right-to-Work and Common Situs laws, the Taft-Hartley Act, and Workman's Compensation) that could have an effect on the management of project personnel should be referenced. An assessment should be made of prevailing labor practices and conditions. Policy should be established and responsibility should be assigned with regard to the following issues:

- o Use of union versus open shop
- o Use of locally negotiated labor agreements or project agreements

An effective management program for human resources and labor relations policy requires that all existing productive or counterproductive conditions be carefully weighed. Actions should be taken to overcome counterproductive conditions and to monitor productive conditions to maintain or improve their advantages. Examples of counterproductive conditions might be a shortage of skilled craftsmen, etc. Examples of productive conditions might be the existence of successful area training programs or a cooperative management labor productivity campaign.

Project team training programs should be established, as appropriate, for management, professional and construction personnel. Training may include topics such as:

- o Administrative policies and procedures (e.g., reporting requirements, substance abuse policy, etc.)
- o Safety
- o Value engineering
- o Technical aspects of the improvement being advanced
- o Public relations sensitivities
- o Project control

Training could encompass a variety of formats, including classroom instruction, workshops, seminars, site visits, presentation by managers, informal on-site discussions, etc. For ongoing modernization projects, training should be a continuous process for all affected operating and construction personnel.

3.1.4 Interagency Agreements, Approvals and Permits

Invariably, in an urban or public context, numerous agencies and organizations will be directly or indirectly involved in each phase and their roles and responsibilities must be thoroughly understood and properly coordinated. Formalized agreements documenting the roles, responsibilities and participation of all affected groups should be established and may include the following:

- UMTA (headquarters and regional office)
- UMTA PMO contractor
- State DOT
- Metropolitan planning organization (board and staff)
- Regional transit authority (board and staff)
- City government (mayor, council, administrative departments)
- County government (elected officials, administrative departments)
- Local utilities (electric, telephone, water, gas, railroads)
- Citizen organizations
- Environmental/historic preservation advocates
- Chamber of commerce/business advocates
- Land/building owners/developers

The use of steering and advisory committees is an effective way to assure the involvement of the effected groups listed above. A steering committee should be comprised of elected officials or representatives appointed by elected officials. Where a transit authority is the lead agency, the panel would be derived from its board of directors or a subcommittee thereof. Advisory committees should be created to facilitate communications among special groups and could include:

- Technical
- Citizen
- Financial
- Fire/life safety
- Operations and maintenance
- Traffic maintenance
- Environmental
- Joint development
- Underground utilities
- Security
- Safety certification review

It should be recognized that the composition and function of these committees can be expected to evolve as a project moves through the various development phases.

Consideration must include those government agencies having responsibility for decision-making, approvals, and the issuance of licenses and permits for which avenues of communications and working relationships should also be established. Situations may also arise in which private sector entities are involved in the implementation of a transit capital improvement. These may require special statutes to permit various aspects of land acquisition, construction, operation, etc.

3.2 SYSTEM DEFINITION/CONFIGURATION/PERFORMANCE

The performance characteristics and physical attributes of a transit capital improvement must relate to the overall system into which it will function. For new fixed guideways, the sponsor has maximum control of the system definition, but in the case of modification to an existing system (extensions or modernizations), the new project will be constrained and must be made compatible.

3.2.1 Project Definition

At each phase of project development, the owner or project sponsor, should define realistic and attainable goals and guiding policies which will lead to successful implementation of the project. A record should be maintained of the background and purpose of the project as it evolves. At the project's start, certain parameters are established that must be duly recognized and considered as the overall scope of the project and as the defined limitations within which it will be executed. Included among these parameters is either a functional or physical description of the items to be developed. These parameters serve as the general basis on which the project is authorized for funding and implementation. They are, therefore, relatively firm considerations. Should any of these "givens" be altered during the course of the project, there is normally an accompanying cost and an adverse time impact. Thus, owners should strive to avoid changes to the established baseline unless absolutely necessary. From the initial system requirements and description of the project to be developed, the configuration and design would, in an ideal situation, evolve smoothly to even finer levels of detail.

3.2.2 Configuration

The physical and technical definition of a project must evolve in an orderly manner throughout the project development process. To assist in the evolution of the physical definition, design criteria must be established early in the project. In addition, the performance characteristics of the completed project must be documented. Design/performance criteria should exist for the following elements:

- System-wide - capacity, safety, security, emergency procedures, system dependability, vehicle availability, ride quality, accessibility, comfort, convenience, aesthetics, environmental, etc.
- Subsystem - vehicles, control, communications, power distribution, fare collection, support equipment, etc.
- Fixed Facilities - guideway, stations, central control facility, maintenance and storage facility, administration and personnel operating facilities, etc.

Once set, the design criteria and the performance characteristics may be augmented, but should otherwise not be changed during the life of the project, unless it is clearly demonstrated that cost-effective trade-offs exist. The performance characteristics provide the measure for evaluation of technical accomplishment of the project. System components may initially be described in terms of functions and, to the extent existing, physical requirements. These descriptions should be modified and converted to engineering documentation as the design evolves.

Among the most important management considerations relating to the system configuration and performance are the following:

- Design Documentation - Once design criteria have been established, standards should be selected or developed in each of these same areas. Each design task within an organization's area of responsibility should be scoped, planned, and scheduled in the same manner. Task statements which include requirements, assumptions, and a detailed list of deliverables should be prepared. The design tasks should result in the preparation of drawings and/or specifications for all items and systems.

- Interface Definition - Early in the system definition process, a critical activity is the identification and documentation of system interfaces which may place constraints on the configuration or performance; e.g., power supplies, other utility and service interfaces, or physical constraints. The preparation of interface drawings and specifications should be undertaken during the design process.

- Reliability and Maintainability - System and equipment reliability and maintainability evaluations, the preparation of a System Reliability Plan and a System Maintainability Plan, and the carrying out of Reliability and Maintainability Program activities have a significant and valuable impact on system configuration, detail design and on system operation.

- Peer Review - A peer review is a structured, independent review of an organization or project by a team of experts which are completely external to the subject under review. The team members should have at least the same level of expertise and experience as those who are responsible for the project. Peer reviews usually cover all design phases and are intended to improve the overall quality of the project. Categories of peer review include organizational, project management and aspects of project design, construction, operations, or maintenance. Peer reviews are typically narrowly defined and should be limited to special topics or situations with a specified purpose, scope, format and duration.

- Value Engineering (VE) - VE has a vast potential for reducing both capital and O&M costs of major transit projects. VE is a formal, systematic, investigative technique which includes studying a product, system, or facility in order to identify and analyze the functions that it has been designed to perform. The costs to be incurred by constructing and utilizing the product as designed over its total life cycle are calculated, and alternative designs are generated in order to determine the most cost effective method of performing the identified functions, consistent with requirements for quality, reliability, maintainability and safety. A VE study is a creative, multi-disciplined team effort that experience shows is best implemented when the design is approximately 30 percent completed (at the end of PE). VE can also be applied beneficially throughout Final Design and into construction. A VE consultant may be used to manage the VE study effort, but a qualified team of professionals could be selected to participate. The consultant should have experience in conducting VE studies for transit projects. Participants in the study are usually most effective if they have not been significantly involved in the design being studied.

- Operation and Maintenance (O&M) Interface - Provision should be made for incorporating O&M concerns in design and construction solutions, particularly during the design phase. Procedures should be established to provide for a continuous review of all design stages carried out jointly by owners, consultants, and O&M personnel to ensure that the final design incorporates those features that are consistent with projected O&M needs and costs. This can be accomplished by early development of system operating strategies and projection of operating statistics from these strategies. Estimation of operating costs and, for revenue - generating systems, estimation of operating revenues, are essential elements in selection and design of the system configuration. A System Operating Plan and a System Maintenance Plan should be developed and the evolving design evaluated with respect to them. Consideration should be given to evaluating economy of design, system continuity and safety, and reliability in relation to budgeted construction costs.

- Design Reviews - Responsibility should be assigned for providing and coordinating design reviews by the owner, consultants, and operational staff to ensure that project objectives are being met. During design review, attention should be directed to consistency with design criteria, possible errors and omissions, and constructibility. Determining the extent of review or multiple reviews required should be based on consideration of the consequences of failure, the owner's experience with the design organization's in-house checking capability, and aspects of the QA program (see 3.4.3). Prior to final approval, a constructibility review of the planned construction contract should be conducted.

- Test Program - Performance requirements should be translated into test requirements and then into specific test and inspection plans. Policy should be established for acceptance testing of materials, components, and systems. Specific responsibilities should be assigned for preparation of individual unit or equipment test and inspection plans, conduct of the tests, and approval of the results. When applicable, an overall system operational test plan should be prepared. To the greatest extent possible, all aspects of system operation which determine whether the system performance is satisfactory, should be tested prior to acceptance.

- Contract Documentation - Design requirements must be reflected in the items constructed or purchased. As a result, detailed specifications should be prepared for procurements, and a thorough technical review of the final procurement documentation (Requests for Proposals as well as proposed contracts in final negotiation) should be conducted. Evaluation of bids should verify that the requirements are being properly addressed by the proposed contractors.

- Training - System performance, in its initial operational stages, is strongly influenced by the familiarity of personnel with the system. The more a new system differs from existing systems, in operational and maintenance procedures, the more important it is that close scrutiny be applied to expected manpower needs and the more important training programs become. For larger projects with sophisticated systems, the use of training mock-ups or simulators should be considered.

- Constructibility - Throughout planning and design, the issue of constructibility of the proposed project must be addressed to avoid subsequent adverse cost and schedule impact.

3.2.3 Satisfy All Imposed Project Development Requirements

All requirements imposed by planning and funding agencies and the various governmental jurisdictions must be addressed at the appropriate time during the project development process. Typical requirements are defined in Chapter 2, the Transit Capital Development Process. Failure to understand all of the requirements and to incorporate them into the work plans and schedules for each development phase will likely result in subsequent project management problems.

3.2.4 Real Estate Acquisition and Management Program

Many transit capital projects involve real estate. It is essential that the necessary properties not already acquired be obtained in a timely, orderly, and legal manner and in a sequence that will prevent potentially costly delays. A comprehensive real estate program (particularly for federally assisted construction projects subject to the legal requirements of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970) should exist.

Close coordination of real estate matters among the project planners, programmers, designers, engineers, construction managers, and the real estate organization is mandatory. This coordination should stimulate the development, by each element of the team, of general knowledge concerning the nature and scope of the other team members' functions and interfaces. It should result in the development of a real estate schedule that reflects the estimated time of the sequential steps to be taken by the real estate organization throughout the acquisition, relocation, and demolition process.

Such a schedule must be integrated into the project schedule baseline and should allow a degree of adjustment to meet program changes or modifications warranted by changed circumstances. For example, when efforts to acquire a real estate interest by negotiated purchase and voluntary agreement reaches an impasse, necessitating the use of eminent domain (condemnation) procedures, the resulting delays, if not anticipated as a possibility in scheduling, could result in costly construction delays. Also, in the area of relocation assistance, the law requires that all persons to be displaced by the project be relocated adequately in good quality housing comparable to or better than the housing they are leaving. Failure to make advance studies of available family housing resources in the vicinity of a proposed project could delay start of a project.

The following are typical of features of a real estate program for an urban transit project:

- o Identification/Certification of Real Estate Required - Rights-of-way (R/W) (permanent/temporary), easements (permanent/temporary), and lesser interests (permanent/temporary).
- o Appraisal Plan - Staff and/or contract review and support of litigation (condemnation actions).
- o Acquisition Plan - Direct purchase and acquisition by eminent domain (staff/counsel/outside).
- o Property Management Plan - Interim use/maintenance prior to project construction and management of excess property prior to disposal.
- o Relocation Assistance Plan - Availability studies, notification of eligibility of occupants of dwellings, businesses, and farms, relocating occupants/furnishing advisory services, and claims processing.
- o Demolition Plan - Procurement and administration of demolition contracts and use or sale of improvements/salvable materials.
- o Disposal Plan - Screening and disposal by sale, exchange, lease, easement, joint venture development.
- o Schedule and Funding Plan - Schedule of real estate activities to meet requirements for project scheduling, budgeting, administration, and accounting.
- o Transit Development Plan - Assessment of opportunities in conjunction with local land use plans and innovative financing techniques.

3.3 FINANCIAL REQUIREMENTS/RESOURCES

Over the past 20 years, transit project's capital costs have typically been funded primarily by the Federal government (UMTA) with matching funds provided by state and local government sources. Operating costs are primarily funded by farebox revenues with the support of state and local governments. With the encouragement of UMTA, creative financing arrangements are being explored, including private sector participation to support both capital and operating costs, and in some cases, project implementation and ownership.

Transit projects must have realistic cost estimates, and a viable plan for financing both the capital and O&M costs. In cases where a disparity occurs either because funds fall short of expectations or costs increase beyond estimates, the project could be subject to severe delays, or even termination, until (or unless) a balance is achieved.

The remainder of Section 3.3 lays out how to define the financial requirements of the project and the available resources to fund them in a manner which reinforces its management objectives. For a project to advance beyond the planning phase, it must be deemed cost-effective, meaning that its benefits exceed the costs.

3.3.1 Financial Requirements - Cost Estimates

3.3.1.1 Initial Capital Costs

As the physical definition of a transit capital project evolves through the development process from planning and design, to construction and operations, so do the estimated costs to implement, operate and maintain the improvement. Costs estimated in the planning phase can be based only on a relatively crude level of project definition. As engineering and design advance and decisions are made which refine the location, configuration and specifications of the improvement, more precise cost estimates can be made. After contracts for construction of facilities or fabrication of equipment are in place, full capital costs are virtually established, except for contractor claims or unanticipated extras. Even through the Testing and Start-up Phase, some additional requirements may materialize. Thus, it is necessary to maintain a contingency estimate throughout project development which starts as a large percentage of the estimated costs and is gradually lowered as uncertainties and risks are reduced.

Capital costs are defined as those incurred during project implementation and, depending on the nature of the project, could include the following categories:

- Surveys and geotechnical investigations
- Analysis, engineering, architecture and design
- Agency administration and oversight
- Legal fees
- Project and construction management
- Testing
- R/W acquisition and relocation
- Demolition and site preparation
- Utility relocation
- Maintenance of traffic, street modification and restoration
- Maintenance of safe transit operations during construction
- Guideway: at-grade, subway, elevated, bridges, track structures
- Passenger stations and terminals
- Parking lots and garages
- Operating, maintenance and storage facilities
- Non-passenger O&M vehicles and maintenance equipment
- Electrical power supply and distribution
- Passenger vehicles and spare parts
- Vehicle control system
- Voice and video communications systems
- Fare collection system
- Landscaping
- Transit operational support during design, construction and testing
- Contingency reserve
- Escalation

Estimation of capital costs should include all categories of cost associated with the project, and should follow the work breakdown structure (WBS) that is effective at the time. In the earlier phases where the objective is to determine the best alternative, this would require calculations by cost category for the entire project. By comparison, in Final Design, the cost categories are broken down into greater levels of detail to reflect quantities and unit costs of material, equipment and comparison to the bids received.

3.3.1.2 Operation and Maintenance Costs

Estimates of O&M costs are required as inputs for performing cost-effectiveness analysis, and determining the long-term financial implications of the project. O&M costs can be determined only in response to an operating plan which defines service and patronage levels. The output of the operating plan is an estimate of operating statistics which include vehicle-miles, vehicle-hours, peak vehicles, etc., which become inputs used to calculate O&M costs. There are two types of O&M costs -- fixed costs and variable costs relative to service level. Each variable cost item should be associated with the service characteristic to which it is most closely tied. Fixed costs, on the other hand, remain constant, based on the physical transit facility, regardless of the service level. A standard system of accounts should be used for the cost model consistent with UMTA Section 15 requirements.

During project planning, a unit of fixed facility such as length of guideway or number of stations could be considered variable with related maintenance cost per unit. Once the length and number of stations become fixed, so do the costs that are unrelated to service level. An example of variable cost related to service level would be some aspects of vehicle maintenance related to the number of miles traveled. Other vehicle cost factors such as inspection, which are performed periodically, regardless of the number of miles traveled, are considered a fixed cost.

Some modernization projects may reduce O&M costs which can be used to justify the capital investment. Others, such as air conditioning, can increase O&M costs due to increased electrical consumption and maintenance requirements.

3.3.1.3 Subsequent Modernization Cost

The estimated cost to periodically modernize and replace capital equipment and facilities should be based on replacement cycles for the various elements. Since this is a capital expense, a sound financial plan should assure that the resources will be available to maintain the newly implemented capital investment. One way to achieve this is to create a capital replacement or sinking fund with regular contributions that are considered as O&M expenses. Such a fund could be the sole means of paying for needed capital modernization or could be used to supplement anticipated capital grants from government agencies.

3.3.2 <u>Financial Resources - Funding/Revenue Sources</u>

3.3.2.1 Objective/Requirements

Adequate funding sources must be identified in order to offset the capital and O&M cost requirements of a transit project. In addition to being an element of sound planning, the demonstration of financial capability is an UMTA legislative and policy requirement. UMTA's Major Investment Policy [Ref. 10] calls for an independent assessment of local fiscal efforts when localities propose to overmatch Federal funding. UMTA requires evidence that a grantee can produce the required match, cover any system operating deficits and finance rehabilitation and replacement costs.

During the planning phases, when cost projections, revenues and funding sources are least accurate, sufficient latitude should be available in the identification of funding capabilities to deal with all possible eventualities. This includes overestimation of patronage and farebox revenues, underestimation of capital and O&M costs, and overestimation of sources of funding. Thus, the total financial capability should be much more substantial than the requirements estimated at the planning phase to accommodate a worse-case situation.

3.3.2.2 Capital Costs

While the Federal government, through UMTA, has been the primary source of capital funding for transit over the past 20 years, greater reliance has been placed on local commitments in recent years. The two main categories of UMTA funding are Section 9, which is distributed on a formula basis primarily for routine capital replacement, and the discretionary Section 3 which is for major capital investments such as new fixed guideway projects, rail modernization beyond that satisfied by Section 9 funds, and major bus facilities. Given that the availability of UMTA funds is insufficient to satisfy the demand from potential grantees, non-Federal sources should be identified to the greatest degree possible.

3.3.2.3 Operating and Maintenance Costs

For new transit services, elements of the patronage forecast model will provide information from which to estimate the revenue to be generated by alternative operating scenarios and fare structures. Passenger revenues are obviously a function of both patronage and fare structure which are related within the patronage forecast model. Other sources of revenue typically involve advertising, leases and concessions, including parking lot fees. All sources of revenue should be summed on an annual basis and compared to the annual operating cost estimate. The difference is the operating deficit which must be obtained from other sources. In order to offset the operating deficit, a stable source of funding which escalates over time to keep pace with the projected deficit must be found. Policies need to be established on the percentage of the operating budget to be obtained from the farebox and other revenue sources with the remainder to be funded through subsidy arrangements.

3.3.2.4 Alternative Non-Federal Financing Techniques

UMTA's policy on Private Enterprise Participation encourages innovative approaches to public/private partnerships for the financing of transit services and facilities. These and other alternative non-Federal transportation financing techniques can be utilized to fund project capital and O&M costs. Candidate techniques have been documented in Alternative Financing for Urban Transportation: The State of the Practice [Ref. 11] and are listed as follows with locations in which their application has been studied:

- Taxes
  - State Sales Tax and Sales Tax on Fuel (State of California)
  - Motor Vehicle Excise Tax (State of Washington)
  - Local Option Transportation Taxes (State of Florida)
  - Sales Tax (Maricopa County, Arizona)
  - Beer Tax (Birmingham, Alabama)
  - Payroll Tax (Portland, Oregon)
  - Tax Increment Financing (Prince Georges County, Maryland)
  - Lottery (State of Pennsylvania)

- Assessments
  - Transit Assessment District (Denver, Colorado)
  - Special Benefit Assessment Districts (Los Angeles and Miami)
- Fees
  - Transit Impact Fee (San Francisco, California)
- Negotiated Investments
  - Development Bonuses (New York, New York)
  - System Interface Program (Washington, DC)
  - Transfer Center Investment (Portland, Oregon)
- Private Donations and Initiatives
  - Merchant Subsidy (Cedar Rapids, Iowa)
  - Bus Shelter Development (St. Louis, Missouri)
  - Transportation Corporations (State of Texas)
  - Rail Station Construction (Secaucus, New Jersey)
- Use of Property and Property Rights
  - Joint Development Program (Washington, DC)
  - Joint Development of Transportation Center (Cedar Rapids, Iowa)
  - Negotiated Land Leases (Tacoma, Washington)
  - Leasing Facilities (Santa Cruz, California)
- Private Development and Provision of Facilities and Services
  - Privately Financed People Movers (Tampa, Las Vegas, and Los Colinas, Irving, Texas)
  - Contracted Bus Service and Maintenance (Johnson County, Texas)
  - Contracted Transit Service (Snohomish County, Washington)
  - Transportation Zones (San Gabriel Valley, LA County, CA)
- Public Private Partnership in Fixed Guideway Corridor Development
  - Rail Transit Corridor Development (Fairfax County, Virginia)
  - Corridor People Mover Development (Orange County, Florida).

3.4 MANAGEMENT CONTROL SYSTEMS

Once the plan and budget for a project have been established, it is essential that control systems be established to ensure compliance with the requirements of those documents and the goals of the project. As a minimum, control systems for the following should be formally established: configuration, quality, schedule, and cost. Methods for control of quality have been referred to as QC by some and QA by others. QC was originally applied to those specific inspection or test activities conducted to ensure that each item meets specified criteria. QA will be used in this document to reflect the current broader application of managerial and technical approaches used throughout a project to ensure quality.

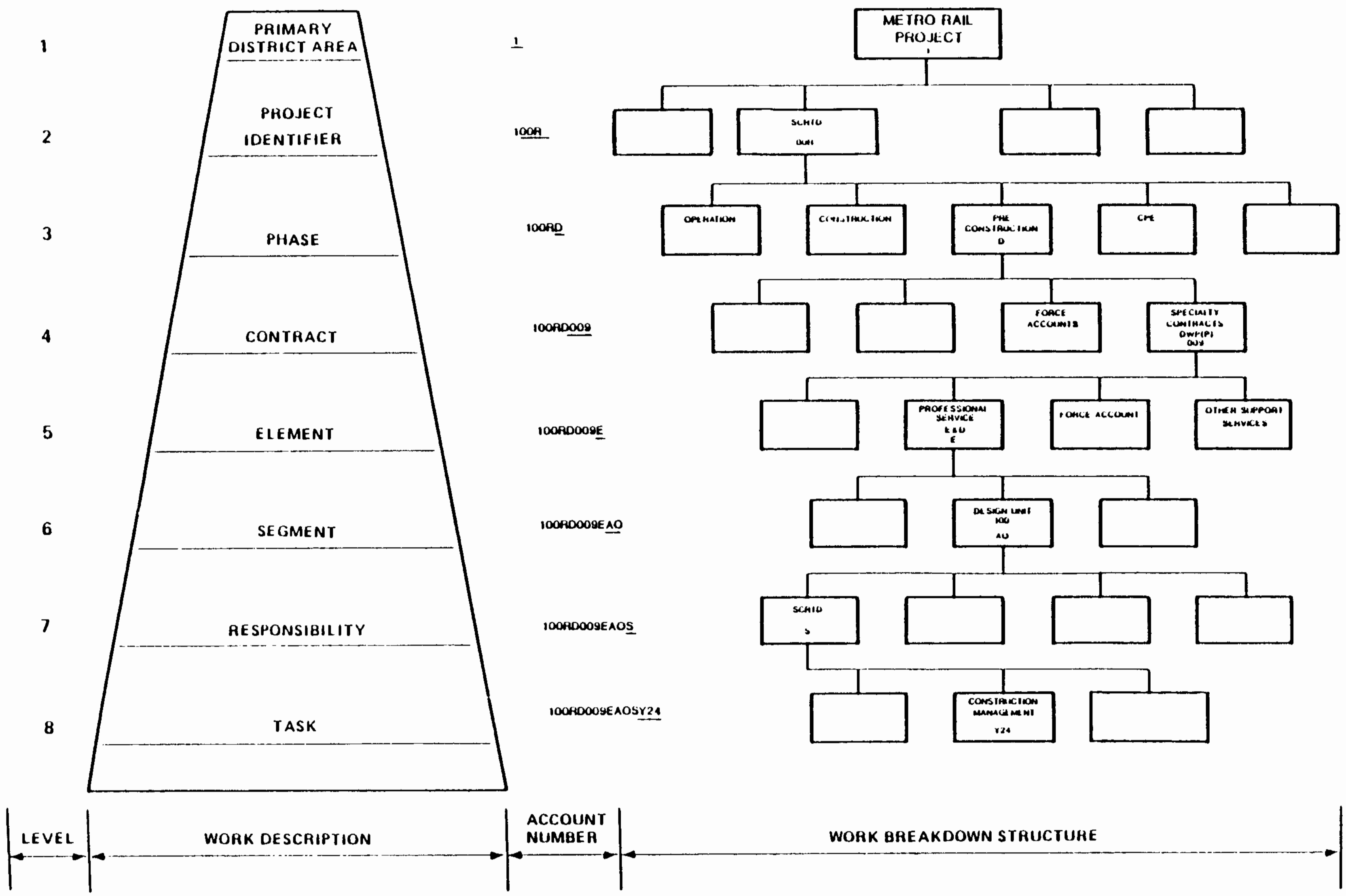
3.4.1 Work Breakdown Structure (WBS)

A critical element of any management control system is a WBS. A WBS should be prepared for the entire project to serve as the basis on which work is divided into manageable work packages. A WBS is a product-oriented family tree composed of hardware, services and data which result from project efforts during the development and construction of an item, system or facility and which completely defines the project/program. A WBS displays and defines the product(s) to be developed or produced and relates the elements of work to be accomplished to each other and to the end product. It is normally prepared in an hierarchical or multi-tiered fashion with the lower tiers being defined during design and project execution. A number, or alpha-numeric identification, is assigned to every WBS element. The WBS should be developed to best suit project management purposes, not simply those of the control or other specialties. A hierarchy of system physical components should be established, however, either within the WBS or separately so that work packages applicable to each configuration item can be identified and followed. Tasking in the PMP or other project master or subordinate plan(s) should be to WBS elements. Figure 3-3 depicts a WBS for the Southern California Rapid Transit District Metro Rail Project [Ref. 12].

3.4.2 Configuration Control

Configuration control consists of the evaluation, coordination, and approval or disapproval of changes in the configuration of an item after establishment of a configuration baseline. A configuration baseline consists of the approved or conditionally approved technical documentation for an item as set forth in drawings and associated lists, specifications, and referenced documents. In an effective configuration control program, drawings are uniquely numbered and otherwise identified. Specifications follow a standard format and each paragraph

FIGURE 3-3. WORK BREAKDOWN STRUCTURE [REF. 12]



is numbered and identified. Complete drawing lists are established and the total number of drawings, the titles of the drawings, the revision status, and the dates the drawings were approved are recorded. Changes to approved drawings or specifications should only be made in accordance with established procedures. Permanent files are maintained of all contract documents which include historical information relating to all project changes. As the project becomes implemented, configuration control evolves to include the documentation of the completed improvement in terms of "as-built drawings."

When applied properly, configuration control ensures that the correct, approved status of the evolving design is known or is available to all project personnel using that information. In addition, this helps maintain control of the item so that the supplied product will more likely be in accordance with the design documentation, and will clearly establish the configuration of the produced item so that replacement equipment or components capable of meeting the original equipment requirements can be procured at a later date.

3.4.3 Quality Assurance

3.4.3.1 Quality Assurance Program

QA is a broad term referring to all activities necessary to verify, audit, and evaluate quality. QA involves establishment of a quality program for the project or, if desired, individual programs for organizations such as the Engineering Department, Construction Department, etc. A QA plan describing the organization(s) for QA and QA procedures should be prepared. The QA plan and other documentation related to the QA program should be made available for review and approval by the parent agency.

"Specifications of General Requirements for a Quality Assurance Program," [Ref. 13] provides guidance for QA programs. The QA organization must have clear access to and support of the project management. Authority and responsibilities related to quality should be clearly established and documented. The QA manager and other personnel whose primary role is QA should be specially trained in QA. While the size of the QA staff will vary depending on project size, personnel throughout the project organization will have QA responsibilities, as specified in the QA procedures. For example, the QA procedures may include well established procedures such as design reviews. The QA program ensures that such procedures are established, documented, and followed.

A well-planned QA program will provide an effective system for ensuring that:

- o All work performed is in accordance with engineering requirements.
- o All equipment is tested throughout development, manufacture, and installation to verify that it will function as specified.
- o Undesirable conditions are detected early and positive corrective action is taken in a timely manner.
- o Control over the system hardware configuration is maintained at all times to define the acceptability of equipment (as established by design reviews, drawing approvals, and design verification testing), to control configuration during retrofits and modification work, and to ensure that the system will be safe for public use.

3.4.3.2 Quality Assurance Activities

In addition to the QA program/organization/training considerations addressed in the preceding section, QA program activities of particular importance are described below.

Design QA - A most important aspect of QA during design is documentation control; not only the design drawing and specification configuration control discussed in Section 3.4.2, but also the preparation and control of design instructions and procedures to ensure quality. Technical review and signature to ensure compliance with established codes and standards is a QA function. QA may also play a role in interface identification and control. QA review and signature approval of drawings should be required.

Procurement of Services, Materials, and Items - Contract documentation control is a major function of QA. Other procurement-related functions include:

- Vendor qualification

- Vendor QA program establishment or review and approval

- Vendor QA program ongoing surveillance

- Contractor drawing approval

- Inspections and tests, including preparation or review and verification of criteria, test and inspection plans and procedures, test and inspection review, conduct, or witness for such inspections and test as:

  - Source inspections
  - Receiving inspections
  - In-process inspections and tests
  - Verification examinations
  - Final inspections and tests
  - Shipping inspections
  - Installation inspections
  - System tests
  - Operational tests

- Material traceability, identification, control systems, and test certification

- Special process control (e.g. welding, heat treatment, and NDE methods)

- Measuring and test equipment control and calibration

- Preservation, packaging, storage and shipping procedures surveillance

- Control of non-conforming items, including trend analysis

QA Audit and Reports - No less than annually, an in-depth audit of the QA program should be conducted and directed to the organization's top management. Annual audits of contractors' QA programs should also be conducted. Non-conformance reports are required. During the construction phase, daily inspection and test reports from QA inspectors may be required.

Corrective Action - Follow-up is essential on non-conforming items, audit deficiencies, and reported problems.

Quality Records - The QA program must include provision for control of test and inspection and other quality-related records. Traceability of records is important.

3.4.3.3 Product Inspection and Test

The inspections and tests should ensure that contractor workmanship complies with requirements and conforms to industry standards; that the configuration of the item conforms to the latest approved documents and/or that deviations are identified; that the item conforms to functional requirements; and that the contractor's documentation verifying acceptability is complete and adequate. To ensure that all work performed complies with requirements, hold points for owner inspection and authority to proceed should be established throughout the process of procurement, manufacture, and test. Resident or nonresident inspectors should be assigned to conduct inspections or witness tests, and a system of documentation should be employed to record data relative to the inspections and the findings.

The requirements should be defined by the specifications, contract drawings, approved contractor drawings, referenced standards, and related owner-approved documentation. Workmanship should be assessed in terms of the specifications and referenced standards, or, if allowed in contract documents, approved contractor's workmanship standards.

An integral part of inspection is a review of the contractor's inspection and test records for the work being inspected. The records should demonstrate the contractor's QA verification of the acceptability of the equipment or work presented and the satisfactory completion of all appropriate prerequisites. The owner can reduce the need to conduct detailed inspections of the contractor's work by rigid enforcement of the requirement for the contractor to have an effective QA program.

3.4.4 Schedule Control

3.4.4.1 Elements of Schedule Control

Schedule control can be described as consisting of five major elements:

Schedule Baseline - A project schedule must be established which considers all of the tasks that must be performed and judgments as to the expected duration of the tasks and availabilities of inputs required to accomplish those tasks.

Monitoring/Reporting System - Regular task status reporting by WBS element is a necessity. Task commencement, task completion, and the accomplishment of other milestones included in the schedule baseline must be monitored. Monthly progress reports are often required in contracts; however, more frequent reporting on aspects of some tasks may be advantageous.

Performance Measurement System - Using the data from the Monitoring/Reporting System, a means should be provided for comparing actual work performed with the scheduled work to be performed and for analyzing any variances that may occur. This comparison should take place as rapidly as possible and should result in the submission of timely status reports to responsible managers.

Schedule Forecast - A system should be provided for routinely forecasting the expected schedule for completion of work packages and the total project.

Schedule Review and Update - Work package schedule forecasts should be made available to the immediately responsible managers. Those managers should conduct a continuous review of progress against the schedule so that resource reallocation or other corrective action within their purview can be undertaken as early as possible. Schedule impacts on other work packages should initiate, through the monitoring/reporting system, timely alerts to higher level managers. Reviews of the project schedule should be conducted by project management on a regular basis in order that developing trends can be identified, as well as whenever the schedule forecast points out potentially significant problems.

Schedule updates shall be made only by the person specifically assigned that authority.

3.4.4.2 Methodology

Logically, a project must be planned before it can be controlled. Techniques of planning and control have evolved from the use of Gantt charts to the use of logical flow networks. The critical path method (CPM) is a method of planning, scheduling, replanning, rescheduling, progress monitoring, progress evaluation and schedule forecasting which has proven to be extremely successful when applied to construction projects. Computer software developers have made available a variety of sophisticated user-friendly CPM programs. A full CPM program involves network diagrams and supporting data.

A network diagram serves as a visual presentation of the sequence of activities needed to fulfill project requirements. As such, it should:

- o Show graphically, in logical sequence, each of the activities necessary to complete the project or project phase.
- o Identify the starting point, duration, and ending point of each activity.
- o Show all interfaces (i.e., interdependencies and relationships with operations of other consultants, contractors, and suppliers and subnetwork diagrams. The information needed to show such interfaces with operations of other consultants, contractors, and suppliers should be furnished by the owner.) The CPM program further involves any modifications that may be required by changes and the updating of network diagrams and their supporting data to report actual progress and current status of the project.

The supporting data for a network diagram should consist of a computer print-out or an equivalent listing that provides, as a minimum, the following information for each activity:

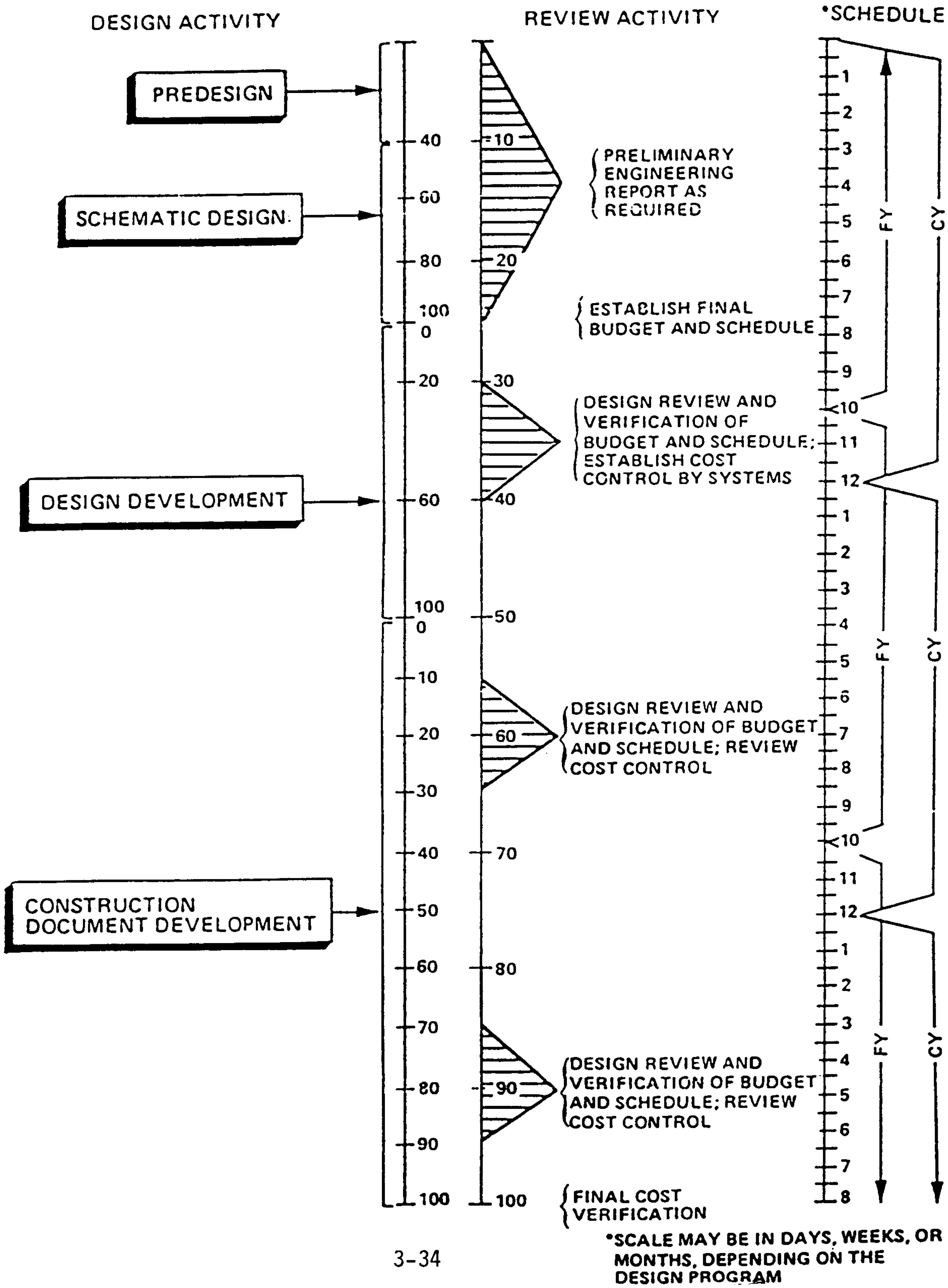
- o Starting and ending node numbers
- o Duration
- o Description
- o Early start and late start dates
- o Early finish and late finish dates
- o Total float time

The reports generated as part of the CPM program should be reviewed continuously and used as working tools by organizations involved in the activities. Information needed for evaluation of progress, including manpower loading charts and equipment schedules, should be specified in project directives and contract documents. For activities under their cognizance, project organizations should submit to the control office an updated network diagram and supporting data at least once a month. The updated network diagram should be prepared in accordance with the following:

- All such activities should be updated and reported on as of the same date.
- All updated data should be furnished in the form required.
- The updated diagram should indicate completed activities, any revision of the logical sequence of the activities, and the critical path of activities based on the current update.
- The supporting data for the updated diagram should include a listing of the actual starting dates for each activity in progress and actual starting and completion dates for all completed activities, and an analysis of changes to expected completion dates that identify which activities contributed to the changed completion dates and why.
- The supporting data also should contain all information needed to indicate the current status of the project, such as design policy memoranda or other technical data issued by the owner or the representative; design/development progress in prime contracts and specialty procurement contracts which necessitates revision to current contracts; changes required by utility companies or local agencies during the course of construction; finalization or revision of agreements between the owner and public agencies; revisions to right-of-way agreements; and revisions necessary to accommodate changed or unforeseen field conditions or changes at interfaces of adjacent contracts.

Figure 3-4 illustrates the design management activities and schedule for a typical project from predesign through construction document development. From 0 to 30 percent represents the PE Phase and from 30 to 100 percent (approximately) represents the Final Design Phase. Emphasized in this figure are the prescribed review activities that are necessary. The time scale can reflect weeks or months, depending on the design program or size of the project.

FIGURE 3-4. TYPICAL PRE-CONSTRUCTION ACTIVITIES AND RELATED SCHEDULES



3.4.5 Cost Control

Project cost control encompasses those techniques used to restrain actual costs to within the limits of the cost estimates while satisfactorily accomplishing project objectives. Cost control must relate to a cost baseline, which in the earliest stages of the project is the project cost estimate. After funding is approved, the estimate is converted to a budget, which then becomes the cost control baseline.

The importance of proper cost estimating is obvious. When the National Research Council was asked to research the causes of increases in costs in construction projects, the Subcommittee on Management of Major Underground Construction Projects (Committee on Tunneling Technology) included in its recommendations the following:

> "Realistic cost estimates, based on the best available information, must be used from project inception. Recognizing that early estimates are based on many uncertainties and variables, and therefore that costs may be overlooked or underestimated, realistic factors for uncertainties and contingencies should be taken into account during early phases. Particular attention must be given to realistic estimating during the preliminary engineering phase because such estimates are usually the basis for project financing. Estimates need to be revised periodically to accommodate changing circumstances." [Ref. 14]

Cost control can be applied even during the period when cost estimates are being formulated. On the Atlanta rail transit (MARTA) project, Parsons Brinckerhoff/Tudor found that the use of clauses in design contracts for no-fee redesign was a very effective technique to restrain costs, if the estimate for the designers' final product exceeded a cost limitation. Initiating close coordination between designers and construction cost experts will also result in cost-controlled designs.

Cost estimates for the approved project are translated into a project budget. The project budget must be realistic, it must establish attainable goals, and must be adhered to. At the same time, realistic schedules must be established. Once the project's WBS is established (See Section 3.4.1), cost control monitoring activities should be related to the WBS-derived work packages.

Responsibility should be assigned for developing baseline cost budgets for managers of work packages and for maintaining those baselines consistent with the WBS, schedule, and overall costs. Authority to revise the baselines should be identified. The work packages should be assigned an identification in a coding system usable with the project accounting system. This procedure will facilitate establishment of a computerized cost tracking and reporting system.

The following principles of cost control and features of a cost control program should be considered:

- Because the baselines for cost control are necessarily projections into the future, allowances for inflation must be included. Inflation allowances should be specific to a cost category (construction labor, materials, services, etc.).

- A contingency fund should be established which may or may not include the inflation allowances. A system should be provided for determining and distributing the contingency funds to provide for cost escalation caused by the inflation or such factors as changed conditions, design revision, and estimating errors. The contingency allowances can be held at the project level or, especially in larger projects, can be distributed to lower levels of management in the WBS. Strict control should be established over the disposition of funds from these accounts.

- The participation of a cost engineer(s) throughout the life of the project should be considered.

- A program should be established for cost risk identification and management.

- A cost reduction program should be established with specific efforts aimed at achieving reductions in such items as:

  - Construction labor costs
  - Purchase prices
  - Warehouse/storage space rent
  - Use of materials
  - Manufacturing costs
  - Fixed asset costs
  - Development costs
  - Administrative costs
  - Distribution costs

- Depending on the item or service being procured and the applicable conditions, care should be exercised in selecting the proper contract type (firm fixed price, unit price, cost plus, etc.) to ensure cost-effectiveness.

- o Contract package size and scope should be selected with proper regard for the resources available and greatest efficiency and economy in using the resources.

- o A system should be established and responsibility assigned for predicting cash flow requirements and for providing for timely receipts and payments.

- o Strict control of project expenditures is an inherent obligation of the project management team. The management team must have adequate delegated authority and flexibility in the management of expenditures, and the determination to use and control them. Authorization should be documented for capital expenditures, for issuance of work orders, and for additional work orders. Procedures should be established for verification of requested payments and processing of partial payments and final payments.

- o Procedures should be developed and responsibility assigned for identifying, evaluating, and accommodating changes that may occur during project design and construction. Procedures should be clear, should permit results to be achieved rapidly, and should provide for full evaluation of the impact of the changes. Proposed changes should be classified as to urgency and the cost impact must be fully assessed. The avoidance of changes and the prompt settlement of change orders and potential or actual claims must be emphasized. Judicious delegation of monetary authority to approve change orders at the field level can expedite this process. A mechanism should be provided for timely resolution of claims.

- o Project management must adopt cost/schedule/progress monitoring and financial reporting systems with sufficient detail to enable key managers to facilitate decision-making. Top managers should take part in the development of the reporting system to ensure that the system meets their needs. The monitoring system should be geared to identify problems or necessary actions before they become critical (or historical) in order that problems may be avoided or actions taken in proper time.

- o Cost and progress reporting should be integrated with the schedule planning and reporting system (see Section 3.4.3). The integrated cost/schedule/progress reporting system should provide management with promptly issued, accurate data on costs, budgets, and the progress of the many entities of the organization. Detail and summary level reports should provide periodic and cumulative costs, comparison of actual costs to the planned costs of each element of work and analysis of any variances from the planned costs which may occur, cost relationships with the schedule and progress, and variations in the defined scope of project work. The system should include reporting of engineering and administrative costs as well as construction and procurement costs. The system should provide forecasts of the expected costs of work packages at completion and of the total project. In addition to routine cost forecasting, as design develops and contracts for materials, equipment and services are awarded, provision should be made for periodic reviews and updates (conducted from an overall management perspective and preferably on a quarterly or semiannual basis) of the system-wide estimate. Elements of the project cost estimate should be subject to varying degrees of re-estimating depending on the status of project development, changes in previously predicted economic conditions, unfavorable experience in contract awards, or refinement of quantities. Project management should determine the degree to which re-estimating is to be performed, recognizing its cost and the extent to which it will interfere with ongoing performance. Schedule impacts should be considered in conjunction with these periodic cost estimate reviews. The cost/schedule/progress reporting system should include an exceptions report, focusing on current problems or items that appear to be causing a problem, and indicating perceived changes in material costs and labor rates as well as actual cash flow compared to an estimated cash flow.

3.4.6 Computer-Based Tools and Techniques

Throughout the 1980's, microcomputers have become valuable tools for the project manager, performing functions which previously were limited to large scale and relatively inflexible mainframe computer systems. Software development has kept pace with the popularity of microcomputers. Project management software assists the manager in the three phases of a project: planning, scheduling and control. The following sections discuss typical capabilities of full-powered project management software.

Project Planning

This section relates project activities to time, required resources and any activities which must precede it. Activities can be specified by sequence or precedence, such as how the activities depend on each other and which must be done before others can begin. The program can determine the project's critical path, which is the sequence of activities that must be done on time if the project is to be completed on schedule. Project planning can be accomplished in concert with the WBS developed for the project.

Resource Management

After breaking the project down into tasks and their relationships, available resources need to be identified, allocated and assigned to a task. Programs permit "resource leveling," the process of smoothing out the use of resources over time to meet constraints on resource availability.

Tracking Progress

Start and finish dates and other scheduling constraints can be determined with the assistance of the project management software, after which actual progress can be assessed. Various schedule displays are possible and permit comparison of actual to the baseline.

Reports

Graphic reports of the project plan and project status are some of the most valuable tools a program can provide. A software program can make updating project reports quick and easy. And to the benefit of all, it is becoming the norm that programs provide graphic and plotted reports. Reporting capabilities can include:

- Network diagram -- CPM or PERT (program evaluation and review technique) charts which shows all project activities and their precedence relationships.
- Gantt (bar) charts show each activity as a horizontal bar extending along the project timeline, milestones, and planned activity progress versus actual progress.
- Network schedule consisting of a tabular listing of all project activities with their earliest and latest start and finish dates. It also shows how much float, or slack time, each activity has.
- Resource reports which include a tabular listing of all resources and their assignment to activities. Resource histograms, vertical bar charts showing assignment of resources over time, are also possible. Some histograms also show load limits such as the maximum allowable assignment of a resource.
- Cost reports consisting of a detailed breakdown of assigned project costs is a minimum requirement. Very useful are cumulative cost reports which depict cash flow requirements. More powerful programs will calculate and graph out earned value as the project progresses. An earned value graph compares project completion with costs expended. These reports will also show the estimated cost to complete the project.

Numerous project management software packages are available for the various phases of a transit capital improvement project. The potential user must define the requirements for project management software and compare the various products available. Several computer publications have periodic reviews of software, including special application software such as project management packages. When selecting software, the user should consider capabilities, user friendliness, training requirements, flexibility and ongoing support available in addition to the initial cost.

3.5 PROCUREMENT, CONTRACTS, DISPUTES AND CLAIMS

3.5.1 Procurement

General policies and procedures for procurement of professional, construction, and other services, right-of-way, materials and equipment should be established consistent with applicable government and agency regulations and the provisions of UMTA Circular 4220.1B (Third Party Contractors Guidelines). These should address requests for procurement, selection criteria for contract award, types of contracts, schedule, price and cost estimates, insurance requirements, and special bonding requirements, if any. Responsibility and authority should be assigned for preparing, negotiating, executing and monitoring of all contracts from both a technical and administrative perspective.

A procurement plan should be prepared for each phase to acquire all required services and items in accordance with the mission and objectives of that phase. The size and content of each procurement package, schedule for delivery, and cost estimate should be included. Specific requirements for the following procurement functions should be established in accordance with the suggested guidance:

- Bid Documents - Bid documents which include a description of the contract scope, the form of contract to be awarded, and the requirements for the technical, management and cost portion of the proposal should be prepared. The documents also describe the process to be used in bidding, proposal evaluation, and contract award.

- Bid Certification Checklist - A checklist which identifies all actions that must be completed prior to advancing a proposed procurement and the responsible individual for accomplishing each action should be developed. All responsible parties should be required to certify by signature that action items have been completed and that the package is prepared for advertising.

- o Advertising - For each procurement, a list of potential bidders who have demonstrated capability to provide the subject service or item in compliance with specification requirements should be prepared. All firms on the list should be invited to bid on the procurement. In addition, the availability of bid documents should be advertised in trade publications such as Passenger Transport and Mass Transit, in small business, minority, and women-owned trade publications, and in other media, including newspapers published and circulated in minority communities.

- o Pre-Bid Conference - A pre-bid conference should be conducted to brief prospective bidders and explain the procurement requirements. Any pertinent changes to bid information resulting from the conference should be issued to all recorded holders of the bid documents.

- o Contractor Selection - Evaluation of the proposals or bids should be made by a designated team representing the owner and in accordance with that prescribed process.

- o Pre-Award Survey - Prior to contract award, a pre-award survey may be appropriate to ensure that the selected contractor possesses the personnel, facilities, procedures, financial resources, and experience necessary to complete the contract in a satisfactory manner. In some cases, it may be appropriate to prequalify prospective contractors prior to the bidding process, thus eliminating the need for the pre-award survey.

- o Contract Award - If the pre-award survey finds that the prospective contractor is satisfactory, a contract should be prepared and executed. If not, the pre-award survey process should be repeated with the next ranked bidder until a satisfactory contractor is identified.

- o Monitoring and Control - Monitoring and control of the contractors work should be accomplished in accordance with the quality assurance plan and the specification of the contract.

The Disadvantaged Business Enterprise (DBE) requirements of all applicable jurisdictions, including UMTA, should be identified. Contracting opportunities should be pursued in concert with the agencies DBE officer as a regular element of each procurement to achieve the project's goals.

In planning for procurements, the concept of work packaging, which relates to the number and size of individual contracts is important. The fewer the number of individual contracts, the fewer will be the problems of administration and coordination. Larger contracts may attract interest from larger, more experienced contractors from outside the immediate geographical area to enhance the competition. However, they may also reduce the competitiveness of the local contractors. Work packaging should be coordinated with DBE goals to have contracts available on which these contractors would be able to participate.

3.5.2 Contractor Selection and Contract Types

The two primary methods for selecting potential contractors (consultants, suppliers, and constructors) to support transit capital projects are through negotiated contracts and through advertised, competitive-bid contracts. However, state and local laws may impose requirements that constrain procurement methods. Competitive bidding is better suited to lump-sum and unit-price contracts than to cost reimbursable contracts. The following, in order of decreasing responsibility upon a contractor for the costs of performance, are the type of contracts that may be considered:

- Lump-Sum, Firm-Fixed-Price
- Fixed-Price with Escalation
- Fixed-Unit-Price
- Fixed-Unit-Price with Escalation
- Cost-Plus-Incentive-Fee
- Cost-Plus-Award-Fee
- Cost-Plus-Fixed-Fee

A full description of each contract type and discussion of the application, advantages and disadvantages is contained in Section G of Management of Urban Construction Programs, Volume II: Supplemental Information [Ref. 9].

In general, the fixed-price type contracts provide for performance of specified work in consideration of a stated price, and the contractor is obligated to accept the risks of uncertainty. These are most applicable to contracts involving materials, equipment and facility construction. Cost-reimbursable type contracts provide for the payment of allowable costs incurred in the performance of the contract and establishes a ceiling of cost which the contractor cannot exceed. These type of contracts are best when uncertainties exist which prevent the preparation of a precise work scope and cost estimate. Cost-reimbursable contracts are most appropriate for professional service contracts and require the contractor to have a sound cost accounting system. The Brooks Law constrains the selection process for architect/engineer contractors.

3.5.3 Dispute Resolution

Responsibility should be assigned and procedures clearly established for resolving disputes in a timely manner. Disputes generally should be resolved at the lowest administrative level possible. Clearly, the best way to deal with disputes is to avoid them by mitigating the conditions which cause them. Disputes can be avoided if contingencies are dealt with in the framework of contract documents. The recognition of contract elements that are vulnerable to change and misinterpretation can help stem disagreements. Clauses dealing clearly with changed conditions and quantity variations should be included in the contract document. In general, disclaimers and exculpatory language should be avoided. Both the owner and contractor should agree to language which permits the project to advance while the dispute is being resolved rather than bringing the contractor's work to a halt. The selection of formal dispute resolution procedures should be a function of the project size and the owner's resources and may include:

- Independent Board of Consultants
- Board of Contract Appeals
- Arbitration
- Mediation
- Litigation

3.5.4 Claims Management

A claim is a written statement by a single party requesting additional time and/or money for acts or omissions by another during performance of a contract. From an owner's standpoint, claims have become the administrative vehicle whereby owners and contractors may equitably allocate the impact costs of events which occur outside the scope of the contract. From a contractor's perspective, claims can be just compensation for unforeseen cost overruns or as a means by which to expand the value of the contract and increase the profit.

No project is totally secure from the risk of cost increase due to claims related to changed conditions and authorized additional work. Project cost overruns due to claims may be attributed to one or more of the following problems:

- o Failure to provide for risk allocation in the contract.
- o Inclement weather or other uncontrollable natural events.
- o Ambiguities in the contract provisions.
- o Strikes.
- o Poorly prepared specifications.
- o Acquisition of permits and approvals from outside agencies.
- o Failure to establish and implement management procedures capable of reducing exposure to unnecessary risk.
- o Site accessibility problems.
- o Extension of time, design or requirement changes, etc., granted to an interfacing contractor which causes delays or changes to the performing contractors.
- o Inadequate or non-existent construction documentation.
- o Frivolous or unfounded contractor claims.

The role of the project manager is to minimize the impact of claims by establishing a claims management process which seeks to avoid the incidence of claims as a first priority. A comprehensive program of claims avoidance recommended by Hill International [Ref. 15] involves the following:

A. Drafting contract documents (outlined below) which protect the interests of the owner and reflect its particular risk philosophy:

1. Owner-Contractor Agreement

   - o Identification of the Parties
   - o Description of the Work
   - o Time
   - o Price
   - o Payment

2. General Conditions

   - o Definitions
   - o Rights and Responsibilities
   - o Time

- o Payments and Completion
- o Substantial Completion
- o Insurance
- o Correction
- o Termination
- o Changes

3. Supplementary Conditions

B. Developing claims and change order processing procedures which promote early equitable settlements of extras to which the contractor is entitled by answering the following questions:

1. Who receives and who analyzes the change order or claim?

2. Will there be support available for review of change orders in the technical group within the owner's organization?

3. Will there be an attorney involved early-on to analyze if a legal basis exists for the change order or claim?

4. What levels within the organization will be notified when a change order or claim has been submitted, and to what depth will they be involved?

5. Will the individual in charge of the project have time to delve into the intricate details to establish whether there is a valid change order or claim and to what the contractor is entitled?

6. Will there be a separate department with this responsibility with knowledgeable staff that can assist the project manager in analyzing the change order or claim?

C. Implementing effective project controls to plan, monitor and document contract progress requires the owner to ask the following questions:

1. Who should prepare the schedule?

2. What method of scheduling should be used? Bar Chart, CPM, Precedence?

3. Who will prepare and approve this schedule?

4. What purpose is the schedule expected to fulfill?

5. How are time extensions determined?

6. Who owns float, if a CPM schedule is utilized?

7. Should subcontractors be required to input their requirements into the project schedule?

8. What are the requirements for notices of delay?

D. Conducting in-house training programs to ensure the effectiveness of the Claims Avoidance Program.

3.6 SAFETY, RISK MANAGEMENT AND INSURANCE

3.6.1 System Operational Safety

Operational safety of the transit capital improvement is a function of the system definition/configuration/performance addressed in Section 3.2 The operational safety program should consist of a series of activities to define safety requirements as an integral part of the system development process and assure their achievement during the Testing, Start-up and Revenue Service Phases. For rail modernization projects the safety program must also consider the safety of existing system operations and the safe integration of the improvements.

Closely related to system safety are system security and system quality assurance. Program plans should be developed to define the technical and management tasks necessary to address issues of system safety, security and quality assurance to ensure that:

- o Requirements are incorporated into the design of facilities and equipment.
- o Potential hazards associated with the proposed project are identified and then eliminated or minimized to obtain an acceptable level of safety and security.
- o Historical data generated by transit agencies with projects having similar characteristics are analyzed and used to support the proposed project.
- o Potential reliability and maintainability problems associated with equipment designs are identified and actions are taken to eliminate or minimize the problems.
- o Manufacturers and suppliers comply with the quality standards established by the owner.
- o Steps required to ensure proper maintenance management of facilities and equipment are implemented prior to the start of revenue service.
- o Safety, security, and fire/life safety considerations are coordinated with system assurance efforts.

The program plans should be developed in concert with system design elements and should be updated prior to the start of each new phase (Construction, Testing/Start-up, Revenue Service) to:

- o Review progress on tasks accomplished in the prior phase.
- o Refine and improve the current task descriptions and activities for the present phase.
- o Identify new tasks which may be required as the system progresses.
- o Explain in detail the safety-related tasks and responsibilities for the next phase.

3.6.2 Construction Safety

As a complement to system operational safety, the following discussion will focus on construction safety of the proposed project from an occupational and health viewpoint. The prevention of accidents during execution of a major transit capital project should be a primary concern of all participants and the responsibility of all levels of management and supervision. Accidents cause suffering to those involved, and result in project delay and additional expense to owners and contractors. A low accident rate is a direct result of a carefully planned safety program that is conscientiously carried out by management and supervisors. Overall responsibility for assuring the development and implementation of a safety program rests with the owner's project management, and the following discussion is offered as general guidance.

3.6.2.1 Basic Assumptions

The safety program for managing any transit construction project should be formulated on the following basic assumptions:

- o Management and supervision are charged with the responsibility of preventing the occurrence of incidents or conditions that could lead to occupational injuries or illnesses.

- o Safety should never be sacrificed for production and should be considered to be an integral part of risk management, quality control, cost reduction, and job efficiency.
- o A good safety record reflects the quality of management, supervision, and the work force.
- o The established policy should be to accomplish the work in the safest possible manner consistent with good work practices. Management at every level should be charged with the task of translating this policy into positive actions.
- o Contractors with a good safety record on prior projects tend to maintain a good record and run a safe and efficient job on new work. Consequently, contractor's safety performance track record on prior work should be a factor in qualifying bidders.

3.6.2.2 General Provisions

The following general provisions should apply:

- o The safety program should outline management safety policies and procedures and be in compliance with and be supplemented by all applicable Federal, state, and local safety and health regulations and standards.
- o Specific contract and owner requirements should be stated.
- o In case of a conflict between standards or regulations, the stricter requirement should apply.

3.6.2.3 Organization

The owner's project manager should have full responsibility for executing and implementing a program of employee protection and accident prevention on the project. A responsible safety manager should be designated to administer and supervise the overall project safety program.

<u>Safety Manager</u>

The owner's designated safety manager should have the authority and ability to enforce established safety requirements and should report directly to the project manager. While the contractors are primarily responsible for safety, the owner's safety manager provides overall safety surveillance and guidance to the contractors and monitors their safety program and safety performance.

Project Contractors

Each contractor should have full responsibility for executing and implementing a program of employee protection and accident prevention which is consistent with the requirements of the overall project safety program.

3.6.2.4 Overall Project Safety Program

The safety manager or other competent safety personnel and project supervisors should conduct daily inspections of work operations, equipment, storage areas, and facilities. Unsafe acts or unhealthy conditions should be noted and pointed out to the supervisor in charge. Serious or repetitive violations should be documented and transmitted to the contractor representative for corrective action.

When a condition or practice exists that could reasonably be expected to cause serious physical harm, extensive damage to property or death, it should be the policy of the project manager to cease operation on the portion of the work affected until the hazardous conditions are corrected. Carelessness or disregard for accepted and mandatory safety and health standards should not be tolerated. Contractors should be expected to discipline or terminate employees who violate established rules and regulations.

Each individual contractor should be held responsible for their own safety program. However, the project manager should provide overall safety surveillance to ensure compliance with established safety and health policies and procedures.

3.6.2.5 Specific Safety and Health Requirements

A list of those procedures, rules, and other mandatory regulations that are required by the locale, type of work, or the client's or other regulatory authority's codes, standards and specifications should be prepared. The following should be included:

- o Specific responsibilities
- o Reporting and recordkeeping requirements
- o Special safety and health rules and codes
- o Safety and medical department and facility requirements
- o Safety orientation and training
- o Enforcement procedures
- o Security program
- o Fire protection and prevention plan

3.6.3 Risk Management and Insurance

Given that all major transit projects have a large number and variety of risks, a risk management program should be established. A team of the owner's staff members and/or consultants should be formed early to provide a multi-disciplinary overview of the project and its elements and to determine how risks affect the technical, legal, political, social and financial aspects of the project from beginning to completion. A risk management program should consider the elements for which discussion follows.

3.6.3.1 Risk Identification

Risk can be defined in terms of the event (what may occur to the detriment of the project), its probability (how likely is the event to occur), and the amount involved (dollars of maximum possible loss or number of losses that could occur). Risk can be explicit or precise, implicit or vague, direct or consequential.

Residual risk is the amount of risk that remains after all steps have been taken to eliminate it. A loss is a loss regardless of who bears it -- owner, contractor, financier, or public -- and it costs money and results in delays. The larger the risk, the more it needs to be considered, but many large risks are not apparent, at least in terms of magnitude. Risk management implies control of events, which can be misleading; in fact, it means responding to events in advance or as they occur.

Risk can be classified further in terms of catastrophic, customary, and indirect risk as well as in terms of insurance risk categories. The classifications are defined and examples of the various risk classifications and categories are given in Table 3-1.

3.6.3.2 Risk Control

The risk management program should provide for the analysis and assessment of risks to determine the maximum protection and funding required. Particular attention should be given to activities on or near the project's critical path through an assessment of risks of delay and alternatives available to mitigate the consequences.

Potential losses should be evaluated and available contingencies identified. The program should provide for an audit in which parameters are rechecked constantly. The project overview by the risk management group should be ongoing, multidisciplinary, and include every significant part of the project.

The following are components of a comprehensive approach to risk control:

- Risk Evaluation - Considering the design contemplated, the cost of alternatives, the contractors' capabilities, the type of contracts (e.g., turnkey or separate jobs), supply prebuying as a feasible alternative, contractual wording (e.g., warranty, indemnification), the basis for considering competitive bids, how well the project will be managed and controlled, contingency plans for emergencies, the financial security of participating contractors and alternatives in the event of default, and the extent to which any one risk can affect the entire project.

- Risk Assessment - Involving constant identification and quantification of uncertainty, nature of risk, and the total amount of potential direct and consequential losses and precise definition of internal and external events.

- Risk Analysis - Involving the analysis of risks to determine if they are avoidable or unavoidable. Logically, avoidable risks should be avoided if it is economically feasible to do so. Unavoidable risks should be analyzed to determine whether they are insurable at rates that are cost-effective. Uninsurable risks should be analyzed to determine whether they are controllable and whether control measures should be taken. Uncontrollable risks represent the amount of residual risk that must be planned for, minimized, and (ideally) funded.

TABLE 3-1. RISK CLASSIFICATION AND CATEGORIZATION

Classification	Examples of Risk Type	Insurance Risk Category
Catastrophic Risks		
Are massive and have direct impact; can cause greater losses than insurance industry's capacity to cover; essential to consult with insurance industry early in design and planning stage; extent difficult to determine.	Earthquake, landslide or collapse, flood, explosion, design failure, civil disturbance	Property and casualty
	Prime contractor failure	Bonding
	War, terrorist attack, social/environment	None
Customary Risk		
Not catastrophic but can cause large financial loss; most always are insurable but economic value of insurance must be measured.	Project works (unfinished or complete), equipment and materials, employee injuries, third-party injury or damage, project delay	Property and casualty
	Subcontractor and major supplier failure	Bonding
	Exchange fluctuation	Political
Indirect Risk		
Losses to a project that may result from domino effect; require intensive analysis to identify and often can be an accumulation of risk; cost of control must be measured against possible loss to project; cause of loss often can be a small subcontractor.	Nonavailability of key components; fire, etc., at key component manufacturer; loss of key component in transit	Property and casualty
	Insolvency of key component manufacturer of supplier	Bonding
	New legislation	Political

- Loss Prevention - Involving established procedures for providing an organization that will ensure the adequacy of supervision, first aid and medical facilities, rehabilitation, and recordkeeping; emergency systems and contingency plans; plan review, site inspection, and compliance with standards and insurance company requirements to minimize property loss; identification of loss potential from bodily injury and property damage caused by unsafe work procedures and hazards and corrective action to be taken; physical security (loss prevention) through plan review, site inspection, review of transit, site-storage, and material handling risks, and security systems; and an on-going audit of the program.

3.6.3.3 Insurance Protection

The concept of insurance protection should be considered carefully and established early in the project's planning and development stage. It should, as closely as possible, approach fully funded self-insurance. This area of management requires expert knowledge, and unless a staff of such a caliber is already employed, outside consultants should be hired to design and implement a program and be employed until staff is hired and experienced enough to assume such responsibilities. Although cost-effectiveness should be the paramount goal of any program, the means of achieving this goal require careful analysis.

Conventional Insurance Approach

With the so-called conventional approach, each contractor and subcontractor arranges a separate program of insurance coupled with owner specifications. Such an approach with a high-cost item like insurance may not be cost-effective for any of the following reasons:

- Lack of economy in volume purchase.
- Lack of financial security (stability) of marginal contractors.
- Specifications that are the minimum necessary to protect the owner.
- The difficulty of administering many individual policies with varying limits of liability subject to different terms and expiration dates.
- Redundant charges by contractors (e.g., general and administrative overhead and profit).

- o Project delay from cross litigation by various insurance companies over claim payments.

- o Contractor delay or failure to collect claims from substandard insurance companies (the owner may be required to make dollar advances to keep contractors solvent).

- o The disjointed, many-faceted approach to life safety and loss-control arising from the multiplicity of insurance companies involved for each contractor.

Coordinated Insurance Program

The alternative to conventional insurance is an owner-designed and -controlled program known as a coordinated insurance program (CIP) or "wrap-up" insurance. While CIP is controversial and subject to debate, it can be cost-effective. The advantages of an owner-controlled program are that:

- o The owner, not the contractor, negotiates policy terms and costs, eliminating redundant charges for expense and profit items.

- o The administrative burden of maintaining records on contractor compliance with contract specifications for insurance is eliminated. (All contractors have the same coverage, limits, and expiration dates of polices.)

- o The safety and loss control programs are uniform.

- o Cross litigation is eliminated.

- o Claim handling is uniform.

- o Small and minority contractor participation in the project is not excluded because insurance is available.

- o Insurance costs are confined solely to the project through self-rating.

- o Cash flow advantages become available to the owner.

The disadvantages of an owner-controlled program are that:

- o Insurance costs are highlighted in one large package.

- o The owner's staff may not be adequately trained or available to handle a program.

- o The contractor should be fully responsible for all costs related to its own performance.
- o The contractor may be better able to manage its own insurance and safety programs (it takes the consequences if it is wrong and relieves the owner of this burden).
- o Management of the risk management program is costly.
- o Insurance costs are not subject to as many competitive forces.

The types of insurance usually placed in an owner-controlled program are workers' compensation, comprehensive general liability, including products and completed operations, railroad protective liability, and builders risk. This coverage applies to the owner and all contractors involved in the project, with the exception of hauling contractors (unless activities are exclusive to the project) and supply contractors. Surety bonds are the responsibility of each individual contractor. However, when an owner-controlled program exists, it is possible to develop a small and minority-contractor surety bond program with insurance companies to enhance the probability of participation by these contractors.

3.7 COMMUNICATIONS

Transit improvement projects can be complex undertakings which require effective communications to be accomplished successfully. Communication is critical on two fronts -- internal to the project team organization and other groups within the agency, and external from the project team to the community at large. Section 3.1.2 discusses project organizational issues and the need to have all affected groups represented on the project team either directly or through the use of advisory committees. Because of the "public" nature of transit projects in terms of financing and impacts of the facility and the transportation benefits of the completed project, communications should aim at enhancing support for the project through the transfer of information.

3.7.1 Program Development

A program should be developed and responsibility assigned for maintaining communications among all participants, affected organizations, and the public.

The communications program should support all project functions (e.g., management control, real estate, design, construction), should establish policies and procedures for reporting project progress, and should include schedules for periodic meetings and reports.

Since consistent communication with the entire community and with specific audiences is necessary, it is essential to impart in varying degrees of detail, information concerning project cost and timing, and the physical status of the developing project. With proper attention to communication, a transit project can maintain effective community support.

3.7.2 Audience

The first requirement is to identify the appropriate individual audiences, which may include:

- The governing body (board, commission or district).
- Local governments (city and county levels).
- State government (departments, agencies, and general assembly, if appropriate).
- Federal government agencies (Departments of Transportation, Interior, Defense, etc.; General Services Administration; and Congress, if appropriate).
- The public sector (civic associations, citizen groups, and business associations, etc.).
- Existing transit system (riders and operating employees).
- Internal project staff (management, supervisory, and employee groups).
- The media (press, radio, and TV).
- Workers on the project.

3.7.3 Responsibility for Reporting

The credibility of a major transit project depends upon quick, responsive, and consistent information being accurately conveyed to all audiences. Regardless of the size of a project, a spokesperson should be clearly identified. It is essential to establish the source of information concerning project performance, schedule, and cost. This source should be centered in an individual or office that generally is designated as "program control." An information officer should be appointed to act as a clearinghouse for the flow of information to and from the public and media. If a multitude of government agencies and government levels are involved, a government liaison or office should be established.

3.7.4 Reporting Systems

The owner should require that reports be made of the principal project tasks at the frequency and in the format necessary to provide essential information for monitoring the project. The owner also has an obligation to prepare reports on the project's financial status and to provide such reports to the government agencies that sponsored public funds for the transit project.

The types of reporting that should be required are:

- o Administrative reports - general administrative, personnel, data processing, and purchasing.
- o Financial reports.
- o Design and construction - architecture, engineering, equipment design, real estate acquisition, construction, and start-up program.

3.7.5 Communications Interface Management

The major interfaces at which performance failure could result in serious disruption of project continuity, or could prevent timely completion should be addressed. These interfaces exist between the companies involved as partners and under contract, functional units, project locations, project phases, project and governmental regulatory agencies, and private and other public interests.

To enhance interface management, the following should be defined clearly:

- o Responsibility, authority, and accountability at the interfaces between various project functions.
- o Inputs and outputs in terms of content and schedule.
- o Lines and procedures for communication.

Procedures for communication within the project organization should include authorizations, reports, meetings, and reviews supported by records management. Procedures for communication with elements external to the project should include public relations; applications for permits and licenses; and reporting requirements imposed by contracts, grants, regulations, and other legal requirements.

CHAPTER 4

SYSTEM PLANNING

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CHAPTER 4
SYSTEM PLANNING

The System Planning Phase is the initial formal step in the life of a transit capital project. It is typically undertaken by the designated MPO with UMTA's financial support. A region-wide evaluation is conducted to determine transit needs and priorities. While the System Planning Phase is not subject to project management scrutiny by UMTA or transit operating agencies, a few areas will be suggested for which early attention may be beneficial for the latter phases of the project. The guidelines presented in Chapter 4 are a supplement to the management principles discussed in Chapter 3.

4.1 LEGAL/INSTITUTIONAL AUTHORITY, MANAGEMENT AND ORGANIZATION

While the authority to perform System Planning should not be an issue, it is important to have the transit operating agency, or another organization which may later have implementation responsibility, involved in the process. This can be accommodated by having such organizations represented on a technical advisory committee, which is an established element of the regional planning process. In addition, the recommendations of the System Planning Phase should define institutional responsibilities for subsequent phases of high priority projects. This could include the need to create a new agency, if necessary.

In the case of regions planning new fixed guideway systems, it may be possible that no existing public organization has the authority to develop and operate such a system. Thus, in the earliest planning phases, the issue of authority in the subsequent phase must be addressed. Since this often requires an act of the state legislature, it may necessitate a lengthy lead time to accomplish. The establishment of an agency's legal authority should also address issues of public financing, preferably the establishment of a dedicated source of non-federal funding, if needed, to develop, implement and operate the transit project.

4.2 SYSTEM DEFINITION/CONFIGURATION/PERFORMANCE

Since the recommendations of the System Planning Phase become the initial baseline from which subsequent phases evolve, it is important to state the purpose and definition of the proposed improvement as specifically as possible. In response to a region's stated goals and objectives and its transportation problems, a priority corridor and a full range of alternative transportation solutions (both fixed guideway transit and non-guideway transit -- TSM) may be recommended for further study. Alternatives should be selected in terms of both their physical and operating characteristics to allow for preliminary evaluation of cost-effectiveness. During System Planning, the analysis of alternatives focuses on identifying fatal flaws such as high capital and operating costs in relation to realistic revenue projections, lack of engineering feasibility, major environmental impacts, or unproven technology, which could prevent implementation. The most potentially cost-effective alternatives are recommended for advancement to the Project Planning Phase.

For modernization projects, the System Planning Phase presents an opportunity to assess the existing transit system with regard to future regional goals, projections and travel patterns. It should include a general assessment of the condition of existing equipment and facilities to function in a cost-effective manner. Given the existing condition of the system and future demands, priorities should be established for modernization, including the alternative not to modernize and ultimately phase out a segment of the system.

4.3 FINANCIAL REQUIREMENTS/RESOURCES

For a new fixed guideway project, a rough estimate of the capital and operating cost of the proposed project must be developed and related to the expected revenue projections to justify an alternative's advancement. The level of detail for this analysis should recognize that the nature of the decision at hand is to choose a corridor and narrow the range of alternatives, not to select one alternative for implementation. Although the estimates may have a sizable margin of error in absolute terms, they should accurately represent the relative costs and benefits of the alternatives. Care should be taken to define the year for which capital costs have been estimated, since costs are sensitive to inflationary pressures and can be subject to future misinterpretation if the year is not clearly defined.

Ideally, for modernization planning, funding requirements should be determined to:

- o Raise the system to the desired level of performance
- o Maintain the system at that level over the long-term

The financial information produced in System Planning helps local officials make regional tradeoffs to support decisions on priorities, and whether resources are available to subsidize system-wide operating deficits and long-term capital programs. During System Planning, a region's overall financial capability is determined through an assessment of historical trends in the funding agency's revenues, expenditures, assets and liabilities, and a determination is made of the capacity of the existing revenue base to meet future transit financial requirements. These requirements represent a financial environment within which decisions on regional investments are made. If funding deficiencies exist, strategies for new revenue sources should be identified, assessed, and to the degree possible, set in place.

4.4 MANAGEMENT CONTROL SYSTEMS

The alternatives recommended for advancement to the Project Planning Phase and their cost-effective components become the baseline against which future project evolution can be measured and controlled. During this phase, no formal management control systems are required other than the standard administrative and grant management procedures of the sponsoring organization.

4.5 PROCUREMENT, CONTRACTS, DISPUTES AND CLAIMS

No special considerations are necessary during this phase other than the standard procurement/contract procedures of the sponsoring agency to satisfy the need for outside services to support System Planning activities.

4.6 SAFETY, RISK MANAGEMENT, INSURANCE

Issues of this nature are not typically addressed in the System Planning Phase. Should the alternatives being considered deviate substantially from proven technology, issues of system safety and risk management may have to be addressed to assure that the alternatives can be candidates for public operation at some point in the future. Some forms of fully automated transit systems may fall into this category.

4.7 COMMUNICATIONS

As a means of maintaining credibility of the planning process, communications should be a fundamental element in two forms -- receiving input from major groups (including elected officials, the general public and transit advocates) and informing those groups of the planning process and its outputs. Such a communications process should be a standard part of the regional planning activities of MPOs.

CHAPTER 5

PROJECT PLANNING

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3.5 PROCUREMENT/CONTRACTS 3.5.1 Procurement Issues 3.5.2 Contract Administrtn 3.5.3 Dispute Resolution 3.5.4 Claims Management	4.5	5.5	6.5	7.5	8.5	9.5	10.5
3.6 SAFETY/RISKS/INSURANCE 3.6.1 Operational Safety 3.6.2 Construction Safety 3.6.3 Risk Mgmt/Insurance	4.6	5.6	6.6	7.6	8.6	9.6	10.6
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CHAPTER 5
PROJECT PLANNING

Project Planning is a direct outgrowth of System Planning -- the next development phase of the selected transit capital improvement strategies. As described in Chapter 2.3, Project Planning can include the bus maintenance facility planning process, a model of which has been developed; rail modernization planning for which there is no standard process; and the AA process for major capital investments for which UMTA has established procedures [Ref. 1]. This chapter focuses on these procedures which create a baseline for the management of new start type projects in subsequent phases. When appropriate, additional guidance is also provided for modernization of existing systems for which AA is not applicable. The guidelines presented in Chapter 5 are a supplement to the management principles discussed in Chapter 3.

UMTA oversight and technical assistance during AA is provided by the Office of Grants Management. As lead (or joint lead) agency for the environmental documentation, UMTA is also responsible for the scope, content and conclusions. Thus, UMTA staff will be actively involved throughout the development of the DEIS which is required for major capital investments and contingent on the outcome of EA for other projects.

5.1 LEGAL/INSTITUTIONAL AUTHORITY, MANAGEMENT AND ORGANIZATION

For planning the modernization of existing transit systems, the operating agency typically has full responsibility and authority. A process must be established for determining system-wide needs and priorities which achieve the agency's longer term goals and objectives while satisfying the shorter term demands of the individual operating departments.

For major capital investments, a local lead agency must be designated to direct the AA. While not a necessity, it would be helpful for future continuity if the lead agency also had the responsibility for implementation of the alternatives being considered. At this stage, however, it is only necessary that the lead agency have the charter, authority, and capability to perform the planning and receive the grants required to accomplish the AA. Because a wide range of skills must be brought to bear to successfully complete the AA, more than one local agency will frequently play an active role and others may have advisory or oversight roles. A memorandum of understanding is advisable in order to clearly define the roles and responsibilities of each participating agency. The management and organization of the AA should reflect these roles and responsibilities.

To guide the AA, a work plan must be developed by the agency early in the program and updated, as required, throughout the study. Initially, the work plan will be a vehicle for obtaining agreement among participating agencies, including UMTA, on the approach to be followed in the study, the level of effort and funding required, and agency responsibilities. As the study advances, it becomes a tool to monitor progress against the schedule and budget and to assure that input data is available when required.

5.2 SYSTEM DEFINITION/CONFIGURATION/PERFORMANCE

5.2.1 Modernization Projects

During the Project Planning Phase for modernization of existing transit systems, effort is focused at the subsystem level. Based on an assessment of condition and determination of modernization required to achieve a desired level of performance, generalized plans, specifications and priorities should be developed for each subsystem considering the costs, benefits and impacts of alternative approaches. This may require performing advance engineering and should include a determination if environmental or historic preservation issues require more detailed analysis/documentation.

5.2.2 Major Capital Investments

These projects are subject to the detailed requirements of AA as described in the following sections.

5.2.2.1 Selection of Alternatives

Throughout the project development process -- from System Planning, to corridor or Project Planning, to PE -- the primary nature of the decisions to be made is a narrowing of options toward selection of a specific project for implementation. The selection of the alternatives to be considered in Project Planning is the single most important activity in the entire effort. The steps in that process and guidelines for their accomplishment include:

Define the Set of Alternatives

- o The set of alternatives must include the necessary baseline options (Do-Nothing or TSM Alternative).
- o The alternatives should include all appropriate modes and alignments, but only those that are appropriate.
- o The set of alternatives should include all options that have a reasonable choice of becoming the Locally Preferred Alternative.
- o The alternatives should encompass an appropriate range of options without major gaps in the likely cost of the alternatives.
- o Where questions remain on feasibility of alternatives, other alternatives should provide related fall back options.
- o The policy and land use setting in which the alternatives are defined and analyzed must be unbiased and consistent across the alternatives.

Define Individual Alternatives

- o The alternatives must, within the limits of their technology, respond to the transportation problems identified in the corridor.
- o Each alternative should be defined to optimize its performance in the corridor.
- o The alternatives must be defined in all physical and technical dimensions (see Table 5-1), including their operating plans. In addition, alternatives should encompass potential institutional arrangements and financing strategies.

TABLE 5-1. DIMENSIONS FOR DEFINING ALTERNATIVES [REF. 1]

Dimension	Characteristics	Options
Mode	o Technology	o Bus o Rail o Automated Guideway o Etc.
	o Degree of Right-of-Way Separation	o Mixed Traffic o Separation except at Interactions o Exclusive R/W
	o Operating Characteristics	o Local vs. Express o Stations vs. No-Stop o Integrated Feeders vs. Transfers o Single vs. Double Lane/Track o Etc.
General Alignment	o Horizontal	o Streets o Medians o Rights-of-Way
	o Vertical	o Elevated o At-Grade o Open Cut o Subway
	o Station Locations	o Parking Provisions o Bus Transfers o Accessibility
	o Length	o Alternative Terminus Locations
Policies	o Operations	o Service Standards o Loading Standards o Etc.
	o Fares	o Flat o Zone o Distance Based o Transfer Charges o Park/Ride Lot Fees

Documentation of the Alternatives for Review at Three Stages:

1. Conceptual Definition consisting of corridor definition, general alignment by alternative and operating strategy by alternative.

After completion of initial engineering, preliminary operations planning and screening:

2. Detailed Definition consisting of specific alignment assumptions, typical sections and stations, initial design standards, initial operating plan.

After conceptual engineering, environmental analysis, operations planning, patronage forecasting and determining a supply/demand equilibrium:

3. Final Definition consisting of plan and profile drawings, proposed design specifications, refined operating plan, inputs to O&M costing.

5.2.2.2 Evaluation of Alternatives

After development of cost data, patronage demand, socioeconomic and environmental impacts, and financing, evaluation of the selected alternatives can take place based on the following measures and characteristics of desirable projects:

- Effectiveness - That it yields benefits in terms of mobility, environmental protection, urban development, energy conservation, etc.
- Cost-Effectiveness - That the costs of the project, both capital and operating, be commensurate with its benefits.
- Financial Feasibility - That funds for the construction and operation of the alternative be readily available in the sense that they do not place undue burdens on the sources of those funds.
- Equity - That the costs and benefits be distributed fairly across various population groups.

5.2.2.3 The Locally Preferred Alternative

After circulation of the DEIS and after the public hearing, local officials select their preferred alternative from among those presented in the DEIS. The selection is then documented in a Locally Preferred Alternative Report which is transmitted to UMTA with a request to approve the initiation of PE. This marks the end of both AA and the Project Planning Phase for major capital investments.

5.3 FINANCIAL REQUIREMENTS/RESOURCES

Financial considerations for modernization projects relate to estimating capital and O&M costs, performing life cycle cost analyses of alternatives, and prioritizing projects within the constraint of the resources available. For major capital investments, on the other hand, the process of financial analysis is much more rigorous since the viability of the project is dependent on a successful outcome. The following sections describe the financial analysis requirements of the AA process for new start type projects.

5.3.1 Capital Cost Estimate

During Project Planning, the capital cost estimating process parallels the alternatives development process and includes:

- o Development of segment costs using:
  - Composite unit cost for typical cross-sections and stations
  - Costs for non-recurring items such as overpasses and cross-overs
  - Costs for difficult segments obtained through engineering analysis
- o Development of system-wide costs including:
  - Vehicles
  - Maintenance facilities
  - Electrification
  - Signal/control systems
- o Allowances for add-on costs including:
  - Contingencies
  - Engineering and Construction Management

A recurring problem in the estimation of capital costs at the planning stage is accounting for the degree of uncertainty and potential error in the estimates. Potential sources of error in cost estimates at the planning stage include:

- Changes in the scope of the project
- Changes in design standards
- Errors in unit cost assumptions
- Unforeseen problems in implementing the project

Efforts to minimize potential errors should consider the following:

- Where uncertainty exists, analysis should be conducted on the potential impacts and likely costs of options for the scope and design standards of each alternative.

- Right-of-way requirements should be carefully assessed.

- Realistic assessments of required mitigation efforts and added physical amenities should be rendered for each alternative, through the public involvement process and reference to previous major transportation projects locally and in other cities.

- Historic cost data used to develop unit cost assumptions should be documented carefully, with particular attention to precise definitions of the individual line items.

Even with the best possible efforts to identify the likely scope, design criteria, and implementation requirements for each alternative, the limited engineering analysis conducted in Project Planning usually leaves substantial areas of uncertainty. Two ways to address the remaining uncertainty are:

- In addition to a best estimate of capital costs, the capital cost analysis should develop upper-bound and lower-bound cost estimates. The lower-bound estimate must be based on <u>reasonable</u> assumptions that are uniformly favorable toward lower capital costs, while the upper-bound estimate must be based on <u>reasonable</u> but uniformly unfavorable outcomes.

- Contingency allowances should vary across individual cost line items. After developing an upper-bound estimate, the remaining uncertainties are largely associated with the unit cost assumptions. These are best handled through contingency allowances that vary across line items according to the uncertainty for each item.

5.3.2 Operating and Maintenance Cost Estimate

A reliable estimate of the costs of operating and maintaining each alternative is crucial to an accurate assessment of its cost-effectiveness and financial requirements. The recommended method of estimating O&M costs for AA is the "resource build-up" approach. The initial phase of work involves a preliminary operations analysis necessary to identify an operating plan for each alternative. These operating plans, combined with route layouts and design standards, constitute the detailed definitions of each alternative.

After the detailed definition of alternatives, two parallel efforts are undertaken. One is the analysis of service and patronage levels necessary to develop a final operating plan for each alternative that optimizes its performance. This effort culminates in the estimation of operating statistics -- vehicle-miles, vehicle-hours, peak vehicles, etc. -- that drive the O&M cost models.

The other effort is the development of the O&M models themselves, which requires a detailed budget statement and an accurate estimate of service characteristics derived from a comparable transit system. The O&M cost models are calibrated simply by identifying those costs that are variable with service levels, and then attributing each variable cost item to the service characteristic to which it is most clearly related. The resulting unit costs can then be applied to variations in service characteristics caused by an alternative that would estimate the O&M costs of that alternative.

5.3.3 Financial Analysis

In AA, financial information is developed to support the decision on mode and general alignment and is used to decide whether to advance a Locally Preferred Alternative into PE. The financial capability analysis performed in System Planning is reevaluated and updated to account for the passage of time between completion of System Planning and initiation of AA. Financial analysis during project planning should include the following elements.

5.3.3.1 Projection of Project Revenue Sources

Existing and proposed sources of revenue for both capital and operating purposes should be projected on an annual basis for five years beyond inauguration of service of the alternative with the longest implement schedule. Techniques typically used for forecasting revenues include comparison, trend analysis, simple regression analysis, and economic modeling. The selected technique should depend on the revenue source being studied, the number of variables being studied, the number of variables influencing the source, the availability of local data for calibration and validation purposes and the technique's ability to produce reasonable estimates over a 15-30 year period. Proceeds from joint development, special assessments, impact fees and other benefit/cost sharing strategies should be supported with market studies of station areas and/or development projects.

5.3.3.2 Operating Deficit Funding Analysis

System-wide operating deficits are derived from estimated farebox revenues and O&M costs. New sources of revenue for operating deficit funding must be identified if deficiencies are found in current or proposed sources. A wide range of revenue strategies should be considered with the objective to select and evaluate stable and reliable sources of revenue which make maximum use of private sector opportunities. The various mechanisms can be narrowed by considering their advantages and disadvantages with respect to expected yield, returns, sensitivity to changing local economic conditions, ease of implementation, collection and disbursement, and equity.

5.3.3.3 Capital Investment Financial Analysis

Annual capital cost estimates should be made based on tentative procurement and construction schedules which cover the construction period, or if bond or long-term contracts are involved, throughout their maturity. Over time, capital requirements must be compared to existing revenue sources and new sources identified if a shortfall exists. New sources could include revenues from broad-based taxes, debt financing, public/private benefit sharing strategies such as joint development, special assessment and tax increment financing, private sector equity financing in the form of vendor contributions or a combination of these mechanisms. Note that a broad-base tax is seldom considered a capital financing option by itself. Taxes are usually used to secure debt.

5.3.3.4 Financial Capability Analysis

In analyzing financial capability, primary consideration should be the capacity of new revenue source to meet future capital requirements and operating deficits, and the financial condition of the non-Federal funding agencies. The financial capability analysis should include assessment of:

- o The future financial condition of the funding agencies and affected community.
- o Yield capacity of the revenue sources.
- o Legal limits of the revenue sources.
- o Political willingness of the community to approve bond referendums or to levy taxes if new taxes are required.
- o Existing or proposed collection and disbursement mechanism associated with the revenue sources.

The analysis of future financial capability should employ forecasts of measures of a locality's economic vitality, debt management, and fiscal burden of transit expenditures, results of public opinion polls if referenda are required, and stated policy and procedures on land development, transit travel incentives, and on the collection and disbursement of transit revenues. Private sector participants should also be assessed for their financial capability. The assessment should consider management practices, financial leverage and profitability.

5.4 MANAGEMENT CONTROL SYSTEMS

For the activities of the AA, the work plan developed at the outset will represent the baseline. The work plan defines the activities to be accomplished and the methodology to be utilized. The cost estimate and schedule defined in the work plan should be realistic enough to support the work of the agencies and consultants involved. Effective organization and management of AA, coupled with a comprehensive communications program, should assure a successful outcome. More important than accomplishing the AA within the time and cost established in the work plan is the thorough review of all reasonable alternatives to achieve the best Locally Preferred Alternative with supporting analyses. This would assure a sound base on which to advance to PE.

Throughout AA, the corridor and alternatives recommended from System Planning evolve in a structured manner to become the Locally Preferred Alternative. The Locally Preferred Alternative will become the configuration baseline for project control purposes for the beginning of the PE Phase. Careful documentation of all aspects of the AA and EIS as required by UMTA, will permit the project to advance with a high degree of credibility and local support.

In a similar manner, results from rail modernization subsystem planning efforts and the bus maintenance facility planning process should provide the scope, schedule and cost baselines for the management and control of specific projects in the PE Phase.

5.5 PROCUREMENT, CONTRACTS, DISPUTES AND CLAIMS

During the Project Planning Phase, considerations related to procurement, contracts, disputes and claims should focus on the funding and services required by the sponsoring agency from state and local agencies and organizations needed to execute the planning and analysis activities, including AA and EIS. Some degree of flexibility should exist in the statements of work for supporting contractors to permit a full exploration of all alternatives and their impacts, some of which may not be apparent at the outset.

The sponsoring agency must be knowledgeable of, and adhere to, all study grant requirements imposed by UMTA and other funding agencies.

5.6 SAFETY, RISK MANAGEMENT, INSURANCE

Issues of this nature are not typically addressed in the Project Planning Phase for new starts. Alternatives being considered should be assumed to have a similar degree of system safety as contemporary versions of the same modal characteristics. Should an alternative under consideration deviate substantially from proven technology, issues of system safety and risk management should be addressed to assure that the alternative can be a candidate for public operation in the future. The impact of any development or testing that is required to assure adequate levels of safety or performance should be factored into the estimates of cost and schedule for the given alternative.

For projects related to an existing transit systems, planning should fully consider the safety of existing employees, patrons and construction personnel. The selection of alternatives and the phasing of projects should seek to minimize the risk inherent with construction on or adjacent to an operating transit system.

5.7 COMMUNICATIONS

An effective public and private sector participation program should be an integral part of the AA process and is a desirable, although less formalized, aspect of ongoing modernization programs. For these types of projects, communications efforts are primarily internal to the existing operating agency to receive input and deal with potential conflicts. By encouraging citizens and organizations to express their opinions and concerns through an open exchange of views, all of the significant issues can be identified which will ensure that major impacts are addressed and that the information necessary for decision-making is developed.

5.7.1 Citizen/Organizational Involvement

The citizen and organizational participation process typically consists of a mix of formal and flexible techniques. Formal techniques include a scoping meeting to initiate the participation process and a public hearing during the circulation of the draft EIS. Between these formal events, the study should include an on-going process which consists of less formal, but no less important activities involving the public, such as public meetings and workshops, advisory panels, technical groups, newsletters, surveys, press releases, presentations, etc. Periodic status briefings are an effective vehicle used to communicate with interested organizations. Whenever possible, existing community institutions should be utilized, rather than creating new groups or organizations.

The number and composition of the participants will vary from study to study, depending on the characteristics of the local community and the perceived impacts of the alternatives. Each study is likely to have a citizen advisory committee, a policy advisory or steering committee, and one or more technical advisory committees. In addition, it may be worthwhile to form informal groups to deal with specific issues such as private sector participation, historic preservation, parkland impacts, business disruptions during construction, etc. A plan for informing and involving outside groups should be prepared during the scoping process and included in the detailed work plan or be issued as a separate methodology report. This report would identify the techniques to be used as well as the points in the process when public involvement will be solicited.

5.7.2 Private Sector Involvement

Private sector participation in the development, operation, and funding of public transit improvements has been encouraged by UMTA. Provisions should be made for private sector involvement throughout Project Planning in order to identify and exploit opportunities for their input and participation.

CHAPTER 6

PRELIMINARY

ENGINEERING

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CHAPTER 6
PRELIMINARY ENGINEERING

The Preliminary Engineering (PE) Phase is initiated at the conclusion of Project Planning, which may have involved the selection of an alternative for additional development, or the development of several subsystem plans for modernization projects. As a supplement to the management principles presented in Chapter 3, Chapter 6 contains project management guidelines specifically related to the PE Phase of a transit capital project.

6.1 LEGAL/INSTITUTIONAL AUTHORITY, MANAGEMENT AND ORGANIZATION

6.1.1 Legal/Institutional Authority

The owner or authority is the organization that has the overall responsibility for designing, and constructing the transit capital improvement project. The owner should be an agency duly authorized by the appropriate governmental unit to administer and finance the transit improvement. This agency must be legally established and fully operational prior to the PE Phase, as this is a mandatory requirement prior to the commitment of any Federal funding.

6.1.2 Management and Organization

The management of PE is the responsibility of the owner who must assure that knowledgeable personnel are available to perform the required services. The level of involvement of the owner's staff can be varied.

Successful examples exist of owners performing the overall management function with a very small staff, relying on a general consultant for the necessary detailed work. Conversely, there are also successful owners who have sufficient staff to do most of the engineering design and construction supervision. Moreover, there are examples of a combination of these approaches. Through careful consideration of the alternatives, it is possible to make a rational decision concerning the amount of detailed involvement in project management by the owner's staff. Whatever the organizational pattern, it is imperative that the owner make certain that the necessary mechanisms exist to permit prompt and final decision-making on all significant questions, and that the various elements work cohesively.

Two basic alternatives exist for organizing the PE effort, depending on the degree of experience of the owners staff: 1) the owner's staff performs all design, or 2) consultants have the primary responsibility for design. Given these extremes, several other arrangements are possible. For larger projects, either the owner or a general consultant can supervise and manage the work of firms retained to design sections of the project. If a general consultant is utilized, the selection should be based on proven successful experience on similar work performed by the firm, and a commitment to assign a manager and staff qualified to provide the services required. Where section designers are used, the owner or general consultant should establish the design criteria/system specification and the initial construction schedule and cost estimate. This provides the constraints under which the section designer must perform the detailed PE.

Continuity in engineering services is essential. Either the owner's staff or a consultant retained for that purpose should be available from PE through final design and construction. An important part of this role is the preparation and updating of schedules and estimates which, when approved by the owner, can be used as a basis for supervising the design and construction. Designers and design managers should be available to provide needed services during construction.

The involvement of two groups during the design stage of a transit project can help assure successful implementation -- construction and operations. For a mature organization which is currently engaged in construction activities and transit operations, their review and approval of design decisions will minimize problems during construction and permit safe and smooth integration of the improvement with existing operations. For new systems, sufficient expertise should be available to perform these review functions by both consultants and the initial department personnel which will have subsequent owner responsibility for construction and operations.

6.1.2.1 Project Management Plan

The development of a PMP is an UMTA requirement; initial preparation occurs prior to PE. Since each rail transit project is unique, its project management must reflect both the specific requirements of the project and its management philosophy. The following PMP outline has been provided by UMTA (unreferenced) as a sample.

1. Parameters and Constraints

   1.1 Project Description
   1.2 Legal Authority and Requirements

2. Organization and Staffing

   2.1 Project Engineering Organizational Charts
   2.2 Key Personnel (with resumes)
   2.3 Interface Points
   2.4 Staff Mobilization Plan
   2.5 Training Plan
   2.6 Agency Policies

3. Management Control

   3.1 Financial Control

   3.1.1 Maintaining Baseline Project Cost
   3.1.2 Performance Measurement
   3.1.3 Contingency Management
   3.1.4 Escalation Factor Derivation
   3.1.5 Contracting Techniques
   3.1.6 Cost Allocation Plan
   3.1.7 Cost Accounting System
   3.1.8 Agency Force Account Plan

   3.2 Schedule Control
   3.3 Change Control
   3.4 Design Control
   3.5 Construction Control
   3.6 Check-out and Acceptance
   3.7 Documentation Control
   3.8 Accounting and Reporting
   3.9 Quality Assurance/Quality Control

4. Labor Relations and Policy

   4.1 Wage Rates and Classifications
   4.2 Wage and Hour Requirements

4.3 State and Local Regulations
4.4 No Strike Agreements

5. Risk Management and Insurance

5.1 Scope
5.2 Risk Identification
5.3 Evaluation
5.4 Risk Control
5.5 Insurance
5.6 Inflation

6. Procurement of Services

6.1 Procedure for Procurement of:

6.1.1 Project Management Services
6.1.2 Design Services
6.1.3 Legal Services
6.1.4 Construction Contracts
6.1.5 Construction Management Including Inspection
6.1.6 Data Processing
6.1.7 Public Relations
6.1.8 Consulting Services

7. Procurement of Materials and Equipment

7.1 Procedure for Procurement of System-wide Components

7.1.1 Permanent Materials
7.1.2 Construction Equipment
7.1.3 System Components
7.1.4 Rolling Stock

7.2 Quality Assurance Plan
7.3 System and Equipment Test and Evaluation Plan
7.4 Identification of DBE Opportunities

8. Design Program

8.1 Design Supervision
8.2 Design Coordination - Internal, External
8.3 Design Review Process
8.4 Configuration Management (trade-off evaluations)
8.5 Constructibility Reviews
8.6 Operation and Maintenance Considerations and Reviews
8.7 Change Control
8.8 Systems Integration
8.9 Reliability, Availability, Maintainability, Dependability and Safety
8.10 Value Engineering and Peer Reviews

9. <u>Right-of-Way Acquisition</u>

   9.1 Identification
   9.2 Appraisal
   9.3 Acquisition Plan
   9.4 Property Management Plan
   9.5 Relocation Assistance Plan
   9.6 Demolition
   9.7 Scheduling and Funding Plan
   9.8 Resale Plan

10. <u>Community Relations</u>

   10.1 Meetings with Community Organizations
   10.2 Interface with State and Local Government Agencies
   10.3 Public Hearings
   10.4 Media Interface

11. <u>Construction Program</u>

   11.1 Construction Management
   11.2 Construction Contract Administration
   11.3 Construction Safety
   11.4 Change Order Control
   11.5 Payments and Claims Close-out
   11.6 Logistics Plan (materials, equipment, temporary site facilities, traffic and utilities provisions and maintenance of existing transit operations)
   11.7 Value Engineering

12. <u>Requirements for Interagency and Master Utility Agreements, Approvals, Permits</u>

13. <u>Conflict Resolution</u>

14. <u>Planning for Operations Start-up</u>

15. <u>General Joint Development Program</u>

6.1.3 <u>Human Resources and Labor Relations</u>

The human resources and labor relations policy should be developed with the objective of obtaining and retaining all levels of efficient personnel under a coordinated planned administrative procedure of recruitment, selection, and utilization of human resources. It should be related to the grantee's Equal Employment Opportunity (EEO) and DBE programs.

6.1.3.1 Regulations

During PE, Federal, state, and local regulations should be given attention. The owner should be responsible for obtaining the required issuances of wage predeterminations and notifications relating to labor relations and human resources. The following are suggested guidelines, but are not necessarily all inclusive:

- o Appropriate and definitive Department of Labor wages and classifications
- o Appropriate reference to work hour provisions
- o Notices required to be posted under the Fair Labor Standards Act
- o Notices required to be posted under the Civil Rights Act
- o EEO and Affirmative Action Plan postings
- o Suggested nondiscrimination forms for use with recruiting sources
- o Required Occupational Safety and Health Administration (OSHA) postings
- o Notices concerning time off for voting
- o Applicable Presidential executive orders and directives

Even though many of the above items appear in Federal and state contracts, a new authority created to administer a transit improvement program may not be familiar with all of these requirements. Referring to the applicable regulations in broad terms or leaving them to the execution of contractors often results in confusion, noncompliance, and other negative impacts that are counterproductive if they occur during the construction phase of the project.

6.1.3.2 Area Awareness Studies

Area awareness studies should be conducted to identify conditions which may have an impact on the project. An awareness of these conditions permits action plans to be developed in order to lessen the negative impacts and maximize the positive impacts. All too often, transit projects suffer costly manpower, worker transportation, safety, and public relations problems because an awareness study was not made prior to construction. Often, an overall demographic evaluation of the area will provide the breakdown of population by ethnic groups (EEO value) and by age and gender groups (workforce value). Among the subjects to be included in awareness studies are:

- Geographical area of labor supply
- Current and projected labor availability by skill level
- Transportation facilities and traffic peak periods
- Availability and cost of worker housing
- Projects in the area that will compete for labor
- Routing and safety of pedestrian traffic during construction
- Parking for workers
- Available lunchroom facilities
- Skill development and training centers
- Labor sources
- Recreational facilities

These studies are vital to the effective implementation of a project. They provide base information that can be updated during construction and can contribute to controlling overtime, maintaining a more balanced workforce, and more readily meeting scheduled completion.

6.1.3.3 Labor Relations

Certain labor relations decisions must be made before construction begins. The most notable of these is whether the negotiation of a local labor agreement for the project is desirable or whether the issue of union versus open shop can, or should, be left to the discretion of each execution contractor. Caution should be exercised to avoid decisions that may lead to inefficiencies or labor shortages on the project, by excluding from participation a significant portion of the local construction labor pool. An in-depth study should be conducted to determine past and current labor relations practices in the area, history of past labor performance, productivity, strikes, and collective bargaining organizations and their effectiveness.

Local User Councils (LUCs) can provide a valuable source of information from other owners about all of these matters. Regular participation in the LUC by the project manager or his delegate should be considered.

6.1.4 Interagency Agreements, Approvals, Permits

All project related items requiring interagency agreements and approvals must be identified and timetables estimated for their preparation. These would include but not be limited to:

- o Utility relocations
- o Encroachment on other public transportation right-of-ways
- o Permits and/or waivers

It is normally necessary to relocate or rearrange existing facilities prior to the construction of major transit project. This includes franchise utilities (power, telephone, cable, gas, steam, etc.) public agencies (highways, streets, sewer, water, drainage, fire services, traffic control, etc.) and railroads. During PE, master utility agreements should be developed, negotiated and completed, to the degree possible. These agreements should ensure that the project will not be delayed either during design or construction stages and should provide for the following:

- o Scope of work and obligations/rights of both parties
- o Who performs design
- o Who accomplishes construction, relocation/rearrangements
- o Who inspects
- o Procedures for billing and payments
- o How disputes are settled
- o Preparation and terms of detailed agreements
- o Salvage materials/credits
- o Substitutions and betterments
- o Conflict resolution method
- o Improvement and replacement standards
- o Parameters work scheduling

6.2 SYSTEM DEFINITION/CONFIGURATION/PERFORMANCE

6.2.1 System Configuration and Scope

The PE Phase involves the further development and quantification of the project alternative selected during the Project Planning Phase. The scope of work for PE services should be prepared using inputs from the appropriate technical and program disciplines. The following list includes elements to be considered for inclusion in the PE scope of work:

- o A listing of all client-furnished input, stating which are provided for information and which are criteria and therefore mandatory. A vital part of these furnished materials is a copy of the PE project management network.
- o A sequential breakdown of the time-phased order in which the work and element will be performed.
- o A definite statement as to how many concept alternatives are required. The wording must be developed with great care; otherwise, the output received may only be a single basic concept with minor differences. For a building, the scope of work could state that the concepts should consider the economic, energy, and functional advantages of a low-rise a multi-story or a building cluster. An example for rehabilitating an existing structure would be a statement requiring concepts that place functions in different areas of the building and the trade-offs for each location. For a bridge, the statement could specify analysis of three named types of girder or truss systems. The key is carefully specifying what is desired. Never assume that a designer will continue to develop an infinite variety of concepts until one is finally accepted.
- o Specification of the product expected, listing all sub-elements such as architectural, structural, mechanical, site, quantitative loads, calculations, organization, review checklist, and review procedure.

In all steps of the PE effort, specific reference should be made to requirements for the number of documents to be produced by the designer and to the distribution list. At the end of every step in the PE process, there should be compatibility of the budget and the scope of the project. After completion of the schematic design, the PE designer could be asked to certify that the firm agrees with the construction budget for the project.

6.2.2 <u>Design and Operational Criteria</u>

Design and operational criteria are to be fully developed for new fixed guideway projects during the PE process, although some modification may be necessary during Final Design. This type of activity is typically accomplished by subsystem during Project Planning for modernization projects.

UMTA staff has prepared a list (unreferenced) of general tasks that should be accomplished during PE for major transit projects. While these apply primarily to new fixed guideway projects, many elements also relate to aspects of rail modernization and bus facility projects. During PE, other work tasks may be necessary to ensure the proper assessment of facility and system standards and the selection of specific facilities and systems that constitute the total project. UMTA suggested work tasks are addressed in the following sections.

6.2.2.1 Perform Surveys

This task includes the following types of surveys required to properly investigate alternative configurations and construction methods as well as to complete PE work:

- Control surveys
- Aerial topography surveys
- Surface topographic surveys
- Major utility surveys
- Subsurface geologic/seismic exploration
  - Compilation and review of geology data from city and state agencies
  - Subsurface test borings and seismic tests, as necessary
  - Interpretation of boring logs and development of geotechnical report
  - Development of segment design criteria based on geologic/seismic tests
  - Building foundation inventory
- Identification of utilities to be relocated and cost estimates
- Demographic Surveys
- Other surveys as required

6.2.2.2 Conduct System Studies

The general system criteria for all facilities and subsystems should be developed for each major element of the PE process after completion of the following evaluations and studies. Completion of this task may require modifications during the preliminary design process as new information suggests alterations to the criteria. Although design criteria should be fully developed by the conclusion of PE, it may require some modification during Final Design.

- Configuration Evaluation - Investigation should include a thorough analysis, sufficiently detailed to demonstrate the energy advantage of the option selected for line, profile and station and to investigate the feasibility of regenerative braking system.

- Evaluation of Operational Alternatives including:

  - Analysis to determine the effect of the proposed operations plan on future extensions of the system.

  - Analysis of station spacing, station length and train headway based on studies for patronage, development and system operating speed.

  - Analysis of effect of incremental development of automatic train operations (ATO) vs. initial full utilization.

  - Analysis to determine effect of alternative modes of operation such as coasting, lower acceleration, etc., on transit performance and vehicle life.

- Travel Demand - By station for 10 and 20 year horizon and determination of the effect of patronage volumes on the initial system.

- Determination of Required Vehicle Size and Train Consist - Study based on a thorough in-depth review of vehicle types available and considering the following factors: patronage volumes, service policy, safety, reliability, maintainability, costs, availability, and influence on structure costs.

- Noise/Vibration Study - To determine acceptable noise/vibration levels for all systems such as trackway noise, etc., for the proposed system and evaluate abatement techniques. Study should include several different techniques, their reduction potential, costs and recommended treatments.

- Evaluation of Barrier Free Fare Collection System.

- Operable Segments - Determine effects of constructing the proposed system in operable segments considering the entire system as the largest segment. Arrange all alternates, estimates or evaluations throughout PE to account for the various operable segments established in these studies which should:

  - Define operable segment limits
  - Assess the impact of these limits on all systems

- Bus routing analysis.
- Corrosion protection.
- Patron security and safety.
- Failure management.
- Elderly and handicapped accessibility.
- Other studies as necessary.

6.2.2.3 Select Way and Structure Types

Develop design criteria to a level consistent with the PE effort. Work to be performed should include the development of various structure types necessary for the project. Alternative alignments should be developed within the corridor. The following way and structure types should be considered during the development of the alternative alignments.

- o Tunnel, cut and cover, open cut, surface, and elevated structures, as appropriate, along the corridor.

- o Tunneling with various profiles and alternative construction methods to permit evaluation in terms of:

  - Costs
  - Feasibility of construction
  - Schedule impact
  - Impact on community and environment

Completion of this work will lead to selection of the final profile and structure type for each portion of the line and a set of preliminary drawings and specifications which will provide a base for preparing a cost estimate. These include:

- o Alignment drawings showing plan and profile for entire system.

- o Details of way structures for all variations in configuration and cross sections, as needed, to show transitions and/or problem areas. These plans should include the location of all crossovers, pocket and lay-up tracks in coordination with operating plans. Particular construction methods for underpinning problems, non-standard elements, or where major subsurface utilities are expected should be specified.

- o Preliminary plans and estimates for all necessary public and private utility line changes. All necessary master utility agreements will be completed before completion of preliminary design to allow for the effects of construction.

- o Preliminary right-of-way (R/W) drawings showing the extent of properties affected which will list property takings and easements required. A schedule of R/W acquisitions and approvals should be prepared in an effort to minimize construction delays.

6.2.2.4 Develop Station Criteria

Station design should include the development of alternative station concepts compatible with the various plan/profile alternatives developed under Way and Structures. Such studies should include alternative construction techniques. Selection of station types and construction methods should be based on cost, compatibility with adjacent construction, effect on schedule and design/construction impact on the community and environment.

The preliminary design drawings and specifications should be of sufficient scope to define all station functions and elements for both the public and ancillary spaces, including equipment and materials, as appropriate. The station design process should involve the following factors, and others as appropriate.

- Develop and recommend policies and obtain agency approval for such elements as toilet facilities, fare collection, security, concession spaces, vertical circulation, graphics, intermodal connections, hours of operation, standardization of layout and materials, attendants, etc.

- Develop system-wide architectural, planning and civil standards and criteria, including those for materials, noise control, signage and graphics, lighting, mechanical and electrical equipment, vertical circulation elements, and handicapped provisions. Investigate all station elements suitable for standardized design and construction.

- Utilizing patronage forecasts, operating plans, joint development potential and design constraints, determine required number of station entrances and exits, intermodal interface requirements, sizes of waiting areas and ancillary spaces, number of stairs, elevators and escalators, and ticketing facilities.

- Based on the selected way, plan and profile, determine specific station location and develop plans, sections and elevations. Determine location and space allocations of ancillary spaces appropriate for system operation and adaptable to future extensions if justified. Station layouts should provide minimum practical volume while incorporating efficient loading of trains and convenient patron usage. Develop functional parking garage layouts where required, using commercial standards and pricing guidelines where possible.

- Coordinate all station elements with those of way and structures and systems groups.

- Select the construction method for each station and determine how the method affects both the station design and surrounding area.

- o Determine if system-wide procurements for electrical and mechanical equipment components are practical and feasible.

- o Complete all utility surveys and agreements to a level that will allow station design and construction to advance without interruption.

- o Prepare preliminary maintenance procedures and estimate annual maintenance costs based on total number and skills of required station maintenance personnel.

- o Determine mitigating measures to minimize adverse community and environmental impacts.

- o Take all appropriate steps necessary for required station area design approvals.

6.2.2.5 Develop Yard and Shop Criteria

Preliminary design work requires the development of all yard functions and the establishment of yard layout criteria before investigating specific site locations. Design criteria should be developed to a level consistent with the PE effort. In establishing the criteria, the following should be determined:

- o General features of the transit vehicle to be used
- o Number of trains to be stored initially and in the future
- o Inspection and repair cycle
- o Maintenance functions to be performed and general procedures
- o Number of employees, crew quarters and parking facilities required
- o Requirements for special shop equipment
- o Material storage for the operating system
- o Wayside system maintenance facilities and revenue collection facility
- o Vehicle test facilities
- o Vehicle test track
- o Central control locations (if in yard, determine size, functions, etc.)
- o Location of training center (if in yard, determine size, functions, etc.)

In the development of yard and shop plans, details, and preliminary specifications, tasks should include the evaluation of all feasible alternative sites and a final selection of the optimum site. The results of PE should be a set of plans, specifications and estimates sufficiently detailed to provide reliable project costs and a method for obtaining required approvals. Alternative locations for outlying storage and maintenance yards should be evaluated based on their effect on operable segments and schedule, area requirements, operational characteristics, impact on community and environment, and the probability of acquiring the proposed site.

Using data developed in the planning stage, alternative layouts, R/W drawings, and cost estimates should be prepared and the optimum site selected, considering availability, costs, neighborhood compatibility, security problems and any other significant aspects. Yard plans should include storage track layout, related track facilities and major shop buildings, detailing both major functions and areas required. The need for future yard expansion should be considered.

6.2.2.6 Design Criteria for System Components

Design criteria for system components should be developed to a level consistent with the PE effort. This will require studies to select those systems and subsystems that are appropriate to this project. Alternative systems should be evaluated in terms of criteria which include:

- o Capital costs
- o Labor requirements; O&M costs
- o Safety, security
- o Reliability, availability, maintainability, dependability and safety
- o Complexity
- o Incremental growth
- o Probable public receptivity
- o Impact on environment

Selection of the optimum elements for the given project should lead to a set of preliminary plans and specifications sufficiently developed to produce project cost estimates. Project plans should be sufficiently detailed to enable the preparation of all approval documents and the processing of those approvals. The project schedule should include an estimate of the length of time required to perform both the Final Design and the Construction Phases for the particular elements and their overall phasing sequence into the project. Where applicable, a preliminary maintenance schedule and an estimate of annual labor-hours and costs should be prepared for the particular system. An estimate of start-up inventory costs for each subsystem should be included with the PE cost estimate, including pre-operative testing and start-up cost schedule, lead time required, and the assessment of spare parts required. A summary of the typical PE Phase outputs for each subsystem includes:

- o Function
- o Capacity
- o Configuration
- o Dimensions
- o Materials/equipment
- o Capital cost
- o O&M requirements and general procedures
- o O&M labor requirements
- o O&M cost
- o Schedule requirements
- o Expansion capabilities
- o Flexibility for future changes
- o Impact on reliability, availability, safety, etc. criteria
- o Preliminary plans and specifications
- o Supporting documentation -- general provisions, standards, etc.

The remainder of this section addresses specific design criteria development issues for typical subsystems.

Vehicles - The number of vehicles required is based upon patronage projections and schedule requirements. Vehicle performance requirements should be evaluated in order to assure that scheduled performance can be met. Each vehicle subsystem should be evaluated in terms of total vehicle compatibility, optimum reliability, maintainability and performance. The resulting vehicle should be similar to existing fleets of railcars so as not to create a totally unique vehicle.

Traction Power - Preliminary layouts of the power system which locate all major subsystems such as substations and tie breaker stations should be prepared. Substation size, spacing and equipment requirements should be evaluated considering:

- o Alternate voltage levels
- o Contact rail options
- o Back-up systems

The line voltage equipment type and sizes, traction and ancillary power usage split, and power delivery system should be determined. Alternative emergency power supply requirements should be evaluated. Local power utilities back-up requirements, procedures and problems involved should be examined. This should include investigating power sources, peak requirements, rate structure, reliability analysis, etc. Those system units which can be prepackaged in accordance with local union agreements should be determined and pre-purchase options, where applicable, should be recommended.

Ancillary Power (Electrical Distribution for Support Facilities) - Voltage, type of equipment, power source, equipment size and emergency/background requirements for the ancillary power system should be determined, along with appropriate room sizes that are required for the equipment.

Train Control - Alternate systems of train control including wayside, signal, cab signalling systems, central control and train supervision, should be studied and evaluated with consideration of the initial and life cycle costs and the long-term probabilities of state-of-the-art modifications and their effect on the system. The compatibility of various manufacturer's equipment in the same control system should be studied and evaluated to show advantages or disadvantages, and costs. The number of interlockings required and the location of major relay rooms and their size should be determined. Those systems which can be pre-packaged in accordance with local labor agreements should be determined.

Communications - Appropriate systems should be studied, evaluated and selected for:

- Telephone service
- Data transmission
- Public address system
- Security
- Fire detection
- Mobile radio
- Cable systems
- Security/anti-intrusion alarms

Applicable systems should be made compatible with the requirement of police and fire communications systems.

Ventilation - The various types of ventilation needed for the project should be determined. This may include:

- o Natural air system
- o Underplatform exhaust system
- o Mechanical ventilation, both normal and emergency
- o Air cooling system (if provided) for stations and/or offices

The Subway Environment Design Handbook [Ref. 16] should be utilized as a detailed source of guidance on the topic of subway ventilation.

Fare Collection - Alternative systems of fare collection and revenue control should be studied and evaluated, based on the existing agency fare structure and in consideration of future system expansion.

Trackwork - Fully mathematized horizontal and vertical centerline alignments should be developed during PE. The trackbed requirements to adhere to noise level and operational criteria developed under the system definition task should be determined. Track weight and gauge should be selected. Preliminary trackwork plans and profiles, typical sections and specifications, including yards should be prepared for the entire system.

Drainage - A layout of all drainage required for track structures, parking lots and major ancillary rooms should be prepared to show all major sumps and where drainage water will be discharged. The need for permits and approvals should be determined, including authorization to discharge waste water. The need for specialized equipment, such as oil separators, should also be determined.

Safety and Fire Protection - A system-wide Safety and Fire Protection Plan, which is consistent with all applicable local and state codes and which has standards that are comparable to the industry, should be prepared. Local and state approvals for proposed systems should be obtained, where necessary. The following systems should be included in the Safety and Fire Protection Plan:

- o Fire detection and protection system
- o Fire management and control plan

- o Passenger fire emergency egress plan
- o Passenger surveillance and security system
- o System security plan
- o Gas monitoring system
- o Passenger gas protection plan

Work Equipment - A work equipment acquisition schedule should be developed. This should include all specialized track equipment such as work trains, rail grinders, etc., and all major shop equipment and vehicles.

6.2.3 Value Engineering and Peer Review

In addition to regular design reviews, VE and Peer Review can be utilized to provide the owner with an independent critique of the decisions and outputs of PE. Peer Review is a commonly utilized technique, an excellent reference for which is available from the American Consulting Engineers Council [Ref. 17]. The following sections focus on UMTA's requirements for VE and Peer Review.

6.2.3.1 Peer Reviews for Bus Facilities

To ensure that bus facilities are effectively designed to enhance bus operations, a review of plans at the completion of PE will be conducted utilizing the expertise of transit operators ("Peers") who provide service under similar circumstances. Peer Review is a separate step in the design process that can add an external perspective to enhance the quality of design, construction and operation. This Peer Review process is required by UMTA for projects funded under the Section 3 discretionary program, and strongly recommended for bus facilities funded under other programs.

6.2.3.2 Definition and Requirements of Value Engineering

The concept of VE has been promoted in recent years by UMTA, sponsor of the study which resulted in Value Engineering Process Overview [Ref. 18] which includes the following definition:

> "Value Engineering (VE) is a systematic, multi-disciplined approach designed to optimize the value of each dollar spent. To accomplish this goal, a team of architects/engineers identifies, analyzes, and establishes a value for a function of an item or system. The objective of VE is to satisfy the required function at the lowest total costs (capital, operating and maintenance) over the life of a project consistent with the requirements of performability, reliability, and maintainability."

UMTA encourages the use of VE techniques on all construction projects and requires it on major capital projects which include new fixed guideway segments or extension of an existing fixed guideway, rehabilitation or modernization of existing fixed guideway pursuant to a full funding agreement, or other projects which the Administrator determines to be major.

6.2.3.3 Timing of Value Engineering Studies

The highest return on the VE effort can be expected when a VE workshop (or study) is performed early in the design process before major decisions have been completely incorporated into the design. VE on a project should be performed at or near the end of PE (30 percent of design).

For some large, complex projects, it may be advantageous to conduct two VE studies. The first VE study should be conducted at the 30 to 40 percent level with the second VE study conducted at the 60 to 75 percent level of completion. For smaller projects, a single VE study at the 30 to 40 percent level should be adequate.

6.2.3.4 The Value Engineering Study Team

The VE study should be performed during a week-long workshop by a multi-disciplined team of professionals specifically assembled for this purpose. Personnel can include electrical, mechanical, civil/structural and construction engineers, as well as specialists in architecture, cost, construction management and transit operations/maintenance. Most, if not all, of the participants should have a minimum of 40 hours of VE training, and experience in VE workshops, so that efficient use is made of the time allowed for the study.

6.2.3.5 The Value Engineering Study/Workshop

The VE workshop should consist of five phases summarized as follows:

- o Information Phase - Obtain project information including design drawings, specifications, cost estimates, design criteria, imposed constraints, site conditions, utilities available, utility rates, and operation and maintenance practices. Receive a presentation by the designers on the progress made to date and visit the site. Review and validate cost information, calculate life cycle costs and construct a cost model. Define the functions of the project; identify the cost and worth of each function; and determine areas of high cost and low worth.

- o Speculation (or Creative) Phase - Generate a list of alternative methods of performing the functions involved in the targeted areas of the design.

- o Analysis Phase - Evaluate each of the generated ideas against both functional and cost-reduction requirements, as well as for its feasibility and potential for acceptance by the owner. The less promising alternatives are screened out leaving a small number to develop into full-pledged proposals.

- o Development Phase - Develop a revised design for each proposed change. After a sketch is drawn up, calculate the life cycle costs for both the original and proposed design, and list the advantages and disadvantages. Consultations can be held with owner and design firm personnel to ensure that the proposed changes are based on the best information available.

- o Presentation Phase - At the end of the workshop, the VE team meets with designated members of the owner's staff and design consultants to present the design and cost details of the recommended alternatives. Written copies of all proposals are furnished for preliminary review by the owner and its consultants.

Within two weeks, the VE consultant submits a draft VE Study Report to the owner. This report should include the project background and description, the scope and methodology of the analyses, a summary of the VE study recommendations, details of each proposal with estimated costs, expected savings, and back-up documentation.

After final decisions have been made by the review board on adoptions and rejection of the various proposals, the final VE report is prepared. The Final Report should include a summary of accepted proposals with revised capital and implementation costs, as well as a list of rejected proposals and the reasons for rejections.

6.2.4 Other Project Development Requirements

6.2.4.1 Prepare Final Environmental Impact Statement (FEIS)

Where required, a DEIS should have been completed during the Project Planning Phase in accordance with UMTA EIS and related procedures. The FEIS should be completed during PE. This step should complete the EIS process for the project and document site-specific information developed during PE. The FEIS should compare the proposed project with the no-build alternative, and any other major alternatives which were considered during the PE effort and will be processed in the same manner of the DEIS. Section 4 (f) of the Department of Transportation Act of 1966 and Section 106 of the National Historic Preservation act of 1966 should also be complied with in the EIS. The following work is part of this process:

- o Coordinate with UMTA environmental specialists to develop and carry out the scoping process which is outlined in Section 1501.7 of the CEQ Regulations.
- o Develop a work program showing how the environmental process will proceed concurrent with PE to ensure that the FEIS will complete circulation concurrent with completion of PE.
- o Ensure that the environmental process will accommodate the possibility of temporary terminus points which are consistent with identified operable segment temporary termini.
- o Other tasks, surveys and studies, as required.

In special cases, a Supplemental DEIS will be required during PE if the DEIS did not contain sufficient detail to allow public comment on site-specific environmental impacts or if a lengthy enough period ensued between the draft and final to make it prudent to reevaluate the proposed project's environmental impacts.

6.2.5 Real Estate Acquisition and Management

A real estate acquisition and management program should be developed. The program should include:

- o Required permanent and temporary interests in real estate and their purpose in relation to the project.
- o Required utility and railroad easements and re-arrangement agreements.
- o Procedures for acquisition, development, and disposal of real estate, including cost scheduling and funding.
- o Procedures for property management.

A system for executing the program which includes policies and procedures for accomplishing such functions as legal certification, property management, relocation assistance for displaced people, and funding of activities to meet project requirements, should be developed.

6.3 FINANCIAL REQUIREMENTS AND RESOURCES

6.3.1 Financial Requirements - Cost Estimates

As part of the design criteria development/preliminary design effort, capital and O&M costs should be calculated and utilized in trade-off analyses.

6.3.1.1 Capital Cost

A project's estimated capital cost is the total cost of final design, real estate acquisition, construction, project management, inspection, testing and start-up, and all other expenditures, both contracted and force account, required to prepare a project for revenue operations.

All cost estimates should be sufficiently detailed to provide order-of-magnitude reliable project costs and should be arranged to allow aggregating in varying combinations for comparative purposes. They should be prepared by construction estimators, where possible, and by contractor type when labor hours, labor category, material costs and all indirect costs can be determined.

The project cost estimate should be prepared in sufficient detail to permit the designation of viable funding sources, e.g., Federal, state, local and private sector, together with anticipated percentage contribution. Minimally, cost estimates are to be provided for the following categories:

- Purchase/install support equipment
- Real estate acquisition
- Professional services
- Demolition of structures
- Construction of facilities/structures
- Construction on R/W
- Vehicles
- Force account services
- Inflation
- Contingencies

The amount added for contingencies is a function of the reliability of the design and cost estimate given the PE level of detail. The percentage for contingency should be high at this stage and become lower as the project evolves towards construction.

6.3.1.2 Operating and Maintenance Cost

Initial estimates of O&M costs for a transit capital improvement developed in the Project Planning Phase should be updated, based on the operating plans and designs formulated in the PE Phase.

6.3.2 Financial Resources - Funding and Revenue Sources

Based on the capital and O&M cost estimates of the PE Phase, the financial plan developed during Project Planning should be assessed for its ability to meet the new funding requirements, if they are higher. If the financial resources are inadequate, additional sources should be identified.

A firm and legal commitment of the funding from respective governmental and private sources should be obtained. UMTA's participation in the "Fully Funded" contract concept designates the grantee fully responsible for non-Federal funding, and all project cost overruns, except as specifically defined.

6.4 MANAGEMENT CONTROL SYSTEMS

Management control for any project consists of the following four basic elements:

- Scope
- Quality
- Cost
- Schedule

All are variables, and if one element is changed in some way, the others are affected. It is, therefore, essential that the initial assumptions (baselines) be identified and controlled.

6.4.1 Work Breakdown Structure

A WBS should be prepared to serve as the basis on which work is divided into work packages that are manageable. A WBS typically is prepared in a hierarchical or multitiered fashion with the lower tiers being defined during design and project execution. However, the WBS should be developed to best suit project management purposes, not those of the control or information system specialties. The WBS should be used as basis for technical, cost, and schedule control; therefore, the packages of the WBS and their assigned costs and schedules must be entirely consistent with the overall physical and functional project description, cost estimate, and schedule.

The use of logic or network diagrams can be a valuable tool in developing the management plan. This tool, which can graphically display the intent of the plan, can highlight critical areas that must be dealt with (e.g., critical decisions, potential conflicts, and restraints). Simple activity-oriented network diagrams (using the major work packages) can define the project scope and reflect the interdependencies among various design, procurement and construction activities, the phases of work, and the impact of external organizations and activities. The network diagrams should reflect all facets of the project from authorization to operation of the facility or system.

6.4.2 Configuration Control

6.4.2.1 Technical Baseline

Responsibility should be assigned for providing clear design criteria and required quality and other standards to those performing design and for coordinating individual design packages with system-wide design. The authority to make changes or waive requirements should also be identified.

6.4.2.2 Review and Approval Process

A schedule should be established, and responsibility assigned, for providing and coordinating a series of reviews during the PE Phase. Reviews should include designers, owners, consultants, and operational construction management staff who will ensure that project objectives are met. As a minimum, the following submittals/reviews should be made.

- In-Progress Preliminary Submittal - This PE submittal is intended to allow an organizational review of the recommended approach, including evaluation of the rejected alternatives. As such, all factors affecting the recommendation must be addressed in the plans and/or design report.

  Major utility conflicts (i.e., any conflict influencing project location or having cost and/or schedule impact) must be identified. Affected parties, including utility owners, railroads, government agencies and private owners, should be listed. Deviations from the conceptual plans should be justified. Attempts to ameliorate impacts discussed in the DEIS must be stated and physical constraints on the project location should be identified. Economic comparison of discarded alternatives should be made.

- Preliminary Design Submittal - This submittal marks the division between preliminary and detailed design. As such, it should:

  - Define the impact of construction on all affected parties including utilities, railroads, governmental agencies, commercial properties, and residential areas. This should include an assessment of the effect of project labor requirements and construction work schedules on other construction work in the area.

  - Serve as a permanent record of design development and reflect the basic concurrence of all parties.

  - Define the scope of work for detailed design of the project.

  - Provide a satisfactory basis for a realistic estimate of the cost of construction, which will serve as a budget.

  - Establish the project scope, or limits, with respect to R/W.

  Separate requirements should be established for the submittals of the various disciplines (e.g., civil, structural, electrical, mechanical, and architectural design). The design report is part of the documentation of PE and as such should address and record the justification for, and analysis of, design requirements. An estimate of the cost of construction must also be prepared and submitted.

6.4.2.3 Control of Design Changes

During the PE Phase of a project, design criteria should be developed sufficiently to permit the design of basic project elements to be firmly established for the final design. Deviations from the design criteria should be made only for compelling reasons, not for expedience. Criteria changes made while the final design is being prepared generally result in extensive revisions to final design drawings and in configuration problems with permanent equipment on order. Such changes result in duplication of previous engineering efforts, which tends to create delays, extra costs, and inefficiency.

During the Construction Phase, revisions of the design, or even redesign, may be necessary to accommodate unanticipated site conditions, accepted VE proposals, final manufacturer's drawings, errors, and other factors. Procedures should be developed for solving design and field problems as they may occur during construction. These procedures should be clearly designed to achieve results rapidly.

6.4.3 Quality Assurance Program

The QA program for PE is encompassed in the Configuration Control Process presented in Section 6.4.2. The submittal and review meetings at various stages of PE and change control procedures ensure that project requirements will be met before continuing with subsequent tasks. Additional guidance on QA in the design process is available in the ASCE publication, Quality in the Constructed Project [Ref. 19].

6.4.4 Schedule Control

6.4.4.1 Schedule Baseline

Responsibility should be assigned for developing baseline schedules for the managers of work packages and for maintaining those baselines consistent with the technical, cost, and overall schedule baselines. Authority to revise the baselines should be identified.

6.4.4.2 Performance Measurement

A system should be provided for comparing actual work performed with the scheduled work, and for analyzing any variances that occur.

6.4.4.3 Use of Critical Path Method

The CPM is a method of planning, scheduling, replanning, rescheduling, and progress evaluation that facilitates the performance of the project team for planning, design, and construction. A full CPM program involves network diagrams and supporting data. For most PE efforts, only a simplified CPM will be required.

A network diagram serves as a visual presentation of the sequence of activities needed to fulfill project requirements. As such, it should:

- o Show graphically, in logical sequence, each of the activities necessary to complete the project or project phase.
- o Identify the starting point, duration, and ending point of each activity.
- o Show all interfaces, i.e., interdependencies and relationships with operations of other consultants, contractors, and suppliers and subnetwork diagrams. The CPM program further involves any modifications required by changes and the updating of network diagrams and supporting data to report actual progress and current status of the project. Consultants and contractors should indicate on the network diagrams interim fixed starting or completion dates for portions of the contract.

The supporting data for a network diagram should consist of a computer print-out or an equivalent listing that provides the following information for each activity:

- o Starting and ending node numbers
- o Duration
- o Description
- o Early start and late start dates
- o Early finish and late finish dates
- o Total float time

Because CPM can be resource loaded to control labor and cash flow requirements, it is a strong management tool. The reports generated as part of the CPM program should be reviewed continuously and used as working tools by the consultants and contractors. The consultants and contractors should furnish any information requested by the owner which reflects evaluation of the performance under the contract (including but not limited to manpower loading charts and schedules).

6.4.5 Cost Control

6.4.5.1 Cost Baseline

Responsibility should be assigned for developing a baseline cost budget in accordance with the WBS discussed in Section 6.4.1. The baseline cost budget must also be consistent with overall costs and the project schedule. The group or individual with authority to revise the baseline costs must be clearly identified.

6.4.5.2 Cost Accounting System

A cost accounting system that provides an orderly tracking system for all project costs should be adopted/defined. This will provide an uninterrupted financial management system for the entire design phase which can be expanded to accommodate subsequent phases. Standardized reporting by baseline cost elements should be performed for meaningful budget analysis.

6.4.5.3 Performance Measurement

A system should be provided for comparing the actual costs to the planned costs of elements of work and for analyzing any variances from the planned costs that may occur.

6.4.5.4 Cost Forecast and Estimate Reviews

A system should be provided for routinely forecasting the expected costs of work packages at completion and of the total project. In addition to routine cost forecasting, as the preliminary design develops, provision should be made for periodic reviews and updates (conducted from an overall management perspective and preferably on a quarterly or semiannual basis) of the system-wide estimate. Elements of the project cost estimate should be subject to varying degrees of re-estimation, depending on the status of project development, changes in previously predicted economic conditions, unfavorable experience in contract awards, or refinement of quantities. Project management should determine the degree to which re-estimation is to be performed, recognizing the cost and the extent to which it will interfere with on-going performance.

6.4.5.5 Contingency Management

A system should be provided for determining and distributing contingency funds to provide for cost escalation caused by such factors as inflation, changed conditions, design revision, and estimating errors. The contingency allowances can be held at the project level or can be distributed to lower levels of management in the WBS.

6.4.5.6 Force Account Plan

The use of force account, or in-house personnel, should be clearly identified and incorporated into the respective phases of the improvement project. Typically, there is a major coordination role by agency/owner staff to interface with the state, city and county agencies affected by the project.

6.4.6 Computer-Based Tools and Techniques

There are many ways in which computers and related software programs can assist designers in the PE phase. Computer programs are available for the various project management tasks, including cost control, scheduling, cost estimates and project administration.

Computer-aided design (CAD) and companion software permits planning, cost estimation, cost allocation and maintenance planning. A CAD system maintains a database of standard elements that can be easily incorporated into a design. Summary and detailed lists of equipment and material quantities can be rapidly produced for alternative design combinations.

6.5 PROCUREMENT, CONTRACTS, DISPUTES AND CLAIMS

6.5.1 Procurement of Design Consultant

Selection of the design consultant is an important function during the predesign phase. The designer with the highest capability should be selected within the constraints imposed by the size and type of work, location, and goals set for the program. A generally acceptable procedure for selection includes a selection board which would:

- Investigate the capability and rate design organizations expressing interest
- Arrive at a short list of capable firms using consistent rating criteria
- Conduct interviews of short-listed firms
- Rank the uppermost firms (at least three)
- Provide a recommendation to management on the preferred firm

6.5.2 Contract Scope of Work

When a project is to be released for design, the scope, criteria, and requirements should have been outlined in some detail. Reviews necessary to ensure budget and cost compatibility should also have been further validated. The next step is to expand this list of criteria in further detail, as necessary, in preparation for structuring the scope of contract work for the project. This refinement process serves two purposes: it reveals further detail of the design program, and it may uncover program problems not previously resolved. At this stage, the process prior to design start is one of review, feedback, resolution, and decision. If this logical iteration is not continuous prior to award of a design contract, then the design phase could continually require decisions to be made that add expense to the project in the form of lost design time and additional cost escalation.

The importance of formulating a definitive scope of work for the designer cannot be overemphasized. The designer selected for a given project must understand, in precise and clear terms, the results expected. If this step in the predesign phase is not carefully and thoroughly considered and coordinated, the following design development phase cannot succeed.

The essential elements of the scope of work should be prepared by the design management team, using inputs from the involved technical and program disciplines. The quality of the design work performed by the designer will be in direct proportion to the quality of the contents of the design scope of work.

6.5.3 Dispute Avoidance/Resolution

Responsibility should be assigned and procedures clearly defined for resolving disputes in a timely manner. Disputes generally should be resolved at the lowest administrative level possible. Among the dispute resolution procedures to be considered are litigation, mediation, arbitration, an independent board of consultants, and a contract board of appeals. Clearly, the best way to deal with disputes is avoiding them by mitigating the causal conditions. This can best be accomplished by a sound procurement process and a well-written/managed contract.

6.6 SAFETY, RISK MANAGEMENT AND INSURANCE

6.6.1 Safety Programs

A safety program should be established to prevent accidents and protect employees, property and the general public. Policies and procedures should be developed in compliance with Federal, state, and local safety and health regulations and standards, and specific contract and client obligations and facility requirements for safety, first aid, and medical attention should be identified clearly. A safety program should encompass both operational safety of the proposed project and implementation (construction) safety.

6.1.1.1 Design Phase Safety

For projects related to an operating transit system, the safety of design support personnel performing surveys, geologic explorations, etc., must be considered and adequately assured.

6.6.1.2 System Operational Safety

System operational safety should be addressed by the development of a comprehensive system safety program plan early in the project development process which would guide operational planning and design of major subsystems, discussed in Section 6.2.2.

6.6.1.3 Construction Safety

Responsibility and authority should be assigned for executing a program to provide a safe work environment during construction. A system should be developed to provide for:

- o Review and approval of enforcement procedures
- o Safety orientation and training
- o Reporting, investigating, and recordkeeping
- o Environmental monitoring to detect and control hazardous conditions
- o Proper documentation of all tests

For projects involving modifications to existing transit systems, special attention must be given to the safety of employees and the riding public, in addition to construction personnel.

6.6.2 Risk Management

Too often the sequential approach in Project Planning does not provide for sufficiently early consideration of risk management. Hence, the insurance industry's contribution to the project's early stages is lost even though most large projects have a large volume and variety of risks (hazards). Every risk should be identified and its full consequences assessed before plans are finalized in order to reduce the chance of some being overlooked and, even more importantly, to permit residual risks (those risks identified but neither avoidable, controllable, nor insurable) to be quantified.

A team of the owner's staff members or consultants must be formed early to provide a multidisciplinary overview of the project and its elements and to determine how risks affect the technical, legal, institutional and financial segments of the project from beginning to completion. Risk control -- prevention of the happening or insurance with a risk taker -- involves an economic decision that should be given high priority in Project Planning. It must be remembered that risk problems are not solved only by insuring. If the risk is unclear, the insurance may be worthless or costly in relation to the benefit.

6.6.3 Insurance Protection

Basically, two major approaches to arranging an insurance program to cover major construction projects exist -- the so-called conventional approach and the coordinated approach. Both are fully described in Section 3.6.3.3.

6.7 COMMUNICATIONS

A comprehensive external communications program is essential to impart, in varying degrees of detail, information concerning the objectives, benefits, impacts, design, cost and schedule of the transit project to the agencies, officials, organizations and citizens affected by the project. With proper attention to communication, a project can maintain and develop support. During PE, it is important to create a forum to receive the input of the various groups which may oppose the project. Misinformation can be overcome by providing appropriate information on the project's benefits and by making modifications to plans and designs to overcome community concerns.

Attention must also be given to internal project team communications to meet project objectives.

CHAPTER 7

FINAL DESIGN

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CHAPTER 7
FINAL DESIGN

The Final Design Phase is the last project development phase prior to construction. During this phase, the design consultant and/or in-house design staff prepares the plans, specifications and bid documents required for awarding the individual facility construction and equipment fabrication/installation contracts. As a supplement to the management principles presented in Chapter 3 and a continuation of the approach described in Chapter 6 for PE, Chapter 7 contains project management guidelines specifically related to the Final Design Phase of a transit capital project.

7.1 LEGAL AUTHORITY, ORGANIZATION AND STAFFING

7.1.1 Legal Authority

The owner has overall responsibility for designing and constructing the transit capital improvement project, and as such, should be a public body duly authorized by the appropriate governmental unit to administer and finance the transit improvement. Since this is a mandatory requirement prior to the commitment of any Federal funding, this authority must be legally established and fully operational prior to the Final Design Phase.

7.1.2 Management and Organization

The overall project management and organization should have been established in the previous phases. At the beginning of the Final Design Phase, the organizational structure for the design component should be reassessed to ensure its validity.

A proven method of ensuring effective management of a transit capital development project is appointment of a design or project management team. The management team leader and the members may be permanently assigned to a separate operating entity (project office), or team members could be assigned on either a permanent on temporary capacity. A formal management structure should be employed, even if it includes only a team manager for a small project within a program. At the time the management team is established, the first order of business should be defining roles and responsibilities of each team member. Attention to the interrelationships of the management team members can often avoid later interface problems that could occur throughout the project's life.

7.1.2.1 Project Manager

The designated project manager provides the leadership for the management team. The project manager should be selected on the basis of his/her organizational ability, and experience with projects of similar size and scope. Regardless of project scale, the line of authority for decision-making should be direct and unencumbered by organizational formality.

The selection of the project manager should be made with careful consideration of individual experience and general technical knowledge. The ability to make sound decisions, lead meetings, motivate people, and think clearly under stress are as important as technical qualifications when selecting a design management team leader.

7.1.2.2 Other Team Members

Other team members should be selected from appropriate technical and program backgrounds commensurate with the type of project being developed. In addition to the technical complement of the team, appropriate qualified persons from budgeting, cost estimating, and contracting disciplines should be appointed. Those members selected from program and administrative support areas should also have direct channels to the decision authority.

7.1.2.3 Responsibilities

The project manager assigned by the grantee should be accountable for all functions and should have full responsibility to complete the project on schedule, within budget, and in accordance with policies and procedures of UMTA and the transit authority.

The manager of design should be responsible for all design phases. For major transit improvement projects, general design consultants typically are retained at project inception to provide services throughout the various design phases. During Final Design, when multiple construction contract bid packages are being prepared simultaneously, subcontracts may be awarded to other firms to ensure the completion of specific designs in accordance with the overall project schedule. The total design effort may include the use of in-house transit agency design staff for specific aspects.

7.1.3 Human Resources and Labor Relations

The human resources and labor relations policy established during PE should be reviewed and updated as required to reflect current and projected conditions. Current and proposed Federal, state and local labor regulations and labor legislation that could impact the project should receive attention. Examples of potentially sensitive legislation include right-to-work laws, common situs picketing, Labor Peace Act amendments, Taft-Hartley Act amendments, prevailing wage laws and amendments to wage and hour laws.

7.1.4 Interagency Agreements, Approvals and Permits

The need for interagency agreements and approvals should be continually monitored and should be fully integrated into the Final Design Phase work in preparation for commencement of construction. The master utility agreements developed during PE should be refined into detailed agreements for each contract/section which should indicate provisions for the following:

- Detailed design for specific relocation/rearrangement
- Schedule
- Cost, salvage, betterment
- Conditions of performance
- Payment for services
- Work orders (direction to proceed)

7.2 SYSTEM DEFINITION/CONFIGURATION/PERFORMANCE

7.2.1 System Configuration and Scope

The purpose of the Final Design Phase is to prepare final drawings, technical specifications, and contract documents required to obtain construction contract bids. The quality of these drawings, specifications, and contract terms has a pervasive influence on contract bids. The owner should strive to place construction contractors in the best possible position to submit realistic bids by providing or considering the following:

- Clear assignment of risks to the party which is best able to control it
- Disclosing all engineering and geotechnical information gathered
- Providing for contract adjustments for differing site condition
- Clearly identifying contract obligations of both owner and contractor
- Clearly defining avenues for contract adjustment for delays resulting from action, lack of action, or delayed action

The following items should be included within the scope of Final Design in support of efforts to refine the project's definition:

- Designation of organizational responsibilities
- Work breakdown structure
- Required design documentation
- Definition of system interfaces
- Value engineering procedures
- Reliability and maintainability
- Interface of maintenance and operations
- Design review schedule

7.2.2 System Performance

System performance requirements should have been established in previous phases. As individual elements are being designed, specific performance characteristics should be verified to ensure adherence to overall performance requirements.

7.2.3 Value Engineering and Peer Review

In addition to scheduled design reviews, VE and Peer Review can be utilized to provide independent critique of the products of Final Design. The focus of VE, however, should be in the PE Phase when the benefits tend to be the greatest. Peer Review may be an appropriate vehicle for specialized independent input to the owner on issues which present unique problems or where an outside critique is desired.

7.2.4 Real Estate Acquisition and Management

The real estate acquisition and management plan established in PE should be reviewed and updated to reflect the Final Design plans and specifications. Where realignment or change in plat plans which affect the real estate have occurred, the acquisition plan and schedule must be updated.

All real estate necessary for the construction work must be acquired in accordance with the construction schedule, preferably before contract award. This also includes the leasing of land required for site access and contractor facilities. Delays in acquiring necessary real estate may force construction activities to "work around" unacquired parcels in order to maintain the project schedule. There is also the risk that a contractor make a claim for additional costs due to a delay in real estate availability.

7.3 FINANCIAL REQUIREMENTS AND RESOURCES

7.3.1 Financial Requirements

7.3.1.1 Construction Costs

Construction cost estimates are prepared by the responsible design consultant or in-house design team at preliminary (30-40%), intermediate (60-85%) and pre-final (90-95%) stages, depending on the project type, and at design completion. Detailed cost estimates are reviewed with the project manager/project engineer to arrive at a construction cost that represents the design scope of work. If this cost exceeds the project budget, it must be determined if the scope of work is to be decreased or the budget amount increased. These reviews and determinations must be made in a timely manner to avoid design delays.

Construction cost indices are also useful in estimating costs. Two national sources for cost indices are Engineering News Record and F.W. Dodge Reports, both of which are published by McGraw-Hill, Inc. Local cost data are typically published by various construction groups. State agencies and associations publish unit cost data for various construction items. These data are beneficial because local labor rates for various crafts are used, together with labor availability in the area.

7.3.1.2 Operating and Maintenance Costs

Previous O&M cost estimates should be continually updated to reflect Final Design plans and specifications. They must fully consider facility components, maintainability, equipment operations and all costs related to O&M after construction and acceptance by the owner.

7.3.2 Financial Resources

Financial resources will have been identified in preceding phases, but at this point, must be compared against the latest cost estimates. During Final Design these resources must be fully committed to provide the revenues required for construction.

UMTA and the owner will negotiate a construction grant contract. A full-funding contract, with a fixed limit on Federal funds, which includes an adjustment for inflation, may be required by UMTA. The full-funding contract will also include a schedule for receipt of the Federal funds during the construction period. It must be recognized that the Federal funding contract will be subject to budget authorizations and successful construction progress. Any state, local and private sector revenue sources also must be legally committed with scheduled contributions during this phase. Only after these commitments are finalized can the project proceed to construction.

7.4 MANAGEMENT CONTROL SYSTEMS

7.4.1 Work Breakdown Structure

A critical element in controlling the design process is to define the items to be controlled in terms of a WBS, whereby the work tasks to be performed are grouped as work packages. The WBS is used to manage and control the technical, cost and schedule components.

7.4.2 Configuration Control

7.4.2.1 Technical Baseline

The technical baseline for Final Design evolves from the baseline produced during PE and is expanded as the Final Design is developed and documented. This occurs through a series of in-progress design reviews.

7.4.2.2 Review and Approval Process

Design review is a precise component of the entire management process, and should be recognized as such and time-phased into the total design management network. The smooth functioning of the design review process and the actual design depends on individual design reviewers' attitudes, communications between disciplines, knowledge of project interfaces, and the skill of the project engineer in establishing the design review objectives. Fundamental to design review and establishing design review checklists are the following basic principles toward ensuring:

- Quality of the design
- Operational and functional objectives are met
- Maintenance of costs within the budget
- Design is biddable, constructible and cost-effective
- Interface compatibility
- Final construction contract documents comply with the design criteria
- A detailed, unbiased, analytical approach is given to all of the above items and is not:

- An argument over designer's choice

- A requirement for the consultant to design more than is specified in the scope of work

- A design competition for iterating an infinite number of schemes until every conceivable design solution is exhausted

The design management networks should contain the planned schedules for completion and review submissions at the specified levels of design for both consultant and in-house design. This design schedule should be discussed during negotiations between the design consultant and the grantee, and should be included in the consultant's contract. All design management personnel having review responsibility should be aware of the finalized schedule. Design management should be procedural, with decisions being needed only in technical interpretations, for minor adjustments in scheduling, and for setting priorities for design packaging, from this point through final acceptance of drawings and specifications. Major decisions involving programmatic issues, scope, and budget should be made in the timeframe appropriate to those decisions.

Three major categories of design review occur in the Final Design Phase. These are typically referred to as 30-percent review, 60-percent review and 90-percent review, although the exact percent complete could vary depending on the nature of the project. The final verification and delivery follow the 90-percent review. The scope of these reviews is presented as follows:

o <u>30-Percent Review</u> - This initial review is to demonstrate that the approach to all major design concepts and features has been resolved and the final design can continue without delay. Outline specifications and a preliminary cost estimate should be prepared by the design group. If an incompatibility with the budget exists and cannot be solved by application of VE, then packaging by the priority lists, if any, established in the predesign phase should be applied. The cost estimate should also be checked against that established for the initial design contract to determine if the original number should be revised or a design-to-cost problem is apparent.

o <u>60-Percent Review</u> - The purpose of the intermediate review is to ensure that all major features of design are progressing in accordance with prior direction, major engineering decisions have been made, most drawings, preliminary specifications and other documents are well advanced. The cost estimate should be checked against the design-to-cost figure established for the project and any cost problems resolved before proceeding to the next stage.

- 90-Percent Review - The drawings and specifications are to be completed and checked when submitted for review at this design level. Only incorporation of comments arising from this review, plus sign-off and approval, should be required to complete the documents. A very extensive review is, therefore, required at this level since it is the last design review. The cost estimate should also be verified against the design-to-cost figure established for this project.

- Final Verification - After delivery of all completed, signed, original documents and prints of each, those making review comments verify or backcheck that previous comments have been satisfactorily resolved, cost estimates and budget are in line, and organizational or individual approvals can be given. Final delivery and acceptance of the completed documents is not to be considered as an opportunity for conducting another design review. Further review comments at this point should be construed as a failure on the part of the reviewer to conduct a proper review with the 90-percent submission.

  Also, further comments that do not pertain to the 90-percent review should not be considered unless the design is in error because of an unsafe condition, nonconstructibility of work as shown, or new work that was not previously shown. Comments made on this submission must be carefully evaluated by the reviewer and the project engineer to gauge their necessity.

7.4.2.3 Procedures for Design Review

Design reviews involve a formalized, structured approach to ensure the reviews are comprehensive, objective, professional and properly documented. Design review schedules must be maintained in order to meet established construction start dates and other program milestones. The basic steps to guide these reviews are presented as follows:

- Presubmission Review - Before detailed reviews of design submissions are conducted, a presubmission or onboard review of the Final Design documents should be performed to determine if the submission is likely to meet the terms of the design scope of work and to consider comments from any prior review. If the documentation for the scheduled submission is incomplete or does not represent what is requested for the coming submission, the project engineer should advise the engineering manager of the schedule impact and recommend appropriate action. The project engineer should then advise the design consultant of the submission discrepancies and indicate that corrective action be taken to maintain the design schedule.

- Review Process - A distribution list should be prepared and used for providing copies of drawings and specifications for agency and consultant reviews at the 30-, 60-, and 90-percent levels. Figure 7-1 portrays a typical distribution list. The project engineer, should conduct an audit against the contract scope of work. The scopes of work for a design project should specify the documents, drawings and specifications that are to be submitted at each design review level.

- Review of Drawings - Design reviews should strive to ensure that the transit agency concepts and criteria are followed and should evaluate the adequacy of the design and drafting for completion, clarity, economy, and format. Reviews should also determine whether the interfaces with adjacent and overlapping projects have been resolved. Reviews should not be a forum for arguing the designers' choice. Although there is more than one way to develop a design, the review should address only whether the design is complete, constructible, cost-effective, and in compliance with established standards and variances granted to the design consultant.

- Review of Specifications - Copies of the specifications should be transmitted through the task leaders to the reviewers for technical review and comment.

- Summarize Review Comments - The comments developed during a review of drawings, specifications, cost estimates, calculations, survey notes, and related items should be transmitted to the project engineer for summarization, review, and action.

- Review Meeting - The purpose of the review meeting is to examine the pertinent review comments with the design consultant to ensure that the design's shortcomings are understood, the necessary transit agency inputs are provided, and the contract documents can be satisfactorily revised and advanced to a conclusion. The review meetings should be chaired by the project engineer and attended by the contract administrator, representatives of the tasks who provided review comments, systems planning personnel, UMTA (or its PMO representative), and the consultant's designers representing the appropriate disciplines. Important to a project's ultimate success is the involvement of those grantee departments which will have responsibility for the construction and O&M phases. Comments should be summarized by the project engineer and transmitted to the design consultant immediately after they are summarized.

7.4.3 Quality Assurance Program

The quality assurance program for Final Design is incorporated into the design production and review process described in Chapter 7.4.2.2. The following elements should comprise the program.

FIGURE 7-1. TYPICAL 30-, 60-, AND 90- PERCENT DESIGN SUBMISSION DISTRIBUTION

Submission	Sect. Imp.		Bridges		Service Facilities		ET		C&S		Stations		Notes
Organization	Dwg.	Spec.	Dwg.	Spec.	Dwg.	Spec.	Dwg.	Spec.	Dwg.	Spec.	Dwg.	Spec.	
Engineering		1		1		1		1					Specs to be shared within engineering
Civil - alignment, trackwork, and fencing	1	1	1		1		1		1(c)	1(c)	1(e)		
- Utilities, drainage, soils, corrosion	1		1	1	1		1		1(c)	1(c)	1(e)		(c) Partial from sepia; specs as determined by project engineer
Bridges	1		2	1							1(e)		
Tunnels													(e) Partial prints as determined by project engineer
Service facilities					1	1							
Communications and signals	1		1				1		2	2	1(e)		
Electrification	2		2		1		2	1	1(c)	1(c)	1(e)		
Stations										3	3		
Construction Management	3	3	3	3	3	3	3	3	3(c)(d)	3(c)(d)	3	3	Two to RCM; one to ACM
Systems Assurance	1	1	1	1	1	1	1	1	1(d)(e)	1(d)	1	1	(d) At 90% only
Cost Estimating	1	1	1	1	1	1	1	1	1(c)	1	1	1	
Document Control	1		1		1		1		1	1(f)			Sepia copy; (f) Prints only
Specifications	1	1	1	1	1	1	1	1	1(c)	1	1	1	
Project Engineer	1	1	1	1	1	1	1	1	1	1	1(g)	1	(g) Sepia copy
DCP Philadelphia	2	2	2	2	2	2	2	2	2(c)	2(c)	3	2	
Environmental	1	1	1	1	1	1	1	1	3(c)		1	1	
Contract Administrator	1	1	1	1	1	1	1	1	1	1	1	1	At 90% only
Systems Planning	1		1	1	1		1				1		
Agency Coordination			1	1	1						1		
FRA (a)	4	2	1(h)	1(h)	4	2	2	2	2	2	4	2	(a) One additional copy of drawings and specs directly to cognizant CO at 90%
FRA Minority Business Office	1	1	1	1	1	1	1	1			1	1	(h) One additional copy for legal review at 90%
Amtrak	4	2	2(b)	2(b)	4	2	4	2	2	2	4	2	(b) Copy to Conrail and CDOT when appropriate
Total Copies 30/60%	26	17	23	19	25	17	23	17	17	14	29	18	
Total Copies 90%	28	19	26	22	28	20	26	20	23	19	31	20	

- o In-progress Submittal - This submittal is intended to provide a clear indication of progress toward detailed design solutions for in earlier submittals. It can also provide a means for the detailed coordination of requirements by others. Areas which should be considered are civil design, right-of-way, structural design, and mechanical and electrical design and other disciplines.

  Deviations from the PE report and the justification for such deviations should be addressed in the transmittal letter for the submittal. An indexed set of all the calculations also should be submitted.

  With respect to the specifications, this submittal is intended to provide the complete framework for development of the contract documents. Format and layout of the specifications should be coordinated prior to submittal of the bid items to be added later. Specifications for items such as concrete, earthwork, and signalization should be developed in detail.

- o Prefinal Submittal - This submittal provides the owner, design consultants and all agencies with the opportunity to review the proposed construction; to serve as a basis for obtaining concurrence from city, county, state, Federal, private utility, and other officials; and to provide a basis for an estimate of construction cost.

  The design, including all disciplines, would be complete and essentially checked. The plans should show all details necessary for construction and must be coordinated among the various disciplines prior to submittal. Detailed checking by the designer could proceed during the prefinal review period.

  During the interval between in-progress and prefinal submittals, the following should be accomplished:

  - Resolution of all previous comments with solutions incorporated in the plans and specifications.

  - Concurrence obtained at the technical level with solutions developed for individual conflicts.

  - Drawings of the contract plans that involve rearrangements of owner facilities completely checked, signed, and sealed.

  - A complete drainage report coordinated and submitted with the plans and specifications.

  The final draft of the design report should be submitted and the specifications book should be complete with the exception of "boiler plate" to be added prior to printing. The complete estimate of construction cost should be submitted.

- o Final Submittal - This submittal is intended to provide proof of completion of design including incorporation of prefinal review comments. The drawings should be checked, signed, and sealed by the designer.

Prints of this submittal should be used to obtain concurrence to advertise for bids.

- o <u>Bid Documents</u> - The original tracings and specifications should be submitted. The submittal should be collated and ready for printing.

7.4.4 <u>Schedule Control</u>

Schedule control of work during the design phase should be implemented and could consist of the following.

7.4.4.1 Schedule Baseline

The Final Design baseline schedule should include all work breakdown tasks in terms of labor resources and time requirements, and should be referenced to input from preceding tasks and to scheduled in-progress design reviews.

7.4.4.2 Performance Measurement

Task commencement, task completion and completed design reviews and document delivery must be monitored through a reporting system that provides assessment reports of work accomplished versus scheduled work. The reports should be provided to the task managers on a weekly basis in order to provide prompt corrective action, if required.

7.4.4.3 Schedule Review and Update

The overall design schedule and schedule for individual tasks should be reviewed at least monthly, and consistently updated to reflect current progress and adjustments to retain specific delivery dates. Updated schedules highlighting schedule changes should be distributed to task managers after each update.

7.4.5 <u>Cost Control</u>

7.4.5.1 Cost Baseline

Cost control activities should be directly related to the WBS defined in Chapter 7.4.1. For Final Design activities, the initial design budget is based on the design cost estimate prepared during the PE Phase. These initial estimates may require revision as design progresses and authorized changes are made in either the content or scope of design services to be provided.

7.4.5.2 Cost Accounting System

For each work package, a unique identification code must be assigned to permit tracking and monitoring of costs. These codes are used to schedule and report work performed and to prepare regular financial reports for management.

7.4.5.3 Cost Forecast and Estimate Reviews

Project cost estimates for construction should be prepared and included in the periodic design reviews discussed in Chapter 7.4.2. Whenever estimated costs to construct exceed the budgetary limits, an in-depth review and assessment must be performed to identify the cause(s).

7.4.5.4 Contingency Management

Contingency funds are used to cover additional costs due to inflation, design changes and/or estimation errors. The amount of contingency reserve should be reduced as the design process evolves and uncertainties are reduced. Strict management control must be maintained over the use of these funds to maintain the project budget.

7.4.6 <u>Computer-Based Techniques and Tools</u>

Computer hardware and software are available to assist in all phases of Final Design. Computerized project management, scheduling, cost estimating and project administrative procedures adopted for the other project phases should also be utilized for the Final Design Phase. The owner should define computerization requirements for all consultants to assure compatibility.

Computer-aided design (CAD) can be utilized to perform calculations, prepare design drawings and develop material and equipment lists. CAD permits rapid modification and revision of complex design criteria. Design consultants should possess their own CAD systems and, when in-house personnel are used for portions of the Final Design, the owner should fully consider the acquisition of CAD-compatible systems.

7.5 PROCUREMENT, CONTRACTS DISPUTES AND CLAIMS

7.5.1 Procurement and Contracts

The procurement of the design consultant should have occurred at the inception of the PE Phase (see Chapter Section 6.5.1). Continuity in design services is essential and the design team used for PE should be available through Final Design and Construction.

7.5.2 Contract Changes

Design contract changes may arise from two sources: (1) addition of new contract requirements or redirection of existing requirements which may come from the project manager or owner and, (2) actions originated by the design consultant to perform additional work.

A change advanced by the design consultant is essentially a request for equitable adjustment to the design contract. These requests may be based on alleged errors or omissions in the specifications of drawings, extra work, unreasonable delays, damage to work, informal suspensions or interferences by project management personnel, and like matters. Typically, a consultant is seeking an increase in the contract price, a time extension, or both.

Changes to design contracts can also affect the design schedule. Whenever an alteration requires schedule revision, the negotiations must arrive at a new design schedule that specifies dates for all submissions and for design completion. All proposed design changes should be processed in accordance with standardized change order procedures that document the request and obtain the necessary approvals.

7.6 SAFETY, RISK MANAGEMENT, INSURANCE

7.6.1 System Operational Safety

All Final Design plans and specifications must adhere to the requirements of the System Safety Program Plan in terms of the design of the physical facilities and the planned operational performance of the resulting system. Safety must encompass users, employees and the public at-large.

7.6.2 Construction Safety

A safety program should be developed to guide contractors, agency staff and consultants during the construction of the transit capital improvement project. The recommendation of the safety program applicable to construction should be incorporated into the bid documents for all potential contractors. The objective of the safety program should be the highest levels of occupational and health safety during construction by following a risk management approach which includes:

- Risk Evaluation - Identification of potential risks, their impacts on the total project and the cost of alternatives to avoid or minimize risk.
- Risk Assessment - Involving constant identification and quantification of uncertainty, nature of risk, and the total amount of potential direct and consequential losses and precise definition of internal and external events.
- Risk Analysis - Involving the analysis of risks to determine if they are avoidable or unavoidable. Avoidable risks should be eliminated if it is economically feasible to do so. Unavoidable risks should be analyzed to determine whether they are insurable at cost-effective rates.

Bidders should be required to submit their OSHA-recordable injury and illness incidence rates and their experience modification rates applicable to Workers Compensation insurance for each of the prior 3 years. Those not passing a selected threshold level should be disqualified. Bidders should be alerted that their current safety statistics are to be included in all progress reviews, and that safety training and motivational programs will be required.

7.6.3 Insurance

7.6.3.1 Final Design Related

Insurance protection is required for both the owner and the designer. If the grantee or owner is not self-insured, the company holding the insurance should be contacted to ensure that all aspects of the additional liability due to the capital improvement project are adequately protected. It may be necessary to increase insurance limits to provide adequate coverage for the owner.

Insurance requirements and liability limits of the design consultants are incorporated into the design contract documents and must also be incorporated into subcontracts. Certificates of insurance in the specified amounts must be provided to the transit agency prior to the initiation of work. Insurance policies purchased for the design contract cannot be cancelled or reduced in amount without first giving written notice to the project director.

7.6.3.2 Construction Related

Plans and requirements should be developed for insurance protection to cover construction activities. A major decision will be the use of conventional (contractor supplied) versus coordinated (owner supplied) insurance. See Chapter 3.6.3.3 for a review of these two approaches.

7.7 COMMUNICATIONS

The internal and external communications program initiated during the PE Phase should continue into the Final Design Phase. Externally, attention should focus on areas receiving negative publicity or subject to adverse impacts because of the pending construction or operation of the subject transit project.

CHAPTER 8

CONSTRUCTION

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CHAPTER 8
CONSTRUCTION

During the Construction Phase, outside contractors and/or agency force account employees construct the fixed facilities, fabricate/install equipment, and integrate them into a functioning system in accordance with the plans and specifications developed during Final Design. As a supplement to the management principles presented in Chapter 3, this chapter contains project management guidelines specifically related to the Construction Phase of a transit capital project.

8.1 LEGAL/INSTITUTIONAL AUTHORITY, MANAGEMENT AND ORGANIZATION

8.1.1 Legal/Institutional Authority of Project Sponsor/Grantee

8.1.1.1 Statutory Authority

The project sponsor/grantee must have legal authority to construct the transit capital improvement, and to perform the required supporting activities such as real estate acquisition. This authority, granted by state and local government bodies, typically includes the ability to receive and disburse public funds or otherwise finance the project and to perform all required supporting activities.

8.1.1.2 Regulations

Government regulations affecting the construction phase of the transit project could involve environmental, health, safety, civil rights, and administrative issues, as well as a variety of codes and ordinances. All applicable regulations should be identified prior to the start of construction and carefully adhered to during construction. These include the provisions of the Urban Mass Transportation Act of 1964, as amended, policies set forth in the Federal Register, UMTA grantee administrative requirements, and applicable Federal, state and local provision of law, statute or procedure.

8.1.1.3 Existing Government Structure

Those authorities having jurisdictional responsibility for approvals, applications, permits, licenses and other regulated processes or procedures, and with whom communications is essential, should be identified early on in the project planning process and incorporated into the appropriate Construction Phase activities. Organizations meeting these criteria include but are not limited to transportation, fire, public works, health and safety, building, planning and zoning, and other similar regulatory departments.

8.1.2 Management/Organization

8.1.2.1 Project Management Plan (PMP)

In the preceding chapters, project management planning requirements and procedures have been described for the various phases in the transit project development process. As discussed in Chapter 2.4.2, the first output and the most significant, is the PMP. It is first established at the beginning of the PE Phase and is thereafter used extensively in guiding and directing subsequent phases. Details of the content of a PMP are found in Chapter 6.1.2.1.

Construction management involves those actions necessary to ensure the successful completion of the project and the delivery of fully functional facilities. This phase of the project is the most critical and labor intensive. For that reason, it is vital that a separate, but complementary management plan be developed to guide construction efforts. In Chapter 6.1.2.1, the UMTA outline for a PMP includes a specific section entitled "construction program." The first element in the section is Construction Management. For ease and consistency, it is recommended that this section of the PMP be developed in sufficient detail to function as the Construction Management Plan. It may be detached for use at the project sites, and should be an extension of the overall PMP.

8.1.2.2 Management Approach

The management approach utilized to ensure the successful completion of fixed guideway transit construction or other related transit system projects relies on establishing:

- o Clear project objectives
- o Coordination procedures and requirements
- o Carefully defined roles and responsibilities
- o A written project plan
- o Frequent communications with all participating parties
- o A process for making timely and appropriate decisions

These elements, when combined and tailored to the individual project, become the strategy for successfully accomplishing the various construction activities. The management strategy defined in the earlier project phases should be modified to accommodate the unique requirements of the Construction Phase including:

- o Procurement of construction contractors
- o Oversight of construction contractors
- o Control of cost and schedule
- o Quality assurance
- o Construction safety
- o Interface with ongoing transit O&M activities
- o Mitigation of construction impacts
- o Prior relocation of utilities and railroads
- o Coordination between different contracts

8.1.2.3 Organizational Objectives

The National Academy of Sciences' 1978 report entitled: Better Management of Major Underground Construction Projects [Ref. 14] indicates that the most frequent cause of project disruption for any major transit project is "delayed decisive action." Delays in decisions or actions may be major contributing causes for disputes, claims, cost overruns, and construction delays.

> Delays in resolving critical issues can usually be attributed to the way in which the decision-making process flows through the organization controlling the project. For that very reason, it is essential that an

organizational structure be developed to ensure clear assignment of responsibilities and authorities and lines of communication from the first line supervisor to the top-most grantee decision-maker. These characteristics, when combined with complete written organizational procedures, become the "organizational objectives" for the project.

8.1.2.4 Owner's Organization

Prior to beginning construction, the grantee should have decided on a project management organization that will be responsible for moving the project from "concept-to-completion". In larger projects this may also mean the establishment of a key management group that will:

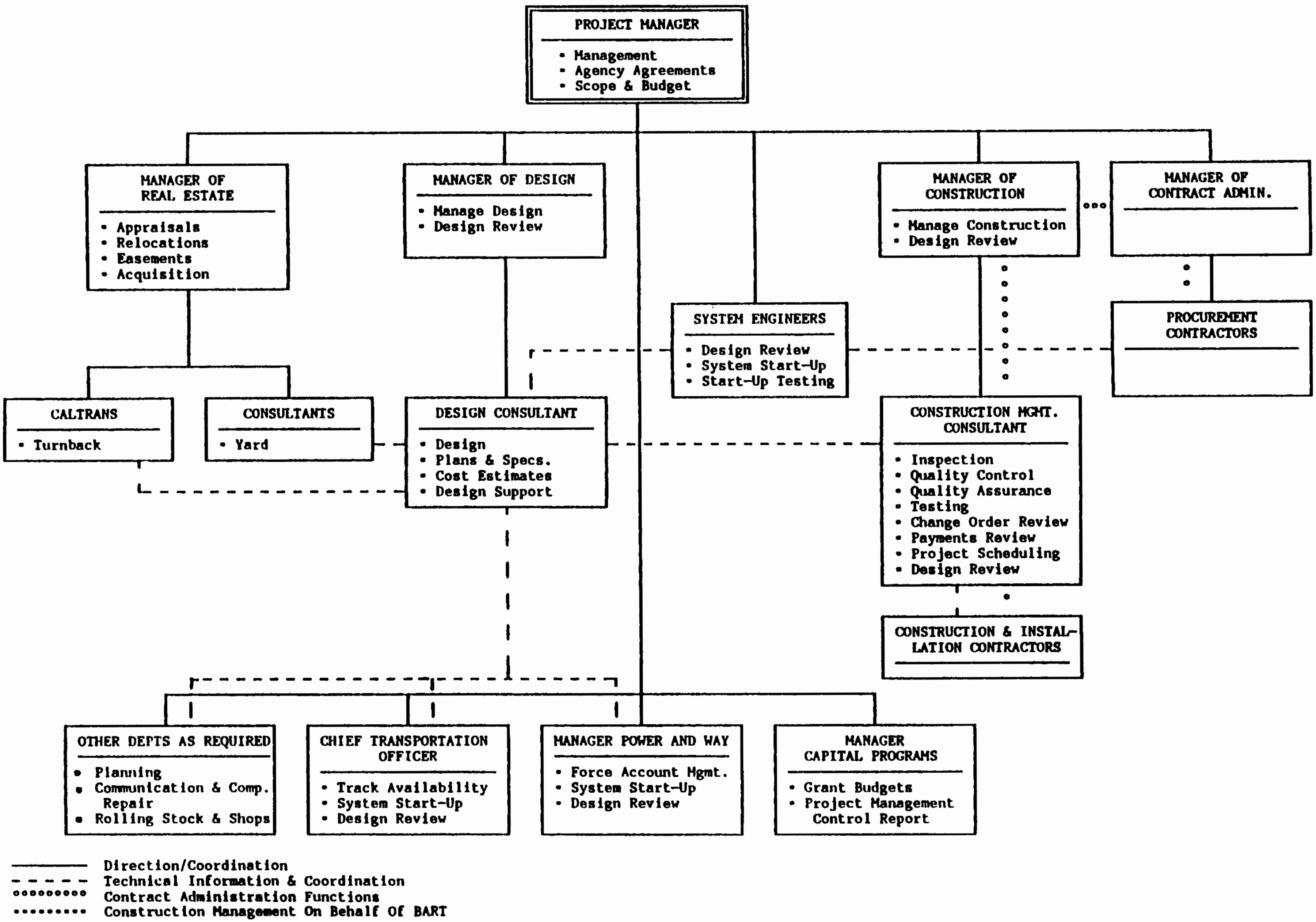
- Be empowered to make decisions and take action
- Be responsive to emergency or rapidly changing conditions
- Perform progress reviews, quality assurance, and related actions
- Track and be responsible for deliverables
- Interface with external agencies
- Function as a single point-of-contact with UMTA, and be responsible for project accomplishment

Figure 8-1 offers one example of a large-scale transit project organization (BART) that has been used successfully to manage the construction activities associated with a major project (Daly City Extension) [Ref. 20].

8.1.2.5 Project Team Functions and Responsibilities

The size, composition, and functional responsibilities of a project team should evolve after careful and detailed consideration of the various activities occurring throughout the project's life-cycle. Consideration should be given to making use of existing technical personnel, managers, and professionals familiar with the project environment. However, care should be exercised, so as not to overburden nor detract from present operations. Additionally, it must be stressed that the "project organization" should not be responsible for routine operations and maintenance of the existing system while trying to manage a complex construction project. Staffing the project organization with qualified

FIGURE 8-1. BART PROJECT ORGANIZATION FOR DALY CITY EXTENSION [REF. 20]



professionals is essential. Appendix A entitled, "Example Project Team Functions and Responsibilities," provides descriptions for duties and responsibilities of positions commonly found on major transit construction projects according to the following organizational hierarchy:

PROJECT MANAGER

<u>Independent Oversight</u>

- o Quality Assurance
- o Safety

<u>Construction Manager</u>

- o Staff Functions
  - Administrative Services
  - Labor Relations Advisor*
  - Affirmative Action*
  - Public Relations*
  - Contract Administration*
- o Cost and Scheduling
- o Technical Services Group
  - Engineering Services
  - Geotechnical Services
  - Consultants
- o Supervision and Inspection
  - Resident Engineer Offices
    - . Office Engineers
    - . Inspectors

* Functions should be performed in other departments and offices in the owner's organization independent of the project organization.

8.1.2.6 Interface Points

Several interconnected functional relationships exist during the Construction Phase of a major transit project. Figure 8-1 provides a quick visual appreciation for the number of points in the BART project organization where internal and external functional elements interact -- points where one element or the other is expected to provide a service or execute work in support of the project, or in the project at points where major events occur.

One of the most difficult and time consuming aspects of project management is the "interface management":

- o Of companies involved as partners and under contract
- o Between functional elements of the organization
- o Between locations
- o Between project phases
- o Between governmental, state, or local regulatory agencies
- o Between private and other public interests

To enhance and establish interface management, it is necessary to clearly define and enforce:

- o Responsibility, authority, and accountability at interfaces
- o Inputs and outputs in terms of organization, function, and schedule
- o Lines-of-communication

8.1.2.7 Appropriate Roles: Staff and Consultants

There are a number of scenarios which can be examined, and that would logically describe separate or combined roles for a grantee's staff and those of a consultant. In all cases, however, there is a recognition of the need for close cooperation between these two groups and for having their roles and responsibilities clearly defined.

The staff, for its part, is an extension of the grantee and the project manager's organization. Their roles have been defined in Section 8.1.2.4 and generally are configured to provide the greatest amount of direct project support and control by delegation of authority and responsibility. Decentralized project control is encouraged, where practical, and the staff is expected to communicate all manner of project information to the grantee and project manager so as to keep them fully informed. The staff is also expected to take advantage of the expertise provided by consultants and to cooperate in ensuring the professional completion of the project.

Grantee consultants may perform two possible roles in transit projects as: (1) an extension of the grantees staff by providing technical support and assistance, or (2) a direct representative of the grantee empowered to function in the role of project manager for the entire project. Either of these roles relies on the grantees staff and that of the consultant to maintain harmonious relations and to have carefully prepared operating procedures. Figures 8-2 and 8-3 [Ref. 20] depict BART's use of a construction management consultant by showing responsibilities and organization, respectively.

8.1.2.8 Key Personnel

Individuals in leadership positions and directly involved in the planning and execution of a project can be considered "key personnel." They may range from the grantee's principal representative,down to and including the Resident Engineers' (REs') inspectors. Consultants working for the grantee will also have "key personnel." Key personnel are those who can directly influence the outcome of the project. Grantees must identify key personnel in their organization, including consultants, and assign responsibility and authority as necessary. Grantees must also identify key personnel in the contractors organization, including the corporate officer-in-charge, which is helpful in managing interfaces, and quickly communicating requirements affecting the project.

8.1.2.9 Managing External Relationships

One of the most essential requirements of management for large, costly, and visible projects is to ensure that external perceptions of the various activities are positive and well-informed. Major transit construction projects are, by their very nature, highly visible and generally cause for considerable public scrutiny. In addition to the general public, numerous Federal, state, local and private organizations share common interests in projects of this type each requiring information regarding various aspects of the project.

Managing the relationships with these diverse groups is tremendously important and absolutely essential in ensuring that correct perceptions of the project are factual and are continuously made available. Key project personnel and staff

FIGURE 8-2. RESPONSIBILITY OF BART'S CONSTRUCTION MANAGEMENT CONSULTANT [REF. 20]

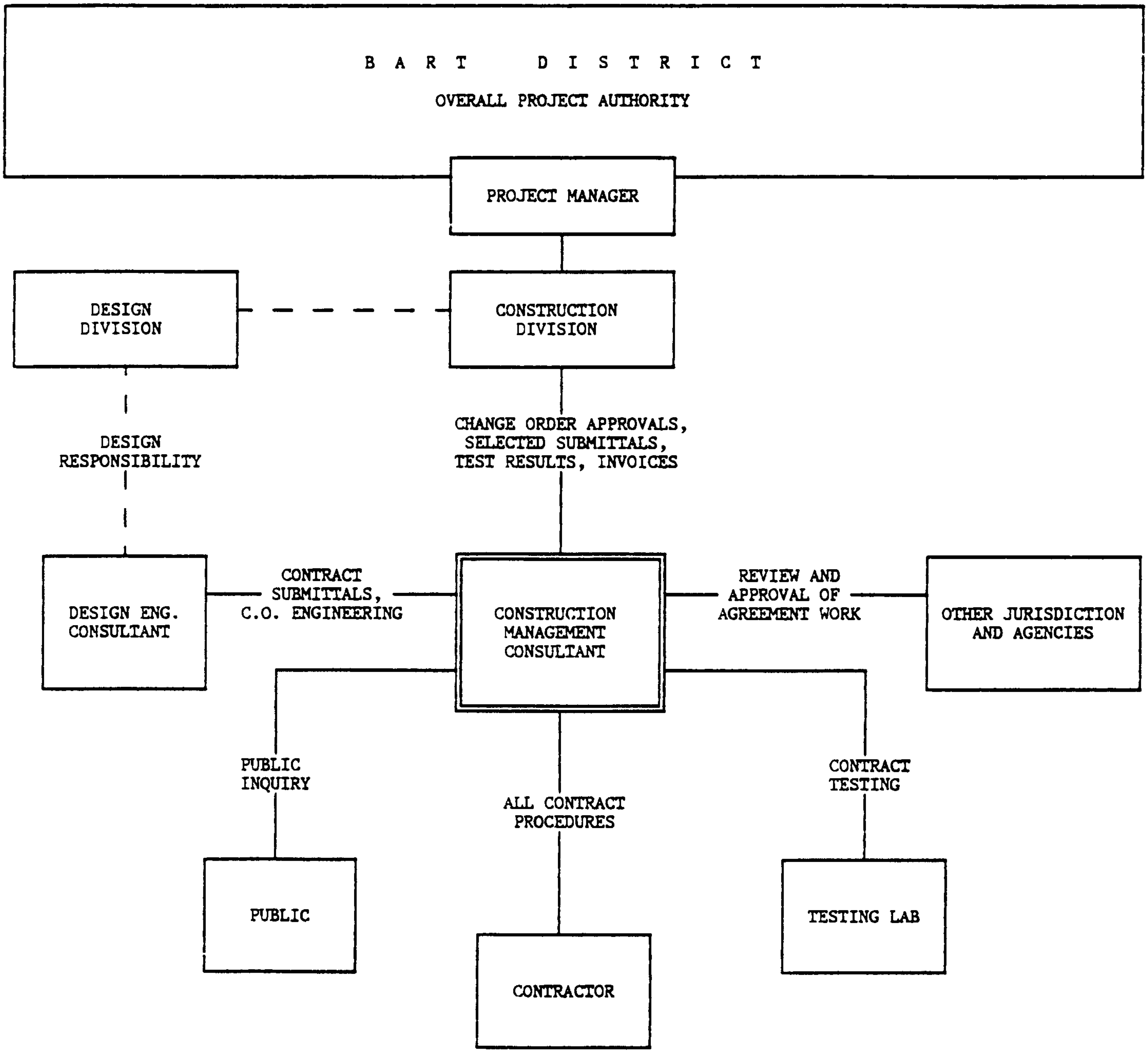
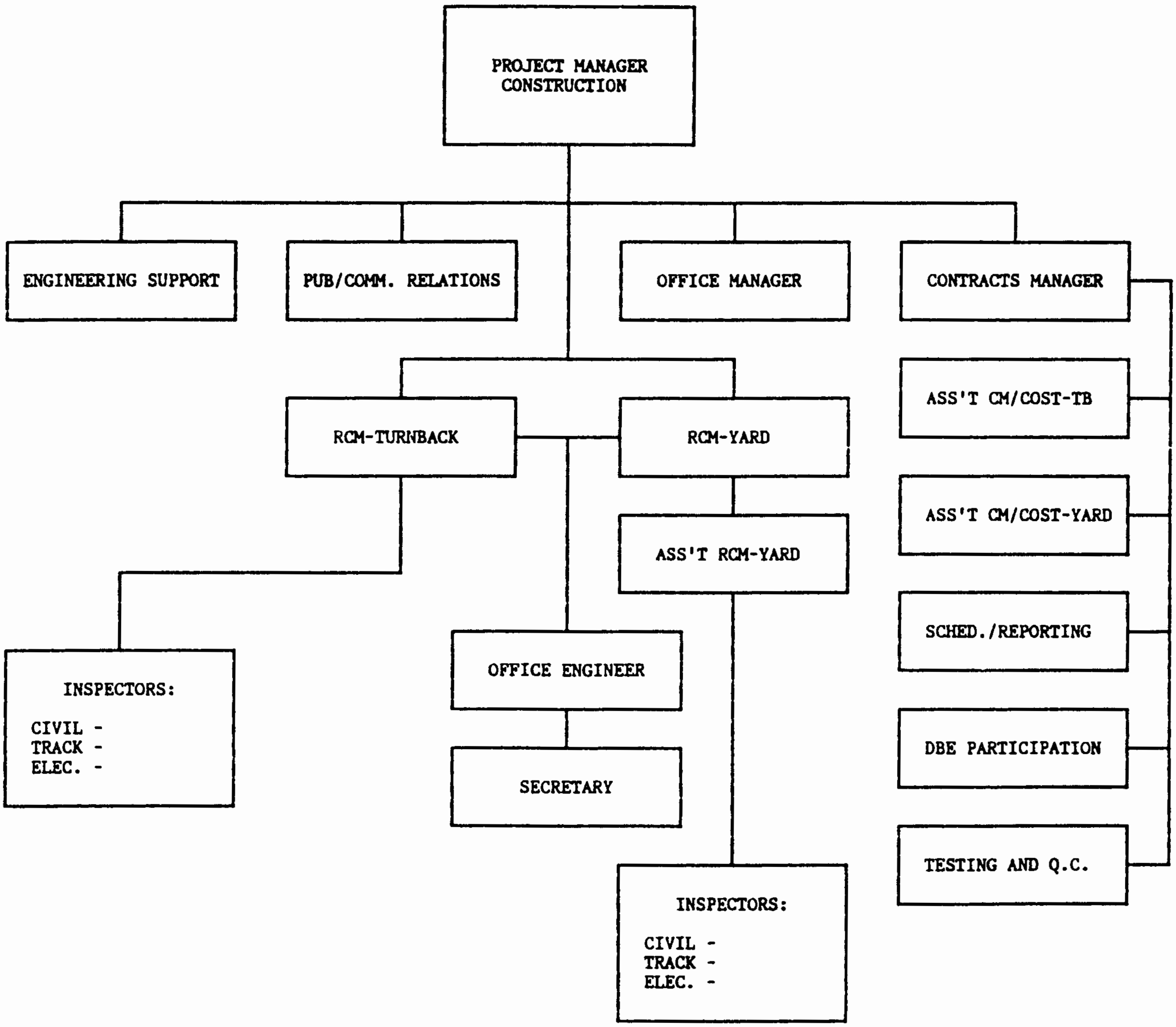


FIGURE 8-3. BART'S CONSTRUCTION MANAGEMENT CONSULTANT ORGANIZATION [REF. 20]



members, particularly in the public relations area, play a major role in presenting correct perceptions to external organizations and the public. It is strongly recommended that the PMP make provisions for the development of the following, as appropriate:

- o A public relations strategy
- o Community relations programs
- o Guidelines for the release of project information
- o Workforce information programs and grievance procedures
- o Internal lines-of-communication for project issues
- o Procedures for quickly responding to external information needs
- o Routine scheduled meetings and forums for the workforce, external organizations and groups to establish effective two-way communications throughout the life of the project

See Section 8.7 for additional guidance related to external communications.

8.1.2.10 Training

All phases of a transit project should incorporate training by the grantee or the project management organization to ensure persons coming in contact with an existing operating transit system are fully knowledgeable of its operating characteristics, procedures and configuration. This is especially important on transit system modernization projects.

Training of personnel involved in construction should emphasize job and occupational safety or unique training that is required to install or assemble components of the various project systems. Training is essential, must be conducted on a regular basis and must be fully supported by key personnel. In addition, personnel to be involved in system operations and maintenance should be trained so they will be fully qualified prior to the time their services are required.

8.1.3 Human Resources and Labor Relations

Management plans for human resources and labor relations should guide the Construction Phase of transit capital projects. The intent of these plans is to provide a careful evaluation of factors which may affect the efficient functioning of the project workforce, and to develop alternatives or techniques for resolving those concerns.

8.1.3.1 Statutory and Regulatory Requirements

Both prior to and during the Construction Phase, government and agency regulations and statutes should be reviewed and the various sections of the management plan modified for compliance. This is especially important for wage compliance, e.g., Davis Bacon Act, and other labor and human resource considerations. Items considered important for inclusion in the management plan include:

- o Wages and wage classifications from the Department of Labor
- o Work period and work hour provisions
- o Fair Labor Standards Act provisions
- o Civil Rights Act provisions
- o EEO and Affirmative Action plans and policies
- o OSHA policies and requirements
- o Union participation, policies, constraints
- o Federal, state, local labor requirements (13c protection)
- o Grievance procedures
- o Lines-of-authority and lines-of-communication

These items, as a minimum, should be considered and fully enforced within the project organization by both the grantee or the designated representative. Both the grantee or a designated consultant should require written plans and frequent inspection for compliance. This may best be executed by designating a member of the project staff as being responsible for monitoring and implementation of the programs. This would usually involve the administrative officer and other members of the staff having labor and human resource responsibility.

8.1.3.2 Labor Relations and Local Agreements

Labor relations have been discussed in detail in previous chapters. It is important to remember that during construction planning careful examination of the existing labor situation is essential to determine the impacts of:

- o Unions
- o DBE participation
- o Local labor situation
- o Contractor labor practices

Each of these areas will have impacts on the project if not fully evaluated and considered in the PMP.

Local agreements are a means of preventing future disruptions or disagreements over the way in which the project is managed and staffed. These agreements may extend between the grantee and local groups, contractors, consultants, unions, agencies, or other organizations who would interface with the project's management staff. All agreements should be approached with caution to ensure that the agreed upon actions are enforceable and in compliance with accepted laws and procedures. Where possible, agreements should be in writing and recorded as part of the PMP.

8.1.3.3 Local Conditions

Prior to construction, there should be a significant amount of data gathered on local conditions affecting the project. From the standpoint of construction, these will primarily focus on labor, equipment and material and will be concerned with their supply and demand in the project area. It is essential that project managers consider and document (in the PMP) conditions in the geographic area and develop alternative operational procedures, if necessary.

8.1.3.4 Labor Compliance Administration

The grantee is responsible for ensuring all project participants apply and conform to Federal, state, and local statutes and regulations governing labor administration and utilization. Within the project organization and that of the grantee, it is essential to have an administrative element or body to document and manage labor compliance actions. This can generally be assigned to the labor relations advisor on the project team or other appropriate designee representing the grantee. There may also be a requirement to establish local coordinating groups to accomplish specific labor actions, of which the grantee is an active member.

8.1.4 Interagency Agreements, Approvals, Permits

8.1.4.1 Interagency Agreements

Interagency master and detailed agreements developed in prior phases with the following type agencies/organizations should be implemented in advance of the construction contract.

- o Federal
- o States, cities, and counties
- o Flood control districts
- o Port authorities
- o Water and sewage districts
- o Associations of government
- o Regional planning councils
- o Citizen groups and associations

The implementation of agreements, such as utility and railroad relocations, in advance of construction, will minimize delays to construction contractors.

8.1.4.2 Permits

The acquisition of the necessary permits, agreements, right-of-way, and other releases, including street closures and traffic control, for the construction of the proposed project is required prior to the start of actual construction. In most cases, agencies listed in paragraph 8.1.4.1 will each require some form of permit or documentation that must be requested and initiated by the grantee. Careful attention to detail in this regard will prevent serious and costly delays in construction.

8.2 SYSTEM DEFINITION/CONFIGURATION/PERFORMANCE

During the pre-construction stages of a major transit project there is considerable effort devoted to the identification of various alternatives, design concepts, costing, environmental impacts, public viewpoints, and a variety of other issues effecting the decisions of whether or not to continue development. It is vitally important that every aspect of the project be fixed at the conclusion of Final Design to preclude confusion and delay as the Construction Phase begins.

8.2.1 Project Definition

The construction contract documents and the project/construction management plans should include a discussion of the project's history and background, the objectives of the project, and its management strategy. Other projects, proposed or actual, which are dependent on or support activities contained in the PMP, should be described. Other information recommended for inclusion in the description includes:

- Project planning criteria
- Financing, budget estimates and targets
- Design parameters
- Acquisition requirements (e.g. real estate, services, etc.)
- Permit requirements
- Licenses
- Construction sequencing and schedule
- Operational aspects of the project

These definitions are important in ensuring a complete understanding of the project and its scope and are intentionally made an integral part of the construction plan.

8.2.2 Configuration

Throughout all phases of the project, including planning, design, and construction, there is a need to have consistency in the manner in which various physical and technical aspects of the project are recorded and defined. Both physical and technical aspects are used extensively to prepare the Configuration Management Plan. In the Construction Phase, this plan is used to ensure the project's original concept is followed and that the completed system will function as designed. Brief definitions of the two project aspects follow:

- Physical - Describes the total system in sufficient detail to permit preliminary design concepts to be prepared. Includes location descriptions, trackage layouts, facilities, interfaces with existing systems, proposed passenger vehicle configuration, above and below ground segments, landscaping, crossings, overpasses, and any other physical definitions of the system which will provide a full appreciation of the system's overall suggested characteristics.

- Technical - Defines the various interrelationships and functions of the system in sufficient detail to guide construction. Includes design/ construction considerations and techniques, system, connections/interfaces with existing systems and utilities, maintainability of the fixed facilities, system operations and characteristics, and any other data which explains or details system operations/performance.

Once the Configuration Management Plan is updated during design, it becomes the guide for accomplishing construction; more importantly it is the "blueprint" for describing how the system will look and function. The plan is also a control device that includes procedures for monitoring and controlling project activities, e.g., guidelines for construction changes, procurement, materials testing, and quality assurance.

8.2.3 Value Engineering

The construction contract bid documents will describe at least one method for actually accomplishing the required design. Contractors may take the initiative to suggest another approach, e.g., lower cost, shorter time, etc., after the contract has been awarded. The grantee should encourage innovative construction methods which have potential for saving time and money. Procedures should be established for evaluating alternative approaches, such as underpinning techniques and tunnelling methods, and for sharing the potential cost savings as an incentive to the construction contractor.

8.2.4 Real Estate Acquisition and Management

Every new transit construction project and some modernization projects require the acquisition of real estate, which must be accomplished in a timely and legal manner to prevent potentially costly delays. Real estate needs should be identified initially during Project Planning, but may not, depending on the availability of information, be precisely determined until the PE Phase is complete. Real estate requirements should include permanent and temporary acquisition and rights-of-way required for construction access.

Once identified, the requirement for real estate must be carefully documented and the necessary legal actions taken to secure the property prior to the start of construction. The PMP should identify the responsibilities for real estate acquisition, locations, availability, restrictions, residual prerogatives of former owners, and any special covenants or construction precautions that must be observed. The Construction Management Plan and individual construction contracts must specify in explicit detail the restrictions and provisions for the conduct of construction on public and private lands. This is particularly important if there are requirements to retain certain landscaped finishes and special requirements for land restoration at the conclusion of the project.

8.3 FINANCIAL REQUIREMENTS/RESOURCES

During the Construction Phase of the transit project, the greatest costs of the project will be incurred. Initial contract bids will provide an indication of the accuracy of the engineers' estimates. Change orders of fixed priced contracts and overruns on cost-reimbursable type contracts may consume contingency reserves. Periodic assessment of the project's financial requirements should occur. If necessary, alternative actions may be required to affect cost reduction and/or increased financial resources to keep the project on a sound financial footing. Cost controls are discussed in Section 8.4.5.

8.4 MANAGEMENT CONTROL SYSTEMS

Project control occurs in all phases of a project and is the responsibility of each manager and each management level. A number of organizational alternatives have been suggested in the preceding sections and all have one element in common -- one person is in charge. That rule should not be violated. There can be technical committees, grantee oversight committees or other control bodies to assist in the overall management of the project, but only one person should be empowered to direct the day-to-day operations of each phase.

8.4.1 Work Breakdown Structure

A work breakdown structure (WBS) is an organization technique for defining work to be accomplished. In construction, this can be applied to project tasks by considering several similar functions or a logical grouping of tasks as a "work package" that is assigned to a management unit. A management unit is the individual or portion of the organization responsible for supervising construction tasks included in the work package. By breaking work into packages, it becomes easier to manage a large complex undertaking such as a transit project. The grantee and the project manager must use care in applying WBS techniques to those situations where there are sufficient supervisory personnel representing the grantee to monitor and check performance. Additionally, each work package must be costed and scheduled into the overall project schedule and plan.

8.4.2 Configuration Control

In the Construction Phase, the technical baseline established during design will be used to monitor construction and fabrication processes. The baseline must be closely adhered to in order to ensure quality, safety, performance, and cost compliance. However, there may be occasions where changes are required. All changes to the baseline must be technically reviewed and approved by the responsible individuals as set forth in the PMP for the Construction Phase.

During the Construction Phase, special emphasis will be placed on recording and documenting any changes which are approved and completed. Changes become a matter of official record and must be approved and requested in writing. The grantee must establish in writing those individuals authorized to approve construction changes and the dollar thresholds of their authority. At the completion of construction "as built" drawings must be prepared.

8.4.3 Quality Assurance Program

Detailed QA program guidelines are presented in Appendix B. They are taken from Management of Urban Construction Programs, Volume II [Ref. 9] and include elements which should occur during either the Construction or Testing and Start-Up Phases. The QA program objectives should be to verify that equipment, supplies, and work performed comply in all respects to the requirements as described in the contract documents and to assure the integrity of the approved design defined by drawings and specifications. As such, it must provide an effective system for ensuring that:

- All project work is performed in accordance with the engineering requirements.
- All equipment is tested throughout development, manufacture, and installation to verify that it functions as specified.
- Early detection of undesirable conditions is accomplished, and positive corrective action is performed in a timely manner.
- Control over the configuration is maintained at all times to define the acceptability of equipment as established by design reviews, drawing approvals, and design verification testing and to preserve the configuration during retrofits and modification work.

The program should provide the documentation required to support the acceptance program. The owner should strive to minimize detailed inspection of a contractor's work by rigid enforcement of the requirement for the contractor to have an effective QC program.

8.4.4 Schedule Control

Schedules are the vehicles whereby managers (with assigned baselines) at all levels of the project management organization are able to maintain accountability for the variety of activities taking place. In addition, schedules permit managers to review project progress, i.e., planned vs. actual accomplishment, and make decisions to modify workplans, as necessary, to meet essential milestones. A variety of schedules and scheduling techniques are available to manage projects of the type common to urban public transportation, including:

- o Major Program Table - Used to measure significance of completed projects on the service targets set for the transportation system; may over several ongoing projects directly influence service levels; can be used to integrate construction activities; revisions are approved by the project manager, or higher, as appropriate.

- o Major Project Schedules - Maintained by the local transportation authority to reflect project milestones and development periods; generally in a bar chart format; details all major projects in the system; may be broken into operating areas for comparison purposes; project manager, executive manager of engineering, or other designated individual with overall system engineering responsibility has authority to revise this schedule.

- o Master Project Schedules - These schedules, normally updated monthly, include comprehensive CPM/PERT/Gantt or comparable scheduling schema, and constitute the working schedules for the projects(s); the project manager, with the assistance of the resident engineer(s) and the various contractors, is responsible for their publication.

- o Special Schedules, Project Engineering Schedule, Project Construction Schedule, and Project Training Schedule - These various schedules, as their names imply, accomplish definitive scheduling functions and are tailored to guide specific activities occurring during project execution; frequency of revision and responsible individuals may vary by project type.

- o Status Reports - Status reports, while not technically schedules, do reflect information that is used to make decisions effecting the outcome of the project or its phases. That same information, i.e., decision will generally impact on scheduling. It is important to ensure that schedules and status reporting are closely coordinated.

8.4.5 Cost Control

Cost controls are applied throughout the project, but become more critical during construction when the financial consequences of an action can be significant. To minimize potential risk, it is recommended that a series of cost control procedures be implemented to help prevent project cost overruns, but still provide the degree of flexibility needed to effectively execute construction tasks. Critical to effective cost control is the aggressive control and settlement of claims and disputes (see Section 8.5.3).

One successful technique has been to assign each manager on the project a "baseline cost" target. It may be tied to the WBS or set up under other guidelines. Managers are responsible to manage their funds by prudent cost accounting procedures and are periodically audited to check progress and performance. This technique essentially assigns cost centers to various construction activities and helps in the overall project management.

As elements of the project are completed or progress forecasting is required, the same techniques described above are used to forecast cost and resource requirements. Managers provide estimates for their area of responsibility. The forecasts are checked and verified prior to approval, fund allocation, and establishment of new management targets. The cost control system should support the prompt payment of contractors, the commitment to which will permit lower bids.

There may occasionally be unforeseen requirements, major design changes or discrepancies, or other events that require the immediate expenditure of funds to correct a project deficiency. Obtaining funds in a situation such as this may be nearly impossible unless some provision has been made to establish a contingency fund. Contingency funds should vary in amount by the size of the project and the percentage of retained funds. Release and distribution of the funds should be fully described in the PMP and summarized in the Construction Management Plan. Funds can be held at project level or distributed to lower levels. For more positive control, it is recommended that funds be retained at the project level.

8.4.6 <u>Computer-Based Techniques and Tools</u>

It is recommended that the grantee obtain, or secure the services of a consultant to establish an automated project management system. Several inexpensive programs are commercially available. It is also recommended that the grantee automate project record-keeping, management plan development, procurement, real estate, and all other project activities as is practical. There should also be requirements placed on the contractors to use the same systems used by the grantee.

In selecting an automated project control system, the grantee should assure that it meets the projects requirements for both capacity and performance, and be user friendly and compatible with most project management applications. It is suggested that once a selection is made there should be enough hardware and software for project managers, resident engineers, and the grantee's management infrastructure and to easily interconnect for data transfer.

8.5 PROCUREMENT, CONTRACTS, DISPUTES AND CLAIMS

8.5.1 Procurement

Careful attention should be devoted to developing a comprehensive procurement management plan. This plan should describe responsibilities and levels of funding authority, priorities, inventory/material management, issuing instructions, receipting procedures, storage, contacting officer/technical representative designees, staffing, contractor procurement services, and the interrelationships between operational requirements and those of the project.

Appendix C is an example of a procurement approval scheme from an actual transit project. Various leadership roles emerge and dollar thresholds are clearly established for varying types of procurement activity. Guidelines such as these should be established in the procurement management plan. The owner should include the procurement process when scheduling project activities and consider the procurement of long lead time items, such as power equipment in advance of construction contracts.

8.5.2 Contract Administration

Contracting, as with procurement, is a function essential to the effective execution of a construction project. The vast complexity and multi-year scope of these types of projects require strict accountability by contracting representatives and careful legal review to preclude cost overruns and schedule delays.

The controls recommended for the procurement process are also suggested for contracting, but with significantly more detailed procedural guidelines and higher levels of approval authority. The stringent controls are suggested to prevent contracts from being handled as "routine" procurement actions which is of major significance when a grantee is managing several multimillion dollar contracts over a short span of time.

Appendix D represents an actual project organization and graphically shows the levels of approval and responsibility for handling contracts supporting construction, professional/technical service maintenance and repair. Appendix E contains additional and more detailed information on the management of contracts after award.

8.5.3 Dispute Resolution

The goal of the project organization should be to avoid disputes and claims through a process of planning and development which results in effective contract documents and procedures. Responsibility for understanding and instituting procedures for minimizing disputes rests at all levels within the project management hierarchy. Project Management and Construction Management Plans must include guidelines for responding to disputes which arise between contractors and the grantee. In most cases, the reason for a dispute or claim against the project grantee can be traced to inadequate consideration or estimate by the contractor or the project organization.

All disputes should be resolved in a timely manner and at the lowest administrative level possible. Procedures for dispute resolution should be clearly defined. For those disputes that cannot be resolved through administrative procedures, consideration should be given to such resolution procedures as an independent board of consultants, board of contract appeals, arbitration, mediation, and as a last resort, litigation. Incentives to speed dispute resolution should be considered. These include payment of interest at a rate exceeding the losing party's normal borrowing rate and reimbursement of the winning party's claim preparation and defense costs and attorneys.

Disputes can be avoided if contingencies are dealt with in the framework of contract documents. The recognition of contract elements that are vulnerable to change and misinterpretation can help stem disagreements. Clauses dealing clearly with changed conditions and quantity variations should be included in the contract document. In general, disclaimers and exculpatory language should be omitted.

Examples of possible contractor oversight that increase risk, miscalculation, or escalation of construction costs include:

- Inadequate investigation of work sites
- Inadequate investigation of working conditions
- Unbalanced bidding
- Bidding below cost
- Poor planning
- Use of wrong equipment
- Failure to follow authorized procedures for adjusting work

Examples of actions by grantees that may lead to disputes include:

- Lack of full disclosure of geotechnical information
- Changing plans or specifications during construction
- Inadequacy of bidding information
- Inadequate time in procurement process for bid preparation
- Narrow interpretation of plans and specifications
- Excessively rigid specification
- Vague or misleading requirements

There must also be procedures, developed with the help of legal staff, which permit construction operations to proceed, if prudent, while disputes are reviewed and settled. The legal staff must also ensure contractual documents are well written, and include specific provisions for dispute resolution.

Project/construction management plans should stress that the sections on inspections, scheduling, quality assurance, etc., are intended as preventative procedures for early identification of potential disputes. They should also define actions to be taken to document contractor performance.

The selection of formal dispute resolution procedures should be a function of project size and the owner's resources. A brief description of the various dispute resolution procedures and their advantages and disadvantages is provided below.

- <u>Independent Board of Consultants</u> - This is a relatively new method. The board is selected by the parties when entering into the contract. It meets periodically as the work proceeds to review progress and incipient problems. The board is intended to have a deterrent effect. The board may serve as an arbitrator or only a mediator, as set forth in the contract documents. Establishing and independent broad of consultants with ongoing responsibility through the life of a project is an innovative means of dispute avoidance and resolution. Cost considerations may make it practical for use only for very large projects.

- <u>Board of Contract Appeals</u> - The various boards of contract appeals of the federal departments serve as models for this procedure. Governed by the Administrative Procedures Act, board members generally are appointed from the ranks of department employees and are given sufficiently independent status to promote impartiality. Their decisions generally are final and binding concerning questions of fact and are subject to appeal concerning questions of law. An in-house board of contract appeals gives the owner greater control over the dispute resolution process. However, there is the ever present risk that institutional bias will impair impartiality, and it is costly to maintain a staff of competent persons to serve as full-time board members or to be diverted from their normal responsibilities for a sufficient time to hear and determine disputes.

- <u>Arbitration</u> - Arbitrators generally are appointed after a dispute has arisen. The method of their appointment and conduct of the hearings is governed by contract, which may incorporate the rules of the American Arbitration Association, and by applicable statutes. The decision of the arbitrators generally is final and binding on the parties,and not subject to appeal. The advantages of arbitration are the independent expertise and impartiality of the arbitrators. Under the law in most states there is no right of pretrial disclosure, arbitrators are not bound by rules of law, and there is no right of appeal on the merits, only for substantial procedural deficiencies. It may take years to resolve complex disputes requiring numerous hearings. Some states still do not have enabling legislation that recognizes arbitration or provides a means of enforcing arbitration awards, which renders arbitration an impracticable means of dispute resolution in those states.

- <u>Mediation</u> - A mediator generally is selected by the involved parties after a dispute has arisen. Their function is to provide an atmosphere in which the parties themselves can resolve the dispute. They may make recommendations for settlement, but recommendations are not binding. Mediation offers informality and the good offices of an independent third party. This method lacks finality and may prolong the time required for ultimate resolution because the mediator's recommendations are not binding.

- Litigation - Litigation in the local courts is the traditional method of dispute resolution. In some cases a jury may be demanded as a matter of right. Judges generally are not specialists since construction cases are relatively few in number as compared with typical civil. Litigation in the local courts deprives the parties of the opportunity to have the facts evaluated by an individual with independent expertise in the usually complex issues. However, it offers procedural safeguards, such as pretrial disclosure and the right of appeal, generally not available in other dispute resolution procedures. Generally, this procedure is the most time-consuming and expensive, and is the least desirable approach.

Two documents dealing with construction disputes have been developed by professional organizations which can provide additional guidance to grantees:

- Avoiding and Resolving Disputes in Underground Construction, Successful Practices and Guidelines [Ref. 21]
- Alternate Dispute Resolution for the Construction Industry [Ref. 22]

8.6 SAFETY, RISK MANAGEMENT, INSURANCE

Both UMTA and the grantee have a vested interest in the establishment of policies and programs addressing safety, risk management, and insurance. Careful consideration of these elements will help guard against construction delays, serious injury, extensive costs, and liability considerations that frequently arise in fixed guideway and other transit projects of the size and complexity usually encountered.

8.6.1 System Operational Safety

The end product that both the grantee and the contractors are striving for is a completed system that meets or exceeds planned safety criteria. Careful definition and design of the system, technical reviews, pilot testing of components, a strong quality assurance program and operational training programs should contribute to the future operational safety of the completed transit improvement project.

8.6.2 Construction Safety

The following safety considerations are recommended for adoption and documentation during all phases of construction:

- o Certification - Approval for projects will be contingent on the grantee and other responsible parties providing written documentation, as part of their PMP, defining the scope and application of a safety management strategy.

- o Responsibilities - In general, the RE for the project will be the individual most closely related to the activities of contractors and other participating organizations. He/she is, therefore, the most logical individual for ensuring compliance with all aspects of the contracts including applicable safety orders. Designation of a responsible individual may vary from situation to situation, however each project must have a person or directive body in place to manage and monitor safety activities.

- o Documentation - Grantees are responsible for preparing a Safety Management Plan. It is normal practice for contracts to include safety specifications and procedures patterned after Federal and state occupational safety and health standards. Employers are required by law to provide a safe place of employment. Appendix F outlines a table of contents for a safety and security manual which may also be referred to as a Safety Management Plan.

- o Procedures and Controls - Contract specifications should describe procedures to be followed in effecting the control and monitoring of a project safety program. As a minimum, the following considerations are recommended:

  - Mandatory safety orientations
  - Weekly safety meetings
  - Site access control procedures
  - Mandatory contractor safety program
  - Preconstruction safety reviews

  Contractor safety considerations include:

  - Employee safety indoctrination
  - Inspection of unsafe working conditions
  - Inspection of tools
  - Housekeeping
  - Safety awareness reinforcement
  - First aid and medical facilities
  - Fire prevention and protection
  - Emergency response
  - Enforcement of subcontractor programs
  - Sanitation

- Public protection
- Protective clothing/equipment
- Tool box/lunch box meetings
- Construction equipment operation
- Employee skill certification

o <u>Accidents and Emergencies</u> - Procedures are required to quickly respond to accidents and emergencies to ensure the safety of personnel and property. The RE, control groups, and contractors must move rapidly following an accident or unsafe incident to isolate the cause and prevent recurrence. In a similar manner, the RE and the contractor should agree on procedures to be followed in the event of an emergency, to include persons to be notified, operational procedures, coordination with public agencies, protection of project and private property, and persons against further harm.

8.6.3 Insurance Protection

As described in Section 3.6.3.3, the grantee has two primary alternatives for insurance protection -- conventional and coordinated, or wrap-up. The latter approach has been gaining popularity for larger projects, but has been criticized for not providing strong incentives for contractor safety performance. The Safety Awareness Program associated with Washington, DC's Metrorail construction, overcomes this limitation by sharing reduced owner insurance cost with contractors, based on their safety performance. Thus, contractors have a monetary incentive to maintain an effective safety program.

8.7 COMMUNICATIONS

8.7.1 Program Development

Communications, both internal to the project team and external to a variety of agencies, institutions and the general public, are critical to the ultimate success of a transit project. This is particularly important in conveying details of the system's cost, safety, impacts on the surrounding community, timing, configuration, and explanations of controversial or project related issues. The ability to maintain strong public support for large and complex projects cannot be overemphasized -- communications is the means to accomplish that support and remove elements of doubt and rumor. Both internal and external communications programs should:

- Be carefully defined and become a part of the PMP.
- Have clear levels of authority for the release of information.
- Define a central figure on the project team or elsewhere in the owner's organization, generally a public affairs officer, with whom external agencies and the public can communicate.
- Represent the entire project, or have defined means for distinguishing between the grantee and the contractors.
- Conduct routine and periodic meetings and release status reports frequently to keep all parties informed.
- Represent themselves as credible and concerned with the public good.

8.7.2 Public Involvement

During the previous development phases of the project, the various groups and agencies affected by the project should have been identified. A comprehensive communications program should be established to effectively deal with their concerns during construction.

As the project progresses and reaches the Construction Phase, public concerns will rise, and it is important to have frequent and factual open dialogue on the details of the construction activities. These sessions should be conducted as close to the actual construction site as possible. The intent is to present an open forum for discussion and public involvement in the decision-making process.

8.7.3 Responsibility for Reporting

The PMP should have a separate section devoted to communication. The grantee will be required to decide how communications will occur and what authority levels are required for release of project specific information. It is common practice for both the grantee and the contractor to have separate public information offices. However, the grantee should set limits in writing for the types of information the contractor may release without prior approval, such as:

- o Routine noncontroversial project information
- o Awards and recognition
- o Information not related to the project or the grantee

Internal reporting of information is established in the PMP and special management plans. The Construction Management Plan should contain considerable detail for communications and include areas, such as the following:

- o Daily work schedules
- o Daily work progress
- o Materials status reporting
- o Accident reporting and emergencies
- o Daily costs and expenditures
- o Grievance procedures
- o Project manager, REs, inspector reporting procedures
- o Quality assurance and quality control
- o Equipment and resource status

The areas listed above, and many more, constitute the daily and periodic communications responsibilities of the project team. They, in turn, must communicate information to the grantee or representative of the grantee. Each grantee must decide how much information is enough to keep the organization fully informed without overburdening the project team. This balance must be carefully decided before the start of construction and changes kept to a minimum, exceptions handled on a case-by-case basis.

8.7.4 Reporting Systems

A number of the communications types listed in the preceding paragraph are systems within themselves and are routinely used during all construction projects to report progress and status of various aspects of the project. The majority of these will have already been established by the contractor and are necessary for controlling construction. The grantee should first determine the reporting system(s) to be used by contractors (to be specified in the bid documents), then determine what additional information is needed to be informed of project progress and keep external groups fully informed. Two of the more important reports the grantee will want to receive frequently will be the summary of project costs and construction (project) progress.

Reporting procedures and requirements are the responsibility of the grantee to establish, but as a minimum should include: safety, cost, status of construction status of fabrication, delays, material shortfalls, stoppages, external factors effecting the project, or other information which provides the grantee with a full understanding of the project's status. External reporting requirements generated by outside agencies will be factored into the overall reporting system and used to develop a comprehensive listing of information that is used by the grantee's organization, the contractor, and other organizations assisting the grantee.

CHAPTER 9

TESTING AND START-UP

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3.3 FINANCIAL ISSUES 3.3.1 Cost Estimates 3.3.2 Funding	4.3	5.3	6.3	7.3	8.3	9.3	10.3
3.4 MGMT. CONTROL SYSTEMS 3.4.1 Work Breakdown 3.4.2 Configuration Mgmt. 3.4.3 Quality Assurance 3.4.4 Schedule Control 3.4.5 Cost Control 3.4.6 Tools and Techniques	4.4	5.4	6.4	7.4	8.4	9.4	10.4
3.5 PROCUREMENT/CONTRACTS 3.5.1 Procurement Issues 3.5.2 Contract Administrtn 3.5.3 Dispute Resolution 3.5.4 Claims Management	4.5	5.5	6.5	7.5	8.5	9.5	10.5
3.6 SAFETY/RISKS/INSURANCE 3.6.1 Operational Safety 3.6.2 Construction Safety 3.6.3 Risk Mgmt/Insurance	4.6	5.6	6.6	7.6	8.6	9.6	10.6
3.7 COMMUNICATIONS 3.7.1 Develop Program 3.7.2 Audience 3.7.3 Responsibility 3.7.4 Reporting Systems 3.7.5 Interface Management	4.7	5.7	6.7	7.7	8.7	9.7	10.7

CHAPTER 9
TESTING AND START-UP

The Testing and Start-up Phase provides the necessary linkage between the Construction and Revenue Service Phases. The purpose of this phase is to accept the newly constructed or modernized facility as meeting the contractual specifications, and integration testing of the operating system prior to beginning or resuming revenue service. This phase actually overlaps with construction since some testing is performed in conjunction with construction contracts. As a supplement to the management principles presented in Chapter 3, Chapter 9 contains project management guidelines specifically related to the Testing and Start-up Phase of a transit construction project.

9.1 LEGAL/INSTITUTIONAL AUTHORITY, MANAGEMENT AND ORGANIZATION

Depending on the institutional arrangements and organizations involved in the implementation of the improvement project, the Testing and Start-up Phase could introduce an agency to operate a new start project, which is different from the agency which had been responsible for planning, design and construction. Even if the same agency manages both construction and operations of the improvement, it would most likely be a different organizational entity, i.e., the "operating division" versus the "project development division." While the operating organization should have provided input and review during the project's development phases, during the Testing and Start-up Phase it will gradually assume responsibility for all operations and maintenance functions. The exact timing and scope of this transition must be clearly identified and planned.

9.1.1 Legal/Institutional Authority

The agency responsible for operations and maintenance of the project must have that authority duly sanctioned by the appropriate governmental unit, typically the state. This authority would include the operation of a public transportation system, and the collection of fares from its users.

9.1.2 Management/Organization

An organization must be designated to perform the testing and start-up functions, and to operate and maintain the completed improvement project. The roles and responsibilities of the various facility and equipment contractors, design and construction management consultants and agency staff must be clearly defined.

9.1.3 Human Resources and Labor Relations

The appropriate labor categories must be available to support the testing and start-up functions. During this phase, staff should evolve to the full complement required at the initiation/resumption of revenue service. All skill levels should have the proper experience and training and, where required, certification of their competence. Training should encompass standard operating and emergency procedures. Management must be prepared to deal with employee unions and to negotiate labor agreements.

9.1.4 Interagency Agreements, Approvals and Permits

All interagency agreements, approvals and permits required prior to the commencement/resumption of revenue service must be identified and accomplished. Specific agency requirements should be incorporated into the test planning process to assure their timely achievement. The most significant agency requirements may be the certification of adequate levels of safety by the state public utilities commission (PUC) to permit system operation. Such requirements should be fully integrated into the project's design and quality assurance plan to avoid delays in receiving the agency's approval.

9.2 SYSTEM DEFINITION/CONFIGURATION/PERFORMANCE

During the Testing and Start-up Phase, the configuration of the constructed system should be documented by as-built drawings. In addition, the completed facilities, equipment, etc., should be tested to verify that the system and all subsystems achieve the performance specified in Final Design. Because Testing and Start-up is a complex, but vitally important element in preparing the new or modernized system for service, a standardized approach is recommended to conduct, monitor and coordinate all system elements. Such an approach is presented in Section 9.4.2.

As-built drawings should be prepared after completion of construction and installation. In doing so, marked drawings furnished by the resident engineer, field and design change notices, and corrections showing "conformed" sets of drawings in the design office should be used.

9.3 FINANCIAL REQUIREMENTS/RESOURCES

The project's overall financial situation should be monitored during the Testing and Start-up Phase, with concentration on operational budgets and revenue projections in addition to any capital cost anomalies. Adjustments in the project's financial plan should be made to accommodate current and projected funding requirements that exceed the defined funding resources. If necessary, system operational plans should be modified to conform to funding limitations.

9.4 MANAGEMENT CONTROL

9.4.1 Cost, Schedule and Progress

The control systems established during earlier phases of the transit project which monitor cost, schedule and progress should be maintained during the Testing and Start-up Phase, with special attention to the integration of those elements responsible for system operations and maintenance.

9.4.2 Quality Assurance

The Testing Phase is a critical element of the overall QA program. A comprehensive QA program for both the Construction and Testing and Start-up Phases is outlined in Section 8.4.3. Specific QA activities of the Testing and Start-up Phase are summarized in this section. They should be guided by a detailed Testing Program Plan (TPP) which should be prepared prior to the initiation of the Testing and Start-up Phase. It should be recognized that some subsystem and component testing will occur concurrently with some construction activities, requiring that the TPP be completed during the Final Design Phase. The TPP should reflect a test management process (an example is depicted in Figure 9-1 [Ref. 12]) and should govern contractually required materials, system integration and pre-revenue operations testing discussed in the following sections.

9.4.2.1 Test Planning

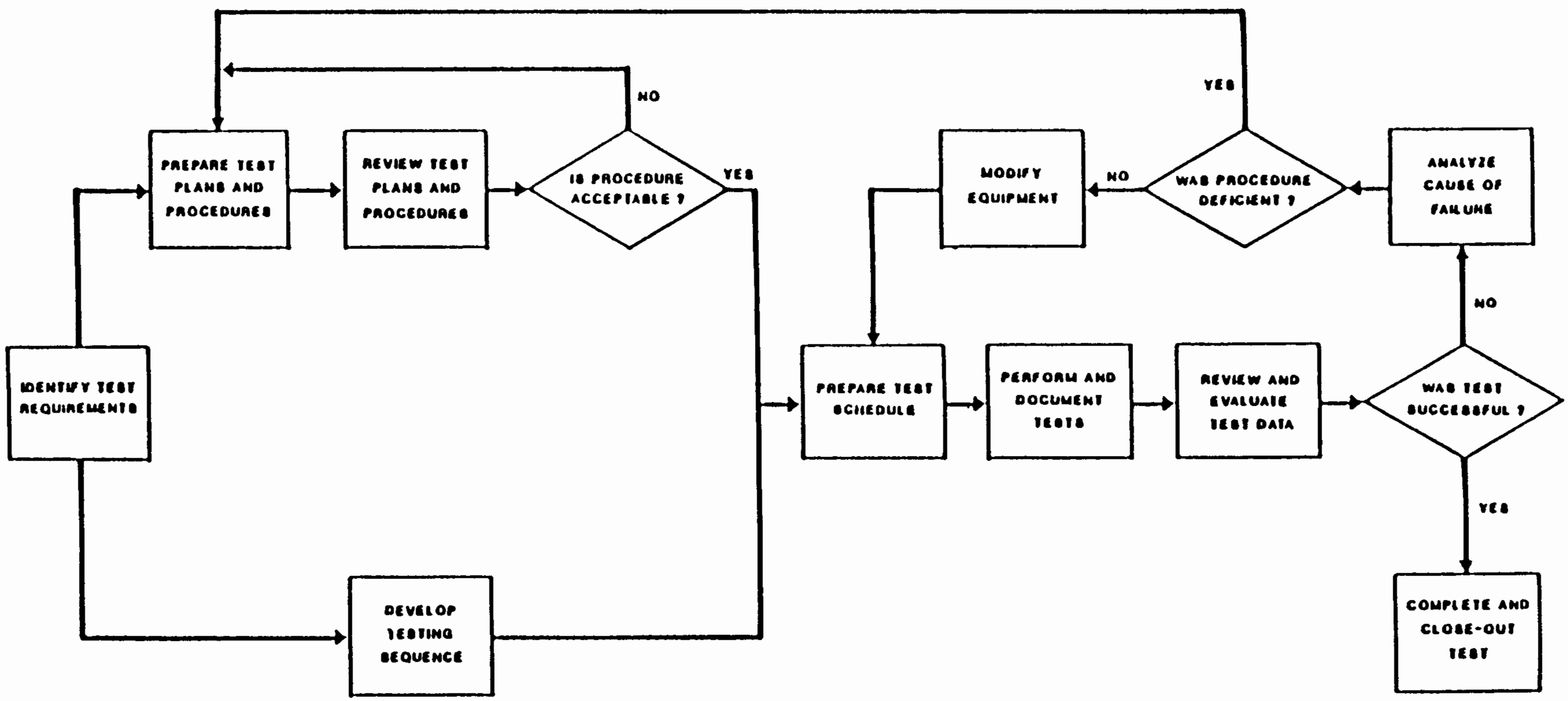
The Test Program Plan (TPP) should:

- Establish the process for conducting, monitoring, and coordinating the test program.
- Delineate the test organization and specify its authority and responsibilities.
- Describe the administrative requirements of the test program.

The TPP should be developed to ensure that management and technical resources are applied in a coherent and organized manner to achieve the test program objectives. The test program should include the following elements:

- Identification and Definition of Test Requirements - Contract specifications should define those tests necessary to ensure that equipment meets performance requirements. In addition to contractually required tests, system integration tests should be identified and performed to ensure that necessary compatibility has been achieved among all elements of the new system and with the existing system.
- Establishment of Test Program Administration System - Administration of the test program on larger projects will be a major undertaking and should be managed through computerization, using a system to monitor, control, document, and report on program status. A test numbering system should be established to assist in the administration and retrieval of testing documents.

FIGURE 9-1. SAMPLE TEST MANAGEMENT PROCESS [REF. 12]



- Development of Testing Sequence and Schedules - The test schedule should conform to, and support, the overall project schedule. The initial schedule established in test planning should be updated regularly during the subsequent phases of the project. The test program should be administered by a test management team established within the overall project organization. A test engineer should manage the test program with assistance from consultants and agency staff, as appropriate.

9.4.2.2 Contractually Required Testing

Contractually required testing should begin during the Construction Phase and continue through the start-up. The following categories of tests should be considered:

- Design Qualification Tests should be conducted by the contractor at the component/subsystem level during contractor engineering to demonstrate compliance to specification.
- Production Verification/Construction Inspection Tests should be conducted by the contractor at the component/subsystem level during production/construction to ensure the product is in accordance with design and/or workmanship standards.
- Installation Verification Tests should be conducted by the contractor at the subsystem level to ensure proper installation.
- Acceptance Tests should be conducted by the grantee representatives at the subsystem level to verify that performance of all delivered equipment is in compliance with specification.
- Demonstration Tests should be conducted by the grantee representatives in the Testing and Start-up and Revenue Service Phases to demonstrate the reliability of the system equipment. An Incident Evaluation Committee, chaired by a supervising engineer responsible for systems safety and assurance should evaluate the relevance of all failures to the reliability demonstration test program and require corrective action to be taken.

Contractors should be responsible for preparing plans and procedures for tests they are contractually responsible for performing. The contractor should submit the test plans and procedures for review and approval. A grantee representative (agency staff or consultant) should ensure that an adequate review is conducted and authorize the contractor to proceed with the test. Test results and reports should also be promptly reviewed by grantee representatives and written approval or rejection provided to the contractor. Grantee representatives should develop plans, procedures, and reports for acceptance and demonstration tests. Tests should be scheduled, conducted, and documented in accordance with the approved schedules, plans, and procedures and should be monitored by grantee representatives. Formal reports on the status of the test program should be issued monthly to project management.

9.4.2.3 Materials Testing

Requirements for testing of materials should be defined in the contract documents for construction materials and for materials required to fabricate equipment. In addition, testing of products for which fabricators submit material certificates or certificates of compliance should be conducted on a random basis or when the validity of the materials/products or documentation are questionable. Contract-specific inspection and test plans should identify the products/materials which most likely require testing.

9.4.2.4 System Integration Testing

System integration testing should be conducted upon completion of the contractually required acceptance tests. The system integration testing should be performed to demonstrate the ability of various subsystems and facilities to work together as a system and for the new or modernized system to function with an existing system. The system integration testing should be performed by the owner's staff with support, as required, from consultants. A test engineer should administer the specific contract for the performance of tests determined necessary.

Each test should be documented in a formal report prepared by the grantee representatives who conducted the test. Tests which affect system safety should be reviewed independently by a Safety Certification Review team to ensure that potential hazards are identified and resolved. During system integration testing, equipment suppliers should be required to participate in tests of their equipment so that problems can be expeditiously investigated and corrected. Equipment changes resulting from systems integration testing should be subjected to the configuration management procedures defined for the project.

9.4.2.5 Start-up Operations

For entirely new systems, during the Construction Phase, the owner should recruit and train personnel to operate and maintain the facilities. Prior to Revenue Service, the owner should simulate service to test whether all system elements are functional and perform as designed. Start-up operations should verify the competence of the personnel and ensure a smooth transition from construction, through testing, to revenue service. Start-up operations should verify, through documented demonstrations:

- The ability of the owner/operator to coordinate plans, rules, procedures, equipment, facilities, and personnel to sustain reliable and safe normal revenue service.

- The ability of owner/operator and outside agencies to coordinate plans, rules, procedures, equipment, facilities, and personnel to provide safety for employees, passengers, and property during abnormal/emergency operations.

9.5 PROCUREMENT, CONTRACTS, DISPUTES AND CLAIMS

9.5.1 Procurement

During the Testing and Start-up Phase, procurement attention for new systems should focus on those services required to operate and maintain the constructed project. This issue is minimized when the operating agency is also the implementing agency. When this is not the situation, an agreement must be made granting operating authority to the selected agency and clearly defining all rights and responsibilities of both agencies.

9.5.2 Contractual Disputes and Claims

Contractual disputes may frequently arise during the Testing Phase due to the unacceptability of the completed facilities and equipment. The goal should be to avoid disputes by clearly specifying in the construction bid documents, the performance requirements and testing procedures for the entire system and all subsystems. (Refer to Section 3.5 for general principles related to the management of contracts and disputes and Section 8.5 for specific dispute resolution procedures associated with construction contracts.)

9.6 SAFETY, RISK MANAGEMENT AND INSURANCE

During this phase, a transition occurs from construction to operations, which directly affects the approach to safety, risk management and insurance. The previously developed System Safety Program Plan should address all aspects of operational safety and should guide standard and emergency operating procedures. Adequate insurance coverage should be effective during Testing and Start-up to cover both the "construction" insurance needs and the "operational" insurance needs for contract personnel, employees and the public.

9.7 COMMUNICATIONS

During the Testing and Start-up Phase, communications should emphasize public relations related to the progress of the transit project as it approaches completion and readiness for public operation. Community relations staff should strive to generate public interest in using the completed facility, and should include creative marketing approaches to achieve this goal.

CHAPTER 10

REVENUE SERVICE

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3.5 PROCUREMENT/CONTRACTS 3.5.1 Procurement Issues 3.5.2 Contract Administrtn 3.5.3 Dispute Resolution 3.5.4 Claims Management	4.5	5.5	6.5	7.5	8.5	9.5	10.5
3.6 SAFETY/RISKS/INSURANCE 3.6.1 Operational Safety 3.6.2 Construction Safety 3.6.3 Risk Mgmt/Insurance	4.6	5.6	6.6	7.6	8.6	9.6	10.6
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CHAPTER 10
REVENUE SERVICE

Transit capital project management concerns typically end at the conclusion of the Testing and Start-up Phase. Attention during the Revenue Service Phase is necessary in order complete the project development cycle. Those responsible for operations should continually strive to maintain a high level of system performance and a process should be instituted for system capital replacement and modernization planning.

10.1 LEGAL/INSTITUTIONAL AUTHORITY, MANAGEMENT AND ORGANIZATION

During the revenue service phase, the transit authority has complete responsibility for all aspects of system operation and maintenance (O&M). For new systems, evolution to transit authority management should gradually begin from O&M reviews in the PE Phase to the Testing and Start-up Phase when O&M personnel begin to assume control of the newly constructed system. In addition to any other system development efforts that may be occurring within a transit authority, an operating organization must be established to perform the following functions:

- Transportation
- Training
- Personnel
- Engineering
- Equipment Maintenance
- Facilities Maintenance
- Public Relations
- Government Relations
- Information Systems
- Planning and Analysis (strategic, modernization, operational)
- Safety
- Security
- Legal
- Claims
- Finance
- Revenue Collection
- Purchasing
- Marketing
- Administration

10.2 SYSTEM DEFINITION/CONFIGURATION/PERFORMANCE

Efforts during Revenue Service should be directed toward maintaining system performance and planning for modifications of the existing system, if needed. At the same time, planning initiatives related to new routes and extensions which would be encompassed within the System Planning Phase discussed in Chapter 4 may be undertaken. The experience of several transit authorities in planning the modernization of their existing rail systems has been documented in Rail Modernization Planning: Review of Current Practices [Ref. 4], and is relevant to the considerations in this section.

In particular, the experience of the Bay Area Rapid Transit (BART) system in San Francisco is applicable to other newly constructed fixed guideway transit systems. Supported by an effective operational performance information system, BART has focused its planning and analysis efforts related to its existing system on overcoming design deficiencies, improving system performance and increasing capacity. This process involves periodically revising the organization's goals and operating performance objectives, developing capital and operating programs to best achieve the goals and objectives, and monitoring ongoing system performance both in general terms and against specific performance objectives.

BART's Reliability Improvement Program (RIP) is a model process which was instituted in the years after the system was constructed to systematically improve system reliability and safety. The RIP includes a definition of key system problems, analysis of their affect on service and measurable performance units, establishment of performance goals, careful assessment of the primary causes of the unsatisfactory performance, design and implementation of the most potentially effective projects to solve the problems, and measurement of the impact of the changes.

10.3 FINANCIAL REQUIREMENTS/RESOURCES

The previously developed project financial plan should have sufficient resources defined to accommodate routine O&M costs which exceed revenues, as well as periodic capital replacement. The newer rail systems have been devoting considerable attention to the subject of capital replacement planning with the goal of making those capital expenditures on equipment and facilities which will maintain their systems at a high level of performance, economy and attractiveness.

10.3.1 Capital Replacement Planning

UMTA has sponsored two studies [Ref. 2 and 4] which have addressed rail modernization planning and analysis issues. More recently, the TRB report entitled Transit Management and Replacement Capital Planning [Ref. 23], documents approaches to dealing with this issue. Because of the UMTA funding categorization, the term "modernization" has become synonymous with "capital replacement" which include the following [Ref. 2]:

- Refurbishment - The restoration of equipment and facilities to adequate standards of performance, which, if neglected, could cause safety hazards or serious disruption of service. Refurbishment should result in the capability to sustain the existing system performance for at least five years with only a nominal increase in life cycle costs.
- Rehabilitation - The substitution of worn or weakened materials, components or subsystems with those having basically the same fit and function as the original equipment. Rehabilitation should result in an improvement in system performance for a range of 5 to 20 years and a reduction in life cycle costs.
- Modernization - The use of proven new materials, components or subsystems to meet higher standards of productivity than are possible with the original equipment or materials. Modernization should result in reasonable improvements in system performance for a period ranging from 10 to 30 years at no increase in life cycle costs.

The system operator should develop a methodology for planning and programming capital replacement projects based on a variety of performance and cost criteria. In addition, the process should permit the implementation of modernization projects on a strictly economic basis. In that situation, the capital cost of a modernization project could be justified by the corresponding reduction in O&M costs. The ratio of the annual O&M cost savings to the capital cost of the improvement is called the return-on-investment or ROI. The time it takes for the annual O&M cost savings to equal the initial capital investment is called the payback period. The greater the ROI or the shorter the payback period, the more attractive is the associated capital investment. An example is the replacement of a manual system with a partially or fully automated system. The new system could be economically attractive if the net reduction in O&M cost was high in relation to the capital cost of the automation equipment.

10.4 MANAGEMENT CONTROL SYSTEMS

Management control systems and procedures should be implemented in accordance with previously developed and approved plans to support the operation of the constructed/modernized capital improvement project.

10.5 PROCUREMENT, CONTRACTS, DISPUTES AND CLAIMS

Procurement and contractual policies and procedures should be implemented in accordance with previously developed and approved plans to provide for the acquisition of services and materials required to support the operation of the constructed/modernized capital improvement project.

10.6 SAFETY, RISK MANAGEMENT AND INSURANCE

Safety, risk management and insurance policies and procedures should be implemented in accordance with previously developed and approved plans to protect employees, users and the public during the operation of the constructed/modernized capital improvement project.

10.7 COMMUNICATIONS

Communications policies and procedures related to the internal organization, public relations and governmental/institutional liaison should be implemented in accordance with previously developed and approved plans to support the operations of the constructed/modernized capital improvement project.

APPENDIX A

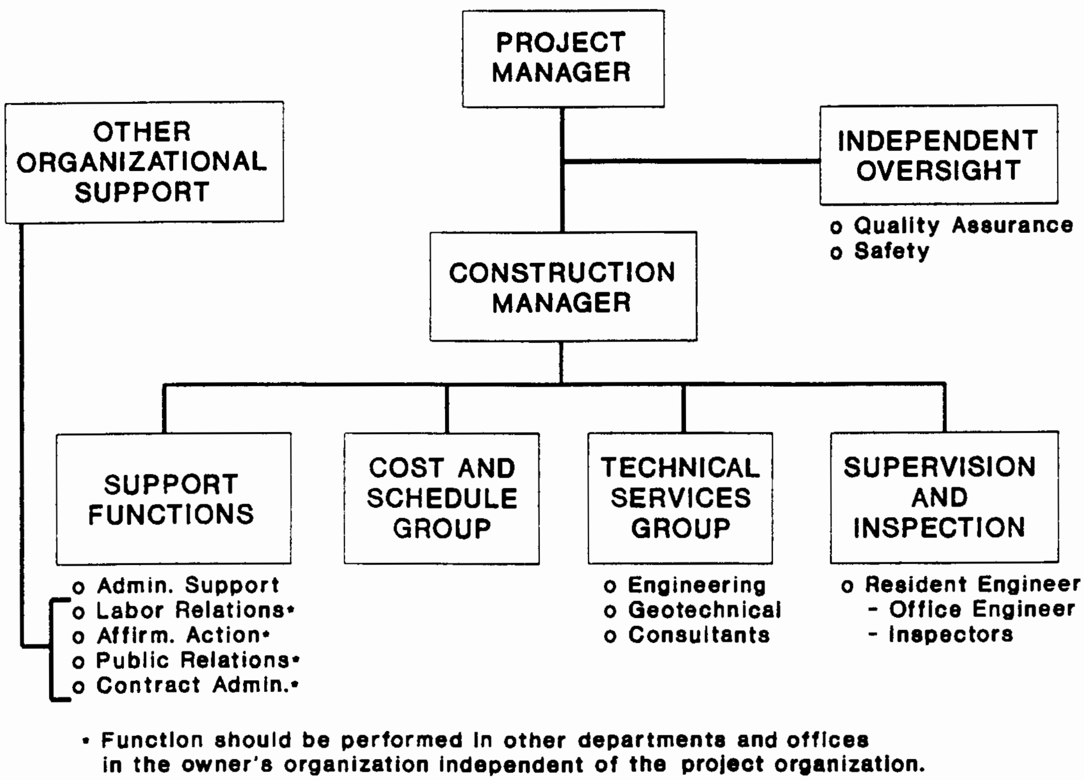
SUGGESTED PROJECT TEAM FUNCTIONS AND RESPONSIBILITIES

APPENDIX A

EXAMPLE PROJECT TEAM FUNCTIONS AND RESPONSIBILITIES

A project team established to manage construction of a transit capital improvement commonly includes the following staff positions for which suggested descriptions for duties and responsibilities are presented. Figure A-1 depicts this implied organization chart.

FIGURE A-1. SAMPLE PROJECT MANAGEMENT ORGANIZATION CHART FOR CONSTRUCTION PHASE



A.1 PROJECT MANAGER

The project team leader is usually designated as project manager (PM). He/she should be selected on the basis of organizational ability and experience on projects of similar size and scope. The selection of the PM should be made with careful consideration of individual experience and general knowledge. The ability to lead and motivate people, think clearly under stress, and the willingness to make decisions, are as important as technical qualifications.

A.2 OTHER TEAM MEMBERS

The other team members should be selected from appropriate technical and program backgrounds commensurate with the type of project being developed. In addition to the technical complement of the team, appropriate qualified persons from budgeting, cost estimating, and contracting disciplines should be appointed. Those members selected from program and administrative support areas should also have straight channels to the decision authority. The total number of team members depends on the project size and complexity, and could consist of the following:

A.2.1 Independent Oversight

A.2.1.1 Quality Assurance Manager

The Quality Assurance (QA) Manager should report directly to the PM and be a source of independent oversight on the contractor's QA program and the Construction Management Organization (CMO) Supervision and Inspection activities.

A.2.1.2 Chief Safety Engineer

The Chief Safety Engineer should report to the PM and have the overall responsibility to develop, monitor and enforce the safety plan for the overall construction program. He/she should serve as the liaison between the PM and the construction contractors and the various contractors' safety personnel and should:

- o Supervise the assistant Safety Engineers.
- o Implement the PM's safety program to eliminate accidents, promote maximum efficiency through safe work methods and conditions, and the reduction of direct and indirect costs of accidents.
- o Make frequent and unscheduled inspection of the work in progress and report hazards or unsafe practices to the Resident Engineers for immediate action or remedy.
- o Conduct regular safety meetings with the contractor's foremen and representatives of the various crafts employed on the construction program.
- o Assure compliance with OSHA and state/local safety requirements and applicable codes.
- o Develop a program of safety and first aid instruction to be offered to both construction management and contractor's personnel.
- o Ensure the Contractor's compliance with the provisions of the project's construction Safety Manual.

The Chief Safety Engineer should coordinate the safety program with the grantee's insurance representatives to develop, monitor and ensure a uniform system of safety, accident prevention and reporting procedures.

Construction plans should be reviewed to identify and eliminate possible hazards, and to assure compliance with state and local safety standards. Should special hazards occur, the Safety Engineer should recommend to the contractor methods of protecting construction and minimizing potential damage.

A.2.2 Construction Manager

The Construction Manager (CM), assisted by one or more deputies, is responsible for the overall supervision and performance of the CMO and is directly and fully responsive to the PM for the execution of the services to be provided. The CM assures that all construction and procurement activities of all contractors meet the schedule, cost and quality objectives of the project management plan and that the highest level of expert advise and assistance is provided in all matters related to construction and procurement. The CM should:

- o Manage the construction.
- o Make recommendations to and assist the PM in the selection of contractors.
- o Advise and keep the PM current on the progress of the work. With the assistance of staff, be responsible for recommending solutions to problems and correcting deficiencies encountered during the course of the work.
- o Inform the PM on quality of work being performed.
- o Make recommendations to the PM for acceptance or rejection of billings for scheduled work, changes or extras.
- o Provide technical advice and assistance to the PM at meetings with other groups as required.
- o Coordinate construction activities with other agencies.
- o Institute and assure an acceptable safety program.

A.2.2.1 CM Support Functions

Several significant functions should be available to support the CM. These include Administrative Support, Labor Relations, Affirmative Action, Public Relations, and Contract Administration. Except for Administrative Support, the other functions should be performed in other departments and offices in the owner's organization independent of the project organization.

Administrative Support

The Administrative Support Section should be responsible for the day-to-day control of the internal matters of the project in support of the CM. Although these personnel meet the needs of the CMO, they also serve to maintain records for the PM's review on equipment, materials and labor hours expended. They should:

- o Maintain complete inventory records on all equipment purchased or rented under this contract.
- o Maintain adequate expendable supplies to meet the needs of the CMO.
- o Maintain personnel records related to time on the job for all team members.

- o Prepare labor and material invoice data.
- o Control of all reproduction equipment and requirements.
- o Keep historical records on all labor and material costs.
- o Provide Personnel Management including hiring, transfer and records of all personnel assigned to the project.
- o Prepare billings for the PM on a regularly scheduled basis.
- o Maintain complete financial accounts for the project and provide reports, as required.
- o Maintain security of the office, equipment and records of the project.

Labor Relations Advisor

The Labor Relations Advisor should assist the CM in matters pertaining to labor market and jurisdictional requirements. The Labor Relations Advisor should serve only as an advisor and should not become directly involved in any disputes which may arise during the course of the assignment. In general, however, he/she should advise the PM of the potential impact of labor problems to the project. The Labor Relations Advisor should also:

- o Assess the labor market in the general area and advise the CM on availability of labor by categories.
- o Periodically review the status of the labor agreements and note any potential problem areas.
- o "Walk-the-job" periodically to evaluate working conditions which may cause labor disputes and advise the CM.
- o Review any disputes and advise the CM on recommendations he may make to the PM.
- o Review contractors' payrolls for labor law compliance.

Affirmative Action

The Affirmative Action Section should be responsible for assuring compliance of equal employment opportunity criteria. This effort includes the monitoring of the various contractors working on the project as well as the selection of the contractors to be awarded construction packages. They should:

- o Develop, institute and monitor a plan for developing construction packages which can be executed by DBE firms.
- o Develop lists of DBE firms and determine their capability to participate as contractors on portions of the project.
- o Review the hiring practices of major firms and determine their compliance with established criteria.
- o Monitor Equal Employment Opportunity programs of the CMO.
- o Work with small contractors and assist them in establishing joint ventures capable of performing on the project.
- o Review supplier lists and assure that DBE firms are being properly represented.
- o Make recommendations to the CM for any non-compliance items.

Public Relations

The Public Relations Section should be responsible for all public relations including activities to:

- o Assist the PM in preparation of news releases regarding the progress of construction.
- o Assist the PM in conducting tours for interested public and governmental groups.
- o Attend meetings of community groups and present information regarding the progress of construction.
- o Assist the PM's Public Relations staff in preparing any general information concerning the project.
- o Prepare general statements concerning the progress of the construction project to present to community groups as required.

Contract Administration

The Manager of Contracts should be responsible to the CM to maintain cognizance over the contractor's performance and to assure conformance with the contract terms and conditions. He/she should also be available to assist the PM in all contractual matters related to construction. The Manager of Contracts should:

- o Establish a line of communication with Contractors to assist in the development of standard and special contract clauses.
- o Review all bid documents and proposed contract terms and conditions for completeness and attend pre-bid conferences.
- o Maintain procurement files.
- o Ensure that procurement procedures are followed to the letter.
- o Evaluate claims.
- o Evaluate change orders to determine impact on base contracts.
- o Provide guidance and consultation to the Resident Engineer (RE) in matters of contract compliance, contract interpretations, preparation of change orders and documentation of claims.
- o Seek advice from the owner's legal department, as required.

During the course of the project, the Contracts Group should assist in the development of construction bid packages. They should then assist in the evaluation of the bids by reviewing contract compliance items and advising the CM of their completeness.

A.2.2.2 Cost and Scheduling Group

The Cost and Scheduling Group (CSG) should function as "the watchdog of dollars and time." The grantee, in coordination with the PM, should have developed a cost and scheduling program. The management tools utilized by the CM should interface with the grantee's system and be entirely compatible. The Chief of CSG should be responsible for maintaining all project control systems. With the assistance of cost engineers and schedulers, the Chief of CSG should:

- Prepare estimated and detailed progress reports at the required reporting intervals, and alert the CM of potential schedule slippage or cost overruns so that alternatives may be developed.
- Monitor change orders and deviation cost estimates, expedite contractor submittals and procurement packages, maintain all project data, information and contract documents.
- Maintain the system of cost accounts, monitor cost progress, and prepare cost reports.
- Monitor schedule progress, develop detail schedules, update or revise the project master schedule for the overall program, prepare schedule status reports, and maintain schedule status information.
- Assist the CM in the preparation of presentations to the PM, Grantee and other groups.
- Maintain continual cost and schedule awareness throughout the job.
- Collect and relate all costs to established budgets for individual elements of work within various work packages.
- Accurately forecast costs and schedules to complete the program.
- Keep the PM completely and regularly informed.
- Identify potential problems (cost and schedule) in advance so corrective measures may be initiated.

A.2.2.3 Technical Service Group

The Technical Service Group (TSG) should be responsible for engineering and/or technical aspects of the assignment. In general, they should be concerned with environmental monitoring, shop drawing review, constructibility and value analysis, start-up operations and training, and geotechnical.

Engineering Services

The Chief of Technical Services should be responsible for those areas of the project requiring engineering analysis and support. He/she should interface with the General Consultant (GC) in the performance of design reviews for constructibility, shop drawing review, and construction phasing and scheduling and should:

- o Maintain liaison with the PM and the GC for the purpose of ensuring engineering control of the project.
- o Coordinate the efforts of the engineering staff in providing engineering services at all levels on the project as required.
- o Evaluate suitability of all material samples and contractor-furnished special equipment and fabricated construction elements and recommend appropriate approval or disapproval.
- o Identify and review potential design changes, make studies or provide clarifying sketches as may be necessary to define the most desirable scope of change.
- o Review the project designs for constructibility and make recommendations as required to insure that construction methods are economical and that future maintenance costs are minimized.
- o Inspect the work, take samples, laboratory test materials and test equipment to assure work conforms to plans, specifications and shop drawings.
- o Perform or coordinate design interpretation as required to supplement the capability of construction supervision.
- o Identify the need for and recommend any specialized engineering tasks that may be required.
- o Examine, control and approve shop drawings, samples and certificates in accordance with the contract.
- o Review and coordinate change orders with Cost Control as required to evaluate impact on design.
- o Direct, review and monitor a monumentation program for the track and other system-wide facilities.
- o Participate in the resolution of those construction problems which may indicate a revision to track alignment. Provide and coordinate office engineering support of field survey party.

Geotechnical Services

The Geotechnical Section has been made a part of the Technical Services staff because of its extreme importance in monitoring the integrity of the construction program and its impact on surrounding structures or personal safety. As delegated by the Chief of Technical Services, the Manager of the Geotechnical

Section should be responsible for all Geotechnical aspects of the project and should:

- o Supervise the pre-bid review of plans and specifications as they relate to instrumentation and other geotechnical items.
- o Conduct the instrumentation program.
- o Supervise the field testing of soils and aggregates.
- o Supervise boring contractors.
- o Examine and approve foundations.
- o Evaluate test piles and pile and foundation load tests.
- o Assist in inspection of geotechnical related items of work.
- o Review the adequacy of temporary support and permanent lining systems for tunnels.
- o Assist in the evaluation of claims relating to differing site conditions.

<u>Consultants</u>

To supplement the expertise provided by the full time staff, periodic or full time consultation should be provided by the GC or other specialty firms.

A.2.2.4 Supervision and Inspection

The Manager of Supervision and Inspection (S&I) should be responsible to the CM and should, with the aid and assistance of the staff of REs, Inspectors and Technicians, oversee and expedite the day-to-day operations of the contractors. The Manager of S&I should have two principal assistants: one responsible for administrative duties, and one responsible for coordination with outside agencies. The Manager of S&I should:

- o Supervise and direct the activities of the REs to assure commonality and uniformity of procedures.
- o Assure compliance with master schedules and advise as to overall status of the construction.

- Develop and implement a labor utilization program whereby inspectors and other RE support personnel are utilized efficiently in accordance with periodic shifts in the work load.
- Develop and implement an experience feedback system for documenting, distributing, and controlling "lessons learned" in one section to assure all other section managers are advised in a timely manner to avoid repetition of problems and provide methods of improvement.
- Monitor the contractor's work for adherence to the established schedule.
- Assure that the recommendations of the Safety Engineer are complied with by all of the contractors' employees.

The Manager of S&I should be responsible for the performance of construction related surveys. Field parties assigned to the department should check the contractors layout, monitor monuments established by the contractor to detect movement of buildings and other facilities, and assist the inspection staff with quantity measurements. Upon completion of the structural units of the system they should establish control monuments, working under the supervision of the Manager of Technical Services.

The Manager of S&I should maintain liaison with the Chief Safety Engineer on all matters relating to the Safety Program. Inspection personnel should monitor the operation of contractors and subcontractors for compliance with safety regulations and should immediately report any violations.

The Manager of S&I and staff should perform the necessary coordination with the various regulatory agencies in order to eliminate or minimize delays to the project and inconvenience to the public. All matters affecting the public should be closely coordinated with the Head of the Public Relations Section.

The CM's authority relative to the contractors' efforts can be delegated to the Manager of S&I. The assigned REs should monitor the progress of the contractors and subcontractors and facilitate cooperation among the various contractors operating within specific areas. The REs should assure all verification of validation and acceptance testing, and recommend final acceptance of the work upon completion of work by the contractor. Final acceptance procedures require pre-final and final inspection demonstrating compliance with contractual provision.

QC of materials and workmanship should be the responsibility of the Manager of S&I.

Resident Engineer Offices

A RE and a relatively small staff consisting of an Assistant RE, Office Engineer, and one or more Senior Inspectors should be assigned to each of the offices. Additional personnel should be assigned, as required. A manual should be developed to guide the functioning of the RE's Office. A sample table of contents of a RE's Manual is included in Appendix G.

During the pre-bid phase of each construction contract, the Manager of S&I, and the RE assigned to the contract should assist in the review of plans and specifications for constructibility, package sizing, material utilization and availability of labor and equipment.

REs should normally be assigned to major portions of the project; for example, underground stations, major lines, above ground facilities, etc. Under the direction of the Manager of S&I, the REs should:

- Represent the PM to the contractors and act for the PM and the grantee.
- Act as the focal point for all correspondence received from the contractor and sent to the contractor.
- Maintain the PM and CMO official correspondence files related to his assigned contracts.
- Maintain the schedule and control the operation of the contractors and subcontractors performing work in his area.
- Schedule and assure performance of required inspections and tests pertaining to his/her area.
- Mediate disputes.
- Supervise personnel assigned.

- o Maintain daily contact with the contractors.
- o Conduct progress meetings.
- o Monitor quality of materials and workmanship.
- o Document and assess and report potential claims.
- o Review invoices for progress payments.
- o Maintain a daily log of work activities.

Assisting each of the REs should be Office Engineers and Inspectors. Their general duties are described below.

Office Engineer - Reports to the RE and should be responsible for routing documentation and record keeping, measurement and computation of quantities, maintaining as-built drawings and other office duties. The Office Engineer should:

- o Maintain the contract records.
- o Establish filing system and supervise secretary to see that files are in good order.
- o Review Inspectors' Daily Reports for completeness.
- o Compute pay quantities.
- o Prepare periodic, semi-final and final estimates.
- o Review activities of Inspectors as they relate to quantity measurements to assure measurement are current and there are no omissions.
- o Receive, log in and transmit contractor's shop drawing and material samples submittals to Chief of Technical Services, and transmit approved drawings to contractors.
- o Continuously review shop drawing log, job schedule and job progress and advise RE whenever it appears shop drawing submittals are lagging.
- o Maintain a set of as-built drawings and conformed specifications.
- o Attend progress meetings and prepare minutes.
- o Compile data required for reports to be submitted by the RE.
- o Assist Inspectors during periods of intensive construction activity.

Inspector - Responsible to the RE for the inspection of workmanship and materials for assigned items of work. He/she should observe, record and report on the activities of contractor, subcontractors, utilities and others on the project site. The duties of the various classes of Inspector (senior, junior, etc.) are generally the same, varying principally in the complexity of the assignments and degree of responsibility. The Inspector should:

- Study the plans, specifications and approved shop drawings to become thoroughly familiar with the contract requirements.
- Observe the Contractor's activities, call his attention to any deviations from the contract, and immediately report any lack of compliance to the RE.
- Record on the Inspector's Daily Report the items of work performed, men and equipment assigned to work, hours worked, weather conditions, idle equipment, delays, disputes, unusual occurrences, changed site conditions, quantities of work measures, and materials received and used.
- Perform field test of materials such as concrete slump and air entrainment.
- Check incoming materials to determine that they have an acceptable laboratory test report or certification.
- Assist surveyors in checking line and grade. Check location of various elements of work, such as concrete forms, to determine if they are in the proper location with respect to basic line and grade.
- Observe workman's activities for compliance with safety rules.
- Assist Office Engineer in computation of quantities.

APPENDIX B

QUALITY ASSURANCE PROGRAM

APPENDIX B
QUALITY ASSURANCE PROGRAM [Ref. 9]

B.1 ORGANIZATION

The development and conduct of the QA program is the responsibility of the owner. Implementation is achieved by assigning responsibility to consultants and contractors. In all cases, overall auditing and surveillance of the program is performed by the owner.

The QA Program should have a distinct responsibility assigned to each individual department under the overall organization structure of a transit capital project. The interrelationships between various departments for QA purposes should be clearly defined in the PMP.

B.2 TECHNICAL REQUIREMENTS

Technical requirements for the QA program should consist of the contractor's QA program, the owner's audit of the contractor's program, the surveillance of the work, the testing program, and control of the configuration.

B.2.1 Contractor's QA Program

Administration of the contractor's QA program should be vested in a responsible, authoritative element of the organization with clear access to management. Sufficient authority should be assigned to ensure that quality requirements are consistently maintained. There should be adequate planning, forceful direction, and control of the program.

The contractor's QA program should address, as a minimum, the following 13 elements:

- o <u>Configuration Control</u> - Documentation should be controlled to ensure that fabrication, installation, inspection, and testing are performed in a manner that meets the latest applicable requirements. All changes to the documentation package should be controlled to ensure they are approved. The configuration of all the contractor's work should be known at all

- Inspection/Test Plans - Plans should be developed to organize inspection and testing to ensure adequate control over the work to verify acceptability. The plans should control the progress of work to provide evidence of acceptability and to discover nonconforming conditions at the earliest time and should ensure that preparations for inspection and testing are provided and that equipment, instrumentation, fixtures, and personnel are available when required.

- Nonconforming Materials - The inspection status of materials should be identifiable at all times, and the means employed to identify the inspection status should be controlled to prevent unauthorized use. Nonconforming materials should be separated to prohibit their use, and procedures for the disposition of nonconforming material, including owner acceptance of rework and "use as is" decisions, should be established.

- Calibration - All measuring instruments and fixtures or gauges used in evaluating items for acceptance must bear evidence of calibration. A system should be employed to ensure that all such measuring devices are recalibrated at appropriate intervals and that out-of-calibration items are withdrawn from use. The standards used to perform calibration should have a known traceable relationship to the National Bureau of Standards.

- Procurement and Receiving Inspection - Adequate control over procurement sources should be maintained to ensure the incorporation of the pertinent technical and quality requirements. Inspection and testing should be performed on procured materials, and adequate records should be maintained.

- In-Process Inspections and Tests - Sufficient control over work activities should be maintained to prevent nonconformance and excessive variability and to ensure compliance with requirements that can be verified only at the time and point of work. Inspections and tests should be performed in accordance with documented procedures that include acceptance criteria.

- Final Inspection and Testing - Inspection and testing of completed work should be performed to ensure that the quality requirements of the contract have been met. The inspection and testing should be performed in accordance with procedures developed by the contractor and approved by the owner. Test results should be recorded and submitted to the owner.

- Shipping Inspection - Provisions should be made to control the handling, preservation, and packaging of items to prevent damage, deterioration, loss, or substitution.

- Installation Inspection - A system of inspection should be employed throughout the installation work to ensure compliance with requirements. Records should be maintained to document which inspections were performed and whether the work conformed to requirements. All records should be available for the owner's review at the time of the owner's inspection and should be subject to audit at any time.

- Contractor Audit - Periodic audits should be conducted by the contractor to verify effective implementation of their QA program.

- Corrective Action - Records should be maintained for all inspections and tests. These records should include data concerning conforming and nonconforming conditions and should be reviewed periodically and summary information provided to the responsible management. Each owner-initiated record reporting unacceptable conditions should be evaluated fully. A response from the contractor to the owner should be required for each such record and should identify the cause, corrective action, and implementation schedule. Prompt action should be taken to correct conditions that cause nonconformance, and an evaluation of the corrective action should be performed to measure its effectiveness.

- Documentation/Records - The contractor should maintain records of its QA program and these should be made available to the owner upon request. These records should include inspection and test results as well as the results of audits performed by the contractor to evaluate the effectiveness of their program.

B.2.2 Owner's QA Audits

Owner QA audits conducted to evaluate the contractor's program should be performed at the source of manufacturing/construction and should include selected supplies. They should involve a review of the QA system; verification of its implementation; and a status, documentation, and configuration evaluation of the hardware.

The audits should be based on applicable portions of the contract specifications, the referenced contract documents, the approved contractor QA program plan, and the owners's QA audit evaluation forms. The general procedure followed during the course of an owner audit should include an interview with the contractor's management to describe the audit process and arrange for coordination with the contractor's personnel; system, hardware, and inspection audits; and informal review of findings with the contractor's management; and a formal report on the audit issued through the office responsible for administering the contract.

During the audit of the contractor's QA program, the owner's resident or itinerant inspection activity is audited. The availability of contract specifications, approved drawings, inspection results, and test procedures is ascertained. Activity and inspection reports are reviewed and findings are documented.

Formal and informal audits are conducted throughout the program to verify that work conforms to the approved configuration. Formal audits are conducted at the time of qualification testing and on the first production items presented for shipment approval. Informal audits are part of the normal surveillance inspection activity.

B.2.3 Contractor Surveillance

The owner should review all work pertaining to the manufacture and/or installation of equipment. For critical items and when the acceptability of an item can be verified only at the time and point of manufacture, in-process inspection should be performed. Equipment manufactured for the system should be inspected before the contractor is granted a "release for shipment." Installation work should be inspected at milestone events such as installation verification and after final testing.

The inspections performed should ensure that workmanship complies with requirements and conforms to industry standards, that the configuration of the equipment conforms to the latest approved documents and/or that deviations are identified, and that the contractor's documentation verifying acceptability is complete and adequate. To assure that all work performed complies with requirements, hold points for owner inspection should be established throughout the process of procurement, manufacture, and test. Resident or nonresident inspectors should be assigned to perform inspections, and a system of documentation should be employed to record data concerning the inspections performed and the findings.

The requirements should be defined by the specifications, contract drawings, approved contractor drawings, referenced standards, and related owner-approved documentation. Workmanship should be assessed in terms of the specifications and referenced standards; however, in their absence, the contractor's workmanship standards would apply if fully documented and not in conflict with general industry practice. Disagreements should be adjudicated by the owner.

An integral part of inspection is a review of the contractor's inspection records for the work being inspected. The records should demonstrate the contractor's

QA verification of the acceptability of the equipment or work presented and the satisfactory completion of all appropriate prerequisites. Prerequisites are contractual events that must be satisfactorily concluded prior to the inspection. Typically, the hierarchy of prerequisites is as follows:

- QA program plan
- Reliability, maintainability, safety requirements
- Drawing approval
- Qualification tests
- Factory tests
- "Release for shipment" inspection
- Installation verification inspection
- Installation and system tests
- Final inspection.

Configuration verification is based on the engineering data that identify all drawings by revision level and date of issue in an indentured form and is supported by the owner-approved contractor drawings. This review ensures that changes in configuration are approved and properly identified as required by the specifications and that any deviations are known.

Documentation in the form of inspection reports should be utilized to identify the materials inspected, the point and time of inspection, the inspector, and the findings. These reports should be held on file for future reference and to support final acceptance. Nonconforming conditions should be identified by the inspector on a "Notice of Rejection" (NOR) Form. Deficiencies in the prerequisites related to the work or equipment under evaluation should be listed on the "Prerequisite Deficiencies" (PRD) Report. The contractor should institute a "Release for Shipment" (RFS) Form for each shipment. Approval of the RFS form is granted by the owner. An Inspection Report (IR) documents each inspection and identifies actions and reports issued.

Subcontractor surveillance inspection should be performed by the owner on a selective basis. The criteria for selection may include the complexity of the work, the uniqueness of the design, and the potential impact of problems on the project schedule. All owner inspection of subcontractors should be coordinated with the contractor for resolution. Inspection of the subcontractor's work by the owner does not relieve the contractor of any responsibility for subcontractors.

Hold points established on the work by the owner may be altered from time to time at the owner's discretion. A hold point is defined as a point in the progress of work (through manufacture, shipping, installation, and testing) at which further progress must be held pending inspection and concurrence by the authority to proceed. Hold points should occur at least prior to shipment or transfer of subassemblies, assemblies, or subcontracted work from one facility to another or to the site and prior to tests that follow installation work. The contractor should make available to the owner's inspectors at the time of inspection evidence of the contractor's inspection and acceptance of work performed prior to the hold point.

Resident inspectors may be assigned to manufacturing facilities if the work to be performed is unique, critical, or complex; involves a high degree of new design; or is long-term in duration with frequent shipments that make nonresident inspection impractical. Hold points should be established for in-process inspection by the resident inspector in concurrence with the owner and coordinated with the contractor. All contractual tests performed by the contractor at the manufacturing facility should be witnessed. As noted above, inspection should be performed on all materials presented for shipment, and surveillance should be maintained to ensure compliance with the configuration control requirements of the contract.

Nonresident inspection provides for surveillance over work performed at the place of manufacture if a resident inspector is not assigned. This activity generally is restricted to inspection of materials presented for shipment. At the owner's direction, the nonresident inspector may be required to witness tests performed at the facility. At the time of test witnessing and inspection, the configuration should be reviewed to ensure compliance with contractual configuration control requirements.

Installation inspection provides for surveillance over the receipt, movement to position, and installation of equipment and systems. Inspection hold points would occur prior to installation verification tests, final tests, and acceptance. Inspections should be performed at such critical events during installation as cable pulling, cable terminating, equipment installation, and conduit and wire tray installation. Surveillance should be provided to ensure conformance to the contractual configuration control requirements. All field modification and retrofit work should be performed under the surveillance of installation inspectors.

Spare Parts should be inspected when received except when a shipment of spare parts is made by a facility under resident inspection or when its receipt coincides with a nonresident inspection visit. Spare parts are subject to the same criteria and documentation requirements outlined above. Parts should be placed into stock only when there is evidence indicating their acceptability.

B.2.4 Testing

Tests should be performed throughout the cycle of development, manufacture, installation, and acceptance to verify that products, subsystems, and systems conform to functional requirements. The contractor should plan the sequence of testing to ensure that adequate time is scheduled and that facilities and personnel are available. All tests should be performed in accordance with detailed procedures and test results should be recorded. The contractor should develop the plans and procedures, perform the tests, and record the test results. The owner should review and approve the contractor's plans, procedures, and test results and should witness the tests to verify performance. The following tests should be performed as indicated.

- Qualification Tests - A qualification test should be performed on products and subsystems to demonstrate that the design complies with the specifications. These tests should be satisfactorily concluded prior to initial delivery of the item.

- Factory Tests - Prior to shipment from the point of manufacture, functional tests should be performed on assemblies, subsystems, and systems to verify that the equipment to be shipped complies with the specifications.

- Installation Verification Tests - These tests should verify that equipment has been satisfactorily installed. Physical inspection, circuit continuity, insulation resistance, and power-on tests should be included.

- System Test - System level tests should be conducted to demonstrate that the installed system is free from damage due to shipment and installation and that the equipment performs in accordance with the specifications. These tests should be performed after completion of the installation verification tests.

- Integration Tests - After completion of the system tests, integration tests should be performed to demonstrate that the system performs satisfactorily when connected to interfacing systems or subsystems.

- Prerevenue Tests - A series of tests should be performed using revenue service operating procedures to demonstrate the compatibility of the physical transit system and operating procedures.

B.2.5 Configuration Requirements

Configuration requirements include the following:

- Indentured Bill of Material - Contractors should be responsible for preparing an engineering data package that establishes the production baseline. Included should be a data list comprising an indentured list of all engineering drawings to the lowest level of repair and replacement by revision or issue and containing all documentation necessary to define and identify the approved baseline configuration. This list is a prerequisite to qualification testing and should be maintained current throughout the program.

- Serialization Records - When serialized equipment is installed, the contractor should maintain serialization as well as configuration records for each installation. A copy of these records should be supplied to the owner at the time an RFS form is initiated by the contractor. The contractor should maintain these records current at all times.

Changes to the approved baselines should be controlled through a rigid system utilizing engineering change proposals, configuration control review and disposition, and issuance of a formal change order. The contractor's program should ensure that all changes are processed in accordance with these provisions. Implementation of all approved changes, modifications, and retrofits of delivered hardware may be performed by the contractor after informing the owner about the modification and after submitting to the owner all drawings and associated documentation that define the change, modification, or retrofit. All such work should be performed under owner inspection.

Changes affecting the following require prior owner approval:

- Performance outside stated tolerances
- Reliability or maintainability
- Physical or functional interchangeability

- o Interface characteristics
- o Test programs, procedures, connections, instruments, or documentation
- o Weight or balance (where it is a factor)
- o Safety
- o Electromagnetic interface characteristics
- o Computer programs for operation, test, or maintenance
- o Compatibility with support or training equipment
- o Delivered products (retrofit)
- o Delivered training, operation, maintenance, or overhaul manuals (when additional funds are required to revise manuals)
- o Present adjustment or schedules affecting operating limits to such an extent as to require new identification
- o Source of repairable items (source control drawings)
- o Schedule or deliveries
- o Spare parts provisioning
- o Owner-furnished equipment

Any engineering change not affecting form, fit, function, or interchangeability and not affecting the above items should not require prior owner approval.

<u>Deviations and waivers</u> apply to all nonconforming conditions that are limited in nature and not considered to be permanent changes and require prior owner approval. Deviations should be requested prior to manufacture for a limited and specified number of units for a specific period of time. Waivers should be requested for specific nonconforming conditions on specific terms during production or inspection. Any deviation or waiver granted must be included in the RFS documentation at the time an RFS form is initiated. When the request is based on a NOR, it should be identified in approved drawings requires the approval of the managing engineer and the concurrence of the QA manager. Deviations or waivers concerning workmanship require the approval of the QA manager. A deviation or waiver concerning the contract specifications and drawings should not be allowed.

B.3 PROGRAM MANAGEMENT REQUIREMENTS

The owner's QA unit is responsible for implementation of the QA program. To ensure that the program is fully and successfully implemented, auditing, monitoring, and witnessing activities should be assigned to those groups within the organization having the required expertise, and an organization chart should describe their relationships. The functional responsibility assignments are described as follows:

B.3.1 Owner's QA

- Review and recommend approval of contractor quality-related submissions.
- Audit the activities of all systemwide work in production and installation.
- Review and approve all source inspection activities in advance.
- Witness critical events such as qualifications tests, first-article submissions, final tests before shipment, installation verification tests, and system tests.
- Process all deviation and waiver requests, approve workmanship-related requests, and obtain concurrence from engineering groups as appropriate.
- Review and approve all RFS requests.
- Review and concur in payment and system acceptance.
- Monitor and audit the implementation of configuration management system.
- Review and concur in all personnel manning and changes in QA program implementation.
- Provide direction to other quality control groups in implementing program and adjudicate all rejection disputes between contractors.

B.3.2 Quality Control

- Develop procedures and check lists for the inspection and test observations to be performed on all contracts.
- Provide for resident inspection at the source of production for contracts or subcontracts in accordance with owner's QA program.
- Provide for nonresident inspection at the source of production in accordance with owner's QA program.

- Function as the central point for receiving and disseminating information on quality-related matters.

- Report on and document functions performed.

- Perform surveillance at the source of manufacture and recommend approval of RFS requests.

- Recommend approval of waivers for workmanship.

- Maintain quality and configuration records and provide routine summary and/or detail reports as required by owner.

- Oversee the receipt of equipment, inspect for shipping damage and completeness, and recommend acceptance.

- Provide for inspection of all physical installation work up to and including all wiring, piping, etc., and associated continuity checks.

- Control the implementation of all changes, modifications, and retrofits on delivered hardware and provide for inspection of the completed work.

- Organize, implement, and conduct the activities of the configuration change control board.

B.3.3 Systemwide Engineering

- Witness qualification testing performed by contractors and their subcontractors on end items (qualification testing performed for contractors or their subcontractors by certified testing laboratories will be witnessed on an exception basis only).

- Review and approve the completeness and acceptability of all testing procedures.

- Review and approve all test reports.

- Witness functional testing of first-article submissions for acceptance of complex hardware.

- Witness special evaluation tests.

- Witness installation verification and final tests for acceptance of delivered vehicles and supervisory and control, traction power, and train control equipment.

- Monitor any changes introduced during testing to ensure that they are properly documented and reported in accordance with approved procedures.

- Review and recommend system acceptance.

B.3.4 <u>Owner's Program/Construction Management</u>

- o Approve deviation and waivers, except those involving workmanship, and support QA in evaluating workmanship deviations.
- o Concur on recommendations for approval for payment and final acceptance.
- o Witness testing as required.
- o Review and concur on test reports verifying acceptability.
- o Review and approve test procedures.

B.3.5 <u>Owner's Test Director</u>

- o Review and comment on the completeness and acceptability of all functional testing procedure submittals.
- o Review and comment on all test reports verifying the acceptability of the reported results.
- o Schedule, organize, and direct the activities for interfacing subsystems or systems to permit system testing.
- o Provide direction for and surveillance over all integrated testing and prerevenue testing activities.
- o Review and recommend system acceptance.
- o Organize and direct the on-site acceptance tests performed by the owner.
- o Witness major subsystem preshipment testing, as required.

B.3.6 <u>Owner's Operations Department</u>

- o Support the warranty program by maintaining equipment.
- o Receive and inspect incoming material and supplies delivered to the owner, such as maintenance equipment, supplies, and spare parts (this does not include construction division contracts).
- o Support integrated and prerevenue testing with operating personnel.

B.4 DOCUMENTATION

Documentation should include the following items:

B.4.1 Contractor Documentation

- QA program plan
- Manufacturing plan
- Configuration management plan
- Test plans, procedures, and results
- Indentured parts listing
- Configuration and serialization records
- Deviation/waiver requests
- RFS requests
- Notices of modification

B.4.2 Owner's QA Program Documentation

- Configuration status reports
- Prerequisite deficiency reports
- RFS forms
- Notices of rejection
- Inspection reports
- Notices of modification
- Deviations and waivers

APPENDIX C

SAMPLE PROCUREMENT APPROVAL SCHEME

APPENDIX C

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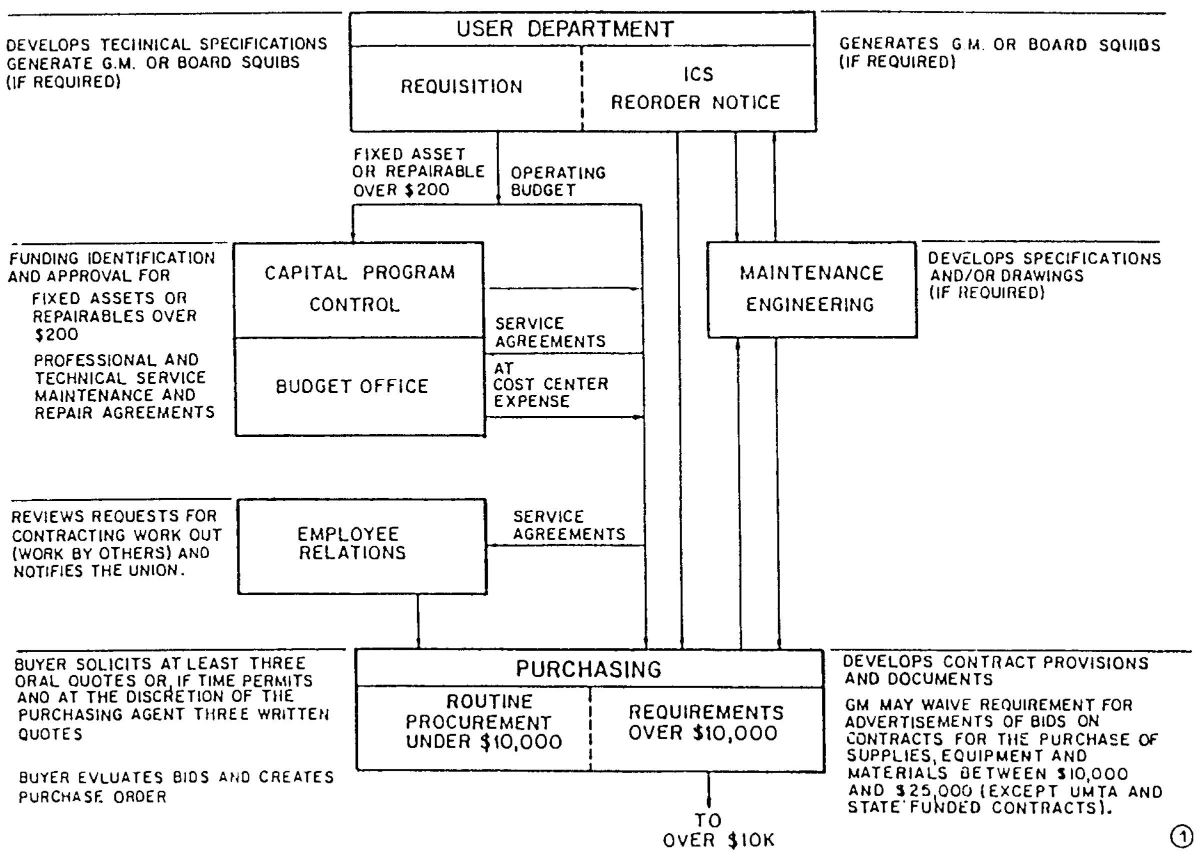

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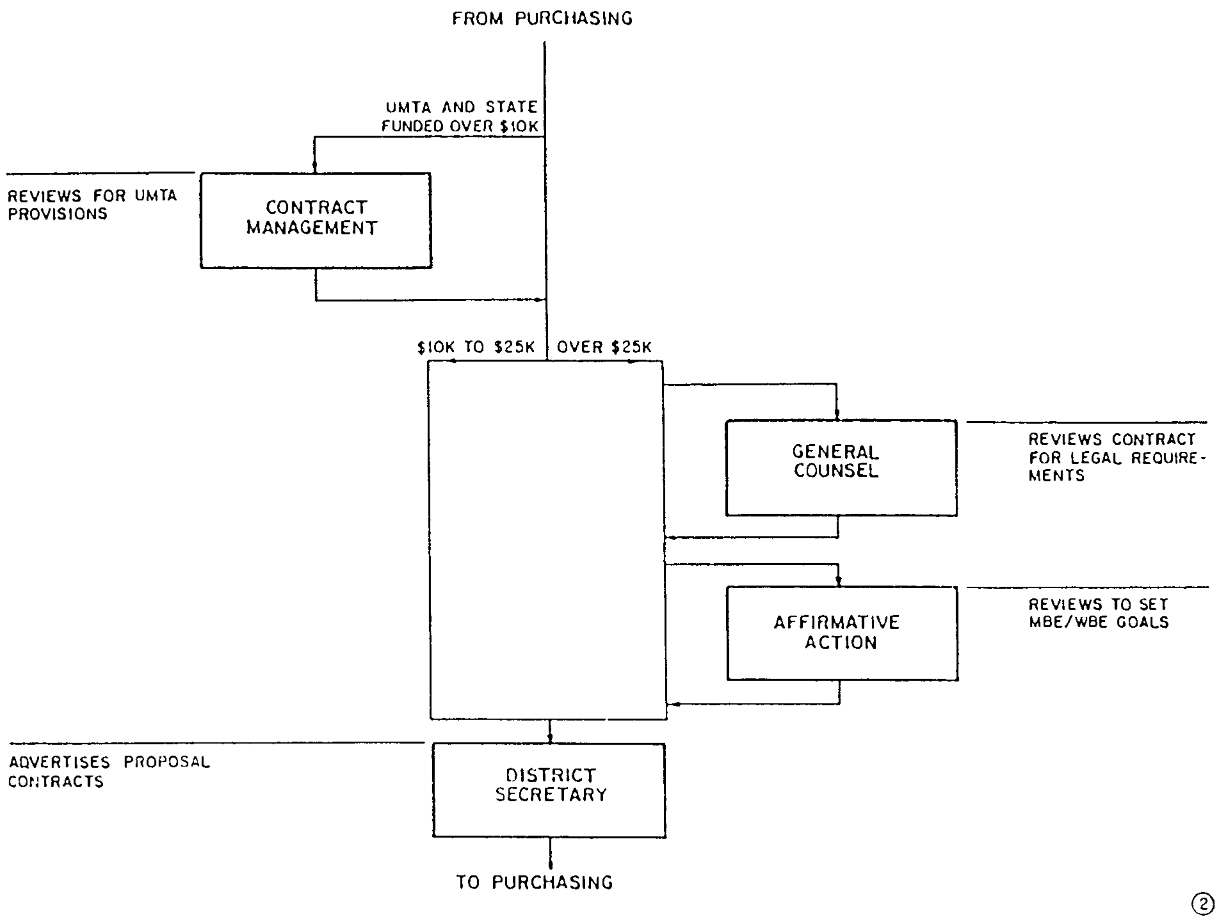
SAMPLE PROCUREMENT APPROVAL SCHEME (Continued)



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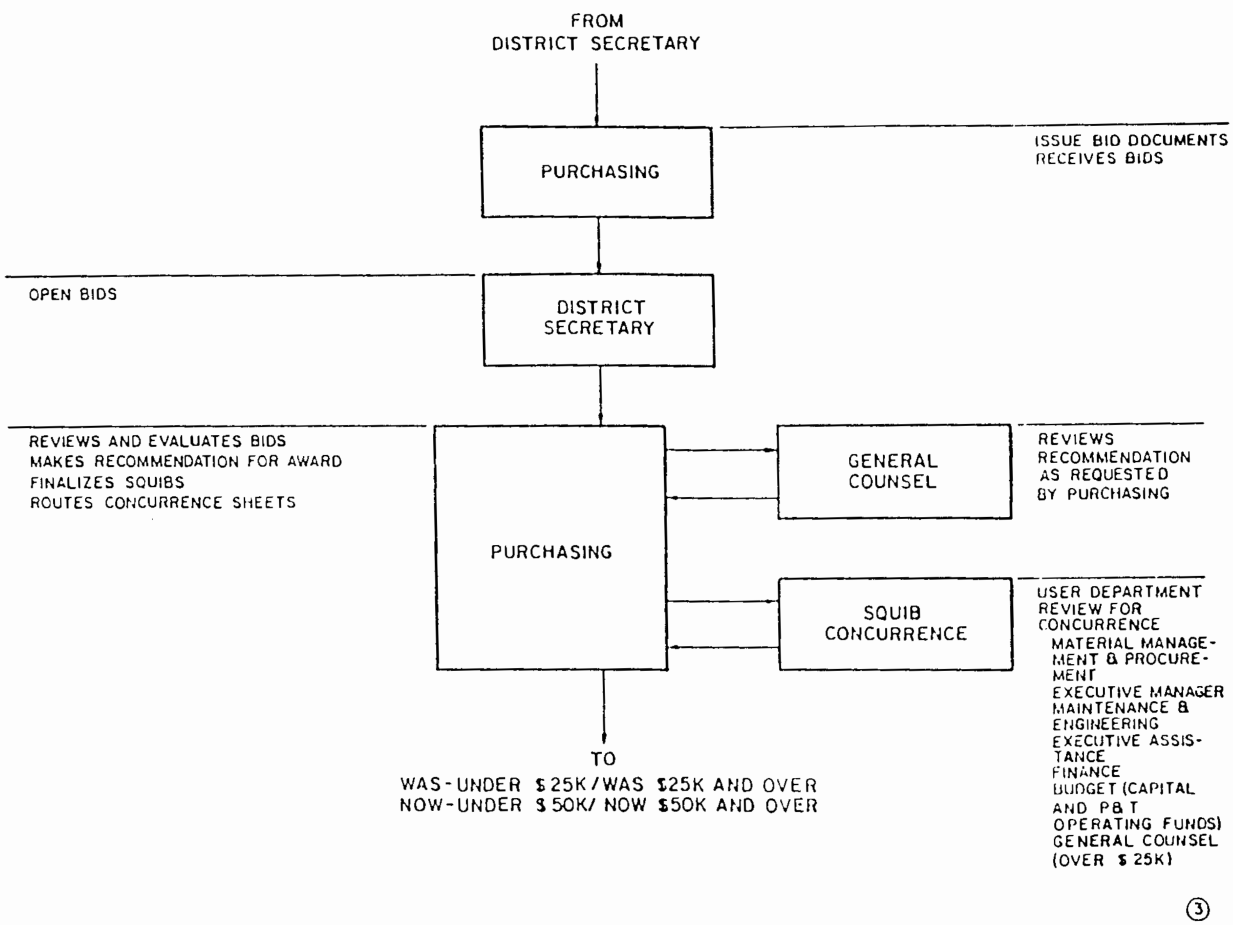

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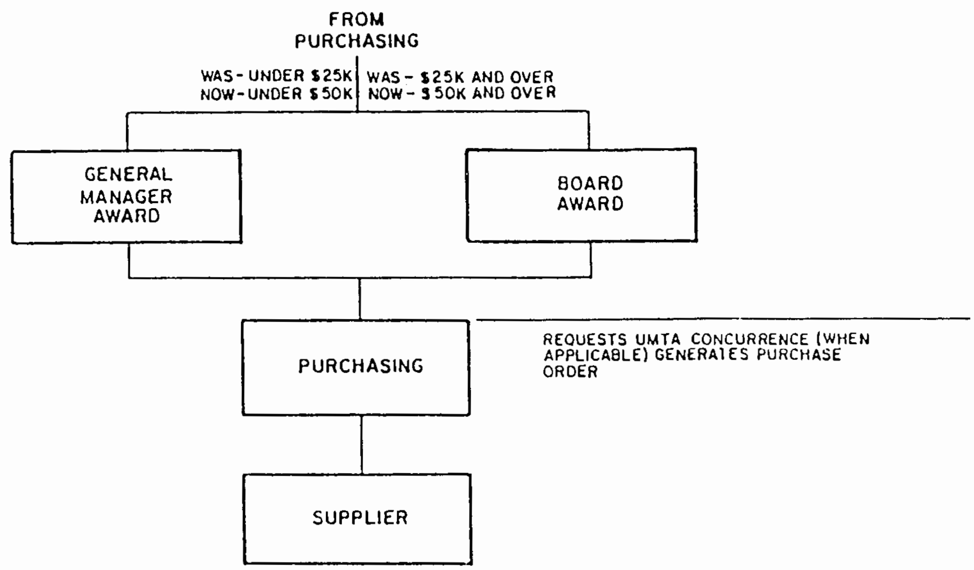

APPENDIX D

SAMPLE CONTRACTING PROCEDURES

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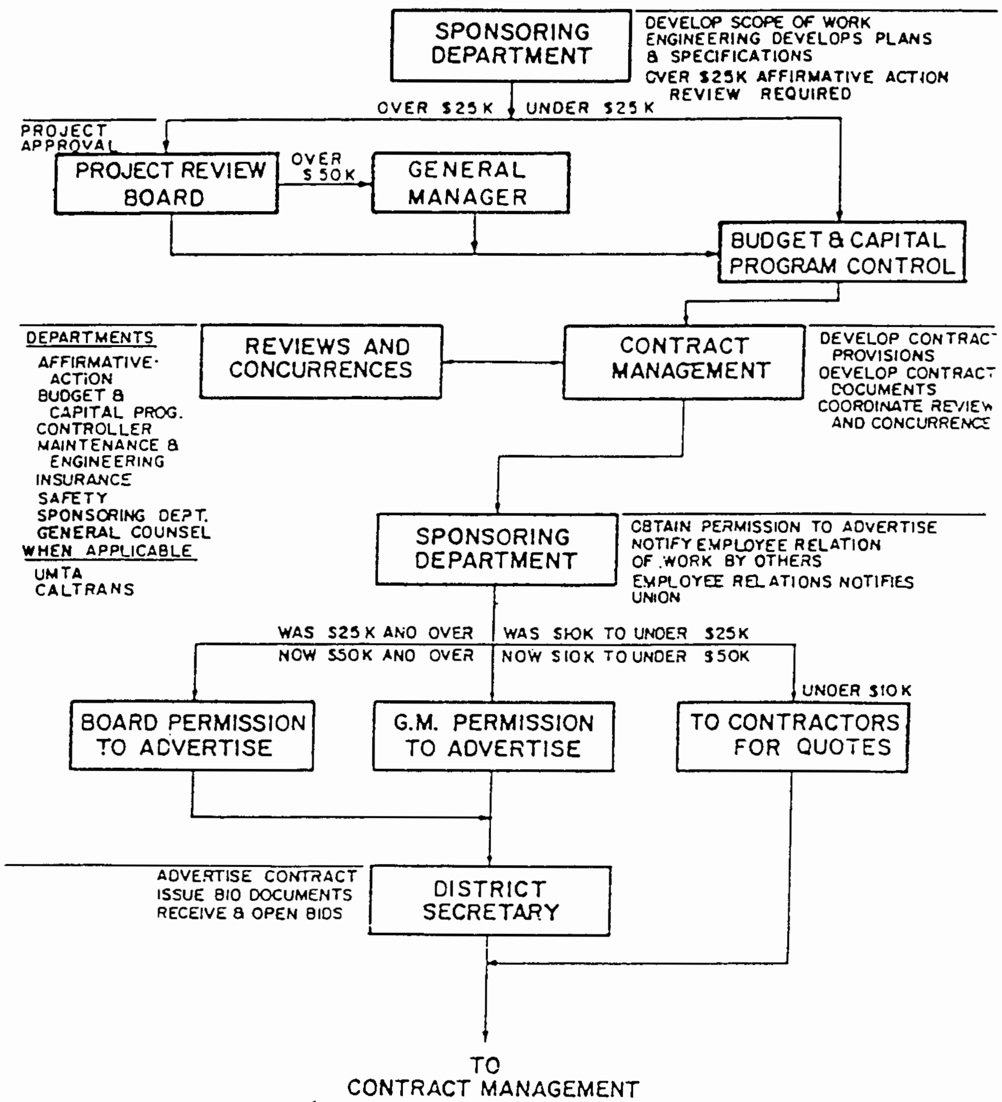

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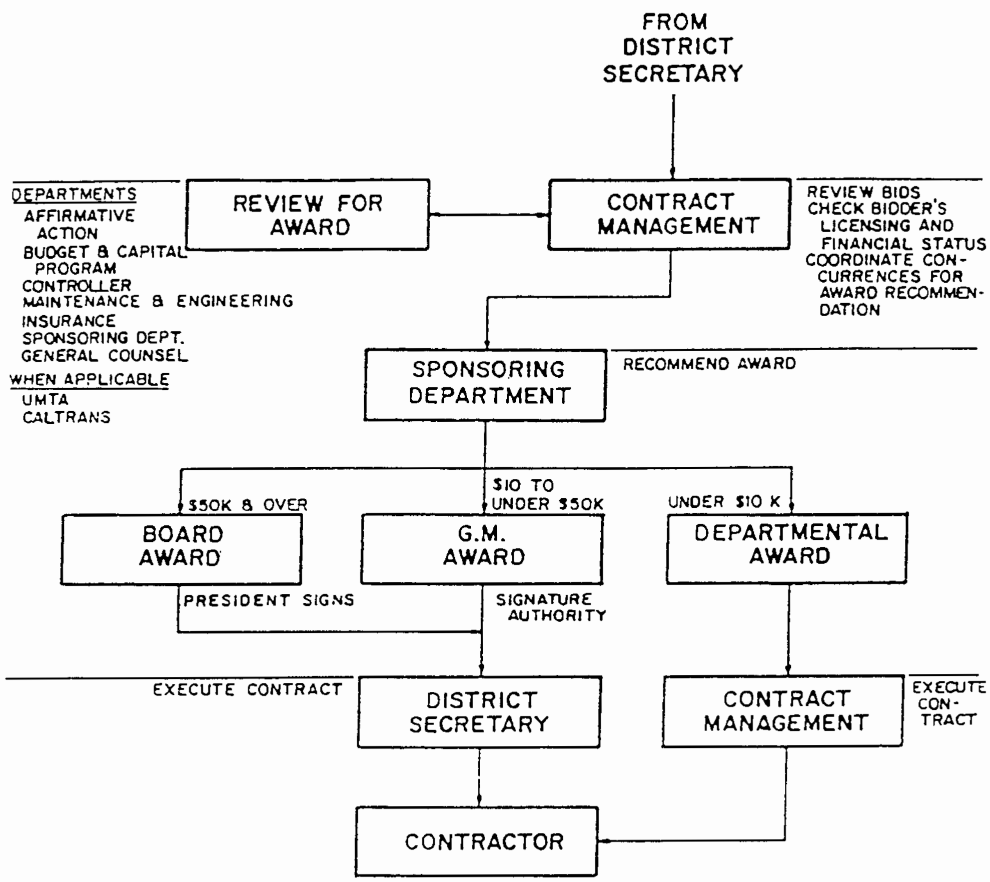
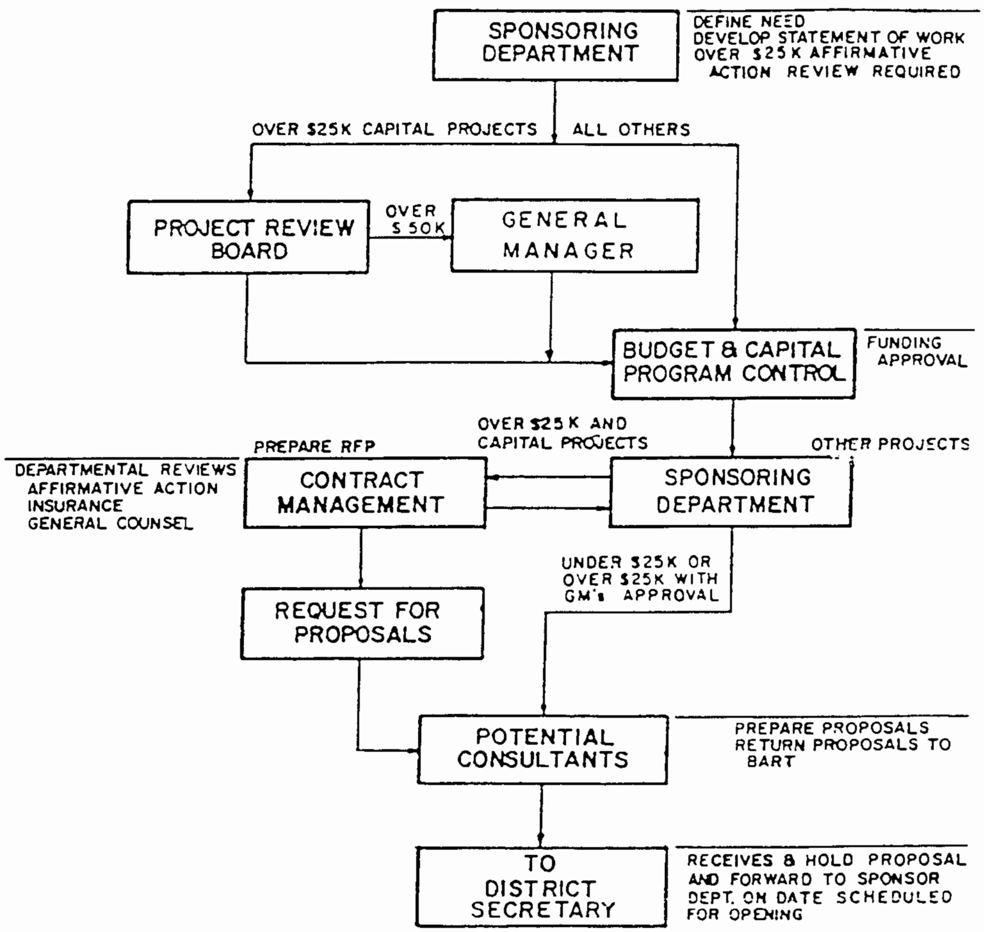
SAMPLE CONTRACTING PROCEDURES (Continued)



SAMPLE CONTRACTING PROCEDURES (Continued)

CONTRACT MANAGEMENT DIVISION
PROFESSIONAL AND TECHNICAL SERVICE AGREEMENT PROCEDURE



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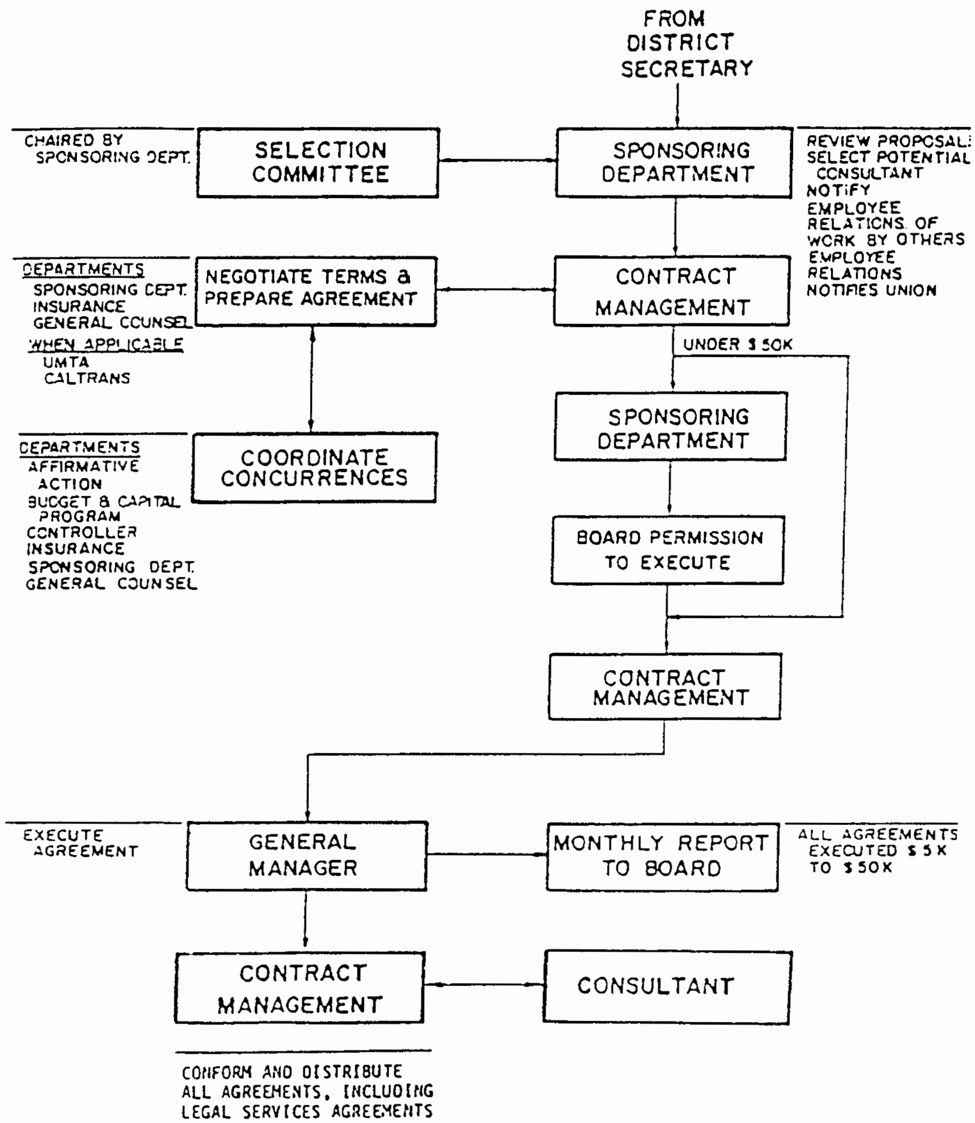
SAMPLE CONTRACTING PROCEDURES (Continued)



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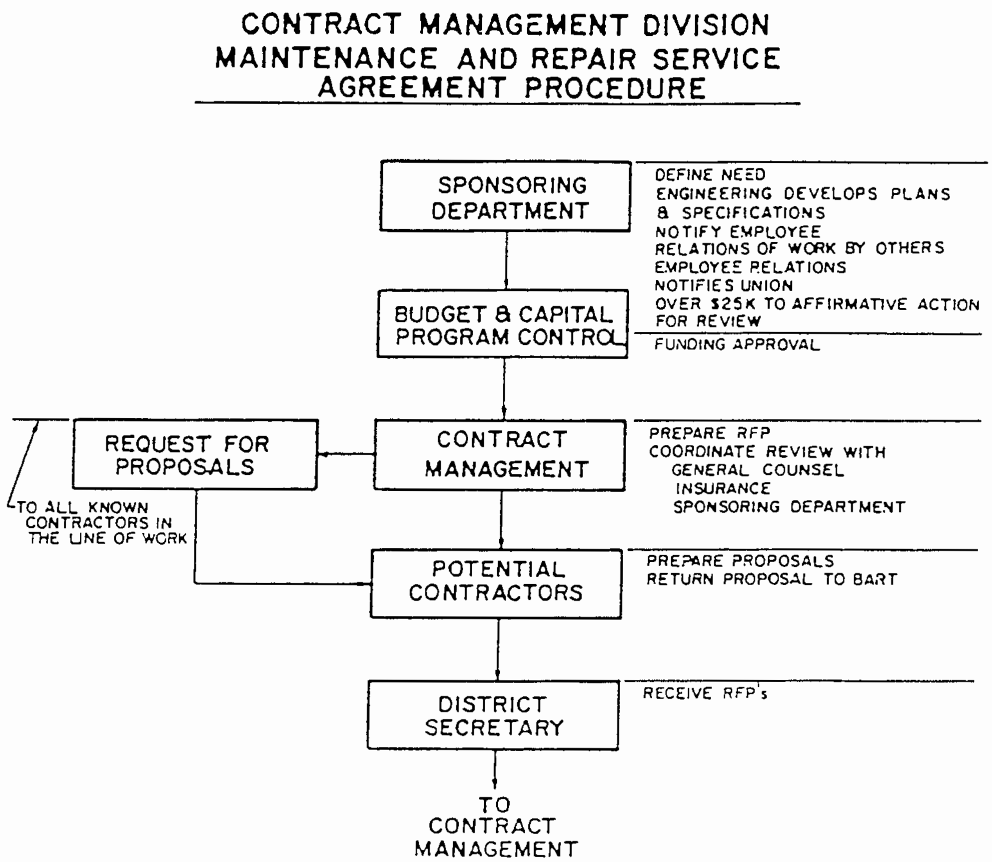
SAMPLE CONTRACTING PROCEDURES (Continued)



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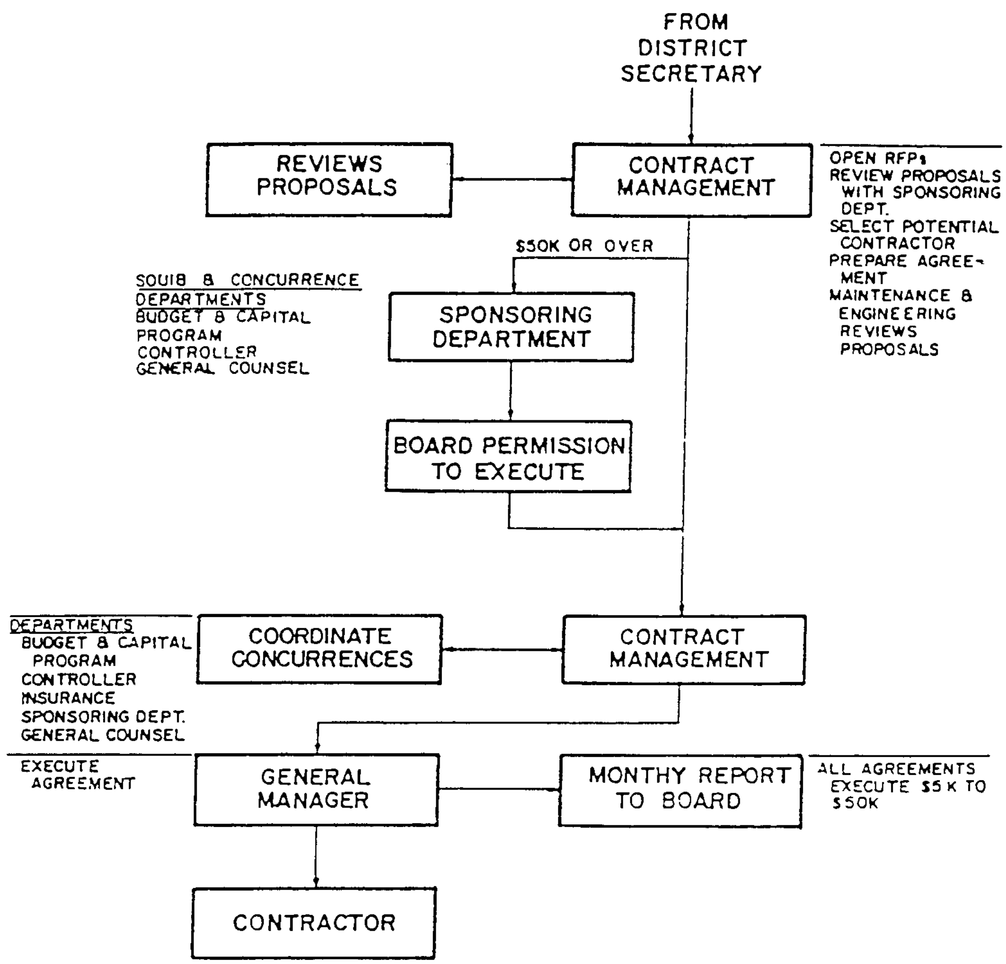
SAMPLE CONTRACTING PROCEDURES (Concluded)



APPENDIX E

FLOW CHARTS: SAMPLE MANAGEMENT AND ADMINISTRATION OF CONTRACTS AFTER AWARD

APPENDIX E

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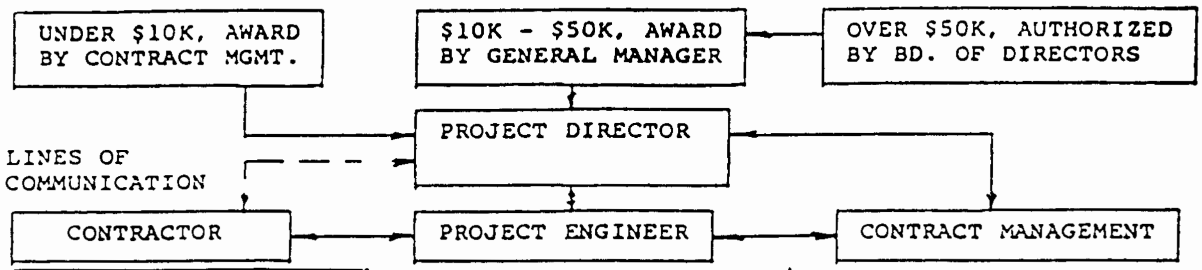
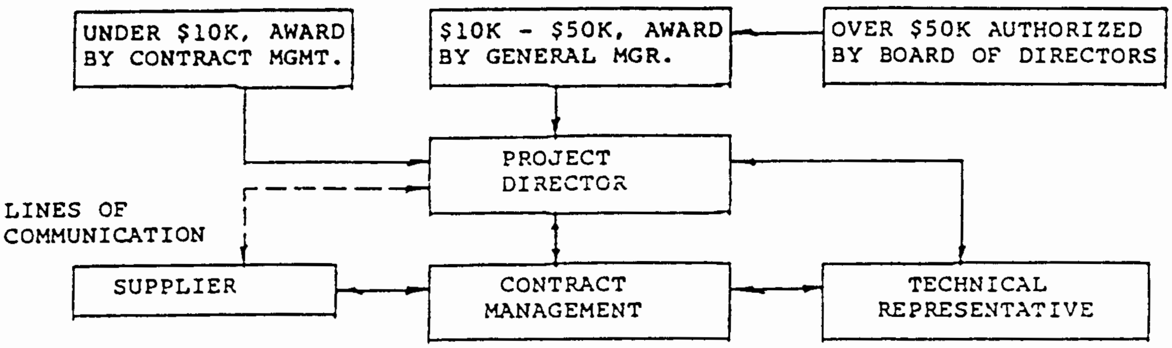


AREAS OF RESPONSIBILITY	PROJECT ENGINEER	CONTRACT MANAGEMENT
	. Administer technical scope of contracts to assure compliance with contract requirements	. Monitor administration of contracts to assure compliance with general and special provisions
PAYMENT APPLICATIONS	. Receive, review, verify and approve invoices and certified payrolls	. Concur with payments
CHANGE NOTICES & ORDERS	. Evaluate changes, initiate change notices and change orders. . Issues REEF C.O.s	. Review, coordinate and process change orders. (See C.O. procedure)
POTENTIAL CLAIMS	. Review for first step resolution	. Review & coordinate District's response to potential claims
ACCEPTANCE OF CONTRACT WORK	. Initiate certifications for: Substantial completion Relief of maintenance. . Initiate final acceptance.	. Process concurrences for: Substantial completion Relief of maintenance Final acceptance. . Site participation, when necessary.
FINAL CLAIMS	. Process final claims	. Coordinate resolution of final claims
FINAL PAYMENT	. Recommend final payment & release of retention	. Process final payment
CONTRACT CLOSEOUT	. Warranty inspections. . Coordinate internal audit.	. Coordinate external audits. . Coordinate files to storage.

APPENDIX E

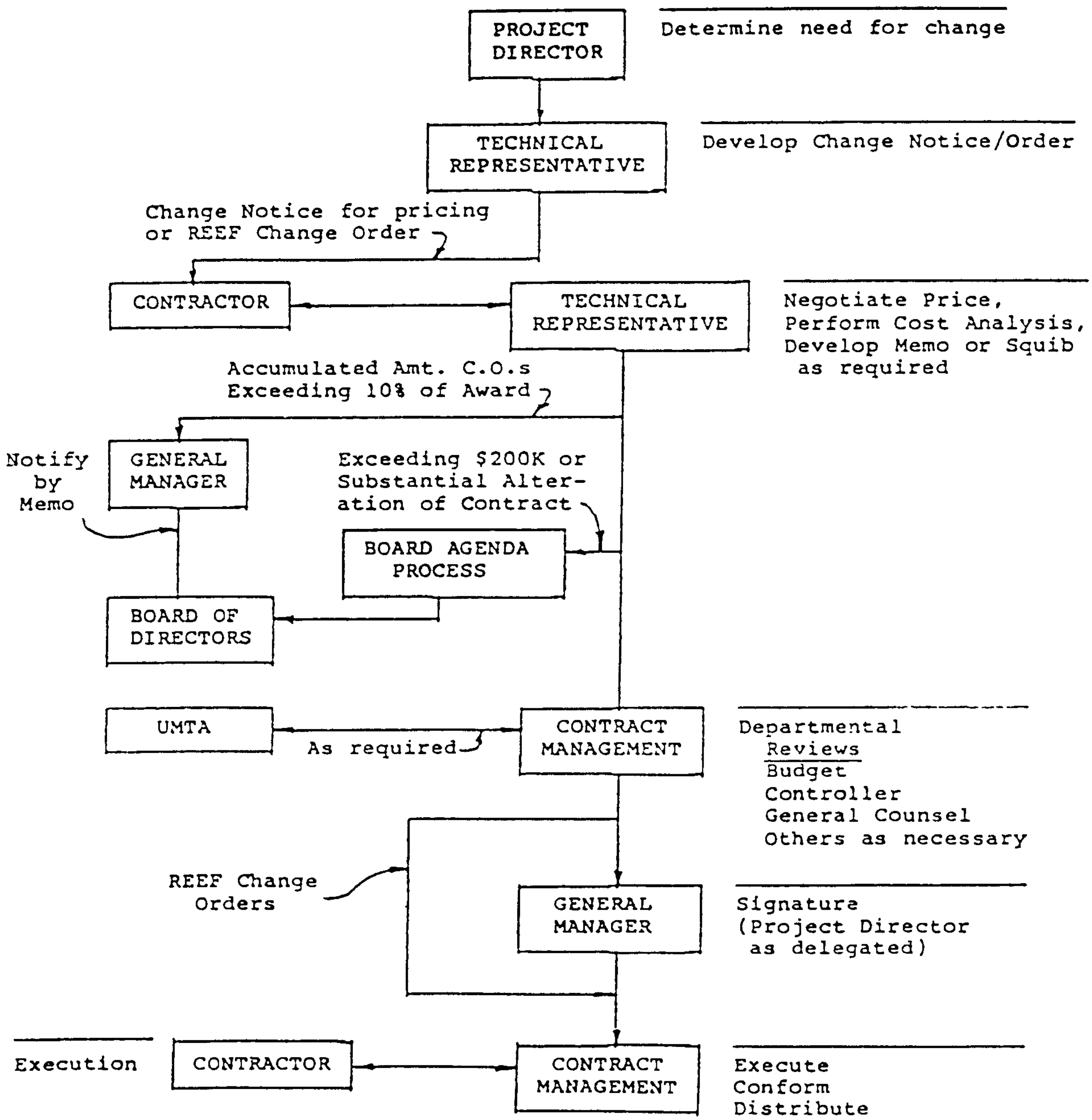
FLOW CHARTS: SAMPLE MANAGEMENT AND ADMINISTRATION OF CONTRACTS AFTER AWARD (Continued)



AREAS OF RESPONSIBILITY		
	. Administer procurement contract general and special provisions	. Monitor manufacture of equipment, including material & process approval, quality control and inspection. . Prepare draft correspondence for technical specification items.
DRAWINGS & SUBMITTALS	. Records & followup	. Review and approve
PAYMENT APPLICATIONS	. Receive, review, verify and approve	. Concur with payments
CHANGE NOTICES AND ORDERS	. Review, coordinate and process change orders. (See C.O. process flow chart)	. Evaluate changes, initiate change notices and change orders
PRODUCT RECEIVING	. Coordinate receiving with Inventory Control	. Inspect and record delivered products. . Product acceptance.
FINAL PAYMENT	. Process Final Payment	. Concur with Final Payment
CONTRACT CLOSEOUT	. Coordinate audits. . Files to storage. . Warranty Administration	

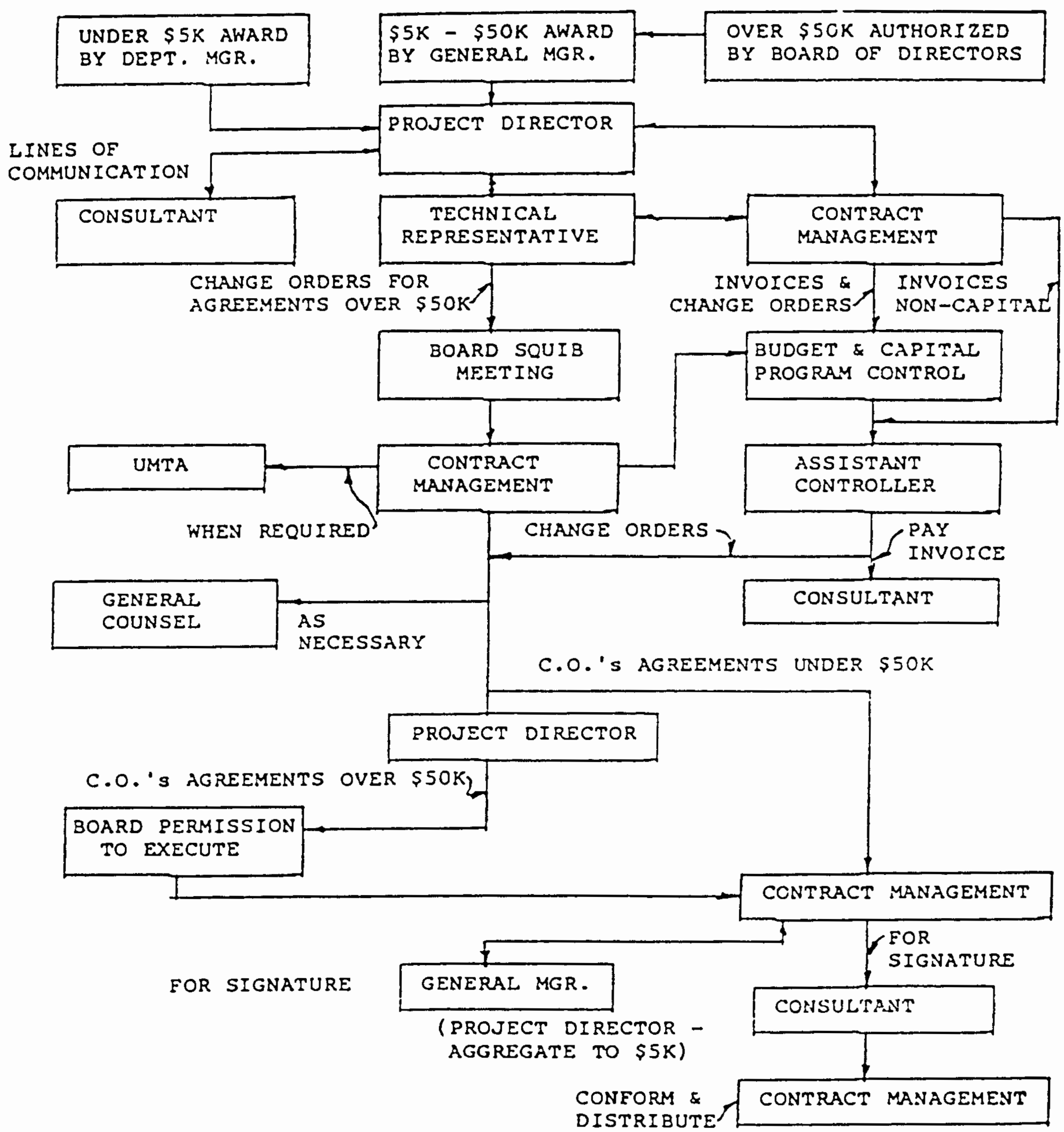
APPENDIX E

FLOW CHARTS: SAMPLE MANAGEMENT AND ADMINISTRATION OF CONTRACTS AFTER AWARD (Continued)



APPENDIX E

FLOW CHARTS: SAMPLE MANAGEMENT AND ADMINISTRATION OF CONTRACTS AFTER AWARD (Continued)

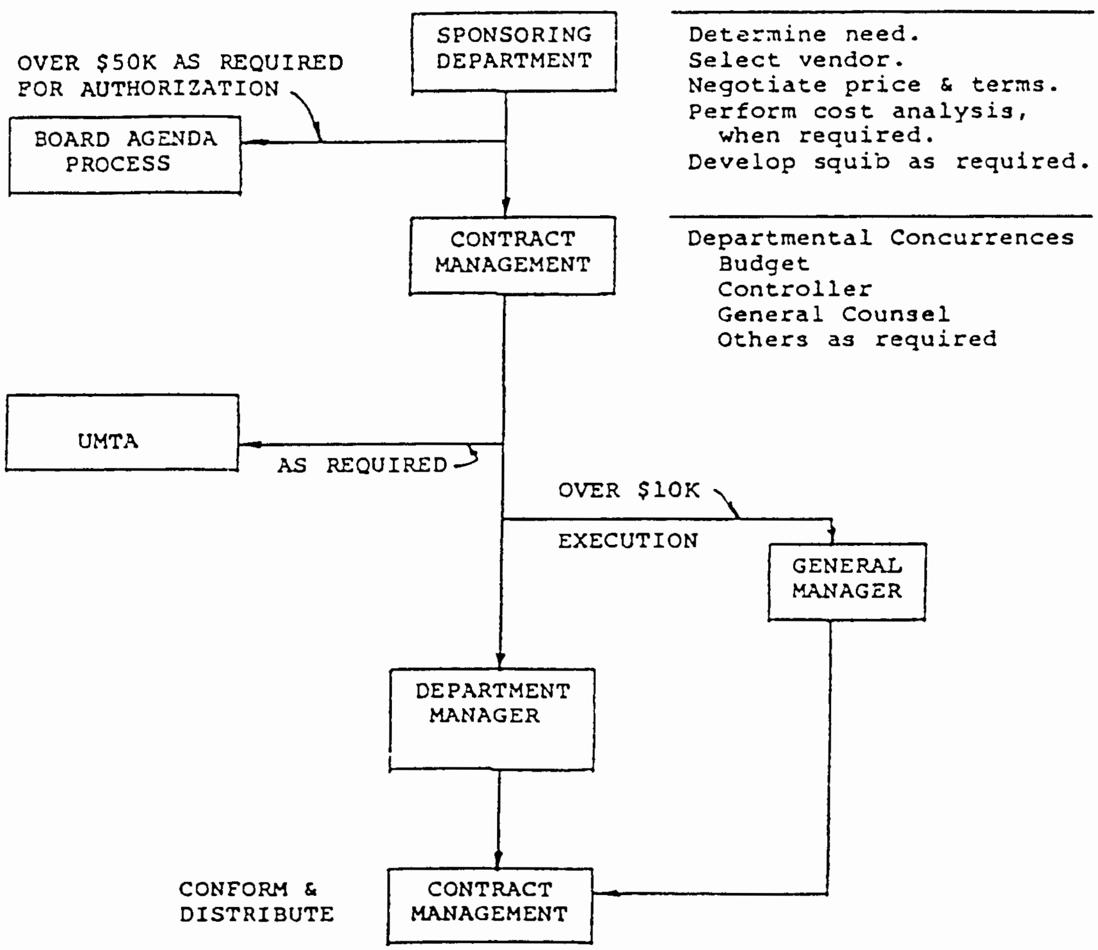


APPENDIX E

FLOW CHARTS: SAMPLE MANAGEMENT AND ADMINISTRATION OF CONTRACTS AFTER AWARD (Concluded)

LEASE/RENTAL AGREEMENTS

- ACQUISITION OF ITEMS UNDER LEASE/RENTAL AND THE ADMINISTRATION OF THE AGREEMENT ITSELF IS THE RESPONSIBILITY OF THE DEPARTMENT MANAGER



APPENDIX F

SAMPLE TABLE OF CONTENTS
FOR A SAFETY AND SECURITY MANUAL

APPENDIX F

SAMPLE TABLE OF CONTENTS FOR A SAFETY AND SECURITY MANUAL

APPENDIX F

SAMPLE TABLE OF CONTENTS FOR A SAFETY AND SECURITY MANUAL (Continued)

APPENDIX F

SAMPLE TABLE OF CONTENTS FOR A SAFETY AND SECURITY MANUAL (Concluded)

APPENDIX G

SAMPLE TABLE OF CONTENTS
FOR RESIDENT ENGINEER'S MANUAL

APPENDIX G

SAMPLE TABLE OF CONTENTS FOR RESIDENT ENGINEER'S MANUAL

APPENDIX G

SAMPLE TABLE OF CONTENTS
FOR RESIDENT ENGINEER'S MANUAL (Continued)

APPENDIX G

SAMPLE TABLE OF CONTENTS FOR RESIDENT ENGINEER'S MANUAL (Concluded)

APPENDIX H

REFERENCES

APPENDIX H

REFERENCES

1. Ryan, James. M., Emerson, Donald J., et. al., Procedures and Technical Methods for Transit Project Planning, Review Draft, UMTA, September 1986.

2. LTI Consultants, Inc., Rail Modernization Planning Study, Appendix: "Development of the Cost-Effectiveness Methodology," UMTA, UMTA-PA-06-0099-86-1, April 1987. (PB87-190351)

3. S.G. Associates, Inc. and Clark, Nexsen, Owen, Barbieri, and Gibson, Bus Maintenance Facility Planning Guidelines, Draft Final Report, UMTA, IT-09-9018, November 1987.

4. Dynatrend, Inc., Rail Modernization Planning: Review of Current Practice, UMTA, IT-09-9020, March 1985. (PB85-230522)

5. FHWA/UMTA, "Environmental Impact and Related Procedures: Final Rule," Federal Register, Rules and Regulations, August 28, 1987, pp. 32646-32669.

6. Day and Zimmermann, Inc., Project Management Oversight Procedures, UMTA, UMTA-PA-06-0092, March 1986. (PB87-184396)

7. Urban Mass Transportation Project Management Guidelines for Grantees, UMTA, Circular 5010.1A, July 22, 1988.

8. UMTA, "Project Management Oversight, "Federal Register, Final Rule, September 1, 1989, pp. 36708-36713.

9. Building Research Advisory Board of the National Research Council, Management of Urban Construction Programs Volume I: Guidelines for Developing a Project Management Plan, UMTA, UMTA-MA-06-0100-81-2, June 1981, (PB81-242380) and Volume II: Supplemental Information, UMTA, UMTA-MA-06-0100-81-3, June 1981. (PB81-242398)

10. UMTA, "Major Capital Investment Projects," Federal Register, Proposed Rulemaking, April 25, 1989, pp. 17878-17892.

11. Rice Center, Alternative Financing for Urban Transportation: State of the Practice, U.S. DOT, DOT-I-86-30, July 1986. (PB87-130266)

12. Project Management Plan for MOS-1 Construction, SCRTD, September 1986, First Revision April 1987.

13. Specifications of General Requirements for a Quality Assurance Program, America National Standards Institute (ANSI), Document Z1.8, November 18, 1971 and American Society for Quality Control, November 1985.

REFERENCES (Concluded)

14. U.S. National Committee on Tunneling Technology, National Research Council, Better Management of Major Underground Construction Projects, UMTA and NSF, 1978. (PB-290855)

15. Loew, W.R. and Rizzo, J.M., "Claims Avoidance, A Project Necessity," Hill International, June 1987.

16. Transit Development Corporation, Subway Environmental Design, Handbook: Volume I, Principles and Application, Second Edition, UMTA, DC-06-0010-76-1, March 1976. (PB-254788)

17. The Peer Review Manual, Third Edition, American Consulting Engineers Council, 1987.

18. Lee Wan and Associates, Value Engineering Process Overview, UMTA, UMTA-DC-06-0483-88-1, January 1988. (PB88-240288)

19. Manual of Professional Practice: Quality in the Constructed Project: A Guide for Owners, Designers and Contractors, Preliminary edition for trial use and comment, ASCE, May 1988.

20. Project Management Plan: Daly City Turnback and Yard Project, BART, October 30, 1986, Revised February 18, 1987.

21. Avoiding and Resolving Disputes in Underground Construction - Successful Practices and Guidelines, The Technical Committee on Construction Practices of the Underground Technology Research Council of the American Society of Civil Engineers and the American Institute of Mining Engineers, Revised January 10, 1989.

22. Alternative Dispute Resolution for the Construction Industry, Association of Soil and Foundation Engineers, 1988.

23. Transit Management and Replacement Capital Planning, Transportation Research Record 1165, TRB, 1988.

APPENDIX I

BIBLIOGRAPHY

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BIBLIOGRAPHY

Alternative Dispute Resolution for the Construction Industry, Association of Soil and Foundation Engineers, 1988.

Anatasi, S.C., "UMTA Watchdog - Project Management Oversight: What It Is and How It Works," Mass Transit, July/August, 1987, pp: 6, 7, and 23.

Avoiding and Resolving Disputes in Underground Construction - Successful Practices and Guidelines, The Technical Committee on Construction Practices of the Underground Technology Research Council of ASCE and the American Institute of Mining Engineers, Revised January 10, 1989.

Barrie, D.S. and Paulson, B.C., Jr., Professional Construction Management, Second Edition, McGraw-Hill, 1984.

Boltz, D.H. and Molinski, J., "Computer Scheduling: On Line and On Time," Civil Engineering, American Society of Civil Engineers (ASCE), June 1987, pp: 56-58.

Breisch, W.E., "How To Motivate the Individual and the Team," Measurement and Control, Vol. 15, November 1982, pp: 419-421.

Building Research Advisory Board of the National Research Council (NRC), Management of Urban Construction Programs, Volume I: Guidelines for Developing a Project Management Plan, UMTA, UMTA-MA-06-0100-81-2, June, 1981, Reprint March 1984. (PB81-242380)

Building Research Advisory Board of the NRC, Management of Urban Construction Programs, Volume II: Supplemental Information, UMTA, UMTA-MA-06-0100-81-3, June, 1981, Reprint March 1984. (PB81-242398)

CAMCO/Construction Control, Construction Management for Utah Transit Authority, Utah Transit Authority, November 2, 1987.

Carnegie Mellon University, Project Finance During Construction, UMTA, PA-11-0033, December 1986.

Carter, C.C., "Editorial" (on PMO), Mass Transit, July/August, 1987, p: 5.

Cetinich, J.N., "Project Management Oversight, The Sacramento Experience," Hill International, Inc., January 1987.

Citizen Participation Handbook for Public Officials and Other Professionals Serving the Public, Third Edition, Institute for Participatory Planning, 1978.

Clough, R.H. and Sears, G.A., Construction Project Management, Second Edition, John Wiley and Sons, 1979.

Construction Contract Claims: Causes and Methods of Settlement, TRB, Synthesis of Highway Practice No. 105, November 1983.

Construction Management Oversight on Major Transit Capital Projects, Hearing before the U.S. Senate, Committee on Banking, Housing, and Urban Affairs, April 9, 1986.

Construction Manual, Office of Direct Federal Programs, FHWA, 1985.

Construction of a New Federally Financed Rail System in Miami, FL, Hearing before the House of Representatives, Committee on Public Works, Subcommittee on Investigations and Oversight, December 13, 1983.

Construction QA/QC Systems That Work: Case Studies, Proceedings of a Session Sponsored by ASCE Construction Division During ASCE Convention in Denver, CO, May 1, 1985.

Construction: Quality Control and Specifications, TRB, Transportation Research Record 986, 1984.

Contract Time Determination, TRB, Synthesis of Highway Practice No. 79, October 1981.

Contractual Relationships: An Essential Ingredient of the Quality Assurance System and Other Quality Control Papers, TRB, Transportation Research Record 792, 1981.

Cresheim Company, Insurance for Urban Transportation Construction, UMTA, UMTA-MA-06-0025-77-13, Reprint, June 1979. (PB-272108)

Day and Zimmermann, Project Management Oversight Procedures, UMTA, UMTA-PA-06-0092, March 1986. (PB87-184396)

DeGoff, R.A. and Friedman, H.A., Construction Management: Basic Principles for Architects, Engineers and Owners, John Wiley and Sons, 1985.

DeLeuw Cather & Company, Contract Implementation Plan for Construction Management Oversight, Guadalupe Corridor Light Rail Transit Project, Santa Clara County Transit District, April 1985.

DeLeuw Cather & Company, Engineers Manual for Construction Management, New Jersey Transit Bus Operations, Inc., December 1985.

Dewey, R.W., Ed., Proceedings - Conference on Construction of Urban Rail Transit Systems - The Challenge of More Cost Effective Construction, UMTA, Williamsburg, VA, UMTA-MA-06-0100-79-7, September 1979. (PB80-130479)

Dynatrend, Inc., Rail Modernization Planning: Review of Current Practice, UMTA, IT-09-9020, March 1985. (PB85-230522)

Engineering and Construction Projects, The Emerging Management Roles, Proceedings of the Specialty Conference, New Orleans, LA, Construction Division, ASCE, March 17-19, 1982.

Fabrick, M.N. and O'Rourke, J.J., Environmental Planning for Design and Construction, John Wiley and Sons, 1982.

Fairweather, V., "The Pursuit of Quality: QA/QC," Civil Engineering, ASCE, February 1985, pp: 62-64.

Fisk, E.R., Construction Project Administration, Second Edition, John Wiley and Sons, 1982.

FHWA/UMTA, "Environmental Impact and Related Procedures," Federal Register, Rules and Regulations, August 28, 1987, pp: 32646-32669.

Fogel, I.M., "Fail Safe Management," Civil Engineering, ASCE, September 1987, pp: 71-73.

Fox, A.J., Ed., Quality in the Constructed Project, Proceedings of the Workshops Sponsored by ASCE, Chicago, IL, November 13-15, 1984.

Frankford Elevated Reconstruction Project, Safety Manual and Reporting Procedures, SEPTA, September 1988.

Greater Bridgeport Transit District, Value Engineering Study: Cross Street Bus Maintenance and Storage Facility, UMTA, UMTA-CT-06-0015-85-1, November 1985. (PB86-155454)

Herbsman, Z., "Project Management Training Using Microcomputers," Journal of Management in Engineering, July 1986, pp: 165-176.

Highway Quality Assurance, Process Control and Acceptance Plans, FHWA, Highway Quality Assurance Seminar, Demonstration Project #42, 1983.

Hill International, Project Management Oversight for the Sacramento Light Rail Transit Starter Line Project, UMTA, April 29, 1988.

Hill, V.F., "Project Poisons and Antidotes," Journal of Petroleum Technology, February 1984, pp: 281-286.

Hirten, J.E., "Managing Capital Projects," Transportation Quarterly, July, 1984, pp: 403-418.

Hribar, J.P. and Asbury, G.E., "Elements of Cost and Schedule Management," Journal of Management in Engineering, July 1985, pp: 138-148.

Kangari, R., "Expert Systems for Risk Analysis," Civil Engineering, ASCE, June 1987, pp: 78-79.

Kerzner, H., Project Management - A Systems Approach to Planning, Scheduling and Controlling, Second Edition, Van Nostrand Reinhold, 1984.

Lee Wan and Associates, Value Engineering Process Overview, UMTA, UMTA-DC-06-0483-88-1, January 1988. (PB88-240288)

Loew, W.R. and Rizzo, J.M., "Claims Avoidance, A Project Necessity," Hill International, June 1987.

"Logic Charts Assist in Project Management," Plant Engineering, November 14, 1985, pp: 50-51.

LTI Consultants, Inc., Rail Modernization Planning Study, UMTA, UMTA-PA-06-0099-86-1, April 1987. (PB87-190351)

Madsen, S.H., "A Project Manager's Many Hats," Civil Engineering, ASCE, February 1985, p: 59.

Management and Control Plan, Sacramento Light Rail Transit Starter Line Project, Sacramento Regional Transit District, September 1985, Revised, December 1985.

Manual of Professional Practice: Quality in the Constructed Project: A Guide for Owners, Designers, and Contractors, Preliminary edition for trial use and comment, ASCE, May 1988.

Marks, G.V. and Lall, B., Ed., Organization and Management of Public Transport Projects, Proceedings of the Specialty Conference sponsored by the Public Transport Committee of the Urban Transportation Division of ASCE, San Francisco, CA, April 11-13, 1985.

McCarthy, R.J., "Constructing a Rail System in a Community - A Public Affairs Overview of Rail Construction Strategies to Gain Community Support," APTA 1989 Rapid Transit Conference in Pittsburgh, PA, June 3 - 8, 1989.

Might, R.J. and Fischer, W.A., "The Role of Structural Factors in Determining Project Management Success," IEEE Transactions on Engineering Management, May 1985, pp: 71-77.

More Construction for the Money, Summary Report of the Construction Industry Cost Effectiveness Project, The Business Roundtable, January 1983, Reprinted July 1987.

National Highway Institute, Preconstruction Engineering Management System, Implementation Manual, FHWA, November 15, 1982.

Padgham, H.F., "Public Performance: A New Role for the Engineer-Manager," Journal of Professional Issues in Engineering, April 1984, pp: 81-87.

Pamukcu, D. and Pruett, J.M., "IPM: A Computer Interactive Project Management Teaching Tool," Computer and Industrial Engineering, Vol. 9, No. 3, 1985, pp: 231-245.

Parsons, DeLeuw, Cather, Dillingham (PDCD), Administrative Procedures Manual, Los Angeles Metro Rail Project, SCRTD, August 1984, Revision No. 2, March 1987.

PDCD, Construction Operations Procedures Manual, Los Angeles Metro Rail Project, SCRTD, December 1984, Revised April 1987.

PDCD, Construction Safety and Security Manual, Los Angeles Metro Rail Project, SCRTD, February 1985, Revision No. 2, February 1987.

PDCD, Contracts/Procurement, Los Angeles Metro Rail Project, SCRTD, March 1987, First Revision, May 1987.

PDCD, Organization and Responsibilities Manual, Los Angeles Metro Rail Project, SCRTD, November 1984, Second Revision, February 1987.

PDCD, Project Controls Procedures Manual, Los Angeles Metro Rail Project, SCRTD, March 1987.

PDCD, Resident Engineer Manual, Los Angeles Metro Rail Project, SCRTD, February 1987.

The Peer Review Manual, Third Edition, American Consulting Engineer Council, 1987.

Project Management Body of Knowledge Standards, Project Management Institute, March 28, 1987.

Project Management Plan, Daly City Turnback and Yard Project, BART, October 30, 1986, Revised February 18, 1987.

Project Management Plan for MOS-1 Construction, SCRTD Metrorail Project, SCRTD, September 29, 1987, First Revision: April 1987.

Project Management Procedures Manual, Volume 1 - Administrative and Support Activities, New York City Transit Authority (NYCTA), Engineering and Construction Department, December 16, 1985.

Project Management Procedures Manual, Volume 2 - Schedule and Cost Control, NYCTA, Engineering and Construction Department, December 16, 1985.

Project Management Procedures Manual, Volume 3 - Engineering Design and Construction, NYCTA, Engineering and Construction Department, December 16, 1985.

"A Proposed Project Termination Audit Model," IEEE Transactions on Engineering Management, August 1983, pp: 123-127.

Public Technology, Inc., Transportation Construction Management, Urban Consortium for Technology Initiatives, September 1980.

Quality Assurance for Local Governments, FHWA, FHWA-IP-83-1, February 1983. (PB84-111509)

Rail Construction Program Management Study, WMATA, Revised, October, 1985.

Relocation and Real Property Acquisition, Proceedings of a Conference Sponsored by the FHWA and Conducted by TRB, Special Report 192, 1981.

"Report on Quality Assurance," Appendix A-6.4 to Report A-6: Modern Management Systems, The Business Roundtable, Construction Industry Cost Effectiveness Project, February 1983.

Rice Center, Alternative Financing for Urban Transportation: State of the Practice, USDOT, DOT-I-86-30, July 1986. (PB87-130266)

Robinson, R., "Building with Software," Civil Engineering, ASCE, May 1986, pp: 78-80.

Ruskin, A.M. and Estes, W.E., "The Project Management Audit: Its Role and Conduct," Engineering Management International, Vol. 2, 1984, pp: 279-286.

Ryan, J.M., Emerson, D.J., et al, Procedures and Technical Methods for Transit Project Planning, Review Draft, UMTA, September 1986.

Schenk, R.W., "Configuration Management As Applied to Engineering Projects," Journal of Management in Engineering, July 1985, pp: 157-165.

S.G. Associates, Inc. and Clark, Nexsen, Owen, Barbieri, and Gibson, Bus Maintenance Facility Planning Guidelines, Draft Final Report, UMTA, IT-09-9018, November 1987.

Shukla, J.H., et al, "CPM Harnesses Mammoth Powerplant Job," Civil Engineering, ASCE, January 1985, pp: 50-53.

Smallowitz, H., "Project Management on a Micro," Civil Engineering, ASCE, October 1985, pp: 58-61.

Specifications of the General Requirements for a Quality Assurance Program, American National Standards Institute (ANSI), Document Z1.8, November 18, 1971 and American Society for Quality Control, November 1985.

Staffing Considerations in Construction Engineering Management, TRB, Synthesis of Highway Practice No. 145, May 1989.

Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, FHWA, FP-85, 1985.

Standards of Practice, Construction Management Association of America, 1986.

Statistically Based Acceptance Procedures, Quality Assurance, and Construction Management, TRB, Transportation Research Record 1056, 1986.

Stevens, W.M., "Cost Control: Integrated Cost/Schedule Performance," Journal of Management in Engineering, July 1986, pp: 157-164.

Summary Report of the FHWA Sponsored 1985 National Value Engineering Conference, San Diego, CA, April 9-11, 1985.

Teicholz, P.M., Ed., Making Project Control Systems Work, Proceedings of a session sponsored by the Construction Division of ASCE in conjunction with the ASCE Convention in Detroit, MI, October 21, 1985.

Tayanipour, S.S., "Design Support of Construction to Reduce Loss and Enhance Quality," APTA 1989 Rapid Transit Conference in Pittsburgh, PA, June 3 - 8, 1989.

Transit Development Corporation, Subway Environmental Design Handbook: Volume I, Principles and Application, Second Edition, UMTA, DC-06-0010-76-1, March 1976. (PB-254788)

Transit Management and Replacement Capital Planning, Transportation Research Record 1165, TRB, 1988.

Transportation Systems Center (TSC), Construction Management Oversight Options for UMTA, UMTA, November 1, 1983.

U.S. National Committee on Tunneling Technology, NRC, Better Contracting for Underground Construction, National Science Foundation (NSF), UMTA, Corps of Engineers, November 1974. (PB-236973)

U.S. National Committee on Tunneling Technology, NRC, Better Management of Major Underground Construction Projects, UMTA and NSF, 1978. (PB-290855)

U.S. National Committee on Tunneling Technology, NRC, Recommended Procedures for the Settlement of Underground Construction Disputes, NSF, UMTA, FHWA, November, 1977. (PB-272964)

UMTA, "Major Capital Investment Projects," Federal Register, Proposed Rulemaking, April 25, 1989, pp. 17878-17892.

UMTA, "Project Management Oversight," Rederal Register, Final Rule, September 1, 1989, pp. 36708-36713.

Urban Mass Transportation Project Management Guidelines for Grantees, UMTA, UMTA Circular 5010.1A., July 22, 1988.

Urban Institute, Guidelines for the Estimation of Transit Cost, TSC, November 1980.

"Value Engineering," Federal Acquisition Regulations, Part 48 (defines Federal VE policies and procedures concerning the incentivization of VE programs and VE proposals) and Parts 52.248-1 through 52.248-3 (contains the solicitation and contract clauses to be used to implement VE programs in design and construction RFPs and contracts).

Veranth, J.M., "Project Scheduling Techniques," Chemical Engineering, April 15, 1985, pp: 61-68.

Wheelwright, J.C., "How To Choose the Project Management Microcomputer Software That's Right For You," Industrial Engineering, January 1986, pp: 46-50.

WMATA, Value Engineering Study Springfield Metrobus Garage Engineering Study Springfield Metrobus Garage Facility, UMTA, UMTA-DC-06-0461-85-1, November 1985. (PB86-165180)