

Contract No. 3136-3

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT

SYSTEM ASSURANCE PROGRAM PLAN
WBS 05

For
Final Design and Construction/Acquisition

February 1986

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1.0 INTRODUCTION

1.0 INTRODUCTION

The SCRTD system assurance program comprises the organization and activities required to ensure that the Metro Rail system, once operational, provides dependable rail rapid transit service. The program is a comprehensive one, extending throughout all phases of the Metro Rail project. This System Assurance Program Plan (SAPP) identifies the goals and purpose of the program, the program's management structure, and the tasks and activities to be accomplished by the program during each phase of the Metro Rail project.

1.1 AUTHORITY

In 1964, California enabling legislation, under Public Utilities Code Part 3, created the Southern California Rapid Transit District (SCRTD). The law included the mandate to develop a rapid transit system.

Because the Metro Rail project is funded in part by the Federal Government, all program planning, including system assurance, falls under the purview of the Urban Mass Transportation Administration (UMTA) and is subject to that agency's review.

1.2 POLICY

A primary goal of the Metro Rail project is to develop and operate a safe and cost-effective rail rapid transit system that provides an acceptable level of service dependability. System dependability can be achieved by incorporating reliability and maintainability requirements in Metro Rail designs, by implementing quality assurance measures, and by effectively planning for maintenance of the operational system. The SCRTD has therefore established a comprehensive program for managing reliability, maintainability, quality assurance, and maintenance planning requirements. These requirements include:

- Procuring equipment which has proven reliable in similar applications on other rail rapid transit systems
- Applying the principle of redundancy in design so that the failure of a single component will not be critical to safety or operational service

- Incorporating maintainability principles in all designs
- Establishing well-defined quality assurance procedures to ensure that materials, components, and equipment delivered by contractors and subcontractors conform to functional and performance requirements
- Establishing appropriate quality assurance and maintenance programs and procedures for the Metro Rail system to maximize operational service with minimum downtime.

The Metro Rail system will, in general, use hardware that has proven its reliability in similar applications at other rail rapid transit systems. While the use of proven equipment is one important system assurance measure, it does not lessen the emphasis that must be placed on all other aspects of system assurance management.

1.3 GOALS

The goals of the SAPP are to define design, construction, testing, and start-up activities and management controls, plans, and monitoring processes to ensure that:

- Reliability, maintainability, and quality assurance considerations, compatible with other system requirements, are incorporated into the Metro Rail system during the design phase. This will minimize the potential for equipment failures and maintenance problems once the system becomes operational.
- Potential reliability and maintainability problems associated with Metro Rail equipment designs are identified and actions are taken to eliminate or minimize the problems.
- Manufacturers and suppliers comply with the quality standards established by the SCRTD.
- Steps required to ensure proper maintenance management of Metro Rail facilities and equipment are implemented prior to the start of revenue operations.
- Safety, security, and fire/life safety considerations are coordinated with system assurance efforts.

1.4 PURPOSE

The purpose of the SAPP is to set forth the requirements for evaluating system assurance needs and implementing system assurance measures in each phase of the Metro Rail project. The plan defines formal requirements, including the:

- Structure of the system assurance management organization
- Implementation of established system assurance criteria
- Mechanisms for identifying and assessing system assurance problems in the design phase
- Methods to eliminate, minimize, or control identified system assurance problems.

1.5 SCOPE

The scope of the SAPP encompasses the management and technical system assurance activities to be performed during each phase of the Metro Rail project: Preliminary Engineering, Continuing Preliminary Engineering, Final Design, Construction/Acquisition, Pre-Operational Testing, and Start-Up Operations. The emphasis of this edition of the plan is on the definition of system assurance tasks associated with the Final Design and Construction/Acquisition Phases, and on reviewing progress on the tasks conducted during Preliminary Engineering and Continuing Preliminary Engineering. This edition of the SAPP defines the reliability, maintainability, quality assurance, and maintenance planning related activities to be performed to support system designers in the finalization of system and subsystem specifications, in conducting the contract award process, and in managing system assurance activities during construction and acquisition.

Tasks associated with subsequent phases (Pre-Operational Testing and Start-Up Operations) are identified in this edition of the SAPP (Exhibits 3-1, 4-1, 5-1, 6-1, and 7-1) but are not described in detail. These task descriptions will be part of a subsequent update.

1.6 UPDATE PROCEDURES

The SAPP is updated during each phase of the Metro Rail project (Construction/Acquisition, Pre-Operational Testing, Start-Up Operations) to:

- Assess progress on tasks accomplished in the preceding phase
- Refine and improve the descriptions of tasks and responsibilities for the present phase
- Identify new tasks which may be required as the system progresses
- Define in detail the system assurance tasks and responsibilities for the next phase.

The analysis, review, and revision process is the responsibility of the Supervisor, Metro Rail Safety and Systems Assurance Office. Inputs for these periodic updates will be solicited from SCRTD Systems Design and Analysis, Transit Facilities Engineering, Construction Management, the General Consultant, the Systems Engineering and Analysis Consultant, the Construction Manager, and SCRTD rail operations and maintenance personnel.

1.7 ORGANIZATIONAL TERMINOLOGY

The following presents a glossary of organizational terms used in the SAPP:

SCRTD	Southern California Rapid Transit District; an agency created by the California legislature and charged with the development of a rapid transit system.
UMTA	Urban Mass Transportation Administration; an administration of the U.S. Department of Transportation, the Federal agency that assists state and local governments in financing transportation, both in capital equipment procurements and in operating subsidies.
MRTC	Metro Rail Transit Consultants; also known as the General Consultant (GC), a joint venture of Daniel, Mann, Johnson, Mendenhall/Parsons, Brinkerhoff, Quade & Douglas/Kaiser Engineers/Harry Weese & Associates (DMJM/PBQD/KE/HWA).

BA&H Booz, Allen & Hamilton Inc.; also known as the System Engineering and Analysis (SEA) Consultant.

PDCD Ralph M. Parsons Co./Dillingham Construction/DeLeuw Cather & Co., also known as the Construction Manager (CM).

1.8 APPLICABLE DOCUMENTS

The following documents were used in preparing the SAPP or provide related information:

Metro Rail System Assurance Criteria, SCRTD Metro Rail System Design Criteria and Standards, Volume I, Section 5.

Safety, Fire/Life Safety, Security and Systems Assurance - SCRTD Metro Rail Milestone Report 7, March 1983.

Metro Rail Project Definition and Objectives, WBS 13DAH, Booz, Allen & Hamilton, December 1981.

Review of Codes, Guidelines, Regulations, and Other Information, Subsystems, WBS 12F, Kaiser Engineers, March 1982.

Content Guidelines for the Development of System Safety Program Plans for Fixed Guideway Transit Systems in the Acquisition Phase, Booz, Allen & Hamilton, April 1981, Contract Number: DOTUM-60-80-CO71004.

Baltimore Region Rapid Transit System, System Assurance Program Plan, State of Maryland Department of Transportation, December 1978.

Safety, Security, and System Assurance Plans - Pittsburgh Light Rail Transit Reconstruction, Booz, Allen & Hamilton, April 1979.

Rapid Transit Systems - APTA Glossary of Reliability, Availability and Maintainability Terminology for Rail Rapid Transit, February 1978.

2.0 SYSTEM DESCRIPTION

2.0 SYSTEM DESCRIPTION

2.1 GENERAL OVERVIEW

The Metro Rail system is an 18-mile rail rapid transit line planned by the Southern California Rapid Transit District to run from downtown Los Angeles via the Wilshire District to Fairfax Avenue, and through Hollywood to the San Fernando Valley. This line is planned to be the core element of a regional rail rapid transit system. While the entire mainline portion of the 18-mile line is planned as subway, future extensions may involve surface or aerial segments. A map of the proposed system is shown in Exhibit 2-1.

Federal funding is currently insufficient to enable construction of either the 18-mile Metro Rail system or the 8.8-mile minimum operable segment identified in the Federal Environmental Impact Statement. Construction of the system will therefore begin on the first 4 miles of the line, identified as the initial operating segment. This initial segment, termed MOS-1, will begin at Union Station, northeast of the Los Angeles Civic Center; run through the central business district; and terminate on the west at the Wilshire/Alvarado Station. The double-track mainline route will be entirely in subway; line segments will be constructed by tunnel boring machines, and stations and crossovers will be excavated by cut-and-cover construction techniques. Three crossovers will be included in the subway portion of MOS-1, one at each end of Union Station and one at the east end of the Wilshire/Alvarado Station.

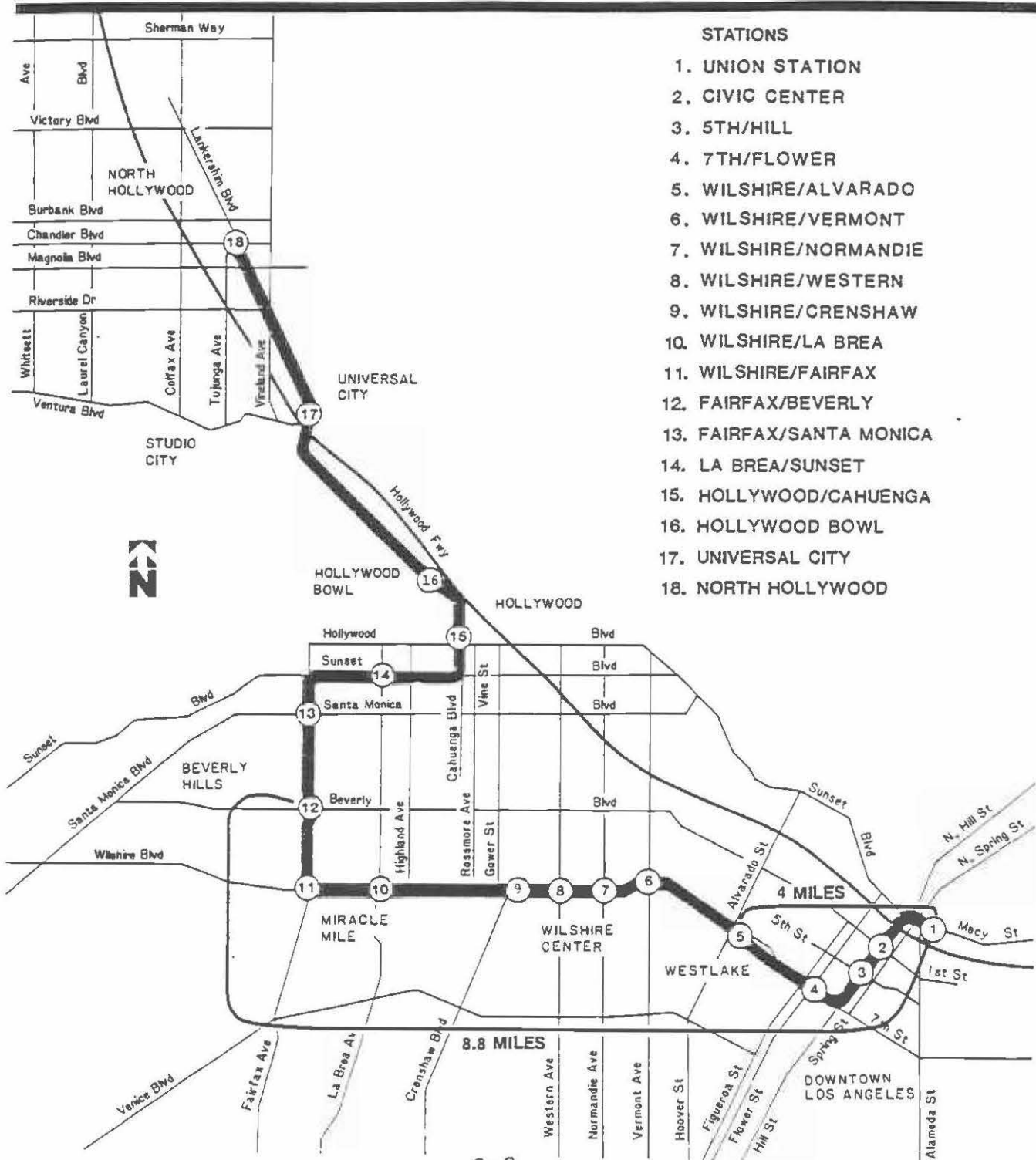
Additional subway and surface track will connect the mainline with the yard, located southeast of Union Station. MOS-1 will include all yard and shop facilities planned for the 18-mile system except for a portion of the yard storage tracks and some shop equipment, which will be installed as warranted by system and fleet expansion.

The MOS-1 line will have five stations. Four of these stations will be of a double-ended design with two mezzanines, the fifth station, Wilshire/Alvarado, will be of the single-center-mezzanine design characteristic of the majority of the stations on the 18-mile line. Each mezzanine free area will have ticket vending machines and will be separated from the paid area by one or two arrays of entry/exit faregate barriers. The fare structure for MOS-1 will be based on a single zone, but fare collection

EXHIBIT 2-1
Map of the Proposed Metro Rail System



Southern California Rapid Transit District
Metro Rail Project
TOTAL 18.6 MILES



equipment will have multi-zone capability to accommodate system expansion. Escalators, stairs, and elevators will provide normal vertical circulation between surface, mezzanine, and platform levels. Stations will be equipped for both attended and unattended operation. Some stations will have adjacent parking facilities, pick-up/drop-off areas, and/or bus pull-in areas to accommodate patrons arriving by automobile or by bus.

The vehicles for the system will be stainless steel, standard gauge, 75-foot-long rail cars, which will be configured in dependent pairs. They will be capable of operating at speeds up to 70 miles per hour and will operate on 750 VDC power supplied via third rail. Each single vehicle will have a capacity for 59 seated passengers, plus space for one wheelchair, and up to 160 passengers at crush loads.

MOS-1 trains will have Automatic Train Protection equipment to ensure safe speed and separation of trains. Automatic Train Operation (ATO) also will be included to regulate train speed and provide precision station stopping and train berthing verification. System operation will be centrally controlled from the Rail Control Center, located in the yard, using communication links with facilities and trains involving telephones, radios, closed-circuit television (CCTV) and data transmission.

Ridership on MOS-1 is projected to be approximately 54,000 per day. To serve this demand, a fleet of 30 passenger vehicles will be required, operating as four-car trains with headways of 5 minutes during peak hours, increasing to 20 minutes during evenings and weekends. However, six-car trains operating at 2 1/2 minute headways will be required to serve projected demand on the 18-mile line.

2.2 PROPOSED MAINTENANCE

During the Preliminary Engineering Phase of the Metro Rail project, general requirements for subsystem and system maintenance were developed. During the Final Design and Construction/Acquisition Phases, as elements of the Metro Rail system reach their final configuration, these general requirements will be refined and preventive and corrective maintenance procedures will be developed, including:

- Maintenance facility layouts and equipment configuration for the vehicle yard and component repair shops, and maintenance-of-way facilities.

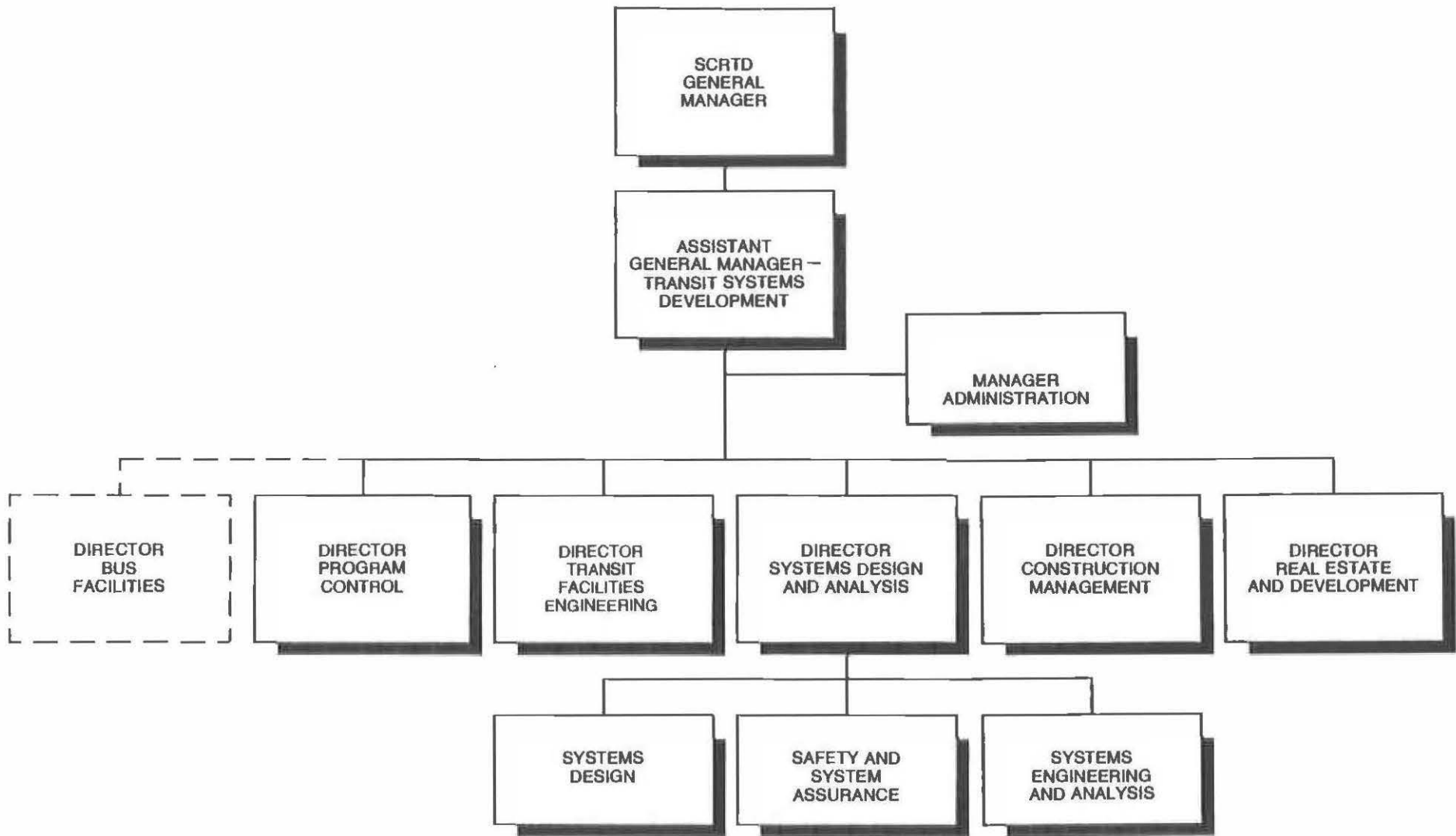
- Development of basic maintenance programs for vehicles, train control, communication, electrification, track, station, fare collection, and other equipment. Included will be a definition of work tasks, frequency, and shop time for scheduled maintenance.
- Development of detailed maintenance practices and procedures, work flows, equipment requirements, etc.
- Development of work standards and labor-hour requirements for preventive and corrective maintenance.
- Identification of diagnostic and troubleshooting requirements and procedures.
- Development of training requirements for maintenance personnel, including the development of classroom and on-the-job training programs.
- Development of maintenance safety rules, procedures, and processes. This activity will be coordinated with the safety group.
- Integration of maintenance reporting and management control systems with present SCRTD capabilities.

2.3 METRO RAIL PROJECT ORGANIZATION

The organizational structure of the Metro Rail project is shown in Exhibit 2-2. This organizational structure has been established to direct the Design, Construction/Acquisition, Pre-Operational Testing, and Start-Up Phases of the Metro Rail project. As the Metro Rail system becomes fully operational, a transition will occur to a new Metro Rail organizational structure encompassing the maintenance and operations functions necessary for revenue service.

Within the Metro Rail project, the Director of Systems Design and Analysis has overall responsibility for the system assurance program and the activities of the system assurance organization, as described below.

The Metro Rail Transit Facilities Engineering and Construction Management Departments will participate in the safety assurance program, given that their design, construction, and procurement decisions will affect, and be affected by, system assurance requirements. Similarly,



2-5

EXHIBIT 2-2
 SCRTD Metro Rail Project Organization

Metro Rail operations and maintenance personnel will also participate in the system assurance program.

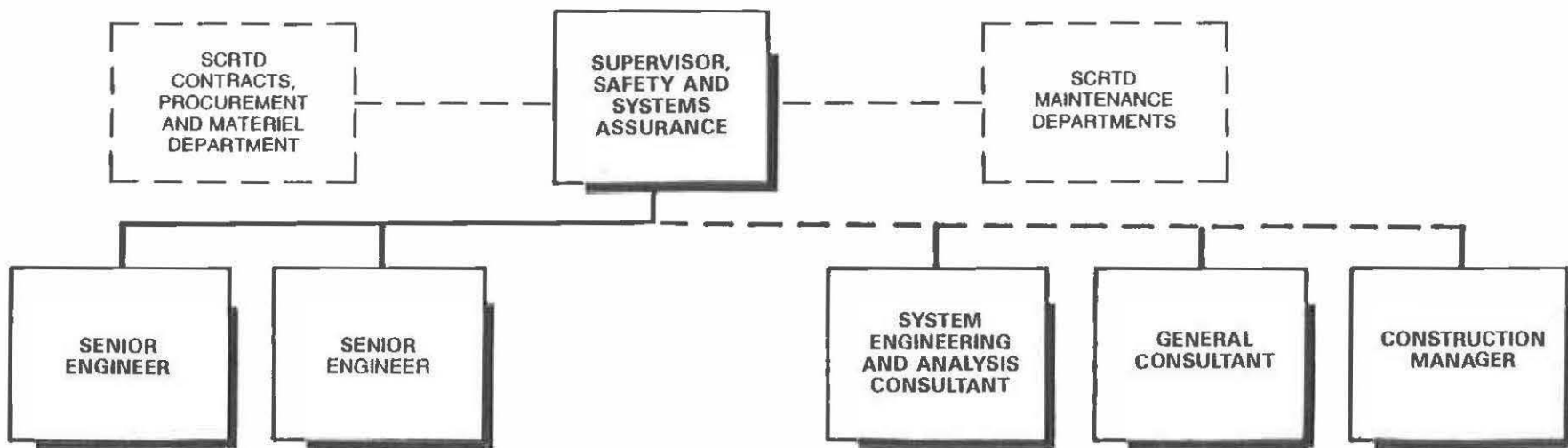
2.4 SYSTEM ASSURANCE ORGANIZATION

The Director of Systems Design and Analysis is responsible for the overall management and coordination of system assurance program activities on the Metro Rail project prior to the start of revenue operations.

Reporting to the Director of Systems Design and Analysis, the Supervisor of Safety and System Assurance (S&SA) is responsible for the day-to-day management of system assurance program activities. The Supervisor of S&SA directs the work of his own staff and of contract consultants supplying technical expertise to the project. As shown in Exhibit 2-3, the Metro Rail system assurance organization includes three contract consultants: the General Consultant (Metro Rail Transit Consultants); the System Engineering and Analysis Consultant (Booz, Allen & Hamilton Inc.); and the Construction Manager (Ralph M. Parsons Co./Dillingham Construction/DeLeuw Cather & Co.). Exhibits 2-4, 2-5, and 2-6 illustrate the project organizations of each of these three consultants.

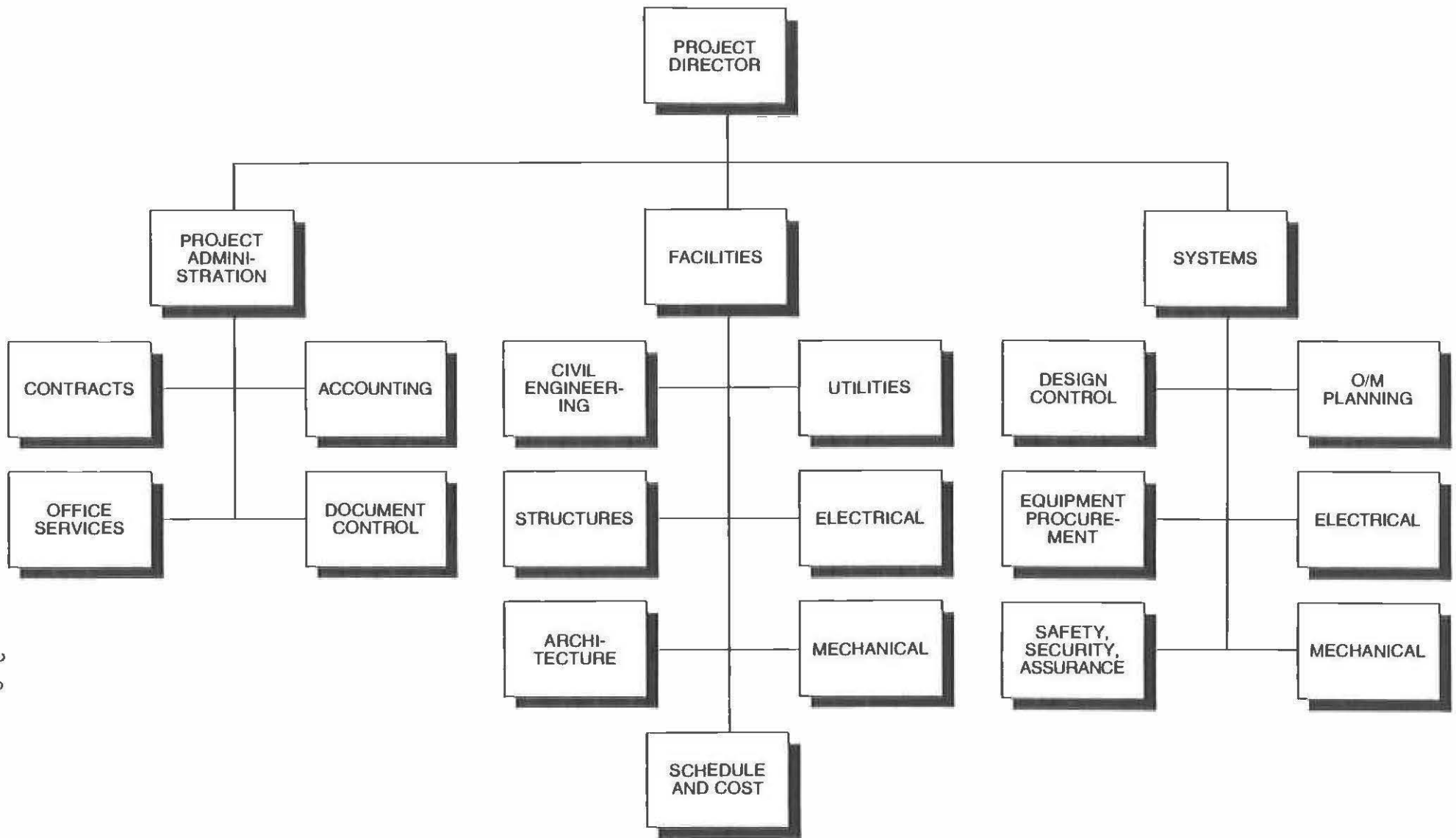
The system assurance organization is responsible for developing and coordinating the implementation of the Metro Rail system assurance program. Specifically, the organization is responsible for:

- Establishing reliability, maintainability, and quality assurance goals and standards
- Analyzing procedures, rules, and practices to ensure adequate reliability, maintainability, and quality assurance practices are maintained
- Periodically collecting system assurance information from other properties to evaluate reliability, maintainability, and quality improvements for the Metro Rail system
- Coordinating the development of a comprehensive maintenance program for Metro Rail facilities and equipment
- Developing the Failure Reporting, Analysis and Corrective Action System (FRACAS) and ensuring it is compatible with SCRTD maintenance management system development



2-7

EXHIBIT 2-3
System Assurance Organization



2-8

EXHIBIT 2-4
 Organization of Metro Rail Transit Consultants

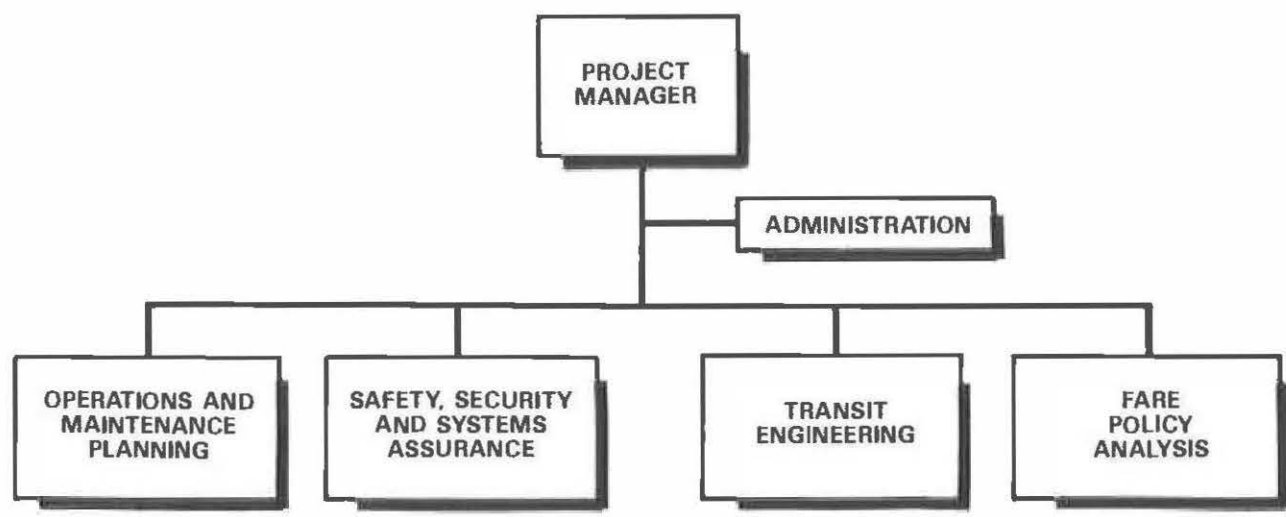


EXHIBIT 2-5
Organization of Booz, Allen & Hamilton Inc.

2-10

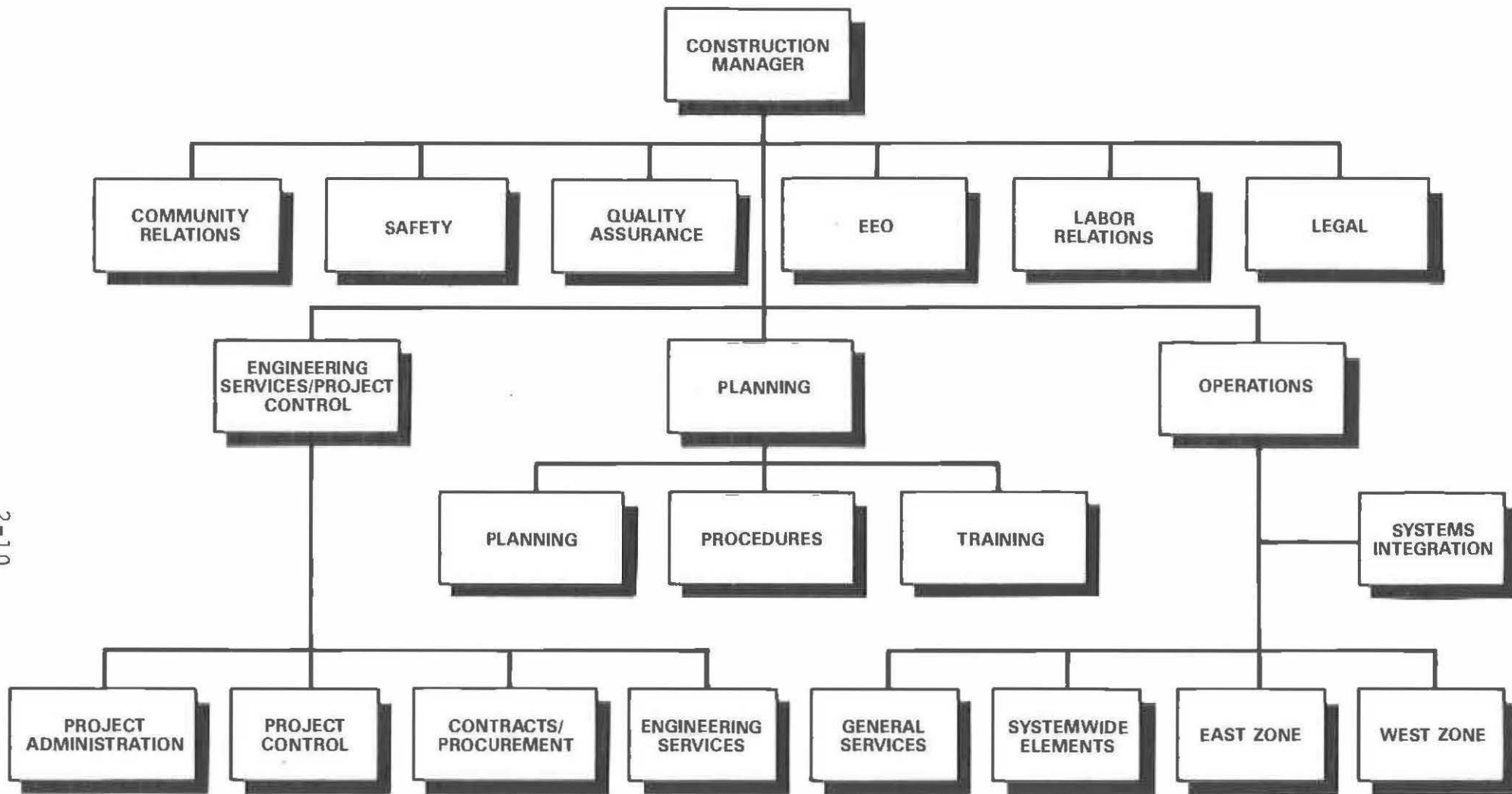


EXHIBIT 2-6
Organization of Ralph M. Parsons Co./
Dillingham Construction/DeLeuw Cather & Co.

- Participating in design reviews and planning sessions pertaining to safety, security, system assurance, and training
- Auditing design changes to the system to ensure that they do not degrade the dependability of the Metro Rail system
- Overseeing, guiding, and supporting activities which may be required to execute the system assurance program throughout all phases of the Metro Rail project prior to revenue service
- Monitoring problems, failures, and corrective actions occurring on Metro Rail equipment during the Pre-Operational Testing and Start-Up Phases
- Informing management of the status of the system assurance program and of monitoring activities.

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3.0 SYSTEM ASSURANCE PROGRAM TASKS

3.0 SYSTEM ASSURANCE PROGRAM TASKS

3.1 GENERAL

The SCRTD system assurance program is designed to ensure that:

- Fundamental reliability and maintainability concepts are incorporated into the design of the Metro Rail system
- Effective quality assurance practices are used during the manufacture of transit equipment and/or construction of facilities
- Maintenance management functions and responsibilities are effectively planned and implemented.

The System Assurance Program Plan (SAPP) identifies activities for each phase of the Metro Rail project:

- Preliminary Engineering
- Continuing Preliminary Engineering
- Final Design
- Construction and Acquisition
- Pre-Operational Testing
- Start-Up Operations.

The SAPP identifies long-term strategies for implementing reliability, maintainability, and quality assurance requirements as a systematic process. At the same time, it delineates activities to be performed by the system assurance organization to ensure their effective involvement in the development of the Metro Rail system.

The SAPP is a dynamic document. While the long-term system assurance strategies will remain basically constant, short-term tasks evolve as the system and subsystem parameters become better defined. The system assurance program is therefore periodically reviewed as the Metro Rail project progresses. These reviews will be reflected in subsequent editions of the SAPP.

The analysis, review, and revision process is the responsibility of the Metro Rail Safety and System Assurance Office with support from other groups (System Design and Analysis, Transit Facilities Engineering, Construction Management, General Consultant, System Engineering and Analysis Consultant, Construction Manager, and SCRTD rail maintenance personnel).

Exhibit 3-1 lists the general system assurance tasks presently identified for each phase of the Metro Rail project. Task numbers in the left-hand column of Exhibit 3-1 correspond to the paragraph numbers in the text.

Exhibit 3-2 identifies the organization/or organizations having principal responsibility for preparing, supporting, and/or reviewing and commenting on each task or activity. Within the matrix, task responsibilities are defined by the following letter codes:

- P Primary responsibility - The identified participant is responsible for the conduct of the task and the preparation of the necessary documentation.
- S Secondary or support responsibility - The identified participant is to provide such support as may be necessary to accomplish and document the task effort.
- RC Review and comment responsibilities - The identified participant is charged with examination of the data and information provided by the primary participant(s). Following each completed review, the designated participant submits Metro Rail review and comment forms to the Safety and System Assurance Supervisor.

Sections 3.2 through 3.6 outline the system assurance activities that relate to all reliability, maintainability, quality assurance, and maintenance planning issues. Chapter 4.0 addresses specific reliability tasks; Chapter 5.0 addresses specific maintainability tasks; Chapter 6.0 addresses specific quality assurance tasks; and Chapter 7.0 specifically addresses maintenance planning.

EXHIBIT 3-1
General System Assurance Activities and Tasks

PARAGRAPH NUMBER	TASK TITLE	PROJECT PHASE					
		PRELIMINARY ENGINEERING	CONTINUING PRELIMINARY ENGINEERING	FINAL DESIGN	CONSTRUCTION/ACQUISITION	PRE-OPERATIONAL TESTING	START-UP OPERATIONS
	<u>CRITERIA DEVELOPMENT</u>						
3.2.1	Develop System Assurance Criteria	●	●				
3.2.2	Update and Revise System Assurance Criteria		●	●	●	●	
3.2.3	Develop System Assurance Input to Milestone Program	●					
	<u>PLANS AND PROCEDURES</u>						
3.3.1	Prepare and Periodically Update the System Assurance Program Plan	●	●	●	●	●	
3.3.2	Prepare Contractor System Assurance Monitoring Plans			●	●		
	Develop the Operations Phase System Assurance Organization					●	●
	Establish System Assurance Improvement Programs					●	●
	<u>ANALYSES AND STUDIES</u>						
3.4.1	Define Reliability and Maintainability Measures	●					
3.4.2	Develop and Update Reliability and Maintainability Numerical Indices		●	●	●		
3.4.3	Conduct System Assurance Trade-Off Studies	●	●	●	●		

3-3 (a)

EXHIBIT 3-1 (Continued)
General System Assurance Activities and Tasks

PARAGRAPH NUMBER	TASK TITLE	PROJECT PHASE					
		PRELIMINARY ENGINEERING	CONTINUING PRELIMINARY ENGINEERING	FINAL DESIGN	CONSTRUCTION/ACQUISITION	PRE-OPERATIONAL TESTING	START-UP OPERATIONS
	<u>DESIGN, CONSTRUCTION, PROCUREMENT, AND TESTING SUPPORT</u>						
3.5.1	Provide General Design Support	•	•	•	•	•	
3.5.2	Provide General Construction/Procurement Support				•		
3.5.3	Participate in SCRTD Design Reviews		•	•			
3.5.4	Identify System Assurance Documentation Requirements for Contract Specifications	•	•	•			
3.5.5	Develop Guidelines for the Preparation of Safety and System Assurance Analyses			•			
3.5.6	Prepare System Assurance Criteria Conformance Checklists		•	•			
3.5.7	Prepare Specification Conformance Checklists			•	•		
3.5.8	Conduct Coordination Meetings with Contractor System Assurance Staff			•	•	•	
3.5.9	Participate in Change Control Board Activities			•	•	•	
3.5.10	Review Contractor Analyses and Reports	•	•	•	•	•	•
3.5.11	Participate in System Integration Test Program Development				•		

3-3 (b)

EXHIBIT 3-1 (Continued)
General System Assurance Activities and Tasks

PARAGRAPH NUMBER	TASK TITLE	PROJECT PHASE					
		PRELIMINARY ENGINEERING	CONTINUING PRELIMINARY ENGINEERING	FINAL DESIGN	CONSTRUCTION/ACQUISITION	PRE-OPERATIONAL TESTING	START-UP OPERATIONS
3.5.12	Review Operating and Maintenance Manuals and Procedures Participate in Testing Program Provide Operations/Maintenance Support Develop System Assurance Management Reports <u>DOCUMENTATION</u>				•	•	•
3.6.1	Establish System Assurance Library	•	•	•	•	•	•
3.6.2	Establish System Assurance Documentation and Review Procedures		•	•			

3-3 (c)

EXHIBIT 3-2
General System Assurance Task Responsibilities

PARAGRAPH NUMBER	TASK / ACTIVITY	METRO RAIL								GENERAL CONSULTANT	CONSTRUCTION MANAGER	RAIL OPERATIONS	RAIL MAINTENANCE
		SYSTEM DESIGN & ANALYSIS						TRANSIT FACILITIES ENGINEERING	CONSTRUCTION MANAGEMENT				
		SAFETY & SYSTEMS ASSURANCE	SYSTEMS ENGINEERING & ANALYSIS	SYSTEMS DESIGN	SYSTEMS ENGINEERING CONSULTANT	FIRE DEPTS AND RESCUE SQUAD	POLICE DEPTS. CORONERS OFFICE						
	<u>CRITERIA DEVELOPMENT</u>												
3.2.1	Develop System Assurance Criteria	S	RC	RC	P			RC		S			
3.2.2	Update and Revise System Assurance Criteria	S	RC	RC	S			RC	RC	P	RC	RC	RC
3.2.3	Develop System Assurance Input to Milestone Program	P		S	S					S			
	<u>PLANS AND PROCEDURES</u>												
3.3.1	Prepare and Periodically Update the System Assurance Program Plan	S	RC	RC	P			RC	RC	RC	RC	RC	RC
3.3.2	Prepare Contractor System Assurance Monitoring Plans	P	RC	RC	S			RC	S	S	P		
	<u>ANALYSES AND STUDIES</u>												
3.4.1	Define Reliability and Maintainability Measures	S	RC	RC	P			RC	RC	S	RC		RC
3.4.2	Develop and Update Reliability and Maintainability Numerical Indices	S	RC	RC	S			RC	RC	P	RC		RC
3.4.3	Conduct System Assurance Trade-Off Studies	P	RC	RC	S	S	S	S	S	S	S		S

3-4 (a)

EXHIBIT 3-2 (Continued)
General System Assurance Task Responsibilities

PARAGRAPH NUMBER	TASK / ACTIVITY	METRO RAIL								GENERAL CONSULTANT	CONSTRUCTION MANAGER	RAIL OPERATIONS	RAIL MAINTENANCE
		SYSTEM DESIGN & ANALYSIS							CONSTRUCTION MANAGEMENT				
		SAFETY & SYSTEMS ASSURANCE	SYSTEMS ENGINEERING & ANALYSIS	SYSTEMS DESIGN	SYSTEMS ENGINEERING CONSULTANT	FIRE DEPTS AND RESCUE SQUAD	POLICE DEPTS. CORONERS OFFICE	TRANSIT FACILITIES ENGINEERING					
	<u>DESIGN, CONSTRUCTION, PROCUREMENT, AND TESTING SUPPORT</u>												
3.5.1	Provide General Design Support	P			S							S	S
3.5.2	Provide General Construction/Procurement Support	P			S					S			S
3.5.3	Participate in SCRTD Design Reviews	P			S					S	S		S
3.5.4	Identify System Assurance Documentation Requirements for Contract Specifications	S	RC	RC	S			RC	RC	P	RC		RC
3.5.5	Develop Guidelines for the Preparation of Safety and System Assurance Analyses	S	RC	RC	P	RC	RC	RC	RC	RC	RC		RC
3.5.6	Prepare System Assurance Criteria Conformance Checklists	S	RC	RC	S			RC	RC	P	S		RC
3.5.7	Prepare Specification Conformance Checklists	S	RC	RC	S			RC	RC	P	S		RC
3.5.8	Conduct Coordination Meetings with Contractor System Assurance Staff	P			S					S	S		S
3.5.9	Participate in Change Control Board Activities	P								S	S		S

3-4 (b)

EXHIBIT 3-2 (Continued)
General System Assurance Task Responsibilities

PARAGRAPH NUMBER	TASK / ACTIVITY	METRO RAIL								GENERAL CONSULTANT	CONSTRUCTION MANAGER	RAIL OPERATIONS	RAIL MAINTENANCE
		SYSTEM DESIGN & ANALYSIS						TRANSIT FACILITIES ENGINEERING	CONSTRUCTION MANAGEMENT				
		SAFETY & SYSTEMS ASSURANCE	SYSTEMS ENGINEERING & ANALYSIS	SYSTEMS DESIGN	SYSTEMS ENGINEERING CONSULTANT	FIRE DEPTS AND RESCUE SQUAD	POLICE DEPTS. CORONERS OFFICE						
3.5.10	Review Contractor Analyses and Reports	P	RC	RC	RC			RC	RC	RC	RC		RC
3.5.11	Participate in System Integration Test Program Development	P	P	P	S	S	S	S	S	S	S	S	S
3.5.12	Review Operating and Maintenance Manuals and Procedures	RC	RC	RC	RC			RC	RC	RC	RC	P	P
	<u>DOCUMENTATION</u>												
3.6.1	Establish System Assurance Library	P											
3.6.2	Establish System Assurance Documentation and Review Procedures	P											

3-4 (c)

3.2 CRITERIA DEVELOPMENT

3.2.1 Develop System Assurance Criteria

System Assurance Criteria were developed as part of the planning process undertaken during the Preliminary Engineering Phase.* The System Assurance Criteria set forth the requirements to be followed by design engineers in equipment selection and facilities design. The System Assurance Criteria will be integrated into all aspects of design, specification preparation, equipment selection, construction, architectural concepts, procedures, and operations.

3.2.2 Update and Revise System Assurance Criteria

During the design process, changes may be made to the System Assurance Criteria based on the results of trade-off studies and alternatives analysis. The System Assurance Criteria will be revised in accordance with established Metro Rail document control and configuration management practices.

3.2.3 Develop System Assurance Input to Milestone Program

As part of the Metro Rail community participation and milestone program, a chapter on system assurance was incorporated into the Metro Rail project Milestone 7 Report.** It described the SCRTD's comprehensive system assurance program in the areas of reliability, maintainability, and quality assurance. The Milestone 7 Report was adopted by the Board of Directors in March 1983.

3.3 PLANS AND PROCEDURES

3.3.1 Prepare and Periodically Update the System Assurance Program Plan

Based on SCRTD goals and objectives for a dependable Metro Rail system, this SAPP has been developed to define the system assurance management and

* Metro Rail System Assurance Criteria, WBS 13DAD, Booz, Allen & Hamilton and Kaiser Engineers, November 1982. Incorporated into SCRTD Metro Rail System Design Criteria and Standards, Volume I, Section 5.

** Metro Rail Project Milestone 7 Report, Safety, Fire/Life Safety, Security and Systems Assurance, Final Report, March 1983, Chapter V.

technical tasks that will be performed during each project phase. The SAPP is periodically updated prior to the start of each phase of the Metro Rail project.

3.3.2 Prepare Contractor System Assurance Monitoring Plans

Plans for reviewing contractor-prepared submittals dealing with reliability, maintainability, and quality assurance will be developed. These plans will identify the system assurance documentation required from major contractors, and will provide procedures for a comprehensive review of the documentation by the SCRTD, the General Consultant, the Construction Manager, and other system assurance program participants.

3.4 ANALYSES AND STUDIES

3.4.1 Define Reliability and Maintainability Measures

During Continuing Preliminary Engineering, the SCRTD prepared standard reliability and maintainability definitions.* The definitions, developed for contractual purposes, established a common baseline for reliability and maintainability measures prior to selection of numerical requirements.

3.4.2 Develop and Update Reliability and Maintainability Numerical Indices

Following development of the Reliability and Maintainability Definitions, the system assurance organization identified numerical requirements for inclusion within contract specifications. Requirements were identified for passenger vehicles as well as for other elements of the Metro Rail system.** The requirements are updated as designs and reliability analyses are submitted by contractors.

3.4.3 Conduct System Assurance Trade-Off Studies

During the design process, situations arise where trade-offs between and within safety, security,

* SCRTD Metro Rail Project Reliability and Maintainability Definitions, Booz, Allen & Hamilton, July 1984.

** Subsystem Reliability and Maintainability Numerical Requirements for Metro Rail, MRTC, November 1984.

and system assurance must be addressed. The system assurance organization coordinates with the safety and security organizations, as well as with involved outside agencies, to resolve these issues. The recommended resolution of these trade-offs is presented to design engineers and Metro Rail management for approval and design implementation.

3.5 DESIGN, CONSTRUCTION, PROCUREMENT, AND TESTING SUPPORT

The system assurance organization participates directly and continuously with the General Consultant and the Construction Manager to ensure that system assurance issues are adequately reflected in architectural, system, and subsystem designs; in procurement specifications; and in the end products which are delivered or installed. The system assurance organization supports the General Consultant and Construction Manager in the manner described in the following sections.

3.5.1 Provide General Design Support

The system assurance organization is responsible for providing information and analyses pertinent to reliability, maintainability, and quality assurance requirements in system and subsystem design. The information provided includes:

- Documents and data from other transit properties on the subject of systems assurance as related to facility and equipment design
- Documentation of trade-off analyses and resolutions taken to coordinate safety, security, and system assurance considerations in system and subsystem designs and specifications.

3.5.2 Provide General Construction/Procurement Support

The system assurance organization is responsible for providing information, analyses, and support pertinent to system assurance in the construction, manufacture, procurement, and installation of Metro Rail facilities and equipment. The system assurance organization assists the Construction Manager and the Metro Rail Construction Management Department as required.

3.5.3 Participate in SCRTD Design Reviews

The system assurance organization participates in all reviews where system dependability could be

affected by design decisions. These reviews include Conceptual Design Reviews, Preliminary Design Reviews, and Final or Critical Design Reviews. The results of the design reviews are documented, and action items are assigned to resolve deficiencies.

3.5.4 Identify System Assurance Documentation Requirements for Contract Specifications

From Preliminary Engineering through the Final Design Phase, the system assurance organization is responsible for identifying contractor or supplier system-assurance-related analyses, tests, tasks, and submittals that form part of the procurement specifications. Within the system assurance organization, the General Consultant has primary responsibility for identifying and phrasing the requirements for system assurance analyses, test requirements, and submittals in the procurement specifications.

3.5.5 Develop Guidelines for the Preparation of Safety and System Assurance Analyses

During Final Design, guidelines* were prepared to present uniform formats and methodologies which will be used for safety and system assurance analyses prepared by Metro Rail systems contractors. The goal of making the Metro Rail system as reliable, maintainable, and safe as possible can be more easily accomplished if safety and system assurance analyses for all contracts are conducted in the same manner and displayed in the same format. This approach will result in more streamlined processing of the information.

3.5.6 Prepare System Assurance Criteria Conformance Checklists

To ensure that the system assurance criteria are properly reflected in contract drawings and specifications, the General Consultant developed comprehensive checklists of items which must be verified during the Metro Rail design review process. The checklists are used by SCRTD system assurance staff to ensure a comprehensive and consistent review of specifications and drawings. Any discrepancies are

* Guidelines for the Preparation of Safety and System Assurance Analyses, SCRTD 5-001, Booz, Allen & Hamilton, June 1985.

formally submitted to the General Consultant and are resolved to the satisfaction of SCRTD system assurance management.

3.5.7 Prepare Specification Conformance Checklists

To ensure that all system assurance criteria incorporated into the specifications are reflected in contractors' final designs and in equipment and materials selection, the system assurance organization will develop checklists oriented to the Construction/Acquisition Phase. The system assurance checklists will be incorporated into the Metro Rail design review, audit, inspection, and testing program to support the safety certification program. The checklists will be prepared by the General Consultant and used by SCRTD and representatives of the Construction Manager during contractor design reviews, audits, inspections, and tests. Any discrepancies between the specification conformance checklist requirements and the contractors' designs or final products will be resolved to the satisfaction of SCRTD system assurance management.

3.5.8 Conduct Coordination Meetings With Contractor System Assurance Staff

The SCRTD will coordinate system assurance planning with cognizant representatives of Metro Rail equipment contractors, facility contractors, and subcontractors. The meetings will be held on an as-required basis to discuss designs, change requests, and submittals.

3.5.9 Participate in Change Control Board Activities

The system assurance organization will be represented on the Change Control Board to assess whether changes to the design of a facility or equipment could affect the dependability of the Metro Rail system.

3.5.10 Review Contractor Analyses and Reports

The system assurance organization will review any contractor analyses, reports, and submittals relating to reliability, maintainability, quality assurance, or maintenance. Such submittals include change proposals, failure analyses, critical/catastrophic items lists, fault tree analyses, test plans, and other relevant Contract Data Requirements List (CDRL) items.

3.5.11 Participate in System Integration Test Program Development

The system assurance organization will participate in system integration and pre-revenue testing activities where the dependability of Metro Rail may be affected. During the Construction/ Acquisition Phase, the system assurance organization will assist the Metro Rail Systems Design and Analysis and Construction Management Departments, the Construction Manager, and Metro Rail operations and maintenance personnel in developing integrated test plans and procedures for system verification and demonstration.

3.5.12 Review Operating and Maintenance Manuals and Procedures

The system assurance organization will review operating and maintenance manuals and procedures which relate to system assurance. These include operating, maintenance, and repair manuals; operators' rulebooks; maintenance checklists and schedules; standard operating procedures; fault isolation and troubleshooting plans; failure plans; etc.

3.6 DOCUMENTATION

The system assurance organization will gather and maintain system assurance documentation as part of a safety, security, and system assurance library.

3.6.1 Establish System Assurance Library

The organization and maintenance of a system assurance library of Metro Rail project and other rail rapid transit properties is a continuing activity. The system assurance data bases provide:

- Archival data of other properties' reports, records, and statistics (as such can be obtained)
- Status records of contractors' analyses, tasks, test certifications, etc.
- Qualitative data for investigation of system assurance problems and quantitative data for statistical analysis.

3.6.2 Establish System Assurance Documentation and Review Procedures

The system assurance organization prepares procedures to review, comment on, and track changes to system assurance criteria, change notices, and other related documentation. This documentation includes:

- Internal and contractor-provided system assurance and related analyses
- Status reports on all contractor-provided system assurance and related analyses
- The resolution of all failures itemized in Failure Modes, Effects and Criticality Analyses
- Quality and system verification and testing documents, if relevant to system assurance
- Training program materials for operating and maintenance personnel.

4.0 RELIABILITY TASKS

4.0 RELIABILITY TASKS

Chapter 4.0 identifies system assurance program tasks specific to reliability planning, analysis, and support.

The reliability tasks presently identified for each phase of the Metro Rail project are listed in Exhibit 4-1 and are described in the following sections. Task numbers in the left-hand column of Exhibit 4-1 correspond to the paragraph numbers in the text.

Exhibit 4-2 identifies the organization or organizations having principal responsibility for preparing, supporting, and/or reviewing/and commenting on each task or activity.

4.1 RELIABILITY PLANS AND PROCEDURES

4.1.1 Prepare a Warranty Management Plan

During Continuing Preliminary Engineering, a Warranty Management Plan was prepared to identify the requirements for a successful warranty program.* The plan identified appropriate warranty provisions and established the Warranty Provisions Working Group. During Final Design, the Warranty Management Plan was expanded to review the bus warranty program, identify its relevance to the rail system, and develop the rail warranty process.

4.1.2 Establish a Warranty Provisions Working Group

During Final Design, a group was assembled to recommend appropriate warranty provisions for inclusion within procurement specifications. To carry out its responsibilities, the group reviewed warranty provisions for other transit system procurements and developed appropriate provisions for SCRTD procurements (see task 4.2.1).

4.1.3 Develop Warranty Procedures, Forms, and Instructions

During the Construction/Acquisition Phase, specific warranty procedures will be developed to ensure

* Warranty Management Plan, Booz Allen & Hamilton, June 1984.

EXHIBIT 4-1
Reliability Activities and Tasks

PARAGRAPH NUMBER	TASK TITLE	PROJECT PHASE					
		PRELIMINARY ENGINEERING	CONTINUING PRELIMINARY ENGINEERING	FINAL DESIGN	CONSTRUCTION/ ACQUISITION	PRE- OPERATIONAL TESTING	START-UP OPERATIONS
	<u>RELIABILITY PLANS AND PROCEDURES</u>						
4.1.1	Prepare a Warranty Management Plan		●	●			
4.1.2	Establish a Warranty Provisions Working Group			●			
4.1.3	Develop Warranty Procedures, Forms, and Instructions				●		
4.1.4	Develop Failure Management Plans				●		
4.1.5	Develop a Failure Reporting, Analysis and Corrective Action System			●	●		
4.1.6	Develop System Integrated Test Program Plan				●		
4.1.7	Develop Reliability Test Demonstration Procedures				●	●	
4.1.8	Establish an Incident Evaluation Committee				●		
4.1.9	Develop Incident Evaluation Committee Policies and Procedures				●		

4-2(a)

EXHIBIT 4-1 (Continued)
Reliability Activities and Tasks

PARAGRAPH NUMBER	TASK TITLE	PROJECT PHASE					
		PRELIMINARY ENGINEERING	CONTINUING PRELIMINARY ENGINEERING	FINAL DESIGN	CONSTRUCTION/ ACQUISITION	PRE- OPERATIONAL TESTING	START-UP OPERATIONS
	<u>RELIABILITY ANALYSES AND SUPPORT</u>						
4.2.1	Develop Warranty Provisions for Contracts			•			
4.2.2	Prepare Failure Management Analyses		•	•			
	Participate in Reliability Test Demonstration						•
4.2.3	Participate on Incident Evaluation Committee				•	•	•
4.2.4	Evaluate the Operational Impacts of Power System Failures			•			
4.2.5	Prepare Single Point Failure Summaries				•		

4-2 (b)

EXHIBIT 4-2
Reliability Task Responsibilities

PARAGRAPH NUMBER	TASK / ACTIVITY	METRO RAIL								GENERAL CONSULTANT	CONSTRUCTION MANAGER	RAIL OPERATIONS	RAIL MAINTENANCE
		SYSTEM DESIGN & ANALYSIS						TRANSIT FACILITIES ENGINEERING	CONSTRUCTION MANAGEMENT				
		SAFETY & SYSTEMS ASSURANCE	SYSTEMS ENGINEERING & ANALYSIS	SYSTEMS DESIGN	SYSTEMS ENGINEERING CONSULTANT	FIRE DEPTS AND RESCUE SQUAD	POLICE DEPTS. CORONERS OFFICE						
	<u>RELIABILITY PLANS AND PROCEDURES</u>												
4.1.1	Prepare a Warranty Management Plan	S	RC	RC	P				RC	RC	RC	RC	S
4.1.2	Establish a Warranty Provisions Working Group	P	S	S	S				S	S	S		S
4.1.3	Develop Warranty Procedures, Forms, and Instructions	S			P					RC	RC	RC	S
4.1.4	Develop Failure Management Plans	S	P		S	RC				RC		S	
4.1.5	Develop a Failure Reporting, Analysis and Corrective Action System	S	RC	RC	P					RC	RC	RC	S
4.1.6	Develop System Integrated Test Program Plan	S	P	S	S	S	S	S	S	S	S	S	S
4.1.7	Develop Reliability Test Demonstration Procedures	P	S	S	S				S	S	S	S	S
4.1.8	Establish an Incident Evaluation Committee	P	S	S	S					S	S	S	S
4.1.9	Develop Incident Evaluation Committee Policies and Procedures	S	RC	RC	P					RC	RC	RC	S

4-3 (a)

EXHIBIT 4-2 (Continued)
Reliability Task Responsibilities

PARAGRAPH NUMBER	TASK / ACTIVITY	METRO RAIL								GENERAL CONSULTANT	CONSTRUCTION MANAGER	RAIL OPERATIONS	RAIL MAINTENANCE
		SYSTEM DESIGN & ANALYSIS						TRANSIT FACILITIES ENGINEERING	CONSTRUCTION MANAGEMENT				
		SAFETY & SYSTEMS ASSURANCE	SYSTEMS ENGINEERING & ANALYSIS	SYSTEMS DESIGN	SYSTEMS ENGINEERING CONSULTANT	FIRE DEPTS AND RESCUE SQUAD	POLICE DEPTS. CORONERS OFFICE						
	<u>RELIABILITY ANALYSES AND SUPPORT</u>												
4.2.1	Develop Warranty Provisions for Contracts	S	RC	RC	S				RC	P	S	RC	RC
4.2.2	Prepare Failure Management Analyses	S	S		P					RC		S	RC
4.2.3	Participate on Incident Evaluation Committee	P		S	S							S	S
4.2.4	Evaluate the Operational Impacts of Power System Failures	S	RC	S	P					RC			
4.2.5	Prepare Single Point Failure Summaries	S	RC	RC	RC				RC	P	RC		

4-3 (b)

that Metro Rail recognizes the benefit of warranty clauses included in the contracts. Procedures will assign responsibility and delegate authority to SCRTD staff for administering the warranty program. In addition, agreements will be reached with contractors on documentation, notification procedures, labor and material costs, etc.

4.1.4 Develop Failure Management Plans

During the Construction/Acquisition Phase, Failure Management Plans will be prepared to develop operational strategies for managing perturbed Metro Rail operations, including non-vehicle failures. These plans will be based on the results of failure management analyses conducted during the Continuing Preliminary Engineering and Final Design Phases (see task 4.2.2).

4.1.5 Develop a Failure Reporting, Analysis, and Corrective Action System

The SCRTD has included various reliability, maintainability, and warranty requirements in Metro Rail contracts. To enforce these requirements, a consistent and effective method for the reporting, analysis, and follow-up of failures is required. During Final Design, a Failure Reporting, Analysis and Corrective Action System (FRACAS) was developed as the baseline document for failure reporting on Metro Rail vehicles, systems, facilities, and equipment.* The FRACAS provides the proposed management system for failure reporting, which including the overall system design, policies, information flows and distribution, and integration with the SCRTD's Transit Management Information System (TRANSMIS).

4.1.6 Develop System Integrated Test Program Plan

The System Integrated Test Program Plan (SITPP), which will be developed during Construction/ Acquisition, will define test requirements and schedules and describe the process of developing test plans and procedures. It will also describe administrative processes and formats for development, review, and approval of test procedures; for development of test schedules; and for periodic management reports.

* Failure Reporting, Analysis and Corrective Action System, Booz, Allen & Hamilton, July 1985 (Draft).

The purpose of the SITPP is to coordinate testing on all system elements to verify the compatibility of equipment, facilities, software, and procedures and their ability to function as a total system under normal, adverse, and emergency conditions.

4.1.7 Develop Reliability Test Demonstration Procedures

The procedures used for the reliability test demonstration of systems elements will be developed by contractors with the help and direction of the Metro Rail system assurance organization. The system assurance organization will manage the reliability test demonstration to ensure all contractual requirements are met.

4.1.8 Establish an Incident Evaluation Committee

An Incident Evaluation Committee (IEC) will be established during the Construction/Acquisition Phase to investigate failures of Metro Rail equipment. The IEC will review failures during acceptance testing, the reliability test program, and the warranty period. The IEC will be charged with determining the relevancy of failures to reliability and warranty provisions.

4.1.9 Develop Incident Evaluation Committee Policies and Procedures

During the Construction/Acquisition Phase, policies and procedures will be developed for the IEC. The policies and procedures will be consistent with failure reporting requirements, contract provisions, and SCRTD maintenance management information capabilities.

4.2 RELIABILITY ANALYSES AND SUPPORT

4.2.1 Develop Warranty Provisions for Contracts

During Final Design, warranty provisions were prepared for all contracts. The provisions addressed warranties for original equipment, spare parts, warranty replacement parts, and special test equipment.

4.2.2 Prepare Failure Management Analyses

During Continuing Preliminary Engineering and Final Design, analyses were conducted to evaluate the

impacts of perturbations on system operations.* Using the Rail Transit Simulator, these analyses examined system recovery capabilities, assessed whether the system could achieve headway objectives for the year 2020, and evaluated the operational effects of North Hollywood configurations.

4.2.3 Participate on Incident Evaluation Committee

A qualified member of the system assurance organization will participate on the IEC. The IEC has been charged with determination of relevant failures, recommendation of failure analysis on each incident, and determination of the corrective actions to be taken by contractors.

4.2.4 Evaluate the Operational Impacts of Power System Failures

A power system reliability model was developed during Final Design to evaluate the operational impacts of alternative power system configurations.** The model calculates the expected annual number and duration of power outages for traction and auxiliary power, based on the reliability and configuration of system equipment.

4.2.5 Prepare Single-Point Failure Summaries

During Construction/Acquisition, single-point failures which could result in significant delays to service or critical or catastrophic safety hazards will be identified based on reviews of failure modes and effects analyses. These single-point failures will be tracked to provide management visibility. Single-point failures that cannot be resolved by design will need to be mitigated by operating procedures.

* Failure Management Analyses, ACEX under subcontract to Booz, Allen & Hamilton, February 1985.

** Operational Impacts of Power System Failures, Booz, Allen & Hamilton, May 1985.

5.0 MAINTAINABILITY TASKS

5.0 MAINTAINABILITY TASKS

Chapter 5.0 identifies system assurance program tasks specific to maintainability planning, analysis, and support.

The maintainability tasks presently identified for each phase of the Metro Rail project are listed in Exhibit 5-1 and are described in the following sections. Task numbers in the left-hand column of Exhibit 5-1 correspond to the paragraph numbers in the text.

Exhibit 5-2 identifies the organization or organizations having principal responsibility for preparing, supporting, and/or reviewing and commenting on each task or activity.

5.1 MAINTAINABILITY PLANS AND PROCEDURES

5.1.1 Develop Maintainability Test Demonstration Procedures

During the Construction/Acquisition Phase, procedures for the maintainability test demonstration will be developed by contractors under the direction and with the assistance of the system assurance organization. The system assurance organization will coordinate the maintainability test demonstration to ensure all contractual requirements are met.

5.2 MAINTAINABILITY ANALYSES AND SUPPORT

5.2.1 Prepare a Maintainability Problems Study

During Final Design, prior to preliminary design reviews on system elements, a study of maintainability design problems at other transit systems will be conducted. The study will result in the development of checklists of maintainability design concepts for each major subsystem.

5.2.2 Participate in the Maintainability Test Demonstration

The system assurance organization will participate in the maintainability test demonstration of all equipment and systems. The system assurance organization, along with the SCRTD rail maintenance organization, will ensure that all contractual requirements are adequately demonstrated.

EXHIBIT 5-1
Maintainability Activities and Tasks

PARAGRAPH NUMBER	TASK TITLE	PROJECT PHASE					
		PRELIMINARY ENGINEERING	CONTINUING PRELIMINARY ENGINEERING	FINAL DESIGN	CONSTRUCTION/ACQUISITION	PRE-OPERATIONAL TESTING	START-UP OPERATIONS
	<u>MAINTAINABILITY PLANS AND PROCEDURES</u>						
5.1.1	Develop Maintainability Test Demonstration Procedures				•		
	<u>MAINTAINABILITY ANALYSES AND SUPPORT</u>						
5.2.1	Prepare a Maintainability Problems Study			•			
5.2.2	Participate in Maintainability Test Demonstration				•	•	•

EXHIBIT 5-2
Maintainability Task Responsibilities

PARAGRAPH NUMBER	TASK / ACTIVITY	METRO RAIL								GENERAL CONSULTANT	CONSTRUCTION MANAGER	RAIL OPERATIONS	RAIL MAINTENANCE
		SYSTEM DESIGN & ANALYSIS						TRANSIT FACILITIES ENGINEERING	CONSTRUCTION MANAGEMENT				
		SAFETY & SYSTEMS ASSURANCE	SYSTEMS ENGINEERING & ANALYSIS	SYSTEMS DESIGN	SYSTEMS ENGINEERING CONSULTANT	FIRE DEPTS AND RESCUE SQUAD	POLICE DEPTS. CORONERS OFFICE						
5.1.1	<u>MAINTAINABILITY PLANS AND PROCEDURES</u> Develop Maintainability Test Demonstration Procedures	P	RC	RC	RC					RC	S	S	
5.2.1	<u>MAINTAINABILITY ANALYSES AND SUPPORT</u> Prepare a Maintainability Problems Study	S		RC	P				RC	RC	RC	RC	
5.2.2	Participate in Maintainability Test Demonstration	P		S	S					S	S	S	

6.0 QUALITY ASSURANCE TASKS

6.0 QUALITY ASSURANCE TASKS

Chapter 6.0 identifies system assurance program tasks specific to quality assurance planning, analysis, and support.

The quality assurance tasks presently identified for each phase of the Metro Rail project are listed in Exhibit 6-1 and are described in the following sections. Task numbers in the left-hand column of Exhibit 6-1 correspond to the paragraph numbers in the text.

Exhibit 6-2 identifies the organization or organizations having principal responsibility for preparing, supporting, and/or reviewing and commenting on each task or activity.

6.1 QUALITY ASSURANCE PLANS AND PROCEDURES

6.1.1 Develop a Metro Rail Quality Assurance Manual

During the Final Design and Construction/Acquisition Phases, the system assurance organization will prepare a Quality Assurance Manual for the Metro Rail project. The manual will address SCRTD policies and quality assurance requirements for design, procurement, construction, and maintenance. The purpose of the manual is to establish a quality assurance organization to define its interfaces with SCRTD departments, and to develop a formalized quality assurance program approach toward procurements, audit programs, inspections, testing, operation, and maintenance. The manual will include standard procedures for training and qualification, document control, measurement and test equipment, corrective action, quality records, etc.

6.1.2 Develop a Quality Pre-Award Survey Manual - Systems

During the Final Design, a Quality Pre-Award Survey Manual was prepared.* The Quality Pre-Award Survey Manual is designed for use in reviewing and

* Quality Pre-Award Survey Manual, Booz, Allen & Hamilton, July 1984.

EXHIBIT 6-1
Quality Assurance Activities and Tasks

PARAGRAPH NUMBER	TASK TITLE	PROJECT PHASE					
		PRELIMINARY ENGINEERING	CONTINUING PRELIMINARY ENGINEERING	FINAL DESIGN	CONSTRUCTION/ACQUISITION	PRE-OPERATIONAL TESTING	START-UP OPERATIONS
	<u>QUALITY ASSURANCE PLANS AND PROCEDURES</u>						
6.1.1	Develop a Metro Rail Quality Assurance Manual			•	•		
6.1.2	Develop a Quality Pre-Award Survey Manual--Systems			•			
6.1.3	Develop a Quality Pre-Award Survey Manual--Civil			•			
6.1.4	Develop a Resident Inspection Plan			•			
6.1.5	Develop a Resident Engineers Manual			•			
6.1.6	Develop a QA/QC Procedures Manual			•			
6.1.7	Develop QA Review Guidelines--Systems			•			
6.1.8	Develop QA Review Guidelines--Civil			•			
6.1.9	Develop Guidelines for Construction Inspectors			•	•		
6.1.10	Develop Contractor/Supplier Inspection and Testing Plans			•	•		
6.1.11	Establish a QA Training and Certification Program for Maintenance Personnel				•	•	

6-2(a)

EXHIBIT 6-1 (Continued)
Quality Assurance Activities and Tasks

PARAGRAPH NUMBER	TASK TITLE	PROJECT PHASE					
		PRELIMINARY ENGINEERING	CONTINUING PRELIMINARY ENGINEERING	FINAL DESIGN	CONSTRUCTION/ACQUISITION	PRE-OPERATIONAL TESTING	START-UP OPERATIONS
	<u>QUALITY ASSURANCE SUPPORT</u>						
6.2.1	Participate in Quality Pre-Award Surveys			•	•		
6.2.2	Participate in Contractor Design Reviews and Milestone Audits				•		
6.2.3	Participate in Source Inspections				•		
6.2.4	Participate in Qualification Testing				•		
6.2.5	Participate in In-Process Inspections and Tests				•		
6.2.6	Participate in Quality Audits				•		
6.2.7	Participate in Acceptance Inspections and Tests				•	•	
6.2.8	Participate on Material Review Boards of Contractors				•		
6.2.9	Conduct Investigations of Quality Problems				•	•	•

6-2(b)

EXHIBIT 6-2
Quality Assurance Task Responsibilities

PARAGRAPH NUMBER	TASK / ACTIVITY	METRO RAIL								GENERAL CONSULTANT	CONSTRUCTION MANAGER	RAIL OPERATIONS	RAIL MAINTENANCE
		SYSTEM DESIGN & ANALYSIS						TRANSIT FACILITIES ENGINEERING	CONSTRUCTION MANAGEMENT				
		SAFETY & SYSTEMS ASSURANCE	SYSTEMS ENGINEERING & ANALYSIS	SYSTEMS DESIGN	SYSTEMS ENGINEERING CONSULTANT	FIRE DEPTS AND RESCUE SQUAD	POLICE DEPTS. CORONERS OFFICE						
	<u>QUALITY ASSURANCE PLANS AND PROCEDURES</u>												
6.1.1	Develop a Metro Rail Quality Assurance Manual	P		RC	S				S	RC	S		RC
6.1.2	Develop a Quality Pre-Award Survey Manual--Systems	S		RC	P				RC	RC	RC		
6.1.3	Develop a Quality Pre-Award Survey Manual--Civil	S			RC			RC	RC	RC	P		
6.1.4	Develop a Resident Inspection Plan	P		RC	RC			RC	RC	S	S		
6.1.5	Develop a Resident Engineers Manual	S						RC	RC	RC	P		
6.1.6	Develop a QA/QC Procedures Manual	S		RC	RC			RC	RC	RC	P		
6.1.7	Develop QA Review Guidelines--Systems	S		RC	P				RC	RC	RC		
6.1.8	Develop QA Review Guidelines--Civil	S						RC	RC	RC	P		
6.1.9	Develop Guidelines for Construction Inspectors	S						RC	RC	RC	P		
6.1.10	Develop Contractor/Supplier Inspection and Testing Plans	P			RC			RC	RC	RC	S		
6.1.11	Establish a QA Training and Certification Program for Maintenance Personnel	S		RC	S								P

(a) 3-6

EXHIBIT 6-2 (Continued)
Quality Assurance Task Responsibilities

PARAGRAPH NUMBER	TASK / ACTIVITY	METRO RAIL								GENERAL CONSULTANT	CONSTRUCTION MANAGER	RAIL OPERATIONS	RAIL MAINTENANCE
		SYSTEM DESIGN & ANALYSIS						TRANSIT FACILITIES ENGINEERING	CONSTRUCTION MANAGEMENT				
		SAFETY & SYSTEMS ASSURANCE	SYSTEMS ENGINEERING & ANALYSIS	SYSTEMS DESIGN	SYSTEMS ENGINEERING CONSULTANT	FIRE DEPTS AND RESCUE SQUAD	POLICE DEPTS. CORONERS OFFICE						
	<u>QUALITY ASSURANCE SUPPORT</u>												
6.2.1	Participate in Quality Pre-Award Surveys	P		S	S				S		S		
6.2.2	Participate in Design Reviews and Milestone Audits	P		S	S					S			
6.2.3	Participate in Source Inspections	P		S	S				S		S		
6.2.4	Participate in Qualification Testing	P		S	S				S		S		
6.2.5	Participate in In-Process Inspections and Tests	P		S	S				S		S		
6.2.6	Participate in Quality Audits	P		S	S				S		S		
6.2.7	Participate in Acceptance Inspections and Tests	P		S	S				S		S	S	S
6.2.8	Participate on Material Review Boards of Contractors	P		S					S		S		
6.2.9	Conduct Investigations of Quality Problems	P		S	S						S		

6-3 (b)

verifying the quality assurance capabilities of potential contractors providing hardware and software. These quality assurance capabilities include quality planning, control, coordination, audit, and analysis activities during the design, procurement, fabrication, assembly, and delivery phases of the contract. The evaluation is carried out in two steps:

- Review of the contractor's quality assurance documentation submitted in the proposal to the SCRTD
- Physical verification of contractor's capabilities through surveys of contractor's and users' facilities.

The manual provides the necessary tools for SCRTD's quality assurance organization to conduct the evaluation by:

- Identifying the quality assurance criteria to be reviewed
- Providing a procedure to conduct the quality pre-award survey
- Providing a checklist for each quality assurance criterion to complete the evaluation.

6.1.3 Develop a Quality Pre-Award Survey Manual - Civil

A similar manual for civil/construction contracts will also be developed, oriented toward the quality capabilities of contractors constructing facilities and providing equipment for stations, track, shop buildings, etc.

6.1.4 Develop a Resident Inspection Plan

During the Construction/Acquisition Phase of the Metro Rail project, an SCRTD representative may reside at the facilities of major contractors. These representatives will observe and sign-off inspections and tests on critical items where the acceptability of the products can be verified only as they are being manufactured. During the Final Design Phase, the system assurance organization will develop a Resident Inspection Plan to identify the critical items, inspection and test activities, and procedures that are to be used by resident inspectors.

6.1.5 Develop a Resident Engineer's Manual

The resident engineer (RE) is the focal point for on-site construction management activities. The RE ensures that all construction is accomplished in accordance with contract documents and safety practices, and within schedule and budget. During Final Design, a manual was developed which provides guidance for REs in the areas of contracts, control of the work, administration, and documentation.* The procedures are to be followed by all resident engineers.

6.1.6 Develop a QA/QC Procedures Manual

During Final Design, the Construction Manager developed a Quality Assurance/Quality Control (QA/QC) Procedures Manual for distribution to cognizant staff of the Construction Manager and contractors.** The manual defines a standard approach for the conduct of all quality assurance/quality control activities on construction contracts.

6.1.7 Develop QA Review Guidelines - Systems

Following contract award and during contract execution, the SCRTD has the responsibility of monitoring the performance of each contractor's work. Monitoring work progress is a comprehensive process that must address various project elements such as technical compliance, schedule and cost adherence, product support requirements, and quality of the end product. The attention and efforts of the SCRTD and its consultants will be directed toward ensuring that the delivered product has attained a level of quality commensurate with industry standards and contractual requirements.

During Final Design, Quality Assurance Review Guidelines - Systems were developed for use in reviewing and verifying the performance of the quality assurance program for contractors providing systems, equipment, and software.*** The guidelines focus on key items to be covered during quality

* Resident Engineer's Manual, PDCD, October 1984.

** Quality Assurance and Quality Control Manual, PDCD, March 1985.

*** Quality Assurance Review Guidelines, Booz, Allen & Hamilton, June 1985.

assurance program reviews, such as organization, program plans, receiving material control, production inspection and testing controls, nonconformance and corrective action controls, configuration control, supplier control, and internal audit procedures.

6.1.8 Develop QA Review Guidelines - Civil

A similar set of guidelines for civil/construction contracts will be developed during Final Design, oriented toward reviewing the quality assurance performance of contractors providing facilities, material, or equipment for stations, track, shop buildings, etc.

6.1.9 Develop Guidelines for Construction Inspectors

During Final Design, guidelines for construction inspectors were developed to provide a standard frame of reference for all personnel engaged in inspection activities.* The manual delineates the authority, responsibilities, and obligations of inspectors and identifies necessary documentation and technical requirements with regard to underpinning, subway excavation and backfill, concrete and steel structures, tunneling and waterproofing.

6.1.10 Develop Contractor/Supplier Inspection and Testing Plans

During the Final Design and Construction/Acquisition Phases, the system assurance organization will work cooperatively with suppliers to develop inspection and testing plans as required by specifications. The system assurance organization will be responsible for reviewing the quality aspects of all inspection and testing plans for systems and facility contracts.

6.1.11 Establish a QA Training And Certification Program for Maintenance Personnel

The system assurance organization will assist the SCRTD rail maintenance organization with development of a quality assurance program for Metro Rail equipment, systems, and facilities. The program will include indoctrination, training, and preparation of course materials for maintenance personnel inspecting and repairing Metro Rail property.

* Guidelines for Construction Inspectors Manual, PDCD, October 1984.

6.2 QUALITY ASSURANCE SUPPORT

6.2.1 Participate in Quality Pre-Award Surveys

During the Final Design and Construction/Acquisition Phases, the system assurance organization will direct and participate in the pre-award survey of the quality assurance capabilities of potential contractors. Input from the system assurance organization will be used to select the most responsive and responsible bidder.

6.2.2 Participate in Contractor Design Reviews and Milestone Audits

The system assurance organization will participate in all design and milestone reviews where system assurance issues are likely to be addressed. These include Conceptual, Preliminary, and Final Design Reviews, Mock-Up Reviews, and First Article Configuration Identification Inspections. The results of the design reviews will be documented, and action items will be assigned to resolve deficiencies in accordance with Metro Rail and contractor practices.

6.2.3 Participate in Source Inspections

The system assurance organization will participate in source inspections of materials, components, and equipment used by Metro Rail contractors. Source inspections may be required for components manufactured by companies which supply components, subassemblies, and assemblies to Metro Rail contractors. These inspections will take place at the "source" of the component (i.e., the plant where it is produced) during the Construction/Acquisition Phase.

6.2.4 Participate in Qualification Testing

The system assurance organization will participate in qualification testing of materials, components, and equipment used in Metro Rail procurements. Qualification tests will take place during Construction/Acquisition to demonstrate that the product performs satisfactorily at the design limits, to confirm access points and redundant features, to demonstrate design life, and to verify interfaces with the next highest level of assembly.

6.2.5 Participate in In-Process Inspections and Tests

The system assurance organization will participate in in-process inspections of Metro Rail equipment and facilities. Inspections will occur during Construction/Acquisition at appropriate points in the manufacturing or installation sequence to ensure compliance with drawings, test specifications, process specifications, and quality standards.

6.2.6 Participate in Quality Audits

The system assurance organization will direct and participate in quality audits of Metro Rail contractors. The SCRTD will conduct scheduled and unscheduled quality audits during the Construction/Acquisition Phase to verify compliance with, and to determine the effectiveness of, contractors' quality assurance programs. Audits will be documented in accordance with Quality Assurance Review Guidelines (See tasks 6.1.7 and 6.1.8).

6.2.7 Participate in Acceptance Inspections and Tests

The system assurance organization will participate in the acceptance testing and inspection of Metro Rail systems, equipment, and facilities. Acceptance tests of equipment will be conducted prior to delivery to verify proper operation. Additional acceptance tests may be performed after delivery to confirm non-degradation during shipment. Acceptance inspections and tests will be conducted during the Construction/Acquisition and the Pre-Operational Testing Phases.

6.2.8 Participate on Material Review Boards of Contractors

During the Construction/Acquisition Phase, the system assurance organization will participate, as appropriate, on Material Review Boards of Metro Rail contractors. (For critical items, the SCRTD will participate on the contractor's Material Review Board.) Contractors will be expected to establish procedures for the disposition of non-conforming material.

6.2.9 Conduct Investigations of Quality Problems

The system assurance organization will conduct investigations into quality problems that arise during Metro Rail construction/acquisition, testing, and start-up. Appropriate documentation and reports will be submitted to senior management.

7.0 MAINTENANCE PLANNING TASKS

7.0 MAINTENANCE PLANNING TASKS

Chapter 7.0 identifies system assurance program tasks specific to maintenance program planning, analysis, and support.

The maintenance planning tasks presently identified for each phase of the Metro Rail project are listed in Exhibit 7-1 and described in the following sections. Task numbers in the left-hand column of Exhibit 7-1 correspond to the paragraph numbers in the text.

Exhibit 7-2 identifies the organization or organizations having principal responsibility for preparing, supporting, and/or reviewing and commenting on each task or activity.

7.1 MAINTENANCE PLANS AND PROCEDURES

7.1.1 Prepare a Preliminary Maintenance Plan

During the Preliminary Engineering Phase of the Metro Rail project, a Preliminary Maintenance Plan was developed which addresses the conceptual development of the maintenance program.* Included are such topics as the planning for maintenance activities, integration with support functions, the work order and control process, and repair philosophy.

7.1.2 Develop and Update the System Maintenance Plan

The Preliminary Maintenance Plan was expanded to include the maintenance policies and objectives of the SCRTD, descriptions of maintenance facilities, preventive maintenance and corrective maintenance programs, maintenance organization and management, materials management, maintenance manual and training program requirements, and operational logistics. The System Maintenance Plan will be updated throughout the system's development.

* Preliminary Maintenance Plan, WBS 14DAG, Booz, Allen & Hamilton, June 1983.

EXHIBIT 7-1
Maintenance Planning Activities and Tasks

PARAGRAPH NUMBER	TASK TITLE	PROJECT PHASE					
		PRELIMINARY ENGINEERING	CONTINUING PRELIMINARY ENGINEERING	FINAL DESIGN	CONSTRUCTION/ACQUISITION	PRE-OPERATIONAL TESTING	START-UP OPERATIONS
	<u>MAINTENANCE PLANNING--PLANS AND PROCEDURES</u>						
7.1.1	Prepare a Preliminary Maintenance Plan	•					
7.1.2	Develop and Update the System Maintenance Plan		•	•	•	•	•
7.1.3	Participate on Maintenance Committee			•	•	•	•
7.1.4	Prepare a Staffing and Training Plan				•		
7.1.5	Develop Training Course Materials				•	•	
7.1.6	Develop Maintenance Safety Rules and Procedures				•		
7.1.7	Develop Pre-Operation Safety Checkout Lists				•		
7.1.8	Develop Metro Rail Part Numbering System				•		

7-2(a)

EXHIBIT 7-1 (Continued)
Maintenance Planning Activities and Tasks

PARAGRAPH NUMBER	TASK TITLE	PROJECT PHASE					
		PRELIMINARY ENGINEERING	CONTINUING PRELIMINARY ENGINEERING	FINAL DESIGN	CONSTRUCTION/ACQUISITION	PRE-OPERATIONAL TESTING	START-UP OPERATIONS
	<u>MAINTENANCE ANALYSES AND SUPPORT</u>						
7.2.1	Conduct Peer Reviews on Maintenance Issues	●					
7.2.2	Establish Yard and Shop Operational Requirements	●	●				
7.2.3	Establish Yard and Shop Functional Requirements	●	●				
7.2.4	Analyze Shop Capacity and Layout			●			
7.2.5	Develop Shop Equipment Lists		●	●			
7.2.6	Analyze Contract Maintenance Options			●	●		
7.2.7	Develop Maintenance Cost Estimates	●		●	●		
7.2.8	Identify Refinements to TRANSMIS			●	●		
7.2.9	Establish Work Standards				●		

7-2 (b)

EXHIBIT 7-2
Maintenance Planning Task Responsibilities

7-3 (a)

PARAGRAPH NUMBER	TASK / ACTIVITY	METRO RAIL								GENERAL CONSULTANT	CONSTRUCTION MANAGER	RAIL OPERATIONS	RAIL MAINTENANCE
		SYSTEM DESIGN & ANALYSIS							CONSTRUCTION MANAGEMENT				
		SAFETY & SYSTEMS ASSURANCE	SYSTEMS ENGINEERING & ANALYSIS	SYSTEMS DESIGN	SYSTEMS ENGINEERING CONSULTANT	FIRE DEPTS AND RESCUE SQUAD	POLICE DEPTS. CORONERS OFFICE	TRANSIT FACILITIES ENGINEERING					
	<u>MAINTENANCE PLANS AND PROCEDURES</u>												
7.1.1	Prepare a Preliminary Maintenance Plan	RC	RC	RC	P			RC	RC	RC	RC		RC
7.1.2	Develop and Update the System Maintenance Plan	S	S	S	P					RC			S
7.1.3	Participate on Maintenance Committee	P	S	S	P			S	S	S	S		P
7.1.4	Prepare a Staffing and Training Plan	S			P								S
7.1.5	Develop Training Course Materials	S			S						RC		P
7.1.6	Develop Maintenance Safety Rules and Procedures	S		RC	P					RC	RC	RC	S
7.1.7	Develop Pre-Operation Safety Checkout Lists	P			RC					RC	RC	S	S

EXHIBIT 7-2 (Continued)
Maintenance Planning Task Responsibilities

PARAGRAPH NUMBER	TASK / ACTIVITY	METRO RAIL								GENERAL CONSULTANT	CONSTRUCTION MANAGER	RAIL OPERATIONS	RAIL MAINTENANCE
		SYSTEM DESIGN & ANALYSIS						TRANSIT FACILITIES ENGINEERING	CONSTRUCTION MANAGEMENT				
		SAFETY & SYSTEMS ASSURANCE	SYSTEMS ENGINEERING & ANALYSIS	SYSTEMS DESIGN	SYSTEMS ENGINEERING CONSULTANT	FIRE DEPTS AND RESCUE SQUAD	POLICE DEPTS. CORONERS OFFICE						
	<u>MAINTENANCE ANALYSES AND SUPPORT</u>												
7.2.1	Conduct Peer Reviews on Maintenance Issues	P		P				P					
7.2.2	Establish Yard and Shop Operational Requirements	S		RC	P			RC					
7.2.3	Establish Yard and Shop Functional Requirements	S						P	S				
7.2.4	Analyze Shop Capacity and Layout	S		RC	P				S				RC
7.2.5	Develop Shop Equipment Lists	S		RC	RC				P				
7.2.6	Analyze Contract Maintenance Options	S	RC	RC	P				RC				
7.2.7	Develop Maintenance Cost Estimates	S	S		P				S				
7.2.8	Identify Refinements to TRANSMIS	S			P								S
7.2.9	Establish Work Standards	RC			S								P

7-3 (b)

7.1.3 Participate on the Maintenance Committee

To ensure an effective interaction between the Metro Rail system assurance organization, its consultants, and SCRTD maintenance personnel, a Maintenance Committee was established. Along with its other coordinating activities, the Maintenance Committee acts as a review board for reports and analyses on maintenance issues. The Maintenance Committee, which meets on a periodic and scheduled basis, will remain active through the Start-up Operations Phase of the project.

7.1.4 Prepare a Staffing and Training Plan

To ensure that adequate numbers of maintenance personnel with appropriate skills are available for the inspection and repair of all Metro Rail systems and facilities, a Staffing and Training Plan will be developed during the Construction/Acquisition Phase. The hiring schedule, staffing levels, and mix of personnel will be identified based on forecast corrective and preventive maintenance requirements and project milestones. The Staffing and Training Plan will also establish a training program that will be designed to:

- Identify training needs based on equipment selected for Metro Rail, specification training requirements, and manuals
- Develop course materials and implement training classes
- Establish an ongoing Maintenance Training Program that is integrated with other SCRTD training and safety programs
- Establish for maintenance employees:
 - Qualification standards and tests
 - Training programs and progress measurements
 - Self-learning opportunities
 - Upgrade and advancement training.

7.1.5 Develop Training Course Materials

The Metro Rail maintenance training program will cover the responsibility areas of facilities and equipment maintenance. Maintenance training in each of these areas will consist of a wide range of courses varying in scope, length, and method of instruction. The courses will be designed to ensure that maintenance personnel are capable of performing their maintenance responsibilities in a safe and effective manner.

The training courses will consist of classroom instruction, practical training, self-programmed study, and/or on-the-job training. Tests will be part of each course and will range from written examinations to demonstrations of equipment troubleshooting and correct equipment usage.

Classroom training will consist of lectures to explain theories and practices and to review specifications, supplier manuals, operating rules, and procedures. Practical training will consist of demonstrations and of hands-on experience in the operation of equipment and tools under close supervision of instructors and/or supervisors. The application of classroom learning to practical training will be stressed throughout the courses.

Self-instruction will consist of study from books and manuals, reviews, quizzes, and sometimes programmed learning with a computer. Instructors will not routinely and directly assist students during self-instruction courses, but will guide the students through the courses and keep track of progress by administering tests at the completion of major course units.

7.1.6 Develop Maintenance Safety Rules and Procedures

Based on CAL/OSHA requirements, operating hazard analyses prepared by contractors, operating and maintenance manuals, and other documentation, safety rules and procedures will be developed during Construction/Acquisition for all maintenance personnel. These safety rules and procedures will be taught as part of the training program to ensure that all maintenance personnel are thoroughly familiar with the rules and procedures necessary for the safe performance of their jobs.

7.1.7 Develop Pre-Operation Safety Checkout Lists

Based on safety requirements and manufacturer documentation, daily safety checklists will be developed during the Construction/Acquisition Phase. The checklists will be used by maintenance personnel for pre-departure checks of passenger vehicles, as well as for other daily or weekly inspections of safety-related equipment or systems.

7.1.8 Develop Metro Rail Part Numbering System

In addition to the part numbers assigned by contractors, the SCRTD material management system (MMS) requires parts to be maintained by SCRTD part number. During Construction/Acquisition, the system assurance organization will assist rail maintenance and material management staff in developing appropriate part numbers for all Metro Rail equipment.

7.2 MAINTENANCE ANALYSES AND SUPPORT

7.2.1 Conduct Peer Reviews on Maintenance Issues

Early in Preliminary Engineering, the SCRTD conducted peer reviews on issues related to maintenance planning, yard and shop layout, and equipment requirements.

7.2.2 Establish Yard and Shop Operational Requirements

During Preliminary and Continuing Preliminary Engineering, criteria for the operational characteristics of the yard and shop were defined.* The criteria identify requirements for yard control, the transfer zone, fleet storage, maintenance storage, car-cleaning, test tracks, turn-backs, shop equipment, service and inspection, component repair, heavy repair, and materials and parts storage.

7.2.3 Establish Yard and Shop Functional Requirements

To provide a basis for the design of the yard and shops and to coordinate the effort of design engineers, a functional plan for the yard and shops was developed during Preliminary and Continuing

* Yard and Shops Operational Criteria, WBS 13DAJ, Booz, Allen & Hamilton, May 1982.

Preliminary Engineering.* The plan identifies the elements of the yard and shops, describes each function, presents recommended configurations for various equipment and facilities, and provides the preliminary layouts of yard and shop facilities.

7.2.4 Analyze Shop Capacity and Layout

Prior to finalizing the design of the main shop, Metro Rail management elected to determine quantitatively whether the shop had the capacity to handle the maintenance requirements of the railcar fleet.** This evaluation was critical to ascertain if the main shop could provide adequate railcar availability for peak service requirements. A simulation model, called SOCSIM (Southern California Simulation), was used to examine the interactions between vehicle and operations characteristics with main shop maintenance capabilities and characteristics.

In addition to evaluating the impact of failures on unscheduled (corrective) maintenance workloads, SOCSIM also incorporated scheduled (preventive) maintenance. Inclusion of preventive maintenance into the model allowed the user to prioritize either corrective or preventive maintenance, and to evaluate the effects on maintenance backlogs.

7.2.5 Develop Shop Equipment Lists

During Continuing Preliminary Engineering and Final Design, the General Consultant, with the assistance of the Maintenance Committee, prepared lists of all shop equipment required to support the MOS-1 system configuration.

7.2.6 Analyze Contract Maintenance Options

During Final Design and Construction/Acquisition, alternative arrangements for maintenance of Metro Rail facilities and equipment will be evaluated based on SCRTD capabilities and cost-effectiveness. Maintenance actions, such as motor rebuild, gardening and cleaning will be studied for potential contracting agreements with specialty firms.

* Functional Plan - Yard and Shops, WBS 14AAG, DMJM/PBQD, May 1982.

** Evaluation of Shop Layout and Capacity, Volumes I and II, Booz, Allen & Hamilton, October 1984.

7.2.7 Develop Maintenance Cost Estimates

During the engineering phases of the project, operating cost estimates for both the full 18-mile system and MOS-1 were prepared.* Maintenance costs were identified for labor and materials for vehicle maintenance, ways and structures maintenance, and subsystems maintenance. These costs will be updated and refined during the Construction/Acquisition Phase.

7.2.8 Identify Refinements to TRANSMIS

The SCRTD has developed an integrated Transit Management Information System (TRANSMIS). The Vehicle Management System (VMS), a component of TRANSMIS, is designed for application to bus and rail systems. During the Final Design and Construction/Acquisition Phases, the system assurance organization will assist the Maintenance Department in developing repair codes, job codes, etc., necessary for the enforcement of reliability, maintainability, and warranty provisions in Metro Rail contracts.

7.2.9 Establish Work Standards

Based on data provided by contractors in their maintenance analyses and submittals, work standards will be developed during the Construction/Acquisition Phase for Metro Rail repair and inspection actions.

* Operating and Maintenance Cost Estimate, WBS 17BAB, Booz, Allen & Hamilton, June 1983, and Operating and Maintenance Cost Estimate - MOS-1, Booz, Allen & Hamilton, December 1984.