

**Southern California Rapid Transit District  
METRO RAIL PROJECT**

**SYSTEM ASSURANCE  
PROGRAM PLAN**

CONSTRUCTION/ACQUISITION EDITION

SCRTD  
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Southern California Rapid Transit District

# METRO RAIL PROJECT

## SYSTEM ASSURANCE PROGRAM PLAN

CONSTRUCTION/ACQUISITION EDITION

REVISION 1

MAY 1989

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1.0 INTRODUCTION

## 1.0 INTRODUCTION

The 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 organization
- Implementation of established system assurance criteria
- Mechanisms for identifying and assessing system assurance problems throughout all phases of the Metro Rail Project
- 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 Construction/Acquisition Phase, and on reviewing progress on the tasks conducted during Final Design. This edition of the SAPP defines the reliability, maintainability, quality assurance, and maintenance planning activities to be performed 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 also identified in this edition of the SAPP.

#### 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 Supervising Engineer, Systems Safety and Assurance, within the Systems and Construction Safety Office. Inputs for these periodic updates are solicited from SCRTD Systems Design and Analysis, Rail Facilities Engineering, Construction Management, the General Consultant, the Systems Engineering and Analysis Consultant, the Construction Management Consultant, and SCRTD rail operations and maintenance personnel.

### 1.7 ORGANIZATIONAL TERMINOLOGY

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

CM CONSULTANT	Construction Management Consultant. The CM Consultant on the Metro Rail Project is PDCD, a joint venture of Ralph M. Parsons Co./Dillingham Construction/DeLeuw Cather & Co.
GC	General Consultant. The GC on the Metro Rail Project is Metro Rail Transit Consultants (MRTC), a joint venture of Daniel, Mann, Johnson, Mendenhall/Parsons, Brinckerhoff, Quade & Douglas/Kaiser Engineers/Harry Weese & Associates.
SCRTD	Southern California Rapid Transit District; an agency created by the California legislature and charged with the development of a rapid transit system.
S&CS	Systems and Construction Safety Office of the SCRTD's Transit Systems Development Department; responsible for establishment of requirements and criteria for safety, fire/life safety, security, reliability, maintainability, and quality assurance, and for development of implementation plans.

SE&A CONSULTANT Systems Engineering and Analysis Consultant. The SE&A Consultant on the Metro Rail Project is Booz, Allen & Hamilton Inc.

SS&A Systems Safety and Assurance group of the S&CS Office; responsible for the systems safety and assurance efforts.

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.

#### 1.8 APPLICABLE DOCUMENTS

The following documents were used in preparing the SAPP:

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 7, Final Report, 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-C071004.

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.

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2.0 SYSTEM DESCRIPTION

## 2.0 SYSTEM DESCRIPTION

### 2.1 OVERVIEW

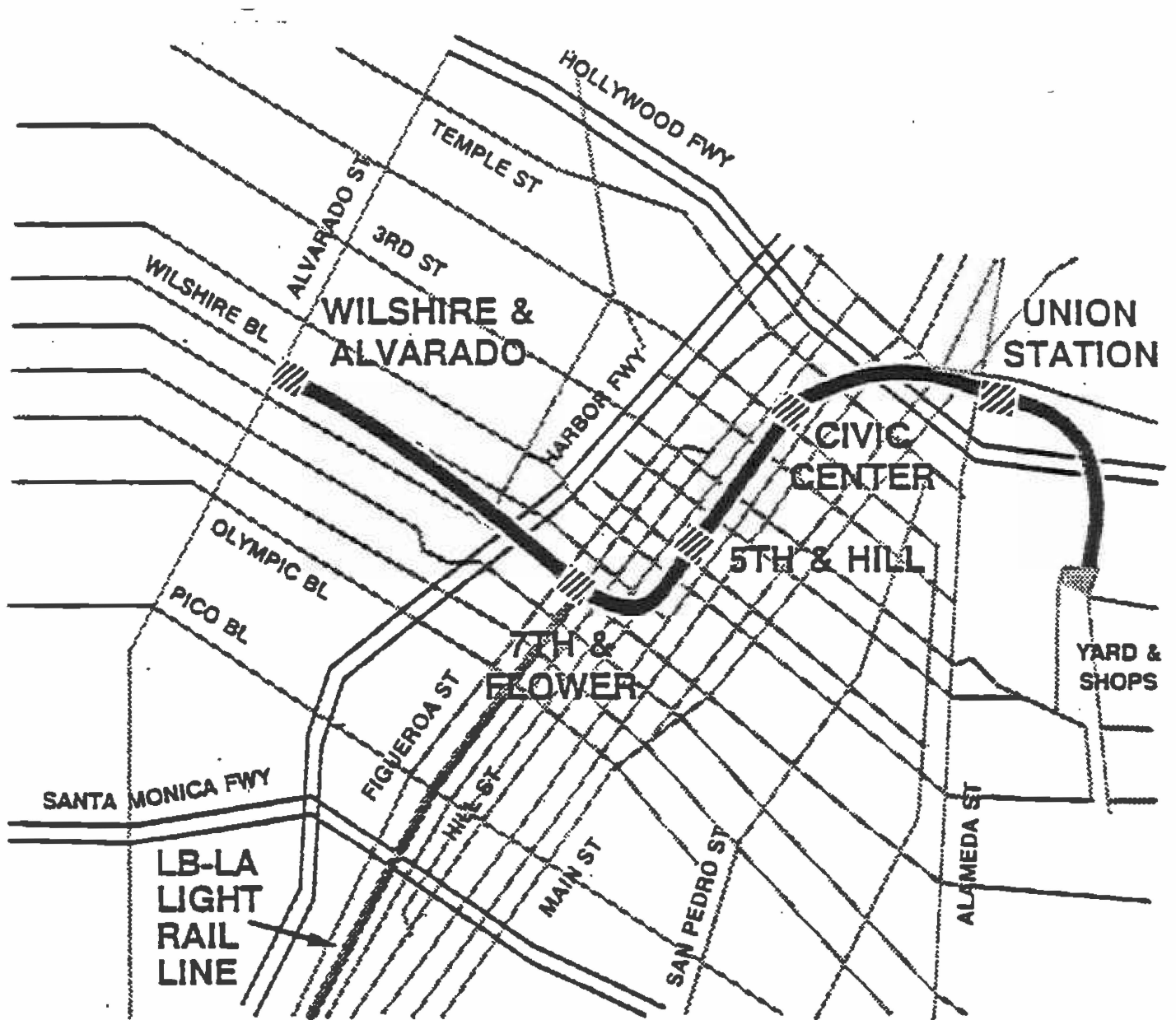
The SCRTD is developing a rail rapid transit system planned to run from downtown Los Angeles to the Wilshire District, Hollywood, and the San Fernando Valley. This system, called Metro Rail, will be the core element of a regional rail rapid transit network which will include both heavy and light rail modes. Funding limitations necessitate that the Metro Rail system be built in stages. Initially a 4-mile segment with five stations and yard and shop facilities will be constructed. This initial segment is identified as Minimum Operable Segment-1, or MOS-1.

As shown in Exhibit 2-1, the MOS-1 main-line route will begin at Union Station, where it will turn southwest and run through the central business district along Hill Street. Turning on 7th Street, the route will head toward the west side of downtown, pass the Harbor Freeway, and continue to the Wilshire/Alvarado Station, where the line will terminate. The main line will be entirely in subway, with line segments constructed by tunneling machines and stations and crossovers excavated by cut-and-cover construction techniques. Three double crossovers will be included in the main-line portion of MOS-1: one on each side of Union Station, and one on the east side of the Wilshire Alvarado Station.

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

Of the five MOS-1 stations, four will be of a double-ended design with two mezzanines. The remaining station, Wilshire /Alvarado, will be of a single-center-mezzanine design. The station at 7th/Flower will be the transfer point between the Long Beach-Los Angeles light rail system and the Metro Rail system. The stations have been designed for unattended operations; however, some stations may be attended at certain times of day.

EXHIBIT 2-1  
MOS-1 System Alignment



A barrier-free, self-service fare collection system will be implemented on a trial basis for MOS-1. Each station mezzanine will contain automated ticket vending machines. Transit Police serving on fare inspection duty will rove the system and conduct random checks of the validity of patrons' fare media. The fare structure for MOS-1 will be based on a single zone; however, the fare collection equipment will have a multi-zone capability to accommodate travel to light rail destinations as well as expansion of the Metro Rail system. Escalators, stairs, and elevators will provide normal vertical circulation between surface, mezzanine, and platform levels of Metro Rail stations.

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. Present plans call for trains on the MOS-1 system to consist of four vehicles, although the system is being designed to accommodate a maximum train length of six vehicles. Each single vehicle will have a capacity of 59 seated passengers plus space for one wheelchair, up to 109 standing passengers at normal loads, and 160 standing passengers at crush loads.

Trains will have automatic train protection equipment to ensure safe speed and separation of trains. Automatic train operation equipment will also be included to regulate train speed and provide precision station stopping and train berthing verification for trains operating on the main line. 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 televisions, and data transmission.

Ridership on MOS-1 by the year 2000 is projected to be approximately 54,000 per day.<sup>1</sup> An estimated two-thirds of these passengers will transfer to or from SCRTD buses serving the five Metro Rail stations. Maximum passenger loading on MOS-1 during peak hours will be from Union Station in the morning and to Union Station in the evening. The 24-hour loading pattern, however, shows relatively constant loadings on each of the links, with the heaviest travel volume occurring on the link between the Wilshire/Alvarado and 7th/Flower Stations.

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1 Source: Keith L. Killough, SCRTD Memorandum, "Station-to-Station Trip Volumes--MOS-1 Option," October 3, 1984.



## 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:

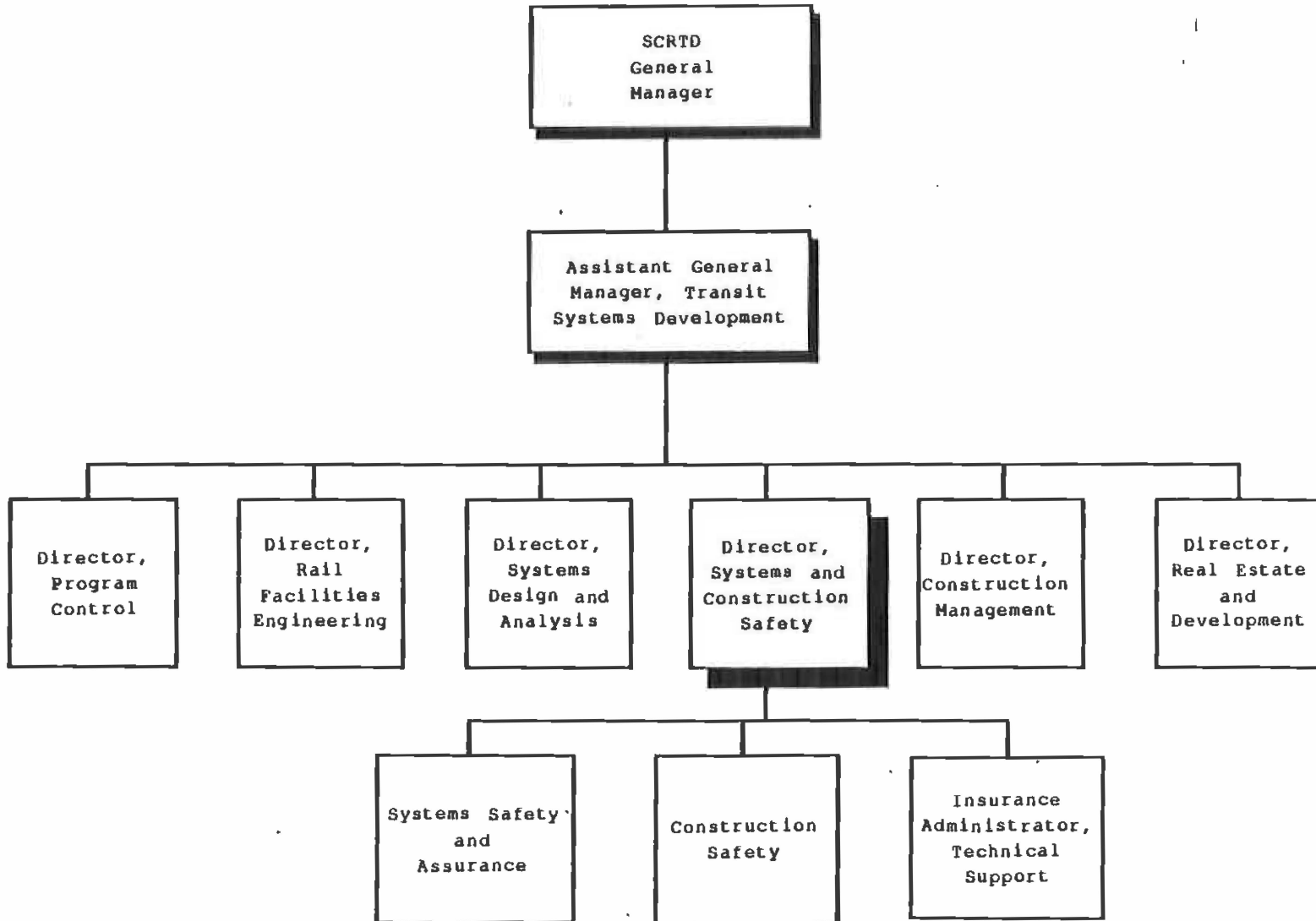
- Development of basic maintenance programs for vehicles, train control, communication, electrification, track, station, fare collection, and other equipment. Included will be a definition of work tasks, frequency, and shop time for scheduled maintenance.
- Development of detailed maintenance practices 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 was 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

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### EXHIBIT 2-2 SCRTD Metro Rail Project Organization



the maintenance and operations functions necessary for revenue service.

Within the SCRTD Transit Systems Development (TSD) Department, the Director of Systems and Construction Safety has overall responsibility for the system assurance program and the activities of the system assurance organization:

Personnel from the TSD Systems Design and Analysis, Rail Facilities Engineering, and Construction Management Offices participate in the system assurance program, given that their design, construction, and procurement decisions affect, and are affected by, system assurance requirements. Similarly, Metro Rail operations and maintenance personnel also participate in the system assurance program.

#### 2.4 SYSTEM ASSURANCE ORGANIZATION

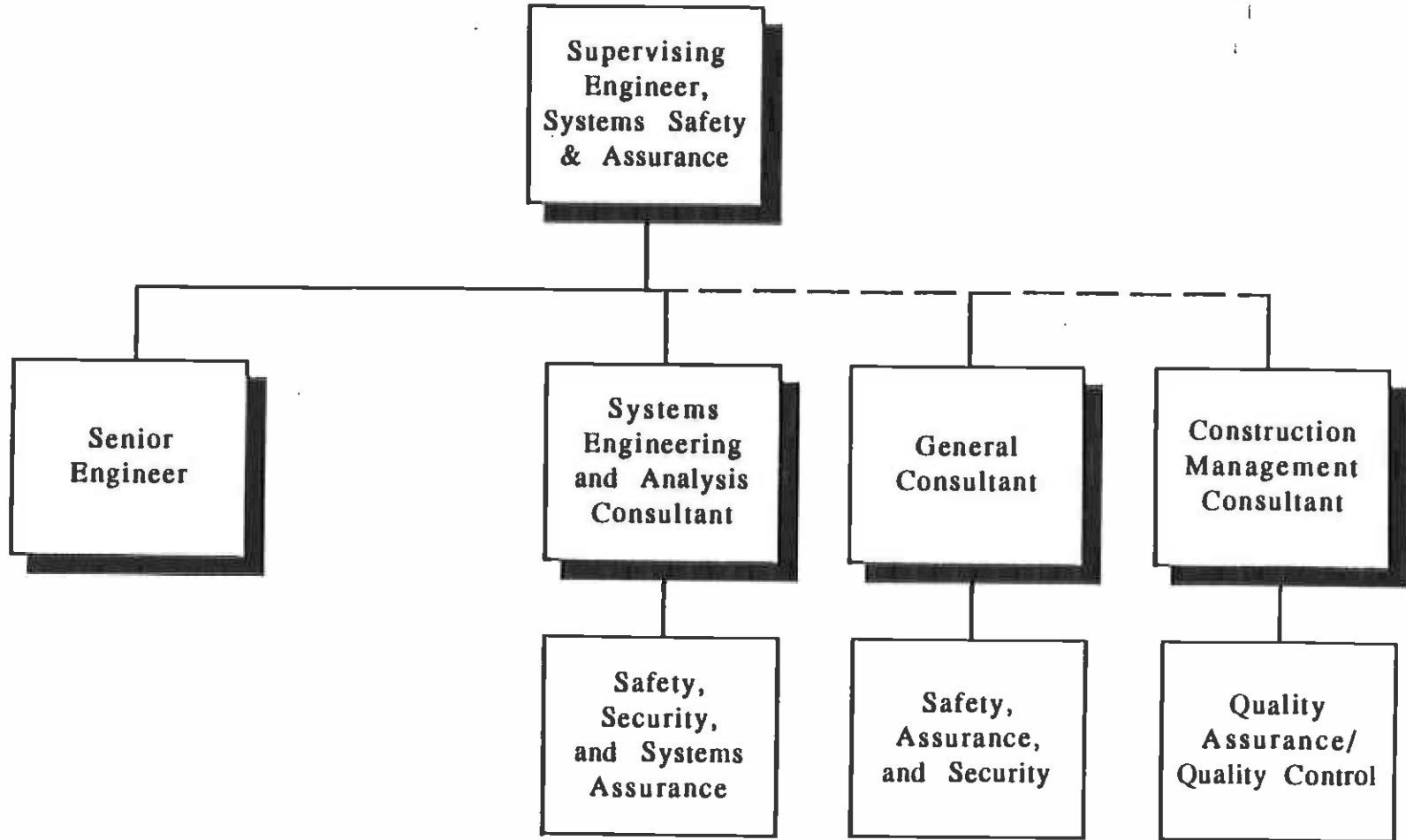
The Director of Systems and Construction Safety (S&CS) is responsible for the overall management and coordination of system assurance program activities on the Metro Rail Project prior to the start of revenue operations.

Reporting to the Director of S&CS, the Supervising Engineer of Systems Safety and Assurance (SS&A) is responsible for the day-to-day management of system assurance program activities. The Supervising Engineer of SS&A directs the work of his own staff and of consultants supplying technical expertise to the project. As shown in Exhibit 2-3, the Metro Rail system assurance organization includes three consultants: the General Consultant (GC); the Systems Engineering and Analysis (SE&A) Consultant; and the Construction Management (CM) Consultant. 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

EXHIBIT 2-3  
System Assurance Organization



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EXHIBIT 2-4  
General Consultant Organization

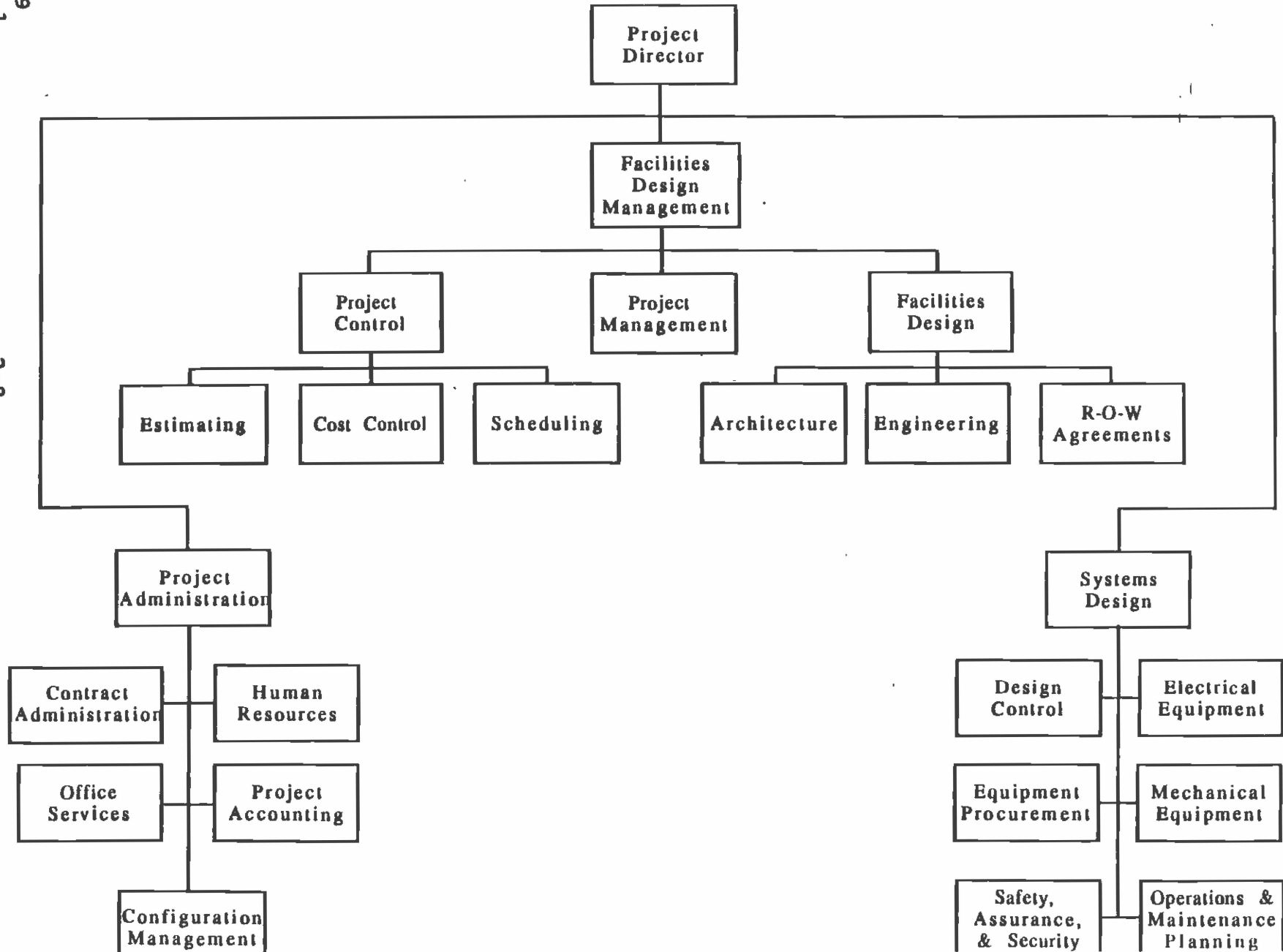


EXHIBIT 2-5  
Systems Engineering and Analysis Consultant Organization

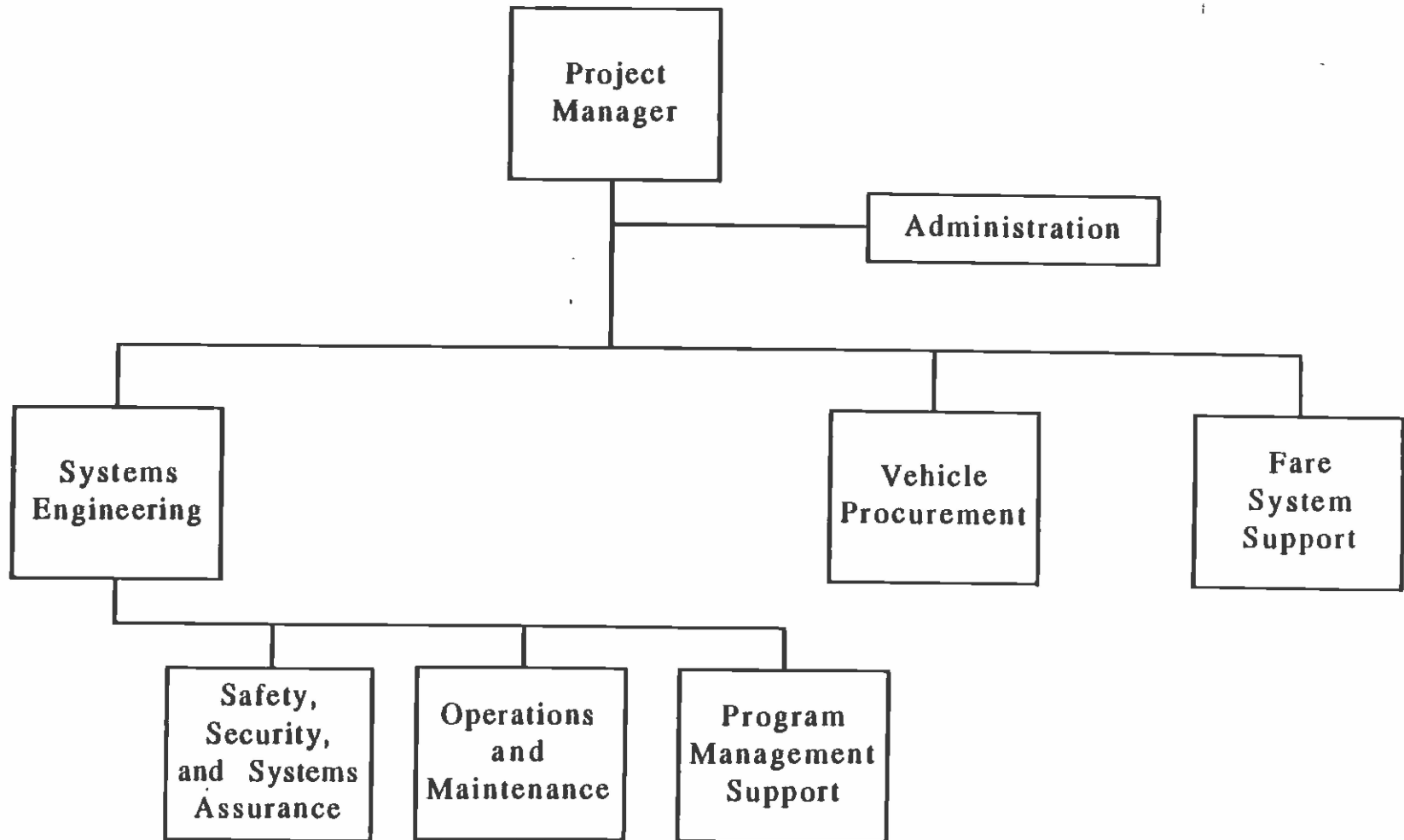
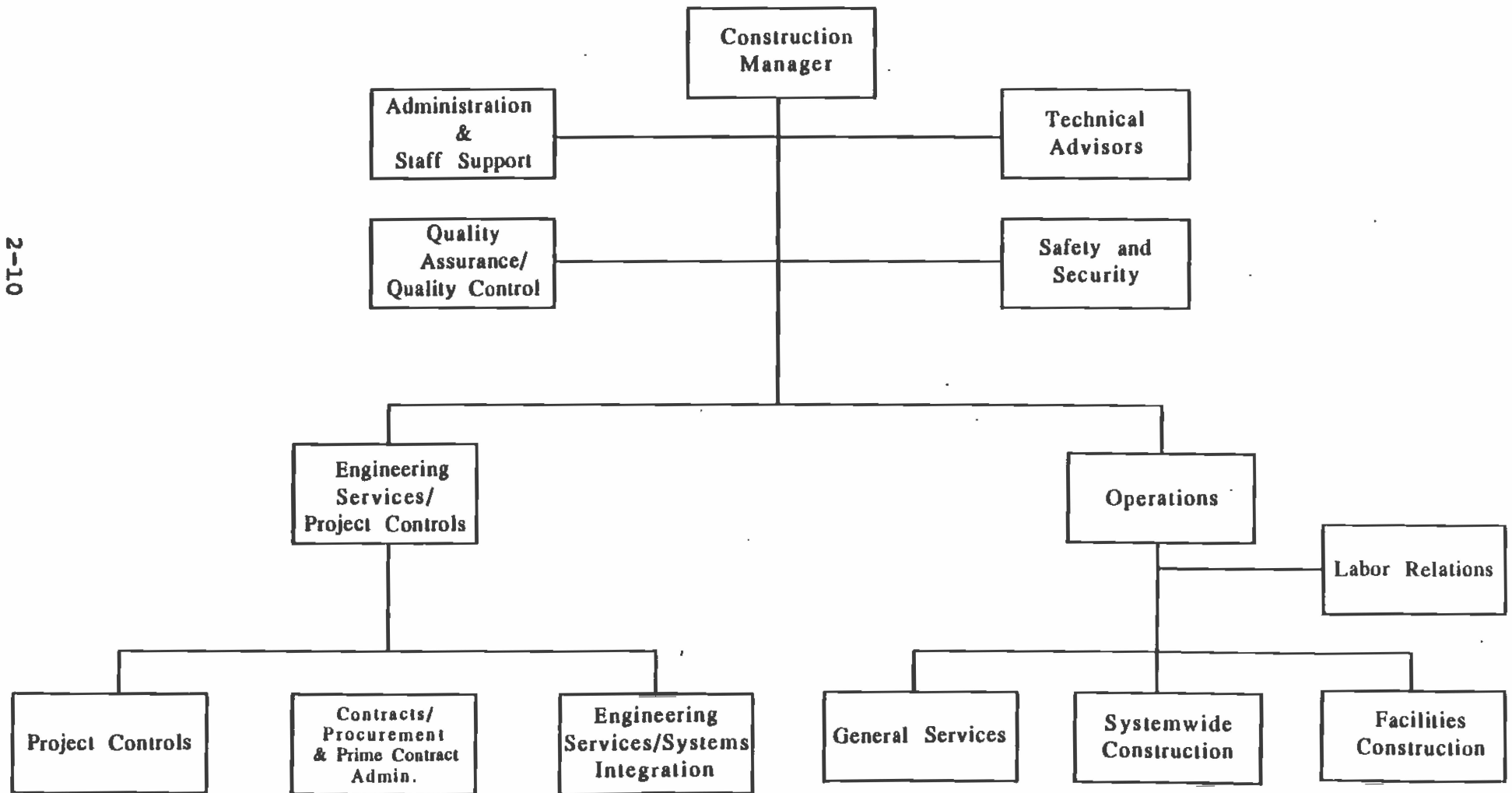


EXHIBIT 2-6  
Construction Management Consultant Organization



- Periodically collecting system assurance information from other properties to evaluate reliability, maintainability, and quality improvements for the Metro Rail system
- Developing a failure reporting system and ensuring that it is compatible with SCRTD maintenance management information system development
- 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 Operations 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 long-term system assurance strategies 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.

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 3-1**  
**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 Submittal Review Procedures				●		
3.3.3	Develop the Operations Phase System Assurance Organization					●	●
3.3.4	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	●	●	●	●		

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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 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 Configuration Control Board Meetings			•	•	•	
3.5.10	Review Contractor Analyses and Reports	•	•	•	•	•	•

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
3.5.11	Participate in Test Program Development				•		
3.5.12	Review Operating and Maintenance Manuals and Procedures				•	•	
3.5.13	Participate in Testing				•	•	•
3.5.14	Provide Operations/Maintenance Support					•	•
3.5.15	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		•	•			
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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 Supervising Engineer of Systems Safety and Assurance.

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.

### 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.<sup>1</sup> The System Assurance Criteria set forth the requirements to be followed by design engineers in equipment selection and facilities design. The System Assurance Criteria are integrated into all aspects of design, specification preparation, equipment selection, construction, architectural concepts, procedures, and operations.

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1 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.

EXHIBIT 3-2

General System Assurance Task Responsibilities

PARAGRAPH NUMBER	TASK/ACTIVITY	TRANSIT SYSTEMS DEVELOPMENT						CONSULTANTS						OPERATIONS		
		SYSTEMS AND CONSTRUCTION SAFETY			SYSTEMS DESIGN AND ANALYSIS			SYSTEMS ENGINEERING AND ANALYSIS CONSULTANT	GENERAL CONSULTANT	CONSTRUCTION MANAGEMENT CONSULTANT	INSURANCE CONSULTANT	FIRE DEPARTMENTS AND RESCUE SQUAD	POLICE DEPARTMENTS AND CORONER'S OFFICE	TRANSPORTATION	EQUIPMENT MAINTENANCE	FACILITIES MAINTENANCE
		SYSTEMS SAFETY AND ASSURANCE	CONSTRUCTION SAFETY	TECHNICAL SUPPORT	SYSTEMS ENGINEERING AND ANALYSIS	SYSTEMS DESIGN	RAIL FACILITIES ENGINEERING									
	<u>CRITERIA DEVELOPMENT</u>															
3.2.1	Develop System Assurance Criteria	S			RC	RC	RC	P	S							
3.2.2	Update and Revise System Assurance Criteria	S			RC	RC	RC	RC	S	P	RC			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	RC	P	RC	RC				RC	RC	RC
3.3.2	Prepare Contractor System Assurance Submittal Review Procedures	P			RC	RC	RC	S	S	S	P					
3.3.3	Develop the Operations Phase System Assurance Organization	S												P	P	P
3.3.4	Establish System Assurance Improvement Programs	P												S	P	P

P = Primary Responsibility  
 S = Secondary or Support Responsibility  
 RC = Review and Comment

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

PARAGRAPH NUMBER	TASK/ACTIVITY	TRANSIT SYSTEMS DEVELOPMENT						CONSULTANTS						OPERATIONS		
		SYSTEMS AND CONSTRUCTION SAFETY			SYSTEMS DESIGN AND ANALYSIS			SYSTEMS ENGINEERING AND ANALYSIS CONSULTANT	GENERAL CONSULTANT	CONSTRUCTION MANAGEMENT CONSULTANT	INSURANCE CONSULTANT	FIRE DEPARTMENTS AND RESCUE SQUAD	POLICE DEPARTMENTS AND CORONER'S OFFICE	TRANSPORTATION	EQUIPMENT MAINTENANCE	FACILITIES MAINTENANCE
		SYSTEMS SAFETY AND ASSURANCE	CONSTRUCTION SAFETY	TECHNICAL SUPPORT	SYSTEMS ENGINEERING AND ANALYSIS	SYSTEMS DESIGN	RAIL FACILITIES ENGINEERING									
	<u>ANALYSES AND STUDIES</u>															
3.4.1	Define Reliability and Maintainability Measures	S			RC	RC	RC	RC	P	S	RC				RC	RC
3.4.2	Develop and Update Reliability and Maintainability Numerical Indices	S			RC	RC	RC	RC	S	P	RC				RC	RC
3.4.3	Conduct System Assurance Trade-Off Studies	P			RC	RC	S	S	S	S	S	S	S		S	S
	<u>DESIGN, CONSTRUCTION, PROCUREMENT, AND TESTING SUPPORT</u>															
3.5.1	Provide General Design Support	P							S		S				S	S
3.5.2	Provide General Construction/Procurement Support	P							S	S					S	S
3.5.3	Participate in SCRTD Design Reviews	P							S	S	S				S	S
3.5.4	Identify System Assurance Documentation Requirements for Contract Specifications	S			RC	RC	RC	RC	S	P	RC				RC	RC

P = Primary Responsibility  
S = Secondary or Support Responsibility  
RC = Review and Comment

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

PARAGRAPH NUMBER	TASK/ACTIVITY	TRANSIT SYSTEMS DEVELOPMENT						CONSULTANTS						OPERATIONS		
		SYSTEMS AND CONSTRUCTION SAFETY			SYSTEMS DESIGN AND ANALYSIS			SYSTEMS ENGINEERING AND ANALYSIS CONSULTANT	GENERAL CONSULTANT	CONSTRUCTION MANAGEMENT CONSULTANT	INSURANCE CONSULTANT	FIRE DEPARTMENTS AND RESCUE SQUAD	POLICE DEPARTMENTS AND CORONER'S OFFICE	TRANSPORTATION	EQUIPMENT MAINTENANCE	FACILITIES MAINTENANCE
		SYSTEMS SAFETY AND ASSURANCE	CONSTRUCTION SAFETY	TECHNICAL SUPPORT	SYSTEMS ENGINEERING AND ANALYSIS	SYSTEMS DESIGN	RAIL FACILITIES ENGINEERING									
3.5.5	Develop Guidelines for the Preparation of Safety and System Assurance Analyses	S			RC	RC	RC	RC	P	RC	RC			RC	RC	
3.5.6	Prepare Criteria Conformance Checklists	S			RC	RC	RC	RC	S	P	S				RC	RC
3.5.7	Prepare Specification Conformance Checklists	S			RC	RC	RC	RC	S	P	S				RC	RC
3.5.8	Conduct Coordination Meetings with Contractor System Assurance Staff	P						S	S	S	S				S	S
3.5.9	Participate in Configuration Control Board Meetings	P						S		S	S					
3.5.10	Review Contractor Analyses and Reports	P			RC	RC	RC	RC	RC	RC	RC				RC	RC
3.5.11	Participate in Test Program Development	P			P	P	S	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	P
3.5.13	Participate in Testing	P			S	S		S	S		S			S	S	S

P = Primary Responsibility  
S = Secondary or Support Responsibility  
RC = Review and Comment

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

PARAGRAPH NUMBER	TASK/ACTIVITY	TRANSIT SYSTEMS DEVELOPMENT						CONSULTANTS						OPERATIONS		
		SYSTEMS AND CONSTRUCTION SAFETY			SYSTEMS DESIGN AND ANALYSIS			SYSTEMS ENGINEERING AND ANALYSIS CONSULTANT	GENERAL CONSULTANT	CONSTRUCTION MANAGEMENT CONSULTANT	INSURANCE CONSULTANT	FIRE DEPARTMENTS AND RESCUE SQUAD	POLICE DEPARTMENTS AND CORONER'S OFFICE	TRANSPORTATION	EQUIPMENT MAINTENANCE	FACILITIES MAINTENANCE
		SYSTEMS SAFETY AND ASSURANCE	CONSTRUCTION SAFETY	TECHNICAL SUPPORT	SYSTEMS ENGINEERING AND ANALYSIS	SYSTEMS DESIGN	RAIL FACILITIES ENGINEERING									
3.5.14	Provide Operations/Maintenance Support	P			S	S								S	S	S
3.5.15	Develop System Assurance Management Reports	P												S	S	S
	<u>DOCUMENTATION</u>															
3.6.1	Establish System Assurance Library	P		P												
3.6.2	Establish System Assurance Documentation and Review Procedures	P		P												
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P = Primary Responsibility  
S = Secondary or Support Responsibility

### 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 are revised in accordance with the established Metro Rail change control process.

### 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.<sup>2</sup> 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 technical tasks that must 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 Submittal Review Procedures

Procedures for reviewing contractor-prepared submittals were developed.<sup>3</sup> These procedures provide for a comprehensive review of the contractors' system assurance documentation by the SCRTD, the GC, the CM Consultant, and other system assurance program participants.

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

3 Contractor Submittal Review and Approval Procedures, SCRTD Metro Rail Project, Rev. 0 (Draft), August 1988.

3.3.3 Develop the Operations Phase System Assurance Organization

For revenue service, the focus of system assurance will shift from Systems and Construction Safety to Transportation, Equipment Maintenance, and Facilities Maintenance. Each of these organizations will establish procedures to monitor and evaluate the quality of service and maintenance, and the performance and reliability of equipment; and to identify opportunities for improving system dependability.

3.3.4 Establish System Assurance Improvement Programs

During reliability and maintainability demonstration testing, opportunities to improve equipment performance will be monitored closely by the system assurance organization as well as by Equipment Maintenance and Facilities Maintenance personnel. Data from the reliability and maintainability demonstration tests will be used to report on problem areas or deficiencies, and to identify opportunities for improvement through design changes, procedures modification, or other corrective action.

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.<sup>4</sup> 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.<sup>5</sup>

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

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

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, 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 is responsible for providing support 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.

#### 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 provides construction and procurement support, as required, to the TSD Offices of

Construction Management and Systems Design and Analysis, and the CM and SE&A Consultants.

### 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 identified contractor or supplier system-assurance-related analyses, tests, tasks, and submittals that form part of the procurement specifications. Within the system assurance organization, the GC had 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<sup>6</sup> were prepared to present uniform formats and methodologies to 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 more easily be 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 Criteria Conformance Checklists

To ensure that the system assurance criteria are properly reflected in contract drawings and

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6 Guidelines for the Preparation of Safety and System Assurance Analyses, SCRTD 5-001, Booz, Allen & Hamilton, Rev. 2, March 1987.

specifications, the GC developed comprehensive checklists of items which must be verified during the Metro Rail design review process. Checklists for systemwide elements and facilities contracts have been developed to support the Safety Certification Program. The checklists are used by SCRTD system assurance staff to ensure a comprehensive and consistent review of specifications and drawings. Any discrepancies are formally submitted to the GC and are resolved to the satisfaction of SCRTD system assurance management.

#### 3.5.7 Prepare Specification Conformance Checklists

Checklists will be developed to ensure that all system assurance criteria incorporated into the specifications are reflected in contractors' final designs and in equipment and materials selection. The 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 GC and used by SCRTD and representatives of the CM Consultant and SE&A Consultant (for passenger vehicle procurement) during contractor design reviews, audits, inspections, and tests. Any discrepancies between the specification conformance checklist requirements and contractor 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 system assurance organization 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 Configuration Control Board Meetings

The system assurance organization is represented on the Configuration Control Board (CCB) meetings by the Director of System and Construction Safety.<sup>7</sup>

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7 Change Control Procedure, Construction/Installation & Procurement Contracts, SCRTD Metro Rail Project, Rev. 1, March 1988.

The CCB is the SCRTD group with the authority to approve or disapprove all proposed changes to established Metro Rail designs. As a CCB member, the Director of S&CS assesses whether changes to the design of a facilities or equipment could affect the dependability of the Metro Rail system.

#### 3.5.10 Review Contractor Analyses and Reports

The system assurance organization reviews 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 Test Program Development

During Construction/Acquisition, the system assurance organization will assist the Systems Design and Analysis Office, the Construction Management Office, the SE&A Consultant, the CM Consultant, and Metro Rail transportation and maintenance personnel with developing test plans and procedures. The test program encompasses tests of fixed facilities and system equipment; system integration and pre-revenue tests; and all safety-related tests. The test program will be implemented throughout construction of the Metro Rail system and during start-up operations. The Metro Rail tests are identified in the Test Program Plan.<sup>8</sup>

#### 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.

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8 Test Program Plan, SCRTD Metro Rail Project, Rev. 1, September 1988.



### 3.5.13 Participate in Testing

The system assurance organization will participate in Metro Rail testing activities. The system assurance organization's participation in testing will include reviewing, coordinating, witnessing, conducting, or auditing tests related to system assurance. Examples of such tests are production verification tests and reliability and maintainability demonstration tests.

### 3.5.14 Provide Operations/Maintenance Support

During the Pre-Operational Testing and Start-Up Operations Phases, the system assurance organization will provide input to evolving operations and maintenance philosophies. The system assurance organization will review new designs or design changes that impact operations and maintenance and will also provide input to operations and maintenance plans and procedures.

### 3.5.15 Develop System Assurance Management Reports

The system assurance organization will develop reports to inform SCRTD management of the status and effectiveness of the system assurance program. The reports will include results of system assurance inspections, tests, and audits. During Metro Rail operations, the reports will also identify adverse trends in service or equipment performance and will include recommendations to improve system dependability.

## 3.6 DOCUMENTATION

The system assurance organization is responsible for compiling and maintaining 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.

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**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.<sup>1</sup> 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).

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1 Warranty Management Plan, Booz Allen & Hamilton, March 1986.

**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 a Failure Reporting and Corrective Action System			•	•		
4.1.5	Develop Test Program Plan				•		
4.1.6	Develop Reliability Test Demonstration Procedures				•	•	
4.1.7	Establish an Incident Evaluation Committee				•		
4.1.8	Develop Incident Evaluation Committee Policies and Procedures				•		

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4-2

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		•	•			
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				•		
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EXHIBIT 4-2  
Reliability Task Responsibilities

PARAGRAPH NUMBER	TASK/ACTIVITY	TRANSIT SYSTEMS DEVELOPMENT						CONSULTANTS						OPERATIONS			
		SYSTEMS AND CONSTRUCTION SAFETY			SYSTEMS DESIGN AND ANALYSIS			SYSTEMS ENGINEERING AND ANALYSIS CONSULTANT	GENERAL CONSULTANT	CONSTRUCTION MANAGEMENT CONSULTANT	INSURANCE CONSULTANT	FIRE DEPARTMENTS AND RESCUE SQUAD	POLICE DEPARTMENTS AND CORONER'S OFFICE	TRANSPORTATION	EQUIPMENT MAINTENANCE	FACILITIES MAINTENANCE	
		SYSTEMS SAFETY AND ASSURANCE	CONSTRUCTION SAFETY	TECHNICAL SUPPORT	SYSTEMS ENGINEERING AND ANALYSIS	SYSTEMS DESIGN	RAIL FACILITIES ENGINEERING										CONSTRUCTION MANAGEMENT
	<u>RELIABILITY PLANS AND PROCEDURES</u>																
4.1.1	Prepare a Warranty Management Plan	S			RC	RC		RC	P	RC	RC				RC	S	S
4.1.2	Establish a Warranty Provisions Working Group	P			S	S		S	S	S	S					S	S
4.1.3	Develop Warranty Procedures, Forms, and Instructions	S							P	RC	RC				RC	S	S
4.1.4	Develop a Failure Reporting and Corrective Action System	S			RC	RC			P	RC	RC				RC	S	S
4.1.5	Develop Test Program Plan	S			P	S	S	S	S	S	S	S	S	S	S	S	S
4.1.6	Develop Reliability Test Demonstration Procedures	P			S	S		S	S	S	S				S	S	S
4.1.7	Establish an Incident Evaluation Committee	P			S	S			S	S	S				S	S	S

P = Primary Responsibility  
S = Secondary or Support Responsibility  
RC = Review and Comment

EXHIBIT 4-2 (Continued)  
Reliability Task Responsibilities

PARAGRAPH NUMBER	TASK/ACTIVITY	TRANSIT SYSTEMS DEVELOPMENT						CONSULTANTS						OPERATIONS			
		SYSTEMS AND CONSTRUCTION SAFETY			SYSTEMS DESIGN AND ANALYSIS			SYSTEMS ENGINEERING AND ANALYSIS CONSULTANT	GENERAL CONSULTANT	CONSTRUCTION MANAGEMENT CONSULTANT	INSURANCE CONSULTANT	FIRE DEPARTMENTS AND RESCUE SQUAD	POLICE DEPARTMENTS AND CORONER'S OFFICE	TRANSPORTATION	EQUIPMENT MAINTENANCE	FACILITIES MAINTENANCE	
		SYSTEMS SAFETY AND ASSURANCE	CONSTRUCTION SAFETY	TECHNICAL SUPPORT	SYSTEMS ENGINEERING AND ANALYSIS	SYSTEMS DESIGN	RAIL FACILITIES ENGINEERING										CONSTRUCTION MANAGEMENT
4.1.8	Develop Incident Evaluation Committee Policies and Procedures	S			RC	RC									RC	S	S
	<u>RELIABILITY ANALYSES AND SUPPORT</u>																
4.2.1	Develop Warranty Provisions for Contracts	S			RC	RC	RC	S	P	S					RC	RC	RC
4.2.2	Prepare Failure Management Analyses	S			S			P	RC						S	RC	RC
4.2.3	Participate on Incident Evaluation Committee	P				S		S	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							
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P = Primary Responsibility  
S = Secondary or Support Responsibility  
RC = Review and Comment



#### 4.1.3 Develop Warranty Procedures, Forms, and Instructions

Prior to acceptance of equipment and facilities, the system assurance organization will develop specific warranty procedures to ensure 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 a Failure Reporting 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, an analysis<sup>2</sup> of Metro Rail Management Information System (MIS) requirements was performed and proposed use of the SCRTD's Vehicle Management System (VMS) to report failures and schedule corrective action for Metro Rail passenger vehicles and rail-borne auxiliary vehicles. The SCRTD's Facilities Maintenance System (FMS) will be used to report failures and schedule corrective action for all other Metro Rail equipment.

#### 4.1.5 Develop Test Program Plan

Throughout construction of the Metro Rail system and during start-up operations, a comprehensive test program will be implemented and will encompass tests of fixed facilities and system equipment; system integration and pre-revenue tests; and all safety-related tests. The test program is designed to ensure that material, equipment, facilities, and software provided under the various procurement and construction contracts conform to requirements; and that equipment, facilities, software, and personnel function effectively together to provide safe and

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2 Equipment Maintenance Management Information System Requirements Analysis, ACEX under subcontract to Booz, Allen & Hamilton, June 1988.

dependable service. The framework for achieving the test program objectives is presented in the Test Program Plan (TPP), which was developed during the Construction/Acquisition phase. The TPP identifies the test program organization, establishes the process for managing test program activities, and defines the administrative requirements of the test program. Appendices to the TPP also provide a preliminary listing of the tests.

#### 4.1.6 Develop Reliability Test Demonstration Procedures

The procedures for the reliability test demonstration of system 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.

#### 4.1.7 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.

#### 4.1.8 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.<sup>3</sup> 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. Another set of analyses<sup>4</sup> was performed and described the failure effects and responses for communications and Automatic Train Control equipment failures. The analyses identified potential hazards and provided a baseline for the development of failure management procedures for operations.

#### 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.

#### 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.<sup>5</sup> 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.

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

4 Failure Management Plan and Analyses for Automatic Train Control and Communication Systems, ACEX under subcontract to Booz, Allen & Hamilton, September 1987 (Draft).

5 Operational Impacts--Power System Failures, Booz, Allen & Hamilton, May 1985.

#### 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.

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**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 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 SCRTD Equipment Maintenance and Facilities Maintenance personnel, will ensure that all contractual requirements are adequately demonstrated.

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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
5.1.1	<u>MAINTAINABILITY PLANS AND PROCEDURES</u> Develop Maintainability Test Demonstration Procedures				•		
5.2.1	<u>MAINTAINABILITY ANALYSES AND SUPPORT</u> Participate in the Maintainability Test Demonstration				•	•	•

EXHIBIT 5-2  
Maintainability Task Responsibilities

PARAGRAPH NUMBER	TASK/ACTIVITY	TRANSIT SYSTEMS DEVELOPMENT						CONSULTANTS						OPERATIONS		
		SYSTEMS AND CONSTRUCTION SAFETY			SYSTEMS DESIGN AND ANALYSIS			SYSTEMS ENGINEERING AND ANALYSIS CONSULTANT	GENERAL CONSULTANT	CONSTRUCTION MANAGEMENT CONSULTANT	INSURANCE CONSULTANT	FIRE DEPARTMENTS AND RESCUE SQUAD	POLICE DEPARTMENTS AND CORONER'S OFFICE	TRANSPORTATION	EQUIPMENT MAINTENANCE	FACILITIES MAINTENANCE
		SYSTEMS SAFETY AND ASSURANCE	CONSTRUCTION SAFETY	TECHNICAL SUPPORT	SYSTEMS ENGINEERING AND ANALYSIS	SYSTEMS DESIGN	RAIL FACILITIES ENGINEERING									
5.1.1	<u>MAINTAINABILITY PLANS AND PROCEDURES</u> Develop Maintainability Test Demonstration Procedures	P			RC	RC			RC	RC	S				S	S
5.2.1	<u>MAINTAINABILITY ANALYSES AND SUPPORT</u> Participate in the Maintainability Test Demonstration	P				S			S	S	S				S	S

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P = Primary Responsibility  
S = Secondary or Support Responsibility  
RC = Review and Comment



**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 Program Plan

During the Final Design and Construction/Acquisition Phases, the system assurance organization prepared a Quality Assurance Program Plan.<sup>1</sup> The plan describes the overall quality assurance process for design, equipment procurement, construction/installation, system start-up, and operations and maintenance. The plan also describes the general activities and responsibilities of Metro Rail Project personnel in implementing the quality assurance program.

#### 6.1.2 Develop a Quality Pre-Award Survey Manual--Systems

During Final Design, a Quality Pre-Award Survey Manual was prepared.<sup>2</sup> The Quality Pre-Award Survey Manual is designed for use in reviewing and verifying the quality assurance capabilities of potential

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1 Quality Assurance Program Plan, SCRTD Metro Rail Project, August 1987 (Draft).

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

**EXHIBIT 6-1**  
**Quality Assurance Activities and Tasks**

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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 Program Plan			•	•		
6.1.2	Develop a Quality Pre-Award Survey Manual--Systems			•			
6.1.3	Develop a Resident Engineer Manual			•			
6.1.4	Develop a QA/QC Procedures Manual			•			
6.1.5	Develop QA Review Guidelines--Systems			•			
6.1.6	Develop Guidelines for Construction Inspectors			•	•		
6.1.7	Develop Contractor/Supplier Inspection and Testing Plans			•	•		
6.1.8	Establish a QA Training and Certification Program for Maintenance Personnel				•	•	

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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				•	•	•
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EXHIBIT 6-2  
Quality Assurance Task Responsibilities

PARAGRAPH NUMBER	TASK/ACTIVITY	TRANSIT SYSTEMS DEVELOPMENT						CONSULTANTS						OPERATIONS		
		SYSTEMS AND CONSTRUCTION SAFETY			SYSTEMS DESIGN AND ANALYSIS			SYSTEMS ENGINEERING AND ANALYSIS CONSULTANT	GENERAL CONSULTANT	CONSTRUCTION MANAGEMENT CONSULTANT	INSURANCE CONSULTANT	FIRE DEPARTMENTS AND RESCUE SQUAD	POLICE DEPARTMENTS AND CORONER'S OFFICE	TRANSPORTATION	EQUIPMENT MAINTENANCE	FACILITIES MAINTENANCE
		SYSTEMS SAFETY AND ASSURANCE	CONSTRUCTION SAFETY	TECHNICAL SUPPORT	SYSTEMS ENGINEERING AND ANALYSIS	SYSTEMS DESIGN	RAIL FACILITIES ENGINEERING									
	<u>QUALITY ASSURANCE PLANS AND PROCEDURES</u>															
6.1.1	Develop a Metro Rail Quality Assurance Program Plan	P				RC	S	S	RC	S					RC	RC
6.1.2	Develop a Quality Pre-Award Survey Manual--Systems	S				RC	RC	P	RC	RC						
6.1.3	Develop a Resident Engineer Manual	S					RC	RC	RC	P						
6.1.4	Develop a QA/QC Procedures Manual	S				RC	RC	RC	RC	P						
6.1.5	Develop QA Review Guidelines--Systems	S				RC	RC	P	RC	RC						
6.1.6	Develop Guidelines for Construction Inspectors	S					RC	RC	RC	P						
6.1.7	Develop Contractor/Supplier Inspection and Testing Plans	P					RC	RC	RC	RC	S					
6.1.8	Establish a QA Training and Certification Program for Maintenance Personnel	S				RC		S						P	P	

P = Primary Responsibility  
S = Secondary or Support Responsibility  
RC = Review and Comment

EXHIBIT 6-2 (Continued)  
Quality Assurance Task Responsibilities

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PARAGRAPH NUMBER	TASK/ACTIVITY	TRANSIT SYSTEMS DEVELOPMENT						CONSULTANTS						OPERATIONS		
		SYSTEMS AND CONSTRUCTION SAFETY			SYSTEMS DESIGN AND ANALYSIS			SYSTEMS ENGINEERING AND ANALYSIS CONSULTANT	GENERAL CONSULTANT	CONSTRUCTION MANAGEMENT CONSULTANT	INSURANCE CONSULTANT	FIRE DEPARTMENTS AND RESCUE SQUAD	POLICE DEPARTMENTS AND CORONER'S OFFICE	TRANSPORTATION	EQUIPMENT MAINTENANCE	FACILITIES MAINTENANCE
		SYSTEMS SAFETY AND ASSURANCE	CONSTRUCTION SAFETY	TECHNICAL SUPPORT	SYSTEMS ENGINEERING AND ANALYSIS	SYSTEMS DESIGN	RAIL FACILITIES ENGINEERING									
	<u>QUALITY ASSURANCE SUPPORT</u>															
6.2.1	Participate in Quality Pre-Award Surveys	P				S		S	S	S						
6.2.2	Participate in Contractor Design Reviews and Milestone Audits	P				S		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	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						
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P = Primary Responsibility  
S = Secondary or Support Responsibility  
RC = Review and Comment

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 Resident Engineer Manual

Resident Engineers (REs) provide on-site monitoring and technical oversight of Metro Rail contractor activities. During Final Design, a manual was developed to provide guidance to REs in the areas of contracts, monitoring, administration, and documentation.<sup>3</sup> The procedures are to be followed by all REs.

#### 6.1.4 Develop a QA/QC Procedures Manual

During Final Design, the CM Consultant developed a Quality Assurance/Quality Control (QA/QC) Procedures Manual for distribution to cognizant staff and

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3 Resident Engineer Manual, PDCD, Rev. 1, July 1988.

contractors.<sup>4</sup> The manual defines a standard approach for the conduct of all quality assurance/quality control activities on Metro Rail contracts.

#### 6.1.5 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.<sup>5</sup> The guidelines focus on key items to be covered during quality 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.

A similar set of guidelines for civil/construction contracts oriented toward reviewing the quality assurance performance of facility contractors is included in the Metro Rail QA/QC Procedures Manual developed by the CM Consultant.

#### 6.1.6 Develop Guidelines for Construction Inspectors

During Final Design, guidelines for Construction Inspectors were developed to provide a standard frame

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4 Quality Assurance/Quality Control Procedures Manual, PDCD, September 1985.

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



of reference for all personnel engaged in inspection activities.<sup>6</sup> 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.

6.1.7 Develop Contractor/Supplier Inspection and Testing Plans

During the Final Design and Construction/Acquisition Phases, the system assurance organization works cooperatively with contractors 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.

6.1.8 Establish a QA Training and Certification Program for Maintenance Personnel

The system assurance organization will assist the SCRTD Equipment and Facilities Maintenance Departments 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.

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 directs and participates in the pre-award survey of the quality assurance capabilities of potential contractors. Input from the system assurance organization is used to select the most responsive and responsible bidder.

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6 Inspector Guidelines, PDCD, Rev. 2, July 1988.

#### 6.2.2 Participate in Contractor Design Reviews and Milestone Audits

The system assurance organization participates 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 are documented, and action items are assigned to resolve deficiencies in accordance with Metro Rail and contractor practices.

#### 6.2.3 Participate in Source Inspections

The system assurance organization participates 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 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 participates in qualification testing of materials, components, and equipment used in Metro Rail procurements. Qualification tests 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 participates in in-process inspections of Metro Rail equipment and facilities. Inspections 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 directs and participates in quality audits of Metro Rail contractors. The SCRTD conducts 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 are documented in accordance with Quality Assurance Review Guidelines (See task 6.1.5).

6.2.7 Participate in Acceptance Inspections and Tests

The system assurance organization participates in the acceptance testing and inspection of Metro Rail systems, equipment, and facilities. Acceptance tests of equipment are 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 are 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 participates, as appropriate, on Material Review Boards of Metro Rail contractors. Contractors are required to establish procedures for the disposition of non-conforming material.

6.2.9 Conduct Investigations of Quality Problems

The system assurance organization conducts investigations into quality problems that arise during Metro Rail Construction/Acquisition, Pre-Operational Testing, and Start-Up Operations. Appropriate documentation and reports are submitted to senior management.

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**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.<sup>1</sup> 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 baseline edition of the System Maintenance Plan<sup>2</sup> was issued during the Construction/Acquisition

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

2 System Maintenance Plan, SCRTD Metro Rail Project, April 1988.

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 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 the Operations and Maintenance Committee			•	•	•	•
7.1.4	Prepare a Staffing, Training, and Hiring 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				•		

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

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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/FMS			●	●		
7.2.9	Establish Work Standards				●		
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EXHIBIT 7-2  
Maintenance Planning Task Responsibilities

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PARAGRAPH NUMBER	TASK/ACTIVITY	TRANSIT SYSTEMS DEVELOPMENT						CONSULTANTS						OPERATIONS		
		SYSTEMS AND CONSTRUCTION SAFETY			SYSTEMS DESIGN AND ANALYSIS			SYSTEMS ENGINEERING AND ANALYSIS CONSULTANT	GENERAL CONSULTANT	CONSTRUCTION MANAGEMENT CONSULTANT	INSURANCE CONSULTANT	FIRE DEPARTMENTS AND RESCUE SQUAD	POLICE DEPARTMENTS AND CORONER'S OFFICE	TRANSPORTATION	EQUIPMENT MAINTENANCE	FACILITIES MAINTENANCE
		SYSTEMS SAFETY AND ASSURANCE	CONSTRUCTION SAFETY	TECHNICAL SUPPORT	SYSTEMS ENGINEERING AND ANALYSIS	SYSTEMS DESIGN	RAIL FACILITIES ENGINEERING									
	<u>MAINTENANCE PLANS AND PROCEDURES</u>															
7.1.1	Prepare a Preliminary Maintenance Plan	RC			RC	RC	RC	RC	P	RC	RC				RC	RC
7.1.2	Develop and Update the System Maintenance Plan	S			S	S			P	RC					S	S
7.1.3	Participate on the Operations and Maintenance Committee	P			P	P	P	P	P	P	P			P	P	P
7.1.4	Prepare a Staffing, Training, and Hiring Plan	S							P						S	S
7.1.5	Develop Training Course Materials	S							S		RC				P	P
7.1.6	Develop Maintenance Safety Rules and Procedures	S				RC			P	RC	RC		RC	RC	S	S
7.1.7	Develop Pre-Operation Safety Checkout Lists	P							RC	RC	RC			S	S	S
7.1.8	Develop Metro Rail Part Numbering System														P	P

P = Primary Responsibility  
S = Secondary or Support Responsibility



EXHIBIT 7-2 (Continued)  
Maintenance Planning Task Responsibilities

PARAGRAPH NUMBER	TASK/ACTIVITY	TRANSIT SYSTEMS DEVELOPMENT						CONSULTANTS						OPERATIONS		
		SYSTEMS AND CONSTRUCTION SAFETY			SYSTEMS DESIGN AND ANALYSIS			SYSTEMS ENGINEERING AND ANALYSIS CONSULTANT	GENERAL CONSULTANT	CONSTRUCTION MANAGEMENT CONSULTANT	INSURANCE CONSULTANT	FIRE DEPARTMENTS AND RESCUE SQUAD	POLICE DEPARTMENTS AND CORONER'S OFFICE	TRANSPORTATION	EQUIPMENT MAINTENANCE	FACILITIES MAINTENANCE
		SYSTEMS SAFETY AND ASSURANCE	CONSTRUCTION SAFETY	TECHNICAL SUPPORT	SYSTEMS ENGINEERING AND ANALYSIS	SYSTEMS DESIGN	RAIL FACILITIES ENGINEERING									
	<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	RC	P								
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	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/FMS	S						P						S	S	
7.2.9	Establish Work Standards	RC						S						P	P	
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P = Primary Responsibility  
S = Secondary or Support Responsibility

Phase. Changes to the baseline are subject to the SCRTD's formal change control process.

7.1.3 Participate on the Operations and Maintenance Committee

To ensure an effective interaction among the Metro Rail system assurance organization, its consultants, and SCRTD transportation and maintenance personnel, an Operations and Maintenance (O&M) Committee was established. Along with its other coordinating activities, the O&M Committee acts as a review board for reports and analyses on operations and maintenance issues. The O&M 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, Training, and Hiring Plan

To ensure that adequate numbers of personnel with appropriate skills are available before the start of revenue operations, a Staffing, Training, and Hiring Plan<sup>3</sup> was developed during the Construction/Acquisition Phase. The job positions and staffing levels used in the plan were defined in the Operating and Maintenance Cost Estimate for MOS-1.<sup>4</sup> A core training program is listed for each job position, and provides a basis for the hiring schedule. For maintenance personnel, the training methods, technical courses, and source of course contents are consistent with the training strategy documented in the System Maintenance Plan.

7.1.5 Develop Training Course Materials

The SCRTD will have a comprehensive maintenance training program to ensure that skills are developed to an acceptable level. Courses will be provided by contractors for their equipment and will also be developed in-house by SCRTD staff. The training program will include certification programs for maintenance staff, as well as specific training courses to enable SCRTD personnel to advance their knowledge in areas required in the performance of their duties.

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3 Staffing, Training, and Hiring Plan, ACEX under subcontract to Booz, Allen & Hamilton, May 1988 (Draft).

4 Operating and Maintenance Cost Estimate for MOS-1, SCRTD Metro Rail Project, February 1988.

The training programs will cover the major areas of rail maintenance: facilities, electronics and communications, systems, and passenger vehicles. A wide range of courses will be provided pertaining to each area, with the courses varying in scope, length, and method of instruction (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.

#### 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 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.<sup>5</sup> 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 Preliminary Engineering.<sup>6</sup> 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.<sup>7</sup> 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.

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

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

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

In addition to evaluating the impact of failures on unscheduled (corrective) maintenance workloads, SOCSIM 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 GC, with the assistance of the O&M 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, alternative arrangements for maintenance of Metro Rail facilities and equipment were evaluated based on SCRTD capabilities and cost-effectiveness. Maintenance actions, such as motor rebuild, elevator/escalator servicing and repair, and station janitorial servicing were studied for potential contracting agreements with specialty firms.

#### 7.2.7 Develop Maintenance Cost Estimates

During the engineering phases of the project, operating and maintenance cost estimates for both the full 18-mile system and MOS-1 were prepared.<sup>8</sup> Maintenance costs were identified for labor and materials for vehicle maintenance, ways and structures maintenance, and subsystems maintenance. The cost estimate for MOS-1 was updated during the Construction/Acquisition Phase to reflect refinements in staffing plans and to include contract costs.

#### 7.2.8 Identify Refinements to TRANSMIS/FMS

The Vehicle Management System (VMS) is a component of SCRTD's integrated Transit Management Information System (TRANSMIS). The Facilities Maintenance System will be linked to TRANSMIS through SCRTD's control computer.

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8 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 and February 1988 (Update).

During the Final Design and Construction/  
Acquisition Phases, the system assurance organization  
will assist the Equipment Maintenance and Facilities  
Maintenance Departments 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.

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