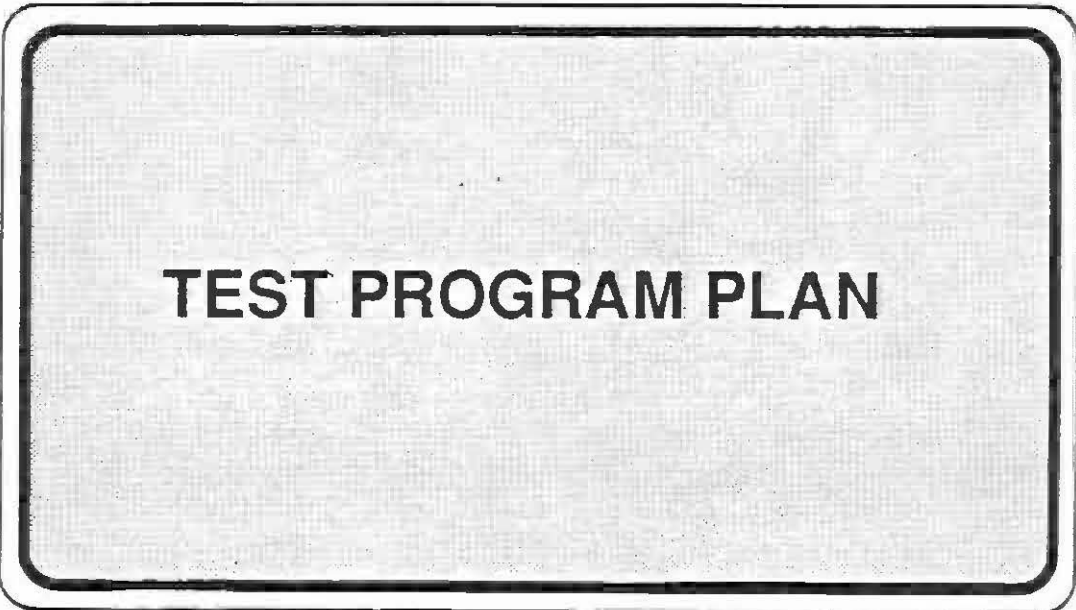


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Southern California Rapid Transit District

# METRO RAIL PROJECT



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SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT  
METRO RAIL PROJECT

TEST PROGRAM PLAN

Revision 2  
May 1990



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T A B L E O F C O N T E N T S

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**1.0 INTRODUCTION**

## 1.0 INTRODUCTION

The Southern California Rapid Transit District (SCRTD) Metro Rail Project is in the construction phase. Contracts have been awarded for the construction of fixed facilities and the procurement of systems and equipment for the initial construction segment, termed Minimum Operable Segment-1 (MOS-1). 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, systems, and equipment required by contract or otherwise specified by the SCRTD; system integration and pre-revenue tests prescribed by the SCRTD; and all safety-related tests. The test program is designed to ensure that:

- Material, systems, equipment, facilities, and software provided under the various procurement and construction contracts conform to requirements
- Systems, equipment, facilities, software, and personnel function effectively together to provide safe and dependable service.

This Metro Rail Test Program Plan (TPP) provides a framework for achieving Metro Rail test program objectives in a coherent and organized manner. The TPP:

- Identifies the test program organization and defines the authorities and responsibilities of program participants (see Chapter 2.0)
- Establishes the process for managing test program activities, including the planning, coordinating, performance, monitoring, and documenting of fixed facility, systems, and equipment tests, and system start-up tests (see Chapters 3.0 through 5.0)
- Defines the administrative requirements of the test program (see Chapter 6.0).

The TPP specifies a standardized approach for managing and accomplishing test program activities. It does not delineate the detailed procedures required to conduct each test. Specific test requirements, such as instrumentation set-up, equipment operation, troubleshooting

responsibilities, test responsibilities, and test budget, will be addressed during the development of each test procedure.

### 1.1 TEST CATEGORIES

All Metro Rail fixed facilities, systems, and equipment must undergo tests from design through completion and operation. Furthermore, tests must be conducted to ensure that Metro Rail operates as a unified system. After the Metro Rail system becomes operational and prior to the start of revenue service, certain start-up tests must be performed to verify the adequacy of Metro Rail personnel training and to verify the reliability and safety of the system. The tests which are required throughout the construction phase and during start-up operations fall into the following categories:

- Design qualification tests
- Production verification tests
- Construction inspection tests
- Installation verification tests
- Acceptance tests
- System integration tests
- System pre-revenue tests
- Demonstration tests.

A brief description of each test category is provided below.

Design Qualification Tests are conducted at the material, component, or subsystem level during contractor engineering on each Metro Rail element to demonstrate compliance with contract specifications. Examples of design qualification tests are: smoke and flammability tests of new material, traction motor/gear unit design tests, dynamometer tests, vehicle mock-up inspection, switchgear design tests, and amplifier frequency response tests. These tests are generally performed at the contractor's facilities or at independent laboratories.

Production Verification Tests are in-process acceptance or factory acceptance tests that are conducted at the material, component, assembly, or subsystem level during production of Metro Rail system equipment and equipment for fixed facilities. These tests ensure that the equipment is manufactured in accordance with the approved design and that the quality of production is in accordance with accepted workmanship standards. Examples of production verification tests are: composition tests of lubricants, high potential/megohm tests, equipment wiring continuity tests, and substation transformer, TV

monitor, and relay rack factory acceptance tests. Production verification tests are performed at the contractor's facilities or independent laboratories.

Construction Inspection Tests are in-process acceptance tests conducted to ensure that supplied materials meet specified standards, that fixed facilities are constructed in accordance with approved design, and that the quality of construction is in accordance with specified workmanship standards and industry codes. Examples of construction inspection tests are: asphalt concrete paving inspection, concrete composition tests, and field paint tests. The construction inspection tests are performed at the Metro Rail construction site, at independent laboratories, or at the manufacturer's facilities.

Installation Verification Tests are in-process acceptance tests conducted at the subsystem or assembly level during the installation of each Metro Rail element. These tests ensure that the on-site installation is in accordance with the approved design and that the quality of installation is in accordance with accepted workmanship standards. Examples of installation verification tests are: station wiring continuity tests, escalator and elevator installation clearance checks, and train control room wiring checks. These tests are performed at the Metro Rail site.

Acceptance Tests are conducted at the subsystem level to verify that the performance of each Metro Rail element and subsystem/assembly contained therein is in compliance with the specification requirements. Some production verification tests may be repeated as acceptance tests to verify proper operation of the element after installation. Examples of acceptance tests are: passenger vehicle running tests, train control room local panel operation tests, substation voltage tests, and station equipment operation tests. These tests are performed at the Metro Rail site and are a prerequisite to the start of Metro Rail system integration tests.

System Integration Tests are conducted at the system level to ensure that Metro Rail elements function properly together. Examples of system integration tests are tests involving interfaces such as passenger vehicles/station/tunnel clearances, wayside equipment and automatic train control, and station power and substations. These tests are conducted at the Metro Rail site.

System Pre-Revenue Tests are conducted at the Metro Rail system level during the pre-revenue phase to simulate revenue service operations during normal and abnormal

conditions, including emergencies, and to verify proper training of SCRTD personnel. System pre-revenue tests involve all elements of the Metro Rail system.

Demonstration Tests are conducted at the subsystem level beginning with the system pre-revenue phase and continuing into the revenue service phase to demonstrate the reliability of individual elements. Examples of demonstration tests are: passenger vehicle, fare collection, and train control reliability tests.

The titles used to identify test categories vary somewhat among Metro Rail Project documents. Exhibit 1-1 provides examples of the test category titles specified in Metro Rail contract documents and indicates their relationship to the TPP test categories specified above. To the greatest extent possible, test program participants should use TPP test category titles to standardize terminology and facilitate test program monitoring.

## 1.2 RELATIONSHIP TO THE SAFETY CERTIFICATION PROGRAM

The Metro Rail safety certification program documents that all safety requirements in design criteria and specifications are achieved, and that the safety content of plans, procedures, and training materials are systematically reviewed. While the safety certification program and the test program are managed as separate programs, they complement and reinforce each other and must be coordinated in the area of safety-related tests.

The Metro Rail TPP and safety-related test procedures are identified as elements that must receive Certificates of Compliance under the safety certification program.<sup>1</sup> Therefore, the SCRTD Safety Certification Review Team must approve the safety content of the TPP and relevant test procedures and recommend to SCRTD senior management that they be certified.

As the test program proceeds, the Safety Certification Review Team must verify that all safety-related tests are successfully completed and, among other things, that all identified hazards are resolved. As these activities are completed, they must be reviewed and documented by the Review Team as part of the certification process.

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1 SCRTD Metro Rail Project, Safety Certification Plan, Rev. 1.1, June 1988.

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**EXHIBIT 1-1**  
**Examples of Test Categories From Contract Documents**  
**and Their Relation to TPP Test Categories**

| TPP TEST CATEGORY                  | TEST CATEGORIES IDENTIFIED IN CONTRACT DOCUMENTS         |                                       |   |
|------------------------------------|--|---------------------------------------|---|
|                                    | Vehicle Specification A650                               | Main Shop Building Specification A112 | Traction Power Specification A631                       |
| 1. Design Qualification Tests      | Qualification Test                                       | Not Applicable                        |   |
| 2. Production Verification Tests   | Acceptance Test<br>Maintainability<br>Demonstration Test | Factory Tests                         | Field Quality Control Test                              |
| 3. Construction Inspection Tests   | Not Applicable   | Inspection<br>Field QC Tests          | Not Applicable  |
| 4. Installation Verification Tests | Not Applicable   | Operational Tests<br>Field QC Tests   | Installation Verification Test                          |
| 5. Acceptance Tests                | Vehicle Acceptance Test<br>Vehicle Performance Test      | Acceptance Tests                      | Operation Verification Test<br>Field Acceptance Testing |
| 6. System Integration Test         | System Integration Test                                  | Not Applicable                        | Start-up Testing  |
| 7. System Pre-Revenue Test         | None Identified  | Not Applicable                        | None Identified   |
| 8. Demonstration Test              | Reliability Demonstration Test                           | Not Applicable                        | None Identified   |

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## 2.0 TEST PROGRAM ORGANIZATION

## 2.0 TEST PROGRAM ORGANIZATION

Participants in the Metro Rail test program include personnel from the SCRTD Offices of Systems Design and Analysis, Construction Management, and Systems and Construction Safety, as well as from two consultant organizations -- the Construction Management Consultant and the Systems Engineering and Analysis Consultant. Exhibit 2-1 depicts the functional relationship of program participants.

The following sections of this chapter describe the roles and responsibilities of test program participants. Because testing is a complex and vitally important element in preparing the Metro Rail system for revenue service, all program participants must work actively, cooperatively, and continuously toward the achievement of program objectives.

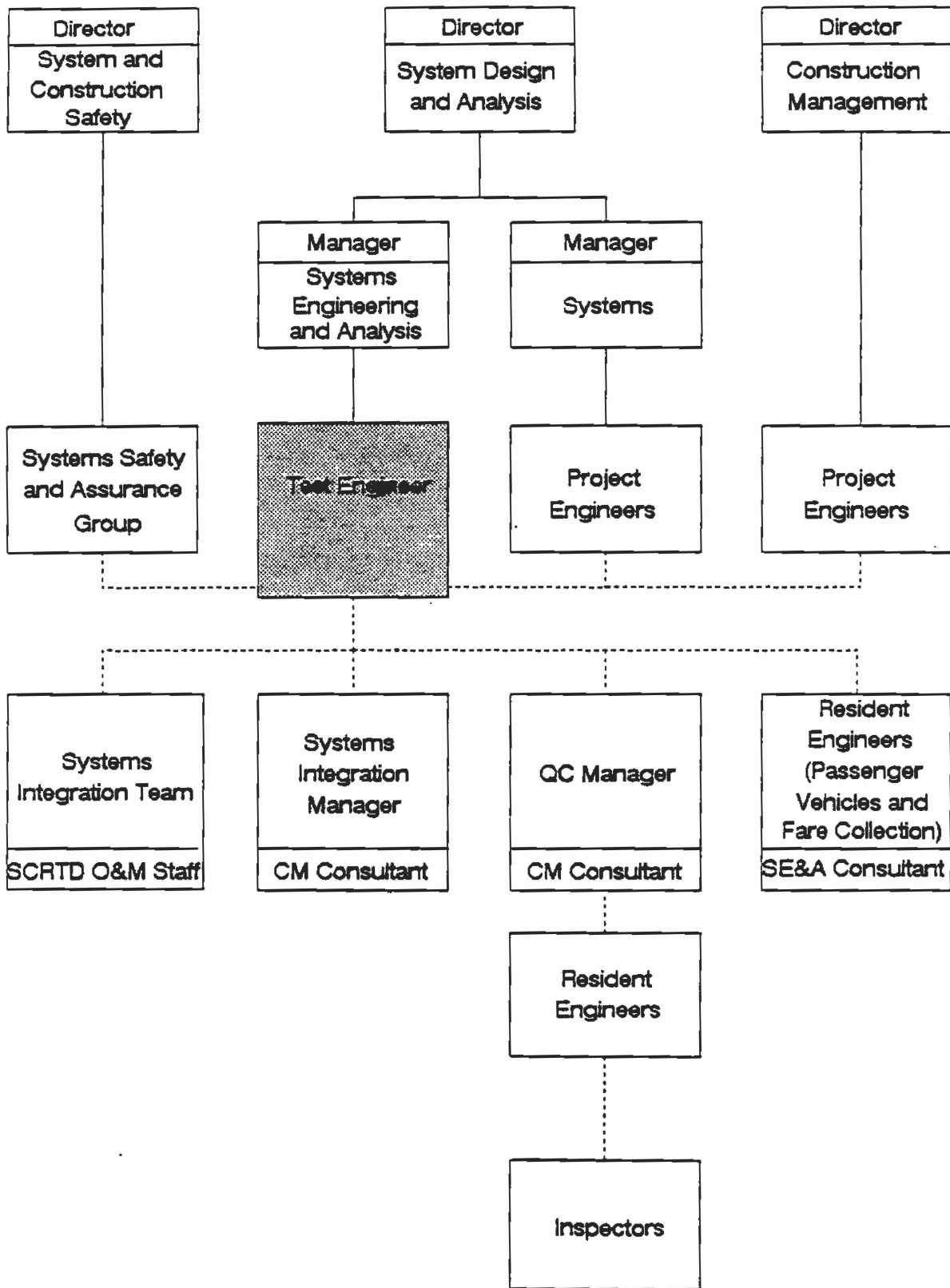
### 2.1 SCRTD

Within SCRTD, personnel responsible for managing Metro Rail test program activities are drawn from the Systems Design and Analysis Office and the Construction Management Office. In addition, personnel from the Office of Systems and Construction Safety participate in the program to ensure that Metro Rail quality assurance and safety standards are maintained. The responsibilities of SCRTD test program participants are described below.

The Director of Systems Design and Analysis is responsible for systems design and systems engineering and analysis, including:

- Management of assigned procurement contracts, including train control, communications, traction power, passenger vehicle, and fare collection equipment procurements
- Overall administration of Metro Rail system testing and activation
- Direction of the Systems Engineering and Analysis (SE&A) Consultant and appropriate direction of the Construction Management (CM) Consultant's assigned procurement activities.

EXHIBIT 2-1  
 Functional Relationships of Test Program Participants



Within the Systems Design and Analysis Office, the Manager of Systems Engineering and Analysis is responsible for directing the efforts of the Test Engineer.

The Director of Construction Management is responsible for Metro Rail construction-related activities and for the procurement of specified systemwide equipment (e.g., escalators and elevators). His responsibilities include:

- Management of assigned procurement and all construction activities
- Review of and recommendation for approval of progress and final payments to contractors
- Overall administration of facility testing
- Appropriate direction of the CM Consultant's efforts.

The Director of Systems and Construction Safety (S&CS) is responsible for the overall management and coordination of system safety and system assurance program activities on the Metro Rail Project prior to the start of revenue operations. With regard to test program activities, the Director is responsible for ensuring that test plans and procedures are reviewed from a system safety, safety certification, quality assurance, reliability, maintainability, and human factors standpoint.

The SCS also provides support for those disciplines by test monitoring and test attendance. SCS provides audit support for safety, systems assurance and test program activities.

The Director of Systems Design and Analysis and the Director of Construction Management designate, for each of their assigned contracts, a Project Engineer to represent the Transit Systems Development Department in overall administration of the contract. The Project Engineers coordinate with consultant Resident Engineers in monitoring contract performance. In addition, the Project Engineers coordinate with the SCRTD's Test Engineer in providing required support to test program activities.

The Test Engineer, who reports to the Manager of Systems Engineering and Analysis, is responsible for coordinating, monitoring, and overseeing Metro Rail testing. During contractual testing, consultant Resident Engineers are responsible for managing test program activities, and the role of the Test Engineer is to monitor and review test activities and results. The Test

Engineer is responsible for monitoring the contractual testing of all systems and systemwide equipment and of designated items of equipment included in facility contracts.<sup>1</sup> The Test Engineer's duties during contractual testing are as follows:

- Review of and comment on test plans for systems and systemwide equipment contracts, and compilation of list of required tests
- Review of and comment on test procedures and test reports for systems and systemwide equipment contracts and designated elements of fixed facility contracts
- Monitoring of contractual test status and schedules
- Witnessing of selected contractual tests. Tests are selected by the Test Engineer based on their relative importance and influence on other contacts.

During non contractual testing, the Test Engineer is responsible for managing all system integration and pre-revenue tests. Examples of the duties to be performed by the Test Engineer include:

- Identification of system integration and pre-revenue test requirements and development of test plan and procedures
- Review and approval of test requests for additional noncontractual tests
- Direction of system integration and pre-revenue test performance
- Submittal of appropriate noncontractual test documents to the Safety Certification Review Team for safety review
- Coordination with SCRTD and consultant staff in scheduling and arranging tests
- Distribution and filing of all noncontractual test reports.

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1 Routine tests of fixed facilities, which are governed by construction industry codes and standard procedures, are covered in Metro Rail quality assurance/control procedures.

The Test Engineer is assisted in these duties by a Systems Integration Team composed of SCRTD operations and maintenance personnel. Members of this team are responsible for participation in the development and review of system integration and pre-revenue test requirements and procedures, and for conducting all such tests under the direction of the Test Engineer.

The Test Engineer is also supported by personnel from the CM and SE&A Consultants, the roles and responsibilities of which are described below.

## 2.2 CONSTRUCTION MANAGEMENT CONSULTANT

The CM Consultant is responsible for the management of all transit facility construction and the procurement of all systems and systemwide equipment, except passenger vehicles and fare collection equipment. The CM Consultant's scope of work includes the enforcement of safety, security, and quality assurance requirements on assigned contracts, and the provision of support for system testing and start-up. The CM Consultant is PDCD, a joint venture formed by the Ralph M. Parsons Company; Dillingham Construction, Inc.; and De Leuw Cather & Company.

The CM Consultant designates a Resident Engineer to manage each assigned contract. The Resident Engineers are supported by inspectors during inspection and test activities. In addition, the CM Consultant designates a Systems Integration Manager to provide system integration and pre-revenue test planning support. Within the CM Consultant's organization, the Quality Control (QC) Manager is responsible for coordinating with Resident Engineers and the Systems Integration Manager to ensure consistency in meeting test program objectives.

The Resident Engineers of the CM Consultant are responsible for conducting the appropriate review and surveillance on their assigned contracts to verify that:

- All required tests are identified and documented
- Tests follow approved and current test procedures
- Test are performed in accordance with the Metro Rail Project schedule.

The Resident Engineers direct the efforts of the inspectors in test performance and witnessing. If the Resident Engineers determine that there are deviations from approved test plans or procedures during test performance, they have contractual authority to enforce appropriate corrective action.

The Systems Integration Manager of the CM Consultant is responsible for providing support for system integration and pre-revenue testing conducted at the Metro Rail site under the guidance of SCRTD's Test Engineer. The Systems Integration Manager assists the Test Engineer in:

- Establishing test requirements
- Developing test procedures and related documentation
- Establishing schedules and documenting the status of tests
- Verifying test prerequisites, such as the availability of support personnel, equipment, and facilities
- Implementing tests
- Witnessing tests
- Coordinating with Resident Engineers to obtain necessary support for test activities
- Ensuring that responsibility for corrective action for test failures is assigned and accepted, and following up to verify correction.

### 2.3 SYSTEMS ENGINEERING AND ANALYSIS CONSULTANT

The SE&A Consultant is responsible for operations and maintenance planning; safety, security, and system assurance support; management information system development; systems design special studies; and system test planning. The SE&A Consultant has been assigned responsibility for managing the procurement of passenger vehicles and supporting the SCRTD in the procurement of fare collection equipment.<sup>2</sup> The SE&A Consultant is Booz, Allen & Hamilton Inc.

- 
- 2 Fare collection equipment is being procured under a joint arrangement with the Los Angeles County Transportation Commission (LACTC). LACTC's consultant, TRANSCAL, has primary responsibility for managing design qualification and production verification tests of the fare collection equipment. SCRTD participates in first article inspections and field service tests of fare collection equipment, and is responsible for installation and acceptance testing of the fare collection equipment for the MOS-1 system.



The SE&A Consultant designates Resident Engineers to manage the passenger vehicle contract and support the SCRTD in management of the fare collection contract. The Resident Engineers are responsible for conducting the appropriate reviews and surveillance to verify that:

- Required tests are identified, performed and documented
- Tests follow approved and current test procedures
- Tests are performed in accordance with the Metro Rail Project schedule.

The Resident Engineers direct the efforts of engineering personnel in test performance and witnessing. If there are deviations from approved test plans or procedures during test performance, Resident Engineers have contractual authority to enforce appropriate corrective action.

The Resident Engineers are responsible for providing support for system integration and pre-revenue testing conducted at the Metro Rail site under the guidance of SCRTD's Test Engineer.

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**3.0 FIXED FACILITY TESTING PROCESS**

### 3.0 FIXED FACILITY TESTING PROCESS

All work performed under Metro Rail fixed facility contracts undergoes inspection and testing to substantiate that contract requirements have been fulfilled.

Contract specifications may identify testing requirements in the areas of:

- Design qualification testing
- Production verification testing
- Construction inspection testing
- Acceptance testing.

The CM Consultant's Resident Engineers are responsible for developing inspection and test plans that identify all required tests for each fixed facility contract. The CM Consultant's QC Manager verifies the adequacy of the plans, and the plans are reviewed and approved by CM Consultant staff and personnel within SCRTD's Office of Construction Management and Office of Systems and Construction Safety. The Resident Engineers are responsible for ensuring that all tests are performed and documented in accordance with approved plans, procedures, and Metro Rail requirements. The process is governed by construction industry codes and standards, and is covered in Metro Rail quality assurance/quality control procedures.<sup>1</sup> The CM Consultant's QC Manager and SCRTD QA/QC personnel monitor compliance by surveillance and audits.

The Test Engineer is responsible for monitoring tests of equipment that is included in facility contracts and has interfaces with Metro Rail systems. The Test Engineer designates the elements to be monitored, and notifies the Resident Engineer and Project Engineer. The Resident Engineer is then responsible for submitting test procedures to the Test Engineer for review and comment; submitting status information to keep the Test Engineer apprised of the test schedule; and transmitting copies of test failure statements and final test reports. The Test

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1 See SCRTD Los Angeles Metro Rail Project, QA/QC Procedures Manual, prepared by PDCD, Rev. 2, July 1988.

Engineer reviews and comments on the test documents and may witness any test on the designated element.

The following facility elements have been designated for monitoring by Test Engineer:

| <u>Element</u> | <u>Contract</u> |
|----------------|-----------------|
| Car Wash       | A130            |
| Vehicle hoists | A112            |
| Truck hoists   | A112            |

**4.0 SYSTEMS AND SYSTEMWIDE EQUIPMENT  
TESTING PROCESS**

#### 4.0 SYSTEMS AND SYSTEMWIDE EQUIPMENT TESTING PROCESS

This chapter describes the testing process for systems and systemwide equipment. The SE&A Consultant's Resident Engineers are responsible for managing testing of passenger vehicles and for supporting testing of fare collection equipment. The CM Consultant's Resident Engineers are responsible for test management of all other systems and systemwide equipment contracts. As illustrated in Exhibit 4-1, the steps in the testing process are:

- Prepare test plans
- Review and approve test plans
- Prepare test procedures
- Review and approve test procedures
- Schedule, perform, and document tests
- Review and evaluate test data
- Repeat tests, if necessary
- Report test completion.

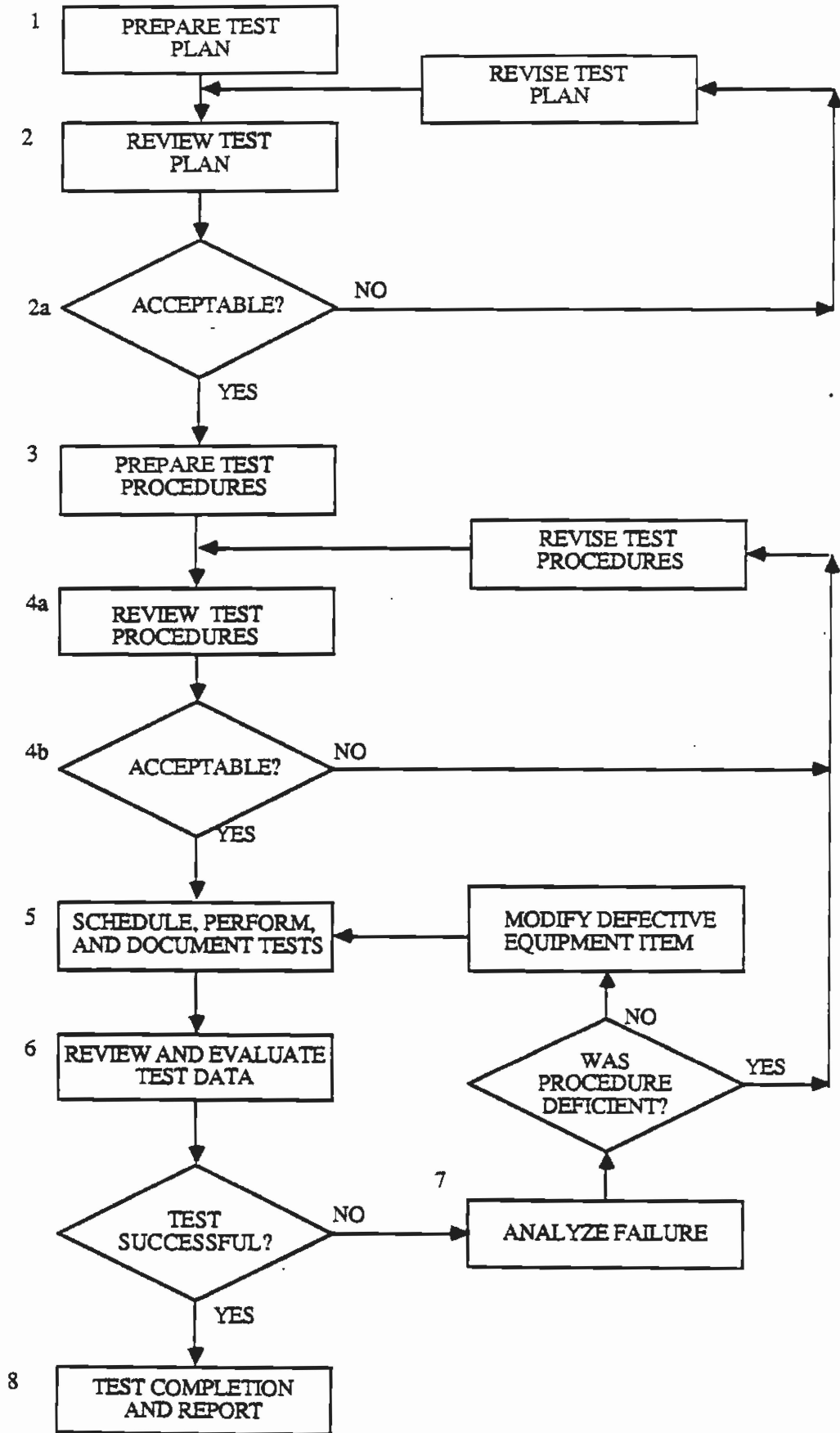
The following sections discuss the steps in the contractual testing process.

##### 4.1 PREPARE TEST PLANS

The first step in the systems and systemwide equipment testing process is to identify test requirements for each Metro Rail element and document those requirements in a test plan. The contract specifications include requirements that the contractor perform certain testing on equipment delivered to the SCRTD. The tests are required to:

- Substantiate design and performance characteristics
- Ensure operational compatibility among all components
- Verify compliance with codes and standards
- Verify that the equipment is acceptable to the SCRTD
- Ensure uniform production quality.

EXHIBIT 4-1  
System Equipment Testing Process



Contract specifications identify testing requirements in the areas of:

- Design qualification testing
- Production verification testing
- Installation verification testing
- Acceptance testing
- Demonstration testing.

The Resident Engineers of the CM Consultant and the SE&A Consultant are responsible for ensuring that all contractually required tests are identified. Each contractor, if required by contract, and/or cognizant Resident Engineer review the contract, identify the required tests, and document them in a test plan for that contract. Test requirements are governed by the contractually required deliverables identified in contract documents.

#### 4.2 REVIEW AND APPROVE TEST PLANS

When the Resident Engineer is satisfied with its quality, the test plan is submitted to the SCRTD Test Engineer, to the Director of Systems and Construction Safety, and to other appropriate Project staff for review and comment.

The Test Engineer assigns a test control number to each test in the plan and uses the plan information to compile a master list of test requirements. (See Chapter 6.0, Exhibit 6-3, for the format for listing required tests.) The test requirements are grouped under the heading of each contract (see Exhibit 4-2). A preliminary list of test requirements for selected system equipment contracts is included in Appendix B.

The Test Engineer returns the test plan and any comments to the Resident Engineer. The Resident Engineer is responsible for reviewing and reconciling all comments. If the test plan is a contractually required submittal, the Resident Engineer notifies the contractor of test plan approval or of the need to revise and resubmit the plan.

#### 4.3 PREPARE TEST PROCEDURES

Once the test plan has been approved, the Resident Engineer notifies the contractor to prepare the contractual test procedures. The formats for contractual procedures are governed by the requirements in the contract specification documents. Each test procedure includes such information as the test objective, success/failure parameters, equipment and instrumentation to be used, test set-up, test methodology, test data evaluation



procedure, sequence of test steps, test duration, and the type of report or data to be issued.

The Resident Engineer coordinates closely with the contractor to ensure that test procedures are delivered in a timely manner for review and comment. To this end, the Resident Engineer monitors the status of test procedure receipt and approval and maintains an up-to-date status log. Copies of the log are provided to the Test Engineer.

#### 4.4 REVIEW AND APPROVE TEST PROCEDURES

Once test procedures have been developed by a contractor, they are submitted to the Resident Engineer and are subjected to the same review and approval cycle described in Section 4.2 for test plans. In addition, the Resident Engineer submits safety-related test procedures to the Safety Certification Review Team for review and recommendation for certification. The SCRTD must ensure that contract documents specify an adequate period of time for review and approval of procedures following their submittal and prior to test performance.

#### 4.5 SCHEDULE, PERFORM, AND DOCUMENT TESTS

Following approval of test procedures, the Resident Engineer directs the contractor to finalize the test schedule and proceed with test performance.

The testing schedule is developed by the contractor and is governed by contractual requirements and milestones. The Resident Engineers are responsible for ensuring that contractors develop appropriate test schedules for contractually required tests. The CM and SE&A Consultants maintain the test schedules for their contracts and are responsible for forwarding copies of the schedules to the Test Engineer. Any changes to the approved test schedules affecting Level III milestones must be subjected to SCRTD's formal change control process.

The Resident Engineers are responsible for ensuring that all contractual tests are performed on schedule and in accordance with approved test procedures. The Resident Engineers designate official test witnesses and have responsibility for enforcing corrective actions if test performance deviates from approved test plans or procedures. The SCRTD Test Engineer may witness selected tests and provide independent verification of test performance and completion.

As described in Section 4.3, each test procedure identifies success/failure parameters, test duration, and the sequence of test steps. As each test step is successfully accomplished, test data sheets are annotated. If

EXHIBIT 4-2  
List of Systems and Systemwide Equipment  
Contracts for MOS-1

| CONTRACT<br>NO. | CONTRACT DESCRIPTION                            |
|-----------------|---|
| A610/A115       | Trackwork Installation/Yard Storage Area Design |
| A612            | Contact Rail                                    |
| A615            | Protective Coverboard                           |
| A616            | Direct Rail Fasteners                           |
| A620            | Automatic Train Control                         |
| A630            | Traction Power Equipment Procurement            |
| A631            | Traction Power Equipment Installation           |
| A640            | Communications                                  |
| A650            | Passenger Vehicles                              |
| A671            | UNIMOG  |
| A672            | Flat Cars                                       |
| A675            | Crane for Flat Car                              |
| A680            | Operational Graphics                            |
| A710/A720       | Escalators/Elevators                            |
| A730            | Shop Equipment (Fixed)                          |
| A732            | Wheel Truing Machine                            |
| A735            | Shop Equipment (Freestanding/Portable)          |
| A740            | Ventilation Equipment                           |
| A745            | Air Handling Equipment                          |
| A760            | Signs and Graphics                              |
| A770            | Trucks and Trailer                              |
| A771            | Sedans, Pickups and Vans                        |
| A772            | Lift Trucks                                     |
| A773            | Vacuums, Hand Trucks, Material Cart             |
| A774            | Scrubber and Cleaner Carts                      |
| A775            | Mobile Emergency and Maintenance Equipment      |
| A780            | Shop and Station Furniture                      |
| A785            | Fire Suppression Equipment                      |
| A790            | First Stores and Consumables                    |
| A795            | Uninterruptible Power Supplies - 50 KVA         |
| A796            | Uninterruptible Power Supplies - 100 KVA        |
| H840            | Fare Collection                                 |

the test is successful, the test data sheets are so annotated. If the test is unsuccessful, the cause of the test failure is analyzed, and the test is repeated. Tests are rescheduled and repeated as described in Section 4.7.

Approved test procedures and associated annotated data sheets are available at the conclusion of each system equipment test for review and determination that the test was successfully completed.

#### 4.6 REVIEW AND EVALUATE TEST DATA

The RE is responsible for reviewing test results and advising the contractor whether or not the test was successful.

#### 4.7 REPEAT TESTS

A repeat test is required when the element being tested does not pass all of the success criteria/parameters identified in the approved test procedures. In the event of a test failure, the cause is analyzed by the contractor and cognizant Resident Engineer.

To successfully complete the test, it may be necessary to modify the element being tested, the test set-up, test procedures, or a combination of these items. Modifications are documented and are subjected to the SCRTD's change control process if they affect a design parameter or specification requirement. If test procedures must be modified, the entire development, review, and approval cycle described in Sections 4.3 and 4.4 must be repeated.

The Resident Engineer is responsible for deciding whether the test needs to be repeated in full, or whether only the part impacting the failed parameter must be repeated. This decision depends on the criticality of the failure.

The contractor or the Resident Engineer prepares a statement describing the extent to which the test needs to be repeated, and the schedule and contractual impacts of repeating the test. A copy of the statement is transmitted to the Test Engineer for review.

#### 4.8 REPORT TEST COMPLETION

A test report, including a copy of approved test procedures and associated annotated data sheets, is prepared upon successful test completion and is maintained by the Resident Engineer. Copies of the report are transmitted to the Test Engineer, the Project Engineer, and the Office of Systems and Construction Safety.

5.0 SYSTEM INTEGRATION AND PRE-REVENUE  
TESTING PROCESS

## 5.0 SYSTEM INTEGRATION AND PRE-REVENUE TESTING PROCESS

This chapter describes the system integration and pre-revenue testing process. The SCRTD's Test Engineer is responsible for test management. The Test Engineer is supported in test planning, test procedure development, and test performance by the CM Consultant's Systems Integration Manager, by operations and maintenance personnel on the Systems Integration Team, and by Resident Engineers and Project Engineers. The Test Engineer also receives support from these personnel in coordinating the availability of facilities, equipment, and personnel during system integration and pre-revenue testing. As illustrated in Exhibit 5-1, the steps in the testing process are:

- Identify test requirements
- Review and approve test requirements
- Prepare test plan and procedures
- Review and approve test plan and procedures
- Schedule, perform, and document tests
- Review and evaluate test data
- Repeat tests, if required
- Report test completion.

The following sections discuss the steps in the system integration and pre-revenue testing process.

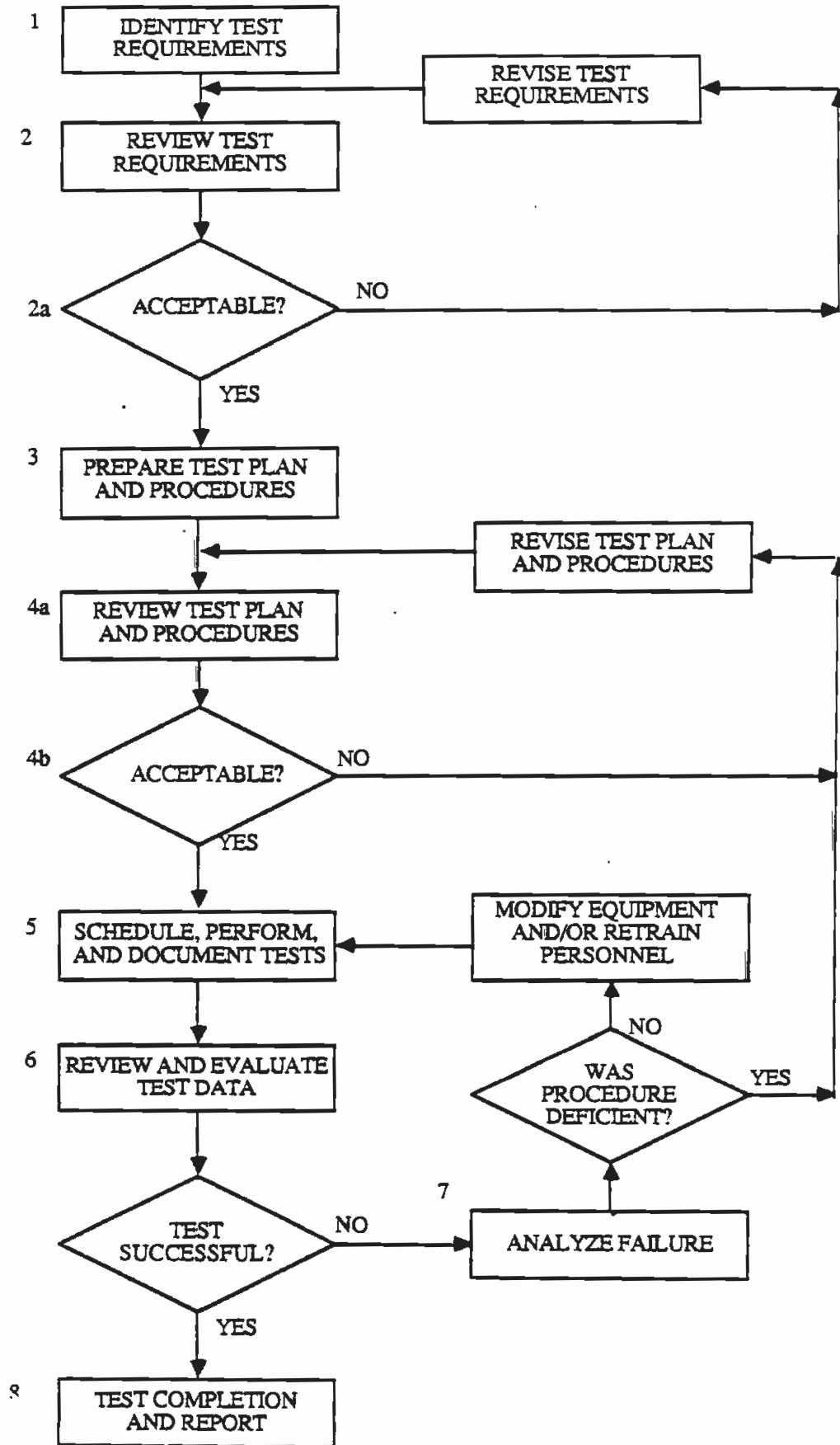
### 5.1 IDENTIFY TEST REQUIREMENTS

In addition to testing that is explicitly defined in contract specification documents, it is necessary to identify tests that are designed to verify:

- Features of a system or subsystem that are not verified by contractual tests
- Compatibility of equipment and/or facilities supplied by more than a single contractor
- Operating procedures developed for use under normal, abnormal, and emergency conditions.

These noncontractual tests are necessary for the successful start of Metro Rail revenue service. Development and performance of noncontractual tests are the responsibility of the SCRTD. The majority of noncontractual tests fall into two categories:

EXHIBIT 5-1  
System Integration and Pre-Revenue Testing Process



- System integration tests
- System pre-revenue tests
  - Normal operations
  - Abnormal operations
  - Emergency situations.

Noncontractual tests are identified and developed by the SCRTD Test Engineer with support from the CM Consultant's Systems Integration Manager and with appropriate input from Resident Engineers, Project Engineers, and the Systems Integration Team.

The Test Engineer documents identified test requirements in a master list. (See Chapter 6.0, Exhibit 6-3, for the format for listing tests.) A preliminary list of system integration and pre-revenue tests is included in Appendix C. The Test Engineer will complete the preliminary list and update it periodically, as contractor submittals providing more detail on equipment design are received.

## 5.2 REVIEW AND APPROVE TEST REQUIREMENTS

The Test Engineer distributes the list of test requirements to test program participants for review and comment. All requirements are submitted to the Office of Systems and Construction Safety for a review of quality assurance and safety-related elements. Following resolution of comments, the Test Engineer submits the list to the Manager of Systems Engineering and the Director of Systems Design and Analysis for review and approval.

Requests to perform any additional tests which are not already included in the master list of noncontractual tests are submitted in writing to the Test Engineer using the Noncontractual Test Request (see Chapter 6.0, Exhibit 6-1). The Test Engineer reviews the Noncontractual Test Request and forwards it to the Manager of Systems Engineering and Analysis and the Director of Systems Design and Analysis for review and approval.

Upon approval, each test is assigned a test control number by the Test Engineer.

## 5.3 PREPARE TEST PLANS AND PROCEDURES

The Test Engineer prepares plans and procedures for approved noncontractual tests. Input is provided by the CM Consultant's Systems Integration Manager, the Systems Integration Team, Resident Engineers, Project Engineers, and personnel from the Office of Systems and Construction Safety.

The test plan defines the purpose of the test; the test location; required equipment, facilities, and personnel; test duration; and a testing sequence. The Test Engineer is responsible for developing the testing sequence for noncontractual tests. The Test Engineer prepares and updates the test sequence with assistance from the Systems Integration Manager, Systems Integration Team, Project Engineers, and Resident Engineers. The purpose of the testing sequence is to:

- Ensure that tests and prerequisite activities are performed in an orderly and logical sequence
- Identify important milestones and those tests or activities that must be monitored closely
- Provide a baseline to develop a schedule for test performance.

Noncontractual test procedures describe test objectives, success/failure parameters, equipment and instrumentation to be used, test set-up, methodology, data evaluation procedures, sequence of test steps, and the type of report or data to be issued. The format for noncontractual test procedures is shown in Exhibit 6-2 of Chapter 6.0.

The Test Engineer maintains a test status log to ensure that the test plan and procedures are distributed in a timely manner for review and comment.

#### 5.4 REVIEW AND APPROVE TEST PLAN AND PROCEDURES

Once the test plan and procedures have been developed, they are subjected to the same review and approval cycle described in Section 5.2. Once approved, the testing sequence included in the test plan provides a basis for developing a schedule for testing.

#### 5.5 SCHEDULE, PERFORM, AND DOCUMENT TESTS

The Test Engineer prepares the system integration and pre-revenue test schedule using information from the approved testing sequence, and the Project Master Schedule, with input from operations and maintenance personnel on the Systems Integration Team and from any outside agencies participating in the tests. Once the test schedule is established, it is distributed to all participating personnel. Any requests for changes to the established schedule must be formally submitted to the Test Engineer. Due to the brisk pace of the system integration and pre-revenue efforts, the Test Engineer has total control of the schedule, and updates it as required with input from participating personnel. The Test



Engineer develops a weekly schedule and distributes it to participating personnel.

The Test Engineer manages the system integration and pre-revenue test program, according to the approved plan, procedures, and schedule. The Test Engineer coordinates with the Systems Integration Team, Resident Engineers, and Project Engineers to schedule the necessary resources. The Test Engineer must ensure that:

- The test can be run safely at the scheduled time and location
- Contractual tests which can or should be run concurrently or in sequence do not conflict with the schedule of system integration and pre-revenue tests
- All cognizant personnel are notified of the system integration and pre-revenue tests.

As described in Section 5.3, each test procedure identifies success/failure parameters, test duration, and the sequence of test steps. As each test step is successfully completed, test data sheets are annotated. If the test is successfully concluded, the test data sheets are so annotated. If the test is unsuccessful, the cause of the test failure is analyzed and the test is repeated. Tests are rescheduled and reaccomplished as described in Section 5.7.

Approved test procedures and associated annotated data sheets are available at the conclusion of each test for review and determination that the test was successfully completed.

#### 5.6 REVIEW AND EVALUATE TEST DATA

Based on the complexity of the elements being tested, the data gathered during the test may require a detailed review. The test data are evaluated by the Test Engineer, with assistance from the Systems Integration Manager and the Systems Integration Team. The Test Engineer determines if each test was successful.

#### 5.7 REPEAT TESTS

A repeat test is required when the elements being tested do not pass all of the success criteria/parameters identified in the approved test procedures. In the event of a test failure, the cause is analyzed by the Test Engineer with the assistance of the Systems Integration Manager, and Systems Integration Team. To successfully complete the test, it may be necessary to modify personnel

training programs, the test set-up, equipment, procedures, or a combination of these items. The Test Engineer decides whether the test needs to be repeated, and what modifications are required for successful test completion. Modifications are documented and are subjected to the SCRTD's change control process if they affect a design parameter or if they have cost or schedule impacts.

#### 5.8 REPORT TEST COMPLETION

Upon successful test completion, a test report, including a copy of approved test procedures and associated annotated data sheets, is maintained by the Test Engineer. The Test Engineer maintains a master record of all noncontractual tests conducted on the Metro Rail Project.

**6.0 TEST PROGRAM ADMINISTRATION**

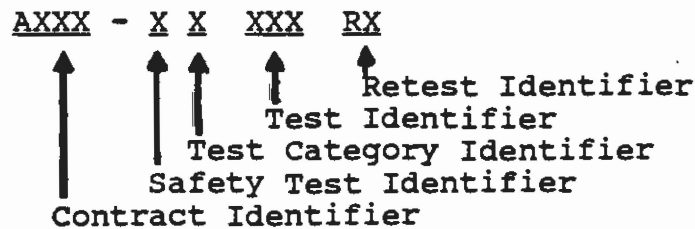
## 6.0 TEST PROGRAM ADMINISTRATION

Test program administrative requirements are described in this chapter. These include:

- Test numbering system
- Contractual test documentation requirements
- System integration and pre-revenue test documentation requirements
- Test program status documentation requirements.

### 6.1 TEST NUMBERING SYSTEM

The Test Engineer assigns control numbers to test requirements to enable their status to be tracked. The test numbering system provides a unique number for each individual test. The test control number is composed of the following identifiers:



Each of these identifiers is briefly described in the following paragraphs.

Contract Identifier (Positions 1, 2, 3, and 4). These are the alphanumeric characters identifying each contract (see Exhibits 3-2 and 4-3). Noncontractual tests are assigned a zero in positions 2, 3, and 4.

Safety Identifier (Position 5). A single alpha character indicates if the test is safety related:

|   |                |
|---|----------------|
| N | Non-safety     |
| S | Safety-related |

Test Category Identifier (Position 6). A single alpha character indicates the category of the test, as follows:

|   |                                |
|---|--------------------------------|
| Q | Design qualification test      |
| V | Production verification test   |
| I | Installation verification test |
| A | Acceptance test                |
| S | System integration test        |
| P | Pre-revenue test               |
| D | Demonstration test             |

Test Identifier (Positions 7, 8, and 9). Within each test category, a three-character numeric entry sequentially identifies each test. The numbers run from 001 to 999.

Retest Identifier (Positions 10 and 11). The letter "R" is entered in position 10, and a single numeric character is entered in position 11. The initial test will carry the number 0. Each subsequent retest will carry the next increasing number.

## 6.2 CONTRACTUAL TEST DOCUMENTATION

The formats of test plans, test procedures, and test results for contractual tests of fixed facilities and system equipment are governed by the requirements specified in contract documents. These formats vary from one contract to another.

## 6.3 SYSTEM INTEGRATION AND PRE-REVENUE TEST DOCUMENTATION

System integration and pre-revenue testing requires the following documents:

- Noncontractual Test Request
- Noncontractual Test Procedure.

The Noncontractual Test Request is used to document required noncontractual tests not previously identified in the master list of system integration and pre-revenue tests. Such a request may be initiated by any Metro Rail Project participant. The Noncontractual Test Request format is shown in Exhibit 6-1. All participants are encouraged to initiate a Noncontractual Test Request whenever they believe a test is needed. The form is designed for ease of completion, so that a proposed test can be evaluated and approved/disapproved before large amounts of staff work are committed. The Test Engineer provides guidance, if necessary, in completing the form. Following approval of the request, the noncontractual test is added to the master list of system integration and pre-revenue test requirements.



# NONCONTRACTUAL TEST REQUEST

Page \_\_\_ of \_\_\_  
Revision \_\_\_  
Date \_\_\_\_\_

PROPOSED TEST TITLE:

TEST PURPOSE:

PREREQUISITE TESTS:

TEST LOCATION:

FACILITIES/EQUIPMENT REQUIRED:

PERSONNEL INVOLVED:

TEST DURATION:

FREQUENCY:

APPROXIMATE COST:

TEST PROCEDURE OUTLINE

REQUESTED BY:

Name: \_\_\_\_\_ Organization: \_\_\_\_\_ Phone: \_\_\_\_\_

APPROVED BY:

Test Engineer \_\_\_\_\_ Date \_\_\_\_\_

Director, Systems Design & Analysis \_\_\_\_\_ Date \_\_\_\_\_

Manager, Systems Engineering & Analysis \_\_\_\_\_ Date \_\_\_\_\_

ASSIGNED TEST NUMBER

#### 6.4 TEST PROGRAM STATUS DOCUMENTATION

Test program status is monitored with the following documents:

- Master lists of test requirements for contractual tests and noncontractual (system integration and pre-revenue) tests
- Test procedures status logs
- Test schedules
- Progress reports.

The Test Engineer is responsible for maintaining master lists of contractual tests to be monitored and noncontractual tests to be managed during the Metro Rail test program. Once test requirements are identified, they are entered on the appropriate master list. The lists are updated periodically to reflect current test requirements.

Test procedures status logs are maintained to track the status of procedures for each test requirement. The Test Engineer is responsible for developing the status log for noncontractual tests. Logs for contractual tests are maintained by Resident Engineers, and copies of logs for systems, systemwide equipment, and designated elements within fixed facility contracts are transmitted to the Test Engineer. The logs are updated periodically to reflect the current status of procedure receipt and approval. A combined format for a master list of tests and a test procedures status log is shown in Exhibit 6-3.

The Test Engineer is responsible for developing test schedules for system integration and pre-revenue tests, and for monitoring contractual test status from schedule information provided by the Resident Engineers. Test schedules are used to plan, monitor, and accomplish test activities. They are updated and corrected as testing proceeds. Any changes that affect Level III milestones are subject to the SCRTD's change control process.

Progress reports are prepared to inform senior managers of the SCRTD and other Metro Rail Project participants of the status of the test program and to enable a timely review of all testing-related issues and resolution of any problems. The Test Engineer prepares progress reports at the end of each calendar month and a final report just prior to the start of revenue service.

Monthly progress reports advise managers of the following information:



# NONCONTRACTUAL TEST PROCEDURE

Test Number

Page \_\_\_ of \_\_\_

Revision \_\_\_

Date \_\_\_\_\_

TEST TITLE:

OBJECTIVE:

SUCCESS/FAILURE CRITERIA: *(Use additional pages as necessary)*

TEST METHODOLOGY/SEQUENCE OF STEPS: *(Use additional pages as necessary)*

TEST EQUIPMENT/INSTRUMENTATION: *(Use additional pages as necessary)*

TEST DURATION:

DATA EVALUATION PROCEDURE: *(Use additional pages as necessary)*

TEST REPORTING DOCUMENTATION: *(Use additional pages as necessary)*

PREPARED BY: Name: \_\_\_\_\_ Organization: \_\_\_\_\_

APPROVED BY:

\_\_\_\_\_  
Test Engineer Date

\_\_\_\_\_  
Director, Systems Design & Analysis Date

\_\_\_\_\_  
Manager, Systems Engineering and Analysis Date

\_\_\_\_\_  
Chairman, Safety Certification Review Team Date



EXHIBIT 6-3

Master List of Metro Rail Test Requirements

05/90  
Revision 2

6-6

Contract No: \_\_\_\_\_ Master List of Metro Rail Tests Sheet \_\_\_ of \_\_\_  
 Contract: \_\_\_\_\_ Revision \_\_\_  
 Prepared By : \_\_\_\_\_ Approved By: \_\_\_\_\_ Date \_\_\_\_\_

| Item | Test Number | Test Title   | Reference Specification | Test Frequency | Safety Test yes/no | Test Group | Scheduled Completion Date | Current Status |
|------|-------------|--|-------------------------|----------------|--------------------|------------|---------------------------|----------------|
| 1    | A000AD000R0 | Operation of Local Train Control and Traction Power Panels | 12.10.1.2               | random test    | NO                 | SEAC       | 12-12-88                  | on hold        |

- Tests completed during the report month
- Test requirements identified
- Tests expected to be completed the following month
- Significant problems encountered and progress made
- Other appropriate information.

Monthly reports are prepared by the middle of the month following the report month.

The final report on the test program is prepared immediately prior to the beginning of revenue service to describe the overall status of testing at that time. The final report includes such information as:

- Summary of the test program's history, achievements, and problems
- Description of the current status of the test program, including a summary of remaining test requirements and operational restrictions
- List of recommended actions that should be taken to complete the test program.