

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT

HAZARD RESOLUTION PROGRAM

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1.0 INTRODUCTION

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The hazard resolution program establishes the requirements to develop, implement, and manage the Southern California Rapid Transit District's (SCRTD) Critical/Catastrophic Items List (CCIL). This document addresses both the general process and documentation requirements for hazard resolution.

1.1 PURPOSE

The primary goal of the Metro Rail system is to provide safe, reliable, and cost-effective transportation. Toward this end, the SCRTD has established a comprehensive safety and systems assurance program. A key element of the program is a systematic and visible approach to resolving hazards which are identified during system development.

The process of hazard resolution revolves around a centralized CCIL, maintained in the Safety and Systems Assurance (S&SA) Section of the Systems Design and Analysis (SDA) Office. The Supervisor of S&SA administers the CCIL. The CCIL serves as a record of resolved and unresolved hazards. The use of the CCIL provides Metro Rail managers with the capability to meet the following objectives:

- Assess the status of hazard analyses submitted by contractors
- Identify uncontrolled hazards in the Metro Rail
- Catalogue hazards as they are identified
- Identify and recommend hazard resolution actions
- Designate responsibility for hazard resolution actions
- Monitor completion of hazard resolution actions
- Ensure that all identified critical and catastrophic hazards are adequately resolved prior to revenue service
- Document the hazard resolution process.

By accomplishing these objectives in a systematic way, the SCRTD assures itself that all possible actions are being taken to achieve the highest practicable level of safety for Metro Rail patrons, employees, emergency service personnel, the general public, and SCRTD equipment.

1.2 SCOPE

The SCRTD's CCIL is designed to facilitate the cataloging, evaluation, and resolution of hazards. The CCIL catalogues identified hazards:

- Internal to one system, e.g., vehicles, automatic train control, communications
- Created by the interfacing and/or integration of systems.
- Which arise due to the integration of people with the operation or maintenance of equipment and facilities.

Throughout the construction, procurement, testing, activation, and operation of the Metro Rail system, hazards are continually identified and resolved. As hazards are identified by SCRTD personnel, contractors, and consultants, the CCIL is expanded and updated. Because safety must be considered in virtually all development activities, SCRTD managers must know the current resolution status of hazards. This information is provided by periodically publishing the CCIL, which describes the resolution status of each identified hazard.

While this procedure is focused on resolving hazards that become apparent during Metro Rail design, construction, procurement, and testing, the same approach will be used during revenue service. When a hazard is identified during operations or maintenance, it will be reported to the responsible safety manager, entered into the CCIL, and tracked to resolution.

1.3 RELATIONSHIP TO SAFETY CERTIFICATION

A significant aspect of the CCIL is its role in the SCRTD's safety certification program. The safety certification program was developed and implemented to ensure that all Metro Rail facilities, equipment, procedures, and training programs are systematically reviewed for compliance

with safety requirements and certified by the SCRTD on a timely basis prior to the start of revenue service.¹

An effective hazard resolution program and a comprehensive and current CCIL are important components of the safety certification program. Management utilization of the CCIL provides visibility that critical and catastrophic hazards not completely resolved by system design specifications are identified and adequately resolved prior to revenue service.

1 Safety Certification Plan, May 1986, page 1-2

2.0 HAZARD RESOLUTION PROCESS

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Chapter 2.0 describes the hazard resolution process. The discussion is keyed to Exhibit 2-1, Metro Rail Hazard Resolution Process. The four steps of the process are:

- Identify and catalogue Metro Rail hazards
- Evaluate the effect(s) of each hazard
- Develop and recommend resolutions for each hazard
- Monitor the incorporation of resolutions.

2.1 STEP I - IDENTIFY AND CATALOGUE METRO RAIL HAZARDS

During Step I, identified hazards to facilities, equipment, employees, and patrons are identified and catalogued. The identified hazards are derived from four primary sources:

- Safety and reliability analyses submitted by contractors
- Information from other rail rapid transit properties
- Results of audits, inspections, and system testing
- Observations and experience of project personnel, such as Resident Engineers.

2.1.1 Safety and Reliability Analyses Submitted by Contractors

To ensure the successful and comprehensive completion of the CCIL, all contractually required analyses must be delivered on a timely basis in an acceptable quality and format.¹ Exhibit 2-2, Metro Rail Safety and Reliability Analyses, lists the safety and reliability analyses required by contract. The analyses include:

- Preliminary Hazard Analyses

¹ Requirements for safety and reliability analyses are detailed in "Guidelines for the Preparation of Safety and System Assurance Analyses," SCRTD 5-001, August, 1985.

EXHIBIT 2-1
 Southern California Rapid Transit District
 Metro Rail Hazard Resolution Process

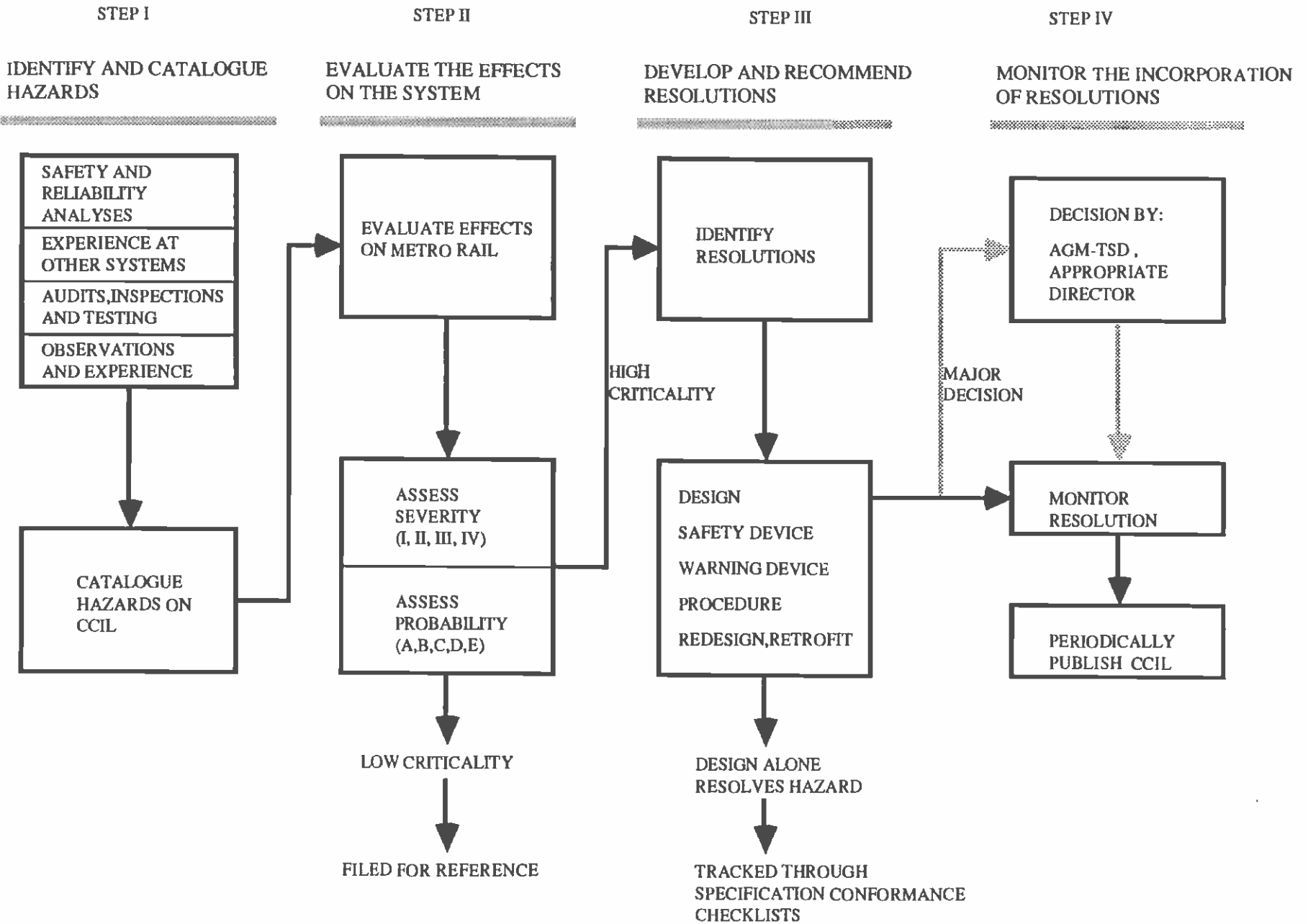


EXHIBIT 2-2
Metro Rail Safety and Reliability Analyses

ANALYSIS	RESPONSIBILITY	SUBMITTAL SCHEDULE
<u>Preliminary Hazard Analyses</u>		
• Preliminary engineering issue	Booz, Allen	March 1984
• Final design update	Booz, Allen	September 1985
• Construction/procurement update	Booz, Allen	TBD ¹
<u>Subsystem Hazard Analyses</u>		
• Final design issue	MRTC	TBD
• Construction/procurement update	MRTC	TBD
• Vehicle	Vehicle contractor	180 days after NTP ² , w/quarterly updates
• ATC	ATC contractor	180 days after NTP, w/quarterly updates
• Fare collection	Fare collection contractor	180 days after NTP, w/quarterly updates
<u>Interface Hazard Analyses</u>		
• Final design issue	MRTC	TBD
• Construction/procurement update	MRTC	TBD
• Vehicle	Vehicle contractor	180 days after NTP, w/quarterly updates
• ATC	ATC contractor	180 days after NTP, w/quarterly updates
• Fare collection	Fare collection contractor	180 days after NTP, w/quarterly updates
<u>Operating Hazard Analyses</u>		
• Construction/procurement issue	Booz, Allen	TBD
• Operations update	Booz, Allen	TBD
• Vehicle	Vehicle contractor	180 days after NTP, w/quarterly updates
• ATC	ATC contractor	180 days after NTP, w/quarterly updates
• Communications	Communication contractor	180 days after NTP, w/quarterly updates
• Fare Collection	Fare collection contractor	180 days after NTP, w/quarterly updates
<u>Critical/Catastrophic Items List</u>		
• Master SCRTD list	S&SA Section	Continually updated
• Vehicle	Vehicle contractor	180 days after NTP, w/quarterly updates
• ATC	ATC contractor	180 days after NTP, w/quarterly updates
• Communications	Communications contractor	180 days after NTP, w/quarterly updates
• Fare collection	Fare collection contractor	180 days after NTP, w/quarterly updates
<u>Reliability Block Diagrams</u>		
• ATC	ATC contractor	180 days after NTP, w/quarterly updates
• Communications	Communications contractor	180 days after NTP, w/quarterly updates
• Fare collection	Fare collection contractor	180 days after NTP, w/quarterly updates
<u>Single Point Failure Summaries</u>		
• Systemwide	MRTC	TBD
• ATC	ATC contractor	180 days after NTP, w/quarterly updates
• Communications	Communications contractor	180 days after NTP, w/quarterly updates
• Fare collection	Fare collection contractor	180 days after NTP, w/quarterly updates
<u>FMECA</u>		
• ATC	ATC contractor	180 days after NTP, w/quarterly updates
• Communications	Communications contractor	180 days after NTP, w/quarterly updates
• Fare collection	Fare collection contractor	180 days after NTP, w/quarterly updates

1 TBD = To Be Determined
2 NTP = Notice to Proceed

- Subsystem Hazard Analyses
- Interface Hazard Analyses
- Operating Hazard Analyses
- Critical/Catastrophic Items List
- Reliability Block Diagrams
- Single Point Failure Summaries
- Failure Mode, Effects and Criticality Analysis (FMECA).

After the safety and reliability analyses are received from the contractors, they are distributed for review and comment to cognizant program participants. At a minimum, each contractor's reliability or safety submittals are reviewed by:

- Systems Design and Analysis Office
 - Systems Engineering
 - Subsystem Design
 - Safety and Systems Assurance.
- Responsible consultant organizations
 - Construction Management consultant
 - General Consultant
 - Systems Engineering and Analysis consultant.
- Relevant committees
 - Fire/Life Safety Committee
 - Security Subcommittee
 - Operations and Maintenance Committee.

The S&SA Section, with appropriate consultant support, collects and compiles all comments for transmittal back to the contractor for resolution. The reviews are designed to ensure that:

- Contractor-recommended resolutions are acceptable to the SCRTD
- The analyses are complete and accurate and comply with requirements in "Guidelines for the Preparation of Safety and System Assurance Analyses," SCRTD 5-001.

Initial editions of contractor analyses are submitted in advance of their preliminary design reviews and resubmitted quarterly until the designs are complete and all resolutions are accepted by the SCRTD.

Under the requirements of "SCRTD 5-001," contractors must submit their hazard analyses in a standardized format. In addition, when a hazard is reported to the S&SA Supervisor, he initiates a hazard analysis form in the applicable format. The hazard forms are contained in "SCRTD 5-001."

2.1.2 Information From Other Rapid Rail Properties

The S&SA Section also initiates a hazard form for hazards in the Metro Rail system which are similar to those at other rapid transit properties. These hazards are identified based on:

- Efforts similar to the Metro Rail CCIL at other transit properties
- Historical evidence or safety studies of existing operations at other properties, where applicable.

2.1.3 Results of Audits, Inspections, and System Testing

During inspections and safety audits, as well as during test operations and system integration, hazards may become apparent that need to be controlled or eliminated prior to revenue service. The SCRTD and consultant engineers have the responsibility to bring any known hazard to the attention of the S&SA Supervisor, who is then responsible for initiating a hazard form for the hazard.

2.1.4 Observations and Experience of Project Personnel

Any SCRTD employee or contractor who believes an uncontrolled hazard exists within the Metro Rail system has the responsibility of notifying the S&SA Supervisor. The S&SA Supervisor will then issue a hazard form to document the hazard, to identify a resolution, and to track its implementation.

2.2 STEP II - EVALUATE HAZARD EFFECTS AND CRITICALITY

Each hazard identified affects safety on the Metro Rail system. Hazards may result in accidents ranging from minor property damage to personal injury and death. Some hazards occur occasionally while others occur almost continuously. To cost-effectively control hazards, they need to be systematically evaluated with respect to their potential severity and probability of occurrence.

Severity categories are defined in SCRTD 5-001. Hazard severity categories are defined to provide a qualitative measure of the worst potential consequences resulting from personnel error; environmental conditions; design inadequacies; procedural deficiencies; or system, subsystem, or component failure or malfunction, as follows:

- Category I - Catastrophic. A hazard that may cause death or system loss.
- Category II - Critical. A hazard that may cause severe injury, severe occupational illness, or major system damage.
- Category III - Marginal. A hazard that may cause a minor injury, minor occupational illness, or minor system damage.
- Category IV - Negligible. A hazard that will not result in injury, occupational illness, or system damage.

The assessment of the hazard should also include its probability of occurrence. Assigning a quantitative probability to a potential hazard is generally not possible early in the design or planning process. However, a qualitative hazard probability can be derived from research, analysis, and evaluation of historical safety data from similar systems.

The qualitative probability of occurrence which is to be assigned in conjunction with the severity categories is described in Exhibit 2-3, Probability of Occurrence Categories.

Hazard analyses submitted by contractors will include an assessment of both the severity of a resultant accident and the probability of occurrence. During the review process, the SCRTD may decide to change the contractor's assessment of the hazard's severity or probability.

For hazards identified by employees or consultant personnel during system audits, inspections, tests, or operations, the S&SA Supervisor will assign an appropriate severity and probability category.

Not all identified hazards will need to be resolved. Hazards of low severity and low probability of occurrence will not require resolution action. Exhibit 2-4, Hazard Resolution Requirements, is used to identify the combinations of severity and probability that require hazard resolution actions. The combinations identified with a "yes" require that the hazard be placed in the active CCIL

EXHIBIT 2-3
Probability of Occurrence Categories

PROBABILITY OF OCCURRENCE RANKING	DESCRIPTIVE WORD	FREQUENCY OF OCCURRENCE	
		SPECIFIC INDIVIDUAL ITEM	FLEET OR INVENTORY
A	Frequent	Likely to occur frequently	Continuously experienced
B	Reasonably probable	Will occur several times in life of item	Will occur frequently
C	Occasional	Likely to occur sometime in life of an item	Will occur several times
D	Remote	So unlikely, it can be assumed that this hazard will not be experienced	Unlikely to occur but possible
E	Extremely Improbable	Probability of occurrence cannot be distinguished from zero	So unlikely, it can be assumed that this hazard will not be experienced

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EXHIBIT 2-4
Hazard Resolution Requirements

SEVERITY OF POTENTIAL ACCIDENT

<i>HIGH</i>	I	II	III	IV	<i>LOW</i>
A	YES	YES	YES	NO	
B	YES	YES	YES	NO	
C	YES	YES	NO	NO	
D	YES	YES	NO	NO	
E	NO	NO	NO	NO	

LOW

PROBABILITY OF OCCURRENCE

and resolved. The combinations identified with a "no" are filed for reference and are not evaluated further.

2.3 STEP III - DEVELOP AND RECOMMEND RESOLUTIONS

All hazards catalogued during Step I and not eliminated from further consideration because of their low criticality in the evaluation process during Step II must be resolved. In Step III, specific hazard resolution actions are identified. These resolutions may take four forms:

- Design for Minimum Hazard. The major effort throughout the system development process should be to ensure inherent safety through the selection of appropriate design features.
- Safety Devices. Known hazards that cannot be eliminated through design selection should be controlled at an acceptable level through the use of appropriate safety devices.
- Warning Devices. Where it is not possible to preclude the existence of an identified hazard, devices should be employed for the timely detection of the condition and the generation of an adequate warning signal.
- Special Procedures. Where it is not possible to reduce the magnitude of a hazard through design or the use of safety and warning devices, special procedures, training, and/or precautionary instructions should be developed.

If the design proves inadequate and the hazards cannot be eliminated or controlled by safety devices, warning devices, or procedures and training, then redesign or retrofit of the system may become necessary.

The CCIL describes all resolution actions for each hazard regardless of their form or state of completion. If a resolution action requires changes to the design of the system, the resolution is considered complete when the changes are incorporated into the appropriate specification documents. Provisions of the safety certification program then ensure that such changes are implemented.

2.4 STEP IV - MONITOR THE INCORPORATION OF RESOLUTIONS

The purpose of Step IV is to identify those resolution actions which have or have not been incorporated. The CCIL indicates which resolutions are complete and which are not. For resolutions which are complete, the CCIL identifies the

contract specification, design criteria or calculations, the local code, the safety or warning device, or the procedures that resolve the hazard.

Evidence of hazard resolution is reviewed by the Safety Certification Review Team, under the direction of the SDA Safety and Systems Assurance Section. The resolution review process has the following objectives:

- To ensure that the resolution of a hazard in one system does not create a new hazard in another system
- To ensure that hazards involving the interface between or the composite of two or more facilities or systems have been resolved
- To ensure that all program participants are providing required analyses in a timely manner, and to point out to the SCRTD management where delinquent receipt is delaying hazard resolution progress
- To identify areas where hazard resolution may require a change in the design of the system or the development of special procedures.

During its periodic meetings, the Safety Certification Review Team evaluates the status of all unresolved critical/catastrophic hazards. This team, with the assistance of appropriate Metro Rail personnel, reviews identified hazards, evaluates their effects on the system and their criticality, proposes resolutions, and monitors the status of resolution actions.

The critical or catastrophic hazards that cannot be resolved by the SDA Director or the S&SA Supervisor are presented, along with the recommendations of the Safety Certification Review Team, to the Assistant General Manager, Transit Systems Development, and the Assistant General Manager, Operations, for decisions. Resolution instructions are distributed to involved personnel by the S&SA Supervisor. The Safety Certification Review Team then monitors the incorporation of the resolutions and reports the progress to SCRTD management.

Unresolved hazards are maintained on a CCIL sheet, identical to those used by contractors (Exhibit 2-5). The CCIL is published periodically and revised as hazards are resolved.

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EXHIBIT 5
Typical CCIL Form



METRO RAIL PROJECT
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
Critical/Catastrophic Items List

Contract: _____ No: _____
Date: _____
Revision: _____
Page _____ of _____
Prepared by: _____

Hazard Number	Hazard Description	Hazard Category	Potential Accident/Injury	Prevention Measures	Resolutions Adopted