SECTION 14 – SYSTEM SAFETY AND SYSTEM SECURITY

SECTION 14 – SYSTEM SAFETY AND SYSTEM SECURITY

14.1.0 GENERAL

The LRT design shall address system elements according to the requirements of the applicable standards listed. Should any standard or requirement conflict, the most stringent standard shall apply. In accordance with RTD's System Safety and System Security Program Plan, RTD's Executive Safety and Security Committee must review and accept all LRT design and any subsequent changes or modifications. The RTD Project Manager and/or Design Engineer shall present design reviews to the RTD Executive Safety and Security Committee for acceptance as design milestones are reached. Additionally, any deviation from RTD's design criteria must be approved by RTD's Executive Safety and Security Committee.

Standards, specifications, regulations, design handbooks, safety design checklists and other sources of design guidance will be reviewed for pertinent safety design requirements applicable to the system. The design shall establish criteria derived from all applicable information. Some general system safety design requirements are:

- Identified hazards shall be eliminated or associated risk shall be reduced through design, including material selection or substitution. When potentially hazardous materials must be used, such materials selected shall pose the least risk throughout the life cycle of the system.
- Hazardous substances, components and operations shall be isolated from other activities, areas, personnel and incompatible materials.
- Equipment shall be located so that access during operations, servicing, maintenance, repair or adjustment minimizes personnel exposure to hazards (e.g. hazardous chemicals, high voltage, electromagnetic radiation, cutting edges or sharp points).
- Risk resulting from excessive environmental conditions (e.g. temperature, pressure, noise, toxicity, acceleration and vibration) shall be minimized.
- Risk resulting from human error in system operation and support shall be minimized as part of the design effort.
- In the case of risk from hazards that cannot be eliminated, alternatives that will minimize such risk shall be considered. (e.g. interlocks, redundancy, fail safe design, system protection, fire suppression and other protective measures, such as clothing, equipment, devices and procedures.)
- Power sources, controls and critical components of redundant subsystems shall be protected by physical separation or shielding, or by other suitable methods mutually agreeable to the design and RTD.
- When alternate design approaches cannot eliminate the hazard, safety and warning devices and warning and cautionary notes shall be provided in assembly, operations, maintenance and repair instructions, and distinctive markings shall be provided on hazardous components, equipment and facilities to ensure personnel and equipment protection. These shall be standardized in accordance with

commonly accepted commercial practice or, if none exists, normal procedures. Where no such common practice exists, the design shall propose the method or methods to be used to RTD for review and approval. The design shall provide all warnings, cautions and distinctive markings proposed to RTD for review and comment.

The severity of personnel injury or damage to equipment as a result of a mishap shall be minimized.

Software controlled or monitored functions shall ensure minimal initiation of hazardous events or mishaps.

Design criteria shall not include inadequate or overly restrictive requirements regarding safety. Where there is appropriate supporting information, recommend new safety criteria as required.

14.2.0 APPLICABLE STANDARDS

The design shall be in accordance with the following standards. Should the standards requirements conflict, the most stringent requirement shall apply.

TABLE 14-A – STANDARDS

Document	Title	Required (R) Guidance (G)
49 CFR 659	State Safety Oversight of Fixed Rail Guideways	R
CCR 723-14	Standards for Rail Fixed Guideway Systems	R
49 CFR 51, 201, 202, 205, 207, 209, 211, 213, 241	Federal Railroad Administration	G
National Fire Protection Association (NFPA) 130	Standard for Fixed Guideway Transit Systems	R
NFPA 101	Life Safety Code	R
Latest Revision	Americans with Disabilities Act	R
	Uniform Fire Code	R
	Local jurisdiction fire and building codes	R
Latest Revision	RTD's System Safety and System Security Program Plan	R
Latest Revision	RTD Safety Certification Program	R

Document	Title	Required (R) Guidance (G)
Latest Revision	RTD's LRT Design Criteria Manual	R
MIL-STD-882D	Military Standard 882D	G
NFPA 70	National Electric Safety Code	R
U.S. Department of Transportation (DOT), FTA, latest revision	Transit Threat Level Response Recommendation	G
U.S. Department of Transportation (DOT), FTA, November 2002	Handbook for Transit Safety and Security Certification	R
U.S. Department of Transportation (DOT), January 2000	Hazard Analysis Guidelines for Transit Projects	G
29CFR1910	Federal Occupational Safety and Health Standards (General Industry)	R
29CFR1926	Federal Occupational Safety and Health Standards (Construction Industry)	R
Transit Cooperative Research Program (TCRP) Report 17	Integration of Light Rail transit into City Streets	G
MIL-STD-1472D	Human Engineering Design Criteria for Military Systems, Equipment and Facilities	G
U.S. Department of Transportation (DOT), November 2004	Transit Security Design Considerations	R

14.3.0 DEFINITION OF SAFETY CONDITIONS

14.3.1 Unacceptable Conditions

The following safety critical conditions are considered unacceptable. Positive action and implementation verification is required to reduce the risk to an acceptable level.

- Single component failure, common mode failure, human error or design features, which could cause a mishap of catastrophic or critical severity.

- Dual independent component failures, dual human errors or a combination of a component failure and a human error involving safety critical command and control functions, which could cause a mishap of catastrophic or critical severity.
- Generation of hazardous ionizing/non-ionizing radiation or energy when no provisions have been made to protect personnel or sensitive subsystems from damage or adverse effects.
- Packaging or handling procedures and characteristics which could cause a mishap for which no controls have been provided to protect personnel or sensitive equipment.
- Hazard level categories that are specified as unacceptable.

Unacceptable hazardous conditions will be identified according to the hazard resolution matrix. Hazard classification at this level is a formal process for determining which hazards are acceptable, acceptable with review by management staff, undesirable or unacceptable. Hazard severity is a subjective measure of the worst credible mishap resulting from personnel error, environmental conditions, design inadequacies and/or procedural efficiencies for system, subsystem or component failure or malfunction. Hazard probability is defined as the probability that a specific hazard will occur during the planned life expectancy of the system element, subsystem or component. The categories of hazard severity, hazard probability and their definitions follow:

Hazard Severity Definition

- Catastrophic – Death or system loss
- Critical – Severe injury, severe occupational illness or major system damage
- Marginal – Minor injury, minor occupational illness or minor system damage
- Negligible – Less then minor injury, occupational illness or system damage

Hazard Probability Definition

- Frequent – Likely to occur frequently; continuously experienced
- Probable – Will occur several times in the life of an item; will occur frequently in fleet/inventory
- Occasional – Likely to occur sometime in the life of an item; will occur several times in fleet inventory
- Remote – Unlikely but possible to occur in the life of an item; unlikely but can be expected to occur in fleet/inventory

- Improbable – So unlikely, it can be assumed occurrence may not be experienced; unlikely to occur, but possible in fleet

The following table (of the RTD System Safety and System Security Program Plan) demonstrates the relationship between severity and probability to define an unacceptable hazardous condition.

TABLE 14-B – HAZARD RESOLUTION MATRIX

	Catastrophic (I)	Critical (II)	Marginal (III)	Negligible (IV)
Frequent (A)	Unacceptable	Unacceptable	Unacceptable	Acceptable/ WR
Probable (B)	Unacceptable	Unacceptable	Undesirable	Acceptable/ WR
Occasional (C)	Unacceptable	Undesirable	Undesirable	Acceptable
Remote (D)	Undesirable	Undesirable	Acceptable/ WR	Acceptable
Improbable (E)	Acceptable/ WR	Acceptable/ WR	Acceptable/ WR	Acceptable

Acceptable/WR means acceptable with management review.

14.3.2 Acceptable Conditions

The following approaches are considered acceptable for correcting unacceptable conditions and will require no further analysis once controlling actions are implemented and verified.

- For non-safety critical command and control functions; a system design that requires two or more independent human errors, or that requires two or more independent failures, or a combination of independent failure and human error.
- For safety critical command and control functions; a system design that requires at least three independent failures, or three human errors or a combination of three independent failures and human errors.
- System designs which positively prevent errors in assembly, installation or connections which could result in a mishap.
- System designs, which positively prevent damage propagation from one component to another or prevent sufficient energy propagation to cause a mishap.
- System design limitations on operation, interaction or sequencing that

preclude occurrence of a mishap.

- System designs that provide an approved safety factor or fixed design allowance which limit, to an acceptable level, possibilities of structural failure or release of energy sufficient to cause a mishap.
- System designs that control energy build-up which could potentially cause a mishap (fuses, relief valves, electrical explosion proofing, etc.).
- System designs in which component failure can be temporarily tolerated because of residual strength or alternate operating paths so that operations can continue with a reduced but acceptable safety margin.
- System designs that positively alert the controlling personnel to a hazardous situation for which the capability for operator reaction has been provided.
- System designs which limit/control the use of hazardous materials.

14.4.0 HAZARD IDENTIFICATION, ANALYSIS, AND RESOLUTION

The Design Engineer shall develop and implement a Hazard Identification, Analysis, and Resolution process in accordance with the minimum criteria outlined in this section and 49 CFR 659. The purpose of hazard analysis and resolution during the design and engineering phase of the project is several fold: to minimize or eliminate potential hazards; support early hazard identification; integrate safe operating procedures into system design and service; and provide for constant and continuous safety evaluation and assessment.

The Design Engineer shall use the requirements established in the following documents:

- 49 CFR 659 using the APTA Guideline's Hazard Resolution Matrix (American Public Transit Association, Manual for the Development of Rail Transit System Safety Program Plans, Checklist Number 7);
- Military Standard 882D (MIL-STD-882D); and
- Hazard Analysis Guidelines for Transit Projects, January 2000, U.S. Department of Transportation.

Subsequent to performing the initial hazard analysis, the Design Engineer shall recommend resolution or mitigation factors to reduce the classification of identified hazards and reclassify identified hazards considering the recommended resolution.

In applying resolution to identified hazards, the Design Engineer shall utilize the following system safety precedence:

- design for minimum risk;
- incorporate safety devices;
- provide warning devices; and
- Develop procedures and training.

14.5.0 PRELIMINARY HAZARD ANALYSIS (PHA)

The Preliminary Hazard Analysis (PHA) activity is the engineering function, which is performed to identify the hazards and their preliminary casual factors of the system in development. The hazards are formally documented to include information regarding the description of the hazard, casual factors, the effects of the hazard, and preliminary design considerations for hazard control by mitigating each cause. Performing the analysis includes assessing hazardous components, safety-related interfaces between subsystems, environmental constraints, operation, test and support activities, emergency procedures, test and support facilities, and safety-related equipment and safeguards.

The analysis also provides an initial assessment of hazard severity and probability of occurrence. The probability assessment at this point is usually subjective and qualitative. To support the tasks and activities of a safety effort, the "causes" of the root hazard must be assessed and analyzed. These causes should be separated in four separate categories:

- Hardware initiated causes
- Software initiated causes
- Human error initiated causes
- Human error causes that were influenced by software input to the user/operator

The Design Engineer shall conduct a PHA process for the project design. PHA work shall begin upon project initiation and continue throughout the project. The Design Engineer shall provide PHA progress reports according to a mutually agreeable schedule. The Design Engineer shall provide a draft and final PHA report on the preliminary engineering. Subsequent to the preliminary engineering, the Design Engineer shall conduct a draft and final PHA report on the final design.

The PHA document itself is a living document, which must be revised and updated as the system design and development progresses. It becomes the input document and information for all other hazard analyses performed on the system.

14.6.0 SAFETY CERTIFICATION

Safety certification is the process of verifying that system elements comply with a formal list of safety requirements. The requirements are defined by design criteria, contract requirements, applicable codes and industry safety standards. The Design Engineer shall develop a preliminary list of safety certifiable items and associated design requirements based on the preliminary engineering. The safety certification process shall apply to all elements of the system. Separate programs shall be developed, for light rail, for commuter rail and for BRT, as appropriate.

The Design Engineer shall identify those system elements and design standards to comply with the major steps in the safety certification process. These steps are implemented beginning with system design and continue through the start of revenue operation.

- Define and identify those safety-critical system elements to be certified.

- Define and identify those security-related elements to be certified.
- Define and develop a Certifiable Items List (CIL).
- Identify safety and security requirements for each certifiable item.
- Verify and document design compliance with the safety and security requirements.

The Design Engineer shall define and identify certifiable items relating to the elements listed in the following table.

Safety Certifiable Elements (minimum)

1. Systems Elements
   - Light Rail Vehicles
   - Traction Power (TES-TPSS, TPDS, TPFS, OCS, catenary)
   - Overhead Contact System (OCS)
   - Train Signals
   - Communications - Central Control System (CCS)
   - Comm- Supervisory Control & Data Acquisition (SCADA)
   - Ticket Vending Machines (TVM)
   - Maintenance Vehicles
   - Signaling - Train Control
   - Track
   - Fire Protection & Suppression Systems
   - Auxiliary Vehicles
   - Grade Crossing Fixtures & Traffic Control System
   - Emergency Response Equipment
   - Intrusion Detection System
   - Signage
   - Tunnel Ventilation Control System (if req.)

2. Facility Elements
   - Tunnel
   - Structures
   - Track
   - Each Station
   - Each at grade crossing

Each at grade crossing within each station

Yard and Shops

Garages/Parking Lots

Each Park-n-Ride

Control or Dispatch Center

Maintenance Facility

Art in Transit

3. Security Elements

Video Surveillance (CCTV)

Parking Structure design

Park-n-Ride design

Incorporation of Crime Prevention Through Environmental Design (CPTED) applied to entire design

Station design

Emergency Telephones (and Radio)

Lighting – Stations, patron areas, park-n-Rides

Security of stairwells and elevators

Access Control

Portal Protection

Each certifiable item shall have an associated checklist or verification form consisting of a minimum of two major sections with the following minimum requirements.

<u>Section 1 -- Design Requirements and Design Verification</u>

The Design Engineer shall Identify and define each certifiable item, design requirement(s), requirement source, applicability, and provide name and signature of person and Design Engineer responsible for identifying element and defining requirements. The Design Engineer shall separately verify design requirements and provide name and signature of person and Design Engineer responsible for concurrence for design review. For each certifiable item, the Design shall define a basis from which to judge compliance with safety requirements.

The Design Engineer shall verify that design complies with identified requirements and supporting documentation, and shall provide name and signature of person responsible and Design Engineer responsible for design verification.

Section 2 -- Construction Verification

The Design Engineer shall supply a signature section on the form or checklist for future verification that construction complies with design through inspection, testing and the provision of documentation to serve as evidence that construction complies with design.

14.7.0 RIGHT-OF-WAY FENCING AND BARRIERS

Right-of-Way (ROW) fencing and/or barriers shall be provided along the entire LRT alignment. The fencing and barriers shall be designed to address the following:

- act as a safety barrier to prevent vehicles, trucks, and other highway/roadway users from accidentally entering the LRT envelope;
- shall be of sufficient height to prevent trespass;
- shall be designed to prevent debris and roadway snow removal activity (snow plows throwing slush, ice and other debris) from entering rail envelope and transit station areas; and
- shall incorporate safety considerations on elevated sections with respect to fall protection and providing adequate space for maintenance-of-way workers.

There may be areas where different fencing or barriers may be more appropriate and aesthetic. In these areas, the fencing and/or barrier design shall be determined on a case by case basis and the design shall be accepted by the RTD System Safety Project Manager. The following table describes ROW conditions and the corresponding fencing and barrier requirements. The design shall conform to the requirements contained in the table. For any situation not specifically defined in the table, the fencing and/or barrier design shall be determined on a case by case basis and the design shall be approved by the RTD System Safety Project Manager. These requirements shall be applied regardless of the horizontal or vertical distance from the rail ROW to the adjacent property use. This includes, but is not limited to horizontal and vertical distances between the automobile traffic lane and the rail ROW where state or federal regulations may not require barrier or fence protection. Where different types of fencing/barriers connect, e.g. at-grade to elevated transition points, or at-grade to retaining wall transition points, the design shall accommodate a seamless transition accommodating the integrity of the fence/barrier. For example, a section of ROW may have a three foot jersey barrier with a six foot fence (total height nine feet) that meets up to a three foot MSE wall with a three foot fence (total height six feet). The fencing shall be designed so it tapers from the higher requirement to the lower requirement and meets the performance requirement of this section. No gaps between transitions are allowed. For example, if the fencing/barrier terminates at a bridge monument, the fencing shall be attached to the monument.

TABLE 14-C – ROW FENCING AND BARRIERS

ROW	Description		Barrier Height and Type	Fence Height and Type	Total Height
Semi-Exclusive & Exclusive ROW	Highway 55mph automobile speed	ROW at Grade	5' concrete	5' - 2" mesh (1)	10'
		ROW below Grade	5' concrete	5' - 1" mesh (1)	10'
		Station at Grade	5' concrete	7' - 1" mesh (1)	12'
	Roadway 35-45 mph automobile speed	ROW at Grade	3' concrete	3' - 2" mesh	6'
		ROW below grade	3' concrete	6' - 1" mesh (1)	9'
		Station at Grade	3' concrete	3'	6'
		Roadway and Sidewalk	3' concrete	5' - 1" mesh (1)	8'
	Bridges	Highway over LRT	5' concrete	5' - 1" mesh (1)	10'
		Roadway over LRT	3' concrete	6' - 1" mesh (1)	9'
Shared ROW	Automobile speeds less than 35mph	Residential street running 25 - 35 mph	18" ballast curb/wall	4' (1)	5' 6"
		Down town street running < 25mph	6" curb	N/A	6"
		Bike Path	N/A	4'	4'

Note: Exact fence height, type and mesh size shall be determined by site-specific hazard analysis taking into account all factors including protection of the overhead catenary system. Final design shall be approved by the RTD System Safety Project Manager.

14.8.0 EMERGENCY ACCESS/EGRESS, STATION DESIGN, AND WALKWAYS

The design shall include emergency access and egress points along the alignment per NFPA 130 requirements. The design shall identify emergency access and egress locations and shall provide a list or matrix of the necessary elements to be provided at each exit, such as lighting, signage, lock hardware, intrusion detection, and other elements as required by NFPA 130 and local jurisdictions. The design shall incorporate a preliminary emergency evacuation plan and diagrams for the corridor, including each station, identifying primary and secondary evacuation routes and points of safety.

LRT station design shall meet the "Means of Egress" requirements for stations as identified in NFPA 130. The Design Engineer shall provide a draft and final Means of Egress Report for all stations documenting that station design meets or exceeds all criteria listed in NFPA 130. The report shall include all calculations, supporting documentation, engineering drawings and other information necessary to demonstrate compliance with NFPA 130. For calculation of occupant load, the Design Engineer shall use projected ridership figures or maximum trainload capacities if accurate projections are not available. Each station shall have a minimum of two main access/egress points remotely located from one another. There shall be sufficient exit lanes to evacuate the station occupant load, as defined in NFPA 130, from the station platform in 4 minutes or less. The maximum travel distance to an exit from any point on the platform shall not exceed 300 feet. Stations shall also be designed to permit evacuation from the most remote point on the platform to a point of safety in 6 minutes or less.

The design shall incorporate walkways as follows. An emergency/maintenance walkway shall be provided along structures. The walkway shall be above TOR at the track edge and shall be located at a horizontal distance from track centerline as determined by regulations plus appropriate Other Wayside Factors, and Running Clearance. The walkway shall have a minimum width of 30 inches. A walkway shall be provided adjacent to one side of every track. In certain instances, with prior approval from the RTD System Safety Project Manager, the walkway may be between two tracks to serve both. Walkways in underground LRT structures, bridges and flyovers regardless of length, shall consist of a solid type material that provides a smooth continuous walking surface (concrete, etc.). Walkways shall have a slip-resistant design and shall be constructed of noncombustible materials.

Along the trackway, walkways shall be provided in addition to the clearance envelope requirements per Section 4.2.4.2, it is required that space be provided for emergency/maintenance walkways adjacent to the trackway. The walkway envelope shall extend at least 2 feet-6 inches from the edge of the clearance envelope and shall extend to 6 feet-6 inches above the walkway. A walkway shall be provided adjacent to one side of every track. In certain instances, with prior approval from the RTD System Safety Project Manager, the walkway may be between two tracks to serve both. In either case the walkway shall permit unobstructed passage from which passengers can be evacuated. Crosswalks shall have a uniform walking surface at top of rail. Walkway continuity shall be maintained at special track sections (e.g., crossovers, pocket tracks, other special track sections). For walkway clearance calculations only, traction power poles shall not be considered a permanent obstruction. This requirement is not applicable to paved track sections in street ROW. Walkways shall be placed to allow passengers to evacuate a train at any point along the trainway so that they can proceed to the nearest station or other point of safety per NFPA 130 requirements.

14.9.0 GRADE CROSSINGS

The LRT design shall incorporate approaches that minimize hazards and risks to LRT, pedestrians, bicyclists and motor vehicle operators. The primary method to minimize grade crossing hazards is to eliminate at grade crossings or minimize the number of at grade LRT crossings. Pedestrian only and bicycle only at grade crossings are generally prohibited and will require a case by case evaluation and written RTD approval. The exceptions to this criteria are pedestrian and bicycle crossings at stations with paved track.

Where planning and design does not allow for the elimination of an at grade crossing, the following system safety precedence shall be applied: design for minimum risk, incorporate safety devices, and provide warning devices. A combination of active grade crossing warning devices and passive warning devices is preferred to solely using passive warning devices. Active warning devices include: gates, bells, flashing lights, and grade crossing indicators for train operators. Passive warning devices include signage and pavement markings.

Design of each at grade crossing shall be subject to the circumstances of that crossing and its relation to the transit corridor. In considering appropriate control and warning devices, consideration shall be given to the following: type of alignment (exclusive, semi-exclusive, or shared ROW); configuration and geometry of crossing (angled or mid-block crossing; operating speed of all users; line of sight of all users; pedestrian activity; school zone; and extreme surges (pedestrians and vehicles).

To enhance pedestrian and bicycle safety at crossings, consideration shall be given to the use of channeling. The purpose of channeling is to create a physical barrier that prevents or discourages persons from taking shortcuts or from crossing the track way in a risky or unauthorized manner. Effective channeling may be developed through the use of fencing, landscaping, bollard and chain, railing, sidewalks or other methods. In all cases, a channeling method that enhances sight lines to an approaching train shall be selected.

Additional elements that may improve pedestrian and bicycle safety at crossings include: swing gates, pedestrian barriers, and automatic pedestrian gates. The purpose of a swing gate is to slow persons who are hurriedly approaching the track way. Swing gate operation depends upon the judgment of the individual. It is not electrically interconnected into approaching train or vehicular traffic signal systems. Swing gates may be appropriate where:

- There is a high likelihood that persons will hurriedly cross the track way, or sight lines and distance are restricted, and
- Channeling or other barriers reasonably prevent persons from bypassing the swing gates, and
- Acceptable provisions for opening the gates by disabled persons can be provided.

Swing gates shall open away from the tracks. Pedestrians shall pull the gate to open it and enter the track way. Gates shall also permit quick exit from the track way, automatically close after use, and be light and easy to operate by all persons.

Pedestrian barriers are also intended to slow persons who are hurriedly approaching the track way. Major advantages of barriers are that there are no operating parts to maintain, and that disabled persons are less impeded. Pedestrian barriers may be appropriate where:

- There is a high likelihood that persons will hurriedly cross the track way, or sight lines and distance are restricted, and

- Channeling or other barriers reasonably prevent persons from bypassing the barriers, and

- Adequate space is available to accommodate installation.

Barrier positioning shall accommodate use by disabled persons and be positioned so persons are turned to face the nearest on-coming train prior to crossing the track way.

Automatic pedestrian gates prevent or discourage a pedestrian or bicyclist from crossing the track way when a train is approaching. Automatic pedestrian gates are electrically interconnected into and activated by the train signal system. Automatic pedestrian gates may be considered in situations where the use of swing gates and barriers may not be effective due to train speeds and severely limited sight distance.

All gated grade crossings shall have video surveillance per the requirements of Section 14.10.0 Video Surveillance. Each gated grade crossing shall have two cameras.

The Design Engineer shall prepare diagrams for swing gates and pedestrian bedstead barriers.

14.10.0 VIDEO SURVEILLANCE

The design shall incorporate video surveillance into the project. The video surveillance system shall be capable of transmitting real-time (30 frames per second per camera) video to RTD's Security Command Center via a fiber optic transmission backbone or other suitable transmission network. The design shall include all system elements including communication houses, transmission infrastructure, color cameras, and digital video recorders. The design shall incorporate video surveillance covering station platforms, emergency telephones, elevator waiting areas, stairwell entries, parking structures, pedestrian tunnels and pedestrian bridges. The minimum number of cameras to provide coverage of these transit elements is as follows.

TABLE 14D – MINIMUM CAMERA COVERAGE

Single level at grade station platform of 300 feet or less *		
Platform type	Fixed color camera	Pan-Tilt-Zoom color camera
Center platform	4	2
Side/ center platform	6	2
Side/Side platform	4	4
Triple platform (side with two centers)	10	3

*For stations with vertical circulation, the minimum number of cameras is as stated above plus: one fixed color camera per elevator waiting area per floor, one fixed color camera per stairwell entry per floor, and one fixed color camera per each emergency telephone.

*For stations greater than 300 feet in length additional cameras will be required. The exact number will be dependent on the station design.

TABLE 14E – PARKING STRUCTURE CAMERAS

Vehicle spaces	Vehicle entrance	Vehicle exit	Elevator waiting area*	Stairwell entrance area*	Emergency telephone*
1 camera per 35 vehicle spaces	1 camera per vehicle entrance lane	1 camera per vehicle exit lane	1 camera per waiting area per floor	1 camera per entrance area per floor	1 camera per emergency telephone

*Subject to approval by the RTD Security Systems Administrator, if the design accommodates a cluster of the elevator waiting area, stairwell entrance, and emergency telephone, a single camera may be used if the video coverage of all three elements is satisfactory.

**All parking structure cameras are color, pan-tilt-zoom.

TABLE 14F – PEDESTRIAN TUNNEL CAMERAS

Pedestrian Tunnel* (all cameras are color, pan-tilt-zoom, 4 cameras minimum per tunnel)	
1 camera focused on each portal entrance/exit (2 cameras)	1 camera inside each tunnel portal entrance/exit focused inside the tunnel (2 cameras)

*For tunnels in excess of 150 feet, additional cameras will be required. If a tunnel has a bend or turn, additional cameras will be required. The RTD Security Systems Administrator will determine the number of additional cameras necessary for coverage.

TABLE 14G – PEDESTRIAN BRIDGE CAMERAS

Pedestrian Bridge (all cameras are color, pan-tilt-zoom, 2 cameras minimum per bridge)
1 camera inside each bridge portal entrance/exit focused inside the tunnel

*For bridges in excess of 150 feet, additional cameras will be required. If a bridge has a bend or turn, additional cameras will be required. The RTD Security Systems Administrator will determine the number of additional cameras necessary for coverage.

Surface park-n-Rides will typically not have video surveillance installed for opening day. However, a minimum network of two, two-inch conduits with pull cords shall be provided as follows for future video installation; one for power and one for communications. As light poles are installed and trenching is done to supply power to these poles, these conduits, shall be installed at each light pole for security. These conduits are of sufficient size to hold any wiring that might be needed for camera installation. Poles in a common area, such as on an island, shall be wired in series (daisy chained). From each common area, the pole closest to the security room shall have a conduit run directly into the security room where the conduits shall stub up. The diameter of the conduit used for this run shall be sufficient to support all poles in that daisy chain. The conduit layout shall be designed to ensure that all poles, either directly or via daisy chain, stub up into the security room.

TABLE 14H – SURFACE PARK-N-RIDE CAMERAS

Surface park-n-ride			
Vehicle spaces	Vehicle entrance	Vehicle exit	Pan-tilt-zoom color camera*
1 fixed color camera per 25 vehicle spaces	1 pan-tilt-zoom color camera per vehicle entrance <u>lane</u>	1 pan-tilt-zoom color camera per vehicle exit <u>lane</u>	Minimum of 1 camera, than 1 camera per 250 spaces

*In addition to the network of fixed cameras, each park-n-Ride shall have a minimum of one pan-tilt-zoom color camera, then 1 additional camera per 250 vehicle spaces.

All camera locations will be presented to RTD's Security Systems Administrator for review and acceptance.

The video surveillance system shall be consistent with existing RTD equipment including digital video recorders, switches, routers, cameras and operating system. The system shall be capable of providing real time video (30 full frames per second per camera) at RTD's Security Command Center. The system shall record images consistent with RTD's existing system at 15 full frames per second per camera, and shall provide recorded archive storage of two weeks (14 days) at 15 full frames per second per camera.

14.11.0 EMERGENCY TELEPHONES

The design shall incorporate emergency telephones into the project. The emergency telephones shall be consistent with existing RTD units and meet performance requirements of RTD's existing emergency telephone network. The design shall incorporate emergency telephones covering station platforms, elevator waiting areas, stairwell entries, parking structures, park-n-Rides, pedestrian tunnels and pedestrian bridges. Emergency telephones shall be placed as follows.

TABLE 14I – EMERGENCY TELEPHONES AT STATIONS

Single level at grade station platform*	
Platform type	Emergency telephones
Center platform	1
Side/ center platform	1
Side/Side platform	2
Triple platform (side with two centers)	2

* For stations with vertical circulation, one additional emergency telephone shall be placed per floor.

TABLE 14J - EMERGENCY TELEPHONES AT PARKING STRUCTURES

Parking Structure	
Elevator waiting area*	Stairwell entrance area*
1 emergency telephone per waiting area per floor	1 emergency telephone per stairwell entrance area per floor (if two stairwells, then 2 ET's per floor, etc.)

Subject to approval by the RTD Security Systems Administrator, if the design accommodates the elevator waiting area and stairwell entrance being adjacent to one another, a single emergency telephone may be used for that location.

For surface park-n-Rides, a minimum of one emergency telephone shall be placed in the design, and then one additional emergency telephone per each 300 spaces.

If pedestrian overpasses or underpasses are incorporated into design, a minimum of one emergency telephone shall be provided for each overpass/underpass. If the overpass or bridge is isolated from other transit elements, additional emergency telephones may be necessary.

The emergency telephone when activated shall connect to 911 and also send notification and audible listening capability to RTD rail control and RTD Security Command Center.

Installed Emergency Telephones shall be constructed pursuant to a minimum NEMA 3R rating (see below) and be Underwriter Laboratory and FCC approved and ADA compliant. The phones shall draw power from the phone line and require no additional power line attachments. The phones shall be capable of off-site live monitoring of emergency conversations. The emergency phones shall be part of a networked management system that is operated by a PC, XP Windows compatible or newer. The software management system will:

- Establish an automatic connection with each phone on a prearranged schedule. Phones will be tested at least one time in every twenty-four hours. The connection shall be initiated either by the PC or the telephone.

- Print an exception report at designated intervals highlighting use and malfunctions.

- Archive and maintain all reporting both of normal functioning and malfunctions.

- Log and archive all call activity at each phone.

- Identify all call activity by date and time, type of activity, and location of data within memory.

- Establish Automatic Maintenance Monitoring which reports stuck buttons, power interruption, microprocessor testing, call interrupt, handset integrity and functioning, handset off hook notification and phone line current.

NEMA 3R – Enclosures constructed for either indoor or outdoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment; to provide a degree of protection against falling dirt, rain, sleet, snow, and that will be undamaged by the external formation of ice on the enclosure. Phones will operate in a temperature range of -40°C to +60°C.

All emergency telephone locations will be presented to RTD's Security Systems Administrator for review and acceptance.

14.12.0 CRIME PREVENTION THROUGH ENVIRONMENTAL DESIGN

The design shall incorporate Crime Prevention Through Environmental Design (CPTED) strategies to the entire design. The purpose of CPTED is to minimize potential threats and vulnerabilities to the transit system, facilities and patrons and maximize safety and security through engineering and design. Good CPTED strategies include: maximizing visibility of people, parking areas, patron flow areas and building/structure areas; providing adequate lighting minimizing shadows; graffiti guards; Mylar shatter guard protection for glass windows; landscape plantings that maximize visibility; gateway treatments;

decorative fencing; perimeter control; fencing; minimizing park-n-ride and parking structure access points; elimination of structural hiding places; open lines of sight; visible stairwells and elevators meaning the exterior walls are constructed of transparent material; and painting with light.

Examples of CPTED strategy include:

- Adequate lighting of all areas appropriate for their use including perimeter lighting in park-n-Rides so the edge of the park-n-Ride is illuminated the same as the rest of the park-n-Ride (refer to station design criteria for lighting levels).

- When using shrubs, use species with a maximum height or spread that will minimize visibility obstructions. The preliminary design shall be approved by RTD prior to final design and implementation.

- When using trees, use deciduous trees with branches no lower than six feet from ground surface.

The design shall incorporate CPTED strategies into the Threat and Vulnerability Analysis and Resolution process described in the following section, 14.13.0 Threat and Vulnerability Analysis and Resolution.

14.13.0 THREAT AND VULNERABILITY ANALYSIS AND RESOLUTION

The design shall incorporate a Threat and Vulnerability Analysis and Resolution process in accordance with the minimum criteria outlined in this section. A risk assessment is a comprehensive study of a system to identify those components most vulnerable to disruption or destruction and to assess the likely impact that such disruption or destruction would have on passengers, employees, and the RTD system. Threat and vulnerability analysis (TVA) work shall begin upon project initiation and continue throughout the project. The design shall incorporate TVA progress reports according to a mutually agreeable schedule. The design shall include a draft and final TVA report on the preliminary engineering. The TVA document itself is a living document, which must be revised and updated as the system design and development progresses. It becomes the input document and information for all other TVA performed on the system.

The process shall assign values to design elements based on their criticality to the transit system operations. The four level risk classification system listed below will be used to assess risk levels.

14.13.1 Severity Categories

See Section 14.3.1, Hazard Severity Definitions.

14.13.2 Transit Risk Assessment Levels

TABLE 14J - TRANSIT RISK ASSESSMENT LEVELS

Category	Characteristic
1	Loss of life, loss of critical information, loss of critical assets, significant impairment of mission, loss of system
2	Severe injury to employee or other individual, loss of information and physical equipment resulting from undetected or unacceptable mission delays, unacceptable system and operations unauthorized access, disruption
3	Minor injury not requiring hospitalization, undetected or delay in the detection of unauthorized entry resulting in limited access to assets or sensitive materials, no mission impairment, minor system and operations disruption
4	Less than minor injury, undetected or delay in the detection of unauthorized entry system or operations disruption

14.13.3 Probability Categories

TABLE 14K – PROBABILITY CATEGORIES

Category	Level	Specific Event
A	Certain	Possibility of Repeated Incidents
B	Highly Probable	Possibility of Isolated Incidents
C	Moderately Probable	Possibility of Occurring Sometime
D	Improbable	Practically Impossible

The design shall incorporate a risk and vulnerability assessment to determine any potential hazards or high-risk areas. The table below is an example of the type of assessment to determine risk and vulnerability.

TABLE 14L - ASSESSMENT OF RISK & VULNERABILITY (RAIL)

Public Transportation Assets	Criticality People	Criticality System
Transit Centers & Stations	High	Potentially High[2]
Rail		
Track/Track Structure/Signals	Low	Potentially High[2]
Cars	High [1]	
Maintenance Yards	Low	Medium
Switching Stations	Low	Medium
Electric Power		
Source for System	Medium	High
Substations	Low	Medium
Command Control Center	Low[3]	High
Revenue Collection Center	Low[3]	Medium
Bridges	Medium	Medium[2]
Tunnels	Medium	Medium[2]
Fans	Low	Medium
Vents	Low	Medium
Emergency Hatches	Low	Medium

TABLE 14M - ASSESSMENT OF RISK & VULNERABILITY (BUS)

Public Transportation Assets	Criticality People	Criticality System
Bus Terminals	High [1]	Potentially High[2]
Bus Vehicles	High [1]	Low
Bus Stops/Shelters	Medium	Low
Maintenance Garages	Low[3]	Medium
Fuel Storage Facility	Low	High
Command Control Center	Low[3]	High
Revenue Collection Center	Low[3]	Medium

[1]Depends on what time of day incident occurs. Greater impact would be experienced during rush hour than non-rush hours

[2]Depends on location in the system where an incident occurs. An incident at a crossover or main junction would have greater impact than one at an outlying station or track segment. Also depend on the alternatives available, such as redundancies, rerouting capabilities, and other factors.

[3]Affects employees only

The design process shall identify any threats that have been located. These identified threats could include,

- Criminal Activity
- Terrorism
- Natural disasters
- Emergency Response

Identified risks and hazards shall be resolved to acceptable levels. The matrix below provides a source for mitigating hazards based on frequency of occurrence and severity. The matrix condenses risk resolution into a table and prioritizes the risks that are evaluated.

TABLE 14N – SEVERITY OF LOSS

Assessed Rating	Probability of Loss	1 Catastrophic	2 Very Serious	3 Moderately Serious	4 Not Serious
A	Certain				
B	Highly Probable				
C	Moderately Probable				
D	Improbable				

	1A. 1B. 1C. 2A.	Unacceptable: Implement Countermeasures to Reduce
	2D. 2C. 2D. 3B.	Acceptable with Management Review
	3D. 4A. 4B. 4C.	Acceptable

The design shall present several options to the RTD in order to decrease the hazards located in the assessment. These options shall be based on the system security precedence:

- Design the system to eliminate the risk
- Design the system to control the risk
- Add safety or security devices to control the risk
- Add warning devices to control the risk, and
- Institute special procedures or training to control the risk.

14.14.0 PARK-N-RIDES, PARKING STRUCTURES, AND ENCLOSED UNDERGROUND OR BELOW GRADE TRANSIT FACILITIES

14.14.1 Surface park-n-Rides

In addition to the items already listed in this chapter, design for surface park-n-Rides shall consider safety and security of patrons and the protection of property. Park-n-Ride design shall incorporate good visibility throughout the park-n-Ride, and good visibility from surrounding streets into the park-n-Ride for patrols by law enforcement and security personnel.

The use of landscaping shall consider maximizing visibility and eliminating hiding places and shadows. Shrubs shall not impede visibility in height and trees shall bear no branches below 6 feet from ground surface. Evergreen trees shall only be used on a limited basis and shall be placed in such a manner that hiding spaces and visual obstructions are not created. Landscape placement shall be subject to approval by the RTD Security Systems Administrator.

Adequate and appropriate lighting is the single most effective deterrent for minimizing crime at park-n-Rides. Lighting shall be provided in accordance with the criteria provided in the stations chapter. The design shall address perimeter lighting by including placement of light poles around the perimeter of the park-n-Ride.

The control and design of park-n-Ride entrances and exits is important to maintaining security of park-n-Rides. Entrances and exits shall be limited to as few as practically possible to control access and egress from the park-n-Ride site and minimize the number of entrance and exit cameras. To compliment the effective use of video surveillance, entrances and exits shall be designed with two speed bumps separated by one and one half standard vehicle lengths to slow the vehicles as they enter and exit to allow adequate time for automobile license plates to be captured by video surveillance.

14.14.2 Parking Structures

In addition to the items already listed in this chapter, design for parking structures shall consider safety and security of patrons and the protection of property. Parking structure design shall incorporate good visibility throughout the structure, and good visibility from surrounding streets into the structure for patrols by law enforcement and security personnel. Walls inside the structure shall be limited to increase visibility and minimize hiding places throughout the structure. Openings in interior walls between levels or ramps shall be protected by mesh or chain link fencing. Openings in exterior walls at the ground level and at below grade level shall be protected by mesh, chain link fence or other treatment to prevent pedestrians from entering or exiting the structure through these openings.

The control and design of parking structure entrances and exits is important to maintaining security of the structures. Entrances and exits shall be limited to as few as practically possible to control access and egress from the structure and minimize the number of entrance and exit cameras.

Stairwell and elevator design shall maximize the interior visibility of the stairwell, elevator and elevator shaft. Materials of wall construction for these elements shall be transparent such as glass and allow visibility from at least three sides.

Each parking structure shall include a security room/office for security or law enforcement personnel.

Parking structures shall have minimum lighting levels of 10 foot candles.

14.14.3 Underground and Below Grade Transit Facilities

Enclosed, underground and below grade transit facilities present unique security design challenges. Design of these facilities shall maximize patron safety and security by the inclusion of counterterrorism measures. Each enclosed, underground or below grade facility shall be covered by video surveillance including: its perimeter; portals, entrances and exits; its interior; and fare vending areas. Patron station areas in these facilities shall be designed as paid fare zones. Thus, patron circulation design shall consider the availability to purchase fare media prior to entering the paid fare zones.

Where facilities serve more than one mode of transportation, the design shall incorporate a means to physically separate modal areas using automatic doors. Each modal area shall also have a separate ventilation system. This design shall allow one modal area to operate in the event of a major incident occurring in an adjacent modal area and prevent cross contamination.

Facility access control is an important aspect of design and shall be designed as follows. All access points (entrances and exits) to the facility and all interior doors shall be controlled by proximity reader access control. The proximity reader access control system shall be a Lenel system as currently installed at RTD facilities and shall be networked into the existing system. All access points or portals capable of accommodating a motor vehicle shall be equipped with automatic portal protection that will prevent unauthorized vehicles from entering the facility. The portal protection shall have a K-12 rating, shall include a guard shack, and shall be located at a minimum distance of 150 feet from the facility entry portal. Portals for train access shall include intrusion detection capable of distinguishing between an authorized train and any other unauthorized vehicle or person attempting to gain access through the train portal. Intrusion detection alarm notification shall be sent to light rail central control and RTD Security Command Center. The facility design shall incorporate a means to establish a vehicle checkpoint at a minimum distance of 150 feet from each facility vehicle entry portal.

The design shall protect the facility from progressive collapse. In the event of an internal explosion, the design shall prevent progressive collapse due to the loss of one primary column. Column design shall consider sizing, reinforcement or protection so that the threat charge will not cause the column to be critically damaged.

Loading docks and shipping/receiving areas are prohibited in underground and below grade facilities. All deliveries shall be accommodated for at the exterior of the facility above grade.

Each enclosed, underground or below grade facility shall include a security room/office for security or law enforcement personnel.

14.15.0 PUBLICLY ACCESSIBLE RECEPTACLES

Publicly accessible receptacles are any receptacle with a void space that the public can access. Examples include but are not limited to trash receptacles, bike lockers, and newsracks. Placement of publicly accessible receptacles shall be subject to threat and vulnerability analysis and shall not be placed within 250 feet of a station, station area or patron gathering area for outside locations. An exception is the use of an explosion resistant trash receptacle. An explosion resistant trash receptacle shall be capable of containing an explosion of four (4) pounds of TNT or the C4 equivalent and shall be third party tested or certified. For enclosed areas, underground, or below grade transit stations, facilities, structures and tunnels, placement of publicly accessible receptacles is strictly prohibited. In parking structures, placement of publicly accessible receptacles is strictly prohibited.

14.16.0 CONFIGURATION MANAGEMENT

Any change or deviation to this design criteria must be approved by RTD's Executive Safety and Security Committee. All project design shall be reviewed and accepted through a signature process by the following personnel: Assistant General Manager, Rail Operations; Sr. Manager of Engineering; and Manager, Public Safety. The signature review and acceptance procedure shall be applied at each design phase or milestone. Any change to an accepted design, shall also be subject to a signature review and acceptance process by the same personnel.