Appendix A2 is a comparison between the proposed MUTCD Light Rail-Highway Grade Crossing Part (Part X) and various other "manuals": *Manual On Uniform Traffic Control Devices, Railroad-Highway Grade Crossing Handbook*, California Public Utilities Commission (CPUC) *General Orders*, and the California Department of Transportation (CALTRANS) *Traffic Manual.* This appendix examines vehicle and pedestrian signs, signals, and pavement markings, as well as at-grade, motor vehicle and pedestrian crossing devices. The contents of this appendix draw upon the materials prepared by Jim Curry from Engineering Management Consultants in Los Angeles for the Metro Blue Line.

The following is a brief description of the other manuals referenced for comparison:

- The *MUTCD* and the *Railroad-Highway Crossing Handbook* describe standards concerning traffic control systems for railroad-highway grade crossings that are to be implemented on all highways open to public travel.

- The CPUC *General Orders 26-D, 72-B, 75-C, 95, 118, 135*, and *143-A* are regulations governing railroad grade crossings and certain aspects of LRT design that apply only to agencies in the state of California.
    - *General Order 26-D* regulates clearances on railroads and street railroads with references to side and overhead structures, parallel tracks, crossings of public roads, highways, and streets.
    - *General Order 72-B* regulates the construction and maintenance of crossings at-grade of railroads with public streets, roads and highways.

- *General Order 75-C* regulates the protection of crossings at-grade of roads, highways, and streets with railroads.
- *General Order 95* regulates overhead electrical line construction.
- *General Order 118* regulates construction, reconstruction, and maintenance of walkways adjacent to railroad trackage as well as the control of adjacent vegetation.
- *General Order 135* governs the occupancy of public grade crossings by railroads.
- *General Order 143-A* describes rules for the design, construction and operation of LRT systems including streetcar operations.

- The *Caltrans Traffic Manual* establishes engineering guidelines, policies, and procedures for traffic functions of Caltrans. It also contains current highway design standards, criteria, and policies. "Chapter 11 — Rules and Regulations Prescribing Uniform Standards and Specifications for Official Traffic Control Devices" is the only provision adopted by the Department of Transportation (CA) as Rules and Regulations and therefore has the force and effect of law.

REFERENCE	DESCRIPTION	PROPOSED MUTCD LIGHT RAIL-HIGHWAY GRADE CROSSING PART (PART X)	MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES/RAILROAD-HIGHWAY GRADE CROSSING HANDBOOK	CALIFORNIA PUBLIC UTILITIES COMMISSION GENERAL ORDERS 26-D, 72-B, 75-C, 95, 118, 135, AND 143-A	CALIFORNIA DEPARTMENT OF TRANSPORTATION TRAFFIC MANUAL
	MOTOR VEHICLE REGULATORY SIGNS				
R1-1	Stop Sign	May be used where need established by detailed traffic engineering study. (10-2.1.1)	Shall be used only where need established by detailed engineering study. (8B-9)		
R3-1	Illuminated No Right Turn Sign/No Right Turn Symbol Sign	Shall be used at non-gated crossings where LRVs are side-running and where traffic making right turns across the tracks is controlled by stop signs or traffic signals without a red right turn arrow displayed when an LRV is approaching. (10-2.1.2) Should be used at gated crossings where LRVs are side-running and where traffic making right turns across the tracks is controlled by stop signs or traffic signals without a red right turn arrow displayed when an LRV is approaching. (10-2.1.2) Not recommended where LRVs operate in mixed traffic. (10-2.1.2) Display to be steady, not flashing. (10-2.1.2) Symbol sign to be 24" or 36" diameter circle with red circle and diagonal, white turn arrow, and black background. (10-2.1.2) Sign to be 24" x 30" with red message on black background may be used as alternate. (10-2.1.2) Further research needed to determine specifications for placement location and mounting height. (10-2.1.2)	Permits use of variable message or internally illuminated symbol sign that is lighted and made legible only when movement restriction applies; particularly desirable at signalized intersections. (2B-15) When used in conjunction with traffic signals, illuminated signs shall be designed and mounted to avoid glare and reflections that detract from the signal indications. (4B-26) Symbol sign only. (2B-15) Should be provided for right turn movements at intersections controlled by traffic signals located within 200 feet of crossings. (8B-7) At least one sign should be placed over the roadway or at a right-hand corner of the intersection. (2B-15)	(75-C) May be used in conjunction with other crossing signs and equipment when authorized in advance by CPUC.	Permits use of variable message or internally illuminated symbol sign that is lighted and made legible only when movement restriction applies. (4-45) Limits use of No Right Turn Sign to surface streets where needed to prohibit turning movements into freeway exit ramps. (4-45) Should be placed on near right corner. Also, signs should be placed where they can be most easily seen by drivers intending to turn. (4-45)
Proposed R3-1a	No Left Turn Symbol Sign/When Flashing Sign/Flashing Amber Beacon	May be used instead of Illuminated No Left Turn Sign. (10-2.1.2)			

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R3-2	Illuminated No Left Turn Sign/No Left Turn Symbol Sign	Shall be used at non-gated crossings where left turns are made across the tracks and where traffic making left turns is controlled by stop signs or traffic signals without a red left turn arrow displayed when an LRV is approaching. (10-2.1.2) Should be used at gated crossings where left turns are made across the tracks and where traffic making left turns is controlled by stop signs or traffic signals without a red left turn arrow displayed when an LRV is approaching. (10-2.1.2) Not recommended where LRVs operate in mixed traffic. (10-2.1.2) Display to be steady, not flashing. (10-2.1.2) Symbol sign to be 24" or 36" diameter circle with red circle and diagonal, white turn arrow, and black background. (10-2.1.2) Sign to be 24" x 30" with red message on black background may be used as alternate. (10-2.1.2) Further research needed to determine specifications for placement location and mounting height. (10-2.1.2)	Permits use of variable message or internally illuminated symbol sign that is lighted and made legible only when movement restriction applies; particularly desirable at signalized intersections. (2B-15) When used in conjunction with traffic signals, illuminated signs shall be designed and mounted to avoid glare and reflections that detract from the signal indications. (4B-26) Symbol sign only. (2B-15) Sign to be 24" x 24" with red and black symbol on white background. (8B-7) Should be provided for left turn movements at intersections controlled by traffic signals located within 200 feet of crossings. (8B-7) At least one sign should be placed over the roadway or at a left-hand corner of the intersection. (2B-15)	(75-C) May be used in conjunction with other crossing signs and equipment when authorized in advance by CPUC.	Permits use of variable message or internally illuminated symbol sign that is lighted and made legible only when movement restriction applies. (4-45) Limits use of No Left Turn Sign to surface streets where needed to prohibit turning movements into freeway exit ramps. (4-45) Should be placed on near right-hand and far left-hand corners. (Revision Dated 3/30/87, Page 2)
Proposed R3-18, R3-19	Preferential LRT Right-of-Way Sign	May be used on semi-exclusive alignments mounted on a post located adjacent to the LRT right-of-way or overhead directly above the LRT right-of-way. (10-2.1.3)			

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Proposed R4-1a	Do Not Pass Stopped LRV Sign	May be used where LRVs stop in the street to receive or discharge passengers where there is no safety zone. (10-2.1.4)			
Proposed R5-1b	Encroachment Restrictions Sign	Should be placed on the LRT trackway facing traffic at crossings. (10-2.1.5) Alternatively, it should be mounted on a pole on the curb. (10-2.1.5) Further research needed to determine installation guidelines. (10-2.1.5)			
Proposed R6-3b, R6-3c	Divided Highway With Median Running LRT Crossing Sign	May be used as a supplemental sign on approaches to crossings where LRT LRVs operate in the median of a divided highway. (10-2.1.6) May be mounted beneath a stop sign or separately. (10-2.1.6)			
R8-8	Do Not Stop on Tracks Sign	Should be used whenever an engineering study determines that the potential for motorists stopping on the tracks is high. (10-2.1.7) May be located on right near side of crossing. (10-2.1.7) May be placed on left near side of multi-lane streets with medians and one-way streets. (10-2.1.7)	Should be used whenever an engineering study determines that the potential for motorists stopping on the tracks is high. (8B-8) May be located on near or far right-hand side of crossing. (8B-8) May be placed on both sides of street on one-way streets. (8B-8)		Should be used whenever an engineering study determines that the potential for motorists stopping on the tracks is high. (4-60) Should be placed on far right side of crossing; on both sides of multi-lane streets and one-way streets. (4-60)
R10-6a, Proposed R10-6b	Stop Here on Red Sign	Should be used at certain locations to clarify signal control. (10-2.1.8)	May be needed at certain locations to clarify signal control. (2B-37)		
Proposed R10-6c, R10-6d	Caution Stop Here Sign	May be used at certain gated crossing locations instead of Stop Here on Red Sign. (10-2.1.8)			

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R15-1	Crossbuck Sign	Shall be used on each roadway approach to every gated crossing. (10-2.1.9) Should only be used in conjunction with automobile and/or pedestrian gates. (10-2.1.9)	Shall be used on each roadway approach to every grade crossing. (8B-2) May be placed back to back or otherwise located at crossings where visibility is restricted. (8B-2)	(75-C) Required in accordance with Standards 1-R, 8, 8-A, 9, 9-A, and 9-B.	
R15-2	Number of Tracks Sign	Shall be used at crossings where there are two or more tracks except optional where automatic gates are installed. (10-2.1.9)	Shall be used at crossings where there are two or more tracks except optional where automatic gates are installed. (8B-2)	(75-C) Required at crossings where there are two or more tracks in accordance with Standards 1-R, 8, 8-A, 9, 9-A, and 9-B.	
R15-4a, R15-4b, R15-4c	Pedestrian and/or Bicycles Only Crossing Sign	Shall be used to indicate an at-grade rail crossing for pedestrians and/or bicycles to restrict motor vehicles from using the crossing. (10-2.1.10)		(75-C) Used to indicate a crossing for pedestrians only. (Standard No. 1-D)	
	MOTOR VEHICLE WARNING SIGNS				
W10-1	Railroad Advance Warning Sign	Shall be used on each roadway in advance of every gated crossing. (10-2.2.1)	Shall be used on each roadway in advance of every grade crossing except at low volume crossings, in urban business districts, or where it is not possible to install sign so that it can be seen. (8B-3) May be installed on both sides of street on one-way streets. (8B-3) (Handbook) Distance from track where sign is installed dependent on highway speeds, but not closer than 100 feet. Table provided that shows distances for different highway speeds.	(75-C) Required in accordance with California vehicle Code Section 21362.	Shall be placed in advance of all crossings in accordance with California Vehicle Code Section 21362. (4-24)

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W10-2, W10-3, W10-4	Advance Warning Sign/Parallel Streets	May be installed on highways that are parallel to LRT alignment in advance of either gated or non-gated crossings in accordance with Section 8B-3. (10-2.2.1)	May be installed on streets running parallel to railroads to warn motorists making turns across the tracks. (8B-3)		
	Advance Warning Sign, Train-Activated Hazard Identification/Flashing Amber Beacon, and Train When Flashing Sign		Shall be used to supplement an appropriate Advance Warning Sign. (4E-1) Should be operated only during those hours when hazard or regulation exists. (4E-5) (Handbook) Used instead of Advance Warning Sign. Should be considered at locations where flashing light signals cannot be seen until motorists are close to crossing.	(75-C) May be used in conjunction with other crossing signs and equipment when authorized in advance by CPUC.	Hazard Identification Flashing Beacon shall be used only to supplement an appropriate advance warning sign (Caltrans W47 or Caltrans W41A). (9-57) Shall be operated only at times when hazard exists. (9-57) Refers to Caltrans Standard Plans for installation details. (9-56, Standard Plans Pages 269, 237)
Proposed W10-5	LRT Crossing Sign	May be used in advance of non-gated, signalized LRT crossings. Shall not be used on streets parallel to the tracks. (10-2.2.2) Further research needed to determine if needed in advance of non-gated signalized crossings. (10-2.2.2)			May be used in advance of LRT crossings controlled by traffic signals or stop signs. (CTCDC Draft Light Rail Safety Manual)
Proposed W10-5a	LRT Crossing Sign/ Look Both Ways	Shall be used where LRVs operate two-way at unsignalized crossings. (10-2.2.2)			May be used in advance of LRT crossing controlled by traffic signals or stop signs. (CTCDC Draft Light Rail Safety Manual)

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Proposed W10-6a, W10-6b	Illuminated LRV Approaching Sign	Should be used at non-gated crossings on semi-exclusive LRT alignments for traffic making left turns across the tracks where a red left-turn traffic signal arrow is displayed when an LRV is approaching. (10-2.2.3, Table 10-3) Should be used at non-gated crossings on semi-exclusive side-running LRT alignments for traffic making right turns across the tracks where a red right-turn arrow is displayed when an LRV is approaching. (10-2.2.3, Table 10-3) May be used at non-gated crossings for traffic making left turns (and right turns where LRVs are side-running) across the tracks where traffic making left or right turns is controlled by stop signs or traffic signals without turn arrows. (10-2.2.3, Table 10-3) May be used at gated crossings for traffic making left turns (and right turns where LRVs are side-running) across the tracks. (10-2.2.3, Table 10-3) Display to be flashing (alternatively, steady, followed by a short flashing period). (10-2.2.3) Sign to be 24" x 24" (symbolic) with 36" x 12" (legend) in amber on a black background. (10-2.2.3) Further research needed to determine specifications for placement location and mounting height. (10-2.2.3)	When used in conjunction with traffic signals, illuminated signs shall be designed and mounted to avoid glare and reflections that detract from the signal indications. (4B-26)	(75-C) Auxiliary signs and signals may be used in conjunction with other crossing signs and equipment when authorized in advance by CPUC.	

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	PEDESTRIAN WARNING SIGNS				
Proposed W10-5	LRT Crossing Sign	Shall be used at signalized pedestrian crossings of LRT tracks except where LRT and railroad trains share the right-of-way. (8E-2.2.2) Shall be installed on both sides of the LRT tracks where LRT tracks run adjacent to railroad tracks. (8E-2.2.2)			May be used in advance of LRT crossings controlled by traffic signals or stop signs. (CTCDC Draft Light Rail Safety Manual)
Proposed W10-5a	LRT Crossing Sign/ Look Both Ways	Shall be used at unsignalized pedestrian crossings of LRT tracks. (10-2.2.2 and 10-3.6.2) Shall be attached to the flashing light signal assembly at non-gated, unsignalized, pedestrian-only LRT crossings of semi-exclusive, separate rights-of-way. (10-3.6.2) Shall be installed at all four quadrants of motor vehicle, gated, LRT crossings without pedestrian gates. (10-3.6.2) Shall be mounted on a sign post separately from the automatic gates in the two quadrants with automatic gates. (10-3.6.2) May be mounted separately on a sign post or attached to the flashing light signal assembly in the two quadrants without automatic gates. (10-3.6.2)			May be used in advance of LRT crossings controlled by traffic signals or stop signs. (CTCDC Draft Light Rail Safety Manual)
W10-7	Illuminated Second Train-Look Left/Right Sign	May be used to supplement LRT Crossing Sign. (10-2.2.4) Should be placed on far side of crossing. (10-2.2.4) Sign shall be 30" x 18" with amber lettering on black background. (10-2.2.4)		(75-C) Auxiliary signs and signals may be used in conjunction with other crossing signs and equipment when authorized in advance by CPUC.	

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	MOTOR VEHICLE PAVEMENT MARKINGS				
	Advance Warning Pavement Markings	Shall be used on every approach in advance of gated crossings, except parallel exclusive left or right turn approach lanes. (10-2.4.1) RXR symbols shall be used in each approach lane on multi-lane streets. (10-2.4.1) Shall not be used on parallel streets for center-running LRT configuration. (10-2.4.1)	Shall be placed in each approach lane at crossings where railroad signals or automatic gates are installed and at other crossings where vehicle approach speeds exceed 40 mph or where an engineering study indicates that there is a significant potential conflict between vehicles and trains. (8B-4) May not be required at minor crossings or in urban areas if an engineering study indicates that other devices provide adequate control. (8B-4)	(75-C) Refers to Caltrans Traffic Manual.	Shall be placed in each approach lane at crossings except exempt crossings specified in California Vehicle Code Section 22452. (6-13,14) Shall be placed in each approach lane at LRT crossings where automatic gates or flashing lights are installed. (6-14) See Caltrans Standard Plans, Page 9.
	LRV Dynamic Envelope Pavement Markings	Should be delineated by differential pavement, contrasting pavement texture, or solid white lines on semi-exclusive or non-exclusive rights-of-way. (10-2.4.2)		(72-B) Crossing area between lines two feet outside rails of each track to be maintained by railroad.	

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	PEDESTRIAN PAVEMENT MARKINGS				
	Pedestrian Crossing Pavement Markings	Pedestrian crossings or crosswalks in street running route segments should be delineated by continuous white line striping on both sides or contrasting pavement texture. (10-2.5.1) Area outside of LRV dynamic envelope may be marked with diagonal white striping at 45 degrees or white striping at 90 degrees to line of crosswalk. (10-2.5.1) May paint LOOK LEFT or LOOK RIGHT if single track LRT configuration. (10-2.5.1) Fencing and/or landscaping may be used to channelize pedestrian movements. (10-2.5.1)	Crosswalks should be marked at all intersections where there is substantial conflict between vehicle and pedestrian movements, at other appropriate points of pedestrian concentration, or where pedestrians could not otherwise recognize the proper place to cross. (3B-18) Crosswalk lines shall be solid white lines, marking both edges of the crosswalk for full width of pavement. (3B-18) Optionally for added visibility, area of crosswalk may be marked with diagonal white striping or white striping at 90 degrees to line of crosswalk, without any striping marking edges of crosswalk. (3B-18) Raised pavement markings may be substituted for markings of other types. (3B-16)	(72-B) Crossing area between lines two feet outside rails of each track to be maintained by railroad.	

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	LRV Dynamic Envelope Pavement Markings	Shall be marked at pedestrian crossings where LRVs operate in semi-exclusive and non-exclusive configurations. (10-2.5.2) Should be marked with contrasting pavement texture to identify LRV's dynamic envelope through a pedestrian crossing. (10-2.5.2) May be marked with 4-inch wide lines as an alternate. (10-2.5.2) ADA strips may be considered a contrasting pavement texture. (10-2.5.2) Shall not be delineated within crosswalks by pavement markings, except where safety zones are used. (10-2.5.2) Shall be delineated along its full length where LRVs operate in a pedestrian or transit mall. (10-2.5.2)		(72-B) Crossing area between lines two feet outside rails of each track to be maintained by railroad.	
	Colored Pavements		Situations could occur where colored pavements could supplement other traffic control devices. (3E-1) Where used, white colored pavement shall be used for delineation on shoulders and for crosswalks. (3E-2)		

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	ILLUMINATION				
	Illumination	Should be installed if an engineering study determines that better visibility is needed at crossings where night service is operated. (10-2.6)	Where an engineering analysis determines that better visibility of trains is needed, may be installed at and adjacent to railroad grade crossings where a substantial amount of railroad operation is conducted at night, particularly where train speeds are low, where crossings are blocked for long periods, or accident experience indicates that motorists experience difficulty in seeing trains or traffic control devices during hours of darkness. (8B-5)		Safety lighting may be provided at railroad grade crossings where a substantial amount of railroad operation is conducted at night, particularly where train speeds are low, where crossings are blocked for long periods, or a study indicates that motorists experience difficulty in seeing trains or traffic control devices during hours of darkness. (9-61, also Figure 9-28)
	GUIDE SIGNS				
Proposed I-7a	Light Rail Station Symbol Sign	May be used to direct motorists or pedestrians to LRT station. (10-2.3.1)			Used to direct motorists to rail station facility. (Revision Dated 06/21/88, Page 4)
	Name of LRT System, Name of Station, Direction to Station, or Next Exit Sign	May be used with Light Rail Station Symbol Sign. (10-2.3.1)			

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	MOTOR VEHICLE CROSSING GATES				
	Post-Mounted Flashing Light Signal and Automatic Gate	Shall be installed at crossings where LRVs operate on semi-exclusive right-of-way at speeds exceeding 35 miles per hour or legal speed limit of parallel traffic plus 10 miles per hour. (10-3.2 and Table 10-1) Shall be installed at mid-block crossing locations where LRVs operate on semi-exclusive, separate rights-of-way. (10-3.2) May be used to control conflicting left and right turn movements from parallel roadways at locations where they control cross traffic. (10-3.2) May be used at locations where LRVs speeds are less than 35 miles per hour if determined by engineering study. (10-3.2) Should be located on the inside edge of the sidewalk where possible so that sidewalk is blocked when gate arm is lowered. (Insert to 8C-4)	Selection of traffic control devices to be used at a grade crossing to be determined by engineering and traffic investigation. (8D-1) Where automatic flashing lights and crossing gates are used, backlights shall be used at crossings with traffic in both directions. (8C-2) Sidelights may be used for traffic approaching on streets parallel to the tracks. (8C-2) Bell may be operated in conjunction with the flashing lights. (8C-2)	(143-A) Automatic gate crossing signals required at LRT grade crossings where trains operate in fenced semi-exclusive right-of-way. (Traffic signals or other approved devices may be authorized only in special locations, where speeds do not exceed 35 mph, Table 1.) (75-C) Backlights and bells not required on signals installed on medians.	
	Cantilever Supported Flashing Light Signal and Automatic Gate	Shall be used at mid-block crossings. (10-3.3) Shall not be used adjacent to intersections controlled by traffic signals with mast arms. (10-3.3)	May be used at locations where better visibility is required, particularly on multi-lane approaches. (8C-3) (Handbook) Provides some discussion of the factors to be considered for cantilever-mounted flashing lights.	(143-A) Automatic gate crossing signals required at LRT grade crossings where trains operate in fenced semi-exclusive right-of-way.	

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	PEDESTRIAN CROSSING SIGNALS				
	Walk/Don't Walk Pedestrian Signals	Shall be used at signalized pedestrian crossings. The signal shall display the standard symbolic WALK/DON'T WALK pedestrian signal indication. (10-3.6.1) Should be installed between LRT tracks and railroad tracks where LRT runs adjacent to a railroad. (10-3.6.1)	Pedestrian signal indications shall be installed in conjunction with vehicular traffic signals where any one or more of several specified conditions exist. (4D-1) Pedestrian signals shall be displayed except when the traffic signal is being operated as a flashing device. (4D-7) Bottom of pedestrian signal housing shall be not less than seven feet nor more than 10 feet above sidewalk grade. (9-26)		Pedestrians are better controlled by pedestrian signal faces than by vehicular signal faces. Refers to MUTCD for installation criteria. (9-26) Signal faces shall be international symbol type. (9-26) Bottom of pedestrian signal housing should be not less than seven feet nor more than 10 feet above sidewalk grade. (9-26)
	Post-Mounted Flashing Light Signal Assembly in Non-Gate Quadrant	Shall be used at all gated crossings without pedestrian automatic gates. (10-3.6.2)	Bell may be operated in conjunction with the flashing lights. (8C-2)	(143-A) Automatic warning signals to control pedestrian traffic are required at LRT grade crossings where trains operate in fenced semi-exclusive right-of-way. (75-C) Crossbuck Sign shall be mounted above signal mast arm.	
	Post-Mounted Flashing Light Signal for Pedestrian-Only Crossings	Shall be used at non-gated, unsignalized LRT crossings of semi-exclusive, separate rights-of-way. (10-3.6.2) Should be mounted adjacent to the LRT crossing facing each direction. (10-3.6.2)		(75-C) To be used at pedestrian crossings where required by the CPUC.	

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	PEDESTRIAN GATES				
	Pedestrian Automatic Gates	Shall be installed at crossings where sight distance is not adequate. (10-3.6.3) Should be used at pedestrian crossings where pedestrian risk of collisions with LRVs is medium to high. (10-3.6.3) When installed on all quadrants, pedestrian safety zones and escape routes shall be clearly marked. (10-3.6.3)			
	Swing Gates	Should be used at pedestrian crossings where pedestrian risk of collisions with LRVs is medium to high. (10-3.6.4) Should be supplemented with pedestrian warning signs. (10-3.6.4) Active internally illuminated TRAIN-LOOK LEFT/RIGHT should be installed when LRVs operate in a single-track two-way alignment.		(143-A) Minimum side clearances to obstructions higher than eight inches shall be 30 inches on station platforms, in yards and along shop aisles, and other locations, including emergency walkways, where passengers, employees, or other persons are permitted or required to be while trains are in motion. (NOTE: LRV dynamic envelope width approximately 5' from centerline of tracks plus 18" or 7'6" clearance required from centerline). (9.06.c(1))	
	Bedstead Barriers	May be used at pedestrian crossings where pedestrian risk of collisions with LRVs is low to medium. (10-3.6.6) Shall not be used where LRVs operate in both directions on a single track. (10-3.6.6)			

REFERENCE	DESCRIPTION	PROPOSED MUTCD LIGHT RAIL-HIGHWAY GRADE CROSSING PART (PART X)	MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES/RAILROAD-HIGHWAY GRADE CROSSING HANDBOOK	CALIFORNIA PUBLIC UTILITIES COMMISSION GENERAL ORDERS 26-D, 72-B, 75-C, 95, 118, 135, AND 143-A	CALIFORNIA DEPARTMENT OF TRANSPORTATION TRAFFIC MANUAL
	Z Crossings	May be used at pedestrian crossings where pedestrian risk of collisions with LRVs is low to medium. (10-3.6.7) Shall not be used where LRVs operate in both directions on single track. (10-3.6.7)			
	MEDIANS/VEHICLE INTRUSION BARRIERS				
	Center Line Median	Should be constructed on approaches to gated crossings. (Insert to 8C-4)	Continuous traffic divisional islands, referred to as medians, may be used in advance of an intersection to separate opposing traffic. (5A-5) Necessity for islands should be determined by careful study. Refers to AASHTO criteria for the design of islands. (5B-1) Mountable type of curb is preferable, but barrier curb may be used on islands where traffic control devices are installed. (5B-3)		
	Low-Profile Pavement Bars Between LRV Trackway and Roadway	Low-profile pavement bars, rumble strips, or rough textured pavement may be used to discourage vehicular encroachment onto trackway. (10-2.4.3)			Rumble strips shall not be used unless determined to be the only reasonable solution; shoulder rumble strips may be installed where appropriate. (6-15,16)

REFERENCE	DESCRIPTION	PROPOSED MUTCD LIGHT RAIL-HIGHWAY GRADE CROSSING PART (PART X)	MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES/RAILROAD-HIGHWAY GRADE CROSSING HANDBOOK	CALIFORNIA PUBLIC UTILITIES COMMISSION GENERAL ORDERS 26-D, 72-B, 75-C, 95, 118, 135, AND 143-A	CALIFORNIA DEPARTMENT OF TRANSPORTATION TRAFFIC MANUAL
	TRAFFIC SIGNALS				
	Traffic Signal Preemption When Train Approaching	Should be used where crossing equipped with automatic railroad crossing warning devices is located within 200 feet of intersection controlled by traffic signals. (10-3.4.1) May be required where crossing is located more than 200 feet from intersection controlled by traffic signals. (10-3.4.1) Limited service preemption should be used where possible. (10-3.4.1) May be used where LRVs operate in semi-exclusive alignments. (10-3.4.2)	Should be used at signalized intersections where crossing equipped with an active traffic control system is located within 200 feet of intersection (4B-21, 8C-6).	(75-C) Should be provided where railroad tracks pass in or near street and highway intersections to avoid conflicting aspects of the traffic signals and the railroad crossing signals.	
	Traffic Signal Priority When Train Approaching	May be used where LRVs operate in semi-exclusive or mixed traffic. (10-3.4.2, 10-3.4.3)	Traffic control signals may be modified to grant priority control to transit. (4B-22)		
	Traffic Signals with Protected Left-Turn Phase	Shall be used at crossings in semi-exclusive alignment where left turns are made across the tracks. (10-3.4.2) Motorists turning left across the tracks should be serviced after the LRV has cleared the crossing, generally before the cross-street traffic. (10-3.4.2)			

The following is a list of published reference materials associated with LRT operations in shared right-of-way. These materials were assembled and reviewed by the Research Team in Task 1.

1. APTA Rail Safety Committee—Grade Crossing and Pedestrian Safety Task Force. *LRT Grade Crossing Design Features.* (June 12, 1994) 43 pp.

   This report provides a synopsis of the various approaches to grade crossing design taken by LRT systems in the U.S. and Canada. It represents one component of the ultimate objective of the task force, which is to investigate and report on the state of the art of grade crossings and pedestrian safety, and to develop recommendations.

   The information presented includes detailed descriptions of the grade crossing design features of several of the systems studied in TCRP, Project A-5. This report provided excellent support materials for the survey conducted by the Research Team.

2. Calgary Transit. *Rail Operating Rule Book and Operating Procedures Manual.* Alberta, Canada (March 1993), v.p.

   The rules and procedures contained within this book are intended to provide safe, courteous, effective, and efficient public transit service. These rules address

employee conduct, operating information, entry to right-of-way, emergencies, and systems failure resolutions.

The information contained within this Rule Book assisted the Research Team in its LRT system survey.

3. California Traffic Control Devices Committee, Light Rail Safety Subcommittee. *Light Rail Traffic Manual.* (June 1994) 24 pp.

This manual assembles (for easy reference) the basic signals, signs, markings, and other information related to the operation of light rail systems in semi-exclusive and non-exclusive environments. It is intended to assist those involved in the planning, design, and operation of light rail systems. Further, the intent of this manual is to enhance safety by providing information to facilitate the orderly and predictable movement of all traffic, including light rail, throughout the public highway system, and to provide such guidance and warnings as may be needed to ensure the safe and informed operation of individual elements of the traffic stream.

The information contained in this manual assisted the Research Team in developing a draft section of the *MUTCD* which includes recommendations concerning signs and pavement markings, signals and gates, and pedestrian crossing control systems at or near LRT grade crossings (Task 5).

4. Federal Highway Administration, Department of Transportation. *Manual on Uniform Traffic Control Devices.* Washington, DC (1988), v.p.

This manual sets forth the basic principles that govern the design and usage of traffic control devices for different classes of road and street systems. These devices include "signs, signals, markings, and devices placed on, over, or adjacent to a street or highway by authority of a public body or official having jurisdiction to regulate, warn, or guide traffic."

The Research Team was primarily interested in Part VIII (Traffic Control Systems for Railroad-Highway Grade Crossings) and has worked to provide materials for possible use in the *MUTCD.* The Research Team has prepared a draft section that includes recommendations concerning signs and pavement markings, signals and gates, and pedestrian crossing control systems at or near LRT grade crossings (Task 5).

5. Federal Highway Administration, Department of Transportation. *Traffic Control Devices Handbook.* Washington, DC (1983), pp. 8-1 to 8-81.

Part VIII of this handbook addresses the selection, operation, installation, and maintenance of railroad-highway grade crossing traffic control devices. Its purpose is to assist the personnel involved so as to ensure safety and efficiency within the railroad crossing environment.

The information contained in Part VIII of this handbook assisted the Research Team in developing a draft section of the *MUTCD* which includes recommendations concerning signs and pavement markings, signals and gates, and pedestrian crossing control systems at or near LRT grade crossings (Task 5).

6. Federal Transit Administration, Department of Transportation. *Safety Management Information Statistics 1992 Annual Report.* Washington, DC (June 1994), 48 pp.

This report is a compilation and analysis of mass transit accident and casualty statistics reported by transit systems in the United States during 1992. The data are presented in trends, graphs, and tables.

The statistics and analysis provided background information for the accident analysis performed in Task 3 of TCRP, Project A-5.

7. Heathington, K. W., Richards, S. H., and Fambro, D. H. "Guidelines for the Use of Selected Active Traffic Control Devices at Railroad-Highway Grade Crossings," *Transportation Research Record 1264.* Transportation Research Board, National Research Council, Washington, DC (1990) pp. 50-59.

This paper summarizes field studies that assessed the effects of two traffic control devices (chosen following a detailed laboratory study) on driver behavior and safety at typical grade crossings. The two devices evaluated were: 1) four-

quadrant gates with skirts and flashing light signals; and 2) highway traffic signals with white bar strobes in all red lenses. The authors then developed guidelines for using these devices under various field conditions.

This paper described a field study similar to that which may be used in Phase II of TCRP, Project A-5, thus assisting the Research Team in preparing the research plan for Phase II (Task 7). In addition, the guidelines developed acted as a foundation for portions of the TCRP, Project A-5 research effort.

8. Hoey, W. F. and Levinson, H. S. "Signal Preemption by Light Rail Transit: Where Does It Work?" Institute of Transportation Engineers, 59th Annual Meeting, *Compendium of Technical Papers.* San Diego, CA (1989), pp. 330-334.

This paper sets forth principles to be used when planning LRT lines with signal preemption. The text begins with an overview of LRT operations and the historic development of LRT signal preemption. Following a discussion of the current practices and their limitations, the authors then present their recommendations for successful LRT signal preemption.

The information presented in this paper assisted the Research Team in identifying situations where LRT signal preemption might solve existing conflicts. The authors highlighted several key factors affecting the success of LRT signal preemption: LRV lane reservation, passenger demand, parallel street traffic, cross

street traffic, turns across the LRT tracks, availability and volume/capacity status of parallel streets, and density of residential development.

9. Illuminating Engineering Society of North America. *American National Standard Practice for Roadway Lighting.* New York (1983), 53 pp.

This Standard Practice serves as the basis for design of fixed lighting for roadways, bikeways, and pedestrian ways. The Standard Practice deals entirely with lighting and does not give advice on construction practice. It is neither intended as, nor does it establish a legal standard for roadway lighting systems. Its purpose is to provide recommended practices for designing new roadway lighting systems, and it is not intended to be applied to existing lighting systems until such systems are redesigned. Variations may be considered from this Standard Practice based upon sound engineering judgment.

This Standard Practice was referenced in all applicable recommendations put forth by the Research Team.

10. Institute of Transportation Engineers Committee 4D-2. *Proposed Guidelines for Light Rail Transit Signal Indications.* Washington, DC (July 1994), 2 pp.

These guidelines address the shape, color, indication, convention, size, and location of LRT signals. They are intended to be applicable to those agencies

with new or planned light rail systems, or those agencies planning to upgrade their existing systems.

For the most part, the guidelines proposed by the Research Team are consistent with those put forth by ITE Committee 4D-2.

11. Institute of Transportation Engineers Committee 6A-42. *Final Report: LRT Grade Separation Guidelines.* Washington, DC (June 1, 1990), 40 pp.

ITE Committee 6A-42 focused upon the question of when or when not to grade separate light rail transit operations. This report describes work which has been done to date and draws conclusions which can be used as guidelines for light rail planning and design. The committee suggests using threshold average daily cross street traffic (ADT) ranges as initial screening criteria to assist in the determination of at-grade operational feasibility. However, the committee's recommendations are applicable only at the conceptual design level; site-specific detailed analyses must be performed prior to final grade separation decisions. This report also describes the different LRT grade crossing situations identified by ITE Committee 6A-42, reviews current analytical techniques, and examines the results of such analyses.

Although TCRP, Project A-5 concentrates on at-grade LRT operations, the Research Team found it useful to examine those situations when grade-

separation became necessary. The synopsis of current techniques for analyzing LRT crossings also proved extremely informative.

12. Institute of Transportation Engineers Committee 6Y-37. *Final Report: Guidelines for Design of Light Rail Grade Crossings.* Washington, DC (July 30, 1990), 96 pp.

This report summarizes the work and key findings of ITE Committee 6Y-37. The objective of ITE Committee 6Y-37 was to review traffic engineering experiences and procedures for light rail transit systems throughout North America, and develop guidelines for the design of at-grade light rail crossings. This report first describes the activities of related committees and then presents a detailed explanation of the survey methodology. A brief description of each light rail system and findings (i.e., problems, potential solutions, and the relationship of crossing type to traffic volumes and crossing control/LRV priority) is provided as well as a series of potential solutions. This report also includes a description of the questionnaire data base and recommendations for action and further research.

Because some of the work performed by ITE Committee 6Y-37 parallels the research undertaken in TCRP, Project A-5, this report was extremely valuable to the Research Team. For example, for its system survey, the Research Team used a modified version of the questionnaire prepared by ITE Committee 6Y-37.

Also, the findings and conclusions of ITE Committee 6Y-37 support those of the Research Team.

13. Institute of Transportation Studies. "Special Report: Pedestrian Safety." *Tech Transfer*, No. 45 (April 1994), pp. 2-7.

This report contains several articles describing the California pedestrian safety plan, sources of local funding for pedestrian safety programs, and two pedestrian enhancement projects, one of which has been awarded ISTEA funds and another which is awaiting approval. An annotated bibliography of recent publications addressing pedestrian safety issues is also included with this report.

The articles in this report assisted the Research Team by identifying some of the pedestrian safety concerns of local and state agencies. In addition, the annotated bibliography provided an excellent resource for further literature review.

14. Korve, H. W., Bates, J. M., and Markowitz, F. "Development of Standards on Traffic Control Devices for LRT Grade Crossings." Institute of Transportation Engineers, 59th Annual Meeting, *Compendium of Technical Papers.* San Diego, CA (1989), pp. 326-329.

This paper focuses on the lack of U.S. standards for traffic control devices for LRT grade crossings. After describing some potential problems associated with current practices, the authors present European solutions to these difficulties.

Since state regulations for LRT crossings are uncommon, the authors recommend that uniform national standards be developed, per the criteria provided in the FHWA *Traffic Control Devices Handbook.*

The issues discussed in this paper were analogous to the goals of the Research Team. The problems described by the authors agreed with the findings of the Research Team, and the solutions presented helped the team to formulate recommendations for standard traffic control devices.

15. Korve, H. W. and Jones, M. M. "Overview of Light Rail At-Grade Crossing Operations in Central Business District Environments," *Transportation Research Record 1433.* Transportation Research Board, National Research Council, Washington, DC (1994) pp. 134-142.

This paper provides an overview of current and future at-grade operations issues being addressed by LRT agencies in 15 North American cities, where at least a portion of downtown service is supplied at-grade. The nature of intersection conflicts and their solutions as well as future at-grade crossing issues and proposed strategies were discussed. The effects of increased service levels and LRT construction programs on future LRT at-grade crossings were also evaluated. Finally, the authors proposed policy changes that centered on considering at-grade crossing strategies during the preliminary stages of LRT planning efforts.

The information obtained from the various LRT properties provided background information on system characteristics that may contribute to both existing and future at-grade crossing constraints. Since the ten systems studied for TCRP, Project A-5 were included among the agencies contacted in this study, this paper served as an excellent reference. The fact that the issues were presented from the point-of-view of the individual transit agencies was particularly helpful and assisted the Research Team in assembling detailed system descriptions and developing conflict solutions.

16. Levinson, H. S. "Capacity Concepts for Street Running Light Rail Transit." Second International Symposium on Highway Capacity, Sydney, Australia, *Proceedings.* Australian Research Board Limited and Transportation Research Board (August 1994).

This paper reviews streetcar and LRT ridership and operating experience. It then develops general approaches to capacity that build upon the basic relationships contained in the 1985 HCM for two basic conditions: (1) operation of conventional streetcars and (2) LRT operating in trains. For the latter condition, it suggests that the capacity is the lesser of (a) that based on signal green time, station dwell times, and train clearance times, and (b) that based upon a maximum of one train every other cycle.

This paper provided input to the guidelines developed by the Research Team.

17. Levinson, H. S. "Street-Running Rail Transit: A Historical Perspective," presented at Annual Meeting Transportation Research Board. Washington, DC (January 25, 1995).

The paper sets forth the strengths and weaknesses of street-running rail transit. It gives examples of where streetcar lines, interurban electric railways, and rapid transit lines relocated sections of route to private rights-of-way to improve safety, travel times, and reliability. It indicates that it is generally important to avoid (or minimize) street-running today, since there are more potential conflicts among autos, buses, pedestrians and trains, and since there is a need to maximize speeds and reliability. Street-running in the CBD generally should be viewed as a first stage that leads to incremental transitions to reserved rights-of-way. The goal is to plan for and provide off-street or reserved operations as soon as possible and as resources permit. By showing the experiences of various transit systems in an historical perspective, the paper identifies techniques that may be applicable to current rail transit development.

This paper provided input to the guidelines developed by the Research Team.

18. Mass Transit Administration. *Central Light Rail Line: Interim Rules and Instructions for Employees.* Baltimore (August 1991), 54 pp.

The rules and instructions contained within this book are intended to guide employees in the performance of their duties and to insure reliable, clean, safe,

and courteous transit service. These rules address employee conduct, operating procedures, signals and interlockings, electric power, communications, and operations by other railroads.

The information contained within this book assisted the Research Team in its LRT system survey.

19. Massachusetts Bay Transportation Authority. *Rules for Operators and other Employees of the Light Rail Lines.* Boston (August 1992), 134 pp.

The rules contained within this book are intended to provide safe, reliable, and efficient public transportation service. These rules address employee conduct, operating information, emergencies, and inspections.

The information contained within this book assisted the Research Team in its LRT system survey.

20. Meadow, L. J. "Los Angeles Metro Blue Line Light Rail Safety Issues," *Transportation Research Record 1433.* Transportation Research Board, National Research Council, Washington, DC (1994) pp. 123-133.

This paper describes some general safety issues associated with light rail transit operations but focuses on the problems experienced on the Los Angeles Metro Blue Line (MBL) and the measures implemented to alleviate those difficulties. An

overview of the system is provided, followed by a detailed discussion of the grade crossing safety program.

Since the MBL is one of the properties studied in TCRP, Project A-5, this paper was useful because it described the safety issues experienced and addressed by the transit agency itself. The photo enforcement program and the proposed use of four-quadrant gates and illuminated warning signs were of particular interest.

21. Niagara Frontier Transit Metro System, Inc. *Rail System Rule Book.* New York (March 1991), 82 pp.

The rules contained in this book govern the conduct and performance of all NFT Metro employees. These rules address employee behavior, operating information, equipment, signals, electric power, and normal and special train operations.

The information contained within this Rule Book assisted the Research Team in its LRT system survey.

22. Public Utilities Commission. *Safety Rules and Regulations Governing Light Rail Transit, General Order 143-A.* State of California (June 7, 1991), 27 pp.

General Order 143-A lists the rules and regulations that have been adopted for LRT in California. This order governs LRT infrastructure, from required equipment

to construction of LRVs, as well as operations. Provisions for historical streetcars and reporting requirements are also included.

The recommendations offered by the Research Team followed the rules and regulations presented in General Order 143-A when applicable. For example, the Draft MUTCD Part VIII Section E utilizes the maximum speed guidelines set forth by the CPUC.

23. Raglan, D. R., Hundenski M. J., Holman, B. L., and Fisher, J. M. "Transit Volume and Collisions Involving Transit and Non-transit Vehicles." *Accident Analysis and Prevention,* Vol. 24, No. 5 (1992).

This study reports an analysis of collisions occurring between public transit vehicles operated by the San Francisco Municipal Railway System (MUNI), the public transit agency for the City of San Francisco, and non-transit vehicles. The analysis, focusing on weekday collisions during 1987, demonstrated a strong association between hourly transit collisions rates and hourly traffic volume. The collision rate varied from 0.01 per 1,000 MUNI vehicle-hours of operation during the interval 5 A.M. to 6 A.M., a time of very low traffic volume, to 0.93 (approximately 1 collision per 1,000 MUNI vehicle-hours of operation) during the interval 5 P.M. to 6 P.M., a time of very high traffic volume. Using a power function to predict either the total number of collisions, or the rate of collisions per 1,000 MUNI vehicle-hours, almost 90% of total variance was accounted for by traffic volume. A similar pattern was found for collisions judged either avoidable

or unavoidable. A peak in the collision rate between 2 A.M. and 3 A.M. could not be accounted for by traffic volume alone. That peak occurred in the one-hour interval following the 2 A.M. closing of bars in San Francisco and was composed entirely of a sharp increase in unavoidable collisions. Increasing traffic volume appeared to operate through two mechanisms: (1) an increase in the number of opportunities for a collision, defined as a quantity proportional to the product of the number of MUNI and non-MUNI vehicle, and (2) an increase in the probability of a collision occurring between any given pair of vehicles.

This report provided inputs to some of the safety analysis proposals identified in the research.

24. Regional Transit. *Rail Operations Rules.* Sacramento (April 1991), 53 pp.

The rules contained within this book address employee conduct, train operations, signals, switches, speed, emergencies, radio procedures, and wayside operations.

The information contained within this book assisted the Research Team in its LRT system survey.

25. San Diego Trolley, Inc. *Rules for Employees.* San Diego (July 1989), 63 pp.

The rules and instructions contained within this book are intended to govern the performance and conduct of employees and to guide employees in their

performance of their duties. These rules address general behavior, train operations, signals and interlockings, special operations, electric power, and communications.

The information contained within this book assisted the Research Team in its LRT system survey.

26. San Francisco Municipal Railway. *MUNI Metro Light Rail Operations: Rules and Regulations.* San Francisco (March 1984), 159 pp.

The rules contained within this book address employee conduct, troubleshooting, emergencies, and various types of operations.

The information contained within this book assisted the Research Team in its LRT system survey.

27. Santa Clara County Transportation Agency. *Light Rail Operating Rule Book.* California (May 1989), v.p.

The rules contained within this book address employee conduct, radio procedures, signals, switches, signs, emergencies, troubleshooting and various types of operations.

The information contained within this Rule Book assisted the Research Team in its LRT system survey.

28. Southern California Rapid Transit District. *Metro Blue Line Rail Operations Rule Book.* California, 75 pp.

This Rule Book contains the rules necessary to ensure safe, reliable, and friendly service. These rules address employee conduct, equipment, normal and special train operations, and traction power, signals, and switches.

The information contained within this Rule Book assisted the Research Team in its LRT system survey.

29. Southern California Rapid Transit District. *Standard Operating Procedures for the RTD Blue Line.* California (September 1991), 75 pp.

The Standard Operating Procedures manual contains instructions explaining operation, performance, and procedural responsibility for the Metro Blue Line. It also provides additional information covering the various systems, components, and sub-system functions and interactions.

The information contained within this manual assisted the Research Team in its LRT system survey.

30. Tidwell, J. E. and Doyle, D. *Driver and Pedestrian Comprehension of Pedestrian Law and Traffic Control Devices.* AAA Foundation for Traffic Safety, Washington, DC (December 1993), 24 pp.

This study attempted to measure pedestrian and driver knowledge of proper pedestrian/motorist interaction and to determine the degree that the general public understands traffic control devices established for safe interaction of vehicles and pedestrians. The authors developed a questionnaire which was distributed through driver license examination stations in the 48 contiguous states as well as to participants in the American Association of Retired Persons defensive driver training courses. The results of the study indicated significant lack of knowledge on the part of the respondents on several pedestrian safety issues. The Research Team subsequently recommended guidelines for pedestrian safety programs, revisions to current sign protocols, and future research issues.

The information contained in this study was useful in both the study of LRT/pedestrian conflicts and the development of recommendations for pedestrian crossing control systems. In particular, the survey results assisted in the development of several new signs which are being suggested as part of TCRP, Project A-5.

31. Transportation Research Board, National Research Council. "Light Rail Transit: Planning, Design, and Implementation," *Special Report 195.* Washington, DC (1982), 175 pp.

This special report contains the papers prepared for and delivered at the Third National Conference on Light Rail Transit, held in March 1982 in San Diego, CA. The papers provide an overview of light rail transit and policy and planning concerns, addressing issues such as institutional arrangements, community and citizen participation, feasibility factors, development constraints, and energy considerations. In addition, the papers examine engineering design of LRT fixed facilities and railcar technology as well as operating issues such as surface operations, self-service fares, intermodal services, and general traffic concerns.

Because this report focused on technical and institutional issues that are unique to light rail transit, it provided the Research Team with an overview of the wide range of concerns associated with LRT. The papers addressing surface operations, design factors and considerations, and traffic impacts were particularly useful.

32. Transportation Research Board, National Research Council. "Light Rail Transit: System Design for Cost-Effectiveness," *State-of-the-Art Report 2.* Washington, DC (1985), 240 pp.

This report contains the majority of the papers presented at the Fourth National Conference on Light Rail Transit (1985) as well as several presented at the TRB 1985 Annual Meeting. The papers provide an overview of the cost-effectiveness aspects of LRT design, including systems, construction, operation, and vehicles.

Several papers contained in this record focused on issues directly related to the research efforts of TCRP, Project A-5. Topics such right-of-way design and on-street operations were of particular interest.

33. Transportation Research Board, National Research Council. "Light Rail Transit: New System Successes at Affordable Prices," *Special Report 221.* Washington, DC (1989), 667 pp.

This special report contains the papers presented at the Fifth National Conference on Light Rail Transit, held in March 1988 in San Jose, CA, as well as six additional papers submitted to TRB. The papers provide an overview of recent worldwide light rail developments, including the status of new LRT systems and the lessons learned. In addition, topics such as policy and planning considerations, systems design, new vehicle performance, and operations and maintenance were covered.

Several papers contained in this record focused on issues directly related to the research efforts of TCRP, Project A-5. Topics such as system design and at-grade crossings were of particular interest. The papers covering new LRT properties provided significant assistance in the system inventory conducted by the Research Team.

34. Transportation Research Board, National Research Council. "Light Rail Transit: Planning, Design, and Operating Experience," *Transportation Research Record 1361.* Washington, DC (1992), 359 pp.

This record contains the technical papers presented at the Sixth National Conference on Light Rail Transit, held in May 1992 in Calgary, Alberta, Canada, as well as two papers presented at a TRB Annual Meeting. The papers provide a comprehensiVe overview of current LRT developments, including descriptions of major LRT systems, planning and finance issues, management and staffing concerns, design and engineering considerations, operations and maintenance topics, and vintage trolley operations.

Several papers contained in this record focused on issues directly related to the research efforts of TCRP, Project A-5. Topics such as system design, urban operations, signal control, and grade crossing control were of particular interest. The paper by H. W. Korve and P. M. Wright on guidelines for traffic control devices for at-grade LRT crossings which was included in this record provided significant assistance in the development of similar recommendations for TCRP, Project A-5.

35. Tri-County Metropolitan Transportation, District of Oregon. *Metropolitan Area Express Rail Operations Rule Book.* Oregon (March 1994), 62 pp.

This Rule Book contains the current body of Tri-Met's Rail Operations rules. It has been designed for three purposes: (1) to identify Tri-Met's operating practices and standards; (2) to aid in the instruction of these practices; and (3) to serve employees as a reference manual whenever questions arise on the correct course of action.

The information contained within this Rule Book assisted the Research Team in its LRT system survey.

36. Tri-County Metropolitan Transportation, District of Oregon. *Standard Operating Procedures Manual.* Oregon (September 1992), v.p.

This manual contains instructions that explain how to perform the duties of Rail Transportation employees and is to be used in conjunction with the *Rail Operations Rule Book.* It may also provide background on various elements of the Tri-Met system.

The information contained within this manual assisted the Research Team in its LRT system survey.

37. U.S. Architectural and Transportation Barriers Compliance Board. *Americans with Disabilities Act Accessibility Requirements.* Washington, DC (December 1991), 5 pp.

This document is an overview in tabular form of accessibility requirements, effective dates, regulations, and enforcement of Titles I-IV of the Americans with Disabilities Act.

The Research Team was primarily interested in Title II-B, which focuses on accessibility requirements for transportation facilities. Recommendations made by the Research Team incorporated these provisions.

38. Verband Öffentlicher Verkehrsbetriebe (VÖV). *Verordnung über den Bau- und Betrieb der Straβenbahnen (Straβenbahn-Bau- und Betriebsordnung-BOStrab).* Germany (December 1987), 123 pp.

The information contained within this book assisted the Research Team in its LRT system survey. This book also assisted the Research Team in developing a draft section of the *MUTCD* which includes recommendations concerning signs and pavement markings, signals and gates, and pedestrian crossing control systems at or near LRT grade crossings (Task 5).

39. Vuchic, V. R. *Urban Public Transportation, Systems and Technology.* Prentice-Hall (1981), v.p.

This book presents definitions, descriptions, and analyses of transit systems and technology, focusing on the physical systems and predominantly engineering aspects. The text begins with a history of the development of transit and its

impact on urban development. Definitions and the theory of urban passenger transport modes are then presented, followed by a description of the various transit modes and their roles in urban transportation. Physical and mechanical theories and analyses (e.g., traction, vehicle motion, etc.) are also covered. The detailed descriptions and analyses of the different transit modes center on their technical/operational complexities and their relative roles in urban transportation. System performance is discussed with both theoretical analyses and empirical data, with an emphasis on capacity. Finally, the book reviews paratransit and specialized technologies with limited roles as transit carriers.

Through its use of practical examples and applied models, the book provided a comprehensive look at the basic concepts and facts about actual, real-world transit systems. The chapter focusing on rail technology modes served as an excellent resource for the Research Team. The detailed account of the different types of right-of-way was particularly useful.

The following log describes the on-site surveys conducted at the ten LRT systems analyzed as part of Task 2. A sample interview guide is included at the end of this appendix.

BALTIMORE, MARYLAND

The Research Team surveyed the Baltimore Light Rail Transit System (operated by Maryland Mass Transit Administration (MTA)) on August 11 and 12, 1994. The forward LRV cab video was shot on Thursday, August 11, 1994, and the interview with MTA staff was conducted on Friday, August 12, 1994. The meeting attendance included:

- **Joe Love**, Manager of Maintenance Engineering Division, MTA (Primary Contact for TCRP, Project A-5)
- Derek A. Jones, Superintendent, Systems Maintenance, MTA
- Jerry W. Flanders, General Superintendent, Systems Maintenance, MTA
- James E. Price, Superintendent, Rail Car Maintenance, MTA
- Betty G. Donaldson, Chief Supervisor, Light Rail Transportation, MTA
- Robert J. Herstein, Section Chief, State Highway Administration, Maryland Department of Transportation
- Frank J. Murphy, P.E., Engineer Supervisor, Traffic Division, City of Baltimore

BOSTON, MASSACHUSETTS

The Research Team surveyed the Boston Light Rail Transit System (operated by Massachusetts Bay Transportation Authority, the "T") on August 18 and 19, 1994. The

forward LRT cab video was shot on Thursday, August 18, 1994, and the interview with the "T" staff was conducted on Friday, August 19, 1994. The meeting attendance included:

- **Donald A. Smith**, Jr., Chief, Green Line Operations (Primary Contact for TCRP, Project A-5)
- Alan H. Castaline, Chief Planning Officer
- John K. Weiser, Staff Engineer

BUFFALO, NEW YORK

The Research Team surveyed[1] the Buffalo Light Rail Transit System (operated by the Niagara Frontier Transportation Authority) on Thursday, July 28, 1994. The meeting attendance included:

- **David P. Rugg**, Manager, Operations Safety (Primary Contact for TCRP, Project A-5)
- James R. Nagle, Sr., Manager, Rail Maintenance
- Daniel L. Hall, Train Control Supervisor

CALGARY, ALBERTA (CANADA)

The Research Team surveyed the Calgary Light Rail Transit System (operated by Calgary Transit) on August 4 and 5, 1994. The forward LRV cab video was shot on

[1] "Survey" indicates that both the forward LRV cab videotaping and the interview were conducted.

Thursday, August 4, 1994, and the interview with Calgary Transit staff was conducted on Friday, August 5, 1994. The meeting attendance included:

- **Greg Hull**, Superintendent of Safety and Training (Primary Contact for TCRP, Project A-5)
- Tom Williams, Supervisor, Signals and Power
- Shawn Curran, Signals Services Supervisor
- Ahmad Radmanesh, Traffic Signal System Engineer

LOS ANGELES, CALIFORNIA

The Research Team conducted the forward LRV cab video taping of the Los Angeles Light Rail Transit System's Blue Line (operated by the Los Angeles County Metropolitan Transportation Authority (LACMTA)) on Thursday, June 30, 1994. The interview with LACMTA staff occurred on Friday, August 26, 1994. The meeting attendance included (from LACMTA unless otherwise noted):

- **Linda J. Meadow**, System Safety Manager (Primary Contact for TCRP, Project A-5)
- Harold E. Storey, Manager, Operations System Safety
- Rita Malone, Rail Transportation Division Manager
- Vijay Khawani, Manager, Operations and Maintenance Safety
- J. Byrd
- R. Torres
- W. Jones
- R. Francis

- J. Armstrong
- B. Moore
- R. Townley, Rail Construction Corps
- J. Kennedy, Los Angeles Department of Transportation
- L. Bass, City of Long Beach
- Jim Curry, Engineering Management Consultant
- K. Hansen, City of Compton
- K. Kirby, County of Los Angeles

PORTLAND, OREGON

The Research Team surveyed the Portland Light Rail Transit System (operated by Tri-County Metropolitan Transportation District of Oregon (TRI-MET)) on Thursday, July 7, 1994. The meeting attendance included:

- **Terry Dolan**, Assistant Manager, Rail Transportation (Primary Contact for TCRP, Project A-5)
- Ron Higbee, P.E., Engineering Services Director, Technical Services Division
- Gerald Fox, Rail Corridor Design Manager
- Gregg Weston, P.E., Engineering Supervisor
- Bob Banks, Project Engineer, Signals
- Harold C. Juram, Rail Operations Planning Manager
- Harry Saporta, Safety Manager
- Cork Jennings, Maintenance of Way Manager
- Mike Bauer, City of Portland, Traffic Engineering

SACRAMENTO, CALIFORNIA

The Research Team surveyed the Sacramento Light Rail Transit System (operated by Sacramento Regional Transit District) and met with SCRTD staff on Thursday, June 2, 1994. The meeting attendance included:

- **Paul O'Brien**, Light Rail Manager (Primary Contact for TCRP, Project A-5)

The Research Team also interviewed the City of Sacramento, Department of Public Works, Traffic Engineering Division on Wednesday, June 15, 1994. The meeting attendance included:

- Dennis R. Murphy, Signal Engineer

SAN DIEGO, CALIFORNIA

The Research Team surveyed the San Diego Light Rail Transit System (operated by the San Diego Trolley, Inc.) on Thursday, June 9, 1994. The meeting attendance included:

- **Peter D. Tereschuck**, Vice President of Operations (Primary Contact for TCRP, Project A-5)

SAN FRANCISCO, CALIFORNIA

The Research Team interviewed the San Francisco Light Rail Transit System staff (San Francisco Municipal Railway) on Friday, June 10, 1994. The meeting attendance included:

- **Peter Straus**, Director of Service Planning (Primary Contact for TCRP, Project A-5)
- Kathleen R. Gilbert, Deputy General Manager and Chief Transportation Officer
- Dan Rosen, Transportation Manager
- Duncan J. Watry, Transit Planner, Service Planning, Scheduling, and Data Services

The Research Team conducted the forward LRV cab video taping on Thursday, June 16, 1994.

The Research Team interviewed the San Francisco Department of Parking and Traffic, Traffic Engineering Division on Wednesday, July 6, 1994. The meeting attendance included:

- Bond M. Yee, P.E., City Traffic Engineer
- Jack Fleck, Traffic Engineer
- Javad Mirabdal, Transportation Planner

SAN JOSE, CALIFORNIA

The Research Team conducted the first survey of the San Jose Light Rail Transit System (operated by the Santa Clara County Transportation Agency (SCCTA)) on Friday, March 4, 1994. The meeting attendance included (from SCCTA unless otherwise noted):

- **John Elson**, Senior Transportation Engineer (Primary Contact for TCRP, Project A-5)
- Art Taylor, Manager of Central Maintenance

- Michael T. Flanigon, Way, Power, and Signals Superintendent
- Bob Murphy
- Odila Nielsen
- Alf Bennett
- Terry Sawuel, Light Rail Signal Supervisor
- Chuck O'Connor, Light Rail Control Supervisor
- Linda J. Meadow, System Safety Manager, Los Angeles County Metropolitan Transportation Authority
- Vijay Khawani, Manager, Operations and Maintenance Safety, Los Angeles County Metropolitan Transportation Authority
- Jim Curry, Engineering Management Consultant

The Research Team conducted the second forward LRV cab video taping on Thursday, May 19, 1994.

The Research Team re-interviewed the SCCTA staff on Wednesday, September 14, 1994. The meeting attendance included:

- John Elson, Senior Transportation Engineer
- Michael T. Flanigon, Way, Power, and Signals Superintendent