Appendix M Metro's Grade Separation Policy and Evaluation Study

ATTACHMENT A

MTA Grade Crossing Policy for Light Rail Transit

Draft Revised Policy
November 18, 2003

Metropolitan Transportation Authority

PURPOSE

The Grade Crossing Policy is intended to provide a structured process for the evaluation of potential grade separations vs. at grade operation along light rail lines. The policy recognizes the operational and safety issues of at-grade versus grade-separated solutions as well as the institutional and monetary implications. It is recognized that local, state and federal government officials are involved in the process as well as the communities along the light rail line and therefore, no rigid MTA policy can dictate the ultimate solution. However, the purpose of the policy is to provide a process that addresses all of the principal concerns and clarifies the trade-offs involved in grade separation decisions. Furthermore, the policy is intended to minimize the up-front costs associated with consideration of grade separations as well as minimizing the likelihood of unanticipated consequences such as budgeting for an at-grade solution when a grade separation would ultimately be required.

This policy prescribes both the overall review process as well as the specific technical studies that would be accomplished within the review process. (Refer to the attached Appendix for a list of definitions of traffic engineering technical terms incorporated in the policy as well as the technical support for the policy.)

This Policy does not address conditions at existing crossings; although some of the analysis procedures and indicated treatments can be applied to existing crossings, the intention of the Policy is to develop assessments of conditions at proposed grade crossings before they are constructed.

GRADE CROSSING REVIEW PROCESS

Figure 1 illustrates the overall review process. The policy includes up to three sequential phases of review and three corresponding Milestones would take place before arriving at the "Final Decision" on a crossing:

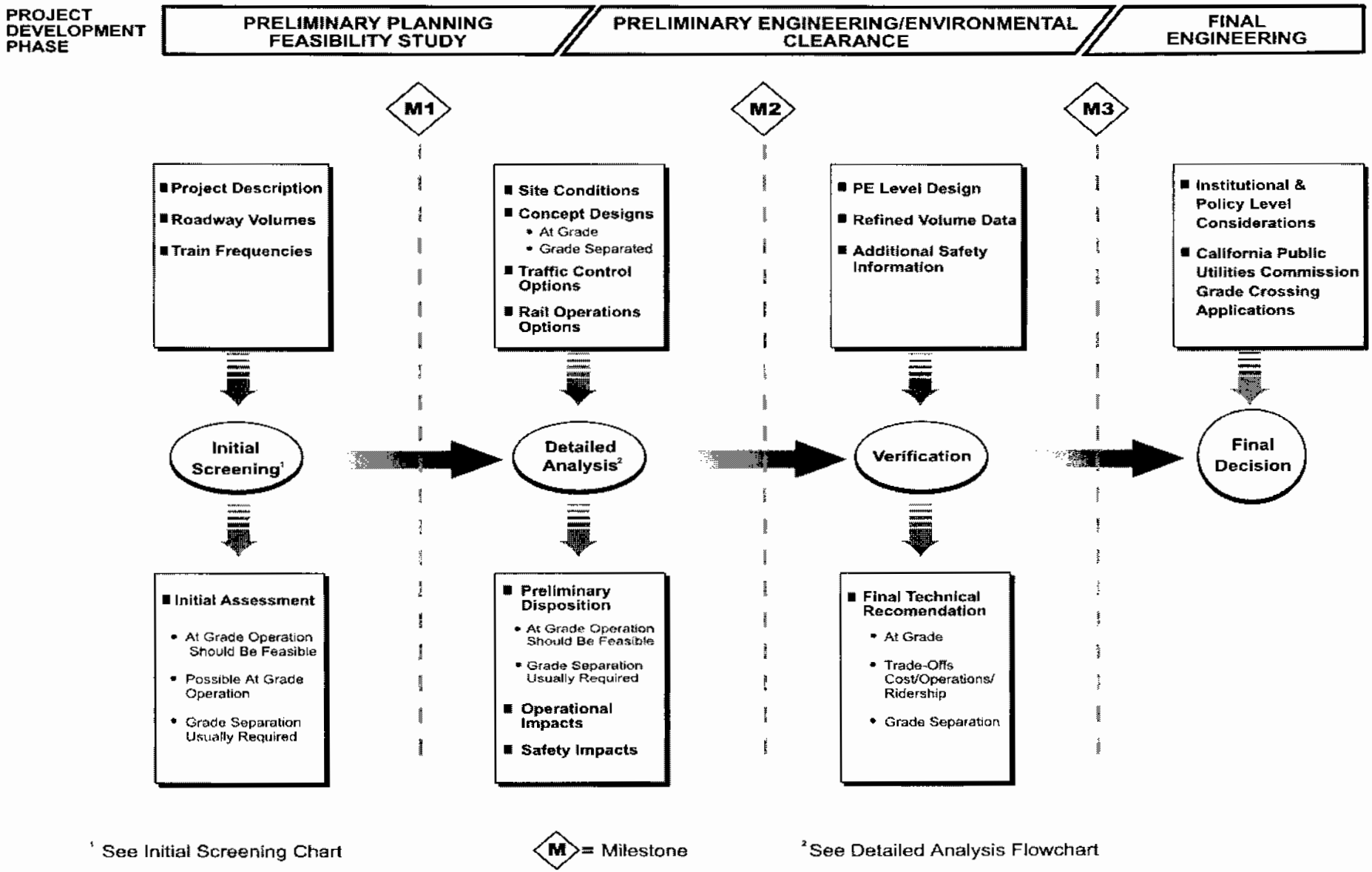
- Milestone 1 – Initial Screening – A preliminary, planning level assessment of the roadway crossings based upon readily-available, planning-level data for roadway volumes and train frequencies leading to an initial categorization of roadway crossings into three groups: "At Grade Should be Feasible", "Possible At Grade Operation", and "Grade Separation Usually Required".

- Milestone 2 – Detailed Analysis – A detailed operational evaluation taking into account peak period, movement-by-movement analysis of roadway traffic in conjunction with assessment of potential impacts to rail operations due to priority control. Provides more refined assessment of feasibility of at grade operation and also identifies operational trade-offs between roadway traffic conditions and rail operations. Also includes initial review of safety issues based upon site-specific evaluation of geometric conditions and observed and/or projected usage of the crossing. Results in a preliminary determination of locations that may be operated at grade versus grade-separated.

- Milestone 3 – Verification – This step includes the process of developing consensus regarding the proposed design solution with local constituencies including other involved agencies and the community as appropriate. This step may include preliminary engineering studies and cost estimates for alternative treatments. It may also include refinement of projected traffic volumes and validation of traffic and rail operations using simulation modeling. Finally, it may include additional effort on safety issues and countermeasures. At the conclusion of this milestone, it is expected that all technical studies will have been completed leading to a final recommendation by MTA for the crossing configuration.

As shown on the flowchart, Milestone 1 effort is usually accomplished during a preliminary planning feasibility study, Milestone 2 and 3 effort is usually accomplished during preliminary engineering and environmental clearance, and a final decision should be secured in conjunction with final engineering of the LRT Project.

Figure 1 – Light Rail Roadway Crossing Review Process



- Final Decision – Final disposition of the crossing configuration based upon all of the preceding technical analysis, engineering studies, and agency consensus building. The California Public Utilities Commission must approve of each grade crossing application under the provisions of General Order 75-C. Other third party agreements and requirements must be met.

The boxes across the top of Figure 1 shows the required inputs for each of the analysis phases and the boxes across the bottom of the chart indicate the information which is available following each step in the process.

The Policy presumes that the technical evaluations that are accomplished will be conducted in a cooperative fashion with involved jurisdictions including the local highway authority and the California Public Utilities Commission (CPUC). This cooperation would include obtaining available data regarding the proposed crossing locations, review of technical studies, and development of technical consensus regarding the issues and results.

In accordance with the degree of project development and the level of detail regarding the proposed LRT project, it is expected that the Initial Assessment (Milestone 1) would be prepared in conjunction with a Preliminary Planning Study or Conceptual Design Feasibility Study, and that the Detailed Analysis (Milestone 2) and Verification (Milestone 3) would be accomplished during the Preliminary Engineering (PE) / Environmental Clearance phase of project development.

In California, formal application under the provisions of General Order 75-C (for grade crossings in general) and in conformity to General Order 143-B (for light rail) needs to be approved prior to construction. This Policy presumes the formal CPUC process constitutes the "Final Decision", however, preliminary informal review of the proposed grade crossings with the CPUC staff should take place during Milestones 2 and 3 if not earlier. Obtaining a technical consensus with involved third parties during preliminary engineering is important so that a firm construction budget can be developed.

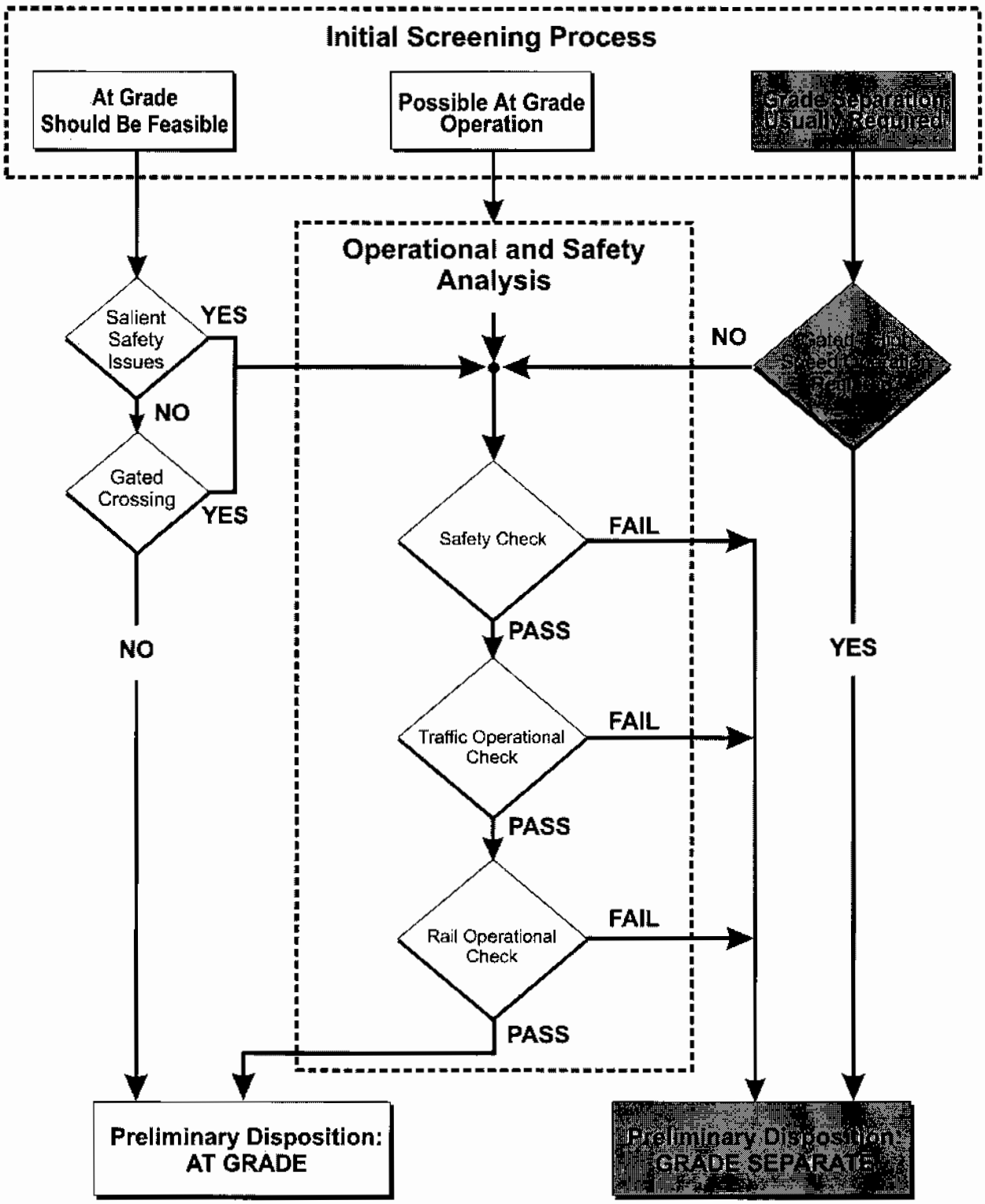
GRADE CROSSING REVIEW METHODOLOGY

Figure 2 provides a diagram that depicts the analysis process incorporated in the policy. As indicated at the top of the flowchart, the Initial Screening conducted as part of Milestone 1 will result in one of three outcomes. In many instances, the initial determinations for crossings screened as "At Grade Should Be Feasible" or "Grade Separation Usually Required" will be confirmed. However, for all crossings initially screened as "Possible At Grade Operation" as well as for certain conditions as depicted in the flowchart, and engineering study of operational and safety issues needs to be conducted as part of the detailed analysis leading up to Milestone 2, and the results of the engineering study may change the resulting outcome. Regardless of the analysis path selected, at the conclusion of the detailed analysis including engineering studies as required, the preliminary disposition of each crossing will be identified as either "At Grade" or "Grade Separate" at the conclusion of Milestone 2.

Specific analysis procedures for each milestone are further described in the text on the following pages.

(Refer to Appendix A for technical support for the methodology.)

Figure 2 – Evaluation Flowchart



MILESTONE 1 – INITIAL SCREENING

Input Data – Initial Screening:

The initial screening is based upon readily available planning-level information regarding the project description, roadway volumes and number of lanes, as well as train frequencies:

- Project Description Data – As a minimum, identifies all of the potential grade crossings or grade separations. (Conceptual designs are not needed for the Initial Screening.)

- Roadway Volumes and Number of Lanes – The Initial Screening is based upon the estimated peak hour per-lane volume of traffic crossing the alignment (highest directional volume). It is preferable to evaluate the year of opening volumes and the 20-year forecast volumes, if available. If these are not available, existing volume data factored to a future year may be used.

- Train Frequencies – The desired headways for train operation need to be identified. If operations planning has not been accomplished, train frequencies should be based upon comparable lines, or 6- minute headways (10 trains per hour each direction) can be assumed as a nominal frequency.

Methodology – Initial Screening:

Plot each roadway crossing on the Initial Screening Chart (Figure 3) to determine which of the three zones the crossing lies within. (Refer to the "Notes on Traffic Turning Data" in Appendix A for recommended handling of left-turn movements, if available.).

In the event a crossing lies very close to one of the two threshold lines, the crossing may be considered in the more restrictive category, since existing traffic counts are subject to day-to-day fluctuation and forecasts are estimates only.

Results – Initial Screening:

After the technical analysis has been completed, each crossing should be assigned to one of three categories:

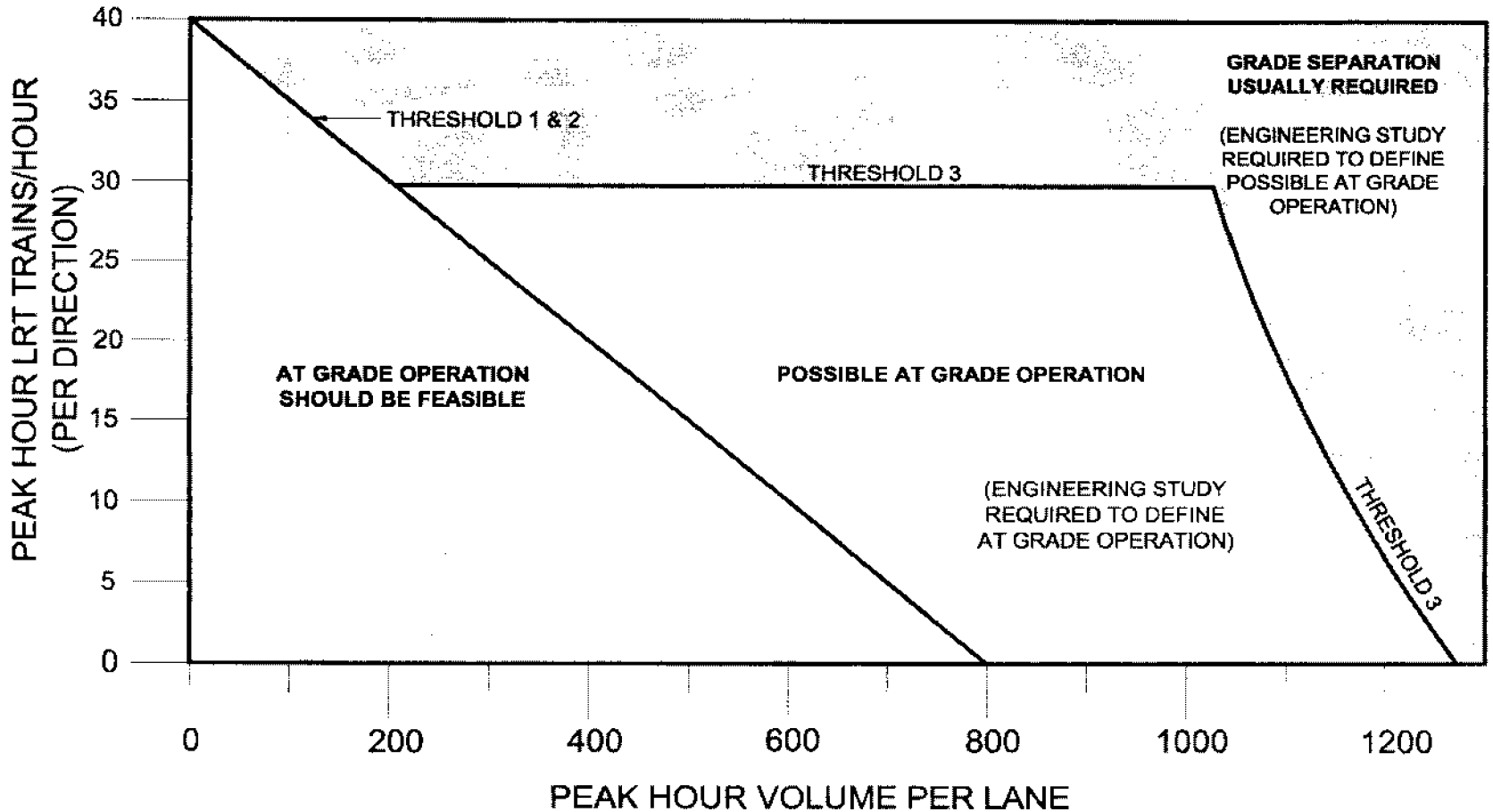
- At Grade Operation Should Be Feasible

- Possible At Grade Operation

- Grade Separation Usually Required

At this point in time MTA should share the results of the Initial Screening with third parties that may have comments on the data and results. Also, MTA should begin to identify and address other issues such as site-specific geometric issues, recurrent traffic queues, accident history, etc., that may indicate safety concerns over and above the traffic operational analysis.

Figure 3 – Nomograph for Initial Screening



NOTES:

- ROADWAY VOLUME IS PEAK HOUR, HIGHEST PER LANE FLOW RATE
- ADAPTED FROM INSTITUTE OF TRANSPORTATION ENGINEERS INFORMATIONAL REPORT, LIGHT RAIL TRANSIT GRADE SEPARATION GUIDELINES, 1992, THRESHOLD 1 AND THRESHOLD 2 COMBINED.

MILESTONE 2 – DETAILED ANALYSIS

Input Data – Detailed Analysis:

The Detailed Analysis phase utilizes all available planning information and includes conceptual design plans for the crossings. The following inputs are required:

- Site Conditions – Geometric and traffic operational conditions at the grade crossings should be identified. Geometric conditions includes the lane configuration of the crossing roadway back to and including the nearest signalized intersection or major intersection on either side of the crossing as well as driveways, curb delineation, channelization, or other features which could affect traffic operation in the vicinity of the crossing.

  From an operations perspective, considerations include the approach speeds of trains and roadway vehicles, accident history and observed risky behavior, recurrent queuing in the vicinity of the crossing, whether there is a background traffic signal progression along the cross street, pedestrian activity, or other unique operational conditions. The use of the roadway including whether it is a school bus route or along a pedestrian route to school, if used by a high percentage of heavy vehicles or vehicles carrying hazardous substances, or if the crossing is required to be used frequently by emergency response units should be identified.

  Other existing conditions to remain that could affect operations should be noted such as parallel freight rail lines that are to remain in operation with LRT.

- Concept Designs – The crossing geometry needs to be conceptually defined. This will include whether the crossing will be a "mid block" crossing or whether the LRT line will be median or side-running along an existing roadway intersecting with the cross street at the crossing. The number of tracks and the approximate track alignment is key. The concept design should also identify the proposed method of traffic control (e.g., gates or traffic signal with stop bars located).

  The location of the trackway and the roadway configuration, including any changes proposed in conjunction with provision of a grade crossing should be identified. This should include consideration of stop bar locations, and bicycle and pedestrian accommodations including the provision of appropriate "refuge zones" between roadway lanes and the trackway.

  The conceptual design plans should identify lane geometrics that can provide suitable operation with the LRT grade crossing. For example, for on-street alignments at intersections with traffic signal control, turn bays should be provided to hold traffic turning across the trackway. Left turn bays should also be provided where feasible on street running alignments at intersections on the cross street to accommodate track clearance for gated crossings and to preclude opposing left turns from "locking up" in the LRT median.

  In accordance with General Order 143-B of the CPUC, the allowable alignment speed will depend upon the degree of separation between a parallel roadway and the track alignment.

- Traffic Control Options (Including Safety Devices) – The detailed analysis will identify traffic control options, for which there are two principal choices under current regulations of the California Public Utilities Commission: (1) greater than 35 mph / 56 kph operation with traffic control using automatic crossing gates or (2) lower speed (35 mph / 56 kph or less) operation with a traffic signal used as the primary traffic control device. In most instances, gated crossings will also require pre-emption of traffic signals within the influence zone.[1] In addition to the primary means of traffic control, known supplemental traffic control, warning or safety devices that are proposed should be identified.

  If the crossing is signalized, the proposed signal phasing should be identified including necessary slot clearance provisions such as green extensions for downstream signal heads. In some cases, a range of alternative timing plans, including variations in cycle length may need to be reviewed to determine which provides the best operation. In addition, there are a number of possible traffic control strategies including "full priority", "partial priority", "green band", or "pre-emption". One or more options may be under consideration, which would lead to a number of possible grade crossing solutions, each with different traffic and rail operational results.

- Rail Operations Options – In addition to the intended train frequencies, the rail operations information should include the speed profile through the crossing, station dwell if there is an adjacent platform, and the proposed location of "hold points" if one of the operational considerations to obtain at-grade operation is accepting train delays.

Methodology – Detailed Analysis:

The flowchart previously shown in Figure 2 depicts the analysis process.

In many instances, an immediate assessment of the Preliminary Disposition of the crossing can be made (as indicated in the tracks to the extreme left and right hand sides of the flowchart:

- At Grade – If the Initial Screening was *"At Grade Should Be Feasible"*, and the crossing is proposed as a traffic signal controlled, "low speed" crossing, and there are no salient safety issues, then the result of the Detailed Analysis phase is "*Preliminary Disposition At Grade"*. Note that two additional decision points may trigger the operational and safety analysis shown in the middle track of the flow chart: 1) gated crossings, for which a queuing analysis needs to be performed to determine the need for traffic signal pre-emption or other queuing control techniques, and 2) locations where the site conditions or crossing usage indicates the need for safety review at this stage of the process.

- Grade Separation – If the Initial Screening indicated *"Grade Separation Usually Required"* and the crossing is proposed as a gated, crossing with pre-emption of adjacent traffic signal (if present) or unimpeded, "high speed" rail operations are required, then the result of the Detailed Analysis is *"Preliminary Disposition Grade Separated."* If, on the other hand, lower speed operation through the crossing with use of a traffic signal to control the crossing is acceptable, then as shown in the decision point, additional operational and safety analysis can be done for this alternate approach.

[1] Per the current requirements of the Manual of Uniform Traffic Control Devices (MUTCD) the influence zone is a minimum of 200 feet (60 m) but could be greater, depending upon engineering study of likely recurrent queuing into the grade crossing.

All other conditions, including all of the locations that were initially screened as "Possible At Grade Operation", will require "Engineering Study" consisting of an operational and safety analysis as described immediately below to be accomplished in order to make a determination as to whether the crossing could be operated at grade.

Traffic Operational and Safety Engineering Study Procedure:

The engineering study is a multi-step manual evaluation of the Level of Service of adjacent or co-incident traffic signal controlled intersections, queuing and other safety factors along with identification of impacts to rail operations including delays and patronage. Queuing analyses should take into account various operational scenarios including evaluation of the range of queuing anticipated given likely operational conditions, e.g., crossing gate blockage times may be longer with near-side stations. (Refer to Appendix A for a more detailed description of the process.)

1. Identify Operational Volumes – Review the traffic volume assumptions and make adjustments if appropriate.

2. Compute Influence Zone Queue – The influence zone queue is the queue which builds from an adjacent signalized intersection along the cross street towards the grade crossing (see Figure 4).

3. Compute Crossing Spillback Queue – The crossing spillback queue is the queue that builds back from the grade crossing towards an adjacent roadway-roadway intersection (see Figure 4).

4. Evaluate Cross Street Queues vs. Available Storage – The extent of queuing along the cross street should be compared to the roadway geometry to determine whether either the crossing spillback queue is impacting an adjacent major intersection or if an adjacent major intersection is generating an influence zone queue which would impact the grade crossing. Queuing can be determined by computation or, for existing conditions, by observation. In the event crossing queues are spilling back, mitigation measures are required. (Refer to Appendix A for specifics).

5. Evaluate Impact of Pre-Emption – In the event the crossing will be pre-empted, an evaluation of the impact on cross street vehicle platoons should be accomplished to verify the ability of the roadway to "recover" from pre-emption events.

   The analysis methodology requires four steps:

   - Step 1 – Identify Useable Green Ratio for Non-Compatible Phase
   - Step 2 – Adjust Useable Green Ratio to Reflect Train Frequency
   - Step 3 – Evaluate Base Case Volume/Capacity of Controlling Intersection
   - Step 4 – Apply V/C Adjustment

   The results of the numeric analysis (refer to Appendix for details) should be evaluated as shown in Table 1:

Table 1 – Criteria for Evaluating Impact of Pre-Emption on Cross-Street Progression

Adjusted Volume/Capacity Ratio Of Controlling Intersection (1)	Quality of Cross Street Progression (2)		
	Little or No	Moderate	High
V/C < 0.85	OK	OK	OK
0.85 <= V/C <= 0.95	OK	Marginal (3)	Marginal (3)
V/C > 0.95	Marginal (3)	Marginal (3)	Fail (4)

Notes:

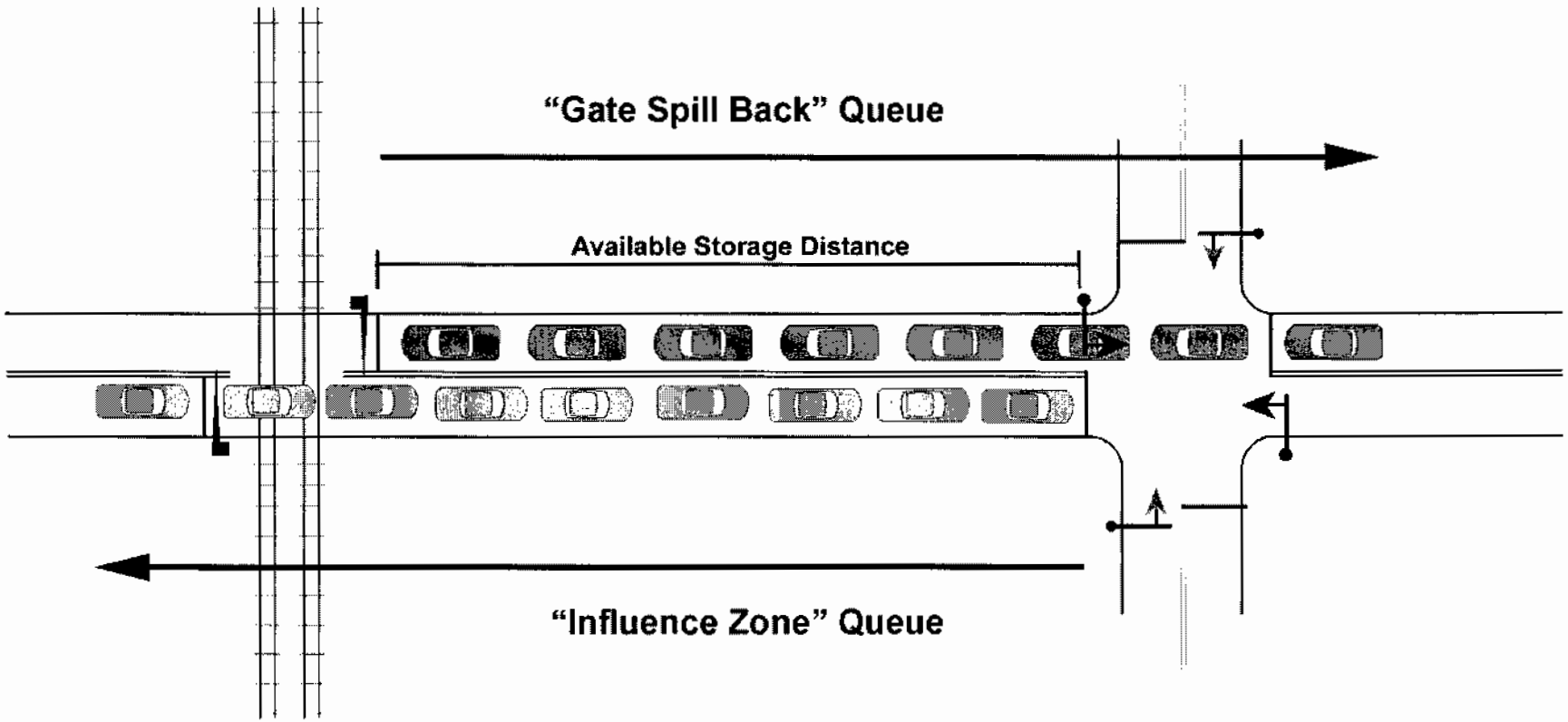
(1) "Controlling Intersection" is the cross street intersection within ½ mile proximity to the LRT grade crossing (including the LRT intersection for median-running conditions) which has the highest degree of saturation; the V/C of the controlling intersection should be adjusted for impact to non-compatible phase (see text for analysis procedure).

(2) Based upon "Arrival Type" definitions as provided in Highway Capacity Manual 2000: "High" is arrival type 5 or 6, "Moderate" is arrival type 4, and "Little or No" is arrival types 1 – 3.

(3) Indicates impact to cross streets; operation as gate-controlled crossing with pre-emption as required by Highway Capacity Manual 2000; however, operation with priority control with traffic signal should be feasible, subject to engineering review. Engineering review should take into consideration the need for maintaining progression along the cross street as well as any extenuating factors.

(4) Indicates significant adverse impact to cross streets; operation as gate-controlled crossing with pre-emption as required by Highway Capacity Manual 2000 inadvisable; location should be considered for grade separation, subject to engineering review.

Figure 4 – Grade Crossing Queues Illustrating Queue Overflow Beyond Capacity



6. Compute Controlling Intersection Level of Service (LOS) – The controlling intersection is the signalized intersection at the grade crossing or along the cross street within the influence zone (as identified in Step 2) which is the most congested during the peak period. The LOS of the controlling intersection provides an indication of the feasibility of transit priority solutions with traffic signal control at the grade crossing and whether the impact of operation as a gated crossing is feasible. (Refer to Appendix A for discussion of service levels.)

7. Safety Analysis

   As a standard practice, a safety review should be conducted for all grade crossings as part of the design of the project. However, for the purpose of determining the need for a grade separation, a safety analysis should be conducted for grade crossings where the decision to grade separate is questionable in order to determine whether adverse safety conditions, in conjunction with adverse operational conditions, would suggest a grade-separated solution.

   Given that there are a wide range of safety mitigations and design features which can be incorporated into the design of an LRT alignment; substantial experience has been gained with treatments over the past decade; and, substantial documentation of available measures and design treatments is readily available to designers, it is difficult to identify specific numeric thresholds for grade separation based purely on safety concerns without consideration for the effect of safety provisions proposed in conjunction with the at-grade design.[1]

   The factors presented in Table 2 should be considered in a preliminary safety review. Table 2 indicates potential mitigation for each identified safety concern. Engineering Study should be accomplished to determine which of the factors is a concern at the crossing, possible countermeasures, potential applicability, and effectiveness of potential mitigations.

   The recommended approach for conducting the safety review is to assemble a "diagnostic team" to field review the proposed crossing. The diagnostic team should include representation from MTA operations, MTA rail construction, MTA planning, the responsible local highway authority, and the CPUC. Procedures for conducting the field diagnostic review are provided in the federal Highway Grade Crossing Handbook.

   The Engineering Study of safety features should determine whether effective mitigations are available to address identified safety concerns. If mitigation is not possible, then a grade separation should be considered.

   (Refer to Appendix A for more discussion of the safety review and analysis.)

[1] Excepting recurrent queuing across the tracks that cannot be managed or eliminated with traffic control techniques.

Table 2 – Safety Concerns and Potential Mitigation

Safety Concern	Mitigation
Traffic Queuing	Anti-Queuing Traffic Control Measures; Grade Separation if None Feasible
Approach and Corner Sight Distance	Supplemental Active Warning Devices Reduce Allowable Train Speed
Visual Confusion/Sign or Signal Clutter	Removal of Unnecessary Signs/Signals
Prevailing Traffic Speed	Control Traffic Speed with Traffic Signal Control or Reduced Speed Limit
Large Truck Percentage	Restrict Truck Traffic. Improve Signing or Traffic Signal Timing to Keep Trucks of Tracks
Heavy Pedestrian Volumes	Channelization, Active Warning Devices and Pedestrian Control Devices, Traffic Control Officers for Events
School Access Route	Channelization, Active Warning Devices and Pedestrian Control Devices, Education, and Crossing Guards
Emergency Vehicle Route	Identify and/or Provide Alternative Route Provide Remote Notification of Crossing Status
Accident History	Remedy Specific to the Accident Cause
Gate Drive Around Potential	Photo Enforcement, Medians, Four Quadrant Gates
Delineation and Roadway Marking	Increase Contrast at Crossing or Improve Delineation
Traffic Control Observance	Install Active Signs. Increase Enforcement

Preliminary Disposition

After the operational analysis data is developed, crossings are assigned a Preliminary Disposition as either at grade or grade separated based upon consideration of the Detailed Analysis data and further consideration of possible priority strategies.

There are three basic "tests" that the engineering study ultimately addresses. If the grade crossing passes all three tests, a preliminary disposition of at-grade can be assigned. If the grade crossing fails any of the three tests, then a preliminary disposition of grade separate should be assigned. The tests are as follows:

- Safety Check

  Pass- Safety concerns are minor and/or can be mitigated.

  Fail- Engineering study determines mitigations are not available to address safety concerns to adequate level.

- Traffic Operations Check

  Pass- (1) Intersection is at a level of service (LOS) A-D; or (2) Intersection is a LOS E-F but signalized crossing with Green Band Operation (little or no transit Priority) is acceptable.

  Fail – Intersection is at LOS E-F with gates/pre-emption or traffic signal with Priority (e.g., green band operation with little or no priority is unacceptable).

  The following is a fuller explanation of the Traffic Operations Check:

  Gated Crossings / Level of Service A-D – At locations which are proposed as gated, if the LOS of the controlling intersection is A, B, C, or D (e.g., acceptable operations), then the roadway network should be able to absorb the impact of crossing gate operation and pre-emption of adjacent traffic signals within the influence zone (if present). An operational analysis should also be performed to verify that traffic queues can be managed.

  Signalized Crossings / Priority Strategy / Level of Service A-D – At locations which are proposed as traffic signal controlled, and the LOS of the controlling intersection is A, B, C or D (e.g., acceptable operations), then a priority strategy should be identified and the crossings should be able to operate at grade.[1]

  Signalized Crossings / Green Band Operation Acceptable – In the event a timing plan compatible with roadway traffic patterns can be identified that provides a means to progress trains through a number of intersections without stopping (or if the delay impact at an isolated intersection is small enough to allow LRV operation with little or no transit priority), then operation within a fixed background timing plan and little or no transit priority may be acceptable. [2]

[1] The priority strategy may be "partial priority" providing an early green or holding a green phase (up to a specified number of seconds) for the LRT train, or it may be "full priority" allowing additional techniques such as greater split modification with the "early green" and "green hold" techniques as well as other methods such as omitting conflicting phases or serving the LRT phase out of the normal sequence.

[2] Evaluation of the feasibility of green band operation should include identifying all of the traffic signals which would operate as a "group", the approximate "splits" between north-south and east-west timing, the basic concept of the "offsets" provided in the plan, and the points where the LRT train may need to "hold" to wait for the "green band".

At locations where the Detailed Analysis indicates LOS E-F for the controlling intersection (and green band operation is not desirable), or for gated locations where the Initial Screening indicated grade separation would be likely, the result of the Detailed Analysis phase is *Preliminary Disposition Grade Separate*. It is still possible to further test these conditions for at grade operation during the Verification Phase, but the expectation is that grade separation will be necessary.

- Rail Operations Check

  Pass- Impact of the speed and signal control assumptions used in the traffic check are acceptable to the rail operating plan and patronage assumptions (e.g., do not cause unacceptable levels of delay to the overall run time). This would include the proposed speed profile through the crossings, taking into account the presence of adjacent stations or other factors affecting speeds. In addition, for options with traffic signal control, there should be an evaluation of possible train delays associated with the crossing based upon the identified priority control strategy.

  Fail- If the speed and signal control assumptions used in the traffic check are unacceptable (e.g., cause unacceptable levels of delay).

Results – Detailed Analysis

At the conclusion of the Detailed Analysis phase, the following information and conclusions will be available:

- Preliminary Disposition – At grade or grade separated
- Concept Designs – All options, at grade and/or grade separated; concept designs should address "other issues" such as complex or unusual geometry, heavy pedestrian traffic or school routes, etc.
- Traffic Operations Analysis – Identification of controlling intersection, Level of Service, projected queuing vs. available storage
- Priority Control Options – For at grade alternatives, traffic signal or gates with proposed stop lines; conceptual definition of proposed method of traffic control (e.g., green band, full priority, or partial priority) with timing considerations
- Train Operational Impacts – Rail operating speed profile through grade crossings with assessment of possible train delays at traffic signal controlled locations
- Special Studies (Optional) – Any supplemental studies required as a result of site-specific considerations which could affect the crossing disposition

In the event MTA is able to develop in concept agreement from CPUC staff and other involved responsible agencies and parties including the local highway authority, no further analysis is required to determine whether a crossing will be at grade or grade separated. MTA should proceed with filing of grade crossing applications and final design of the crossings when project funding is assured and a firm construction schedule can be established.

MILESTONE 3 – VERIFICATION PHASE

The Verification Phase includes any additional efforts that are necessary to arrive at a Final Technical Recommendation of the crossing status with regard to at grade or grade-separated operation. As noted under Milestone 2, this effort is only required if MTA cannot obtain agreement on the crossing status based upon the Detailed Analysis conducted as part of Milestone 2.

It is anticipated that efforts performed as part of Milestone 3 will be specifically tailored to resolve outstanding issues. The scope of these efforts should be established in cooperation with involved third party agencies and participants. As such, the Verification Phase may include the following types of studies:

- Preliminary Engineering – Especially for grade separated options, feasibility studies to develop the cost of grade separation may need to be performed to provide an understanding of the trade-offs involved.

- Traffic Simulation Modeling – In the event the results of the manual Detailed Analysis process are not conclusive, simulation modeling may need to be accomplished to demonstrate how the crossings will operate at grade and to verify the predicted traffic and train operations impacts.

- Detailed Safety Studies – To the extent that outstanding safety issues remain after consideration of the initial review conducted as part of the detailed analysis, additional Engineering Study of remaining safety issues may be required. The scope of these studies should be defined based upon the safety concerns, which are outstanding.

Input Data – Verification Phase:

The following input data is required, in accordance with the anticipated geometric design and/or traffic modeling process:

- Engineering Design – Key feasibility issues including configuration (over vs. under), impact adjacent stations (if present) need to be identified for consideration in the preliminary engineering effort.

- Refined Traffic Volumes – In the event traffic simulation will be accomplished, the boundary for the simulation model will need to be established and detailed traffic volume data at the turning movement level of detail that reflects upstream constraints in the roadway network capacity and is internally consistent (upstream to downstream) from intersection to intersection is needed.

- Safety Studies – As required to evaluate safety concerns and mitigations.

Methodology – Verification Phase:

- Preliminary Engineering – If provided, the preliminary engineering should demonstrate the configuration of a feasible solution including the proposed design, required right-of-way, cost, and secondary impacts (e.g., noise and visual, sight distance, etc.)

- Simulation Modeling – If provided, traffic simulation studies should test alternative methods of traffic signal timing and identify travel times, delay, and queuing that could affect traffic and train operations.

- Rail Operations – The results of the simulation modeling may be used to revise the estimate of traffic signal delay and of overall travel time for the rail line. If at grade operation through a number of crossings would result in substantially different end-to-end travel times, it may be appropriate to assess possible impact upon the projected patronage of the facility and the resulting cost-effectiveness (cost per new rider).

- Safety Studies – Further Engineering Study to be accomplished in accordance with the outstanding safety issues.

Results – Verification Phase:

At the conclusion of the Verification Phase, the results from the supplemental studies should be considered and the Preliminary Disposition of the grade crossings reviewed in the light of the additional information. The trade-offs between the cost and benefits of at grade and grade-separated options should be reviewed and a *Final Technical Recommendation* for at grade or grade separation operation should be made.

When the results of the Verification Phase have progressed to the point that draft findings can be shared, third party input should be obtained.

FINAL DECISION

The final decision on the crossings will be based upon all of the technical input into the process including the Final Technical Recommendation; however, the policy recognizes that the ultimate decision will involve institutional consideration of the proposed crossing treatments and will require third party approvals, primarily consisting of approval of the crossings by the California Public Utilities Commission under the provisions of General Order 75-C (for grade crossings) and consistent with General Order 143-B (for light rail transit). Additional agreements including those to obtain necessary right-of-way, and for identifying any sharing of construction and/or maintenance costs would need to be addressed as part of the Final Decision.

ATTACHMENT B

Evaluation of Exposition Light Rail Transit Project With Proposed MTA Grade Crossing Policy

Revised Draft for Board Approval
November 19, 2003

Metropolitan Transportation Authority

Executive Summary

OVERVIEW

This report summarizes the initial screening and detailed analysis of proposed grade crossings along the mid-corridor segment of Exposition Light Rail Transit Project (Expo LRT) and provides recommendations regarding which LRT roadway crossings may be operated at grade versus those crossings for which grade separations are recommended. The findings in this report were developed using methodologies in the proposed "Grade Crossing Policy for Light Rail Transit" (November 10, 2003) that was prepared in order to provide MTA with a structured process for determining the feasibility of at grade LRT operation.

This report addresses the roadway crossings along the mid-corridor generally paralleling Exposition Boulevard; it does not include evaluations for crossings of Figueroa, Flower, or any of the roadways associated with the alternatives being considered for connecting the mid-corridor segment to Metro Center in downtown Los Angeles – as the feasibility of at grade operation at Figueroa and Flower depends upon the alignment option, evaluation of these roadway crossings will be provided in a separate document that addresses the route alternatives for the northern terminus of the Expo LRT project.

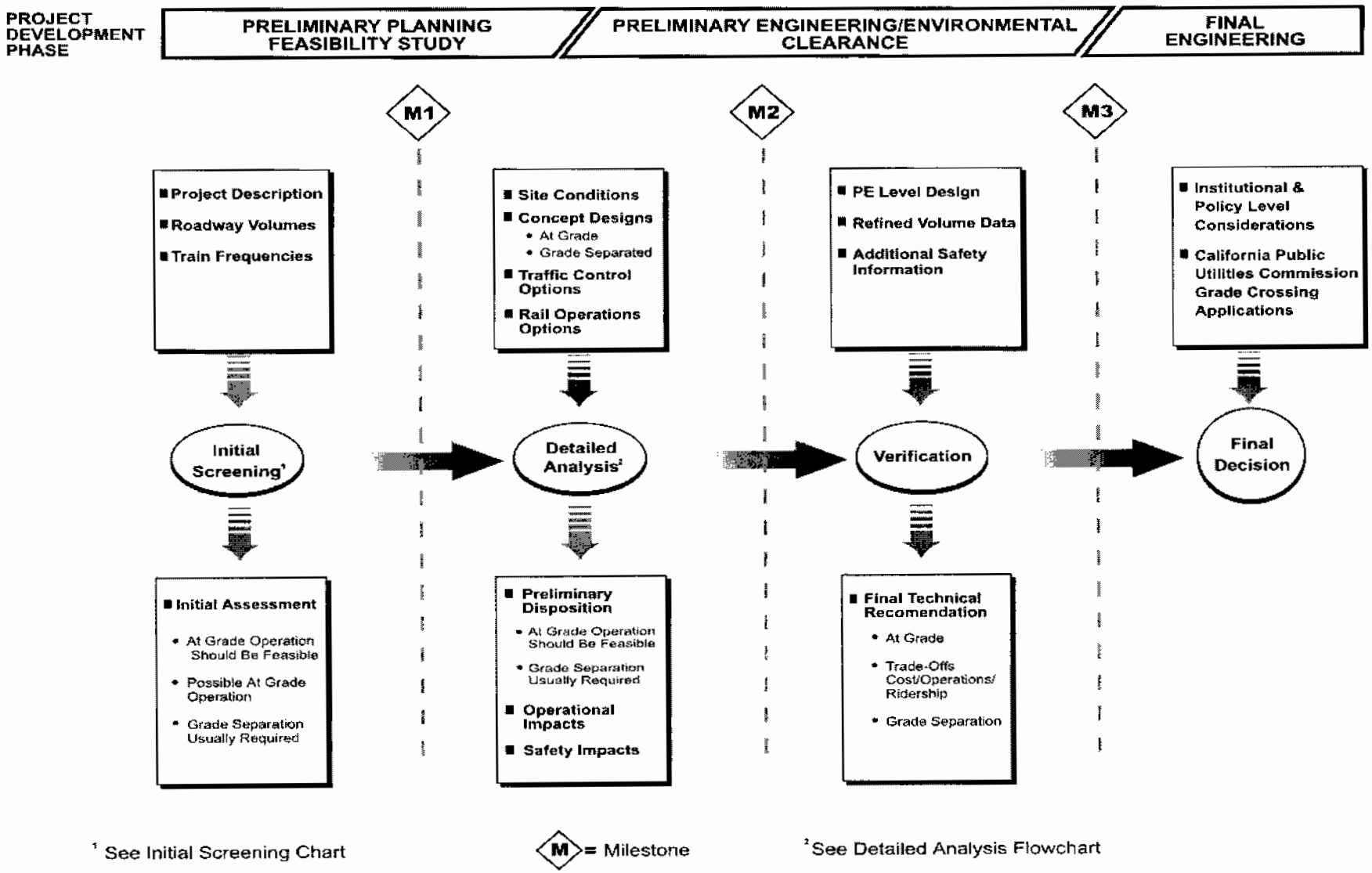
The analysis has been prepared using revised traffic projections which have been prepared based upon a more recent run of the MTA travel forecast model than was originally used to develop the Draft Environmental Impact Statement/Report (DEIS/R). The new model runs and intersection volume forecasts were prepared to address comments received from the Los Angeles Department of Transportation (LADOT) as well as Culver City regarding the traffic forecasts shown in the draft environmental document. The revised traffic forecasts have been reconciled against recent traffic ground counts and provide for a more consistent basis for analysis of traffic operations and impacts.

This report includes identification and initial review of safety issues associated with the crossings that may be operated at grade along with identification of potential mitigation of noted safety concerns. As design development of the Expo LRT project proceeds and greater detail is available regarding the specific configuration of each crossing, the proposed design should incorporate appropriate provisions to enhance safe operation. Additional safety analysis may be required to establish the specific design features.

GRADE CROSSING POLICY

The Grade Crossing Policy for Light Rail Transit (see Exhibit 1) was developed to provide a standard process and prescribed analysis methodology for evaluating the feasibility of at grade LRT operations. The recommended policy includes three phases of review before arriving at the "Final Decision" on a crossing: Milestone 1 is a planning-level Initial Screening resulting in the classification of the crossing into one of three categories – (1) *"At Grade Operation Should Be Feasible"*, (2) *"Possible At Grade Operation"*, or (3) *"Grade Separation Usually Required"*. The Detailed Analysis included in Milestone 2 is intended to re-evaluate the crossings so that a "Preliminary Disposition" – either *"At Grade"* or *"Grade Separated"* is determined. Optional additional effort under Milestone 3, Verification, may be required to resolve outstanding technical issues. The policy includes provisions for active participation in the process by local jurisdictions and involved agencies such as the California Public Utilities Commission. As such, the process is intended to build technical consensus while limiting up-front engineering effort.

Exhibit 1 – Light Rail Grade Crossing Review Process



FINDINGS

At this point in the process, all of the Milestone 1 (Initial Screening) effort and most of the Milestone 2 (Detailed Analysis) effort has been completed. The Milestone 2 technical analysis has been developed and provided in draft form to local jurisdictions as well as the California Public Utilities Commission staff. After completion of preliminary field diagnostic reviews of the grade crossings and all comments on the Milestone 2 analysis have been incorporated, then Milestone 2 will be completed providing resolution of most of the configuration issues.

Initial Screening Results

Exhibit 2 depicts the Initial Screening results for the fifteen locations where traffic volume forecasts are available between Vermont Avenue and Venice Boulevard.[1] The Initial Screening identified three locations where at-grade operation should be feasible, two locations where grade separation will probably be required, and with possible at grade operation at the ten remaining locations, subject to detailed operational analysis, as summarized below:

- *At Grade Operation Should Be Feasible* – Denker, Gramercy and Farmdale
- *Possible At Grade Operation* – Most of the crossings are in a group towards the at grade end of the range, with La Brea at the high end very close to the grade separation threshold
- *Grade Separation Usually Required* – La Cienega and Venice

(Venice Boulevard is beyond the reach of the currently proposed project. However, should the line be extended to the west, then a grade separation would be required. A Venice grade separation would need to include the Washington and National crossings as well since there is not enough distance available between Venice and Washington for a complete transition to an at grade alignment.)

Detailed Analysis

In accordance with the provisions of the Policy, Detailed Analysis was accomplished for the ten locations identified in the Preliminary Screening as "Possible At Grade Operation". In addition, a preliminary safety review was conducted for all crossings even though not strictly required by the Policy.

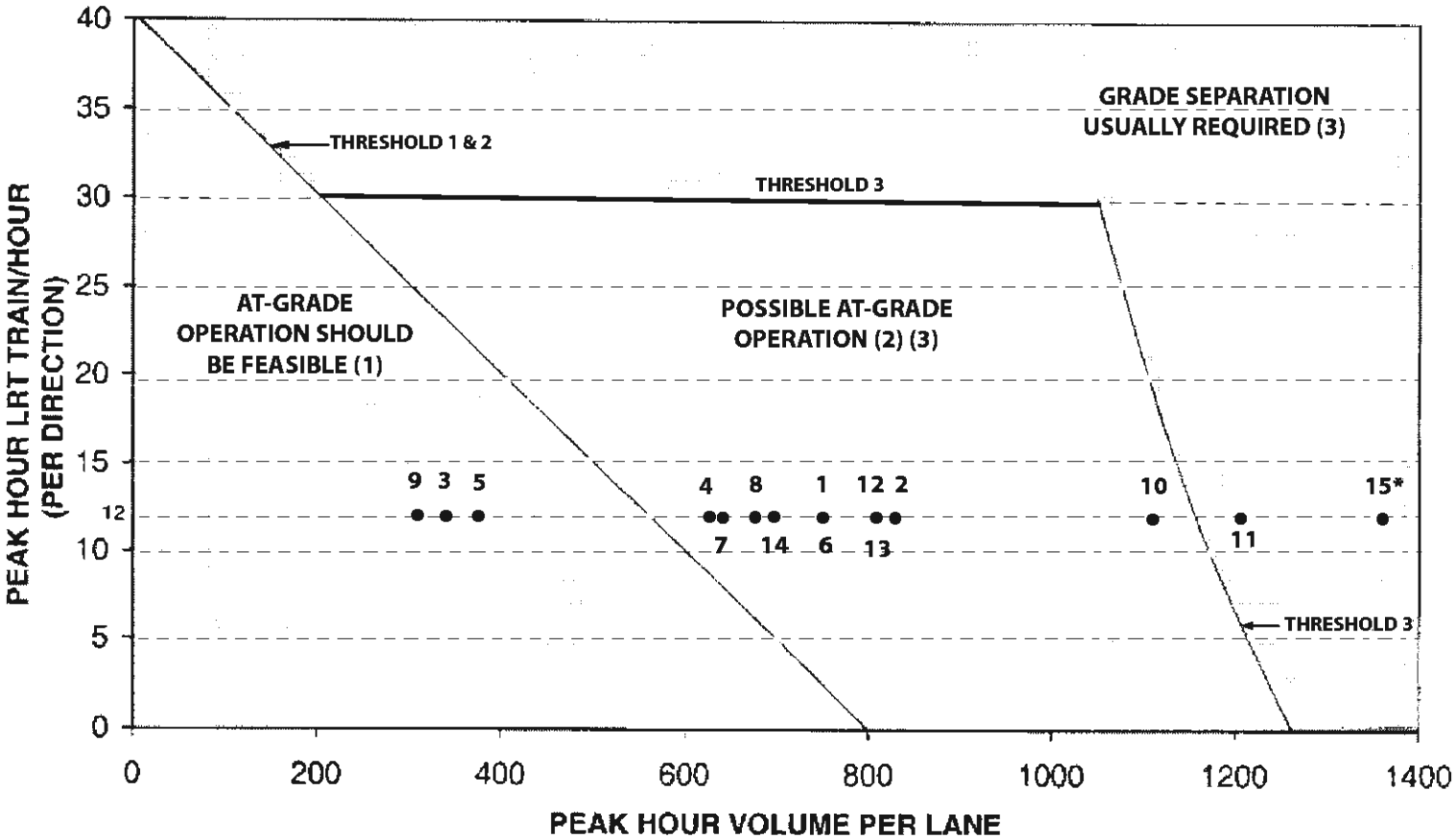
As a result of the Detailed Analysis which includes evaluation of traffic operations, crossing safety and rail operations checks, it was determined that one location originally in the "grey area" – La Brea Avenue in the City of Los Angeles – would require grade separation and the remaining nine locations could be operated at grade.

The results of the Detailed Analysis including the traffic operations check and safety check are shown on Exhibit 3, along with the Initial Screening results for each crossing. As indicated on Exhibit 3, a total of three grade separations are indicated – La Brea, La Cienega, and Venice.

[1] Traffic volumes at 7th Avenue and 11th Avenue are substantially lower than any of the locations that were analyzed. In addition, Hayden Road is proposed to be closed to vehicles under the current design and was therefore not reviewed.

Exhibit 2 – Initial Screening Results

1 Vermont
2 Normandie
3 Danker
4 Western
5 Gramercy
6 Arlington
7 Crenshaw
8 Buckingham
9 Farmdale
10 La Brea
11 La Cienega
12 Jefferson
13 National
14 Washington
15 Venice



NOTES:

(1) WITH CROSSING GATES AND PRE-EMPTION OR TRAFFIC SIGNAL PRIORITY
(2) WITH TRAFFIC SIGNAL PRIORITY AND SOME LRT DELAY
(3) ENGINEERING STUDY REQUIRED TO DEFINE OR CONFIRM AT GRADE OPERATION
* VOLUME EXCEEDS CHART CAPACITY (1622)

Exhibit 3 – Roadway Crossing Recommendations Summary Table

Roadway Crossing	Traffic Control		Initial Screening	Detailed Analysis		Preliminary Disposition	Comments
	Signal	Gates		Operations	Safety		
1 – Vermont	X		◎	◎	◎	O	Provide pedestrian safety enhancements
2 – Normandie	X		◎	O	O	O	
3 – Denker	X		O	-	O	O	
4 – Western	X		◎	O	◎	O	Provide pedestrian safety enhancements
5 – Gramercy	X	X	O	-	◎	O	Signal and/or gates required to address complex geometry and pedestrian crossing
6 – Arlington		X	◎	O	◎	O	Provide pre-signal with pre-emption for track clearance
7 – Crenshaw	X		◎	◎	◎	O	Provide pedestrian safety enhancements; provide pre-signal; operate with priority control
8 – Buckingham		X	◎	O	◎	O	Provide pre-signal with pre-emption for track clearance
9 – Farmdale		X	O	-	◎	O	Provide ped safety enhancements; provide pre-signal with pre-emption for track clearance
10 – La Brea	-	-	◎	③	③	③	Recommended for grade separation
11 – La Cienega	-	-	③	-	-	③	Recommended for grade separation
12 – Jefferson	X	X	◎	◎	◎	O	Improved channelization & traffic controls needed for at grade operation
13 – National	X	X	◎	◎	◎	O	At-grade operation with queue controls & crossing gates; long term grade separation
14 – Washington	X	X	◎	◎	◎	O	At-grade operation with queue controls & crossing gates; long term grade separation
15 – Venice	-	-	③	-	-	③	Recommended for grade separation

Legend

Symbol	Initial Screening	Detailed Analysis	Preliminary Disposition
O	At grade should be feasible	OK, acceptable	At grade
◎	Possible at grade operation	OK with mitigation	-
③	Grade separation usually required	Fails, unacceptable	Grade separate

In addition to the traffic operations and safety checks, the Detailed Analysis included a rail operations check. The purpose of the rail operations check is to determine whether the proposed traffic control provisions (e.g., pre-emption and priority) needed for operation at grade would result in unacceptable levels of LRT operational delay. The rail operations check was accomplished for the corridor as a whole rather than on a crossing-by-crossing basis. The assessment was conducted by comparing two scenarios that were developed to bracket the minimum and maximum travel time variations resulting from alternative traffic control strategies in the mid-corridor:

Common Assumptions – Both Scenarios

- LPA Alignment
- Median Running at 35 mph w/ Traffic Signal Control East of Gramercy
- Side Running at 55 mph Maximum Speed w/ Gated Minor Crossings West of Gramercy

"Gated" Scenario

- Pre-Emption with Gated Crossings at Arlington, Crenshaw, La Brea, Washington & National
- Grade Separation at La Cienega

Traffic Signal Controlled" Scenario

- Traffic Signal Control with Partial Priority at Arlington, Crenshaw, La Brea and La Cienega
- Traffic Signal Control with No Priority at Washington & National

The results of the rail operations analysis are shown below in Exhibit 4. The analysis indicates that with all of the alternative grade crossings operated without pre-emption there is an approximate three-minute impact to overall run time, corresponding to a an approximate ten percent impact for this portion of the alignment. The companion travel model evaluation indicated the resulting patronage impact due to the longer run time with traffic signal controls would be about five percent. Since the Detailed Analysis indicates La Brea would need to be grade separated, and since Arlington has been confirmed for operation with crossing gates and pre-emption, the resulting impact of utilizing traffic signal control with partial priority only at Crenshaw, Washington and National would be even less. On this basis, the rail operations check was evaluated as "OK".

Exhibit 4 – Rail Operations Analysis Results

Scenario	Traffic Delay	Travel Time	Average Speed	Ridership	
	Minutes	Minutes	Miles/Hour	Daily Boardings	Net New Trips
"Gated"	6.4	24.8	22.0	45,000	21,000
"Traffic Signal"	8.8	27.7	19.7	43,600	20,000

Crossing-by-Crossing Synopsis of Findings

A crossing-by-crossing summary of the findings and key issues follows. The crossings are addressed from high to low relative to the traffic conflict levels identified in the preliminary screening.

Preliminary Disposition Grade Separated

Initial Screening – Grade Separation Usually Required

- Venice Boulevard (Culver City) – The Expo LRT alignment if extended would enter into the Venice Boulevard intersection. Regardless of the specific track alignment, there are no LRT-compatible traffic movements at the intersection – a separate phase would be required either to allow LRT trains to traverse Venice along a continuation of the Exposition Corridor, or to make a turn at this location. As the intersection is already at LOS F without an LRT phase under existing conditions, there is no capacity to accommodate an LRT phase and inclusion of an LRT phase would exacerbate the traffic congestion. The conflict volume as shown on Exhibit 1 depicting the results of the Initial Screening is more than 1,600 vehicles per hour per lane making this location the most congested point along the corridor. Therefore, on the basis of conflicting volume alone the recommendation is for a grade separation at this location.

- La Cienega Boulevard (Los Angeles) – This location was identified for grade separation in the conceptual engineering drawings for the Locally Preferred Alternative (LPA) designated in the DEIS/R). The initial screening indicated that grade separation is usually required. This location has the highest level of conflicting traffic with the LRT trackway and the roadway is highly congested. In accordance with the Policy, since the proposed operation at this location is greater than 35 mph, the recommendation is to proceed with design development of a grade separation as shown in the conceptual engineering drawings.

Detailed Analysis Indicates Grade Separation Required

- La Brea Boulevard (Los Angeles) – In the initial screening, this location fell just below the grade separation threshold in the road crossing policy. Detailed analysis indicates that crossing gates would be required to meet the proposed rail operating speed that exceeds 35 mph in this segment (although speeds may be slower due to stops at the La Brea station), however, this would require pre-emption of the Jefferson / La Brea traffic signal which presently generates queues of vehicles backing up across the trackway. Control of the queuing would require installation of a traffic signal at the crossing and use of priority control in lieu of pre-emption to avoid excessive traffic impacts. However, there is a concern that the "readability" of the crossing is not adequate with traffic signal control alone (e.g., without gates). Due to these factors, both the "operations" and "safety" criteria were judged as "fail" in the detailed analysis. Therefore, the recommendation is that MTA proceed with preliminary engineering of a grade separation at this location.

Preliminary Disposition At Grade

The assessment of the remaining twelve locations is *"At Grade"*. Three locations were identified as feasible for at grade operation under the Initial Screening and no further analysis was performed. For the remaining nine locations, the Detailed Analysis procedures described in the Policy were carried out; and feasible at grade operation was identified, subject to the conditions noted for each crossing.

The results by location are described below, listed in order of decreasing levels of conflicting traffic as characterized in the Initial Screening analysis:

Initial Screening – Possible At Grade Operation Subject to Detailed Analysis

- Normandie Avenue (Los Angeles) – The initial screening for this location using the recommended Policy was "Possible At Grade Operation". Detailed operational analysis was accomplished which confirmed the viability of at grade operation using traffic signals to control traffic at the crossing with transit priority to minimize LRT delays. This analysis identified that roadway congestion levels were low enough to accommodate transit priority and the safety review did not identify any extraordinary safety issues.

- National & Washington Boulevards (Culver City) – These two roadway crossings comprise two corners of a triangle with the Washington/National intersection as the third corner and would need to be operated with an integrated timing strategy involving both the rail movement as well as roadway movements to accommodate at grade operation. A queuing check performed as part of the detailed analysis; this analysis confirmed that the common intersection of Washington / National is within the influence zone of both crossings. In order to manage these queues, a possible at grade operations traffic control strategy would be to treat the grade crossings like signalized intersections and to provide "slot clearance" so that traffic heading towards or away from the common intersection of Washington/National would be given additional clearance time downstream from the grade crossings thereby avoiding trapping vehicles in a standing queue at either location. In addition to the queuing issue, the safety review indicated crossing gates would be desirable to enforce compliance with the grade crossing stop bars as well as to address the sight distance issues due to the angled crossings. However, it is proposed that the crossing gates be operated on a timing plan in coordination with the traffic signal timing, subject to an LRT train requiring service through the grade crossing. In doing so, pre-emption of the traffic signal would not be required due to the fact that the LRT would be operating in a prescribed slot under the control of the traffic signal at Washington/National; e.g., the LRT would operate at low speed through the crossings with little or no priority adjustment available (depending upon the ambient traffic level). A countdown timer could be used at the Venice station to indicate an appropriate departure time so that no perceived delay would occur for eastbound trains. (A countdown timer for westbound trains could be provided at the La Cienega station as well to avoid the need for trains to wait for service at the grade crossings.)

  The analysis of Venice indicates grade separation would be required at that location, and if a grade separation were provided at Venice, it would not be feasible to completely transition to at grade within the setback to the Washington grade crossing. Therefore, an ultimate grade separation at Venice would need to span both Washington and National.

Such a grade separation would eliminate any delays to traffic or LRT trains due to conflicts at the two grade crossings due to interim operation at grade.

- Jefferson / National (Culver City / Los Angeles) – Designated as a grade separated crossing in the conceptual engineering drawings for the LPA, this location is proposed as an at grade crossing using a design concept which emerged from the Value Engineering session for the project. In applying the Policy to the proposed crossing, and assuming the roadway configuration is sized to meet the roadway Level of Service requirements for good traffic operation, this location was evaluated as possible for at grade operation in the Initial Screening. Because of the unusual configuration of the grade crossing within an intersection, both traffic signals as well as crossing gates may be required for safe operation – e.g., when no LRT train is present, a traffic signal would still be required to control conflicting traffic movements. With at grade operation, the traffic signal would be placed in an "all red" phase and then crossing gates would be lowered to enforce compliance with the grade crossing stop bars. Field visits to the site indicated queuing of eastbound traffic along National back from the La Cienega/National intersection. This queuing would need to be addressed by providing additional storage and/or by coordination of operations between the two intersections. Given the operational complexities, the evaluation of this location indicates possible at grade operation, subject to verification of effective channelization (roadway reconfiguration) and traffic controls.

  It should be noted that efforts are underway to develop an alternative approach that would result in reconfiguration of the proposed La Cienega grade separation and National Boulevard so that traffic would be carried along a new roadway segment south of the Exposition Corridor between Ballona Creek and La Cienega so that the grade crossing would be eliminated. Such a solution, if feasible and cost-effective, could eliminate the need for an at-grade crossing, which would be a preferred solution given the challenges to at grade operation at this location.

- Arlington Avenue (Los Angeles) – The Detailed Analysis indicated adequate roadway capacity exists to provide a high degree of transit priority, so adequate operations should result even with crossing gates and pre-emption. The safety review indicated that the Rodeo intersection south of the trackway should be designed to act as a pre-signal to limit the likelihood that cars would be queued on the tracks. The City of Los Angeles noted that vehicles making left turns from Arlington onto Exposition Boulevard could potentially "interlock" in the grade crossing and have suggested development of opposing northbound/southbound left-turn bay in the median. Additional design studies are necessary to determine the impact to adjoining properties and curb utilization at the intersection in the event such pockets were provided. The safety review of this location indicated that a pre-signal should be provided to preclude northbound traffic along Arlington from queuing across the grade crossing while waiting for a green light at Exposition.

- Vermont Avenue (Los Angeles) – The detailed operational analysis was accomplished and the results indicated at grade operation would be potentially feasible, and with the revised traffic forecasts, a favorable level of service indicates a moderate degree of priority would be available to facilitate LRT movements. Given the fact that the first station along Exposition Boulevard is located near Vermont, it is reasonable to assume that the station could serve as a "time point" for westbound trains and that a countdown timer could be provided so that trains would depart to receive clearance through the grade crossing with minimal traffic signal delay – such a countdown timer could also

facilitate movement through to the Crenshaw station in the event LADOT can develop a common timing plan that would provide slots for trains between these two roadways. The safety review indicated the need for pedestrian enhancements due to the potentially high levels of pedestrians present at the crossing and in the vicinity of the station. Additional traffic control efforts including possible use of traffic control officers may be required to manage event-related traffic.

- Buckingham Road (Los Angeles) – At grade operation should be feasible according to the Detailed Analysis of traffic operations. The safety review of this location indicated that a pre-signal should be provided to preclude northbound traffic along Arlington from queuing across the grade crossing while waiting for a green light at Exposition.

- Crenshaw Boulevard (Los Angeles) – The Detailed Analysis indicated that the traffic operations check would fail in the event this grade crossing were to be controlled with crossing gates and provided with traffic pre-emption. However, at grade operation would be feasible treating this location as an on-street condition with traffic signals used to control all movements. This approach is consistent with the results of the safety review, namely that a pre-signal would be desirable to prevent northbound traffic from queuing across the grade crossing. A traffic simulation study conducted by LADOT confirmed that at grade operation would be feasible with traffic signal control. The level of service analysis indicates some slack time may be available to provide a low degree of priority to LRT trains. As noted with regard to Vermont, use of a countdown timer in conjunction with a common timing plan may substantially reduce the likelihood of additional delays to westbound trains at Crenshaw with traffic signal control. The safety review also identified the need for further study of the pedestrian activity levels at the crossing and incorporation of appropriate safety provisions.

- Western Avenue (Los Angeles) – The traffic operations check performed as part of the Detailed Analysis indicated at grade operation would be acceptable. The safety review identified the need for further study of the pedestrian activity levels at the crossing and incorporation of appropriate safety provisions.

Initial Screening – At Grade Operation Should Be Feasible

- Gramercy Place (Los Angeles) – The Initial Screening indicated at grade operation would be acceptable. The safety review identified the need for further study of the impact of the angled crossing and complex intersection geometry and the selection of appropriate traffic control and traffic safety measures for successful at grade operation.

- Denker Avenue (Los Angeles) – At grade operation should be feasible according to the Initial Screening. No further issues were identified as a result of the safety screening. The ultimate design should incorporate standard safety features.

- Farmdale Avenue (Los Angeles) – The Initial Screening indicated at grade operation would be acceptable. The safety review identified the need for further study of the pedestrian activity levels at the crossing and incorporation of appropriate safety provisions.

Safety Review

The proposed Roadway Crossing Framework includes provisions for initial safety reviews of the roadway crossings that are considered for "Possible At Grade Operation". In addition, the MTA Board specifically requested a review of operations and safety for five mid-corridor roadway crossings in the City of Los Angeles Mid Cities area:

- Crenshaw Boulevard
- Arlington Avenue
- Gramercy Place
- Western Avenue
- Vermont Avenue

Consideration was therefore given to potential safety concerns at the five crossings as well as all of the other locations where feasibility of at grade operation was in question under the Framework. The specific safety concerns that were reviewed, subject to available data included:

- Traffic Queuing
- Approach and Corner Sight Distance
- Visual Confusion/Sign or Signal Clutter
- Prevailing Traffic Speed
- Large Truck Percentage
- Heavy Pedestrian Volumes
- School Access Route
- Accident History
- Gate Drive Around Potential
- Delineation and Roadway Marking
- Traffic Control Observance

As a result, a number of initial recommendations for safety treatments are included in the report. It is important to recognize that, as the level of design development proceeds, on-going review of safety concerns and design provisions should be incorporated in the project development process for proposed traffic and pedestrian crossings.

NEXT STEPS

In accordance with the proposed Policy, and the technical findings to date, the following "Next Steps" are recommended:

Technical Studies

- Develop Grade Separation Concepts and Costs for La Brea Avenue
- Conduct preliminary field diagnostic visits with CPUC and cities
- Incorporate results of design options studies for Jefferson/National intersection
- Expand analysis to include alignment options under consideration in downtown branching study

Agency Coordination

- Continue coordination with LADOT and other departments as appropriate
- Address traffic controls for Washington/National crossings including concerns on impacts of interim terminal station at Venice with Culver City
- Coordinate with California Public Utilities Commission and Caltrans