Appendix E

Noise and Vibration Impact Memorandum

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Mid-City/Exposition Light Rail Transit Project

Noise and Vibration Impact Report for the Improvements at Farmdale Avenue and Exposition Boulevard

Prepared by:

ATS CONSULTING

801 S. Grand Avenue

Suite 575

Los Angeles, CA 90017

August 2010

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Acronyms

CEQA	California Environmental Quality Act
CPUC	California Public Utilities Commission
dBA	A-weighted decibel
Expo	Exposition Construction Authority
Expo LRT	Mid-City/Exposition Light Rail Transit
FEIS/EIR	final environmental impact statement/environmental impact report
FTA	Federal Transit Administration
LRT	light rail transit
Metro	Los Angeles County Metropolitan Transportation Authority
MFR	multi-family residence
Mod	Moderate Impact
NEPA	National Environmental Policy Act
Severe	Severe Impact
SFR	single family residence

1. INTRODUCTION

ATS Consulting prepared this noise and vibration study for submission and consideration by the California Public Utilities Commission (CPUC) and the Federal Transit Administration (FTA). Its purpose is to evaluate the proposed passenger station at the Farmdale crossing on the Expo LRT project (the proposed project), in comparison to the analysis in the previously certified FEIS/EIR for the Expo LRT project, in order to assist in determining whether a further environmental documentation is necessary.

The Farmdale Avenue crossing is the final crossing to be considered by the CPUC for the Expo LRT line, and is the subject of an amended application filed with the CPUC on July 29, 2009. All other crossings requiring CPUC approval have been approved, and much of the Expo LRT line is currently under construction.

This study examines Expo's original plan for an at-grade crossing, as modified in the course of this proceeding, with a new station added with near-side platforms east and west of Farmdale Avenue at which all LRT vehicles would come to a full stop on approach to the Farmdale Avenue crossing. As part of the proposed project, the Expo Inn property located at 4523 West Exposition Boulevard, on the northeast corner of Exposition Boulevard and Farmdale Avenue, would be acquired and all structures demolished to construct an LAUSD staff parking lot. A stop-and-proceed procedure may be utilized until the proposed station is constructed.

A Final Environmental Impact Statement/Environmental Impact Report (FEIS/EIR) (Ref. 1 and 2)[1] was prepared evaluating the entire Expo LRT project, including a standard at-grade crossing proposed at Farmdale Avenue. That FEIS/EIR was certified by the Los Angeles County Metropolitan Transportation Authority (Metro) in 2005. That FEIS/EIR was used as CEQA documentation by CPUC in its December 2007 decision approving all of the at-grade crossings for the Expo LRT project except the proposed at-grade crossings at Farmdale Avenue near Dorsey High School and at Harvard Boulevard near the Foshay Learning Center. The FEIS/EIR was also used as the CEQA documentation by the CPUC in its February 25, 2009 decision approving the construction of the Expo LRT project over the existing pedestrian tunnel crossing at Harvard Boulevard.

This analysis is being prepared for submission to the CPUC in response to its February 25, 2009, decision with respect to the proposed at-grade crossing at Farmdale Avenue and in response to subsequent discussions between Expo and LAUSD. In its February 25 decision, the CPUC denied the Exposition Construction Authority's (Expo's) application for a proposed at-grade crossing at Farmdale Avenue. After considering various options for the Farmdale Avenue crossing, the CPUC found that a pedestrian overcrossing with Farmdale Avenue closed to traffic is a practicable alternative to the at-grade crossing as then proposed. The CPUC accordingly left the proceeding open to allow Expo to file an amended application or new application. The CPUC decision also stated that the CPUC is a responsible agency under CEQA, and that the CPUC as a responsible agency may act in a lead role for conducting any necessary future environmental review with respect to the Farmdale Avenue crossing, if such review involves either a Supplemental EIR or an Addendum to the existing FEIS/EIR. The decision stated that the CPUC would not act as a responsible agency if a subsequent EIR was required.

Subsequent to the CPUC decision, Expo filed an amended application with the CPUC, suggesting several possible options for the crossing at Farmdale Avenue, including a pedestrian overcrossing with Farmdale closed, an at-grade crossing subject to a stop-and-proceed requirement for all trains, construction of an

[1] All references are listed at end of report.

LRT station in conjunction with an at-grade crossing at the intersection of Farmdale and Exposition, and an at-grade crossing subject to an interim stop-and-proceed requirement with later construction of an LRT station. The CPUC held a prehearing conference on the amended application on September 30, 2009, and at the direction of the Administrative Law Judge, the parties initiated a discussion of issues in hopes of achieving a safe solution acceptable to the parties that would more expeditiously resolve the proceeding. These discussions indicated that the construction of a near-side LRT station in conjunction with an at-grade crossing at the intersection of Farmdale Avenue and Exposition Boulevard would provide a safe solution that might also facilitate a more expeditious resolution of this proceeding.

This study examines the proposed project, which involves the construction of an LRT Station at the Intersection of Farmdale Avenue and Exposition Boulevard. This is Expo's original plan for an at-grade crossing, as modified in the course of this proceeding, with a new station added with "near-side" platforms east and west of Farmdale Avenue at which all LRT vehicles would come to a full stop on approach to the Farmdale Avenue crossing. As part of the proposed project, the Expo Inn motel property located at 4523 West Exposition Boulevard, on the northeast corner of Exposition Boulevard and Farmdale Avenue, would be acquired, and all structures demolished, in order to construct an LAUSD staff parking lot. The Expo Inn motel was considered a noise sensitive receptor in the original FEIS/EIR.

The following options were previously considered and evaluated but are no longer being proposed, as a result of the CPUC decision dated February 25, 2009, and subsequent discussions among the parties, conducted at the suggestion of the Administrative Law Judge in this proceeding, to identify an option that could provide a basis for more expeditious resolution of this proceeding. These options accordingly are not evaluated in this study.

- At-grade Expo LRT crossing at Farmdale Avenue
- Stop and proceed for Expo LRT trains at the at-grade crossing at Farmdale Avenue.
- Pedestrian overcrossing and closure of Farmdale Avenue at Exposition Boulevard.
- Pedestrian overcrossing, with Farmdale Avenue remaining open at Exposition Boulevard.
- Train overcrossing at Farmdale Avenue.
- Train undercrossing at Farmdale Avenue.

1.1 Purpose of This Study

The purpose of this noise study is to compare the effects of the proposed options with the environmental impact analysis set forth in the previously certified FEIS/EIR for the Expo LRT project. This study evaluates whether implementation of the proposed project would result in new significant impacts or increase the severity of previously identified significant environmental effects under CEQA. CEQA provides, in Public Resources Code Section 21166, that once an EIR has been prepared for a project, no subsequent or supplemental EIR is to be prepared unless one of the following circumstances occurs:

1. Substantial changes are proposed in the project which will require major revisions of the FEIS/EIR.
2. Substantial changes occur with respect to the circumstances under which the project is being undertaken which will require major revisions in the FEIS/EIR.
3. New information, which was not known and could not have been known at the time the FEIS/EIR was certified as complete, but becomes available.

CEQA Guidelines § 15162 further clarify this requirement for evaluating proposed changes to a project. This guideline indicates that once an FEIS/EIR has been certified, no additional FEIS/EIR is to be prepared unless there are substantial changes in the project, substantial changes in circumstances or new information of substantial importance, all of which shows that there will be either a new significant adverse environmental impact or a substantially more severe adverse environmental impact.

According to the National Environmental Policy Act (NEPA) Regulations (40 C.F.R. 15029[c][1]), a federal agency must prepare a supplement to a Draft or Final EIS if (1) there are substantial changes to the proposed action that are relevant to its environmental effects, or (2) there are significant new circumstances or information relevant to the environmental concerns that bear on the proposed action or its impacts.

Pursuant to Public Resources Code § 21166 and CEQA Guideline § 15162, and NEPA Regulations (40 C.F.R. 15029[c][1]), the purpose of this study is to evaluate whether the potential project changes, represented by the proposed action set forth above, would result in new significant environmental effects or a substantial increase in the severity of previously identified significant environmental effects.

1.2 Noise

In accordance with both CEQA and NEPA requirements, the noise assessment of this study and the FEIS/EIR noise study follow the procedures outlined in the FTA Guidance Manual *Transit Noise and Vibration Impact Analysis* (Ref. 3). The basic steps in the analysis are:

1. Identify noise-sensitive receptors. Noise-sensitive land uses along the corridor were identified through review of aerial photographs and field visits. The sensitive receivers were grouped together based on their location relative to the tracks. Within each cluster, the distance to the closest receptor was used for the noise predictions. Section 2 discusses the noise sensitive receptors that could be affected by the proposed project.
2. Determine existing noise levels. Noise measurements have been performed at five locations in the vicinity of the Farmdale crossing, two for the FEIS/EIR analysis and three for this study. The results of the measurements are summarized in Section 2.
3. Determine appropriate impact thresholds. Noise impact has been assessed using the FTA criteria (Ref. 3). The FTA noise impact thresholds, which are based on land use and existing noise levels, are presented in Section 3. The noise measurements were used to estimate existing noise levels at each cluster of sensitive receptors.
4. Predict future noise levels and identify potential noise impacts. The noise predictions use models given in the FTA guidance manual and are based on the forecasted future number of daily trains and distribution of these trains throughout the day (early morning, daytime, and nighttime), the distance from the tracks, the projected train speed, the type of track structure, and other site specific conditions. The predicted noise levels for each are compared to the applicable FTA impact threshold for each cluster of sensitive receptors to identify potential noise impacts. The noise impact assessment for light rail train noise is presented in Section 4 along with assessments of potential noise impact from crossing bell noise and the forecasted changes in traffic volumes.
5. Evaluate noise mitigation measures. Noise mitigation alternatives have been evaluated for all locations where potential noise impact is predicted (see Section 5).

A brief introduction to noise and vibration fundamentals and definitions of the technical terms used in this report is attached as Appendix A.

The noise impacts and recommended mitigation measures for the proposed project are summarized in Table 1. All of the predicted noise impacts can be eliminated with sound walls that were previously specified in the FEIS/EIR. Following is a summary of the impacts and mitigation:

- **Proposed Project** (LRT Station): The noise impacts with the construction of a split LRT station at the intersection of Farmdale Avenue and Exposition Boulevard would be similar to those for the previously proposed at-grade crossing. The only difference is a small decrease in noise levels due to slower train speeds as the vehicles approach the station. The decrease would not be sufficient to change the noise impacts at any of the clusters of sensitive receptors. The noise mitigation for the proposed project would be the same as described in the FEIS/EIR.

Table 1. Summary of Noise Impacts and Mitigation Recommendations

Location	Side of Tracks	Number of Impacts		Noise Barrier Description			Residual Impacts
		Moderate	Severe	Civil Stations	Length, ft	Height[(2)]	
Potomac Ave to Vineyard Ave	N	0	0	--	--	--	0
Buckingham Rd to Farmdale Ave[(3)]	S	20	2	355+00 to 371+00	1600	6 ft	0

Notes:
(1) Includes both moderate and severe impacts.
(2) Sound wall heights are measured from the top of rail.
(3) The sound wall from Buckingham Road to Farmdale Avenue is identical to the wall originally specified in the FEIS/EIR.

1.3 Vibration

The FEIS/EIR vibration assessment was based on vibration testing of the prototype Gold Line vehicle. Subsequent testing after the Gold Line was operational has validated the FEIS/EIR prediction procedures. The conclusion of the FEIS/EIR was that there would be no vibration impacts. The vibration levels for the proposed project would be the same as for the at-grade design evaluated in the FEIS/EIR. Because no impacts were found in the FEIS/EIR, no additional vibration analysis is necessary.

2. EXISTING CONDITIONS

2.1 Sensitive Receptors

Aerial photographs were used to identify sensitive receptors in the project area within 200 feet of the proposed alignment, and the land uses were confirmed through a site visit. The sensitive receptors in the study area have been grouped into clusters of buildings that have similar levels of existing noise and that are approximately the same distance from the Exposition Corridor right of way. The clusters are listed in Table 2. The clusters west of Farmdale are shown in Figure 1 and the clusters east of Farmdale are shown in Figure 2. There are multi-family residences on the north side of Exposition Boulevard from Farmdale Avenue to Hillcrest Drive, with a minimum distance of 85 ft between the closest residence and the proposed alignment. There is a multi-family residence between Farmdale Avenue and Chesapeake Avenue on the south side of Exposition Boulevard, and single-family residences between Chesapeake Avenue and Hillcrest Drive. In the FEIS/EIR, a motel on the northeast corner of Farmdale Avenue and Exposition Boulevard was considered as a sensitive receptor. However, as a condition of the proposed project, this motel would be demolished and replaced with a parking lot. The nearest residence behind the motel is a single-family residence at a distance of 210 feet from the centerline of the nearest track.

Table 2. Sensitive Receptor Clusters

Cluster No.	Side of Project Alignment	Approx. Station Number	Land Use	FTA Impact Category	Min. Dist. to Near Track Centerline (ft)	Number of Buildings	Estimated Number of Units(1)
1	N	371+00	Motel	3	75	1	10
1a(2)	N	371+00	SFR	3	210	1	1
2	N	369+00	SFR	3	150	1	1
3	N	367+00	MFR	3	85	6	24
4	N	364+00	MFR	3	90	6	24
5	N	360+00	MFR	3	90	6	24
6	N	357+50	MFR	3	90	6	24
7	S	374+00	School	2	50	2	10
8	S	370+00	MFR	3	55	1	10
9	S	367+00	SFR	3	55	2	2
10	S	364+00	SFR	3	60	2	2
11	S	361+00	SFR	3	55	2	2
12	S	358+00	SFR	3	60	2	2
13	S	355+00	SFR	3	50	2	2

Notes:
(1) Approximate number of dwelling units for residences and classrooms for Dorsey High School
(2) Cluster 1a is the nearest sensitive receptor behind Cluster 1 (the Expo Inn), which would be demolished as part of the proposed project.

Figure 1. Sensitive Receptor Clusters West of Farmdale

Figure 2. Sensitive Receptor Clusters East of Farmdale

2.2 Existing Noise Levels

The existing noise environment in the study area has been documented through a series of noise measurements. The first set of measurements was performed in 2000 for the EIS/EIR studies (Ref. 1) and the second set was performed in 2007-2008 as part of this study. The locations where noise measurements were performed are shown in Figure 3 and the measurement results are summarized in Table 3. The noise measurements consisted of long-term (minimum of 24 hours) and short-term (1 hour or less) measurements. The hourly results of the two long-term measurements are shown in Figure 4 and Figure 5. Following are brief discussions of the measurement results:

LT-10 (FEIS/EIR): A 24-hour measurement was performed at 3500 Muirfield Avenue from July 12, 2000, to July 13, 2000. The overall Ldn for the measurement was 60 dBA. The hourly noise levels are shown in Figure 4. This site was on the south side of Exposition and it appears that the main noise source was traffic on Exposition north.

ST-10 (FEIS/EIR): A short-term measurement of one hour was performed at Dorsey High School beginning at 5:45 pm on July 13, 2000. The overall noise level for the measurement was 56 dBA (hourly Leq). This is similar to the hourly noise level of 58 dBA measured during the long-term noise measurement at LT-10, indicating similar noise levels at the two locations.

LT-1 (current study): A 24-hour measurement was performed at 4421 Exposition Boulevard on the north side of Exposition starting at 11:45 a.m. on February 26, 2008. The overall Ldn for the measurement was 65 dBA, which is significantly higher than the Ldn of 60 dBA measured at LT-10 (3500 Muirfield). The higher noise levels at LT-10 were probably due to Exposition Boulevard north carrying substantially more traffic than Exposition Boulevard south. The noise levels were highest at 7 a.m. and 6 p.m., indicating that vehicular traffic on Exposition during peak traffic times is the primary noise source in this area. The hourly noise levels for this measurement are shown in Figure 5.

Table 3. Noise Measurement Results

Measurement Site:	Location	Start		Duration	Ldn (dBA)	Leq (dBA)	
		Date	Time			Day	Night
LT-10	3500 Muirfield Road	7/12/2000	6:00 p.m.	24 hr	60	58	52
ST-1	3500 Muirfield Road	2/6/2008	11:00 a.m.	1 hr	--	58[1]	--
ST-10	Dorsey High School	7/13/2000	5:45 p.m.	1 hr	--	56[1]	--
ST-2	Dorsey High School	5/14/2007	2:25 p.m.	1 hr	--	56[1]	--
LT-1	4421 Exposition Blvd.	2/26/2008	11:45 a.m.	24 hr	65	62	57

Notes:
(1) The short-term measurements were used to estimate noise levels during daytime hours.

Figure 3. Aerial Photograph of Noise Measurement Sites

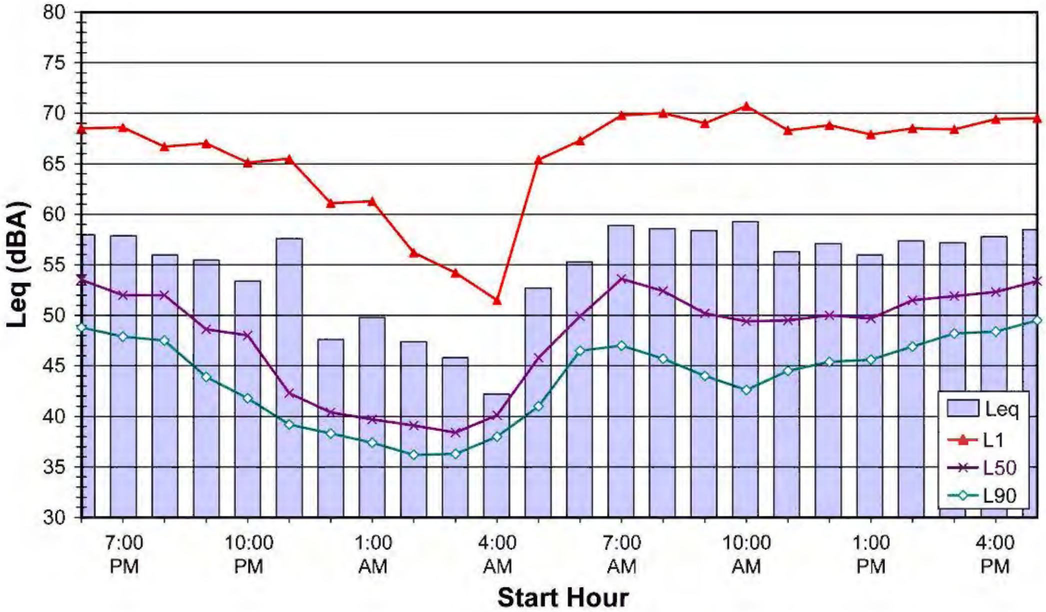


Figure 4. 24-Hour Measurement at 3500 Muirfield Drive (LT-10)

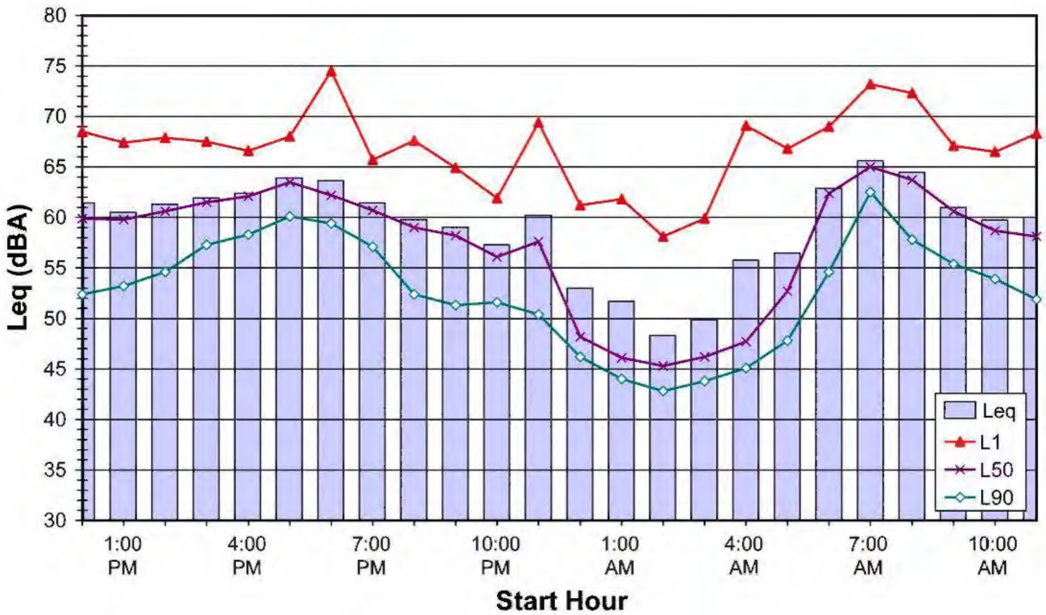


Figure 5. 24-Hour Measurement at 4421 Exposition Boulevard (LT-1)

ST-1 (current study): This one-hour measurement was performed at 3500 Muirfield Avenue, the same location as EIS/EIR measurement LT-10. The measurement began at 10:57 a.m. on February 6, 2008. The measured Leq was 58 dBA. The measured level during the same hour at LT-10 was 56 dBA and the overall daytime Leq at LT-10 was 58 dBA. These values are consistent with the more recent measurement at ST-2 indicating that community noise levels are substantially unchanged since the measurements in 2000.

ST-2 (current study): A short-term measurement of one hour at Dorsey High School starting at 2:15 pm on May 14, 2007. The location was close to ST-10. Classes were in session when the measurement was started and students were let out at 3:08 pm. The Leq for the period of 2:15 to 3:05 PM was 56 dBA, identical to the EIS/EIR measurement at ST-10. The primary noise source was traffic on Exposition Boulevard. The measurement was terminated at 3:05 to avoid having the measurement result influenced by the noise from students who had just finished their school day and were leaving the campus.

3. IMPACT CRITERIA

3.1 Federal Transit Administration

The FTA criteria (Ref. 3) were used to assess noise impact for this study. The FTA noise criteria are based on well documented studies of human response to noise and are widely applied for assessing rail transit projects. FTA uses the three land use categories described in Table 4. Included in Table 4 are the category descriptions and the noise metrics used for characterizing existing and future noise levels. The impact thresholds are illustrated in Figure 6.

The noise-sensitive receptors along the Exposition line near the Farmdale crossing include single-family residences, multi-family residences, a motel and Dorsey High School. The residential land uses and the motel are FTA Category 2 and the high school is an FTA Category 3. There are also several commercial land uses along the proposed project corridor that are not generally considered to be noise sensitive by FTA.

Table 4. Land Use Categories

Land Use Category	Noise Metric (dBA)	Description of Land Use Category
1	Outdoor Leq(h)[(1)]	Tracts of land where quiet is an essential element of their intended purpose. This category includes lands set aside for serenity and quiet and such land uses as outdoor amphitheaters and concert pavilions, as well as National Historic Landmarks with significant outdoor use. Also included are recording studios and concert halls.
2	Outdoor Ldn	Residences and buildings where people normally sleep. This category includes homes, hospitals and motels where a nighttime sensitivity to noise is assumed to be of utmost importance.
3	Outdoor Leq(h)[(1)]	Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, and churches where it is important to avoid interference with such activities as speech, meditation, and concentration on reading material. Places for meditation or study associated with cemeteries, monuments, museums, campgrounds and recreational facilities can also be considered to be in this category. Certain historical sites and parks are also included.

Notes:
(1) Leq for the noisiest hour of transit-related activity during hours of noise sensitivity.
Source: FTA, 2006

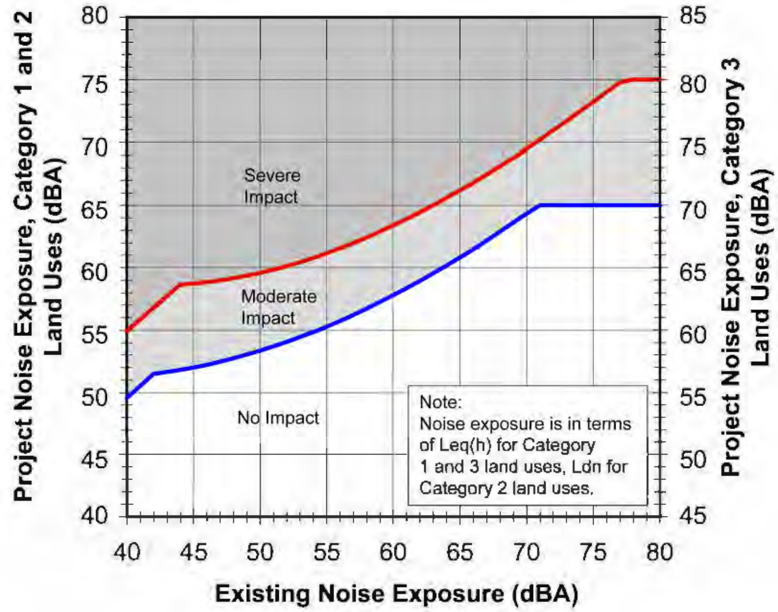


Figure 6. FTA Noise Impact Criteria

The FTA noise impact criteria are a sliding scale as shown in Figure 6. The existing noise is shown on the horizontal axis and the amount of new noise that can be created by the project before there would be impact is on the vertical axis. For Category 1 and 2 land uses, the left vertical axis is applicable. Existing noise exposure is measured using hourly Leq for Category 1 and Ldn for Category 2. For Category 3 land uses, the right vertical axis is applicable and existing noise exposure is measured using the maximum hourly Leq during the period that the facility is in use. The basic concept of the FTA noise-impact criteria is that more project noise is allowed in areas where existing noise is higher, but the decibel increase in total noise exposure (the decibel sum of existing noise and project noise) decreases.

FTA defines two levels of noise impact: Moderate Impact and Severe Impact. In accordance with the FTA manual, noise mitigation to eliminate the impacts must be investigated for both degrees of impact. Mitigation of severe impacts is generally required unless mitigation is truly infeasible. Mitigation of moderate impacts must be evaluated, but the decision whether to mitigate a moderate impact can include consideration of factors such as cost of the mitigation, the number of receptors that would benefit from the mitigation, and the amount that the predicted levels exceed the impact threshold.

Dorsey High School is considered to be a Category 3 land use. Referring to the right hand axis in Figure 6, the impact thresholds for a Category 3 land use given an existing daytime Leq of 56 dBA are:

Moderate Impact:	61 dBA
Severe Impact:	66 dBA

These impact thresholds apply to the maximum one hour Leq from the project during the period that the facility is normally in use. A common source of confusion is that the future Leq would be the decibel sum of the existing (56 dBA) and the noise from the project (61 dBA Leq at the moderate impact threshold). The decibel sum of 56 dBA and 61 dBA is 62 dBA.

Residential areas near Farmdale Crossing are considered to be a Category 2 land use. Based on the long-term noise measurements, the noise impact thresholds for residential land uses in the study area are:

North of Exposition

Existing Ldn:	65 dBA
Moderate Impact threshold (project noise):	61 dBA
Severe Impact threshold (project noise):	66 dBA

South of Exposition

Existing Ldn:	60 dBA
Moderate Impact threshold (project noise):	58 dBA
Severe Impact threshold (project noise):	63 dBA

3.2 Los Angeles Unified School District

LAUSD acoustic guidelines from the January 2007 version of the LAUSD School Design Guide (Ref. 4) are as follows:

Allowable maximum background sound level from HVAC noise

Classrooms:	45 dBA max, 40 dBA target
Conference rooms, library, office:	45 dBA
Cafeteria, Gymnasium, Corridor, Locker Rooms:	50 dBA
Multipurpose room:	40 dBA max, 35 dBA preferred

Allowable maximum background sound level from traffic noise or playground noise
(same as for HVAC noise)

The current version of the LAUSD School Design Guide does not include a specific target noise level for exterior noise levels, just the limits given above for interior noise levels. In previous versions of the LAUSD School Design Guide (e.g., the 2003 version) a maximum one-hour Leq of 67 dBA was given as the maximum allowable exterior noise exposure for school facilities. However, exterior standards are not included in the January 2007 Design Guide. Note that in this case the impact threshold of an exterior sound level of 67 dBA Leq is slightly higher than the FTA severe impact threshold applicable to the Dorsey High School campus.

4. NOISE IMPACT ASSESSMENT

4.1 Light Rail Trains

Noise sources associated with future operation of light rail vehicles within the Exposition Corridor in the vicinity of the Farmdale Crossing include:

- Wheel/Rail Rolling Noise: Wheel/rail noise is from the interaction of steel wheels rolling on steel rails. It is directly related to train speed and the combined roughness of the wheels and the rails. This is the primary noise source for light rail vehicles operating on tangent (straight) track.
- Wheel/Rail Impact Noise: Because this project will be constructed with continuously welded rail, wheel impacts will only occur where two rails intersect for turnouts or crossovers. The current project design does not include any turnouts or crossovers in the vicinity of Farmdale Avenue.
- Wheel Squeal Noise. Wheel squeal is generated by the slip-stick interaction of the wheels and rails as vehicles negotiate tight radius curves. There will not be any tight radius curves in the vicinity of Farmdale Avenue.

- Auxiliary Equipment: This includes fans, blowers, air conditioning units, and traction power motors. These sources are usually only audible at relatively low speeds (< 30 mph).
- Grade Crossing Bells: The CPUC requires that gate protected crossings be equipped with bells to alert pedestrians that a train is approaching the crossing. The default operating condition is for the crossing bells start ringing approximately 30 seconds before a train reaches the crossing and continue until the train has cleared the crossing and the gates are in the upright position. The CPUC has granted variances for a number of light rail grade crossings that allow stopping the bell ringing once the gates reach the down (closed) position, which results in a bell ring time of 10 to 15 seconds. The FEIS/EIR (Ref.. 1) used the assumption that bells would ring for 12 seconds each time a train passes in either the eastbound or westbound direction.
- Train Horn: CPUC General Order 75-C requires that an on-vehicle audible warning be sounded in advance of each gate-protected grade crossing. Metro policy on the Gold Line is to sound a quacker before each gate-protected crossing. The quacker generates a sound level of 75 dBA at 100 ft in front of the train. It is assumed that a similar warning device will be used on the Exposition Corridor. At train speeds above approximately 35 mph the sound from the quacker adds an insignificant amount to the cumulative noise exposure. At lower speeds, the sound from the quacker is equal to the noise level of trains traveling at 35 mph. Therefore, the train speed is assumed to be 35 mph.

The noise prediction model uses the formulas given in the FTA Guidance Manual (Ref. 3); the principal formulas are summarized in Appendix B. The following assumptions were used to estimate LRT noise:

Headway:	5 minutes commute periods, 10 minutes daytime, 20 minutes off-hours (schedule is summarized in Appendix C).
Speed:	55 mph (35 mph in the vicinity of Farmdale Ave).
Train length:	3 cars during commute periods, 2 cars at all other times.
Train noise:	Lmax of 77 dBA for 2-car train operating on ballast and tie track at 40 mph (based on previous measurements of Gold Line operations).
Propagation:	Soft ground (same as assumed for EIS/EIR studies (Ref. 1)).
Crossing bells:	Default conditions: noise level of 85 dBA at 10 ft, ring duration of 12 seconds each time gates are activated. Bells located at northwest and southeast corners of the intersection.
Traffic noise:	No significant change in traffic volumes would occur with the proposed project.

The predicted noise levels and impacts for the proposed project are unchanged from those described in the FEIS/EIR, except for the replacement of Cluster 1 (a motel which would be demolished under the proposed project) with Cluster 1a (a single-family residence). The project noise levels at both of these sensitive receptors were below the noise impact threshold, so the results and the mitigation recommendations of the FEIS/EIR are unchanged. The FEIS/EIR predicted noise impacts for the at-grade crossing, the alignment of which is similar to the proposed project.

5. MITIGATION RECOMMENDATIONS

The predicted noise impacts from light rail operations were limited to the southern side of the alignment where the tracks are closer to residential areas. All of the predicted noise impact can be eliminated with sound walls along the rail right of way. The locations of the sound walls on the south side of the alignment were specified in the FEIS/EIR, and have not changed (Figure 7). The recommended sound walls eliminate all of the noise impacts for the proposed project.

Although most sound walls for rail transit systems are constructed of poured or precast concrete panels, many lighter-weight materials are equally effective as sound walls. The primary requirements are that the sound walls be constructed of a material with a minimum surface density of 4 lb/sq ft and, if there are breaks in the wall for access or drainage, the breaks should be carefully designed to avoid providing a “short-circuit” path for sound to get through the wall.

Table 5. Recommended Sound Wall Locations

Location	Side of Tracks	Noise Barrier Description		
		Civil Stations	Length	Height[(1)]
Potomac Ave to Vineyard Ave	N	--	--	--
Buckingham Rd to Farmdale Ave[(2)]	S	355+00 to 371+00	1600 ft	6 ft

Notes:
(1) Sound wall heights are measured from the top of rail.
(2) The sound wall from Buckingham Road to Farmdale Avenue is identical to the wall originally specified in the FEIS/EIR.

Figure 7. Proposed Sound Wall (from FEIS/EIR)

APPENDIX A. FUNDAMENTALS OF NOISE AND VIBRATION

Sound is mechanical energy transmitted by pressure waves in a compressible medium such as air. Noise is generally defined as unwanted or excessive sound. Sound can vary in intensity by over one million times within the range of human hearing. Therefore, a logarithmic scale, known as the decibel scale (dB), is used to quantify sound intensity and to compress the scale to a more manageable range.

Sound is characterized by both its amplitude and frequency (or pitch). The human ear does not hear all frequencies equally. In particular, the ear deemphasizes low and very high frequencies. To better approximate the sensitivity of human hearing, the A-weighted decibel scale (dBA) has been developed. On this scale, the human range of hearing extends from approximately 3 dBA to around 140 dBA. Figure 8 shows a range of typical noise levels from common indoor and outdoor activities.

Using the decibel scale, sound levels from two or more sources cannot be directly added together to determine the overall sound level. Rather, the combination of two sounds at the same level yields an increase of 3 dB. The smallest recognizable change in sound level is approximately 1 dB. A 3-dB increase in the A-weighted sound level is generally considered noticeable, whereas a 5-dB increase is readily noticeable. A 10-dB increase is judged by most people as an approximate doubling of the perceived loudness.

The two primary factors that reduce levels of environmental sounds are increasing the distance between the sound source and the receiver and having intervening obstacles such as walls, buildings, or terrain features that block the direct path between the sound source and the receiver. Factors that act to make environmental sounds louder include moving the sound source closer to the receiver, sound enhancements caused by reflections, and focusing caused by various meteorological conditions.

Below are brief definitions of the measurements and other terminology used in this report:

- *Equivalent Sound Level (L_{eq})*: Environmental sound fluctuates constantly. The equivalent sound level (Leq), sometimes referred to as the energy average sound level, is the most common means of characterizing community noise. Leq represents a constant sound that, over the specified period, has the same sound energy as the time-varying sound.
- *Maximum Sound Level (L_{max})*: L_{max} is the maximum sound level over the measurement period. Sound level meters usually have a selector for measuring sound with either the FAST or SLOW meter setting, which represent time constants of 0.25 and 1 second respectively. Lmax measured using the FAST meter setting will typically be 1 to 3 decibels higher than when measured using the SLOW meter setting. If not stated, the term L_{max} is usually taken to indicate the FAST sound level meter setting.
- *L_{xx}:* This is the percent of time a sound level is exceeded during the measurement period. For example, the L90 is the sound level exceeded 90 percent of the measurement period.
- *Day-Night Sound Level (L_{dn})*: L_{dn} is basically a 24-hour L_{eq} with an adjustment to reflect the greater sensitivity of most people to nighttime noise. The adjustment is a 10-dB penalty for all sound that occurs between the hours of 10 p.m. and 7 a.m. The effect of the penalty is that, when calculating L_{dn}, any event that occurs during the nighttime is equivalent to 10 of the same event during the daytime. L_{dn} is the most common measure of total community noise over a 24-hour period and is used by the Federal Transit Administration (FTA) to evaluate residential noise impacts from proposed transit projects.

- *Sound Exposure Level (SEL)*: SEL describes a receiver's cumulative noise exposure from a single noise event. It is represented by the total A-weighted sound energy during the event, normalized to a one-second interval. SEL is a useful intermediate quantity for estimating Ldn from train passbys.

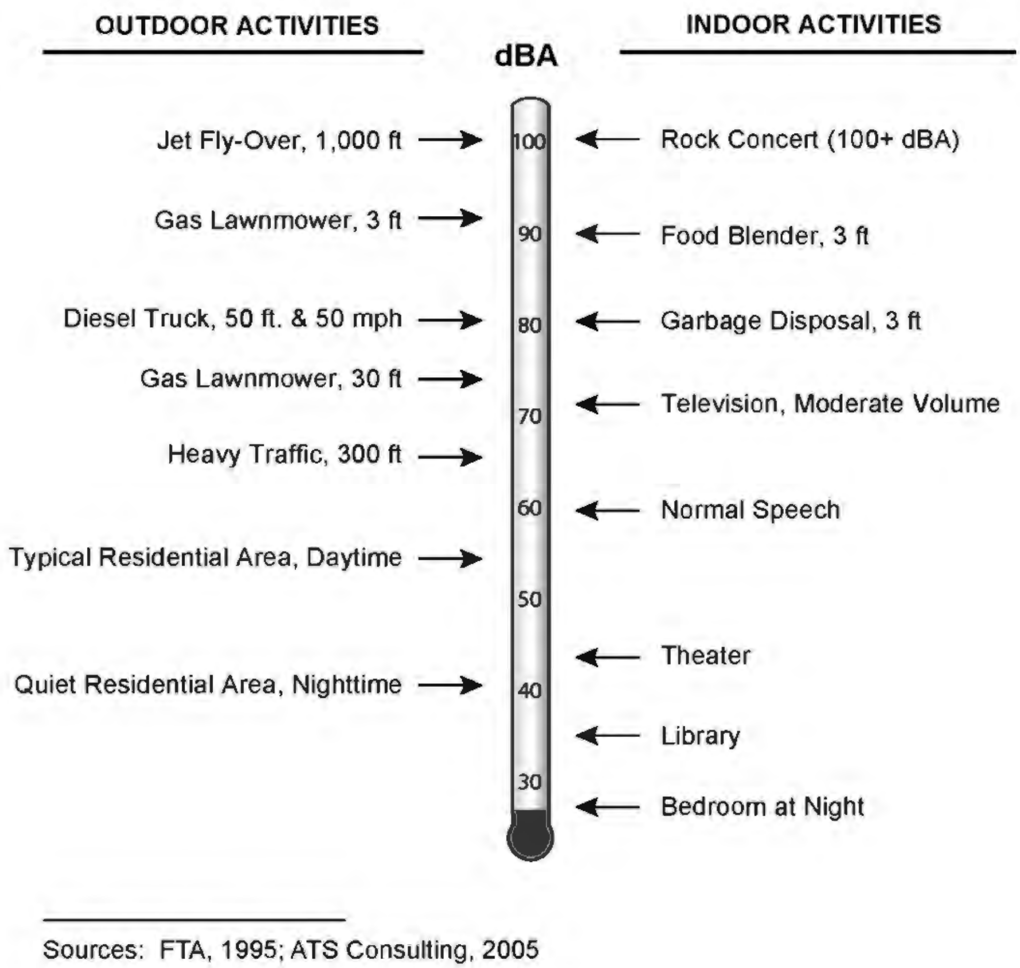


Figure 8. Graph of Typical Indoor & Outdoor Noise Sources and Levels

Vibration is an oscillatory motion that can be described in terms of displacement, velocity, or acceleration. The response of humans to vibration is very complex. However, the general consensus is that for the vibration frequencies generated by sources such as light rail trains, human response is best approximated by the vibration velocity level. Therefore, vibration velocity has been used in this study to describe train-generated vibration levels.

Train-generated vibration, which is caused by the interaction of the wheels and rails, may be perceived by building occupants as perceptible vibration. It is also common for ground-borne vibration to cause windows, pictures on walls, or items on shelves to rattle. Although the perceived vibration from train passbys can be intrusive to building occupants, the vibration is almost never of sufficient magnitude to cause even minor cosmetic damage to buildings.

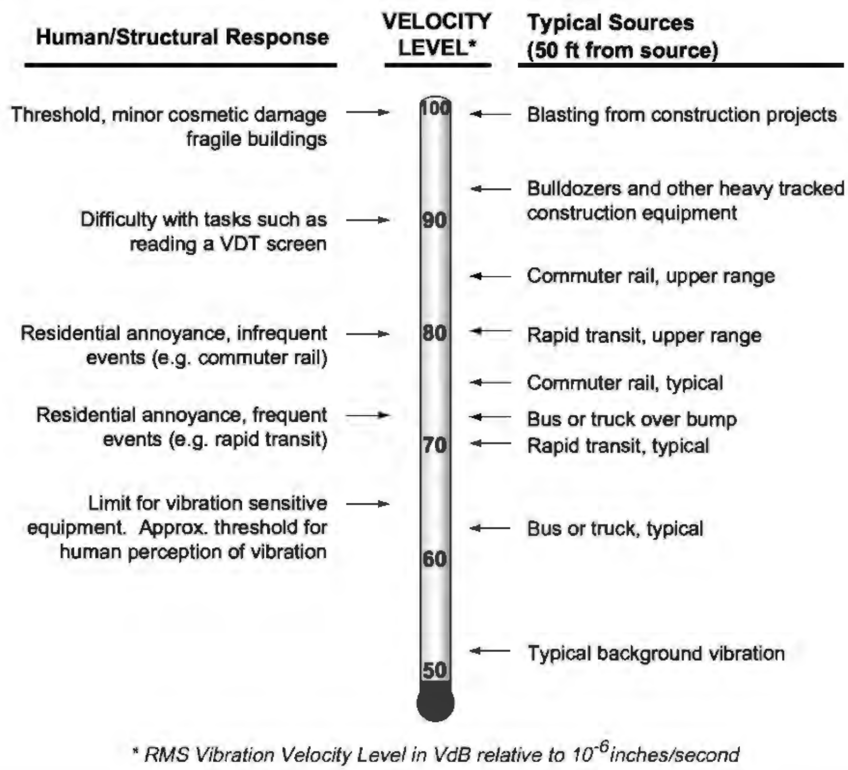
When evaluating human response, ground-borne vibration is usually expressed in terms of root mean square (RMS) vibration velocity. RMS is defined as the average of the squared amplitude of the vibration signal. As for sound, it is common to express vibration amplitudes in terms of decibels defined as:

$$L_v = 20\log\left(\frac{v_{rms}}{v_{ref}}\right)$$

where v_{rms} is the RMS vibration velocity amplitude in inches/second and v_{ref} is the decibel reference of $1\text{x}10^{-6}$ inches/second.

To avoid confusion with sound decibels, the abbreviation VdB is used for vibration decibels. Figure 9 shows typical vibration levels from rail and non-rail sources as well as the human and structure response to such levels. The threshold of perception for most people is around 65 VdB. Vibration levels in the 70 to 75 VdB range are often noticeable but acceptable and levels in excess of 80 VdB are often considered unacceptable.

This report also describes and illustrates the frequency spectrum of the measured train vibration levels. The spectra are presented in terms of the 1/3 octave band levels. The frequency content of noise and vibration signals is often evaluated using either octave bands or 1/3 octave bands. An octave is defined as a frequency range in which the upper band is twice the lower limit. Octave bands are typically referenced by their geometric mean frequency, or center frequency. For 1/3 octave bands, each standard octave band is divided into three one-third octave bands. As with octave bands, 1/3 octave bands are referenced by the center frequencies.



FTA, 2006

Figure 9. Typical Vibration Levels

APPENDIX B. FORMULAS USED FOR NOISE PREDICTIONS

Calculation of Reference Ldn for trains in a single direction from SEL:

$$Ldn_{ref\,(LRV)} = SEL_{ref\,(LRV)} + 10 \times \log\left(N_{day} + 10 \times N_{night}\right) - 49.4$$

where:
N_{days} = Number of trains in a single direction during daytime hours
N_{night} = Number of trains in a single direction during nighttime hours

Calculation of Ldn for trains in a single direction:

$$Ldn_{LRV\,(direction)} = Ldn_{ref} - 10 \times \log\left(D/D_{ref}\right) - G \times \log\left(D/42\right) + T_{adj} + 20 \times \log\left(S/S_{ref}\right)$$

where:
D = Distance of receiver from track centerline
D_{ref} = Reference distance of 50 feet
G = Ground Factor (=0 for hard ground)
T_{adj} = Track adjustment. A factor of +4 is added for aerial structures with embedded track. (No adjustment is made for ballast and tie track)
S = Speed in project area of 55 mph
S_{ref} = Reference speed of 40 mph

Calculation of project Ldn from trains:

$$Ldn_{project} = 10 \times \log\left[10^{\left(Ldn(WB)/10\right)} + 10^{\left(Ldn(EB)/10\right)}\right]$$

where:
Ldn(WB) = Day-Night Sound Level for westbound trains
Ldn(EB) = Day-Night Sound Level for eastbound trains

Calculation of SEL for an individual grade crossing bell:

$$SEL_{Bell} = 10 \times \log\left[E \times 10^{\left(L\max/10\right)}\right] - 20\log\left(D/D_{ref}\right)$$

where:
E = Crossing bell duration
Lmax = 80 dBA at a reference distance of 10 feet
D = Distance of receiver from crossing bell.
D_{ref} = Reference distance of 10 feet

Calculation of Ldn for an individual grade crossing bell:

$$Ldn_{Bell} = SEL_{Bell} + 10 \times \log\left(N_{day} + 10 \times N_{night}\right) - 49.4$$

where:
N_{days} = Number of trains in **both** directions during daytime hours
N_{night} = Number of trains in **both** directions during nighttime hours

Calculation of project Ldn from grade crossing bells:

$$Ldn_{project} = 10 \times \log\left[10^{\left(Ldn(Bell\ 1)/10\right)} + 10^{\left(Ldn(Bell\ 2)/10\right)}\right]$$

where:
Ldn(Bell 1) = Day-Night Sound Level for first crossing bell
Ldn(Bell 2) = Day-Night Sound Level for second crossing bell

Calculation of noise increase due to increase in traffic volume:

$$Noise_{new} = Noise_{old} + 10 \times \log\left(\frac{Traffic_2}{Traffic_1}\right)$$

where:
$Traffic_1$ = Existing traffic volume
$Traffic_2$ = Future traffic volume

APPENDIX C. EXPOSITION LINE TRAIN SCHEDULE

Table 6. Exposition Line Train Schedules

Hour	Inbound Trains			Outbound Trains		
	Headway (minutes)	Number of Trains	Length (cars)	Headway (minutes)	Number of Trains	Length (cars)
0	30	2	2	30	2	2
1	0	0	2	0	0	2
2	0	0	2	0	0	2
3	0	0	2	0	0	2
4	15	4	2	15	4	2
5	15	4	2	15	4	2
6	5	12	3	5	12	3
7	5	12	3	5	12	3
8	5	12	3	5	12	3
9	10	6	2	10	6	2
10	10	6	2	10	6	2
11	10	6	2	10	6	2
12	10	6	2	10	6	2
13	10	6	2	10	6	2
14	10	6	2	10	6	2
15	5	12	3	5	12	3
16	5	12	3	5	12	3
17	5	12	3	5	12	3
18	8	8	2	8	8	2
19	10	6	2	10	6	2
20	20	3	2	20	3	2
21	20	3	2	20	3	2
22	20	3	2	20	3	2
23	20	3	2	20	3	2

Source: Exposition Corridor Phase 2 Operating Plan

REFERENCES

1. "Mid-City Exposition Light Rail Transit Project Final Environmental Impact Statement/Environmental Impact Report," Los Angeles County Metropolitan Transportation Authority, October 2005.
2. "Noise and Vibration Impact Assessment for the Mid-City/Exposition Light Rail Transit Project," Harris Miller Miller & Hanson, October 2005.
3. U.S. Department of Transportation, Federal Transit Administration, Transit Noise and Vibration Impact Assessment, FTA report FTA-VA-90-1003-06, May 2006.
4. Los Angeles Unified School District, LAUSD School Design Guide, October 2003.

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