The importance of vehicle throttle setting information for rail transit noise impact assessments

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A noise impact assessment conducted for the proposed Denver RTD North Metro commuter rail project illustrated the importance of accurate vehicle throttle setting information. During the early phase of the analysis, trains with diesel multiple unit (DMU) vehicles were evaluated. The U.S. Federal Transit Administration (FTA) detailed noise analysis methodology prescribes an adjustment of up to +6 dB for diesel-powered vehicles operating at higher throttle settings, which can have a significant effect on the assessment results. For the North Metro analysis, detailed speed and throttle setting profiles along the corridor were developed by vehicle engineers. However, such information is often not available for commuter rail environmental studies so that conservative assumptions must be made. FTA recommends that if throttle setting data are not available then the highest setting should be assumed, resulting in a +6 dB adjustment to the noise projections over the entire rail corridor. If the speed profile for the corridor is available, another approach is to assume that the vehicles will operate at the highest throttle setting only where accelerating. This paper illustrates the importance of obtaining accurate throttle setting profiles for rail transit noise impact assessments by comparing the analysis results with different throttle setting assumptions.

1 INTRODUCTION

Harris Miller Miller & Hanson Inc. (HMMH) was retained by URS Corporation to conduct a noise impact assessment for the proposed Denver Regional Transportation District (RTD) North Metro Corridor commuter rail project. The North Metro Corridor is approximately 29 kilometers (18 miles) long, connecting Denver Union Station to State Highway (SH) 7 through the communities of Denver, Commerce City, Thornton, and Northglenn, Colorado. Figure 1 shows the location of the North Metro Corridor, extending north from Denver Union Station, as well as the locations of several other transit corridors in the area.

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The Draft Environmental Impact Statement[1] (DEIS) for the project considered two different vehicle technologies: diesel multiple unit (DMU) technology, and electric multiple unit (EMU) technology. This paper discusses the noise analysis for the DMU vehicles.

2 NOISE ANALYSIS METHODOLOGY

HMMH conducted the noise analysis for the North Metro Corridor in conformance with the procedures and criteria prescribed in the U.S. Federal Transit Administration (FTA) guidance manual.[2] The noise exposure from a DMU vehicle pass-by is computed from a reference sound exposure level (SEL). SEL describes the cumulative noise exposure from a single event, normalized to a one-second interval. The SEL can then be used to calculate the cumulative one-hour exposure, or hourly equivalent sound level ($L_{eq(h)}$), and the cumulative 24-hour exposure, or day-night sound level (L_{dn}). The FTA guidance manual provides a reference SEL of 85 dBA at a distance of 15.2 meters (50 feet) for one DMU vehicle traveling at 80.5 kilometers per hour (50 miles per hour) on ballast and tie track with continuous welded rail (CWR). The $L_{eq(h)}$ for a DMU train pass-by is then computed using Equation (1) as follows:

$$L_{eq(h)} = SEL_{ref} + 10 * Log(N) + C_T + K * Log\left(\frac{S}{50}\right) + 10 * Log(V) - 35.6 \quad , \qquad (1)$$

where N = average number of DMU vehicles per train, C_T = throttle correction, K = 0 for DMU vehicles, and V = average hourly volume of train traffic, in trains per hour.

The throttle correction, C_T is computed using Equation (2) as follows:

$$C_T = \begin{cases} 0 & for\ T < 6 \\ 2 * (T - 5) & for\ T \geq 6 \end{cases} , \qquad (2)$$

where T = average throttle setting of DMU vehicles (ranging from 1 to 8). Therefore, the throttle correction (C_T) at throttle settings 1 through 5 is zero dBA, the correction at throttle setting 6 is +2 dBA, the correction at throttle setting 7 is +4 dBA, and the correction at the maximum throttle setting of 8 is +6 dBA.

3 SPEED AND THROTTLE PROFILE ASSUMPTIONS

3.1 Detailed Speed and Throttle Profile

In order to conduct the noise impact assessment for the North Metro project, the noise exposure at all noise-sensitive receptors needed to be calculated. Therefore, train speed and throttle information was needed for the entire route. Vehicle engineers provided detailed speed and throttle profile information for the North Metro Corridor at 30.5 meter (100 foot) increments referenced to the project civil stationing. Unique speed and throttle profiles were provided for trains traveling in the northbound and southbound directions as shown in Figure 2. In this figure the red (dark) and blue (light) lines indicate the train speeds in the northbound and southbound directions, respectively, as a function of the distance from Denver Union Station. As shown, the projected train speeds for the North Metro Corridor are as high as 127 kilometers per hour (79 miles per hour).

3.2 Maximum Throttle Setting at All Locations

While it is typical for speed profiles to be provided on a project of this type, the throttle setting information is not always available. If a detailed throttle profile is not available then the average throttle setting may be used. The FTA guidance manual suggests that a conservative assumption for the throttle setting be made so as to not underestimate the noise exposure at sensitive receptors, stating: "If this input is not available, assume a throttle setting of 8." The rationale for this assumption is that if it is unknown where along a rail alignment the train may be operating at maximum throttle, it is more conservative to assume that it will be operating at maximum throttle throughout the entire corridor, i.e. near all noise-sensitive receptors. This assumption results in an adjustment of +6 dBA to the noise analysis for all receptors, and in an overestimation of the noise impacts due to the project.

3.3 Maximum Throttle Setting where Accelerating

Another method for conducting the noise analysis on commuter rail projects where throttle setting profiles are not available is to assume that the train is operating at the maximum throttle setting only where it is accelerating. This approach has been used successfully on many commuter rail noise analyses similar to the North Metro project. As stated above, detailed speed profile information is typically available during the environmental phase of the analysis. The throttle profile can be estimated from the train speeds by assuming that the throttle setting is < 6 (resulting in a throttle setting correction, C_T of zero dBA) at all locations where the train is not accelerating. At all locations where the train is accelerating the maximum throttle setting of 8 is used, resulting in a throttle setting correction, C_T of +6 dBA. While this is still a generally conservative approach to conducting the noise impact assessment, it is more realistic than assuming the train to be operating at maximum throttle everywhere. It should be noted, however, that although this is typically a conservative approach, there are limited conditions where high throttle settings, resulting in greater noise impacts, may occur when trains are not accelerating (e.g. when trains are climbing up a grade).

4 NOISE IMPACT ASSESSMENT

The noise impact assessment for the North Metro Corridor was based on comparing the predicted project noise exposure to the existing noise exposure at noise-sensitive receptor locations along the rail corridor. Using FTA criteria, noise impact locations were identified and the impacts were categorized as either "severe" or "moderate."

The noise analysis assumed that the operating period for revenue rail service would be approximately between 4:00 A.M. and 01:30 A.M. on weekdays. North Metro trains would operate with headways of 15 minutes during peak periods (roughly 6:00 A.M. to 10:00 A.M. and 3:30 P.M. to 7:30 P.M.) and with headways of 30 minutes during all other times in the design year (2030). The DMU train sets would consist of five powered FRA-compliant vehicles for all operations in the design year (2030).

Due to the numerous at-grade crossings along the North Metro Corridor, the assessment indicated that the greatest contributors to noise impact were the loud train horns that would be sounded as trains approach the crossings as required by the U.S. Federal Railroad Administration (FRA). Thus, the primary noise mitigation measure that was adopted by the project was the establishment of quiet zones, so that train horns would not need to be routinely sounded near the

at-grade crossings. For the purposes of comparing the results of the noise impact assessment using different throttle setting information, the effects of horn noise are therefore excluded.

4.1 North Metro Noise Impact Assessment with Detailed Throttle Information

The results of the detailed noise impact assessment for the North Metro Corridor DEIS with DMU train sets indicated that there would be a total of 927 noise impacted receptors, with 535 in the severe noise impact category 392 in the moderate noise impact category. The noise impacts projected for the various cases are listed in Table 1. The impacts in this table refer to the number of impacted residential dwelling units or institutional land use buildings or locations. For example, there might be 10 noise impacts that correspond to one multi-family residential building or one noise impact that corresponds to a school.

4.2 Noise Impact Assessment with Maximum Throttle Setting at All Locations

The results of the conservative noise impact assessment, assuming the maximum throttle setting of 8 for all locations along the North Metro Corridor, indicate a total of 1,197 noise impacts; this number includes 724 severe noise impacts and 473 moderate noise impacts. Thus, the assumption of maximum throttle setting resulted in approximately 30% more noise impacts along the corridor, most of which are in the severe noise impact category.

4.3 Noise Impact Assessment with Maximum Throttle Setting where Accelerating

The results of the noise impact assessment, assuming the maximum throttle setting of 8 only at locations along the North Metro Corridor where the train is accelerating, indicate a total of 995 noise impacts; this number includes 588 severe noise impacts and 407 moderate noise impacts. These numbers are much closer to the North Metro noise impact assessment results based on the detailed throttle profile information. There is less than a 10% increase in the number of noise impacts compared to the results of the detailed North Metro DEIS analysis.

5 COMPARISON OF NOISE IMPACT ASSESSMENT RESULTS

Figure 3 shows a comparison of the noise impact assessment results for a representative section of the North Metro Corridor. The three maps in the figure cover the same area, which is located between 128th Avenue and 136th Avenue. The North Metro rail line is seen running through the middle of the maps. The top map shows the noise impact locations in this area from the DEIS analysis, labeled with red (dark) circles including both severe and moderate impacts.

The middle map shows the noise impact locations with the maximum throttle setting assumed at all locations. Again, the noise impacts from the DEIS analysis are labeled with red (dark) circles and the additional noise impacts for this case are labeled with yellow (light) circles. In this area of the North Metro corridor, there are four clusters of additional noise impacts at second and third row homes back from the alignment compared to the DEIS assessment results.

The bottom map in Figure 3 shows the noise impact locations with the maximum throttle setting assumed at all locations where trains are accelerating. The noise impacts from the DEIS analysis and the additional impacts for this case are labeled with red (dark) and yellow (light) circles, respectively. There are three clusters of additional noise impacts at second row homes back from the alignment compared to the DEIS assessment results.

6 CONCLUSIONS

While it is important in the environmental analysis of a commuter rail project such as the North Metro Corridor to disclose any potential adverse impacts, the above comparison indicates that the number of noise impacts could be overestimated by approximately 30% if the DMU throttle is assumed to be at the maximum setting of 8 throughout the entire corridor. A more reasonable, but still conservative approach is to assume that the DMU will operate at the maximum throttle setting only where accelerating. This comparison indicates that for the North Metro commuter rail project, the number of noise impacts would only be overestimated by approximately 10% using this assumption.

In conclusion, when conducting noise impact assessments for commuter rail projects such as North Metro, it is best whenever possible to utilize detailed vehicle speed and throttle profile information. However, if the throttle setting information is not available, it is suggested that the maximum throttle setting of 8 be assumed at all locations where the DMU is accelerating and that a throttle setting of less than 6 be assumed elsewhere.

7 ACKNOWLEDGEMENTS

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8 REFERENCES

1. U.S. Department of Transportation, Federal Transit Administration, Regional Transportation District, “North Metro Corridor Draft Environmental Impact Statement and Section 4(f) Evaluation,” (2009).

2. U.S. Department of Transportation, Federal Transit Administration, Office of Planning and Environment, “Transit Noise and Vibration Impact Assessment,” FTA-VA-90-1003-06, (2006).

Table 1 – North Metro Corridor Noise Impact Assessment Results Comparison.

Noise Impact Assessment Case	Number of Moderate Noise Impacts	Number of Severe Noise Impacts	Total Number of Noise Impacts
North Metro Noise Assessment with Detailed Throttle Information	392	535	927
North Metro Noise Assessment with Maximum Throttle Setting at All Locations	473	724	1197
North Metro Noise Assessment with Maximum Throttle Setting where Accelerating	407	588	995

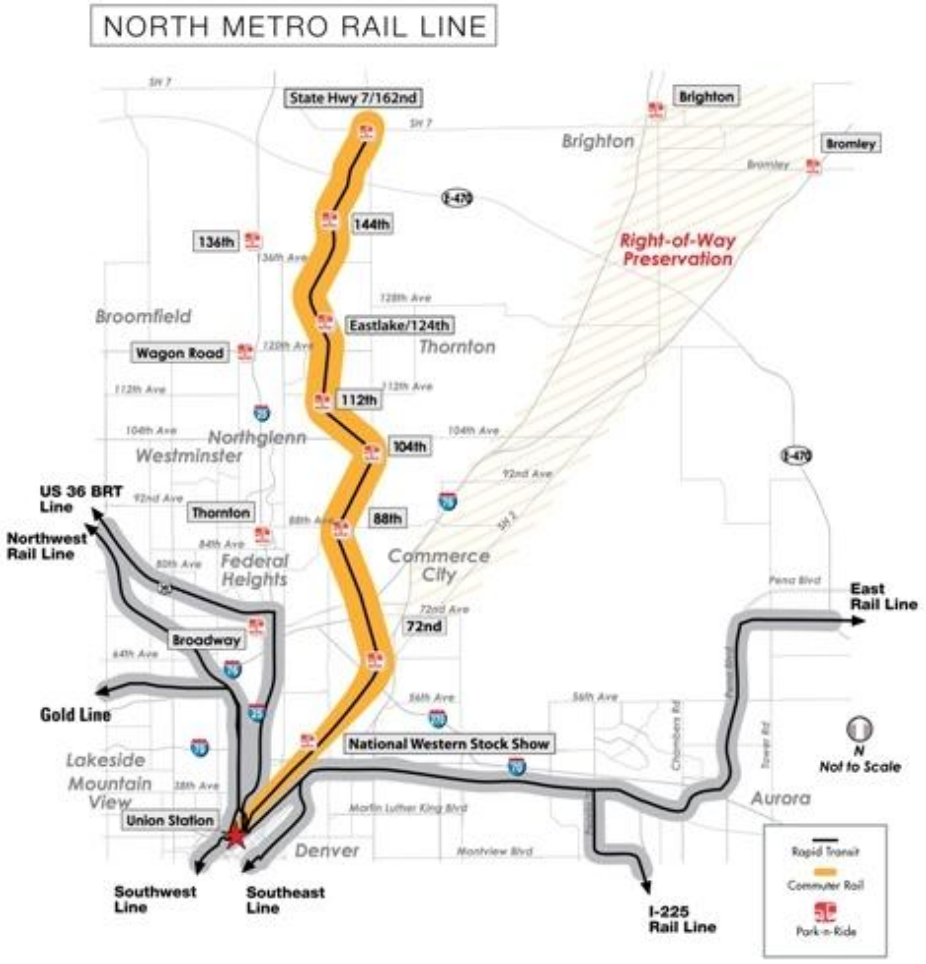

Fig. 1 – North Metro Corridor Map.

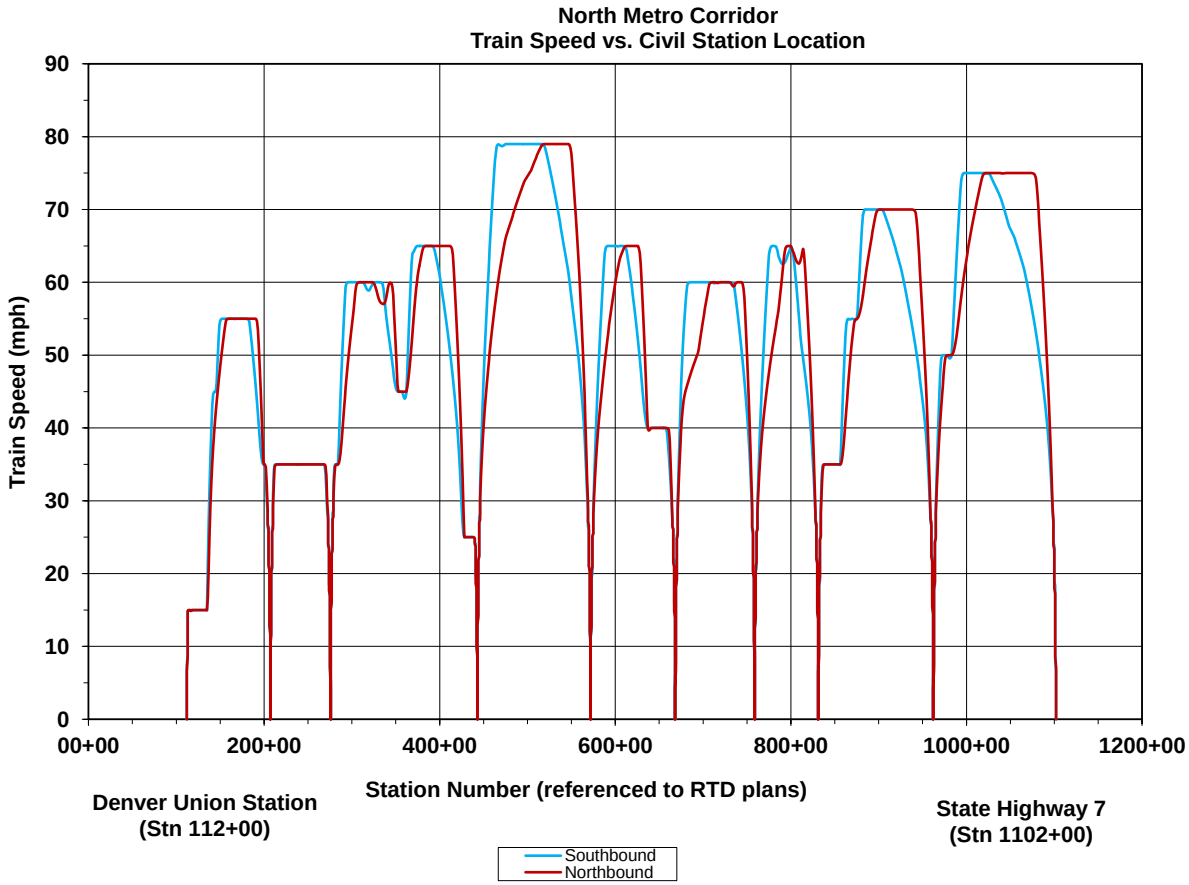

Fig. 2 – North Metro Corridor Speed Profile.

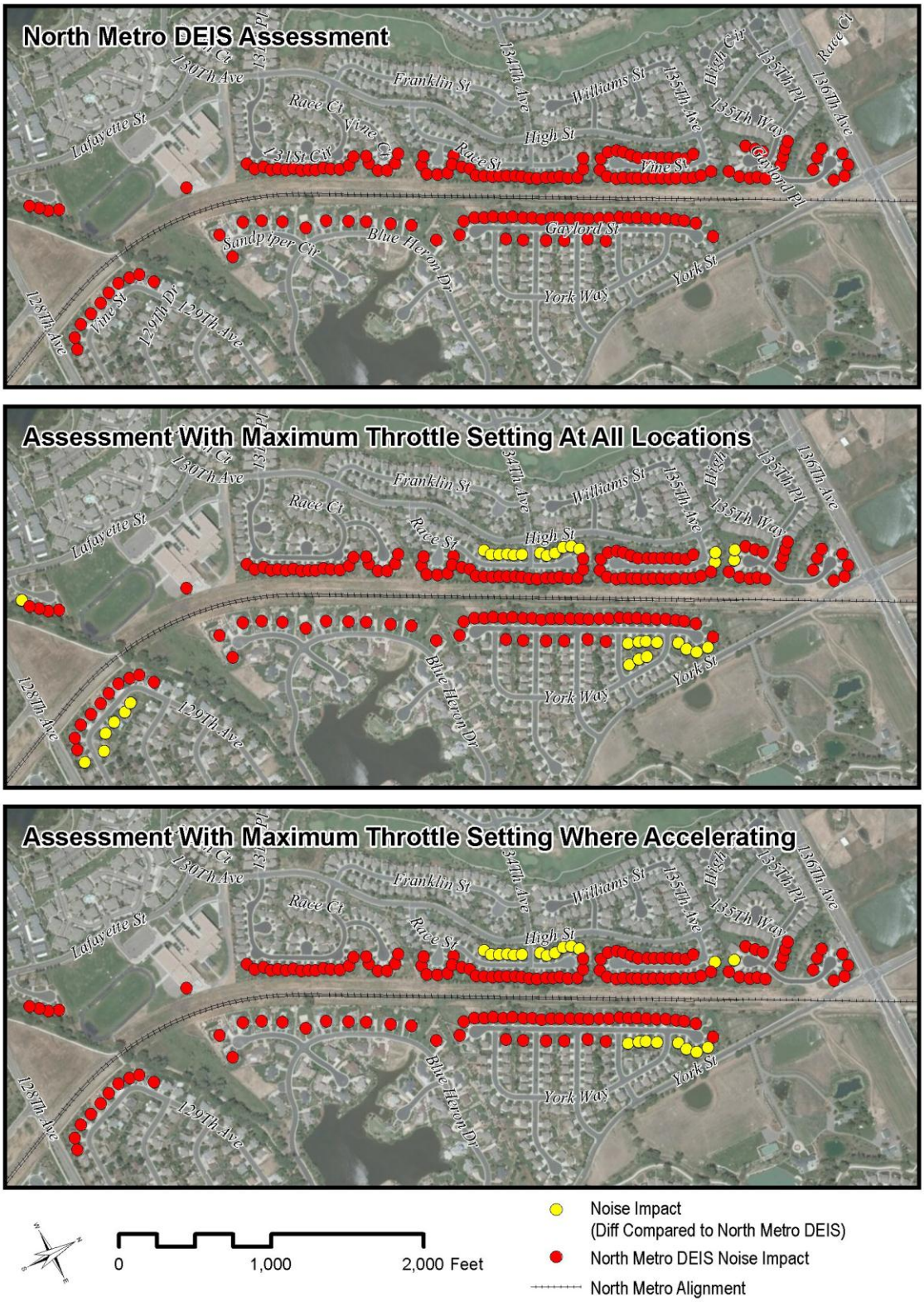

Fig. 3 – Comparison of Noise Impact Assessment Results.