Impact of Speed and Throttle Adjustment on FTA Noise Model in Transit Rail Analysis Including Case Study

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1 Introduction

This paper provides a comparison of results using the US Federal Transit Authority (FTA) Detailed Noise Modelling method [1] for calculating the noise impact from railway for various speeds and throttle settings.

2 FTA Model – Locomotive and Rolling Noise

2.1 Dependence on Speed

The FTA Detailed Noise Modelling method accounts for the noise generated by various sub-sources, including the locomotive engine, rail car ("wheel-rail interaction" or "rolling noise"), and noise from whistles. For the purpose of this study, only locomotive and rolling noise are considered.

In diesel-locomotive trains, locomotive noise is dominated by the diesel engine, which emits a steady noise at a given throttle setting. The equivalent continuous sound level (L_{eq}) at a point of reception is therefore affected by the exposure time to the source. As such, a locomotive travelling at a faster speed will result in a lower L_{eq} at a point of reception than a locomotive travelling at slower speeds at that same point.

Rolling noise, on the other hand, is generated by the vibrations of the track and wheel due to surface roughness [2]. The radiated noise from the wheel/track vibrations is therefore modelled as increasing with increasing speed.

Figure 1 shows the 1-hour equivalent sound levels ($L_{eq, 1hr}$) from a single locomotive and a single rail car at 15 m (50 ft), illustrating the increasing and decreasing sound levels as a function of speed for rolling noise and locomotive noise (respectively).

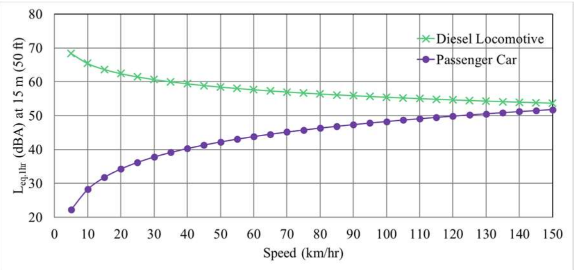

Figure 1: Diesel-Electric Locomotive and Rolling Noise as a function of Speed

2.2 Contribution from Locomotive Throttle

Locomotive sound emissions are also affected by the throttle setting. At low throttle (notch 5 or lower), the FTA model uses an adjustment of 0 dBA to the locomotive emission level. At notch 8, a +6 dBA correction is added.

Table 1 shows a comparison of the calculated $L_{eq, 1hr}$ at a receptor 15 m (50 ft) from the railway line at a height of 1.5 m (5 ft) above grade using the FTA method for three different speeds. The values are presented for one locomotive (notch 1 and 8), one rail car, as well as a sample train consisting of two locomotives and twelve cars.

The results indicate that the worst-case results are calculated for the trains operating at lower speeds and full throttle.

Table 1: FTA Sound Levels for Varying Speed and Throttle.

Speed (km/hr)	$L_{eq, 1hr}$ (dBA) at 15 m				
	Locomotive		Rolling Noise	Sample Train	
	Notch 1	Notch 8		Notch 1	Notch 8
20	62.4	68.4	34.3	65.5	71.5
70	57.0	63.0	45.2	61.5	66.4
120	54.7	60.7	49.9	62.4	65.4

3 Case Study

3.1 Description

In order to further illustrate the above concepts, consider a commuter train having 12 cars and 2 locomotives travelling along a railway line 15 m from the closest façade of a proposed noise-sensitive development. The site is also in the vicinity of a train station where commuter trains decelerate, stop, and accelerate. Typically, locomotives run at full throttle (notch 8) when accelerating, and low throttle when decelerating or travelling at speed [3].

A noise assessment is to be performed in order to determine requirements for the proposed development's façade construction (i.e., walls and windows) such that the indoor acoustical environment is acceptable for the intended use. Note that while this example may apply broadly, the example is typical for a GO Transit commuter train (Greater Toronto Area of Ontario).

When using the Ontario Ministry of the Environment model (Sound from Trains Environmental Analysis Method, STEAM [4]), a conservative assumption regarding speed (that is, the modelled speed that would result in the highest predicted sound level) would be the maximum allowable speed through a corridor. It should be noted that STEAM does not account for variations in throttle and generally produces an increasing predicted sound level (combined wheel-rail and locomotive noise) with increasing speed above 30 km/hr.

3.2 Assessment Scenarios

The case study compares three different scenarios, each using the FTA Detailed Noise Analysis method.

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- Design Speed Without Accounting for Accelerating/Decelerating Trains
- Design Speed Accounting for Accelerating/Decelerating Trains
- Actual Speed Accounting for Accelerating/Decelerating Trains

In each case, the following parameters are used in the assessment:

- 8 trains in an hour (half are decelerating toward the station and half are accelerating from the station)
- 2 locomotives and 12 cars per train
- Locomotives at notch 8 for accelerating trains and notch 1 for decelerating trains (where applicable). Note that where acceleration/deceleration is not considered in a scenario, it is assumed that all locomotives operate at notch 1
- Design speed of 120 km/hr, and actual speed in the vicinity of the proposed development is 35 km/hr

3.3 Results

Based on the above operating parameters, Table 2 provides the predicted $L_{eq,\ 1hr}$ at the receptor point 15 m from the railway at a height of 1.5 m above grade. Note that varying the setback distance, intervening ground characteristics, and receptor height would affect the results for each of the scenarios by the same amount.

3.4 Discussion

It is clear from the results in Table 2 that using the FTA model with the assumption that trains are operating at track design speed does not predict the most conservative sound levels at the receptor. In this example, the predicted sound level at the receptor location is 4.7 dB lower for the “Design Speed” assessment (ignoring the impact of acceleration/deceleration) when compared to the “Actual Speed” assessment (which accounts for acceleration and deceleration). This is a significant difference.

Furthermore, it’s shown that even when acceleration/ deceleration is included in both assessment scenarios, the “Design Speed” assessment still predicts a sound level that is 2.9 dB lower than the assessment which assumes trains are operating at “Actual Speed” (where the speed is largely dictated by proximity to the station). This under-prediction is again significant and could result in a development design that may not sufficiently protect the development from railway noise.

For context, it should be noted that based on GO Transit acceleration deceleration data [3], a speed of 35 km/hr (either accelerating or decelerating) extends approximately 200m from the stopping point of the locomotive. It should also be noted that the under-prediction using the design speed applies in this example at almost all speeds, though the difference is reduced at higher “Actual Speeds” (further from the station).

Taking a wider view of the phenomenon, Figure 2 provides the speed/sound level relationship for the theoretical train operation including for acceleration/deceleration.

It is clear from the figure that although the speed/sound level relationship does exhibit a point of inflection (in this case at approximately 100 km/hr), the increase in sound level at higher speeds is much less significant than the increase in sound level with decreasing speed below the point of inflection.

Table 2: Predicted Sound Levels for Three Scenarios

	$L_{eq,1\ hr}$ (dBA)		
	Accel	Decel	Total
Design Speed – No Accel/Decel	68.4	68.4	71.4
Design Speed – Incl Accel/Decel	71.4	68.4	73.2
Actual Speed – Incl Accel/Decel	75.1	69.2	76.1

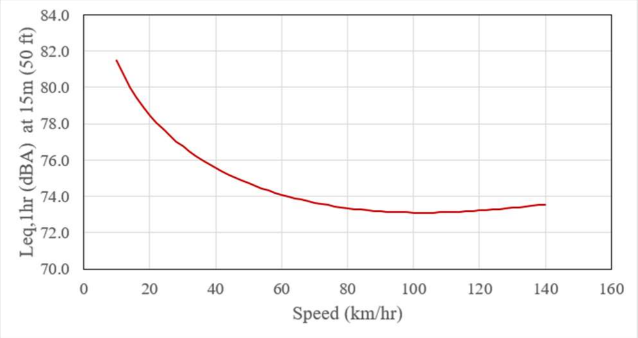

Figure 2: Sound Emission as a Function of Speed – Sample Train Scenario

4 Conclusion

The study provides a comparison of the emitted sound levels from diesel locomotives and rail cars as functions of speed using the FTA Detailed Noise Assessment Method. The results show that modelling trains travelling at lower speeds and full throttle provides higher predicted sound levels than trains travelling at higher speeds and low throttle.

Based on the Case Study, it is proposed that a suitably conservative approach to predicting sound levels at proposed noise sensitive receptor locations would be to use actual speeds of trains at the location of the proposed noise sensitive use as opposed to assumed design speeds that would yield lower predicted sound levels for the train operation.

References

[1] A. Quagliata et al., Transit Noise and Vibration Impact Assessment Manual, FTA Report No. 0123, September 2018.

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[4] V. Schroter, Sound from Trains Environmental Analysis Method, July 1990.