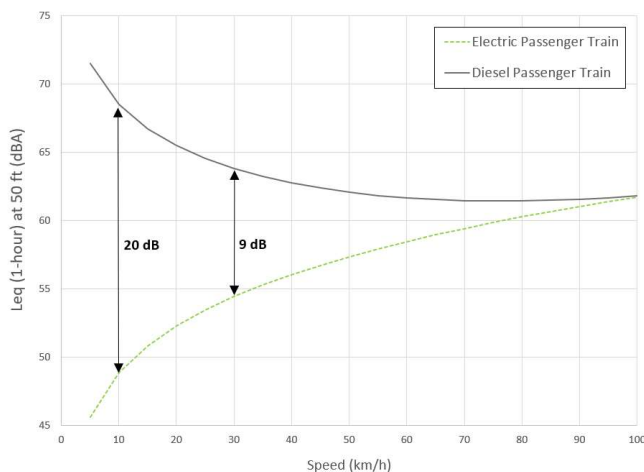


# INFLUENCE OF LOCOMOTIVE SPEED AND THROTTLE PROFILES IN NOISE MODELLING

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## 1 Introduction

Locomotive speed and throttle settings are key parameters when modelling sound levels from diesel trains. Typically, for large stretches of rail corridors, average speeds and throttle settings are used to model noise emissions. In many cases, this is an appropriate approach to approximate the emission of sound from railways, however, there are scenarios where this approach can significantly affect the accuracy of predicted results. In the context of this study, the requirement for noise mitigation was based on an increase in sound level from an existing scenario to a future scenario. Further complicating the assessment was a change in train technology from diesel to electric locomotives. As seen in Figure 1, the predicted sound levels from diesel trains (at throttle < 6) and electric trains differ significantly at lower speeds.

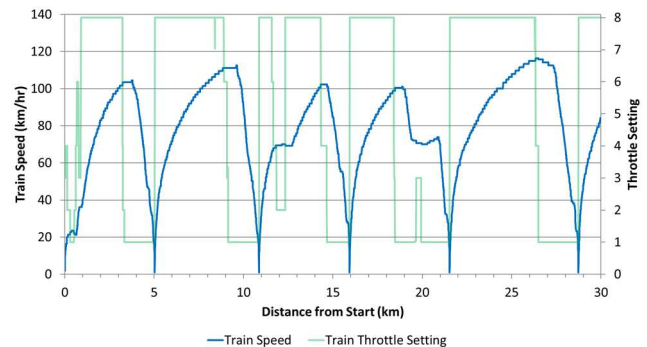


**Figure 1:** Comparison of Predicted Sound Levels from Diesel and Electric Passenger Trains

Consequently, a new approach to incorporate detailed speed and throttle setting variability along railway corridors was necessary to accurately model rail sound. The detailed modelling would accurately represent the change in sound levels that would occur at lower speeds, particularly around commuter rail stations.

## 2 Method

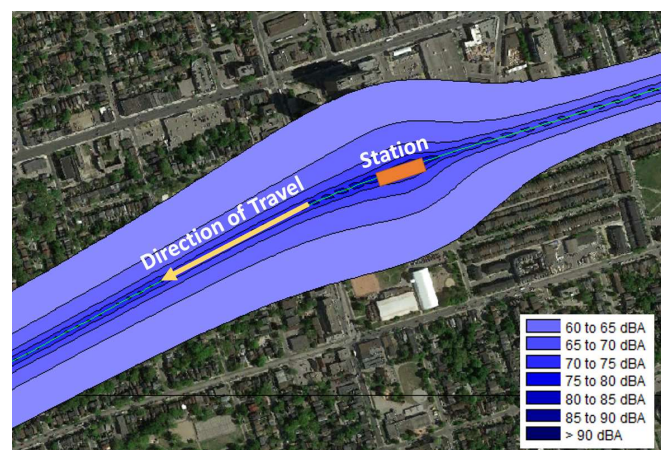
To determine the variability of the speed and throttle settings on a train within the study area, speed and throttle setting were obtained from data loggers on the locomotive. As seen in Figure 2, speed and throttle settings vary significantly along the rail corridor.



**Figure 2:** Typical Speed and Throttle Settings for a Locomotive on a Passenger Train

The data obtained was post-processed to generate the average speed and throttle setting for each 10 m segment of railway. This post-processing was done for each type of speed and throttle profile that would occur on the rail corridor, including such things as: local and express trains, non-revenue train movements (i.e. no station stops), direction of travel (i.e. eastbound or westbound), and the inclusion of the effect of new stations in the future.

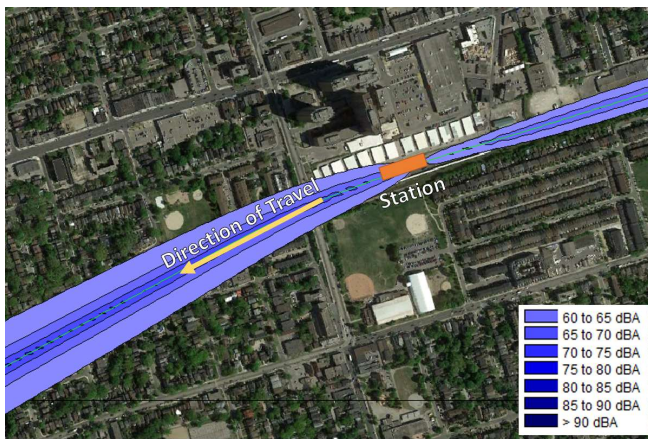
Modelling of train emission levels was done with the Federal Transportation Authority's railway model (FTA, 2018) implemented with Cadna/A, a commercially available 3-D noise propagation software package. Within Cadna/A the rail corridor was modelled in 10 m segments with unique speed and throttle settings for each segment, reflecting the typical operations of each train. A sample of resulting predicted sound levels for diesel and electric trains are presented in Figures 3a and 3b, respectively.



**Figure 3a:** Sample of Predicted Sound Level Contours Incorporating Speed and Throttle Profiles – Diesel Locomotive

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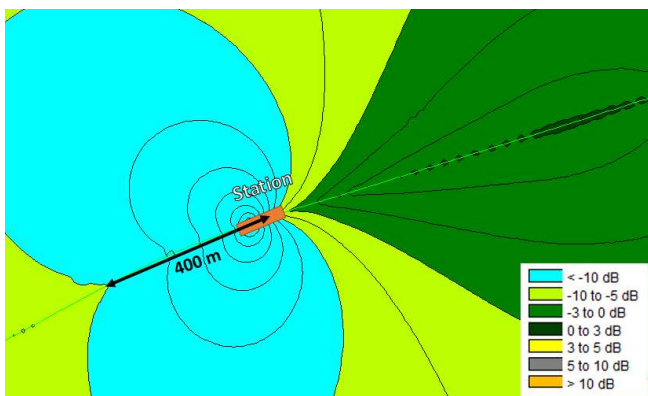


**Figure 3b:** Sample of Predicted Sound Level Contours Incorporating Speed and Throttle Profiles – Electric Locomotive

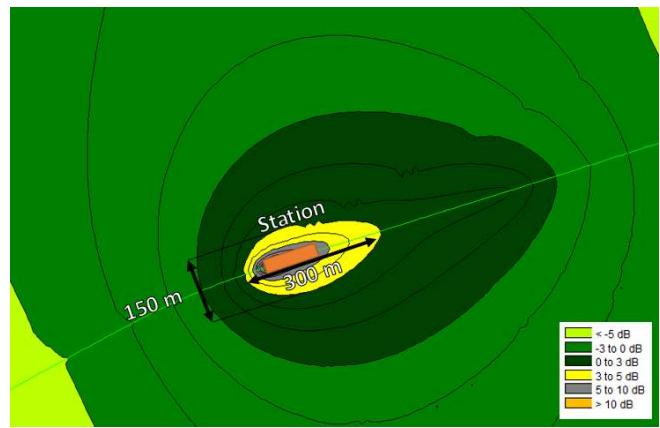
These figures demonstrate the change in predicted sound level that occurs from incorporating detailed speed throttle settings into the modelling. The variation in the sound level contours in Figures 3a and 3b are a result of speed and throttle settings only. In Figure 3a it can be seen that as a train pulls into a station, its speed decreases and the throttle is set to 1; resulting in lower sound levels. As the train pulls out of the station, although the speed is slow, the throttle setting is at 8 resulting in higher predicted sound levels. In Figure 3b, where only speed influences the predicted sound levels of electric locomotives, sound levels decrease significantly around the station where speeds are low.

### 3 Results

In general, we see the largest differences from using the average in lieu of detailed data around stations, with localized differences in prediction over 10 dB in some cases. With FTA predictions, the use of average speed and throttle settings are likely to over-predict sound for electric trains and under-predict sound for diesel trains. Figures 4a and 4b demonstrate the difference in predicted sound levels when using detailed data in lieu of average data. In these figures, the average speed was 65 km/h and the average throttle was 5.



**Figure 4a:** Difference in Predicted Sound Level Contours Between Average and Detailed Speed and Throttle Profiles – Diesel Locomotive



**Figure 4b:** Difference in Predicted Sound Level Contours Between Average and Detailed Speed and Throttle Profiles – Electric Locomotive

When considering changes in sound level, as is typically done for rail assessments in Ontario, the inaccuracy of using average speed and throttle settings can be compounded when accompanied by changes in locomotive technology.

### 4 Discussion

Based on the results of this study, the use of detailed speed and throttle profiles is critical in areas surrounding stations, where trains will be slowing to a stop and accelerating out of the station. Given the significant influence the throttle setting of the train has on the predicted sound level (+6 dB between throttle 5 and throttle 8) this is critical for diesel locomotives. In scenarios where a change in locomotive technology is incorporated into the analysis, these detailed profiles are again critical at lower speeds due to the large difference between predicted emissions from electric and diesel locomotives at these speeds (20 dB at 10 km/h and 9 dB at 30 km/h). For scenarios where trains are travelling at continuous speeds, or speeds are generally high, the detailed speed and throttle profiles will not significantly improve the accuracy of the modelling. In these scenarios, the use of average speed and throttle data would be appropriate.

### 5 Conclusion

The incorporation of detailed speed and throttle profiles improves the accuracy of predicted sound levels using the FTA algorithms. This is particularly critical when considering train movements around stations, at low speeds, or when changes in locomotive technology are being considered.

### References

- [1] U.S. Department of Transportation, Federal Transit Administration. Transit Noise and Vibration Impact Assessment Manual, 2018.