EVALUATION OF ROAD TRANSPORTATION NOISE MODELLING ALGORITHMS AND SOFTWARE PACKAGES

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1. INTRODUCTION

In a joint project sponsored by the Ontario Ministry of Transportation, the Ontario Ministry of the Environment, and GO Metrolinx, transportation noise modelling algorithms and software packages have been assessed. The goal is to determine the best computerised noise prediction models for road, rail, and light-rail transit sources, to replace ORNAMENT, STEAM, STAMSON, and STAMINA within the province of Ontario. This evaluation was based on a quantitative and qualitative evaluation of a number of factors. This paper focuses on the road noise model evaluation.

The analysis examined both software packages (for cost, usability and performance) and the prediction algorithms.

2. ALGORITHM EVALUATION

Acoustical algorithms were evaluated, with the goal of providing recommendations regarding transportation noise modelling in Ontario. Transportation noise modelling algorithms included in this evaluation were chosen to correspond with current practices within Ontario, as well as to explore options commonly utilised within the United States and Europe.

Transportation noise modelling algorithms explored in this study include FHWA TNM, FHWA-RD-77-108 (STAMINA), NMPB-96, ORNAMENT, RLS-90, and VBUS. Criteria used to rank algorithms include Noise Emission, Noise Propagation, Consistency with Ontario Guidelines and Practices, and Versatility and Technical Performance.

Traffic noise emissions are generally calculated accounting for traffic mix, speed, pavement type, and road gradient. In addition to these factors, TNM and NMPB-96 also consider engine noise variations due to acceleration. RLS-90, NMPB-96, and VBUS do not consider heavy and medium vehicles separately as do FHWA TNM, FHWA-RD-77-108, and ORNAMENT. From a traffic noise emission standpoint, the TNM algorithm was ranked 1st, as it uses up-to-date noise emission data, and considers the full scope of vehicle types used in Ontario.

Noise propagation calculation was ranked based on consistency with current Ontario practices, customisability, meteorology, and the effects of ground absorption. Again, the FHWA TNM algorithm was found to provide to best combination of these factors.

It should be noted that a large variation in distance attenuation factors was observed between different algorithms under controlled settings. Variation of calculated propagation values increases with distance. Figure 1 shows an example of the dispersion observed in propagation attenuation factors between models. This variation highlights the importance of adopting a standardised model to be used across the province.

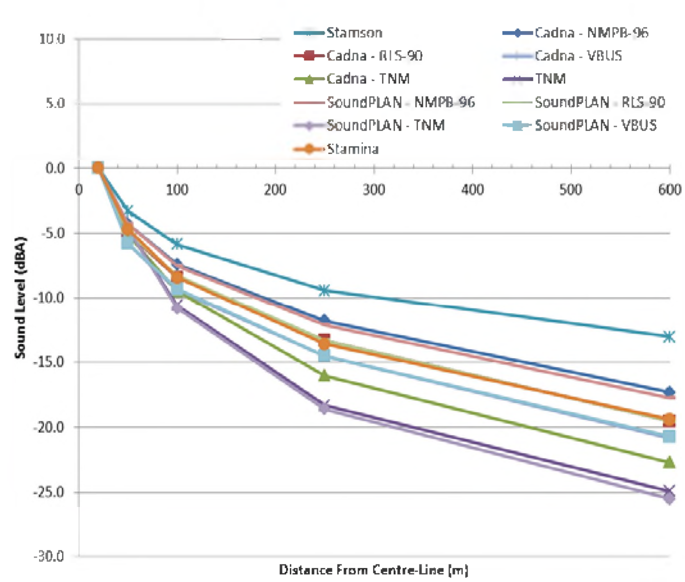

Figure 1. 1st Storey, No Barrier, Reflective Ground

In order to rank noise modelling algorithms, it is important to consider compatibility with current practices. Both required and extraneous input possibilities were considered. TNM is the modern algorithm most similar to STAMINA an STAMSON in terms of inputs, and has with the least amount of extraneous inputs likely to cause errors or in consistencies in the results provided by different modellers/ analysts. Therefore, FHWA TNM was ranked 1st for this category.

Technical performance was evaluated by considering the speed of the calculation as well as the potential to propagate errors. Each algorithm had deficiencies and virtues. Notably, the FHWA TNM algorithm calculates a complicated propagation algorithm for 1/3 octave band emissions separately for each vehicle type and throttle setting. As a result, FHWA TNM is significantly slower than the other algorithms. There was no algorithm with clearly better technical performance, so FHWA-RD-77-108, RLS-90, and VBUS were ranked as a tie for 1st.

Ranking of Algorithms

Overall, the most preferable algorithm is the FHWA TNM algorithm. This algorithm is implemented in the three top ranked software packages. The TNM algorithm is more robust and technically more advanced than most other road traffic algorithms. In addition to outranking the other algorithms in terms of technical capability the TNM algorithm is also more applicable within North America, where heavy vehicles are not only larger, but also more common.

3. SOFTWARE EVALUATION

The primary goal of the software evaluation study was to investigate the performance of readily-available software packages. Software packages explored in this study include STAMSON 5.1, STAMINA 2.0, TMN 2.5, Cadna/A, and SoundPLAN.

Software packages were evaluated in order to assess a number of key performance indicators. Assessed performance indicators include Cost and Market Penetration, Usability, Output, and Acoustical Performance.

Although Cadna/A and SoundPLAN are expensive and similarly priced, Cadna/A is prevalent in Ontario amongst consultants (it is mainly used for industrial noise). Although TNM 2.5 is relatively inexpensive, it is currently not used extensively within Ontario. Similarly, STAMINA is less commonly used than STAMSON, although both software packages are free. In terms of cost and market penetration, STAMSON and Cadna/A have ranked 1st and 2nd, respectively.

Considering factors such as ease of use, hardware restrictions, export and import options, and customisability, the advanced software packages Cadna/A and SoundPLAN were found to be most usable. TNM 2.5 includes features that are not available in STAMINA and STAMSON; however, the graphic user input system in the current version of TNM is very limited compared to Cadna/A and SoundPLAN.

Key output formats evaluated include the ability to provide point of reception impacts, ranked impacts, partial impacts (impacts for individual contributors), noise contours (lines of equal noise level). Tied with a rank of 1st, Cadna/A and SoundPLAN implement all of the above output formats. TNM 2.5 is not able to output partial levels without separating modelling runs. All output types are possible in both STAMINA and STAMSON, although data manipulation is necessary. STAMINA and STAMSON cannot easily produce noise contour plots.

Acoustical performance was evaluated by considering consistency between different implementations of the same algorithm, as well as speed of calculation. Only small deviations were observed for separate implementations of RLS-90 and VBUS. Implementations of NMPB-96 had slightly more variation, but there was not a clearly superior implementation. As a result, all software packages were ranked neutrally in terms of acoustical performance of all algorithms, with the exception of TNM.

Some significant variations in FHWA TNM results were observed between different software packages. The Cadna/A implementation is missing a number of key modelling parameters – namely flow resistivity (as opposed to ground absorption), grade adjustment, and import/export options. Both Cadna/A and SoundPLAN correct a number of known glitches within TNM 2.5. However, both packages include an option to include these errors for conformity with TNM 2.5. Unfortunately, neither software package is endorsed by the FHWA, and as a result, each program includes a disclaimer, and notes not being fully implemented. As a result, despite obvious errors, and long calculation times, TNM 2.5 was ranked preferable in terms of acoustical performance.

Ranking of Software

Cadna/A and SoundPLAN achieved 1st and 2nd rank, respectively, with TNM 2.5 ranking 3rd. Based on the unofficial nature of the Cadna/A and SoundPLAN implementations of the TNM algorithms, TNM 2.5 was ranked most preferable in terms of TNM implementation.

4. INTERIM RESULTS

Our work to date points towards recommending the use of the current TNM 2.5 algorithm and software package for use in evaluating road noise impacts. The official FHWA TNM software package is relatively inexpensive. The algorithm includes up-to-date noise emission factors, consistent with North American traffic types.

Other more advanced software packages such as Cadna/A and SoundPLAN offer better user interfaces and additional analysis features. However, there are inconsistencies in the results from TNM 2.5, Cadna/A, and SoundPLAN, which are still being investigated.

Should TNM 3.0 be released and endorsed by the FHWA, as is expected in the near future, it will offer many improvements over TNM 2.5 in terms of usability.

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