AN APPROACH TO GENERATING AND CALIBRATING A SOUND CONTOUR MAP

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1. INTRODUCTION

Urbanized areas in modern cities are typically exposed to a high level of noise pollution from many sources. A prevalent source of noise pollution typically comes from roadways due to high transportation volumes. The City of Windsor has this problem as it has the busiest international border crossing between Canada and the United States. For this study, a noise contour map of a 5 km square area was done as an undergraduate engineering project using Bruel & Kjaer's Lima software.

The process for accurate noise model results can be quite time consuming, however the accurate results are important when used to evaluate problematic areas. A noise contour map can be created based only on traffic count data of vehicle type and volume; however those results may not truly reflect actual noise levels. To calibrate a model, it is beneficial to perform a reverse engineering analysis on the model by using actual noise measurement data acquired along the study area.

2. PHSICAL MAP GENERATION

The creation of the road emission model in LimA was a tedious task. Geographical data was acquired from several sources; the roads were created using ArcGIS data and the background bitmap image was made by stitching together high-resolution snapshots taken from Google Maps. Generating buildings and structures required he tracing polygons overtop of the background bitmap images and assigning height information. Along with the building heights, elevation contours were implemented into the map in order to properly represent the elevation changes within the study area. These included man made berms.

The road volume data which was inputted into the model was taken from annual average daily road traffic (AADT) data provided by the City of Windsor. In addition to the AADT data, the percentage of heavy vehicles, percentage of daytime/nighttime traffic split, speed limit and road surface type were considered. Data concerning the day night split was not available so an assumption for the two different major types of roads for the area was made. The major roads (EC Row and Huron Church Road) would be assumed to have a heavy traffic concentration of 20% during the day and 80% during the night and the daytime/nighttime traffic split was even by overall volume. This was assumed since these roads are major transportation routes and are dominated with international heavy truck traffic. Smaller roads in the model were assumed to have very little commercial traffic with only 5% of all traffic expected to be heavy trucks. As most of the traffic on the smaller roads typically occur during the day, it was assumed that 85% of the total traffic volume occurred during the day period.

3. INPUTTING MEASURMENT DATA

To calibrate the model, sound level measurements were to be taken at chosen locations. Road segments were grouped into emitter groups by observing how the traffic flow occurred with major intersections being the start and end points for the groups. Once the roads were sorted into different emitter groups, it was possible to make general estimations of where different measurement points would need to be taken so that each emitter group would have an independent associated measurement point. In order for the measurement to be useful, it had to be taken within an ideal distance of the emitter group of interest. A good practice is to take one measurement per emitter group in locations where only the emitter group of interest will the main contributor to the reading. Once the ideal locations were identified, 20 minute L_{eq} readings over a 24 hour periods were made. Using the measured noise data in conjunction with the road traffic data allowed for the program to calibrate the acoustic contour map.

4. CALIBRATION OF MODEL

Once all of the important characteristics of the sound map were entered into LimA the synthesis of calibrated noise contours was possible. The estimated propagation of noise using the British CRTN model produce reasonable results for the study area as it predicted the largest noise levels around the major roads Huron Church Road and EC Row. These two, as predicted, had the highest emissions and the greatest impact in the surrounding areas. Huron Church road had the biggest impact over the area of the study due to it being the center dividing line of the study area as well as the busiest road. Its noise emissions were the only major contributors to many areas of the map as it produced noise levels over 45dB far into residential areas.

The reverse engineering process was carried out using a function of the LimA software. LimA has the option to back calculate the emissions of the measured noise sources.

Ideally, adjusting the road emissions with actual sound measurements will produce a more accurate noise contour since it will correct errors that may have been present in the original model based on simplifying assumptions. The resulting noise contours with and without the reverse engineering is given in Figure 1.

Figure 1. Noise Contour Map of Reversed Engineered Model and Original Model

By inspection of the revised results, it is apparent that after the reverse engineering process, there were minor changes to the predicted road emissions. This also demonstrated is good to see as it showed the original model was a very close approximation of a real life situation.

5. DISCUSSION OF RESULTS

The predicted noise levels in residential areas increased after the calibration process due to the increased levels from the main emitting roads. This change is likely due to the inaccuracy of the provided traffic data. The reverse engineering procedure thus helped to account for discrepancies in the old data as the actual sound pressure level measurements were more current. However, most of the contours had little differences showing that the CRTN model had a fairly accurate calculation of noise propagation.

LimA was able to perform an analysis of the areas which were affected by different noise level ranges. The data showed that after making adjustments from the original road calculation, the noise emissions overall increased. CRTN calculated the L_{10} values which is the maximum sound pressure level which is experienced 90% of the time. This calculated value is different from the typically L_{eq} which is required measurement type by the Ministry of the Environment in Ontario, so direct comparison of the results and Ontario regulation could not be made. The areas affected by higher sound pressure levels over 60 dBA increased slightly. They covered about 40% of the overall area with only 35% of the area actually being in the MOE recommended range of under 55 dBA and 22% of the area alone being within the range of 55-60 dBA it can be said that there is a noise problem in the study area. Fortunately for the regions with levels below 65 dBA mitigation using noise barriers is possible. However this statistical examination fails to examine how the zoning correlates with the noise data. The industrial areas at the southern part of the study area appears to have a higher noise level present which isn't a major problem; as few people live around this area. The majority of residential areas other than houses directly adjacent to Huron Church road appear to have acceptable noise levels. The area near the Ambassador Bridge also has high emission contours that affect the nearby residential areas as well as the University of Windsor campus which borders it. These emissions would be more difficult to mitigate as the bridge is too high for effect use of noise barriers to block the sound emanating from the bridge.

6. CONCLUSSION

A noise contour map can be a very powerful tool if created properly. It provides a graphical examination of problematic areas within a study region and can be used for urban planning and design for noise mitigation in attempt to reduce noise emissions at sensitive residential receptors. The synthesis of the map presented was constructed using the most recent and corrected data available. Upon examination of the reverse engineering results and statistical analysis, it was demonstrated that although there was a change of emission coverage within the study area, the change was small. However, the reverse engineering of the source emissions was an important step in the process as it used actual measured noise data at a locations close to the source to either verify the model based on traffic volume data only or to identify areas where additional analysis was required. Subsequently, through the reverse engineering process, the road noise emission results were successfully back calculated to provide corrected noise emission levels which better correlated to the actual measured noise levels. This was important as it ensured that the noise contour map was correctly adjusted to match reality and is not simply just a theoretical model.

7. ACKNOWLEDGEMENTS

The authors would like to extend their gratitude to Bruel & Kjaer for their in-kind contribution of the Lima software used for this study. Without their support and help, this senior undergraduate project would not have been possible. Thanks is also given to the financial support provided the University of Windsor's Faculty of Engineering as well as the numerous industrial financial sponsors throughout the City of Windsor.