EFFECTS OF EXCESS GROUND ATTENUATION ON AIRCRAFT NOISE CONTOURS

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Introduction

Various airport noise prediction programs are used to calculate expected noise level contours around airports based on the details of the aircraft operations. One of the major factors influencing these contours is the excess attenuation of the sound from the aircraft when the sound is propagating at near grazing incidence to the ground. When considered in detail, this excess attenuation is a complex phenomenon, but airport noise prediction programs use quite simple approximations to estimate the effect of excess ground attenuation.

The attenuation of sound from an aircraft traveling close to the ground will depend on a number of factors that will vary as the aircraft passes by. The attenuation will be influenced by the spectrum and directionality of the aircraft noise source and these effects will vary with time as the aircraft passes an observation point. The resulting attenuation will also be influenced by the acoustical impedance of the ground as well as various meteorological effects. Thus, to accurately predict the attenuation of the sound from an aircraft, quite complex calculations would be required on a point by point basis as the aircraft passes an observation point.

Most airport noise prediction programs include only quite simple approximations to these complex effects. The influence of each aircraft fly-by is typically only calculated for the point of closest approach to the observation point and not as a complete point-by-point calculation for the complete fly-by. Usually, only overall A-weighted or PNL-weighted levels are considered. The excess ground attenuation is usually calculated in two separate parts: (a) ground-to-ground propagation, and (b) air-to-ground propagation.

Calculation Procedures

Figure 1 compares five different ground-to-ground attenuation algorithms. Of the five, the SAE model gives the largest attenuation at most distances. This SAE algorithm is used in the American INM and NoiseMap airport noise prediction models. Transport Canada's NEF_1.7 prediction program provides the lowest ground-to-ground attenuation. A Swiss procedure, an algorithm from an older version of NoiseMap, and an experimental

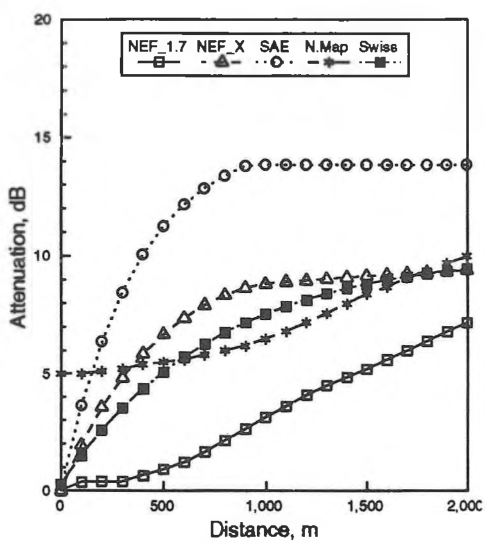

Figure 1. Comparison of ground-to-ground attenuation calculations.

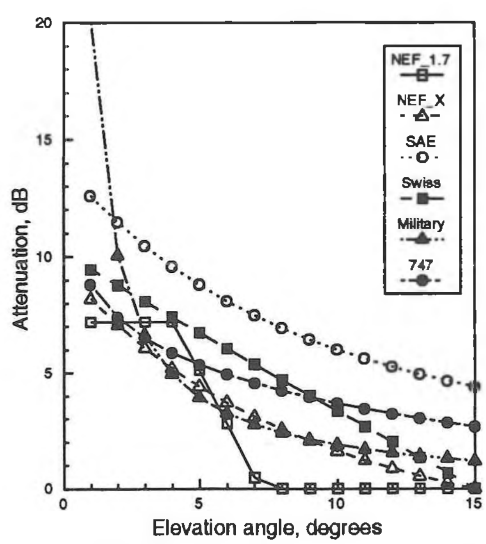

Figure 2. Comparison of air-to-ground calculations and measurements.

version of the Transport Canada program include intermediate values of ground-to-ground attenuation.

Air-to-ground attenuation calculations are compared in Figure 2. Again, the SAE model gives the highest attenuations and the procedures used in the NEF_1.7 program tend to give lower air-to-ground attenuations. As in the previous plot, the Swiss procedure and the experimental NEF_X program give intermediate results. This figure also includes an average curve of measurements of a Boeing 747 aircraft. This curve tends to approximate the intermediate predictions of air-to-ground attenuation. The curve labeled Military is a fit to the measured air-to-ground attenuations of various types of military aircraft.

Both Figures 1 and 2 indicate that there are quite large differences among the various procedures and that predicted aircraft noise levels could vary by several decibels. Figure 3 compares the combined effects of the SAE procedure with the NEF_1.7 program calculations. The differences in predicted attenuations are plotted versus elevation angle and distance from the source. Differences as large as 11 dB were found. The average difference for all distances and angles shown in Figure 3 is 4.85 dB.

Single Aircraft Examples

The large differences between excess ground attenuation calculations are expected to significantly effect the area of the airport noise contours. Contours for single aircraft types were first compared. Figure 4 compares four different calculations of NEF 20 contours for 100 take-offs of a Boeing 737-D17 aircraft. For this example the NEF_1.7 and NEF_X results had similar areas that were approximately double the areas calculated by the INM and NoiseMap programs. Although the NEF_1.7 and NEF_X programs tended to produce larger area contours, the differences between the different sets of contours varied with the aircraft type and the contour noise level.

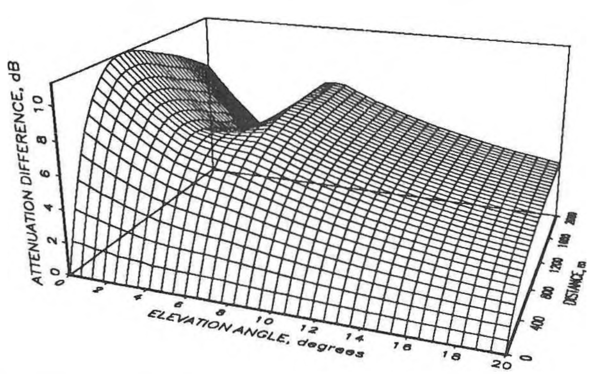

Figure 3. Differences between INM and NEF_1.7 excess ground attenuation calculations.

Complete Airport Examples

Comparisons were also made of complete airport noise contours resulting from the actual mix of aircraft operations at each airport. Figure 5 compares calculated contours for Ottawa airport. For the NEF 20 contour at this airport, the NEF_1.7 program produced contours approximately 60% larger than the INM program. The experimental NEF_X program with reduced excess ground attenuation produced contours with areas intermediate to the other two programs. The differences in the areas of these contours are thought to be largely due to differences in the calculation of excess ground attenuation and vary with both airport size and contour level.

Conclusions

Excess ground attenuation calculations included in commonly used airport noise prediction programs are only rough approximations to the actual propagation phenomena. There are considerable differences between the procedures used in different airport noise programs. As a result, the areas of the noise contours calculated for individual aircraft or for the mix of aircraft at actual airports can vary considerably between computer models. This is clearly an area where improvements to calculation procedures are necessary.

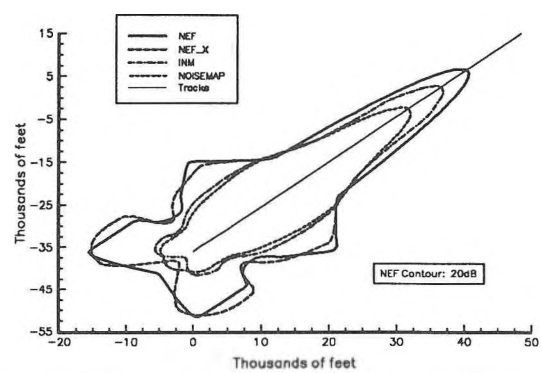

Figure 4. NEF 20 contours for 100 take-offs of a 737-D17 aircraft.

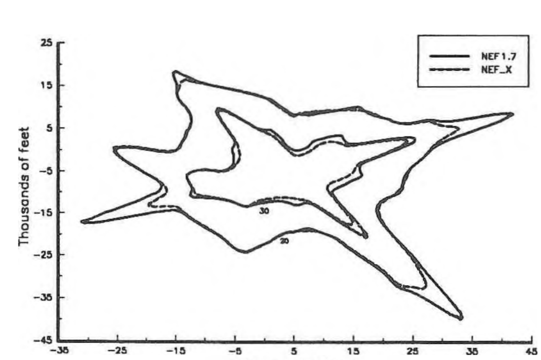

Figure 5. Calculated NEF 20 contours for Ottawa airport.