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SOURCE MODELLING IN THE NEW NORDIC PREDICTION METHODS FOR ENVIRONMENTAL NOISE

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ABSTRACT
In order to predict environmental noise accurately it is necessary to combine point source sound propagation theory with source models based on a number of point sources. In this paper measurements are reported from some well defined propagation cases for road and rail traffic sources. These measurement results are compared with calculated values using different source descriptions. Best agreement is obtained when using several low sources with different heights above the reflecting surface. The results will be used in the new Nordic predictions methods for environmental noise expected to be ready in 2001.

1 - INTRODUCTION
In the future Nordic prediction methods for environmental noise advanced sound propagation theory will be used. As such theory is based on point sources it is necessary to describe all sources as a combination of point sources which may or may not be directional. In order to benefit fully from accurate propagation theory it is also necessary to separate the emission part completely from the propagation part. This is best done by describing the source output in terms of its sound power level. Then it is no longer possible to mix emission and propagation as is now the case for most prediction methods. This paper will not give any detailed answers but merely give some examples and outline some of the solutions to be considered for the location of the equivalent point sources. More information is given in [1] and [2].

2 - ROAD VEHICLES
Road vehicles are normally described by one or two point sources the total emission of which are determined by pass-by measurements which are suitable for large scale statistical measurements. Provided we have an accurate source model and accurate propagation theory such measurements can be used to determine the sound power level. Ideally the sound power level should be determined for tyre/road, engine, transmission and exhaust separately. Different tests have been carried out under conditions sensitive to source locations and the results have been simulated by combining different source models with sound propagation theory. Some results are shown in the following.

In figures 1 and 2 some measurements on a stationary, modern passenger car are reported together with comparisons with calculations according to the future Nordic prediction method. A very low microphone position, 0,2 m, was used in figure 1 in order to create a worst case solution as far as ground attenuation is concerned and in figure 2 a very high position was selected to illustrate the screening of the engine. Figure 1 shows a very good fit between measurements and basic propagation theory with a source height of 0,3 m and a corresponding image source at $-0{,}3$ m. Figure 2, on the other hand shows that, for high receiver positions, the primary source is screened to such an extent that the best fit is obtained using the image source only multiplied by the reflection coefficient of the surface. The bad fit at low frequencies is probably caused by unstable operating conditions of the engine.

In figure 3 the corresponding effects for tyre/road noise is shown. The measurements were carried out on VW Passat passenger car passing by at 70 km/h with its centre 2,5 m from the edge of the asphalt surface. The microphone was located another 7,5 m away at a height of 0,2 m and the ground impedance was determined both for the asphalt and the grassland using the method described in [3]. The agreement

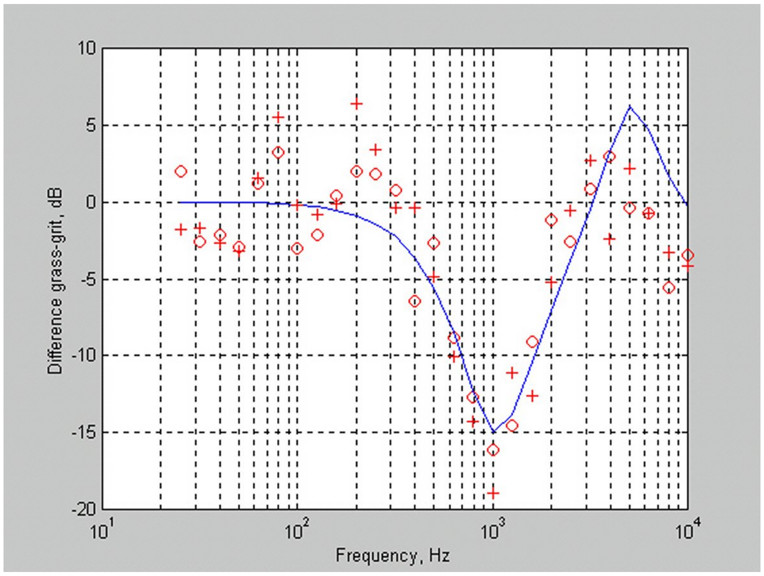

Figure 1: Difference between propagation over grassland (160 krayls) and gravel (2000 krayls) at 7,5 m with 0,2 m receiver height; full line indicates calculated values with 0,3 m source height, + and o indicate left and right side measurements on the stationary car with engine running at 3000 rpm.

between measured and calculated values is excellent. The figure also shows that the height of the source is very critical at high frequencies and less critical below about 1000 Hz.

3 - RAIL VEHICLES

The dominant sources of trains are normally the rail/sleepers and the wheels. Sometimes engine noise is also important and for high speed trains aerodynamic sources have to be included as well. The balance between the sources will vary with the speed. As to rail and wheels the rail tends to dominate below about 1000 Hz and the wheels above. Different tracks and wheels will contribute differently and the conditions will normally vary from country to country because of differences in trains and tracks. We have concentrated our studies on wheel/rail noise and tried to match measurements with calculations under some well defined propagation conditions. In the following some results from measurements on the new track between Arlanda airport and Stockholm City will be reported. The ground impedance of the stubble field on which the measurements were carried out was measured to the equivalent of a flow resistivity of 630 krayls. It was very flat and the track was almost level with the ground. Measurements took place both at an unscreened reference position and at several positions screened by a low, about 0,8 m high barrier.

Figure 4 shows the difference between calculated and measured values at the reference position used at 25 m distance. The measure compared is the difference between two heights. We can see that the best fit is obtained using the average of 5 source heights located between the top of the rail and half the wheel height. The figure also reveals that the source height is more important at high frequencies.

In figure 5 the reference values behind figure 4 have been used to calculate values to compare with measurements on a 0,8 m high screen situated 1,5 m from the nearest wheels. We can see that good agreement is obtained when we average over 5 sources between the top of the rail and half the wheel height. In figure 6 the comparison is extended to another receiver height.

4 - INDUSTRIAL SOURCES

These sources are normally described by their sound power levels which are often determined from measurements on a measurement surface in a free field above a reflecting plane. As these standards assume + 3 dB difference between a free field and a free field above a reflecting plane we introduce errors when we combine these sound power levels with sound propagation theory which, of course, will often yield +6 and not +3 dB at low frequencies. An example of the magnitude of this error is given in figure 7. The reason for not having a maximum deviation of +3 dB is that the calculations have been carried out using a boxshaped measurement surface which leads to additional errors compared to a hemispherical surface. If this error is considered to be important the low frequency sound power levels must be corrected using a proper source model of the source concerned.

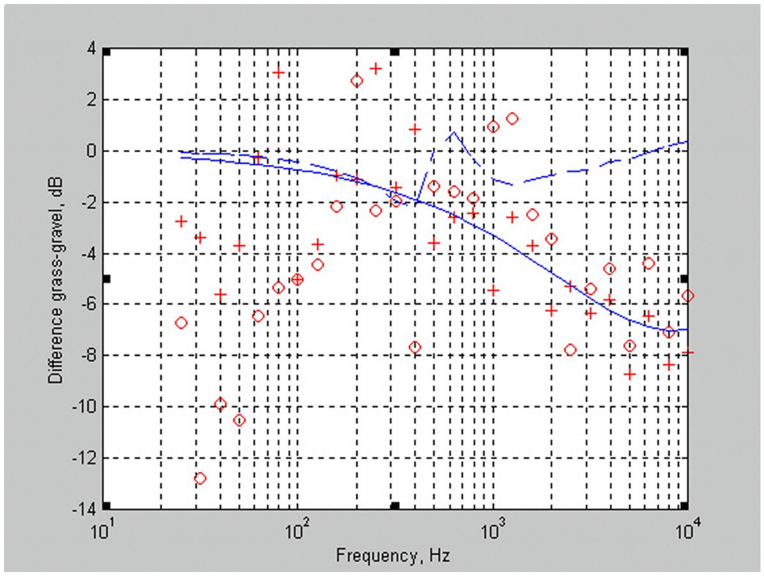

Figure 2: Difference between propagation over grassland (160 krayls) and gravel (2000 krayls) at 7,5 m with 4,5 m receiver height; full line indicates calculated values using statistical absorption coefficient and dashed line calculated values using sound propagation theory with 0,3 m source height, + and o indicate left and right side measurements of the stationary car with engine running at 3000 rpm.

5 - CONCLUSIONS

Accurate calculations require more accurate source models. Modelling real sources as a series of point sources seems to work well.

ACKNOWLEDGEMENTS

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REFERENCES

1. **Hans G. Jonasson**, *Measurement and modelling of noise emission of road vehicles for use in prediction models*, SP, 2000

2. **Kjell Holmberg, Hans G. Jonasson, Xuetao Zhang**, *Source modelling of train noise*, SP, 2000

3. **Mikael Ögren, Hans G. Jonasson**, *Measurement of the acoustic impedance of ground*, SP, 1998

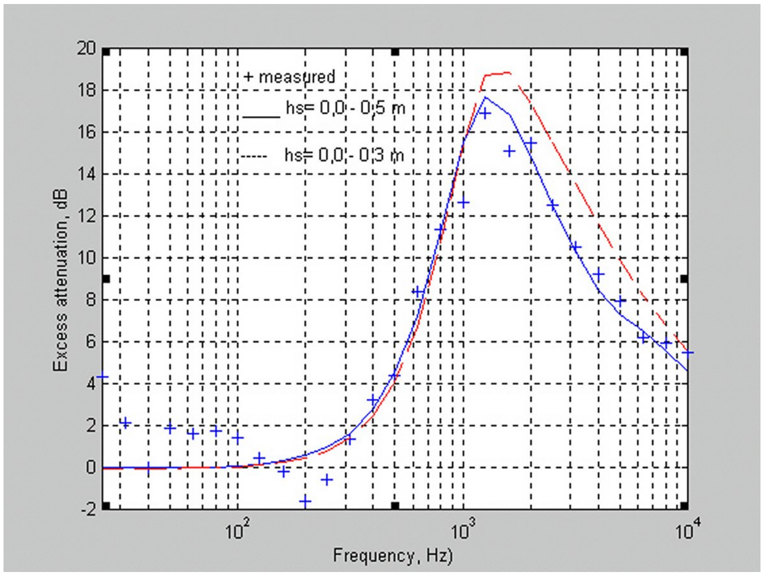

Figure 3: Excess attenuation rel free field + 6 dB at 0,2 m for pass-by noise after propagation over 2,5 asphalt (20000 krayls)+ 7,5 grassland (160 krayls).

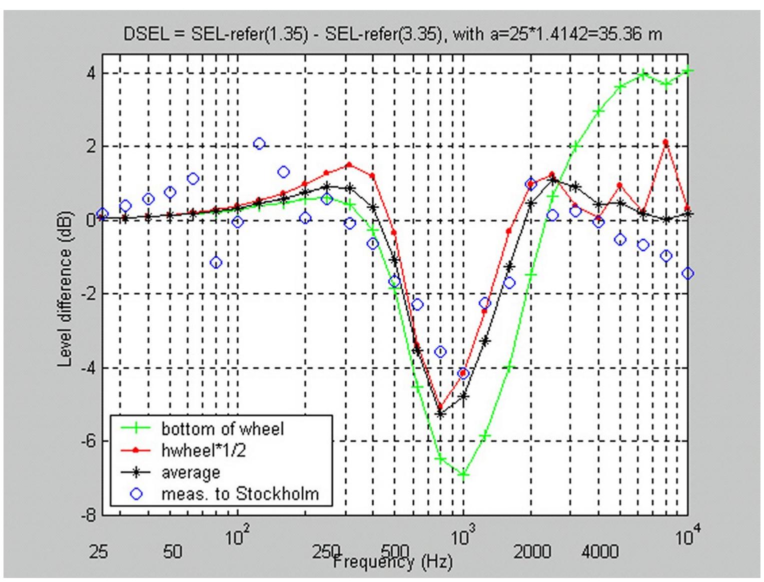

Figure 4: Difference in SEL between 1,35 m and 3,35 m above the ground at 25 m distance.

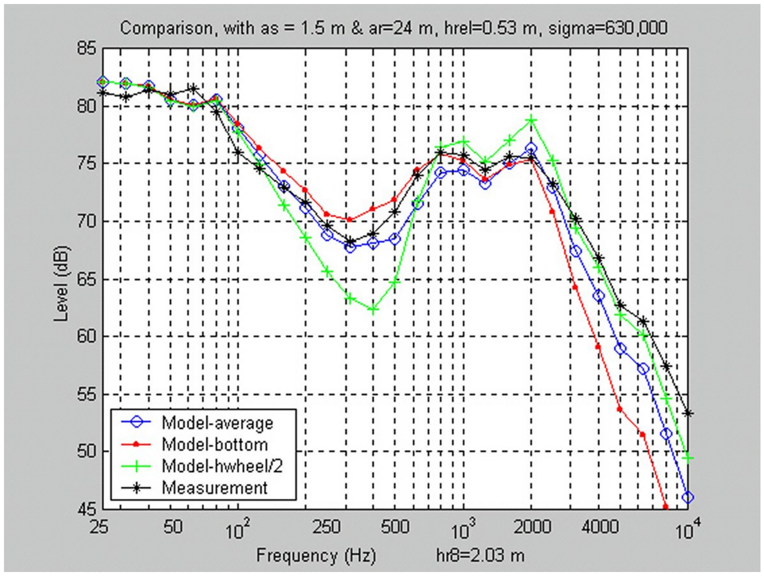

Figure 5: Measured and calculated SEL-values with a 0,8 m high barrier; the receiver is at 25 and a height of 2,03 m; the SEL-values have been calculated from 7 different angles of incidence.

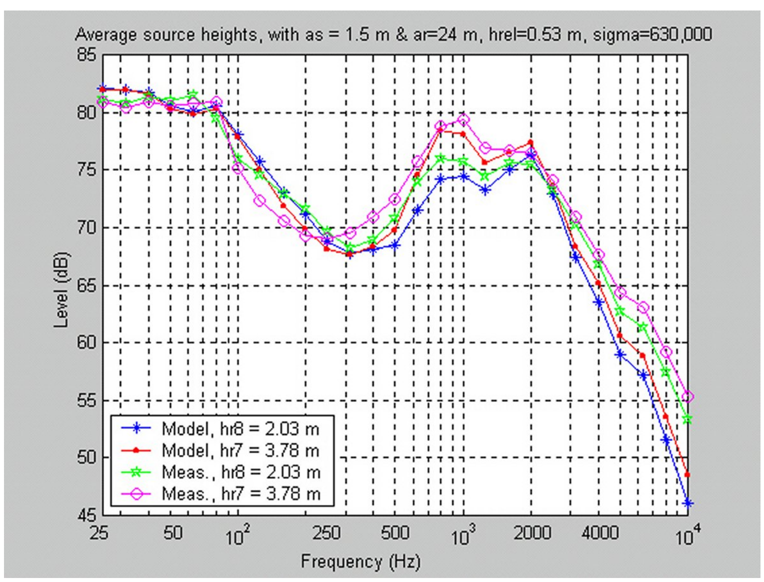

Figure 6: Measured and calculated SEL-values with a 0,8 m high barrier; the receiver is at 25 and a height of 2,03 m; the SEL-values have been calculated using 7 different angles of incidence and 5 different source heights.

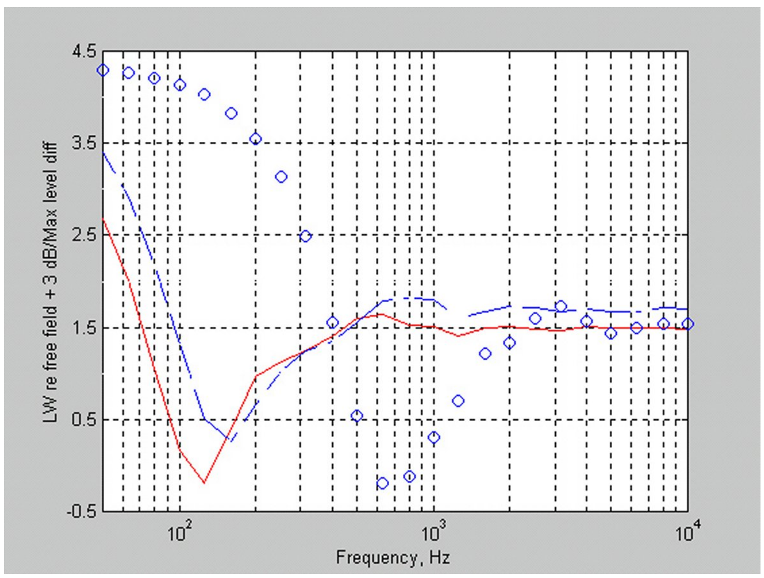

Figure 7: Calculated deviation from L_W + 3 dB for 3 different sources, (---) electric compressor, (—) circular saw, (ooo) a 0,3 m high reference sound source.