IMPROVEMENTS IN ACCURACY FOR THE CALCULATION OF NOISE PROPAGATION FROM AREA SOURCES.

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1. INTRODUCTION

For the calculation of environmental noise, area sources must be approximated by a suitable number of point sources. This paper describes the procedures used by SoundPLAN to ensure the needed accuracy while maintaining a high calculating speed. As the view to the source is different from different receiver positions, the number and location of the point sources representing the area source are adapted on line to the requirement of the geometry of source, ground and obstacles in between.

2. APPROXIMATION OF AREA SOURCES

2.1 DEFINITIONS FROM THE ISO 9613

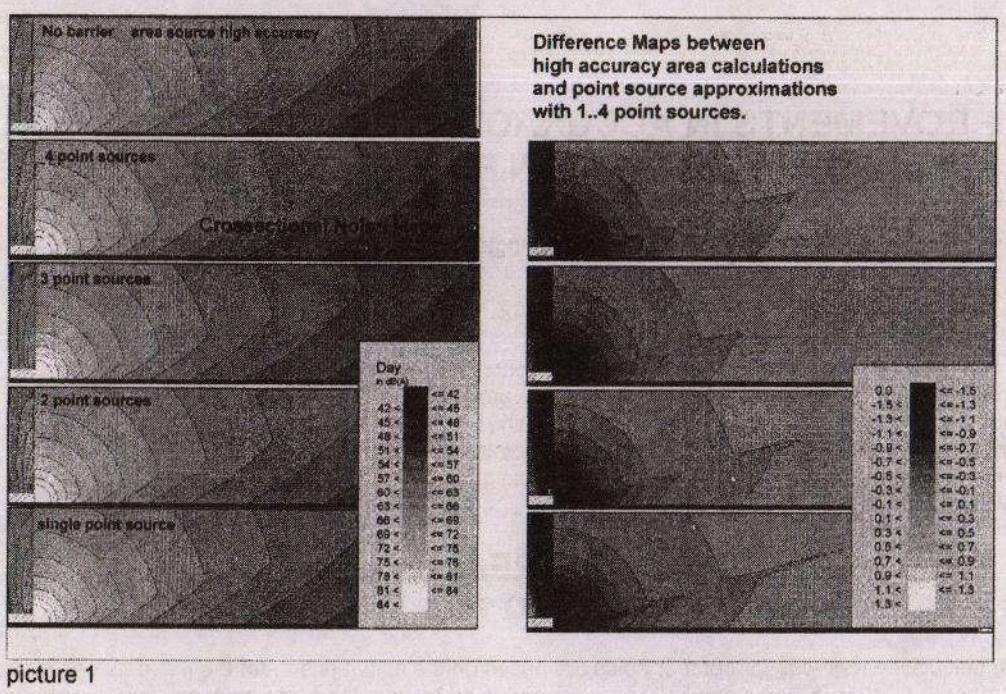
Most calculation methods for outdoor noise are based on the assumption that the noise comes from a point source. Area sources and line sources need to be broken down into point sources in order to carry out the calculations for the propagation mechanisms. The method of approximation to convert area sources into a number of point sources has big influence on accuracy and on calculation times. Breaking down the source into too many point sources will increase the calculation time, while representing the area with too few point sources will decrease the accuracy.

> The ISO 9613 states the point sources representing the area source need to have approximately the same strength and height above the local ground plane, the same propagation conditions to the point of reception, and the distance d from the single equivalent point source to the receiver exceeds two times the largest diameter D of the relevant area of the sources (d>D).

Point sources shall represent suitable areas where the source strength is constant and the propagation conditions are the constant. If the conditions are not met, the area must be subdivided until the substitute point sources are good representations of the area source.

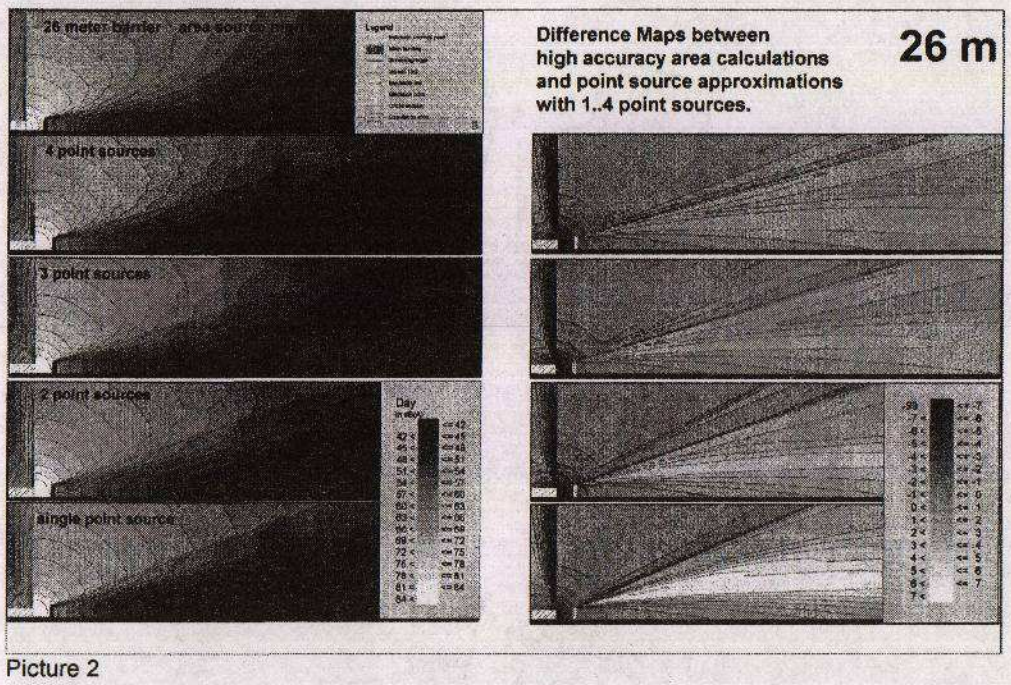
2.2 NEED FOR INTERPRETATION OF THE ISO 9613

In the list of requirements, the size of the point source compared to the distance to the receiver is explicitly listed as well as the constant height above the ground plane. No specific variation of the allowable height above the ground plane is mentioned. One factor that can have an even bigger influence on the variation of the results than the ground effect was not mentioned explicitly; The changes in screening due to the selection and positioning of point sources representing the area. When the area is the outside wall of a factory and a barrier (wall, berm or building) is located in the propagation path, the approximation of the area source can become a big problem.



picture 1

Picture 1 shows the noise contour lines in a cross-section through an industrial building and the area around it. Calculations have been carried out varying the number of point sources representing the area and comparing this to a reference calculation which was calculated with a high number of point sources to show the true contours. In the case of free field conditions, a single point source is sufficient in most cases. The differences in the example of picture 1 are less than 1 dB(A). 250 Hz was used for the source to depict the maximum differences in the ground effect.



Picture 2

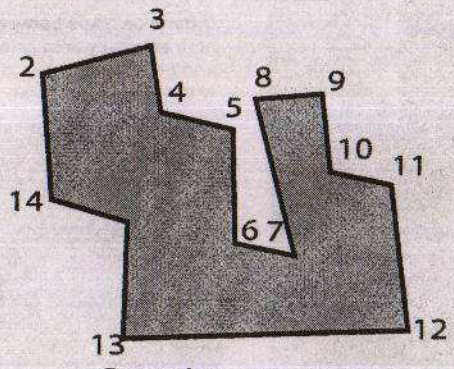
Picture 2 shows the same situation with a high wall in front of the building. The variations of the noise levels are clearly visible in the difference plots between the accurate solution and the approximation using a few point sources. The maximum differences found in this simple situation were 6.5 dB(A). The calculations used a source of 2kHz to point out the variations due to the screening.

The height above the local ground plane results in a variation of the ground effect. The position of the point source determines the amount of screening. As the screening function has a saturation, receivers along the ground in this example have less of a variation than receivers above it. In real life high buildings or hillsides can create any of the variations of picture 2. When screens slope and only partially expose the source area, the problem is magnified and it is difficult to always foresee when these accuracy problems will occur. As it is impossible to increase the number of point sources representing an area to the point where accuracy problems will not occur, another adaptive method of solving the problem needs to be found.

2.3 THE SOLUTION OF THE PROBLEM IN SOUNDPLAN

In SoundPLAN the problem was solved by leaving the area source as an area source during the calculation for each receiver checking if the propagation conditions for the entire area remain uniform. If this is the case the area can be represented as a point source, otherwise it will be split and the test for uniform conditions will be carried out again. This iterative disintegration is carried out until the differences are at a minimum or the specified number of iterations has been reached.

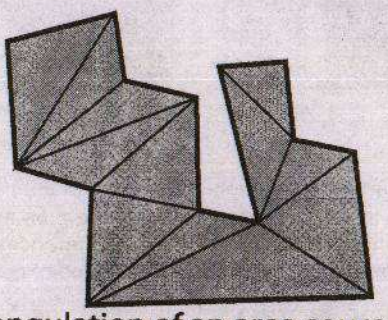
To really understand the procedure, we must begin with the representation of area sources in SoundPLAN:
Area sources can be complex in shape. In picture 3 we have a source polygon of 13 points.



Complex area source

Picture 3

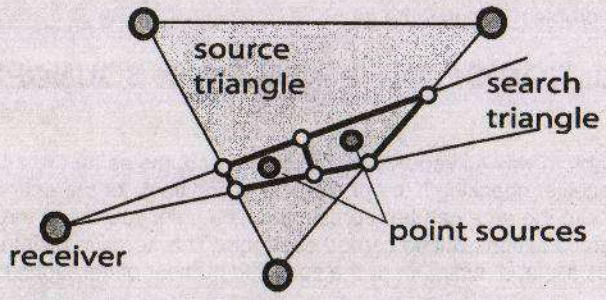
As indicated in picture 4, the source polygon in SoundPLAN is actually a series of triangles. Triangles can represent any shape and are suitable to follow complex 3D shapes.



Triangulation of an area source

Picture 4

A single source triangle is calculated by intersecting it with the search triangle and regarding the resulting intersecting polygon as the new source. The source then is subjected to the test of d>D and if needed split in the middle. The d>D test is repeated until all parts of the area source conform.

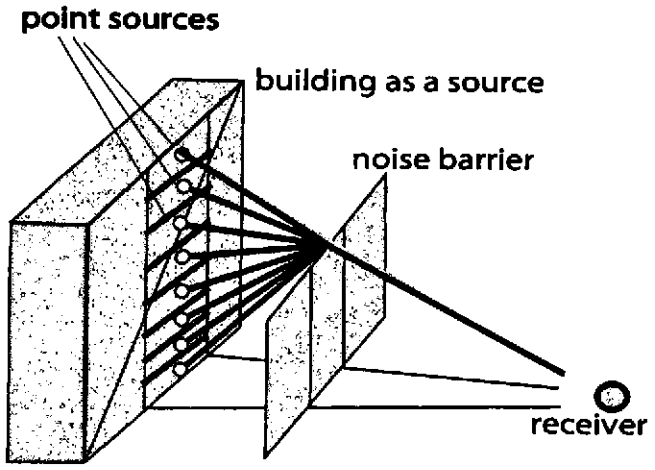


Intersecting sources and search triangles

Picture 5

The tests for uniform height above the ground is replaced by a test that actually calculates the ground effect for all corners of the source polygon. If the variance in the ground effect is bigger than a user defined threshold value, the source is subdivided the same way as with the d>D test.

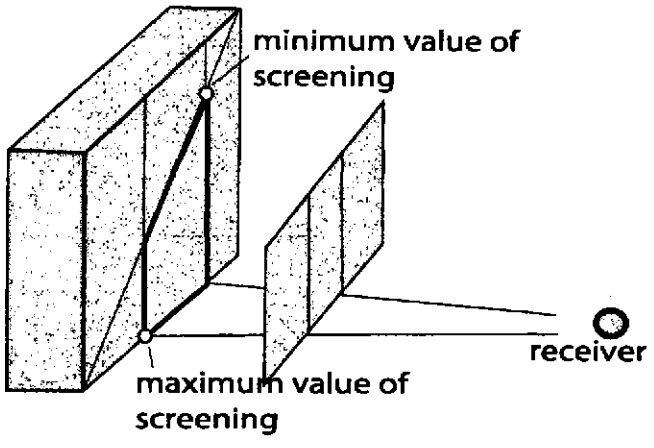
When buildings are the sources and a screen is present in the propagation path, the magnitude of screening at large depend on the extra path length. This factor needs to be considered in the approximation of the area source.



Subdivision of a source with varying propagation conditions

Picture 6

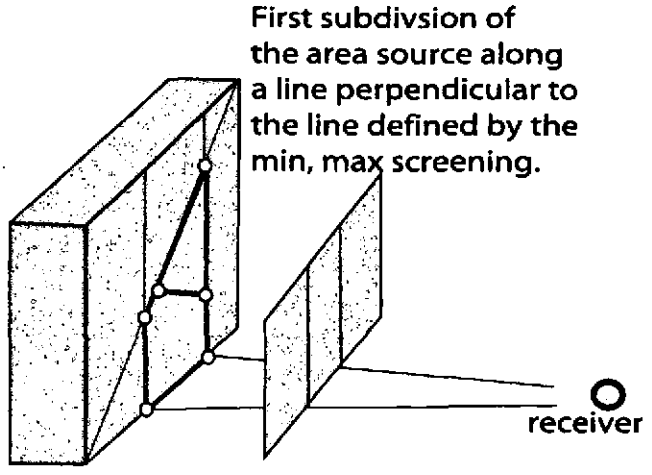
Applying the iterative disintegration method to the problem of a partially shielded vertical area source will result in the subsequent division of the area source



Picture 7 shows the intersection of the source polygon with the search triangle. The ground effect and the screening is evaluated for all points of the new source polygon. The minimum and

maximum value of the parameters are noted and the polygon is divided perpendicular to the line between the minimum and the maximum value.

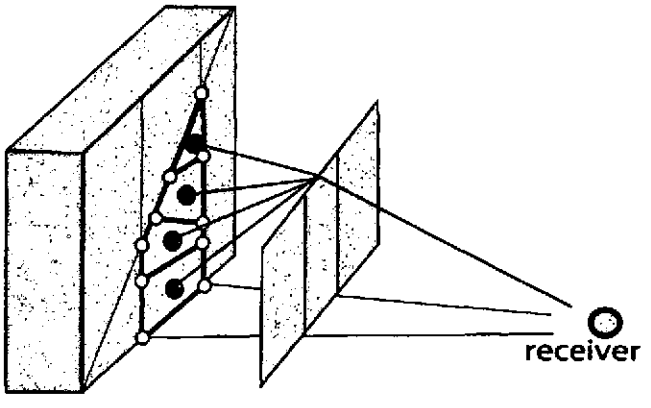
Picture 8 shows the new source polygons. Again, the ground effect and screening are evaluated for the points of the polygon and, if needed, the polygons are subdivided etween the points marking the minimum and maximum.



Subdividing the source 1

Picture 8

Picture 9 shows the final approximation of the area source by a number of point sources. For each of the new area sources the center of gravity for the area is used as the location of the point source.



Subdividing the source 2

Picture 9

The procedures implemented in SoundPLAN free the user from needing to decide how to convert area sources into a series of point sources, the software does it correctly without user intervention.

In SoundPLAN 2 parameters control the number of iterative subdivision. The first is the maximum allowable differences of ground effect and screening within the area source. The second is the number of iterations permitted. In practical tests the maximal spread in ground effect and screening of 1 dB and a maximum number of iterations set to 4 proved to produce stable results. The iterative approximation optimises the calculation time while maintaining a high level of accuracy.

The procedures proved to be reliable for screening with horizontal screens and screens of varying height as well as changes in ground type and the height of the source relative to the ground plane.