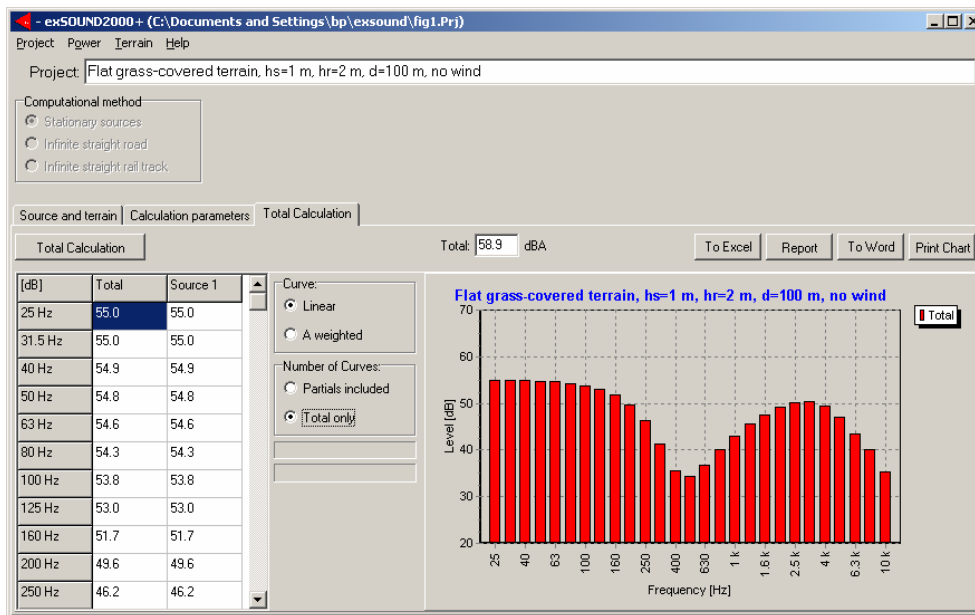


exSOUND2000+

User's Guide





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1. Introduction

In 1996, the Nordic Council of Ministers decided to establish a new generation of environmental noise prediction methods utilizing results of research and development having taken place since the first Nordic prediction methods were published in the 1970s and early 1980s.

The idea was to develop a sound propagation model and to build up source-related prediction methods for road and rail traffic and other environmental noise sources, all applying the same propagation model.

The propagation model should predict the sound pressure level, generated by a point source, in one-third octave bands from 25 Hz to 10 kHz at a receiver, based on the one-third octave band sound power levels of the source.

The propagation model should predict for a variety of weather conditions so that noise from different types of environmental noise could be treated in the same way rather than according to existing models that are valid for different weather conditions. This latter fact is due to historical rather than technical reasons.

Complicated terrain should be handled by an explicitly elaborated procedure. In previously used prediction methods, it has been essential to have a skilled user interpret the terrain and decide how to present it in the calculation. Such a subjective practice will necessarily lead to undesirable variation in calculated results. With the new Nordic propagation model, an explicit procedure can be carried out by a computer leading to unambiguous results.

The outcome of the work was a comprehensive outdoor sound propagation model and source models for road and rail vehicles. The final model denoted Nord2000 has been described in the following reports:

- B. Plovsing and J. Kragh, *Nord2000. Comprehensive Outdoor Sound Propagation Model. Part 1: Propagation in an Atmosphere without Significant Refraction*, DELTA Acoustics & Vibration, Report AV 1849/00, Kgs. Lyngby 2001.
- B. Plovsing and J. Kragh, *Nord2000. Comprehensive Outdoor Sound Propagation Model. Part 2: Propagation in an Atmosphere with Refraction*, DELTA Acoustics & Vibration, Report AV 1851/00, Kgs. Lyngby 2001.
- H. G. Jonasson and S. Å. Storeheier, *Nord2000. New Nordic Prediction Method for Road Traffic Noise, Version 1.0*, SP Report 2001:10, Borås 2001.
- H. G. Jonasson and S. Å. Storeheier, *Nord2000. New Nordic Prediction Method for Rail Traffic Noise, Version 1.0*, SP Report 2001:11, Borås 2001.



A summary can be found in the following report:

- J. Kragh, B. Plovsing, S. Å. Storeheier, and H. G. Jonasson, *Nordic Environmental Noise Prediction Methods, Nord2000. General Nordic Noise Propagation Model and Applications in Source-Related Prediction Methods*, DELTA Acoustics & Vibration Report AV 1719/01, Lyngby 2002.

The five reports and a number of background reports can be downloaded from the web site: <http://www.delta.dk/nord2000>

exSOUND2000+ is based on the Nord2000 method with the limitations described in Section 2.

The present User's Guide contains a description of Nord2000 which enables the user to apply *exSOUND2000+*. If a more detailed description of the scientific basis of Nord2000 is required, this can be found in the reports mentioned above.



2. **Limitations**

All 2-D features of the Nord2000 propagation model have been implemented in *exSOUND2000+* except a few. The limitations of *exSOUND2000+* are:

- Only one scattering zone (forest or housing area) is allowed, and the principle for calculating the reduction in efficiency when the scattering zone has a limited height has been slightly simplified compared to the method described in the reports.
- Correction for the efficiency of a vertically erected reflecting surface is not included and has to be added manually to the result if the path is a reflected path.
- Diffraction around the vertical edges of a screen with a finite length is not included.
- Only one type of surface property (impedance and roughness) is allowed for each terrain segment. Therefore, a mix of surface properties has to be handled by subdividing the segments.
- x-coordinates in the terrain profile must be in ascending order.

It is expected that the contribution from vertical reflecting surfaces outside the direct propagation path as well as diffraction around vertical edges of a finite screen will be included in future versions of *exSOUND2000+*. However, it must be recommended in case of a complicated 3-D environment to use the software SoundPLAN™ instead.

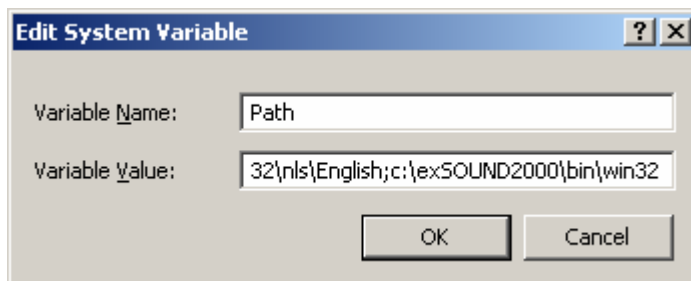


3. Installation on a Windows PC

This section describes the installation of *exSOUND2000+* on a Windows 2000 or XP PC. In the description it is assumed that the program MATLAB™ has not been installed on the PC. The presence of MATLAB™ may conflict with the use of *exSOUND2000+* unless the MATLAB™ version is Release 13. In the latter case step 2) and 3) below shall be omitted.

The installation is carried out as follows:

- 1) Copy the folder *exSOUND2000* on the CD to the folder on the harddisk where you want to install *exSOUND2000+*. In the following this folder will be called *<my_folder>*. The folder may be the root directory (e.g. C:\).
- 2) Run *mginstaller.exe* in the *<my_folder>\exSOUND2000* directory by using the Start/Run menu or by double-clicking *mginstaller.exe* in Windows Explorer. This application installs the MATLAB™ math and graphics run-time libraries. The application asks you to enter a directory to which to install the run-time libraries and proposes *<my_folder>\exSOUND2000*. It is recommended that you accept this proposal by pressing *<Enter>*. The application is also expected to add the string *;<my_folder>\exSOUND2000\bin\win32* to your Path environment variable. Step 3) below contains a description of how to make sure that your path is configured correctly and, if necessary, how to configure it manually. However, first it is recommended to continue the installation by step 4) and return to step 3), if necessary.
- 3) Open the *System Properties* in the Windows *Control Panel* (Windows 2000: Start/Settings/Control Panel/System, Windows XP: Start/Control Panel/System) and choose the sheet *Advanced*. Then press the button *Environment Variable*. Click *Path* in the window *System Variables* and press the button *Edit*. Append the string *;<my_folder>\exSOUND2000\bin\win32* to the system variable value and press *OK* a sufficient number of times to close *System Properties*.



- 4) Start *exSOUND2000.exe* from the Start/Run menu, by double-clicking *exSOUND2000.exe* in Windows Explorer or preferably by assigning a shortcut to *exSOUND2000.exe* and by double-clicking the shortcut. If you get the message "A required .DLL file, LIBUT.DLL was not found", the PATH environment variable has not been configured correctly, and you have to do it manually as described by step 3).



4. Prediction Model, Definitions

4.1 Short-Term Noise Levels

The Nord2000 model and *exSOUND2000+* allow calculation of one-third octave band sound pressure levels from 25 Hz to 10 kHz for specified weather conditions including rapid turbulent motions of the atmosphere. Therefore, the model applies to calculation of short-term noise levels for time periods shorter than 30 minutes or 1 hour.

Long-term noise levels which include the effect of slowly varying large-scale motions of the atmosphere (synoptic scales) can be obtained by combining the calculated short-term noise levels with meteorological statistics. In practice, short-term level calculations are made for a limited set of meteorological classes, and the long-term level is the weighted average of these results. This approach makes it possible to calculate long-term levels such as the yearly average L_{den} and L_{night} specified as noise indicators in the EU Directive on environmental noise, maximum noise levels for longer periods, or even complete statistical distributions of noise levels.

4.2 Prediction Model

In general, *exSOUND2000+* can be used without any knowledge of the Nord2000 reports mentioned in Section 1. However, a few model definitions have to be known by the user in order to apply the program. This section contains all necessary definitions.

Terrain

In Nord2000 any terrain shape must be approximated by a broken line (a chain of straight-line segments). Figure 1 shows for three categories of non-flat terrain how such segmented terrain may look.

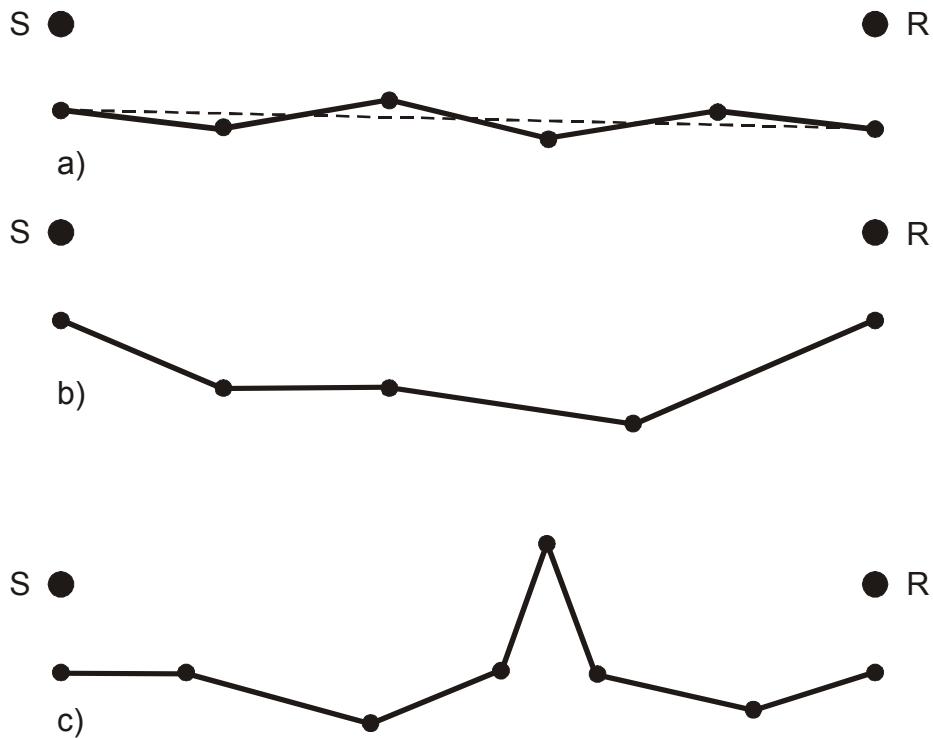


Figure 1
Examples of segmented terrain: a) moderately non-flat terrain, b) valley-shaped terrain, c) terrain with a screen.

In *exSOUND2000+* the terrain is defined by a table as shown in Table 1. Each row in the table corresponds to a point of discontinuity in the terrain profile. Such a terrain point is assigned a horizontal distance x , a vertical height z , a ground type GT and a ground roughness GR . The first point (x_1, z_1) is the ground point vertically below the source, and the last point (x_n, z_n) is the ground point vertically below the receiver. The surface properties of the first segment between (x_1, z_1) and (x_2, z_2) are defined by the ground type GT_1 and the ground roughness GR_1 and so on. Due to this definition the ground type and ground roughness in the last row are not applied. The values of x must be in ascending order. Behind the source and the receiver the terrain is assumed to continue with the same slope as the first segment and last segment, respectively.



Ground point no.	Distance x	Height z	Ground type	Ground roughness
1	x_1	z_1	GT_1	GR_1
2	x_2	z_2	GT_2	GR_2
...
n-1	x_{n-1}	z_{n-1}	GT_{n-1}	GR_{n-1}
n	x_n	z_n	N/A	N/A

Table 1
Terrain definition.

The ground type is defined by the flow resistivity of the ground surface (in Nord2000 this parameter is used to calculate the ground impedance using the Delany and Bazley impedance model). The ground type may be specified directly by the flow resistivity or indirectly by using the letters A to G defined in Table 2. In the frequently occurring case where it is possible only to distinguish between “soft” and “hard” ground, it is recommended to use the ground types D and G, respectively.

Ground class	Ground type σ [Nsm ⁻⁴]	Description
A	12500	Very soft (snow or moss-like)
B	31500	Soft forest floor (short, dense heather-like or thick moss)
C	80000	Uncompacted, loose ground (turf, grass, loose soil)
D	200000	Normal uncompacted ground (forest floors, pasture field)
E	500000	Compacted field and gravel (compacted lawns, park area)
F	2000000	Compacted dense soil (gravel road, parking lot)
G	20000000	Hard surface (dense asphalt, concrete, water)

Table 2
Classification of ground type.



In Nord2000 each segment in the segmented terrain profile is generally assumed to be perfectly flat. In most cases this is a reasonable assumption when a real terrain has been approximated appropriately by a segmented terrain. However, in a few cases the terrain height may fluctuate strongly along the segment. These fluctuations are supposed to take place within a short range; otherwise the problem should be solved by further subdividing of the terrain. Such fluctuations can be handled roughly in Nord2000 by specifying a ground roughness. The ground roughness is the rms-value of the ground height fluctuations within the segment. The ground roughness is recommended to be represented by one of the four roughness classes shown in Table 3 based on an estimate of the range of height fluctuations. The present version of *exSOUND2000+* does not support the use of the letters N, S, M, and L.

Roughness class	Ground roughness [m]	Range of heights [m]
N: Nil	0	± 0.25
S: Small	0.25	± 0.5
M: Medium	0.5	± 1
L: Large	1	± 2

Table 3
Classification of ground roughness types.

Source (Extended Source)

If a source cannot be approximated by a single point source when using the Nord2000 propagation model, the real source has to be approximated by a number of incoherent point sources, and a calculation has to be carried out for each such sub-source.

In *exSOUND2000+* this is handled by introducing an “extended” source which is a number of point sub-sources placed vertically above each other. The extended source which is shortly denoted *source* in *exSOUND2000+* is placed vertically above the first point in the specified terrain profile (the source ground point). Each sub-source in the source is assigned a height vertically above the source ground point and a linear sound power level in one-third octave bands between 25 Hz and 10 kHz.

If the source also has an extent horizontally which requires sub-sources placed horizontally, this can be handled by dividing the real source into a number of extended sources. However, most often such horizontal subdivision is of less importance than vertical subdivision because the latter seriously affects the



ground effect whereas approximately the same propagation conditions are seen for sub-sources with the same height but spaced horizontally.

In *exSOUND2000+* three more parameters are attached to each source:

- Duration
- Direction
- Source correction

The **duration** is the source emission time within the reference time (defined below). The source is assumed to be steady during the source emission time. The duration in relation to the reference time determines the contribution to the equivalent sound pressure level. When calculating instantaneous or maximum noise level, the duration has to be equal to the reference time.

The **direction** is the geographical direction (compass direction) to the source seen from the receiver as shown in Figure 2 (0° , 90° , 180° , and 270° indicate that the source is placed north, east, south, and west of the receiver, respectively). The direction is used together with the wind direction (defined below) to calculate the wind component in the direction of propagation.

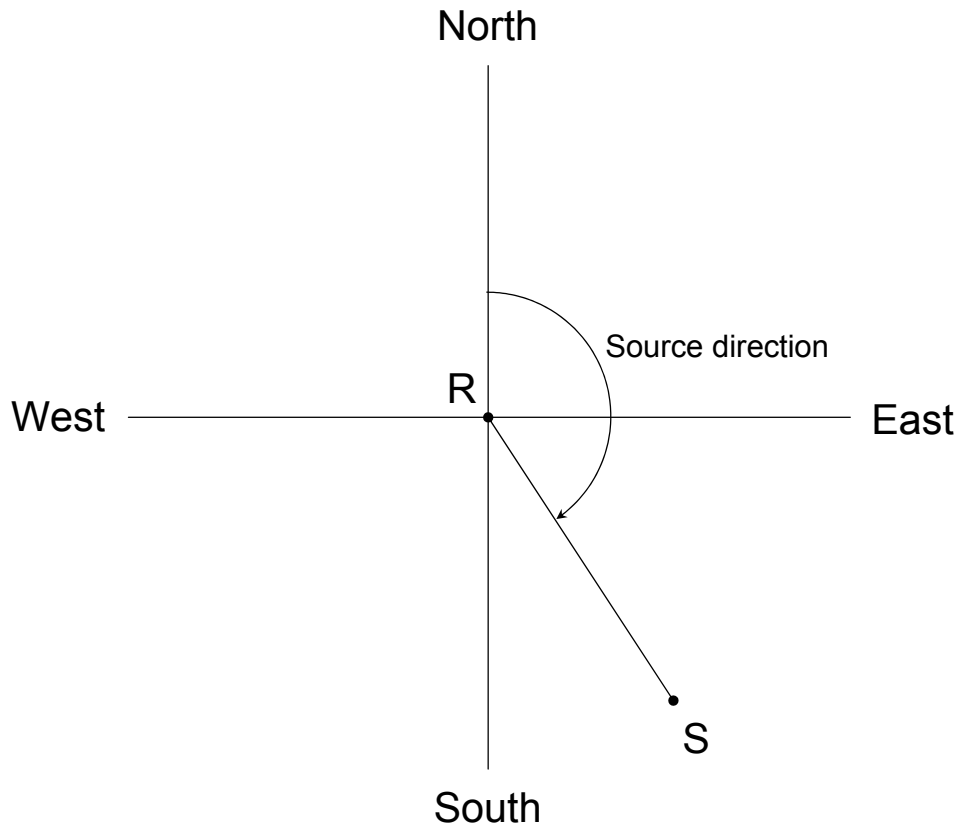


Figure 2
Definition of source direction.



Source correction is a value in dB which is added to the sound power level. This correction can be used for several unspecified purposes including directivity of the source.

In case of moving sources (road or rail traffic), the movement is simulated by a number of stationary extended sources placed equidistantly along the straight traffic path, and the source duration is defined by the driving speed of the vehicles or trains. The sound power levels are corrected for the number of road vehicles or the total length of the train type in the considered time period.

Receiver

In *exSOUND2000+* the receiver is placed vertically above the last point in the specified terrain profile (the receiver ground point). The receiver height is the height measured vertically above the receiver ground point.

Reference Time

The reference time is the time period considered when calculating the equivalent sound pressure level. When calculating instantaneous or maximum noise level the reference time has to be equal to the source duration.

Meteorological Parameters

The meteorological parameters considered when calculating short-term noise levels are:

Height of wind: The height (in m) in which the wind speed and wind direction has been measured. The typical height for a synoptical weather station is 10 m.

Wind speed: The average wind speed $u(z)$ (in m/s) at the specified height z .

Roughness length: A constant which determines together with the wind speed at a specified height the vertical wind speed profile according to the following equation:

$$u(z) = A \ln \left(\frac{z}{z_0} + 1 \right)$$

The roughness length z_0 depends on the type of surface as shown in Table 4. For normal grass-covered ground without bushes and trees a value of 0.05 is recommended.



Type of surface	z_0 [m]
Water surface, sand	<0.01
Meadow, grass	0.01 - 0.1
Bushes, single trees	0.05 - 0.5
Forests	0.5 - 1
Built-up areas	1 - 2

Table 4
Classification of ground roughness types.

Wind direction: The average wind direction (in °) at the specified height. The wind direction is the geographical direction from where the wind is blowing. Hence, northerly, easterly, southerly, and westerly winds correspond to winds blowing from the geographical directions of 0°, 90°, 180°, and 270°, respectively.

Standard deviation of wind speed: The standard deviation of the wind speed (in m/s) at the specified height of the wind. This quantity is normally not available from standard weather stations, but a reasonable estimate can be determined by the following equation where σ_u is the standard deviation, u is the average wind speed, and k is a constant. For flat ground without bushes, a value k of 0.15 can be recommended whereas a higher value should be used for rough terrain and terrain with bushes (k about 0.3). In any case, it is recommended not to use a value below 0.5 m/s at 10 m height.

$$\sigma_u = k u$$

Temperature at the ground: The temperature at height 0 in the temperature profile (which is assumed to vary linearly with the height). The temperature 2 m above the ground normally available from a standard synoptical weather station is a reasonable estimate of the ground temperature.

Temperature gradient: The average temperature gradient (in °/m) between the source and the receiver height. This quantity determines together with the temperature at the ground the temperature profile. For neutral weather condition the temperature gradient is -0.01 °/m called the lapse rate. During night-time the temperature gradient may be positive (about 0.05-0.1 °/m) and negative during day-time on a sunny day (about 0.1-0.2 °/m).

Standard deviation of temperature gradient: The standard deviation of the temperature gradient (in °/m). This quantity is normally not known and will also have a much more limited influence on the calculated results than the standard deviation of the wind speed. Therefore, it is recommended normally to use a value of 0.



Turbulence strength, wind: The wind turbulence strength is defined by the structure parameter C_v^2 . This value is most often not available, but $0.12 \text{ m}^{4/3}\text{s}^{-2}$ is recommended for a normally turbulent atmosphere.

Turbulence strength, temperature: The temperature turbulence strength is defined by the structure parameter C_t^2 . This value is most often not available, but 0.008 Ks^{-2} is recommended for a normally turbulent atmosphere.

Relative humidity: The relative humidity (in %) can be obtained from standard synoptical weather stations and is used for the calculation of the air absorption. International standard atmosphere (ISA) is defined by a temperature of 15°C and a relative humidity of 70%.

Scattering Zone (Forest or Housing Area)

In *exSOUND2000+* it is possible to predict the effect of sound propagation through “scattering zones”. Scattering zones are urban areas or vegetation. In urban areas the sound propagation is influenced by multiple reflections, diffuse scattering by irregularities of building facades, diffraction at house corners, and absorption by buildings and ground surfaces. In vegetation, mainly forests, the sound propagation is influenced by reflection, scattering, and absorption due to trunks, branches and foliage. In such areas, sound propagation is much too complicated for a deterministic model, and it has been necessary to use a statistical scattering model. Such a model will not predict the exact sound pressure level at a specified location, but rather the average sound pressure level at a specified distance from the source. Thus, the sound shadow behind an object and the increase in sound level in front of the object are not taken into account.

The present version of *exSOUND2000+* allows one scattering zone between the source and receiver. The parameters in the prediction are:

Start of scattering zone: The x -coordinate of the limit of the scattering zone closest to the source. The value has to be greater than or equal to x_1 in the terrain profile.

End of scattering zone: The x -coordinate of the limit of the scattering zone closest to the receiver. The value has to be less than or equal to x_n in the terrain profile and greater than the start of the scattering zone.

nQ : A value (in m^{-1}) which quantifies the density and size of the objects in the scattering zone.

In case of housing areas nQ is determined by the following equation where n' is the fraction of the plan area of all buildings to the total area of the scattering zone (a value between 0 and 1), \bar{S} is the surface area (sum of walls and roof surfaces) of an average building (m^2), h is the height of the highest building (m) and A_b is the average building plan area (m^2).



$$nQ = \frac{n' \bar{S}}{4 h A_b}$$

In case of forests, nQ is determined by the next equation where n'' is the density of trees (m^{-2}), and d is the mean trunk diameter (m).

$$nQ = n'' d$$

Mean height: The mean height of scattering zone above the ground surface.

Absorption coefficient: The average energy absorption coefficient of the scattering objects. The value shall be between 0 and 0.4 and is normally in the range 0-0.2.

Proportionality constant: A scaling constant in the scattering zone model. In case of a forest, the value is fixed to be 1.25, and in case of a housing area the value shall be in the range 0.4 to 1. A value of 0.7 is recommended for normal use while 0.4 is recommended as a “safe” estimate not to overestimate the attenuation.

Mean trunk radius: The mean radius of the trunk in a forest (is not used in case of a housing area).



5. User Interface

5.1 Definitions

This section contains a few definitions used when describing the user interface in the following.

Project

A project is a collection of input data to be used by a computation method (see below). A project can be stored in a project file. Each project contains data for one receiver point, only.

Power Data

Power data is a collection of sound power levels of an extended source with an attached height above the ground of each sub-source. The power data can be stored in a power file which can be opened and used by any of the computation methods.

Terrain Data

Terrain data is a definition of the terrain profile between the source and receiver including surface properties. The terrain data can be stored in a terrain file which can be opened and used by any of the computation methods. In the computation methods *Infinite straight road* and *Infinite straight rail track* the terrain profile is the profile between the point on the road or rail track closest to the receiver and the receiver point (perpendicular to the road or rail track).

Computation Methods

When starting *exSOUND2000+*, the user can choose between three computation methods:

- Stationary sources
- Infinite straight road
- Infinite straight rail track

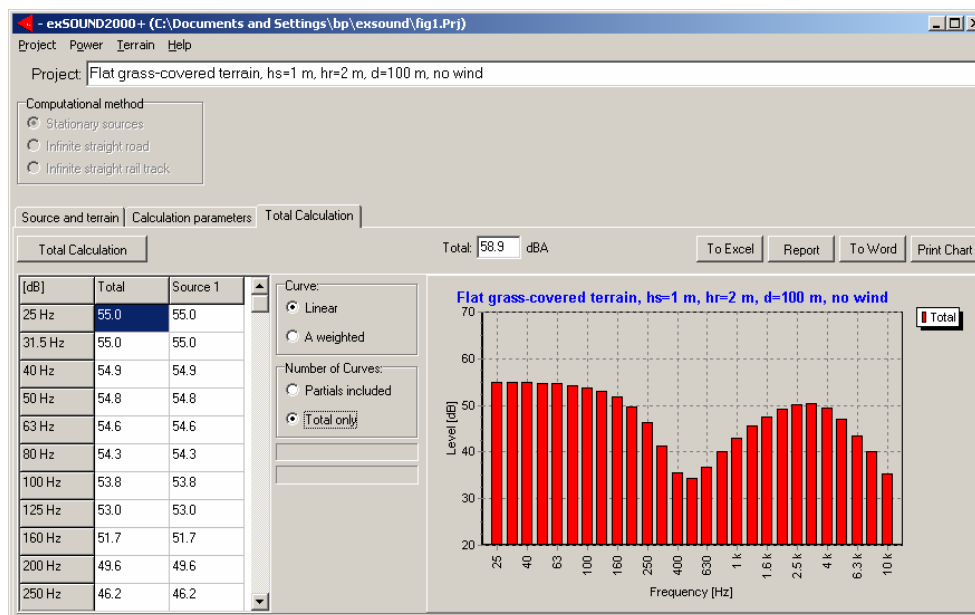
When one of the computation methods and at least a source number of one has been chosen, a project has been defined and the computation method can no longer be changed.



5.2 Calculation Setup, Stationary Sources

The screen window of the program contains as follows:

- A text field used to define the project title
- Three buttons used to choose the computation method
- A sheet called *Source and terrain* for defining the calculation setup related to each individual source-receiver path
- A sheet called *Calculation parameters* for defining the calculation setup of variables common for all sources
- A sheet called *Total calculation* for activating a calculation (by pressing the button *Total calculation*) and showing the result



The three sheets which are used to define the calculation setup and activate a calculation are described in the following.

Source and Terrain Sheet

The number of sources (extended sources) is defined in the field *Source number* or by pressing the wrapper next to the field, and each source may be assigned a title. For each source, a sheet (hereafter called the source sheet) is inserted which contains the calculation setup of the source.

Each source sheet contains a checkbox which is used to define whether the source is included or not in the calculation. Besides, the sheet contains 5 sub-sheets:



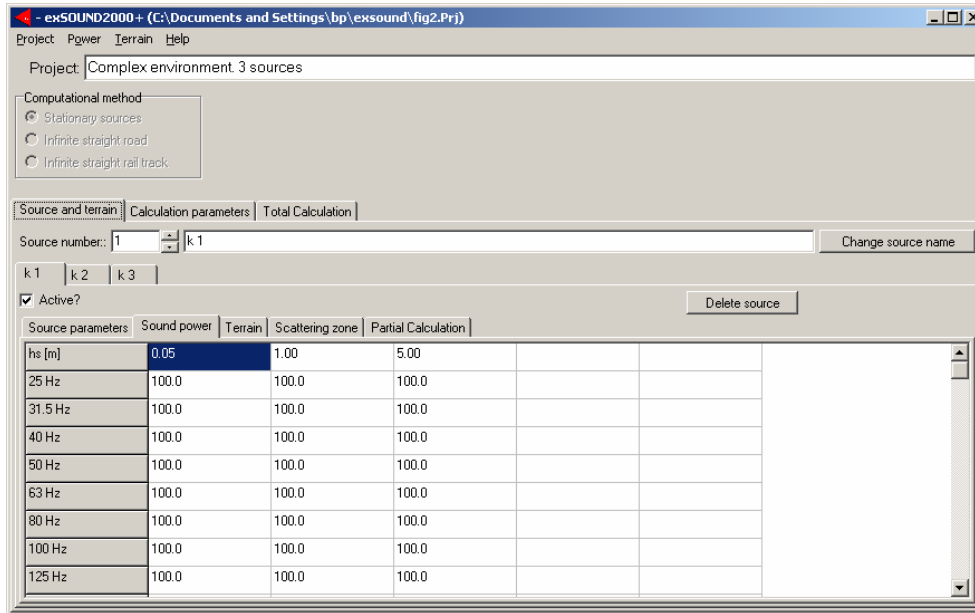
- Source parameters
- Sound power
- Terrain
- Scattering zone
- Partial calculation

The **Source parameter** sheet defines the duration of the source noise emission, the direction to the source, and a possible adjustment of the sound power levels. The parameters are described in Section 4.2 subsection Source (Extended Source).

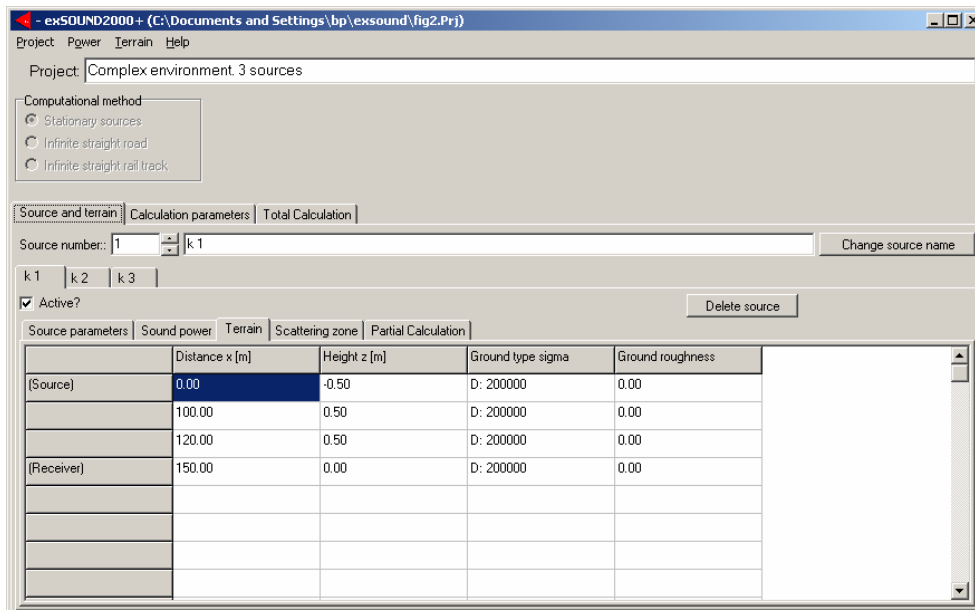
The screenshot shows the 'Source parameters' tab of the 'exSOUND2000+' software. The window title is 'exSOUND2000+ (C:\Documents and Settings\bp\exsound\fig4.Prj)'. The menu bar includes 'Project', 'Power', 'Terrain', and 'Help'. The 'Project' field contains 'Complex environment. 3 sources'. Under 'Computational method', three radio buttons are present: 'Stationary sources' (selected), 'Infinite straight road', and 'Infinite straight rail track'. Below this are tabs for 'Source and terrain', 'Calculation parameters', and 'Total Calculation'. The 'Source number' is '1' and the source name is 'k 1'. There are buttons for 'Change source name' and 'Delete source'. A 'k 1 | k 2 | k 3' selector is visible. The 'Active?' checkbox is checked. The 'Source parameters' sub-tab is active, showing 'Duration: 1.0' with a 'Duration time unit' dropdown set to 'Sec'. Other options for 'Min', 'Hours', and 'Days' are present. 'Direction: 270.0' is shown with a degree symbol. 'Source correction: 0.0 dB' is also displayed.



The **Sound power** sheet defines the sound power level and the height above ground of each point sub-source of the extended source as described in Section 4.2 subsection Source (Extended Source).

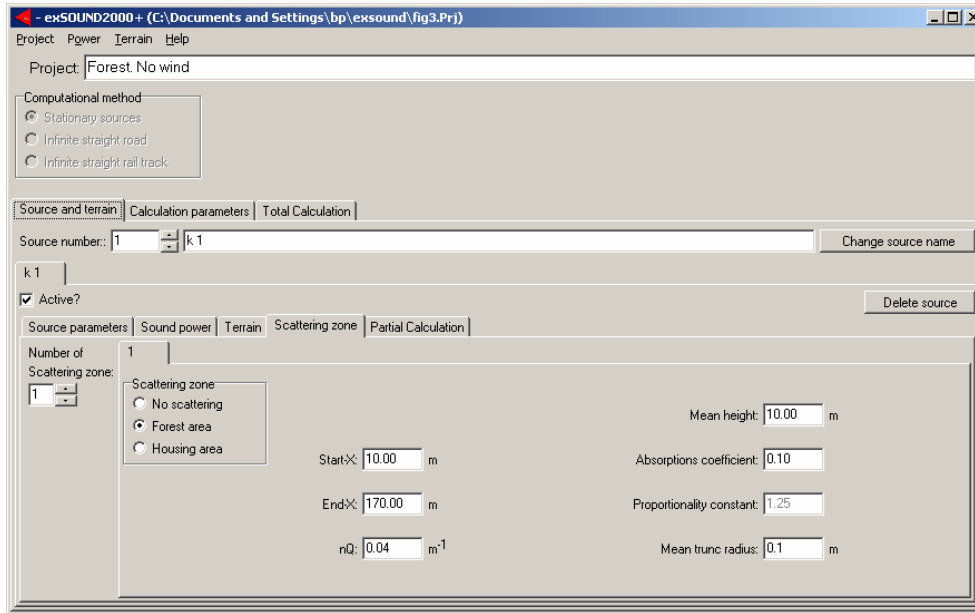


The **Terrain** sheet defines the terrain profile including surface properties as described in Section 4.2 subsection Terrain. The rows in the table representing a ground point may be keyed-in in any order. When leaving the table, the program arranges the rows so that the x-values will be in ascending order. Therefore, a new ground point may be inserted by appending a row at the end of the table.

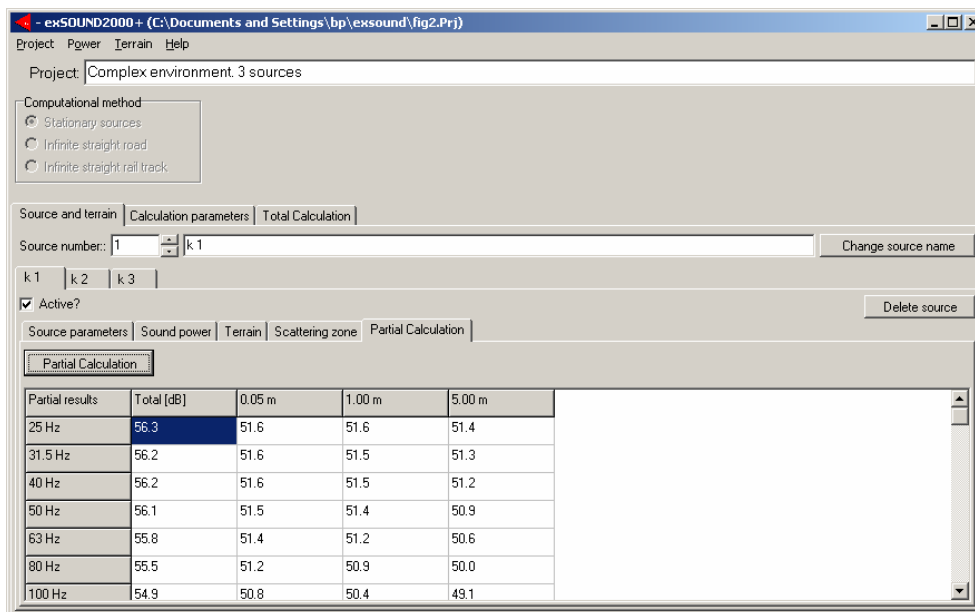




The **Scattering zone** sheet defines the parameters of a possible scattering zone (forest or housing area) as described in Section 4.2 subsection Scattering Zone (Forest or Housing Area).



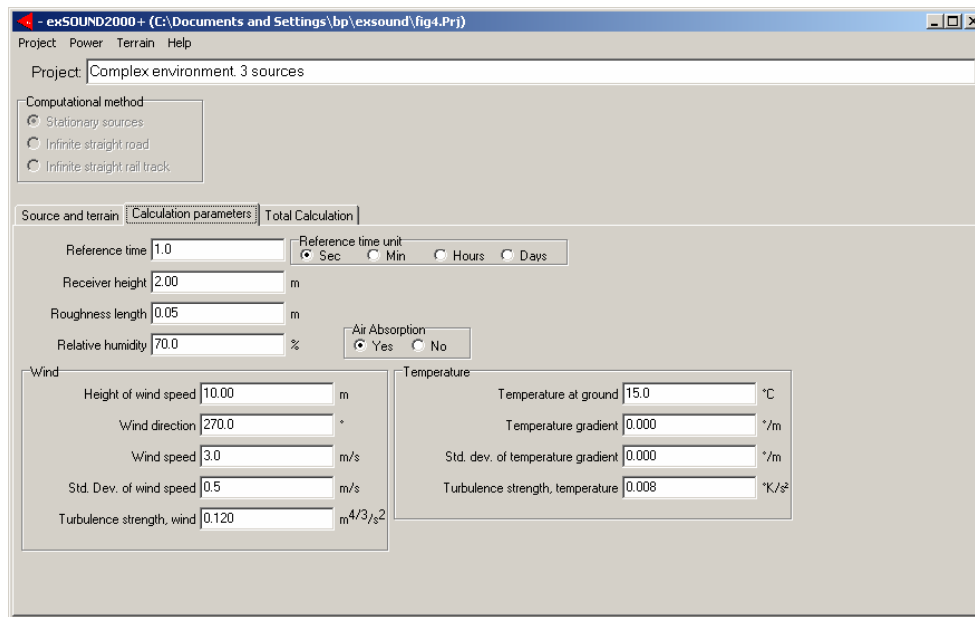
The **Partial calculation** sheet is used for activating a calculation for the current source alone (by pressing the button *Partial calculation*) and showing the result.





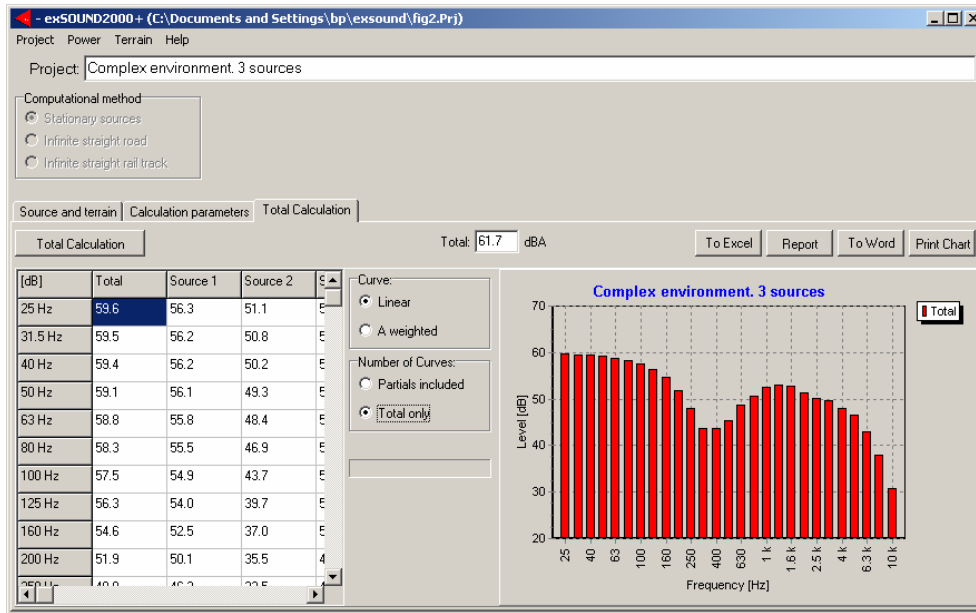
Calculation Parameters Sheet

This sheet contains a set of calculation parameters which are common for all sources. These parameters are the reference time of the equivalent sound pressure level, the height of receiver above ground, and parameters defining the meteorological conditions. The parameters are described in Section 4.2.



Total Calculation Sheet

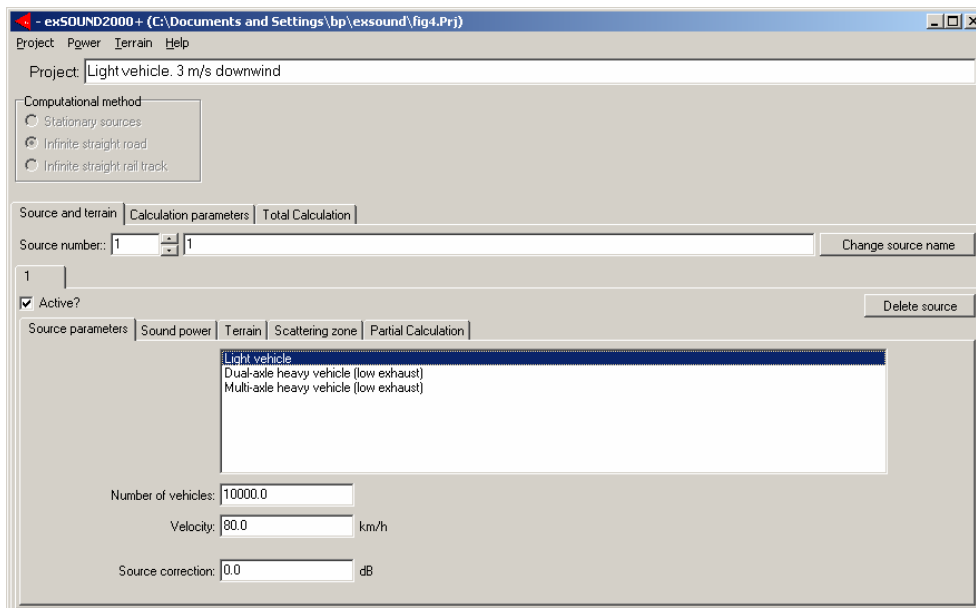
This sheet contains a button *Total calculation* which activates a calculation when pressed. After the calculation has been performed, the result will be shown in a table at the left side of the sheet and in a chart at the right side of the sheet. The table shows the calculated sound pressure level in each one-third octave band (linear weighting) for all sources and for each source separately. In the chart the sound pressure levels may optionally be shown with linear or A-curve frequency weighting, and the user may also choose whether the chart shall show the total result only or whether partial results for each source shall be included. The overall A-weighted sound pressure levels can be found at the top of the sheet. During the calculation, the progress is shown by two progress bars. The lower bar shows progress by the current source number while the upper bar shows progress by the sub-source number along the road or rail track for each source.



5.3 Calculation Setup, Infinite Straight Road

When the computation method *Infinite straight road* has been chosen, the setup sheets are in most cases identical to the sheets used in the method *Stationary sources* described in Section 5.2. The only exception is the sub-sheet *Source parameters* in the *Source and terrain* sheet.

Each source contains a definition of the number of vehicles within the reference time period (defined in the sheet *Calculation parameters*), the speed of the vehicles, and a general adjustment in dB of the source sound power levels defined in the sub-sheet *Sound power*.





In the same way as in the computation method *Stationary sources*, the source may be divided into a number of sub-sources placed vertically above each other above the first point in the specified terrain profile (on the road surface). Each sub-source shall be assigned a height vertically above the source ground point and a linear sound power level in one-third octave bands between 25 Hz and 10 kHz.

Instead of defining the sound power levels of the sub-sources manually, they may be defined by double-clicking the vehicle type in the *Source parameters* sub-sheet. The options are:

- Light vehicle (passenger car, delivery van, etc.)
- Dual-axle heavy vehicle (low exhaust)
- Multi-axle heavy vehicle (low exhaust)

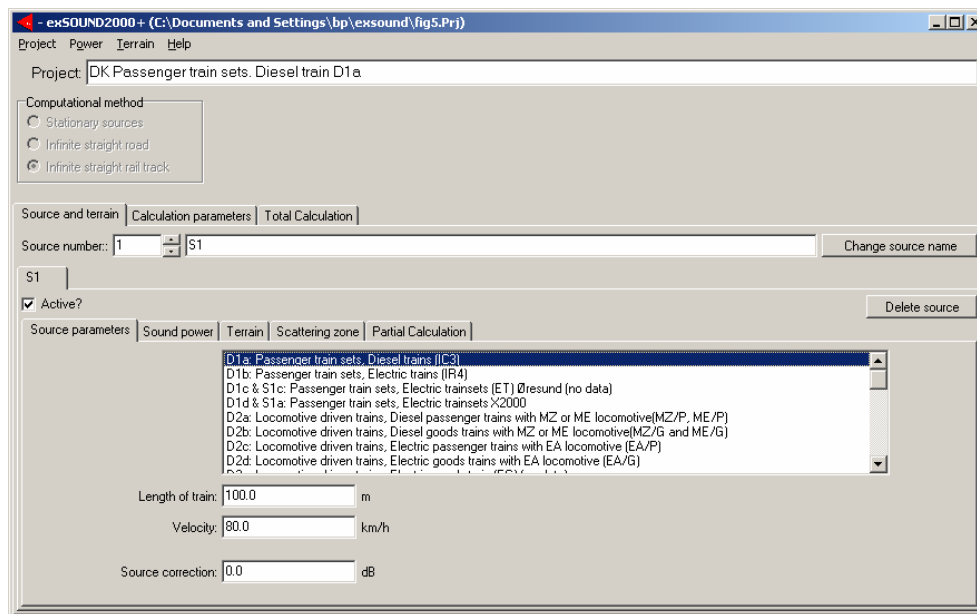
When the computation method *Infinite straight road* has been chosen, the wind direction defined in the sheet *Calculation parameters* is the direction of the wind relative to the normal of the road. Directions of 0° and 180° indicate wind perpendicular to the road with the wind blowing from the road towards the receiver (downwind) or from the receiver towards the road (upwind), respectively. A direction of 90° indicates wind along the road. The wind direction may also be interpreted as the geographical wind direction, in which case the road is situated with a direction from west to east and the receiver placed south of the road.

All sources in a project are parallel roads (because they will have the same wind direction) and may represent different lanes or different types of vehicles on the same lane.

5.4 Calculation Setup, Infinite Straight Rail Track


When the computation method *Infinite straight rail track* has been chosen, the setup sheets are in most cases identical to the sheets used in the method *Stationary sources* described in Section 5.2. The only exception is the sub-sheet *Source parameters* in the *Source and terrain* sheet.

Each source contains a definition of the total passing length of the train type within the reference time period (defined in the sheet *Calculation parameters*), the speed of the train, and a general adjustment in dB of the source sound power levels defined in the sub-sheet *Sound power*.



In the same way as in the computation method *Stationary sources*, the source may be divided into a number of sub-sources placed vertically above each other above the first point in the specified terrain profile. Each sub-source shall be assigned a height vertically above the rail head and a linear sound power level in one-third octave bands between 25 Hz and 10 kHz. In *exSOUND2000+* the rail head is assumed to be 0.2 m above the rail bed which is the source ground point (first point in the specified terrain profile). Please note that this definition of the source height differs from the definition in the computation methods *Stationary sources* and *Infinite straight road* where the source height is the height above ground.

Instead of defining the sound power levels of the sub-sources manually, they may be defined by double-clicking the train type in the *Source parameters* sub-sheet. The source heights which can be seen in the *Sound power* sheet are heights above the rail bed assuming that the rail head is 0.2 m above the ballast surface. The train type options are given in Table 5, Table 6, and Table 7 for Danish, Swedish, and Norwegian train types, respectively. The tables contain individual train types arranged in main categories. The number of train types in the tables and in *exSOUND2000+* corresponds to the number of types considered in the Nord2000 Rail Traffic Noise Method. However, so far source data are not available for all train types as indicated in the column *Available*. In some cases, source data are identical for a number of train types. This is indicated in the column *Equal to*. For example, it can be seen from Table 5 that the source data of the train types D2a, D2b, D2c, and D2d are based on the same data. Therefore, if traffic data of these types are merged, the calculation result will not be affected, but the calculation time will be reduced.



	Main category	Sub-category		Available	Equal to
1	Passenger train sets	D1a	Diesel trains (IC3)	Yes	
		D1b	Electric trains (IR4)	Yes	D1a
		D1c	Electric train sets (ET) Øresund	No	
		D1d	Electric train sets X2000	Yes	S1a
2	Locomotive-driven trains	D2a	Diesel passenger trains with MZ or ME locomotive(MZ/P, ME/P)	Yes	
		D2b	Diesel goods trains with MZ or ME locomotive(MZ/G and ME/G)	Yes	D2a
		D2c	Electric passenger trains with EA locomotive (EA/P)	Yes	D2a
		D2d	Electric goods trains with EA locomotive (EA/G)	Yes	D2a
		D2e	Electric goods train (EG)	No	
4	Local trains	D4a	S-trains 2 nd and 3 rd generation	Yes	
		D4b	S-trains 4 th generation	Yes	
		D4c	Diesel train sets (MR)	Yes	
		D4d	Y-trains, IC2 trains, Re-gioSprinter, Desiro	Yes	D4c

Table 5
Danish train types.



Main category		Sub-category		Available	Equal to
1	High-speed trains	S1a	X2000	Yes	D1d
		S1b	Arlanda train	No	
		S1c	Öresund train	No	
2	Normal speed Inter-City trains	S2a	With RC engine	Yes	
3	Local and regional trains	S3a	X10, X12 (electric)	Yes	
		S3b	Y1 (diesel)	No	
		S3c	Y2 (diesel)	No	
4	Freight trains	S4a	Normal, RC engine (electric)	Yes	
		S4b	Normal, T44 engine (diesel + electric)	Yes	
		S4c	Iron ore train	No	

Table 6
Swedish train types.



Main category		Sub-category		Available	Equal to
1	High-speed trains	N1a	Gardermoen train, Type BM 71	Yes	
2	Normal speed Inter-City trains	N2a	Type BM 70	Yes	
		N2b	Passenger train, electric (locomotive-driven)	Yes	
		N2c	Passenger train, diesel (locomotive-driven)	Yes	
		N2d	Type BM 73	Yes	N1a
		N2e	Type BM 93	Yes	
3	Local trains	N3a	Type BM 69	Yes	
		N3b	Type BM 92	Yes	N2c
		N3c	Type BM 72	Yes	N1a
4	Freight trains	N4a	Ordinary goods, electric	Yes	
		N4b	Container express goods, electric	Yes	
		N4c	Goods, diesel	Yes	

Table 7
Norwegian train types.

When the computation method *Infinite straight rail track* has been chosen, the wind direction defined in the sheet *Calculation parameters* is the direction of the wind relative to the normal of the track. Directions of 0° and 180° indicate wind perpendicular to the track with the wind blowing from the track towards the receiver (downwind) or from the receiver towards the track (upwind), respectively. A direction of 90° indicates wind along the track. The wind direction may also be interpreted as the geographical wind direction, in which case the track is situated with a direction from west to east and the receiver placed south of the track.

All sources in a project are parallel tracks (because they will have the same wind direction) and may represent tracks or different types of train on the same track.



5.5 Export and Print of Results

The calculated result may be printed as a report or as a graph or may be exported to Microsoft Excel or Word.

Report

When pressing the button *Report*, a report is generated, which contains the calculated result and a full documentation of the calculation input data. The report may optionally be saved in a Rich text file (*.rtf) or sent to a printer. A Rich text file can be read by Microsoft Word.

exSound2000 Report

- exSOUND2000+
Light vehicle, 3 m/s downwind 2003-04-29

Calculation parameters:
 Reference time 1.0 days
 Receiver height 2.00
 Roughness length 0.05
 Height of wind speed 10.00
 Wind Direction relative to x-axis 0.0
 Wind speed 3.0
 Standard deviation of wind speed 0.5
 Temperature at the ground 15.0
 Temperature gradient 0.000
 Standard deviation of the temperature gradient 0.000
 Turbulence strength, wind 0.120
 Turbulence strength, temperature 0.008
 Relative humidity 70.0

Source: 1
 Number of vehicles: 10000.0
 Velocity: 80.0 km/h

Height [m]:	0.01	0.15	0.30			
Frequency	Strength [dB]	Strength [dB]	Strength [dB]	Strength [dB]	Partial [dB]	Total[dB]
25 Hz	84.7	84.7	84.7	84.7	43.2	43.2
31.5 Hz	83.1	83.1	83.1	83.1	41.6	41.6
40 Hz	83.7	83.7	83.7	83.7	42.1	42.1
50 Hz	84.9	84.9	84.9	84.9	43.2	43.2
63 Hz	87.5	87.5	87.5	87.5	45.5	45.5
80 Hz	91.5	91.5	91.5	91.5	49.0	49.0
100 Hz	87.0	87.0	87.0	87.0	43.7	43.7
125 Hz	82.6	82.6	82.6	82.6	37.8	37.8
160 Hz	83.9	83.9	83.9	83.9	36.8	36.8
200 Hz	83.4	83.4	83.4	83.4	32.7	32.7
250 Hz	84.0	84.0	84.0	84.0	27.8	27.8
315 Hz	83.3	83.3	83.3	83.3	21.1	21.1
400 Hz	83.1	83.1	83.1	83.1	18.6	18.6

Print Chart

When pressing the button *Print Chart*, a graph with the calculated result will be printed.

To Excel

Each time the button *To Excel* is pressed, a Microsoft Excel workbook will be generated, which contains the calculated linear one-third octave band sound pressure levels. The first time the button is pressed, Excel is started and should not be closed until after the termination of *exSOUND2000+*.



To Word

The first time the button *To Word* is pressed, the application Microsoft Word will be started (unless the application is running already), and the result will be exported to the templates *exsoundrap.doc*, *exsoundfort.doc*, and *exsoundscat.doc*. Be sure that the three templates are present at the work directory with the file attribute Read-only. After the calculation result has been inserted in the template *exsoundrap.doc*, the document can be saved with a name differing from *exsoundrap.doc*. The saved document can now be closed, but Microsoft Word itself has to be kept open. The button *To Word* must not be pressed again until after *exsoundrap.doc* has been saved with another name or closed. Please note that the termination of *exSOUND2000+* will automatically close Microsoft Word.

The templates may be changed by the user to comply with any lay-out requirements as long as the bookmarks within the templates are neither deleted nor changed.