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# DESIGN AND FUNCTIONALITY OF A NEW MILITARY NOISE CALCULATION MODEL

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**ABSTRACT**
Noise from activity in military training fields is often regarded as a problem, and attracts attention from both local communities and national environment authorities. To cope with the different interests it is often necessary to optimize the military activity with respect to noise. Since topography and weather conditions have proven to influence sound propagation outdoors significantly, these effects has to be taken into account in the day to day planning and accomplishing of training activity. The Norwegian Defence Construction Service has initialized the development of a new military noise prediction model that is designed both for planning and follow up of military training activity. The model includes the acoustical effects of varying topography, meteorology and surface impedances. Most important however is the user interface of the program, which is designed for non-expert operation with easy visual point and click operations on a background of digital maps. The paper will present version 1.0 of this military calculation model, with focus on the underlying algorithms and functionality.

## 1 - INTRODUCTION

Noise from military training activities is often regarded as a problem for the local community around the training areas and from national authorities. To cope with the different interests it is often necessary to optimize the military activity with respect to noise.
Topography and weather conditions have great influence on sound propagation outdoors. These effects should therefore be taken into account in both the planning of military activities on existing training field, and in the early phase of planning brand new training areas.
The Norwegian Defence Construction Service has in these matters initialized the development of a new computer program for calculating noise from military activities. The most important aspect about this computer program is that the user interface is supposed to be simple and understandable, with easy point and click operations over a digital map.
In this way the planners of military activities more easily can understand and change the activities in order to minimize the noise annoyance for the local community.
This paper presents the first version of this program. This first version is primarily a demonstration of how a tool like this can be realized. It is emphasized how the computer program is organized, and how the noise is calculated in this version. Finally, future development of the program is outlined.

## 2 - DESCRIPTION OF THE COMPUTER PROGRAM

The structure of the computer program can be divided into three parts; The graphical user interface, the database, and the noise calculation module.
It is important to emphasize that these three parts are completely separate modules, that can be changed as long as the interface in between them is kept unchanged.
Figure 1 shows this structure, and indicates that there is no direct connection between the database and the calculation module.

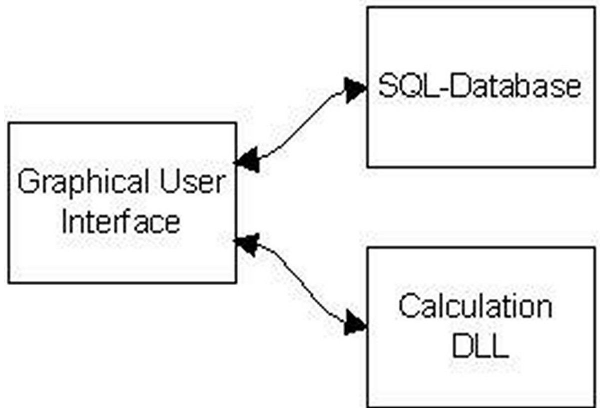


**Figure 1:** Main structure of the computer program.

**2.1 - The user interface**

The most important view in the user interface is the digital map. The user is able to place a noise source on this map, and calculate a chosen noise parameter. The user interface is shown in figure 2.

The rectangle on the digital map is a selected area for a calculation grid surrounding a single noise source. To the right of the digital map there are some switches for changing the weather parameter, that also can be changed with an ordinary dialog box.

The program has two modes; 1) calculations of a selected grid, and 2) an animated mode showing a selected noise contour calculated instantly when the user moves the source with the mouse pointer over the digital map.

**2.2 - The database**

The user interface is connected to the database using an ODBC-connection. This means that the program is independent of the database system, and can be altered without affecting the graphical user interface or the calculation module. The database is designed to be flexible with respect to operational spectral and directivity characteristics of a large variation of noise sources.

Very roughly the database includes:

- The digital map data for the graphical user interface,
- The noise source data for different sources,
- The calculation results from the noise prediction calculation module.

This database content is open for viewing and editing by any ODBC based editor like Microsoft Access. This means that:

- new noise sources can be added,
- new maps, and maps with finer resolution can be added, and
- the calculation result can be studied in more detail.

Embedded tools for editing the database contents is intended to be included in later versions of the program.

**2.3 - Noise calculation module**

The noise calculation module is built as a Windows dynamic link library (DLL), which means that every kind of Windows program in fact can use the functions that the DLL provides. This gives a great flexibility, including the possibility to add new and alternative models for noise propagation. At this moment a preliminary version of a new algorithm is used, with the purpose to demonstrate how topography, directivity and meteorology influences the noise contours. Nevertheless an overview of the model that has been used will be discussed in this section.

The model predicts the sound pressure level at the receiver in one-third octave bands from 25Hz to 10kHz, and it is valid for a point source.

The sound pressure level $L_R$ at the receiver for each frequency band is given by equation 1.

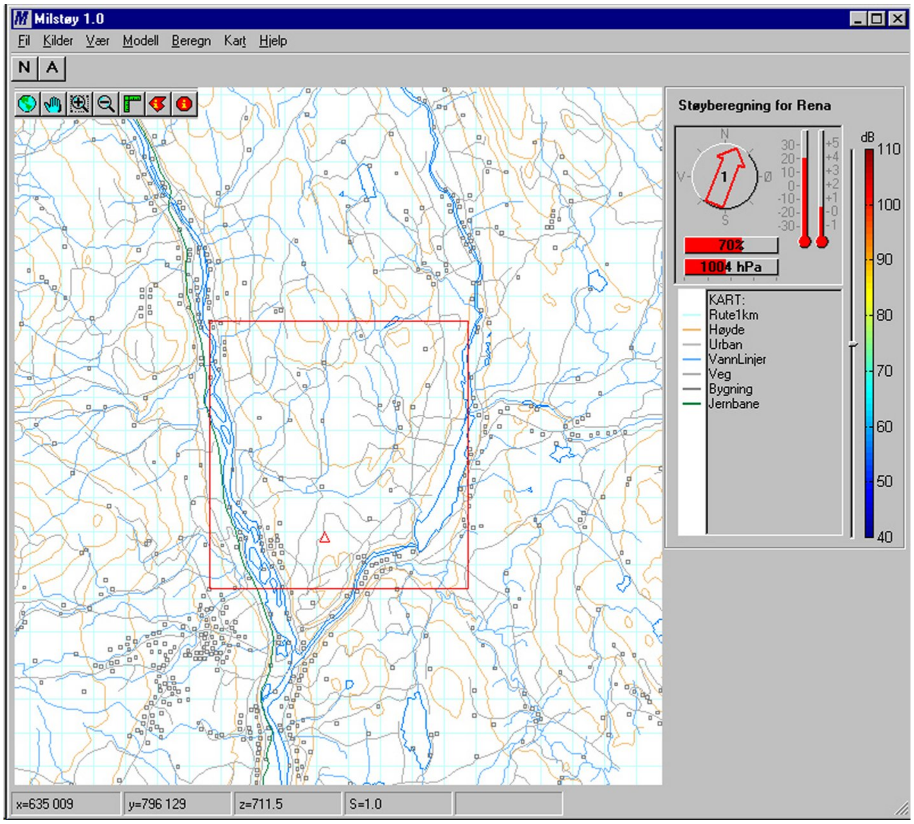


**Figure 2:** The graphical user interface.

$$L_R = L_W + \Delta L_d + \Delta L_a + \Delta L_t \quad (1)$$

where

- $L_W$ is the sound power level for the source within the considered frequency band,
- $\Delta L_d$ is the propagation effect due to spherical divergence of the sound energy,
- $\Delta L_a$ is the propagation effect due to atmospheric absorption, and
- $\Delta L_t$ is the propagation effect caused by topography, terrain surface, wind, and a temperature gradient between the source and receiver.

***Spherical divergence***
The propagation loss given by the spherical divergence is given by equation 2.

$$\Delta L_d = -10\log\left(4\pi r^2\right) \quad (2)$$

where $r$ is the distance between the source and receiver.

***Atmospheric Absorption***
The atmospheric absorption is calculated for the center frequencies in each band on the basis described in ISO 9613-1 [1].

***Ground effects***
The calculation of the ground effects is based on the Fresnel zone method described by Plovsing in [2] and [3].
To include weather effects, we have assumed that the sound speed gradient can be simplified to a linear gradient, and introduce curved rays as proposed by L'Esperance et. al. in [4].
If the receiver is in the shadow zone, an empirical model for the sound pressure is used based on the measurement given by Wiener & Kiest in [5].
The model uses shielding effects for dominating screens only, based on the well-established Maekawa method [6] and the principle outlined in [7].

## 3 - CONCLUSION AND FURTHER WORK

The computer program has been developed at SINTEF for the Norwegian Defence Construction Service. Feedback from many different test users has contributed to the specification of the next version of this software.
This next version is planned to include:

- Importing of digital maps and terrains based on common standards
- Include all kinds of community noise sources like military activity, road and railroad traffic, aircraft activity and industry, with the duration of the source as an important parameter
- A multiple document graphical user interface
- Easy editing of *noise scenarios*
- The calculation model will be based on the new Nordic model for outdoor sound propagation; Nord 2000 [8]
- Automatic report generation

A future version 3 of the program is planned to include a more complete planning and registration tool. To improve the operational value of the program, it will also be supplied with monitoring and knowledge management capability.

## ACKNOWLEDGEMENTS

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