inter-noise 2009
innovations in practical noise control
2009 August 23-26
Ottawa, Canada

END Noise Mapping – The sustainable solution of the German Federal Railway Authority, review to an outstanding project

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ABSTRACT

The Federal Railway Authority of Germany was tendering 2006 a sustainable noise mapping system to fulfil the needs of the END (European Noise Directive). The aim of the project was to develop a system which contains all required model data and results for the first level of the EU noise mapping. In addition the system should be an integrated software solution to explore the model data. It should give public access to the results, include a set of optimized tools to continue the work for the next level of detail and also be a data supplier for local authorities.

The major challenges of this project were: The integration and homogenization of the fundamental data from each individual federal state and different other data suppliers to build an area-wide data model that is consistent and sustainable. Merging the different software products GIS software, database software and noise calculation software to get a completely homogenous software application and transferring the know-how from the model data preparation into this new software application.

The goal was reached in 2008: The results are published via the internet. Local authorities can request base date from the system for their action plans.

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1. INTRODUCTION

In 2005, the European Noise Directive 2002/49/EC[1] (END) relating to the assessment and management of environmental noise (June 2002) became a national law in Germany. The 16 individual federal states were responsible for the noise mapping according to the END for all relevant noise sources except the railways. The Federal Railway Authority of Germany (EBA), an independent federal authority for the regulation of the German railways, became responsible for doing the noise mapping concerning all relevant railways of Germany.

VBUSch[2] (preliminary calculation method for environmental noise at railways) and VBEB[3] (preliminary calculation method for determining the exposure figures caused by environmental noise) were introduced for the calculation of strategic noise maps and the determination of the persons exposed to certain noise levels as well as the number of dwellings, schools and hospitals. All major railways with more than 60 000 train passages per year and all railways in agglomerations with more than 250 000 inhabitants must be considered in phase one of the END. According to these parameters about 9.000 km railway lines and twenty-seven agglomeration areas needed to be processed throughout Germany.

Therefore the EBA was tendering 2006 for a solution including not only the noise mapping for the first phase of the END but also a complete multi server system consisting out of an Oracle database server and a GIS based software solution in combination with a noise calculation software. This system should hold the model data, provide statistics, reports and maps and enable the EBA to do the second round of the noise mapping by themselves.

A team of three companies reflected on a sustainable solution for this challenge. The common conception of the team members Intergraph Deutschland GmbH (a global provider of engineering and geospatial software), Braunstein+Berndt GmbH (software designers and consulting engineers for noise control) and Pöyry Infra GmbH (an international consulting and engineering company) awarded the contract.

Kick-off for that project was in September 2007, first results had to be published in June 2008. There were only 9 months left to install the system, build up an area-wide data model, do the noise calculation, evaluate the results, create the required reports and ensure that information on environmental noise and its effects were made available to the public. The different parts of the project needed to be parallelized to complete this demanding task in time. A first version of the requested software solution was developed parallel to the noise mapping itself. The model data and the results of the noise mapping were then successively transferred into the new system which then generated and published noise statistics, reports and maps at the end of the day.

Some interesting aspects of this project, like the preparation of the data model, the noise calculation as well as an overview on the multi server system will be described in this paper.

2. MODEL DATA PREPARATION

A. General

In order to facilitate the assessment of noise from railways it was necessary to generate a 3D acoustics data model. The required data sets can be classified into:

- source data which defines the position and characteristics of the noise sources
- basic spatial data, e.g. digital ground model, buildings, noise barriers...
- demographic data (inhabitant figures)

As model data isn't available in a comparable state in the Federal Republic (e.g. via ALKIS "Authoritative Real Estate Cadastre Information System"), the state specific data had to be used in the project. The major challenges at this part of the project were: the integration and homogenization of the fundamental data from the Deutsche Bahn AG (DB) and each individual federal state as well as different other data suppliers in order to build an area-wide data model that is consistent and sustainable. This was accomplished by reading and processing roughly 500 data sets in more than 10 different formats including

- filtering of information,
- completing, cleaning and verifying of data sets
- transforming the coordinates into ETRS-89 UTM32 coordinates as well as
- making and checking of the spatial relations.

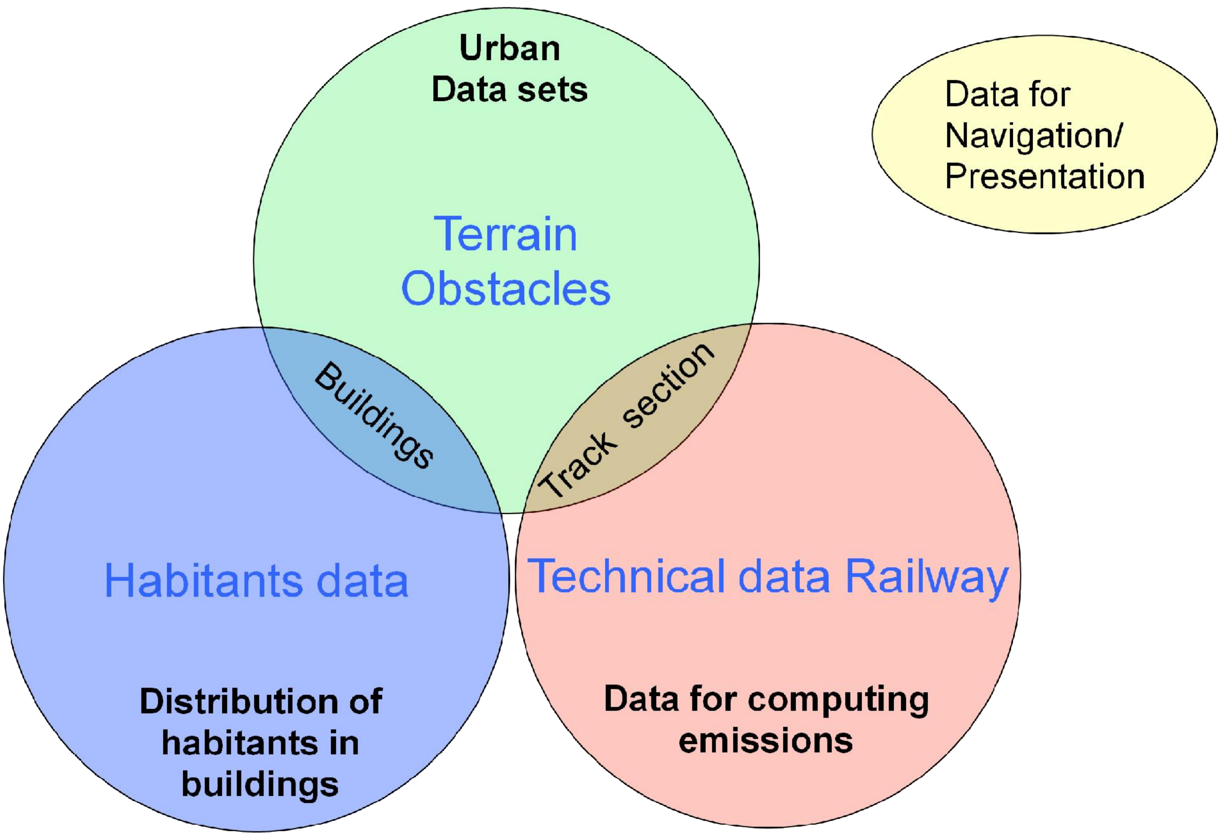

Figure 1: Data integration

B. Source Data

The noise mapping for railway noise in Germany had to be done according to the standard VBUSch which is similar to the German national computation method SCHALL03.

In addition to the number of trains, track related and operational related correction parameters from various data sources need to be combined to determine the emissions of the single railway sections.

$$L_{m,E,RS} = 10\,\lg\left[\sum_i 10^{0,1\,(51+D_{Fz}+D_D+D_l+D_v)}\right] + D_{Fb} + D_{Br} + D_{Bü} + D_{Ra}$$

Operational related correction parameters:

- D_{Fz} = effect of train types
- D_D = effect of brake types
- D_l = effect of train length

Track related correction parameters:

- D_{FB} = effect of track ballast
- D_{Br} = effect of bridges
- $D_{Bü}$ = effect of road crossing
- D_{Ra} = effect of curves

Operational related and track related correction parameter:

- D_v = effect of speed (minimum speed of section speed and max. train type speed)

Figure 2: Formula to calculate the wheel/rail emission level according to VBUSch

The major railways which have to be taken into consideration for this phase of noise mapping have already been specified by the EBA. The geometry for these railways must be derived from DB track network data and segmented into sections of constant emission parameters and i.e. of constant emission levels to build-up the noise relevant railway data set.

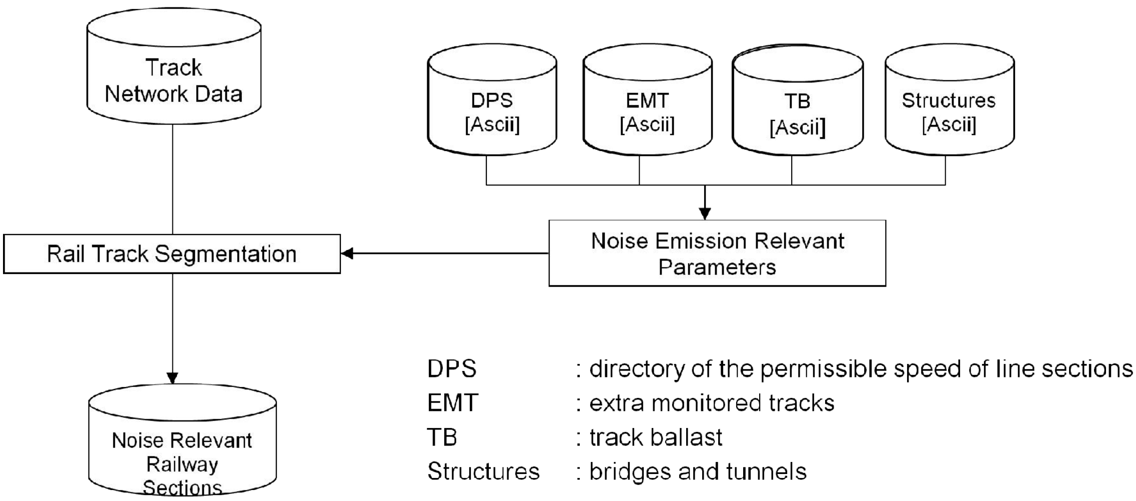

Figure 3: Railway segmentation

C. Terrain Model

In order to do qualified noise calculations, a representative terrain model is needed. Input information in a variety of formats including raster data sets derived from Remotely Sensed information, spot heights, equal heights contour lines or breaklines were available from land surveying offices of every single state.

Data of varying quality was assimilated into a consistent terrain model which covers all the areas relevant for the noise mapping. The assimilation includes:

- using efficient filter algorithms to reduce the amount of data without a corresponding loss of accuracy
- processing of elevation data in the transient areas of state boundaries to get a consistent ground model even there
- an embankment tool to revise and improve the terrain information located near railways by correcting it or creating embankment edges.

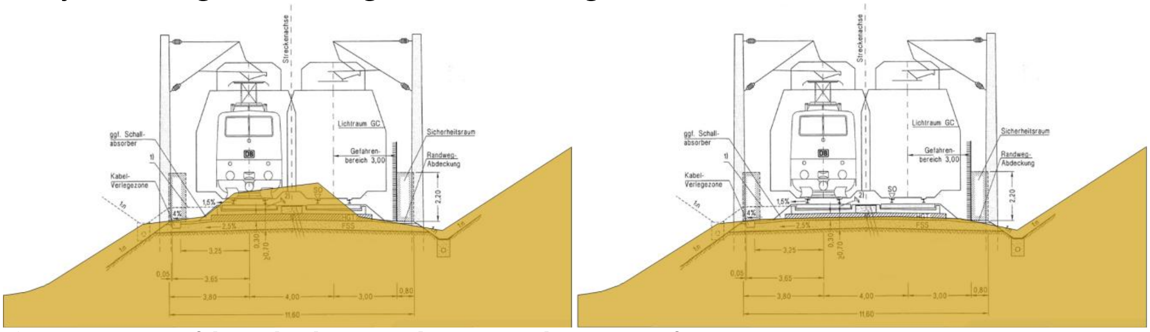

Figure 4: Usage of the embankment tool to correct the terrain information

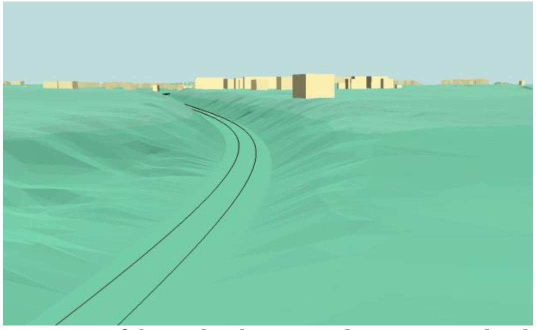

Figure 5: Usage of the embankment tool to create embankment edges

D. Buildings

Building data was available in all kinds of quality, from no more than footprint geometries to complete high-quality building data derived from 3D city models. This data needs to be amalgamated into an adequate data set of buildings for this project.

Here, too, efficient filter algorithms serve to optimize the geometries for the purpose of noise mapping. Initially, we tried to derive missing attributes from other already existing data. An example would be deriving the height of a building from the number of floors and their respective height. In a few cases, unavailable attributes had to be determined by means of generalized or statistic information.

3. NOISE CALCULATION

In order to fulfill the requirements of the noise mapping according to the END the noise indices L_{DEN} and L_{Night} must be calculated for two types of noise calculation using the standards VBUSch and VBEB.

1. A grid noise map where the receivers are determined in a regular grid with a step size of 10 m x 10 m and a point height of 4 m above the ground.
2. A facade noise map where the position of the receivers is determined according to VBEB. That means:
   - Facades longer that 5 meters are divided into smaller segments for which a single receiver is calculated.
   - Facades with a length between 2.5 meters and 5 m are represented by a single receiver
   - Smaller facades are ignored except if multiple subsequent facade segments reach the combined length of more than 5 meters. In this case the combined façade is then treated as a façade longer than 5 meters and if needed subdivided into 5 meter sections.

   This procedure ensures a sensible distribution of inhabitants and dwelling units to the receivers.

Surrounding the railways, buffer areas with a width of approx. 1500m on each side were determined as calculation area. Therefore, the entire calculation area was formed by an aggregation of all the different buffer areas.

However, single calculation areas, which could be processed successively, had to be defined to enable an optimized execution of the noise calculation. For each calculation area an enlarged model area, which covers all model data required for proper noise calculation even in the marginal zones of the calculation areas, had to be defined. To ensure that the results of adjoining calculation areas fit together even in those marginal zones, the model areas need to overlap.

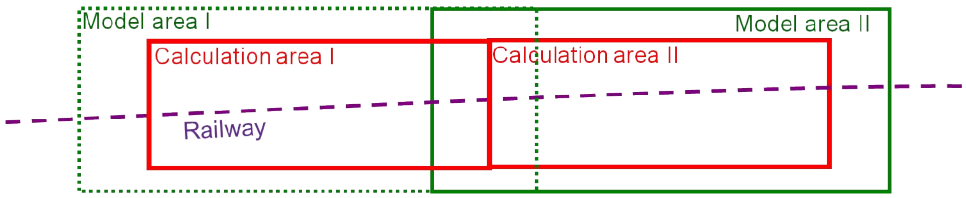

Figure 6: Model area and calculation area

The individual calculation areas were processed as SoundPLAN projects outside the EBA system. The model data and calculation results of these projects were transferred into the Oracle database of the new EBA system after they had been calculated.

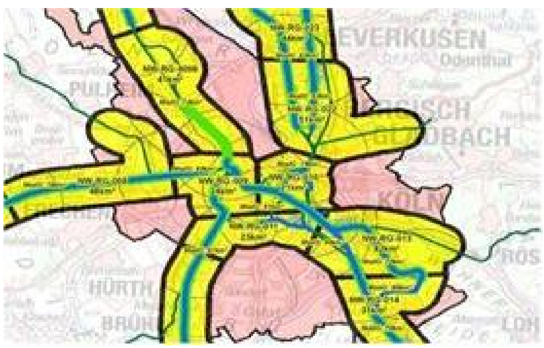

Figure 7: Calculation areas for the agglomeration Cologne

4. SYSTEM OVERIEW

The developed software solution is part of a huge new implemented system. Central parts of this system are a Geoserver, which hosts among others the Oracle database server, file based grid and digital ground model data, as well as the noise calculation server cluster for doing the noise calculations.

EBA GIS, EBA Explorer and EBA Viewer are software applications built on the servers mentioned above. A web server completes the system.

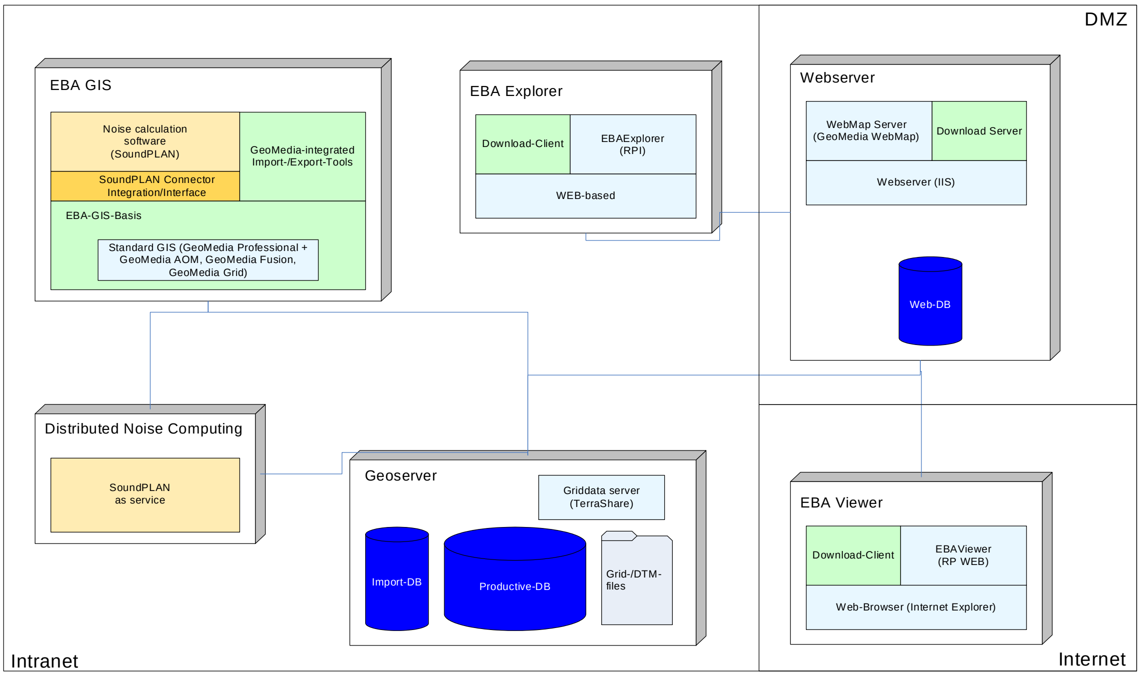

Figure 8: System overview

A. EBA GIS

The EBA GIS is the central application for data integration and quality testing as well as the controlling device for the distributed noise calculation. It is based on the standard GIS application GeoMedia which was adapted for this project. One of its essential tasks is integrating the various data sets into a homogenous data model in order to launch the noise calculations and storing the produced results in the database. All this will be supported by automated workflows.

B. EBA Explorer

Within the project, the EBA Explorer (a thin-client intranet application) serves for a detailed analysis of the data and the results. Basically, the EBA Explorer has access to all the data sets. These possibilities are restricted by an elaborate role based access control which restricts the feasible workflows and associated data.

C. EBA Viewer

The EBA Viewer serves as GIS client for the public and the partners of the EBA. It is an application which is executable in a WEB-Browser to present noise maps and results in a suitable form.

D. SoundPLAN Connector

The SoundPLAN Connector serves as an interface between the GIS GeoMedia and the noise calculation software SoundPLAN. In order to create a data model for the noise calculation and to provide various tools for the data preparation to the GIS, the Connector has direct access to the Oracle database.

E. Distributed noise calculation

Up to 4 calculation servers with multi core CPUs can be addressed for the distributed noise calculation in the EBA system. This provides enough calculation power even for future requirements. This fully automated process is controlled by the SoundPLAN Connector.

5. CONCLUSIONS

The noise mapping project of the EBA is one of the outstanding projects of nationwide noise mapping. Apart from the noise calculation itself, the challenges lie in the data integration and the homogenization of data for the area of Germany. As model data isn't available in a comparable state in the Federal Republic (e.g. via ALKIS), the state specific data had to be used in the project. But even with area-wide available comparable data, these different data still had to be integrated and assimilated. Building up and maintaining a consistent and homogenous data model is one of the accomplishments this multi server solution offers.

The teamwork between all partners of the consortium resulted in a comprehensive pool of know-how which is reflected in the possibilities of the system. GeoMedia and SoundPLAN together build a powerful tool which ensures that the EBA can continue the END noise mapping process for the next phase on their own supported by automated workflows and optimized tools.

REFERENCES

[1] Directive 2002/49/EC of the European Parliament and of the Council) of 25th June 2002, relating to the assessment and management of environmental noise, Official Journal of the European Community L 189/12 of 17th July 2002

[2] VBUSch (preliminary calculation method for environmental noise at railways), published in Federal German Gazette No. 154 of 17th August 2006.

[3] VBEB (preliminary calculation method for determining the exposure figures caused by environmental noise) of 9th February 2007 published in Federal German Gazette of 20th April 2007; p. 4,137).