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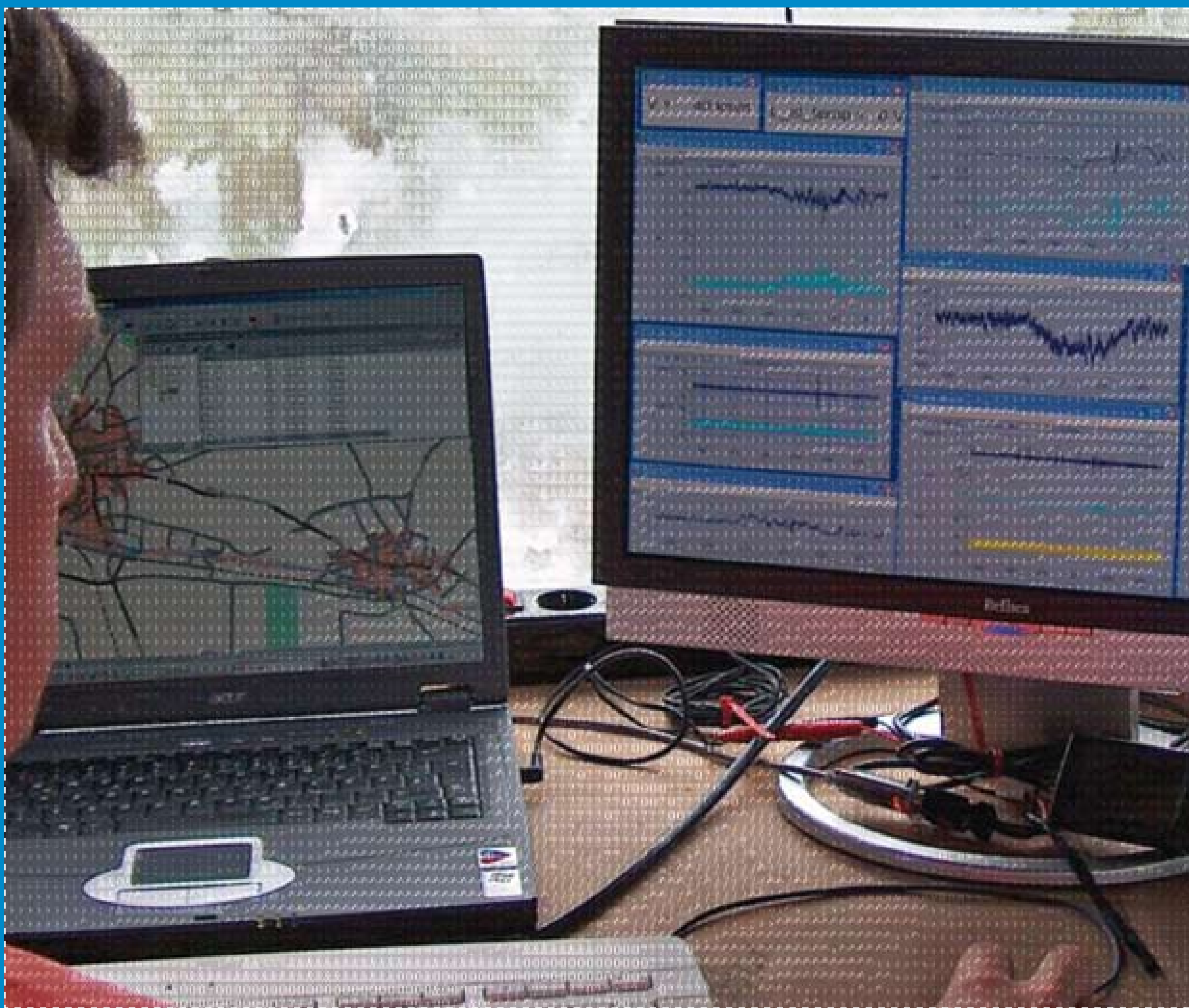
> SonBase – The GIS Noise Database of Switzerland

Technical bases



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sonBASE
Swiss Noise Database

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Published by the Federal Office for the Environment FOEN
Bern, 2009

Impressum

Issued by
Federal Office for the Environment (FOEN)
FOEN is an office of the Federal Department of Environment, Transport, Energy and Communications (DETEC).

Authors
Reto Höin, PLANTEAM GHS AG, Sempach Station
Kirk Ingold, Noise Abatement Division, FOEN
Micha Köpfli, LCC Consulting, Zurich
Thomas Minder, PLANTEAM GHS AG, Sempach Station

FOEN consultant
Fredy Fischer, Noise Abatement Division, FOEN
Urs Walker, Noise Abatement Division, FOEN

Suggested form of citation
FOEN (Pub.) 2009: SonBase – The GIS Noise Database of Switzerland. Technical bases. Environmental studies no. 0908. Federal Office for the Environment, Bern: 61 pp.

Design
Ursula Nöthiger-Koch, Uerkheim

Translation
James Morris, Blackawton (UK)

Cover picture
Federal Office for the Environment (FOEN)

Downloadable PDF file
www.environment-switzerland.ch/uw-0908-e
(no printed version available)
Code: UW-0908-E
This publication is also available in (UW-0908-D).

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> Abstracts

With SonBase, the Swiss Federal Office for the Environment (FOEN) has a technical instrument at its disposal that enables it to obtain scientifically based and comprehensive findings concerning the current extent of noise pollution from the main sources in Switzerland. This report describes the structure and methodological criteria of SonBase. A variety of geographical data are integrated into a homogeneous geographical information system. SonBase forms the basis for comprehensively monitoring the noise situation and its chronological and spatial development, as well as for providing the general public with detailed information about the ongoing status of noise pollution. Noise situations can be modelled and analysed with the aid of scenarios.

Keywords:
SonBase
noise pollution
geographical information system
noise pollution maps
methodology

Mit SonBase steht dem Bundesamt für Umwelt BAFU ein technisches Instrument zur Verfügung, welches wissenschaftlich fundierte und flächendeckende Aussagen zum Ausmass der aktuellen Lärmbelastung aus den wichtigsten Lärmquellen in der Schweiz ermöglicht. Der vorliegende Bericht beschreibt den Aufbau und die methodischen Hintergründe von SonBase. Verschiedene Geoinformationsdaten werden mit berechneten Lärmdaten in ein homogenes Geographisches Informationssystem integriert. Mit SonBase wurde die Grundlage geschaffen, um die Lärmsituation und deren zeitliche sowie räumliche Entwicklung flächendeckend zu verfolgen und um die Öffentlichkeit sachgerecht über den Stand der Lärmbelastung zu informieren. Anhand von Szenarien können Lärmsituationen modelliert und analysiert werden.

Stichwörter:
SonBase
Lärmbelastung
GIS
Lärmkarten
Methode

SonBase sert à l'Office fédéral de l'environnement (OFEV) d'instrument technique pour décrire l'ampleur de la pollution sonore due aux sources majeures de bruit en Suisse. Le présent rapport explique la mise en place et le contexte méthodologique de SonBase. Plusieurs données géoinformatives sont intégrées avec des données de bruit calculées dans un système d'information géographique homogène. SonBase constitue la base qui permet de suivre la situation de bruit et son évolution, aussi bien spatiale que temporelle, à grande échelle et d'informer le public de la pollution sonore en Suisse. Différents outils d'analyses et de calculs de scénarios permettent de modéliser et d'interpréter la situation.

Mots-clés:
SonBase
pollution sonore
SIG
cartes du bruit
méthodologie

Con SonBase, l'Ufficio federale dell'ambiente (UFAM) si è dotato di uno strumento tecnico che permette di valutare in modo scientificamente attendibile ed esaustivo l'entità dell'inquinamento fonico provocato in Svizzera dalle maggiori fonti di rumore. Il presente rapporto illustra la struttura e i principi metodologici di SonBase. Vari dati geoinformatici e dati relativi al rumore elaborati vengono inseriti in un sistema di informazione geografico omogeneo. SonBase costituisce il presupposto sia per un monitoraggio su larga scala della situazione fonica e della relativa evoluzione spaziale e temporale, sia per un'informazione appropriata dell'opinione pubblica sullo stato dell'inquinamento fonico in Svizzera. Attraverso degli scenari è infatti possibile elaborare dei modelli di situazioni foniche e analizzarle.

Parole chiave:
SonBase
inquinamento fonico
GIS
mappa del rumore
metodo

> Foreword

From a health and economic standpoint, excessive and chronic noise is currently one of the most important environmental problems in Switzerland. Noise is practically ever present in our daily life.

Systematic inventorying and monitoring of noise is one of the functions of the Federal Office for the Environment (FOEN). Until now our knowledge of the extent of noise pollution has been very fragmentary and based on selective estimates and projections. This was why the FOEN initiated the “Swiss Noise Database” pilot project at the end of 2004. The objective was to create a powerful tool to carry out nationwide evaluations and analyses of the noise situation. Strategic questions also had to be answered: for example, how does the application of a low-noise road pavement affect noise exposure of the population? And what are the costs to the national economy of property depreciation due to noise?

Within three years the FOEN has developed a modern monitoring system called SonBase which uses a Geographical Information System to make flexible noise pollution calculations possible. Geographical data, e.g. on population and spatial planning, can be captured and visualised on an extensive scale.

The results of the first noise calculation are presented in the FOEN report “Noise Pollution in Switzerland”. This report is published in parallel with it and describes the structure and methodological context of SonBase and indicates how the tool will be further developed in the future.

Gérard Poffet
Vice Director
Federal Office for the Environment (FOEN)

> Summary

SonBase provides scientifically based, nationwide conclusions on the extent of current noise pollution from the main noise sources – road, rail and air traffic – in Switzerland. Various geographical data is integrated with computed noise data in a homogeneous Geographical Information System (GIS).

The core of SonBase is a GIS application based on the ESRI ArcGIS components with Oracle as the database. Among other things it supports preparation, editing and central management of the data and a variety of statistical analyses, spatial queries and generation of reports.

The first nationwide noise calculation in Switzerland used homogeneous basic data based on the vectorised 1 : 25 000 national map issued by the Federal Office of Topography swisstopo (vector 25), and additional Switzerland-wide data on population and spatial planning was input (section 2). Many factors, such as the terrain model and the positional accuracy of noise sources and buildings, can affect the accuracy of the noise calculation and the computing time. One of the crucial factors is to determine the desired basic accuracy. The aim is to achieve results which are as statistically accurate as possible over a large calculation area while keeping the computing time low. The assumptions made and the calculation settings selected are described in section 3. Following the noise calculation, the results were validated analytically by means of a practical example and historic data (section 4).

It is planned to continue to develop SonBase in future by incorporating other types of noise (e.g. firing range noise, military noise), by technical optimisation and by improving and updating the fundamental data (e.g. traffic data) (section 5).

SonBase has created the basis for providing appropriate information to the public regarding the status of noise pollution. SonBase represents an important tool by which noise pollution can be monitored both in Switzerland as a whole and in freely selectable regions and strategic decisions can be made. Noise can be evaluated under Swiss legislation (Environmental Protection Act, Noise Abatement Ordinance) or under the EU Environmental Noise Directive 2002/49/EC.

1 > Objectives and Structure of SonBase

The SonBase GIS application enables the Federal Office for the Environment (FOEN) to supply nationwide, scientifically based evidence on the extent of noise pollution from the three main noise sources – road, rail and air traffic – in Switzerland. The basic structure of SonBase consists of a relational database, a noise calculation module and a GIS user interface. Geobasic data is integrated in a database scheme and optimised by additions and adaptations. This monitoring of current noise pollution and calculation of future noise pollution will provide the Confederation with important information on which to base its strategies to reduce noise pollution.

1.1 Starting point

Geographical information on noise is held by various agencies in the Confederation, cantons and municipalities and by the owners of noise-emitting installations. How current the data is, its quality, format and legal obligations all vary.

Nationwide data on noise pollution was not previously available

The implementing authorities are required to keep Noise Pollution Registers for roads, railways and airfields/airports. They have to record the noise pollution permitted from each individual installation. The Noise Pollution Registers give a snapshot of the actual situation and are used primarily as the basis for planning and implementation of noise abatement measures. The information they contain is generally limited to selective information on where the critical exposure limits in the Noise Abatement Ordinance are exceeded. They are not nationwide and in some cases are not updated or stored in digital form. This means that standardised geographical data for determination of noise pollution in Switzerland is not available nationwide.

1.2 Objectives of the SonBase project

GIS-based noise monitoring

The objective of the FOEN project was to develop a nationwide, GIS-based monitoring system offering various options for extensive analysis and visualisation of the noise pollution from the main traffic sources using geographical data from other areas (e.g. population, number of employees, spatial planning, properties). It was also important to be able to answer strategic questions such as the effectiveness of low-noise pavements and the costs to the national economy of property depreciation due to noise. Another important goal was to promote and standardise data exchange between the Confederation and the cantons.

Informing the population

The completion of a pilot project after a three-year development period and its transfer to the SonBase system created the basis for nationwide monitoring of noise pollution and its temporal and spatial development and giving the public appropriate information on the status of noise pollution.

1.3 SonBase – a challenge

Technical and organisational challenges during the implementation process

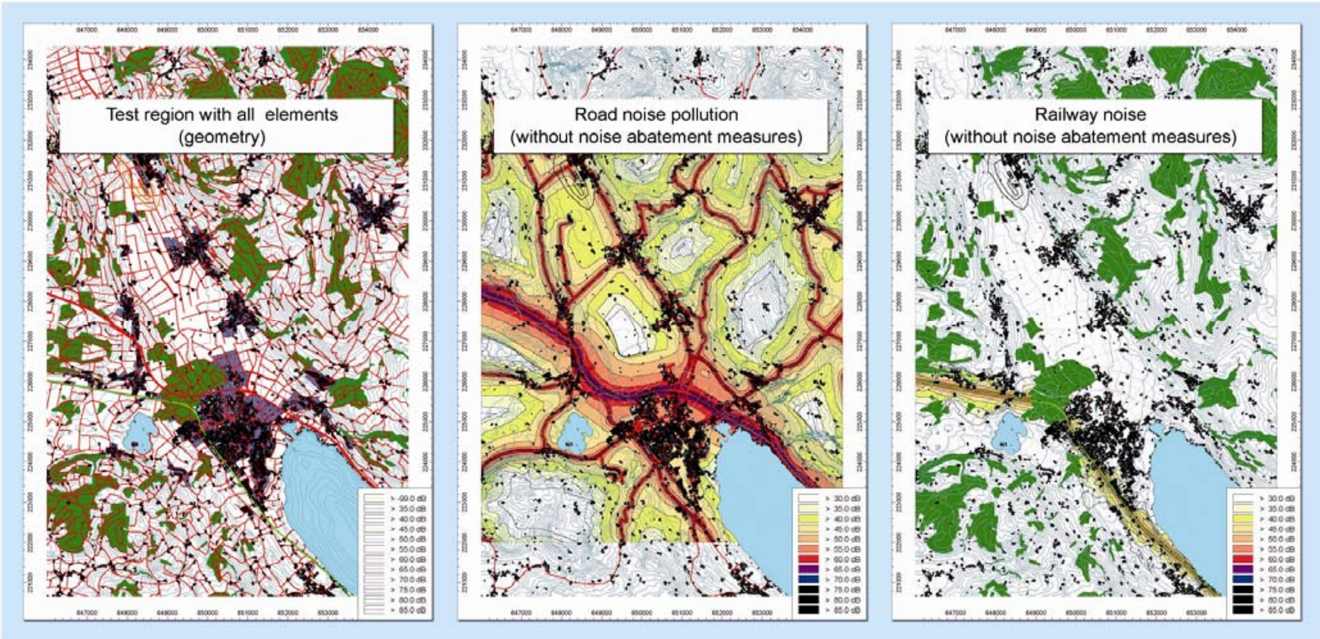
The development of SonBase was a new and demanding task from a technical and organisational point of view. Uncertainties existed, particularly in relation to technical and functional implementation, the technical system requirements and the financial expenditure. The following hurdles had to be overcome:

> Collection of nationwide geographical data and its transfer to a standard digital format.
> Technical implementation: Particularly programming and installation of the GIS platform at the Federal Office of Information Technology, Systems and Telecommunication FOITT, the interaction of different system components (GIS database and noise calculation module), the structure of the relational database (Oracle) and the handling of huge volumes of data.
> Minimising computing time: For noise calculations over the whole of Switzerland, the computing time alone, with 15 commercially available computers operating simultaneously, is about 24 days.

The GIS application was developed in stages on a selected test region with ten municipalities (99 km²) and a suitable prototype (Fig. 1). All the necessary fundamental data and emissions and immissions data from railways and airfields in the test region was input. The missing noise emissions from the roads were obtained from a specific noise calculation module. So-called rating points were generated on the individual buildings and the noise pollution at those points was calculated. Grid data with a resolution of 10 x 10 metres was also calculated across the whole of Switzerland.

Fig. 1 > The test region

Raw data (left) and the result of the first extensive noise calculations – road noise grid maps (centre), railway noise (right)



1.4 Two accuracy levels

The basis for the data has a critical influence on the result of the calculation. Therefore two different accuracy levels (AL) are defined in SonBase:

> **Whole of Switzerland overview variants:** In accuracy level 1 (AL 1) the geographical data available at national level (e.g. Vector25) is used to calculate the traffic noise pollution for Switzerland as a whole. This first calculation was processed in winter 2007/08 with minimum data additions (input of defaults for missing fundamental data).
> **Medium-term detail variants:** In accuracy level 2 (AL 2) the latest data bases on road noise held by the cantonal authorities are used for the calculation – where available. In a pilot phase the relevant data was provided by the pilot cantons of Lucerne, Neuchâtel and Zurich. The data for selected municipalities was imported into SonBase, the noise pollution was calculated and the results were analysed as for AL 1. The GS2 results were also used to validate the results from AL 1. The aim is to input more accurate data into SonBase in stages and consequently improve the accuracy of noise pollution predictions in Switzerland. (see section 4.3).

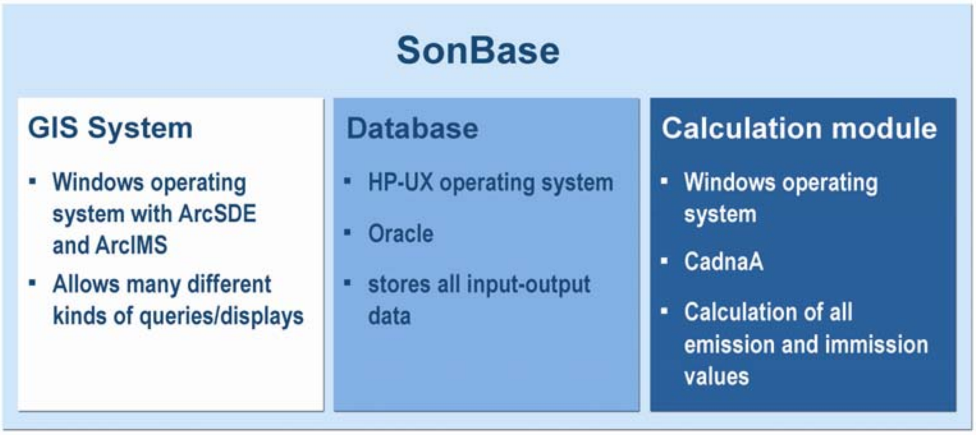
1.5 Technical principles of SonBase

1.5.1 System structure

The basis of the SonBase system is formed by the GIS components ESRI ArcGIS Desktop and ESRI ArcSDE with Oracle as the database. The CadnaA (Computer Aided Noise Abatement) software from DataKustik GmbH, Greifenberg, is used for the noise calculation (Fig. 2).

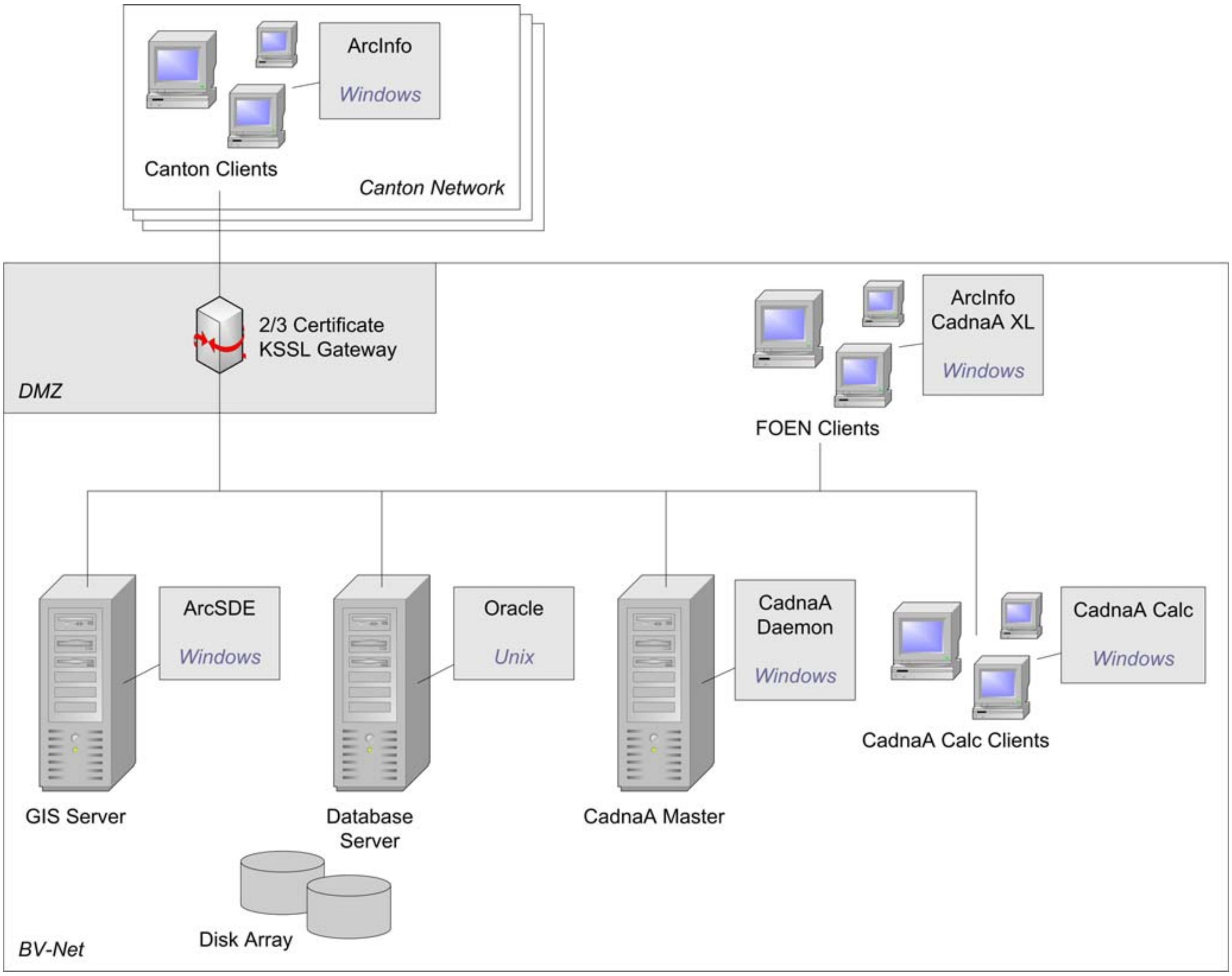
Access is available to both internal and external offices via the ArcGIS desktop client. The SonBase client is an ESRI ArcGIS desktop enhancement which was developed in.NET Framework 2.0. The system architecture is shown in (Fig. 2).

Fig. 2 > The SonBase concept



The specific SonBase enhancements of ArcGIS Desktop support the user in all the process steps – from data import through data validation and completion to analysis and export of the results. An integrated user administration system also allows the flexible issuing of rights to the geographical and technical data. A tool called “Daemon” which communicates with the GIS system via the database is used to control and monitor the noise calculations. Daemon controls the individual steps from data import to reimport of the results of the calculations into the database.

Fig. 3 > Structure of SonBase



When calculating the noise for large regions, it is necessary to divide the area into sections called "tiles" which can easily be held in the RAM of a single computer. This improves the processing speed because outputting of data to the hard disk can be avoided. The tiles are generated and managed automatically by the calculation software on the basis of defined defaults (tile dimensions e.g. 500 x 500 m).

The user administration system allows the flexible issuing of reading and writing rights to the Oracle tables. Rights can also be issued for the individual versions and version types according to the varying needs of users. This guarantees secure working with the database stocks.

Tab. 1 > Technical data for SonBase

DB characteristics of SonBase

DB operating system:	HP Unix
DB technology:	ORACLE 10g
Size:	391 (tables), 3572 (attributes)
Number of data sets:	Per annum: ca. 500 000 000
Memory required:	45 GB
RAM	2 GB reserved for database
Interfaces:	ODBC/SQL
Development language:	VB.Net
Number of users:	Currently about 10

Noise calculations for different types of noise for the whole of Switzerland, which are very demanding on computing power, were carried out on a separate computer cluster with 15 to 30 CadnaA-Calc Clients which is linked to the database (Fig. 4). They are started and monitored via an interface implemented in ArcMap. Computer orders are controlled centrally via the SonBase application interface.

The Federal Office of Information Technology, Systems and Telecommunication FOITT is in charge of the operation, maintenance and performance monitoring of the database and monitors operation of the server infrastructure and associated operating systems. It also provides the agreed memory and guarantees data backup and restoration and operation of the computer centre.

Fig. 4 > Cadna cluster for the noise calculations

The SonBase system architecture selected offers a multiuser capability and guarantees the integrity of the data sets available by role-based user administration and the underlying version control concept.

Dedicated SonBase menu for automatic noise calculations

The specific SonBase enhancement of ArcGIS Desktop offers among other things efficient functionalities for importing, editing and revision of data and an interface for a range of noise calculations (actual status, scenarios and forecasts). These processing tasks are defined via the SonBase enhancement interface. This means that the data relevant to noise is exported in a fully automatic manner and is determined and monitored in the noise calculation software (CadnaA). The results are then reimported to the GIS and are available for analysis. SonBase supports the requirements of the Swiss Noise Abatement Ordinance (NAO) and the creation of strategic noise maps under the EU Environmental Noise Directive 2002/49/EC.

Flexible ArcGIS standard desktop tools in are used for statistical analyses and visualisation of the noise data in the form of maps or statistics. Standard analyses can also be generated fully automatically and efficiently (e.g. number of people, buildings, dwellings, surface area affected by noise) and it is possible to freely select the regions.

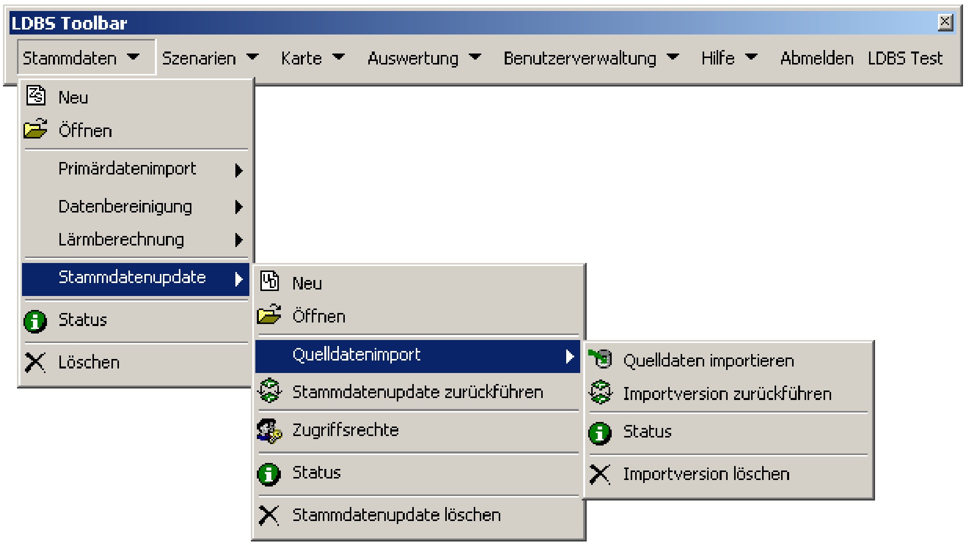
1.5.2 Menu navigation

All the additional GIS functions are accessed via the dedicated “SonBase toolbar”. Administration of user rights to the database is also managed on this toolbar under the menu item “User administration”.

Easy user navigation and administration of data

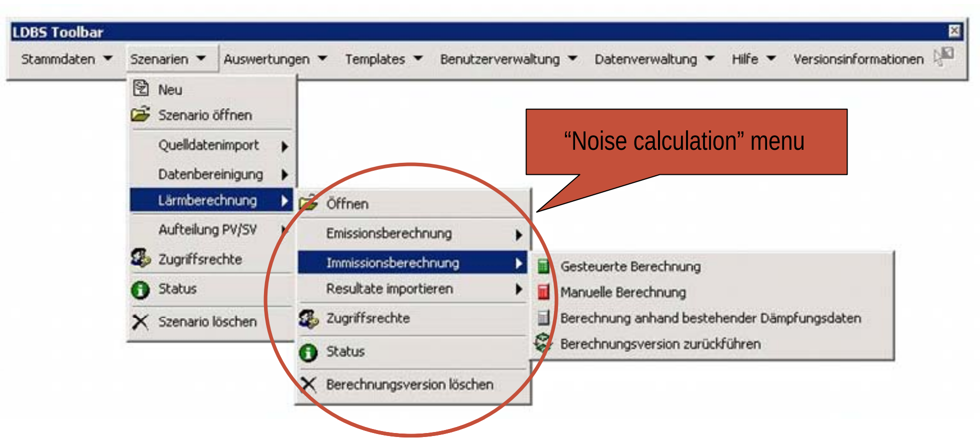
When the application is launched, a dialogue box opens and users are asked to log on. Depending on the user rights, existing time slices, master data updates or scenarios can be accessed. For each separate data type (master data/scenarios), specific menu points cover creation, revision and deletion of geodata and noise data. For example, importing new source data is performed in clearly defined steps by selecting “Versions” (Import, Revision) (Fig. 5).

Fig. 5 > SonBase- toolbar – master data



A particular strength of SonBase is the controlled or manual noise calculations under various standards and across freely selectable geographical regions (whole of Switzerland, canton, municipality, other regions) which are accomplished via the "Scenarios" menu (Fig. 6).

Fig. 6 > SonBase-Toolbar – Scenarios

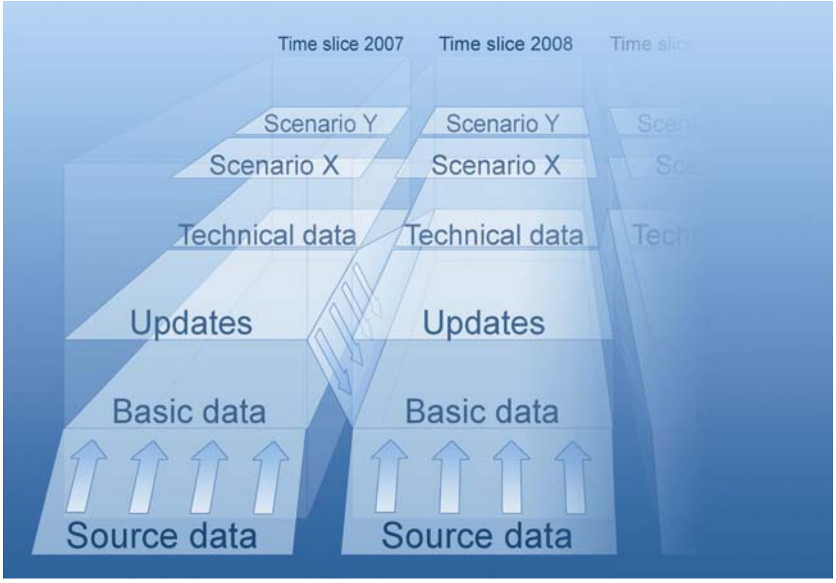


1.5.3 Time slice and version control concept

ArcGIS (via ArcSDE) offers the option of holding geodata sets in various statuses. SonBase extends this functionality to include version types, version administration and setting of role-based access rights and a workflow (Fig. 7). This concept provides the solution for:

> Holding data sets from different data collection dates
> Controlled updating of existing basic data with new source data
> Creating noise reduction plans
> Generating scenarios of any kind
> Ensuring consistency between basic and technical data

Fig. 7 > Time slice and version control concept



Source: e-geo.ch No. 18, Newsletter October 2007

Time slice system

In order to be able to compare different noise situations, it must be possible to store the noise results (emissions, immissions) in a time independent manner in SonBase. A system of so-called "Time Slices" was developed for this. Time slices are recalculated fully and comprehensively (several weeks' computing time). They are then used as the reference until the next time slice calculation (e.g. at 2-year intervals) and as the basis for the noise pollution analyses.

Within this time horizon, any scenarios or forecasts for freely selectable areas of Switzerland can be calculated. The updated data is also continuously stored and processed for the next time slice calculation. As the noise pollution within a time slice is heavily dependent on the emissions forming the basis, the term "Emissions Horizon" can also be used in this context.

By encapsulating the data in "time slices" (individual database schemes), fully independent data sets can be input at intervals of one or more years. This guarantees both archiving and consistent performance.

The strict separation of data according to time makes archiving simpler. Existing basic data (fundamental data including manual updates) can also be combined with new source data (from external data sources). Importing the data via a dedicated container gives a high degree of independence from the data sources, even if data formats or the data structure change.

Calculation of scenarios

The SonBase version control concept offers the option of creating scenarios according to any version. All the functions of SonBase are available within a scenario – from processing of geodata to performing a technical calculation. For example, forecasts can be calculated or additional noise abatement measures planned through scenarios.

The master data can be updated at any time by using the data from the last "time slice" or newly imported source data. However, a new calculation of all the noise data is required to start a new time slice for the whole of Switzerland.

1.5.4 Internet and Intranet

SonBase is not yet fully web enabled. At present data changes and complex analyses can only be carried out through the Client Server environment (external access currently via VPN). Some data is already accessible to the public as noise grids in ecoGIS *(www.ecogis.admin.ch)* and on the FOEN website *(www.bafu.admin.ch/umwelt).*

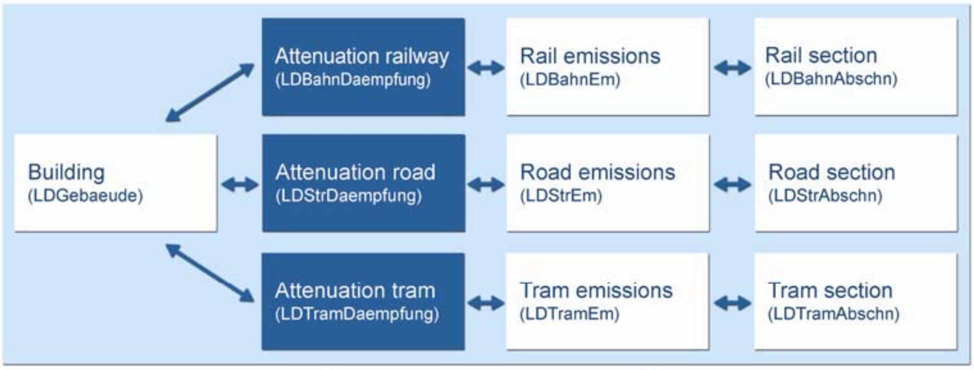
1.5.5 Attenuation table

With SonBase the results of noise calculations are available quickly. Because a single calculation operation for a large area can take several weeks, even with a pool of 15 PCs, it was important to find a way to reduce this computing time considerably. The "Abatement table" tool was integrated in SonBase version 1.0. The emissions from the various source sections (road or rail) and the associated partial immission levels for each reception point are used to determine the attenuation levels between the individual spatial sections and the reception points (e.g. loudest point of each building), which are then stored in SonBase (Fig. 8). The attenuation includes all the relevant propagation losses (e.g. the effects of obstacles, air absorption, attenuation with distance, reflections).

Massive reduction in computing time gives efficient noise calculations

When there are modifications or additions to traffic data, new emissions and the resultant immissions can then be determined directly in the GIS without a complex new propagation calculation, which considerably reduces the computing time.

Fig. 8 > Schematic representation of the attenuation table



LDBahnDaempfung	
ID_Immissionspunkt	Integer
ID_Gebaeude	Integer
ID_BahnEm	Integer
Daempfung	Double

LDStrDaempfung	
ID_Immissionspunkt	Integer
ID_Gebaeude	Integer
ID_StrEm	Integer
Daempfung	Double

LDTramDaempfung	
ID_Immissionspunkt	Integer
ID_Gebaeude	Integer
ID_TramEm	Integer
Daempfung	Double

Source: e-geo.ch No. 18, Newsletter October 2007

2 > Fundamental data and adaptations

A large volume of digital data is combined in SonBase, making nationwide noise calculations possible for the whole of Switzerland. Due to the non-homogeneity of the different data sources, considerable effort had to be invested in supplementing, harmonising and integrating the data.

2.1 Data used

Geodata from different sources is integrated

The geographical basis used for SonBase is the data set for the vectorised 1 : 25 000 map of Switzerland (Vector 25) and the digital elevation model DHM25 issued by the Federal Office of Topography swisstopo. The comprehensive noise calculations also incorporated fundamental data from the Federal Offices for Spatial Development (ARE), Roads (FEDRO), Transport (FOT), Civil Aviation (FOCA), Statistics (FSO) and Civil Protection and Sport (DDPS) (Tab. 2). Thus for example for road traffic noise the 2004 Traffic Model from the Federal Office for Spatial Development ARE (with additions) was included and for rail the Emissions Plan 2015 was incorporated. The 2000 National Census (FSO) was accessed for statistics on people and dwellings. Tab. 2 gives a list of the sources used.

Tab. 2 > Databases used for the first calculation AL1

Data name	Data origin	Accuracy/Remarks
Digital terrain model (DTM)		
Buildings (xy)	Vector25	± 8 m
Roads (xy)	Vector25	± 8 m
Contour lines 10 m; some 5 m (xyz)	Vector25/DHM25	± 8 m
Geodetic points (xyz)	Vector25/DHM25	± 8 m
Road traffic		
Average daily traffic (ADT)	DETEC TM (2004)	Network incomplete
Speeds (v) and gradients (%)	DETEC TM (2004)	Network incomplete
Location of noise barriers/embankments (xy) on national highways	UH-Peri ASTRA	No height data
Rail traffic		
Track location (xy) and emissions (dB)	SBB (EPlan2015)	SBB network only
Noise barriers/embankments (xy, height above SOK)	SBB DfA	
Air traffic		
Aircraft noise isophones, civil airdromes (xy, dB)	FOCA	
Aircraft noise isophones, military airfields (xy, dB)	DDPS	
Spatial planning		
Development zones generalised (xy)	ARE	Incomplete
Sensitivity levels (xy)	ARE	Incomplete
Statistics		
Number of people/dwellings per building	FSO BZ2001	ID: via building coordinates
Number of work spaces per building	FSO BZ2001	ID: via building coordinates

Fig. 9 and Fig. 10 show the roads and railway lines used in SonBase. Various types of roads are differentiated. For aircraft noise, the aircraft isophones available for the civil airports and airfields issued by the Federal Office of Civil Aviation (FOCA) and UNIQUE and those of the DDPS for military aircraft noise are used.

Fig. 9 > Roads used, with traffic volumes by type (DETEC TM, ARE)

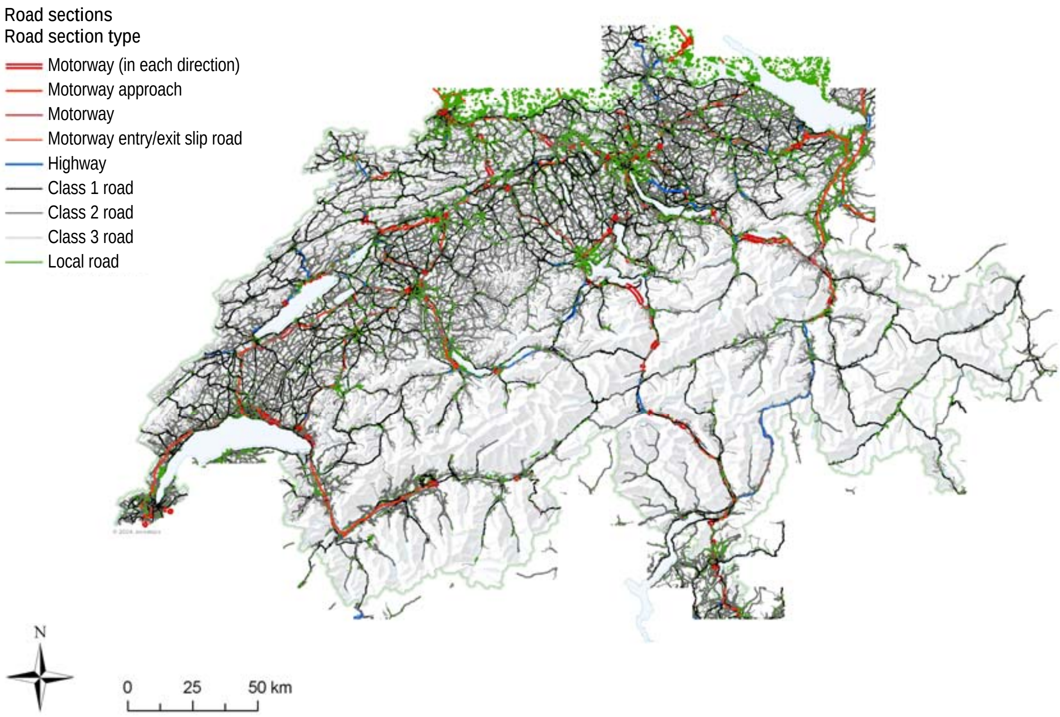


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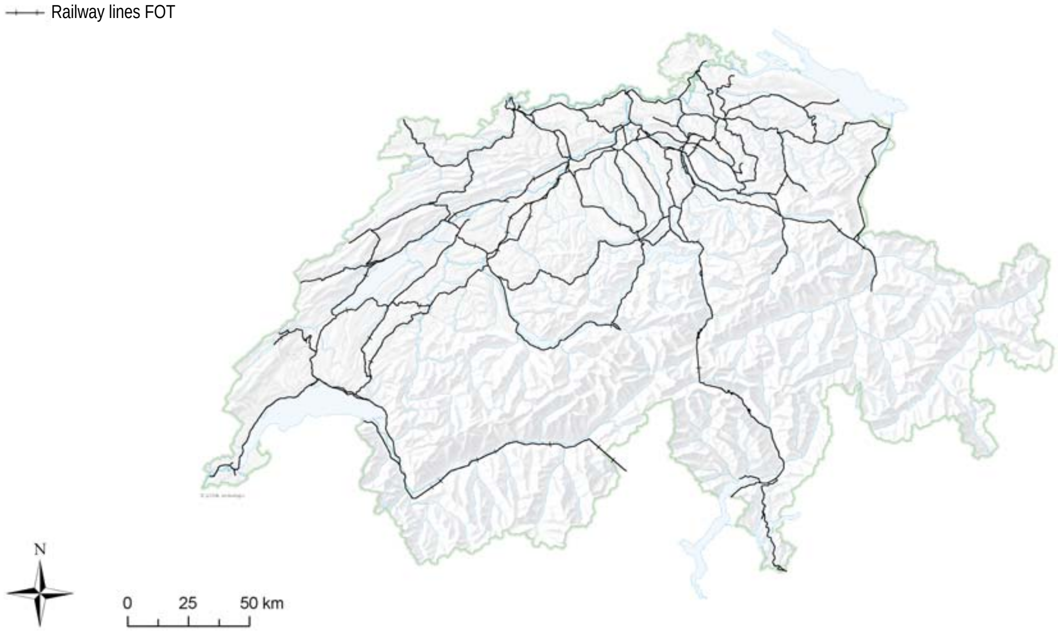
Fig. 10 > Railway lines used (Eplan2015)



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2.2 Harmonisation and integration of data

Because the geographical data available was not homogeneous, considerable effort was expended on additional work to harmonise and integrate the data. Although the road, rail and tram line networks could be imported from the Vector25 data set, links had to be made between the Swiss traffic models. If data was missing, standard values were assumed and used for further processing. Population numbers, number of dwellings, number of rooms and details of the number of storeys were allocated to the individual residential buildings from the statistical data from the 2000 National Census. Additional data on spatial planning (e.g. development zones, administrative boundaries) and on noise abatement measures (e.g. type, location and dimensions, status of abatement work, year of construction, costs) was also included – where available.

Various problems and inaccuracies were found in the fundamental data. The main ones are discussed briefly below:

No building heights

The Vector25 data set does not have concrete information on the individual building heights for all buildings in Switzerland. However, these represent an important factor in noise propagation due to their obstacle effect. Description

As an interim solution, a standard height of 9 m was assumed for all buildings. Actual building heights will be used for the next recalculation of the noise types. Solution

Absorption due to the building envelope

The external envelopes of buildings reflect sound to a certain degree. These reflections were not included in the first calculation in order to reduce computing time. In future calculations the buildings will be allocated a standard absorption. Description

To input a standard absorption of $\alpha = 0.21$ or a reflection loss of 1 dB. Solution

Composite buildings

Composite buildings (e.g. back-to-back and terraced housing) are not modelled separately in the Vector25 data set but are often combined into one building. Although a breakdown of the Vector25 buildings into the buildings in the FSO data set is technically possible, it will be deferred to a future SonBase upgrade. Description

All data (people, dwellings, work spaces) for the FSO buildings located within a combined Vector25 building is combined. Solution

No traffic data

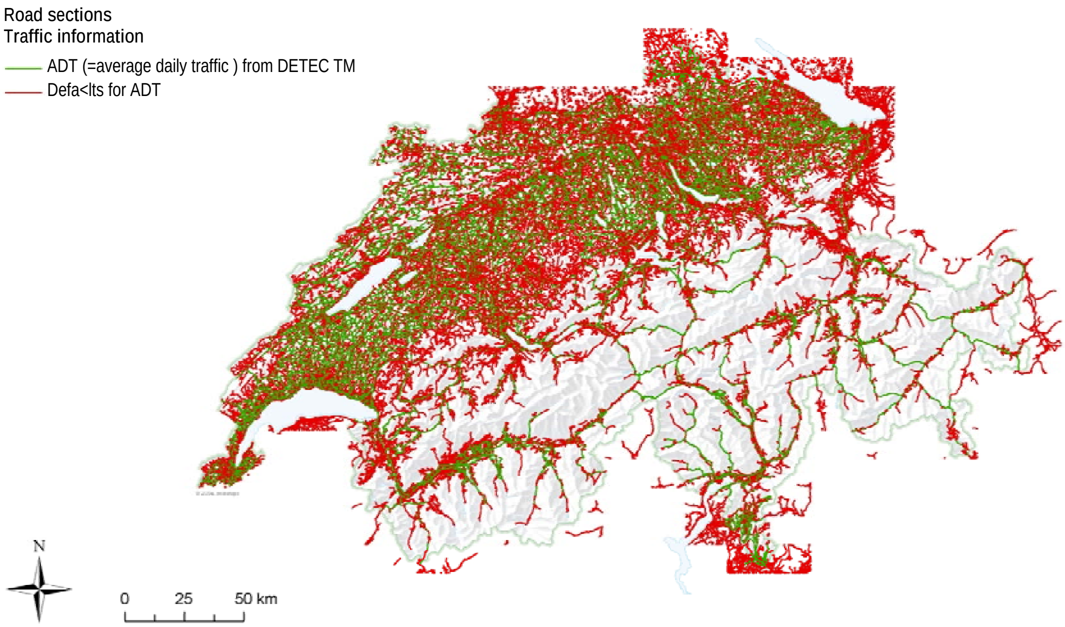
Description

The Whole of Switzerland Traffic Model (DETEC TM) omits some road sections and therefore also the relevant traffic information (Fig. 11).

Solution

Default values were set for the missing road sections (Tab. 3).

Fig. 11 > Roads used by data origin (DETEC TM or defaults)



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Tab. 3 > Default values for average daily traffic for missing road sections

Road type	Default ADT (veh./24h)	Road length with default (Km)		Total road length (Km)
Motorway	21 000	467	17.1 %	2 724
Motorway in each direction	20 000	164	38.2 %	429
Motorway approach	5 500	41	82.0 %	50
Highway	6 500	79	19.2 %	412
Motorway entry/exit slip road	5 900	513	86.1 %	596
Class 1 road	3 400	1 300	14.3 %	9 081
Class 2 road	1 200	8 437	46.5 %	18 127
Class 3 road	450	27 191	97.0 %	28 025
Local class road, core cities (Type 1)	1 300	2 975	93.8 %	3 170
Local class road, regions Types 2, 3, 4	600	13 890	100.0 %	13 890
Total		55 057	72.0 %	76 504

No breakdown of traffic data according to time

Description

None of the traffic data used (from DETEC TM or default values) has details of the breakdown according to day and night periods or the proportion of high-noise vehicles.

Solution

Here standard values also had to be assumed. They are based on the principles in the Noise Abatement Ordinance (Appendix 3, section 33). The following breakdowns and proportions are applied:

> Nd = 0.058*ADT Nn = 0.009*ADT
> Nd1 = 0.9*Nd Nn1 = 0.95*Nn
> Nd2 = 0.1*Nd Nn2 = 0.05*Nn

Where: Nd, Nn Hourly traffic day and night.

> Nt1, Nn1 Partial traffic volume 1:
Cars, delivery vans, minibuses, motor assisted bicycles and trolley buses
> Nt2, Nn2 Partial traffic volume 2:
Lorries, articulated lorries, company cars, motor cycles, tractors

No data on speed

Description

Many relevant speed details are missing from the Whole of Switzerland Traffic Model (DETEC TM).

Solution

The following default values were set for the missing road sections:

> 120 km/h: Motorway, motorway in each direction
> 100 km/h: Highway
> 80 km/h: Motorway approach, class 1 road out of town, class 2 road out of town
> 60 km/h: Class 3 road out of town
> 50 km/h: Class 1 road in town, Class 2 road in town, Class 3 road in town, local class road

Height of noise barriers

Description

The location of noise barriers and embankments along the national highways is known but not their height. Noise protection measures on main roads and other roads are not yet available in digital form for the whole country and could not be included.

Noise embankments are mainly located in rural areas. Their height was generally assumed to be 2.5 m. Solution

Noise barriers are mainly located in urban areas. Their height was generally assumed to be 6.0 m.

Absorption by noise barriers (road and rail)

Noise barriers reflect sound to a certain degree. This reflection was not included in the first calculation (to reduce computing time). In future calculations noise barriers will be assigned a standard absorption on both sides. Description

To input a standard absorption of $\alpha = 0.84$ or a reflection loss of 8 dB. Solution

Modelling of bridges

Modelling is performed for roads and railways located on the ground, with the noise source therefore a standard 0.80 m above the road terrain and 0.50 m above the rail terrain. The situation is analogous for bridges. Although the locations of bridges are known, locating the noise source on the bridge structure requires additional work. Description

This problem has not yet been resolved. The noise sources around bridges are at the level of the terrain model. It is planned to upgrade SonBase to cover this aspect in the future. Solution

Development zones and their sensitivity levels

The generalised development zones supplied by the Federal Office for Spatial Development (ARE) represent usage areas. They also contain various zone types which are explicitly not development zones (e.g. green and nature conservation zones, quarrying and landfill zones, protected reserve zones). Agricultural zones are explicitly not included. Description

What is missing from the (generalised) development zones is the classification of the sensitivity levels (SL), particularly the step-up range from SL II to SL III. These step-ups generally occur along the main traffic arteries (road and rail). Because these step-ups are omitted, the limit considerations and figures generally tend to be overestimated for SL II and underestimated for SL III. If the step-ups are still not available in future, it is necessary to examine whether an area along the main traffic arteries must always be stepped up. The ARE data set also excludes industrial zones (the majority are included under working areas), which makes classification to SL IV practically impossible. Also, an SL cannot be allocated to the missing agricultural and other omitted zones. This makes it impossible to provide evidence of limits being exceeded for a number of people, buildings, dwellings, work spaces and surface area.

The problem of missing step-ups has not yet been resolved.

Solution

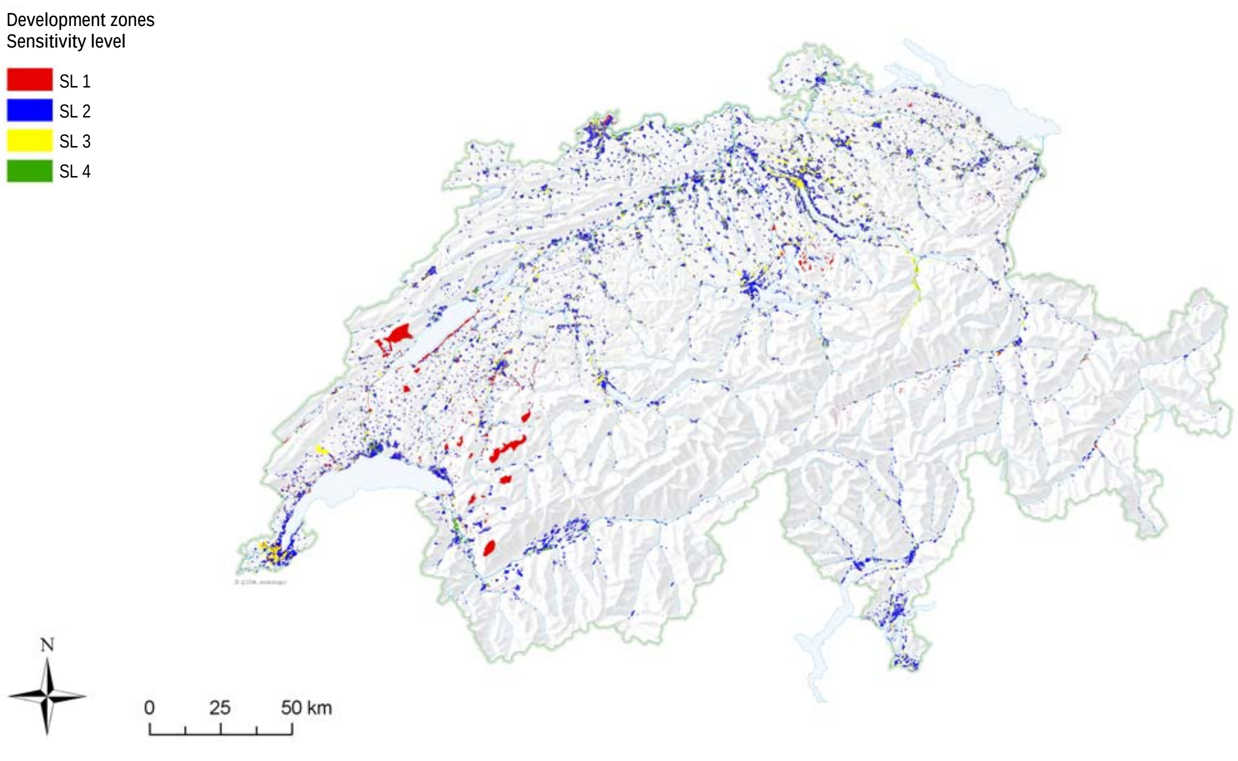
Where a sensitivity level classification is missing, the SL are defined as follows in accordance with the requirements of Article 43 of the Noise Abatement Ordinance (Fig. 12):

> SL I: Intensive leisure zone, green and nature conservation zone
> SL II: Residential zone, zone for public buildings and installations, core zones, townscape protection zone, tourism zone, special zone, hamlet zone, zone for sports and leisure facilities, protected reserve zone
> SL III: Working zone, mixed zone, city centre zone, intensive farming zone, zone for military buildings and installations, quarrying and landfill zone, transport zone
> SL IV: Industrial zone

The actual municipality land use plans do not normally include any zones classified as SL I, or only small areas at most. Therefore the results for limits exceeded in SL I obtained from the SonBase analyses will also give much higher figures.

Note

Fig. 12 > Development zones in Switzerland by sensitivity level



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FSO building coordinates outside the Vector25 buildings

Description

14.5 % of FSO building coordinates are outside building footprints in the Vector25 data. This is due firstly to the fact that some of the coordinates in the FSO survey were defined for the entrance to the building and as a result of the positional inaccuracy they lie outside the Vector25 building. Secondly, the differences in revision status of the national 1 : 25 000 map compared with the survey date of the statistical data (2000) gives rise to differences because newer buildings are missing.

Solution

FSO building coordinates which are less than 8 metres (Vector25 position accuracy) from the nearest Vector25 building (ca. 12.5 %) are allocated to that building. A "virtual" building was constructed around the remaining FSO building coordinates (2 %), (regular octagon with a radius of 0.2 m).

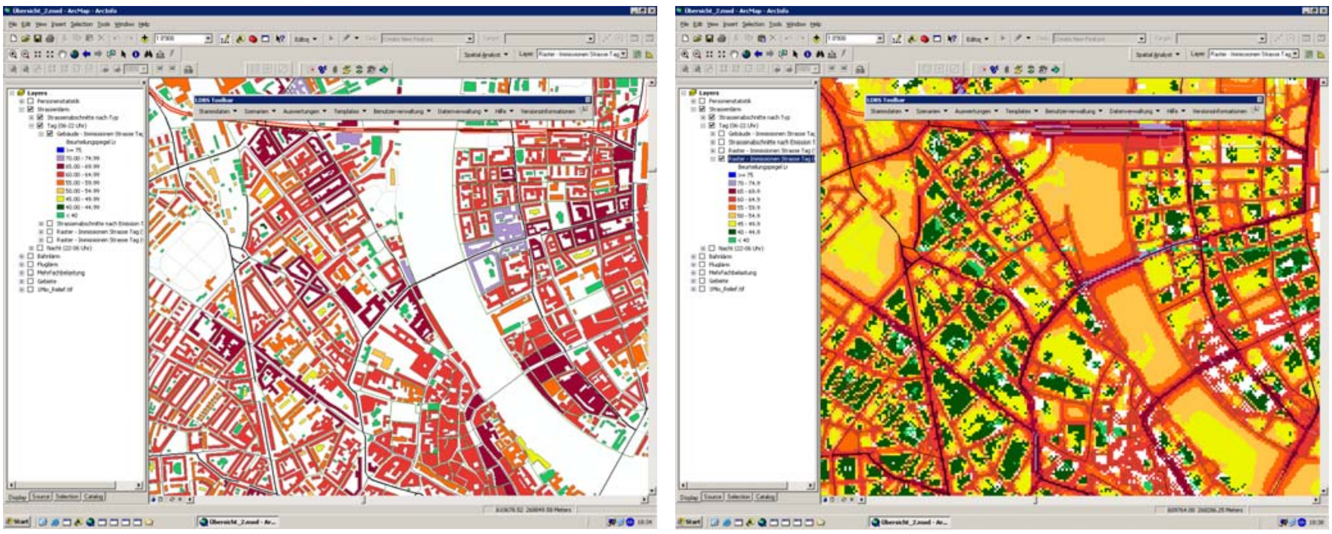
3 > Noise calculation and analysis

The nationwide calculations of road and railway noise using SonBase are carried out in several stages. Further geodata is also included for the analyses of noise pollution in Switzerland. The results can be displayed in cartographic or tabular form. For easier handling, the main queries are pre-programmed in SonBase.

3.1 Calculation of noise

The noise from road and rail traffic is calculated within SonBase by the CadnaA software. In the first stage, the emissions from the sources are computed in the GIS from the fundamental data available (e.g. geobasic data, statistical data, traffic data). The emissions from rail traffic are taken from the 2015 Emissions Plan. Then the propagation loss and resultant immissions are determined for both types of noise by incorporating the digital height model. The results are stored as "Building ratings" (maximum noise level per building) and as grid data (Fig. 13).

Fig. 13 > Section of a building rating **noise grid**



The aircraft noise immission levels held by the Confederation (as 5 dB(A) isolines) were incorporated directly into the system.

Two types of calculation are essentially possible: “Automatic” or “Manual” noise calculations. The former run fully automatically in the background through the noise calculation module using predefined calculation settings (whole of Switzerland, canton and municipalities, freely selected computing area). Their purpose is to generate nationwide standard noise data. For the manual calculations, the user has complete freedom (e.g. calculation settings) and the calculations are started by an automatic reimport to the GIS.

Automatic or manual noise calculations possible

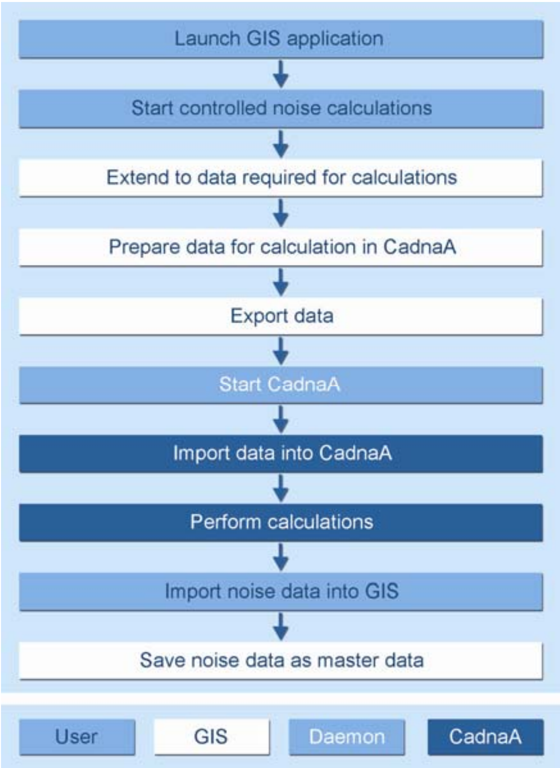
3.1.1 Running a “controlled” noise calculation

The noise calculations run according to a predefined scheme (Fig. 14). In the first step the emissions from the sources are computed in the GIS from the fundamental data (geobasic data, statistical data, traffic data).

Then the propagation losses are calculated in the CadnaA noise module, incorporating the digital height model, and the resultant noise immissions are determined at the reception points. In a first step a computer request is defined and the necessary data and control and prototype files are exported to a file system. Daemon then calls CadnaA and starts and monitors the calculations. The files are imported and the (noise) tiles to be computed – according to status – are written to two folders (IN/OUT). The actual noise calculation consists essentially of three parts: Division of the region into tiles, calculation of the individual tiles through the individual clients and assembly of the tiles by the master (Fig. 15).

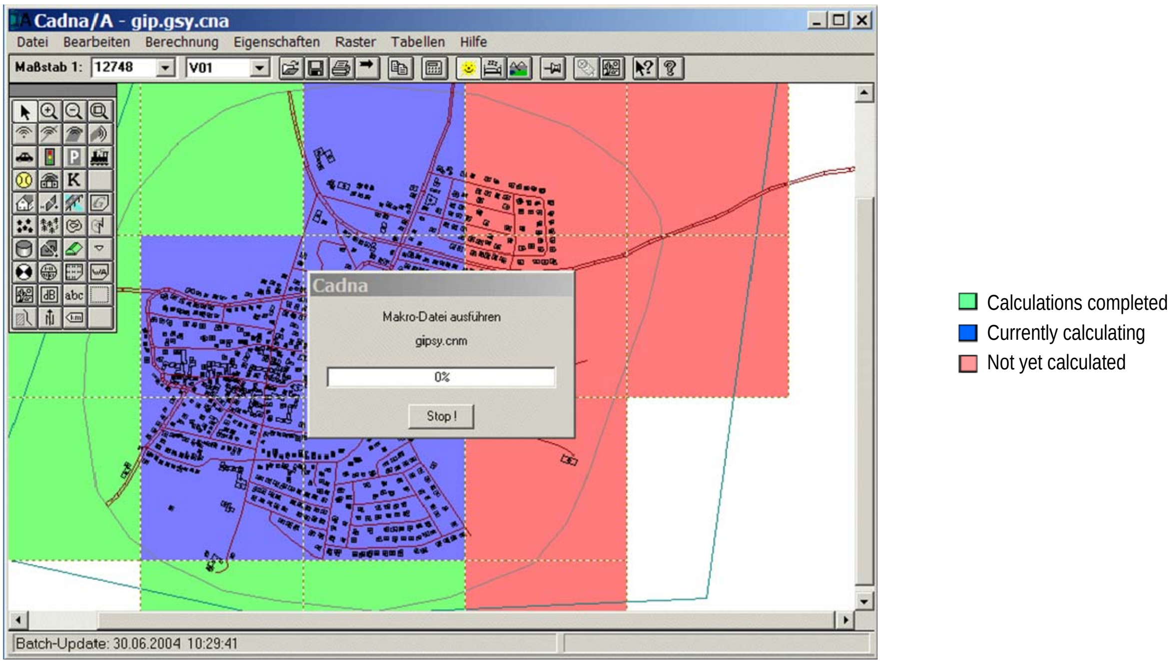
At the end of the computer request the results for the individual tiles are written to a folder (“Auto Task” or “Man Task”) and are available for reimporting to the GIS database, where the isophones can also be generated from the grids.

Fig. 14 > Sequence diagram of “controlled” noise calculations



Source: e-geo.ch No. 18, Newsletter October 2007

Fig. 15 > Calculation and monitoring of noise tiles



3.1.2 Determination of road traffic and railway noise

In SonBase the noise level is calculated for every building in Switzerland (with at least one dwelling or work space), along every elevation and on every floor. To reduce the data volumes, only the loudest sound level by day and night for each building is stored separately for road traffic and railway noise in the SonBase database. This corresponds generally to the simplified noise calculation procedure used in previous studies which operated on a large scale.

The windows in a building are not all equally exposed to noise pollution. The elevation with the highest noise is normally parallel to the road or railway. The windows on the side elevations (at right angles to the noise source) receive about 3 dB(A) less noise. Windows on the rear elevations have around 10 to 20 dB(A) less noise pollution. Whilst the aspect of the dwelling or room has a large influence on the noise levels, the effect of the individual storeys is relatively low. At close range the difference between the ground floor and, for instance, the 5^{th} floor is approximately 3 dB(A) though this falls to zero as distance increases.

In the simplified building representation on the 1 : 25 000 national map (= basis for the first calculation) several connected buildings are sometimes shown as one building, which can result in the loudest calculated building sound level being treated as representative of the whole connected group of buildings. This corresponds to a recognised maximum estimate in noise calculation. But it means that the effects of noise barriers and embankments within close range of the traffic source tend to be underestimated. With sufficient memory it will be possible to store several calculated building sound levels in SonBase in the future.

The noise levels are also calculated in SonBase as grids (resolution 10 x 10 m) for the whole of Switzerland. The composite noise rating is calculated for each grid point at a height of 4.0 m above ground – this height is defined in the EU Environmental Noise Directive – with allowance for the obstacles and sources present. Visualisations of the noise pollution and analysis of different areas (e.g. development zones) are then possible.

Fig. 16 and Fig. 17 show the two types of calculation and their associated results for a small section.

Fig. 16 > Road traffic noise pollution – building analysis

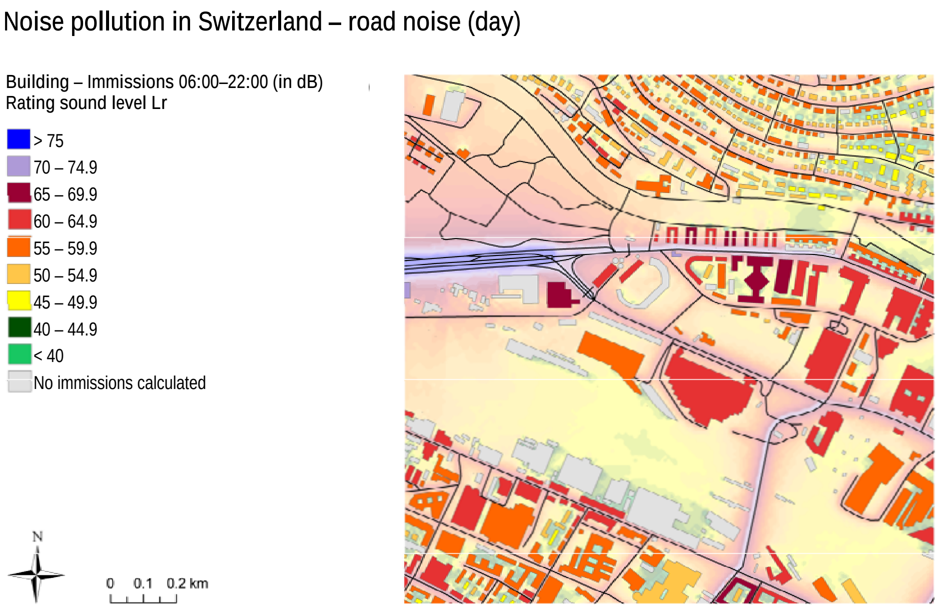


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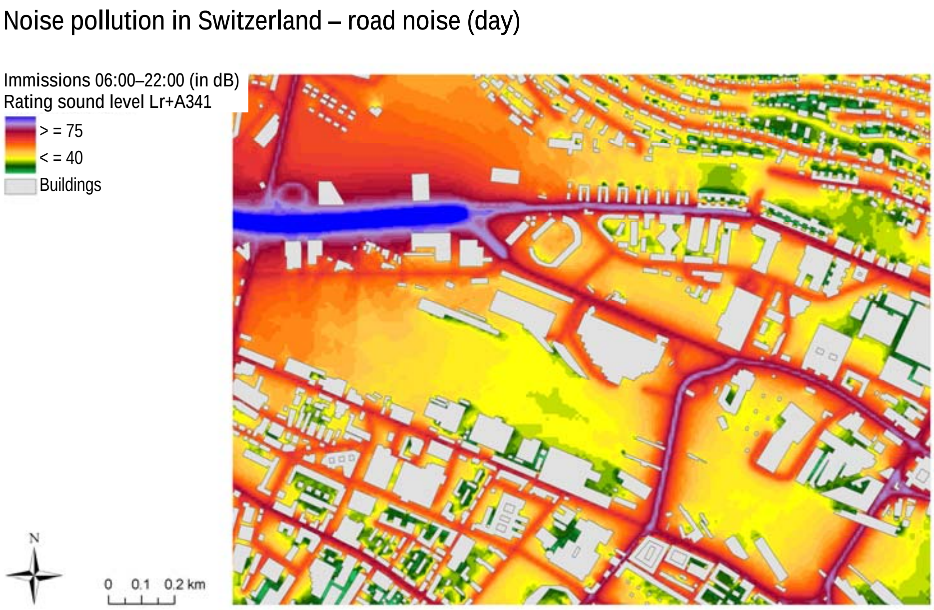
Fig. 17 > Road traffic noise pollution – grid



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3.1.3 Integration of (building) levels with statistical data

Integration of data from the 2000 National Census

To enable statistical analyses of noise pollution in relation to people, buildings and surface area exposed to pollution, further data sets are used in SonBase. The National Census data from the Federal Statistical Office (FSO) is available in geo-referenced form (with xy building coordinates at the centre or entrance of the building). These coordinates are assigned to the building rating symbol in the noise calculation program. This in turn activates the noise calculation for the building concerned.

This process ensures precise integration of the noise pollution with the statistical data (people, dwellings and work spaces for each building), providing evidence of the number of people, work spaces and dwellings exposed to noise pollution in Switzerland.

In this connection it should be noted that many statistical points could not be precisely assigned to a building due to the different data collection times and accuracy levels so that corrections had to be introduced (section 2.2).

3.1.4 First noise calculations

Noise assessment according to the NAO and EU Environmental Noise Directive

SonBase supports the requirements of the Swiss Noise Abatement Ordinance (NAO) and of the EU Environmental Noise Directive 2002/49/EG (strategic noise maps), separately for day and night (Fig. 18).

Fig. 18 > Requirements for the noise calculations, whole of Switzerland (2006)

- **Sound level range** - from 45 dB(A) day and 35 dB(A) night
- **Resolution** - in 1 dB steps
- **Pollution and disturbance measurements day/night (CH, EU):**
  - $Lr_{(day)}$, $Lr_{(night)}$, L_{max} according to NAO
  - L_d, L_e, L_n, L_{den} (EU)
  - L_{eq}
- **Total noise road, rail, air traffic (addition to be defined)**
- **Calculation models covered:**
  - Road traffic noise: StL86+ (StL02), NMBP-Routes-96, RSL-90
  - Railway noise SEMIBEL (compulsory), Dutch calculation method 1996
  - Air traffic: FLULA2 (only noise curves)

Source: FOEN 2008

Computer times were considerably reduced by the PC cluster

The initial propagation calculations for the whole of Switzerland (41 000 km²) were carried out in the noise calculation module and would have taken about 300 computer days on a single computer. This highly intensive work was therefore performed on a computer cluster with a central server and a pool of 15 PCs (Fig. 4). As a result the noise pollution was calculated in the form of grid maps and building ratings (Fig. 19). Overall it was possible to reduce the period purely for calculations – excluding additional export, import and correction tasks – to about three weeks: About 10 days (railway noise) and 14 days (road traffic noise) on a system with an average of 14 computers.

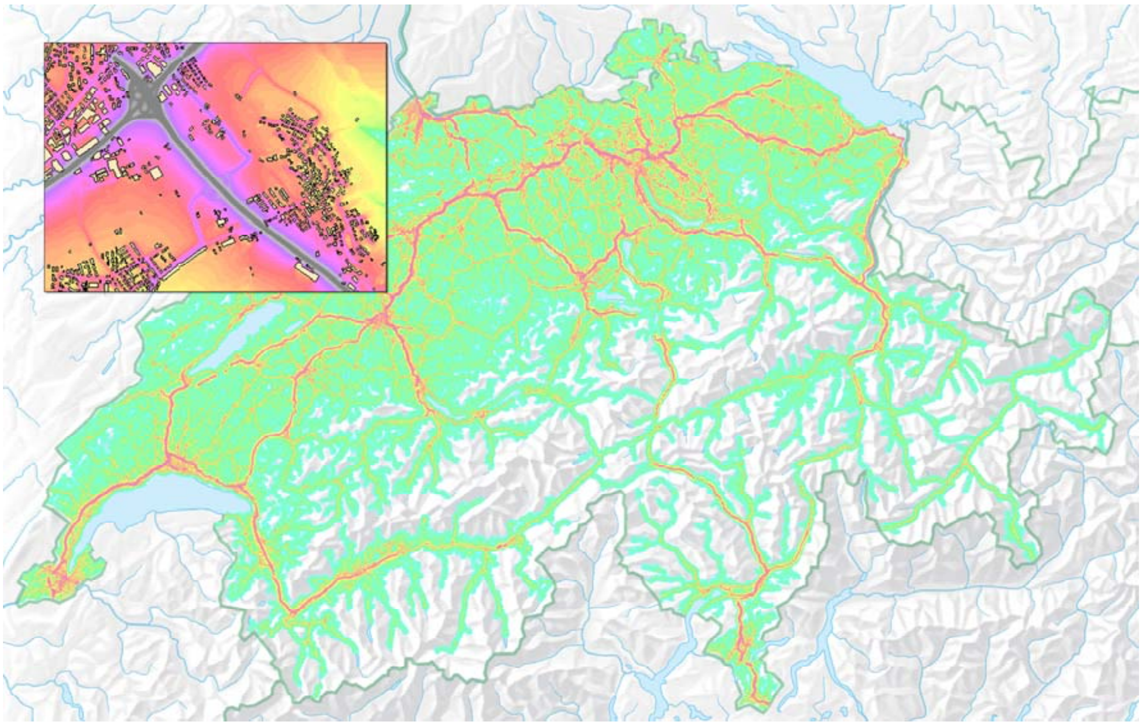
The following parameters affect the calculation accuracy and computing time (e.g. max. error, search radius, projection of line sources, max. reflection classification):

> Terrain model
> Positional accuracy of sources – buildings (for building ratings)
> Positional accuracy of sources – noise abatement measures
> Building heights (screening and reflections)
> Accuracy of traffic data

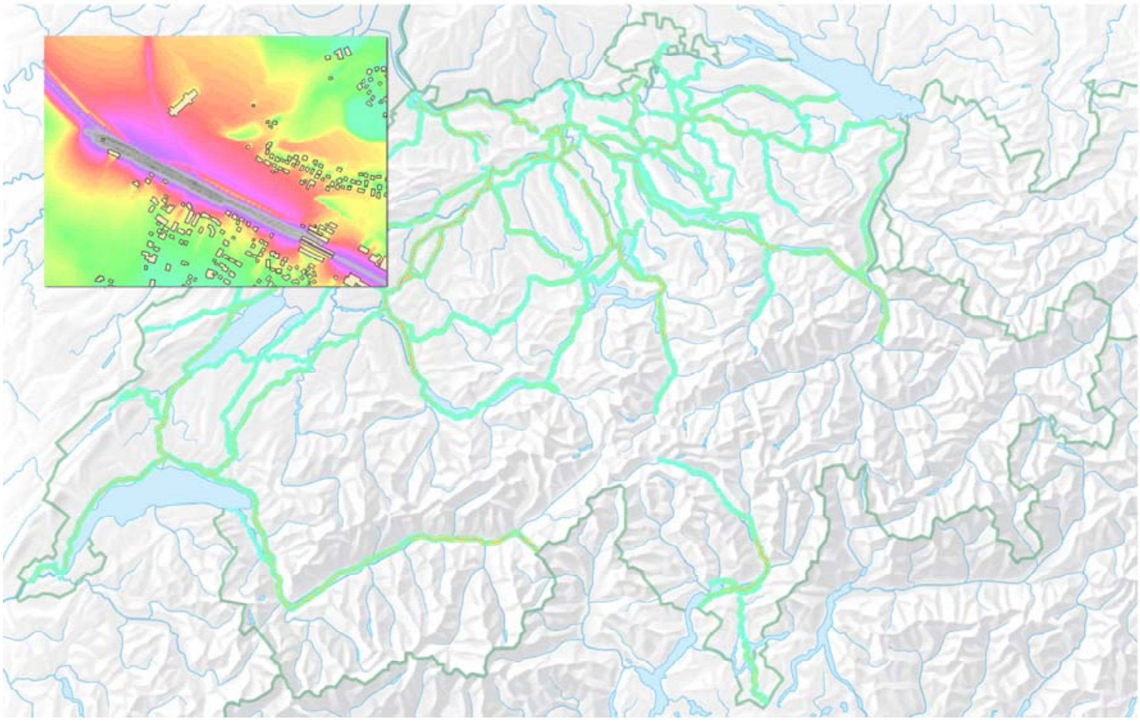
The computing times are huge and depend on the size of the regions and the level of accuracy required. The main point is the choice of an acceptable base accuracy for conclusive results and the question of how these factors can be improved to maximise the overall accuracy. A rather "rough" basic accuracy was used for the grid calculations. Also, the fundamental data available is subject to relative inaccuracies. It therefore appears acceptable to run the calculations at a low accuracy, but the aim was and will remain greater accuracy for calculation of the building ratings.

Fig. 19 > Grid map of noise levels by day

Road noise



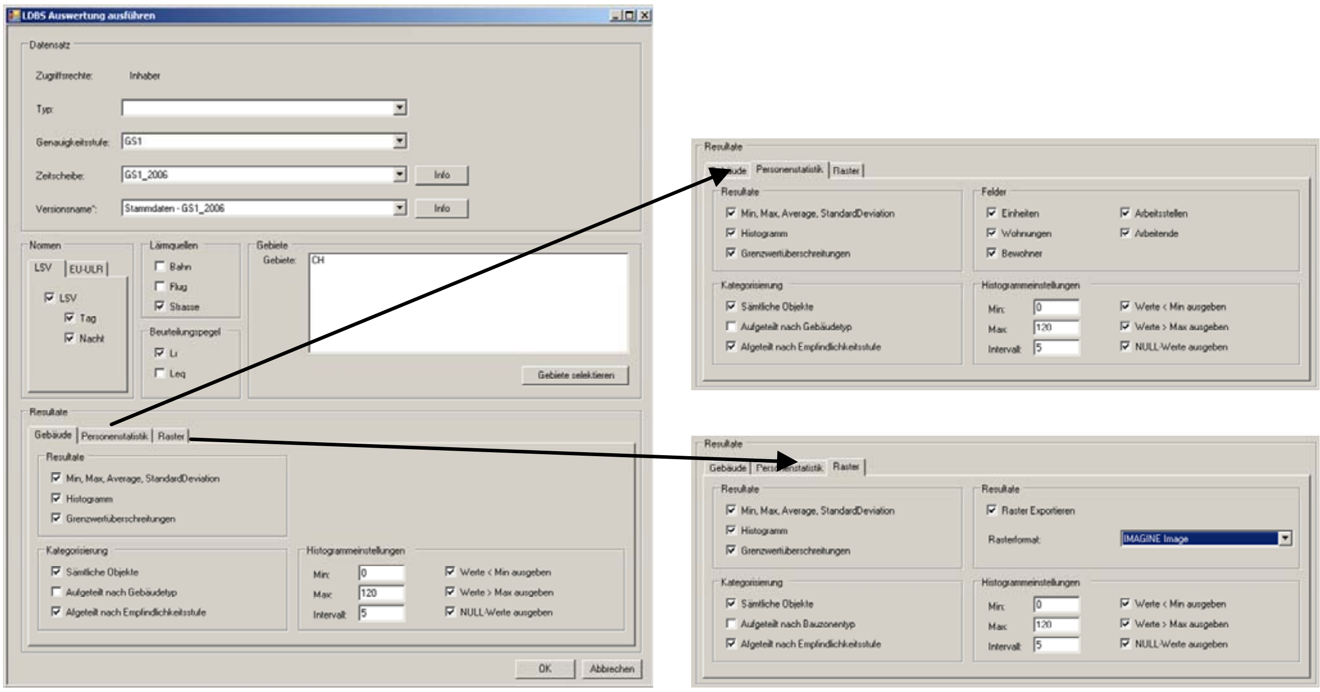
Railway noise



3.2 Analyses of the noise calculation

The noise data calculated and stored in SonBase (10 x 10 metre resolution grid, building ratings) can be analysed in various ways using all current ESRI analysis tools available. For simplified handling, the main queries (number of people, buildings, surface area exposed to pollution) were pre-programmed so that statistical results for freely selectable regions such as conurbations or municipalities can be automatically generated (Fig. 20).

Fig. 20 > Screen for the statistical analyses



Queries on noise pollution are possible using the following parameters:

a) People
b) Buildings
c) Dwellings
d) Work spaces
e) Jobs
f) Surface area

according to noise types:

> Road traffic noise
> Railway noise and
> Aircraft noise

and separated into the following geographical levels:

> For the whole of Switzerland
> For one or more cantons
> For one or more municipalities
> For one or more regions (cities [1], towns [2], urban municipalities [3] and rural municipalities [4])
> For one or more development zones
> For one or more sensitivity levels
> For any defined area

Calculations are only performed for buildings in which either dwellings or work spaces are located (according to FSO data set). Therefore results for buildings always relate to the total for those buildings (Fig. 21).

Fig. 21 > Building ratings for road traffic noise (day)

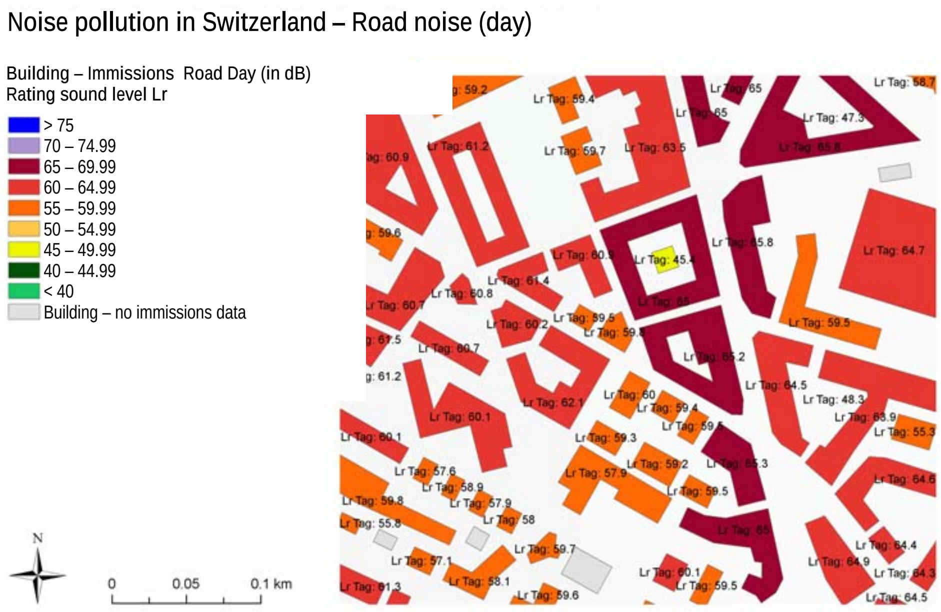


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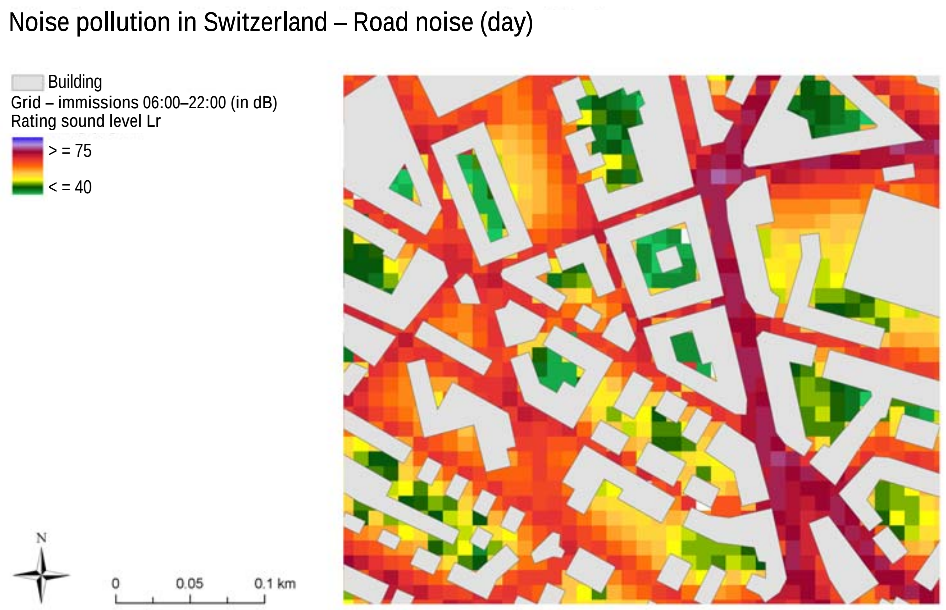
Fig. 22 > Noise grid – Road noise immissions in extensive grid form



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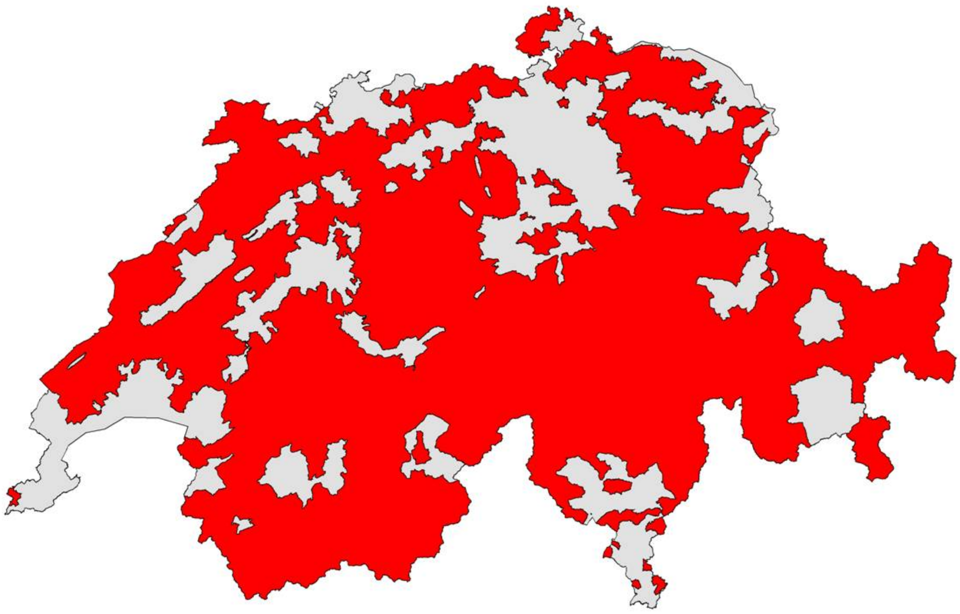
Based on the "Spatial breakdown of Switzerland" by the FSO, statistical analyses are also run in SonBase across various smaller regions of Switzerland. For the noise pollution in "urban" and "rural" areas, existing FSO geographical categories were combined (Fig. 23):

> Whole of Switzerland (categories: cities, towns and municipalities in conurbations, rural municipalities)
> Conurbation ("Whole of Switzerland" level excluding rural municipalities)
> Rural municipalities (rural municipalities only)

Fig. 23 > Breakdown of Switzerland into conurbations and rural municipalities

Grey areas:	*Cities, towns and municipalities in the conurbations*
Red areas:	*Rural municipalities*



The noise pollution is determined by the following thresholds or limits:

- Calculated noise pollution in 5 dB classes (noise determination) for day and night
- Noise pollution based on the legal exposure limits(NAO)
- Noise pollution based on directives and guidelines from the WHO of 55 dB(A) (day) and 45 dB(A) (night).

An important component of SonBase is determination of noise pollution trends, which is possible by changing the input data (e.g. traffic volume, noise barriers, new buildings). The results of these scenarios or forecasts can be stored separately in the database. The acoustic variations and noise effects in the area can be visualised as a differential computation.

In the FOEN report "Noise Pollution in Switzerland. Results of the SonBase National Noise Monitoring Programme" (FOEN 2009) the main results from the first noise calculation and the statistical analyses of noise pollution in Switzerland are shown according to noise type and region (Switzerland, urban areas, rural areas).

4 > Validation of results

Calculation of the noise situation in Switzerland in SonBase is subject to some uncertainties. The accuracy of the results was analysed using various methods. The results show that Accuracy Level 1 is sufficient for large-scale analyses to obtain statistically relevant data.

4.1 Analytical validation for road traffic noise

Uncertainties in the noise calculations were analysed

The calculation of noise pollution from road traffic is based on predefined principles and the emissions and immissions model used (in this case STL86+), but both are subject to uncertainty. The data included for calculation of the standard uncertainty is shown in Tab. 4 and Tab. 5. When the standard deviations of the individual parameters were defined, all the possible influencing factors were taken into account (e.g. possible differences in building heights, urban and rural non-homogeneity, maximum positional accuracy).

A method called GUM was used to determine the prevailing uncertainties. GUM was published in 1993 and indicates the internationally recognised principles for globally standardised determination and representation of measurement uncertainty. The fundamental aspects in determining uncertainty according to GUM are: Inclusion of all the known influencing variables involved, modelling of the process to set up the mathematical model, consideration of probability theory and estimation of all the input variables using probability density distributions.

Due to the uncertainties, data from SonBase AL1 should only be used for large-scale statistical statements. The errors for smaller regions can sometimes be much higher than stated here. Around 66% of the figures calculated have a deviation of less than 2.6 dB(A) (day) and 3.1 dB(A) (night) (Tab. 6).

Tab. 4 > Uncertainties in the calculation of emissions from road traffic noise

		Sensitivity coefficient	Resultant uncertainty Day		Resultant uncertainty Night	
Variable x_i		c_i	$\lvert c_i\rvert \cdot u(x_i)$ [dB]	[%]	$\lvert c_i\rvert \cdot u(x_i)$ [dB]	[%]
Average daily traffic volume (ADT)	[veh/h]	1.0	1.4	40.0	2.0	45.2
Speed	[km/h]	1.0	0.4	10.4	0.8	16.9
HGV proportion	[%]	1.0	0.5	14.8	0.5	11.3
Gradient	[%]	1.0	0.4	11.1	0.4	8.5
Emissions STL86+	[dB]	1.0	0.8	23.7	0.8	18.1
Standard uncertainty u			1.7	100.0	2.4	

ADT Veh/h accuracy; assumed: Nday = 0.058 * ADT, Nnight = 0.009 * ADT
Speed Ratio of V-assumed to V-actual
HGV proportion Ratio of HGV to vehicles by day; assumed Nday2 = 0.10 * Nd, Nnight2= 0.05 * Nn
Gradient Gradient accuracy in %
Emissions STL86+ Accuracy of emissions formula in model STL86+
u(xi) Standard uncertainty

Tab. 5 > Uncertainties in the calculation of the immissions from road traffic noise

		Sensitivity coefficient	Resultant uncertainty	
Variable x_i		c_i	$\lvert c_i\rvert \cdot u(x_i)$ [dB]	[%]
Noise barrier height	[m]	0.2	0.6	20.7
Vector25 position	[m]	1.0	0.2	8.5
Building height	[m]	1.0	0.3	8.6
Propagation STL86+	[dB]	1.0	1.8	62.2
Standard uncertainty u			1.9	100.0

Noise barrier height Accuracy of height of noise barriers along motorways
Vector25 position Positional accuracy of roads, buildings and contour lines from Vector 25
Building height Accuracy of building heights (default = 9.0 m)
Propagation STL86+ Accuracy of propagation formula in model STL86+
u(xi) Standard uncertainty

Tab. 6 > Standard uncertainty result for road traffic noise

	Day [dB]	Night [dB]
Emissions model uncertainty	1.7	2.4
Immissions model uncertainty	1.9	1.9
Standard uncertainty u	2.6	3.1

4.2 Analytical validation for railway noise

Validation of railway noise pollution

Determination of the noise pollution from rail traffic is also based on the calculation principles and on a specific emissions and immissions model (in this case SEMIBEL). The evaluation of rail traffic (including the track corrections) and the calculation of the resultant emissions were not carried out within SonBase. The data was taken directly from the 2015 Emissions Plan issued by the Federal Department of Transport (FOT), which is based on the “Railways Noise Abatement Ordinance” (RNAO).

The calculation of railway noise is also subject to some uncertainties (Tab. 7 and Tab. 8). The results from SonBase should only be used for large-scale statements. 66 % of noise levels calculated have a deviation of less than 2.0 dB(A) (day and night) (Tab. 9).

Tab. 7 > Uncertainties in the calculation of railway noise emissions

		Sensitivity coefficient		Resultant uncertainty
Variable x_i		c_i	$\|c_i\|\cdot u(xi)$ [dB]	[%]
SEMIBEL emissions	[dB]	1.0	0.8	100
Standard uncertainty u			0.8	100.0

Tab. 8 > Uncertainties in the calculation of railway noise immissions

		Sensitivity coefficient		Resultant uncertainty
Variable x_i		c_i	$\|c_i\|\cdot u(xi)$ [dB]	[%]
Noise barrier height	[m]	0.2	0.1	4.2
Vector25 V position	[m]	1.0	0.2	10.2
Building height	[m]	1.0	0.3	10.4
Propagation CadnaA	[dB]	1.0	1.8	75.2
Standard uncertainty u			1.8	100.0

Noise barrier height Accuracy of height of noise barriers along railway lines
Vector25 position Positional accuracy of track, buildings and contour lines from Vector25
Building height Accuracy of building heights (default = 9.0 m)
Propagation CadnaA Accuracy of propagation formula in CadnaA model
u(xi) Standard uncertainty

Tab. 9 > Standard uncertainty result for railway noise

	Day [dB]	Night [dB]
Emissions model uncertainty	0.8	0.8
Immissions model uncertainty	1.8	1.8
Standard uncertainty u	2.0	2.0

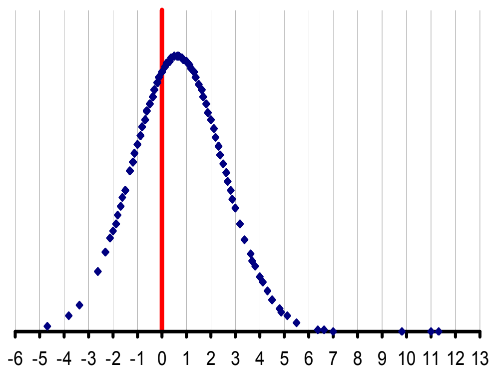
4.3 **Practical validation for road traffic noise**

Comparative calculations were carried out in three regions (Fig. 25). In each case the building ratings resulting from the basic calculation for whole of Switzerland (AL1) were compared with those with more accurate data sets (AL2) (Tab. 10). The calculation models were then refined in several steps and the interim results were compared with the basic values.

The numbers in Tab. 11 and Tab. 12 show the differences between the more accurate AL2 fundamental data on the basis of the model data and settings indicated in the first column of the table compared to the AL1 basic values. The average difference and corresponding standard deviation are given. Positive numbers mean that the more accurate SonBase calculation gives higher average dB levels than the basic model. (Fig. 24).

Fig. 24 > Example

Average difference	*– 0.6 dB(A)*
Standard deviation	*± 1.9 dB(A)*

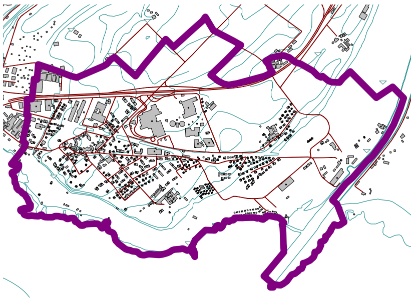


The vertical red line represents the more accurate value while the blue dots show the deviation from the calculated AL1 value. In the example shown, the more accurate values are an average of 0.6 dB(A) below the values in the basic AL1 calculation and the standard deviation of ± 1.9 dB(A) covers 68 % of all the values – assuming a normal distribution.

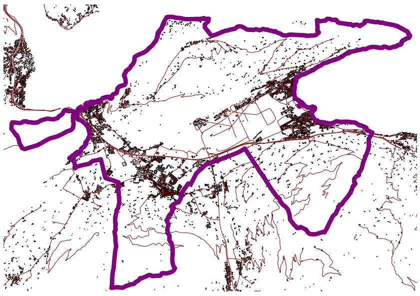
Tab. 11 shows the results when all the buildings within the selected perimeter are included. Tab. 12 includes only those buildings which have noise levels > 55 dB(A) by day and/or > 45 dB(A) at night, which corresponds to the planning value of sensitivity level SL II.

Fig. 25 > Regions investigated for road traffic validation

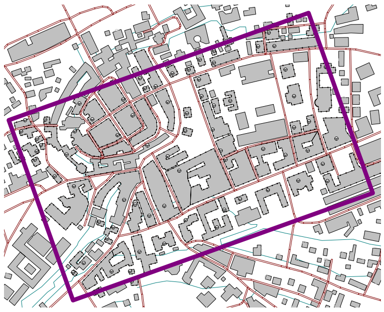
Municipality of Marin-Epagnier (Canton Neuchâtel), area ca. 3.3 km²



Municipalities of Stansstad, Stans, Buochs and Ennetbürgen (Canton Nidwalden), area ca. 39 km²



District of the city of Aarau (Canton Aargau), area ca. 0.3 km²



Tab. 10 > Model principles

	AL1 basic calculation	AL2 refined calculation
Buildings	Vector 25	Official survey data
Contour lines	Vector 25/DHM 25 Equidistance 10 or 5 m	Equidistance 1 or 0.5 m
Roads (position)	Vector 25	Official survey data
Roads (traffic)	DETEC TM or defaults	Meter data
Calculation configuration	Max. error 1.0 dB(A) Max. search radius 1.000 m No projection of line sources	Max. error 0.2 dB(A) Max. search radius 2.000 m Projection of line sources

Tab. 11 > Comparison of average difference and standard deviation of noise pollution per building with improved model principles

	Marin-Epagnier		Nidwalden		Aarau	
	Day	Night	Day	Night	Day	Night
Basic model AL1, Buildings AL2	-0.6 ± 1.9	-0.7 ± 1.8	-1.4 ± 2.9	-1.6 ± 3.0	-2.8 ± 4.6	-3.1 ± 4.9
Basic model AL1, Contour lines AL2			-0.1 ± 0.9	-0.1 ± 0.9	0.1 ± 1.3	0.1 ± 1.3
Basic model AL1, Roads (position and traffic) AL2, Full consideration of all roads, including those for which more accurate data is not available in AL2	-0.9 ± 3.4	-0.3 ± 2.2	0.5 ± 1.5	1.5 ± 1.8	0.4 ± 2.4	0.6 ± 3.2
Basic model AL1, Roads (position and traffic) AL2, Partial consideration: Roads without more accurate AL2 data deactivated	-1.0 ± 3.5	-0.3 ± 2.2	0.9 ± 2.1	2.2 ± 2.2	0.8 ± 3.7	1.2 ± 4.6
Basic model AL1, Calculation configuration AL2	0.5 ± 0.6	0.5 ± 0.7	0.4 ± 1.0	0.5 ± 1.2	0.2 ± 0.3	0.2 ± 0.3
All data and settings according to AL2	-1.1 ± 3.8	-0.5 ± 2.9	-0.8 ± 3.4	0.0 ± 3.5	-2.1 ± 5.1	-2.0 ± 5.8

Tab. 12 > Comparison of average difference and standard deviation of noise pollution per building > 55/45 dB(A) with improved model principles

	Marin-Epagnier		Nidwalden		Aarau	
	Day	Night	Day	Night	Day	Night
Basic model AL1, Buildings AL2	-0.6 ± 2.2	-0.7 ± 2.2	-1.4 ± 3.2	-1.6 ± 3.6	-2.5 ± 4.2	-2.9 ± 4.9
Basic model AL1, Contour lines AL2			-0.1 ± 0.8	-0.2 ± 0.9	0.1 ± 1.4	0.1 ± 1.4
Basic model AL1, Roads (position and traffic) AL2, Full consideration of all roads, including those for which more accurate data is not available in AL2	0.7 ± 2.8	0.1 ± 2.2	0.7 ± 1.7	2.0 ± 1.9	0.3 ± 2.5	0.7 ± 3.1
Basic model AL1, Roads (position and traffic) AL2, Partial consideration: Roads without more accurate AL2 data deactivated	0.8 ± 3.0	0.1 ± 2.3	0.9 ± 1.9	2.4 ± 2.0	0.7 ± 3.8	1.3 ± 4.7
Basic model AL1, Calculation configuration AL2	0.3 ± 0.4	0.3 ± 0.5	0.2 ± 0.4	0.3 ± 0.5	0.1 ± 0.2	0.1 ± 0.2
All data and settings according to AL2	0.4 ± 3.6	0.3 ± 3.6	-0.8 ± 3.8	0.0 ± 4.0	-2.2 ± 4.8	-2.0 ± 5.7

4.3.1 Interpretation of results

Basic model AL1, Buildings AL2

When building data from the official survey is incorporated, lower building rating levels tend to be produced than in the basic calculation. This is particularly striking for the city of Aarau test region. The main reason is that connected houses are modelled as one building in the basic model and the highest noise pollution levels for the groups of houses as a whole are calculated (Fig. 26).

Fig. 26 > Modelling of groups of houses

Buildings according to Vector 25	*Buildings according to Official Survey data*

Basic model AL1, contour lines AL2

Improving the model using more precise contour lines can lead to much higher or lower noise levels for individual buildings, but on average there are no significant deviations from the basic calculatio.

Basic model AL1, road (position and traffic) AL2

The calculation with the accurate road position and better traffic volumes tends to give higher building rating levels for the three test regions analysed, particularly in the overnight period. If only those roads for which more accurate data is available are considered (deactivation of other roads), this tendency is even more pronounced.

Basic model AL1, calculation configuration AL2

In the basic model both the maximum allowable error of 1.0 dB(A) and the maximum search radius mean that noise sources which make a negligible contribution at the immission point or which are further than 1.000 m away are excluded. By refining the calculation configuration (max. error 0.2 dB(A), max. search radius 2000 m), it is possible to reduce this methodological error which always causes the noise pollution to be underestimated, but at the expense of much longer computing times.

Calculation model AL2 (combination of all improvements)

If all the potential improvements listed above are combined, there tend to be slightly lower noise levels in the test regions. However, the results are inconsistent and sometimes subject to quite large deviation which makes extrapolation to the results for the whole of Switzerland impossible.

4.4 Historic validation

Comparisons with previous noise pollution investigations in Switzerland

The most recent national noise evaluation for Switzerland before SonBase was carried out for the study "External Noise Costs of Road and Rail Traffic in Switzerland, Update for the Year 2000" (ARE 2004). That study involved both a recalculation for Switzerland as a whole and comparisons with previous investigations. The recalculations and comparative analyses are compared with the SonBase result below.

4.4.1 Road traffic noise

The noise pollution calculated in SonBase is compared with the following two studies:

ARE 2000
External Noise Costs of Road and Rail Traffic in Switzerland

The road traffic noise exposure is calculated by totalling the following calculations:

> The **quantity structures known in advance**; they cover the canton of Zurich (excluding the cities of Zurich and Winterthur), the canton of Lucerne (excluding the city of Lucerne) and the canton of Nidwalden, with up-to-date, comprehensive noise data in each case.
> A **random noise calculation sample** across the other regions of Switzerland, consisting of 30 grid cells followed by projection. The following sampling plan was defined: PPS sampling with replacement (drawing probability proportional to the number of dwellings in the grid square), grid squares of 400 x 400 metres, no stratification (sample size too small). The noise pollution was calculated by the CadnaA noise calculation model. The necessary fundamentals were supplied by the cantons (location plans and traffic data) and supplemented on the spot (e.g. additional traffic data, signalled speeds, obstacles, building heights).

LUK 1995
From: Müller-Wenk (1999). Life-Cycle Impact Assessment of Road Transport Noise.

The data in the Müller-Wenk study is based on the Canton of Zurich General Noise Register (LUK). The LUK is also described in detail in the study "External Noise Costs of Road and Rail Traffic in Switzerland". In the Müller-Wenk study the dwellings exposed to noise from the surface area-LUK (general noise pollution beyond roads with heavy traffic) and the line-LUK (road traffic noise along national highways and municipal roads with heavy traffic) are added together and extrapolated to Switzerland as a whole.

The comparison indicates good agreement between the SonBase results and the extrapolations from the LUK 1995 and also with the figures in the ARE study for values above the 60–65 dB(A) level class (Fig. 27). The markedly lower figures in the ARE study for the 55–60 dB(A) level class may be an indication that the data in that class was insufficient for extrapolation at that time.

Fig. 27 > Comparison of SonBase with ARE 2000 and LUK 1995: Road

Day

Night

The values for night-time from SonBase and ARE 2000 incorporate the normal distribution of average daily traffic volume (ADT) in the overnight period (22:00–06:00) in line with the requirements of the Noise Abatement Ordinance (NAO). According to the latest information, this underestimates the volume of traffic and noise pollution at night. The LUK 1995 data is based on traffic censuses and noise measurements and confirms the assumption that noise pollution at night tends to be underestimated by SonBase (Fig. 27).

4.4.2 Railway noise

The noise pollution calculated in SonBase is compared with an extrapolation of the data from the Noise Pollution Register of Swiss Railways SBB (SBB-LBK-CH) from 1998 to 2000. The procedure is also apparent in ARE 2000. The SBB-LBK-CH 1998 was used by the Interdepartmental Working Group on Railway noise (IDA-E) as the basis for creation of the noise abatement project for the railways.

The **emissions** cover the traffic, infrastructure and quality of rolling stock in the 1998 analysis period. In accordance with the operational and structural guidelines and the known emission approaches for the vehicles, the proportional emissions for each type of train and the resultant emission rating sound levels for operations during the day (06:00–22:00) and at night (22:00–06:00) were computed for more than 6000 stretches of line.

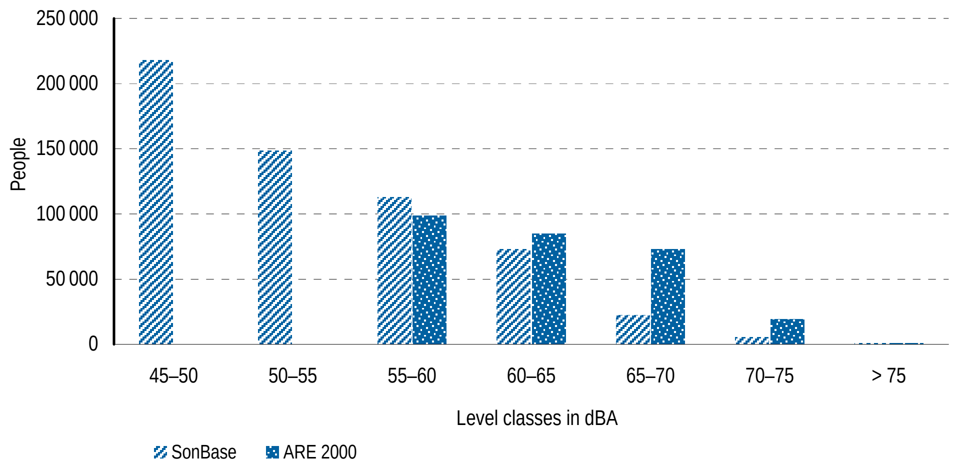
The **immissions** were calculated using the railway noise model (SEMIBEL). The noise pollution was calculated by day and at night at each reception point (representative of smaller building groups). The hectare grid then formed the basis for a distribution of the people per hectare in relation to the volume of the buildings calculated.

The **projection** of the SBB-LBK-CH from 1998 to 2000 included the following steps:

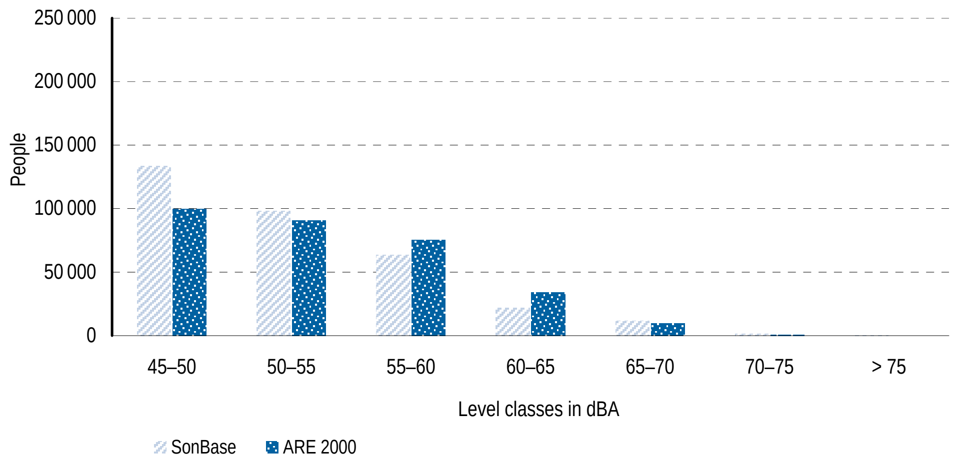
- Assumption that the 1998 and 2000 emissions differ very little.
- The SBB-LBK-CH 1998 is based on the 1990 National Census. Therefore the population numbers were extrapolated from 1990 to 2000 for each municipality.
- The noise pollution from other railways was included with a supplement of 6 % over the SBB noise pollution.

Fig. 28 > Comparison of SonBase with ARE 2000: railway

Day



Night



Results from SonBase agree with noise report

The report on the current status of noise abatement on the railways (DETEC 2007) present similar figures for noise pollution in Switzerland. The total number of people affected by excessive railway noise (265 000 before the start of abatement) can be reduced to around 165 000 by remediation of rolling stock (allowing for the extra traffic and new infrastructure). Structural measures such as noise barriers are not considered.

The number of people exposed to noise pollution above the limits (impact threshold) will be further reduced as a result of the installation of noise barriers along the railway lines which is currently under way and scheduled for completion in 2015.

Therefore the numbers calculated in SonBase agree with the above figures from the FOT noise report. Since the effects of the noise abatement measures are greater than the increase due to extra rail traffic, overall the 2015 Emissions Plan will achieve a reduction in noise compared with the situation before noise abatement on the railways. This noise reduction is particularly marked during the daytime period.

5 > Outlook

Scenarios and forecasts for noise pollution will provide the Confederation in future with an important basis for noise reduction strategies. The effectiveness of traffic management measures can be assessed (shift from road to rail). The economic and health effects of noise can also be quantified. To enable SonBase to perform its functions efficiently, the tool will be continually improved. Other types of noise will be integrated.

The following developments are planned for SonBase:

> Analyses and publication of noise mapping in Switzerland according to Swiss and EU standards, exchange of data and indicators with other authorities and states.
> Studies on the impact of noise (health, economic costs).
> Cooperation with various projects (FOEN): MFM-U, Ruhelabel (quiet mark), combined air-noise pollutant calculation.
> Scenarios and forecasts in Switzerland: Calculation of different variants such as traffic increases and new noise abatement measures in conurbations.
> Integration of other types of noise: Noise from trams, industry and trade, firing, military.
> Technical optimisation of the application, improving and adding to existing fundamental data for greater accuracy. Comparison of the data from the first survey with subsequent noise calculations
> Website, possible data access for cantons and federal authorities.

5.1 The potential of SonBase

5.1.1 Strategies and scenarios

SonBase is capable of calculating different noise conditions within a time slice for scenarios and determining possible changes in pollution and allows comparison of the results with the first calculation for the whole of Switzerland or with other scenarios.

For example, more precise calculations can be carried out across freely definable areas with more accurate computer settings (e.g. reflections, maximum error, maximum source-reception point computing distance). Scenarios can also be used to examine traffic management measures (e.g. shifting goods transport from road to rail) or other measures (e.g. extension or removal of ban on HGV movements at night, speed restrictions) in advance for their impact on noise and local residents. It will also be possible to examine the effect of e.g. future increases in the volume of traffic, the impact of a new by-pass road or noise barriers.

In general, strategic questions relating to possible noise abatement measures and their impact on people and buildings can be calculated and demonstrated simply and efficiently in SonBase.

5.1.2 Analyses according to the EU Environmental Noise Directive or the WHO criteria

In addition to the results on noise pollution according to Swiss legislation (NAO) and based on absolute and stricter limits, analyses according to other criteria and limits can also be performed in SonBase.

Analyses according to EU directives are the main focus. With these analyses the EU will be in a position in future to produce statistical and cartographic noise pollution comparisons between European countries. Some of the analysis criteria will differ from the NAO in Switzerland, (e.g. different day and night periods, additional rest periods, different level corrections). Particular mention should be made of the Day-Evening-Night level L_{den}, which is calculated from the noise pollution for the day (12 hours), evening (4 hours) and night (8 hours):

$$L_{den} = 10 * lg \frac{1}{24}\left(12 * 10^{\frac{L_{day}}{10}} + 4 * 10^{\frac{L_{evening}+5}{10}} + 8 * 10^{\frac{L_{night}+10}{10}}\right)$$

Analyses can also be carried out in relation to the “Noise Night Guidelines” of the World Health Organisation WHO (WHO 2007). These delineate areas in which night noise pollution must not exceed a specific limit – 30 dB(A), 40 dB(A), 55 dB(A) – because of the impact on the health and well-being of the people affected.

Each of these analyses must be configured in the calculation settings in SonBase according to the task and additional noise calculations may be required (e.g. new parameter L_{den} under EU-END).

5.1.3 Determination of economic costs

Cost-benefit evaluation of measures

In future information on the cost of noise reduction measures is also to be integrated in SonBase. It will then be possible to carry out cost-benefit analyses of existing or planned noise protection measures by performing specific analysis steps. Firstly, costs will be determined using the FOEN publication “Economic Acceptability and Proportionality of Noise Protection Measures” (FOEN 2006). Secondly, SonBase will be used to develop the basic information for further analyses of the economic costs of noise (e.g. property depreciation, health costs).

However, additions to the calculations will be necessary. In particular, the noise levels must be calculated separately for all storeys and stored in the database so that specific evidence about the effectiveness of measures can be included in the evaluations.

5.2 Scope for improving accuracy in SonBase

Planned improvements

SonBase uses a variety of fundamental data, which affects the accuracy of the noise calculation results to a greater or lesser degree (e.g. contour lines, position of buildings, sources and noise abatement measures, traffic data). Various potential improvements which will improve the accuracy of the noise pollution results in the future are described in brief below.

Use of more accurate data: The use of data from the Official Survey (AV) with accurate positional data could eliminate a number of weaknesses in the Vector25 data currently in use. In particular, all buildings would be captured separately, so that no further combinations would be necessary, even in relation to the allocation of the FSO statistical data. This will give precise noise pollution information for every building with dwellings or work spaces. Also the positional accuracy of the official survey data is much better than that of the Vector25 data, which could again greatly increase the accuracy of the calculations.

Integration of bridges: By integrating the exact position of bridges, the propagation conditions which correspond with reality can be included in the calculations. The potential exists for integrating this data into the noise calculation programme as the relevant sections on the roads and railways have been identified. The geometries will be incorporated so that integration in the calculation model is possible.

Use of more detailed data on noise barriers/embankments: Integration of the exact geometries of the noise barrier structures yields an improvement in the accuracy of the results within their range of influence. The potential for integration of accurate data already exists in both SonBase and CadnaA. All that is needed is for the relevant accurate data to be available or be collected by the implementing authorities (cantons, ASTRA).

Noise calculation for individual storeys: Calculation and storage of the noise results for individual storeys will also allow consideration of the effectiveness of noise abatement measures which may be lost in the current method as it uses the loudest points on each elevation. Conclusions can also be drawn regarding the effect of measures on the numbers of people exposed, which will ultimately be the basis of a cost-benefit analysis. The requirement for these calculations is precise data, e.g. building heights and number of storeys, which at present is only partially available for Switzerland as a whole.

Noise calculation for several reception points on the building: In addition to integration of storeys, a calculation for several reception points around the building can make the results significantly more precise in terms of the people affected by noise pollution. In a building, only some of the residents live (exclusively) on the noisiest elevation. Noise pollution is at least 3 dB(A) lower along the side elevations and the levels can be as much as 15 dB(A) lower on the elevation opposite to the source.

Use of detailed road traffic data: Improvements or greater differentiation in the traffic data will give emission results which are closer to reality than the defaults currently used for a large proportion of the roads. The differences could be considerable in some cases, particularly for municipal and district roads. This could greatly improve the results for the areas concerned.

Use of current rail traffic data (emissions plans): By using current SBB emissions data for specific years (instead of the notional emissions plan for 2015), the current noise pollution levels can be determined and analysed and the changes over the years can be documented.

Addition of other railway lines: By including other railway lines (especially the private railways), the results in SonBase will be expanded and it will be possible to specify more precisely the number of people, buildings, dwellings, work spaces and surface area affected.

Use of detailed zoning plans including SL classification: The use of more detailed zoning and noise sensitivity level plans with incorporation of step-ups and allocation of SL outside the development zones will give a more accurate assessment of where limits are exceeded in the relevant regions.

Noise calculation settings: It is possible to influence the accuracy of the results by changing the settings in the CadnaA noise calculation program. However, it is always important to assess whether, on the basis of the data available, a "more accurate" calculation actually results in an increase in accuracy. The increased computing time must also be considered.

5.3 Integration of other types of noise

Integration of other types of noise planned

The SonBase system is structured so that other types of noise can be integrated with few adaptations to the database. In principle, it is irrelevant whether the noise pollution is calculated in the system or imported in suitable form from external sources. The following types of noise are predominantly being considered:

> Civil firing ranges (ca. 1840 300 m ranges, ca. 580 50 m ranges, ca. 290 25 m ranges, ca. 200 hunting ranges and ca. 75 other ranges)
> Military firing and exercise ranges (ca. 250 ranges)
> Industrial and commercial installations
> Tram noise
> Leisure and sports facilities

Most of these installations have a relatively low spatial noise impact compared with the transport facilities already considered (roads, railways, air traffic). But experience shows that noise from them is the subject of repeated complaints and the conclusion has to be that considerable numbers of people feel disturbed by this noise pollution.

In this connection it is the case that concrete exposure limits do not exist in Swiss environmental protection legislation for some types of noise (sports facilities, leisure noise) and they have to be assessed on an individual basis. The noise pollution can still be recorded and portrayed, but without an assessment.

5.4 Strategic considerations on further development

The technical noise principles for future projects, plans and political decisions can be developed using SonBase. At present the key points listed below are possible, but the list is not exhaustive.

- Planning the shift in traffic management (transport of goods by rail)
- Monitoring of road traffic and railway noise
- Scenarios for noise abatement (e.g. pavements, speed reduction, noise barriers); development of specific abatement strategies
- Scenarios for traffic management measures (impact on noise pollution)
- Development of principles for the introduction of a “Ruhelabel” (quiet mark)

> Appendix

A1 CadnaA computer settings AL1

For the first calculation in SonBase in the CadnA calculation program (version 3.7, Datakustik GmbH, Greifenberg), the following settings and parameters were used.

Building rating

- Loudest point on each elevation
- Minimum elevation section length: 0.1 m
- Maximum elevation section length: 10.0 m
- Height of first reception point above ground: 1.5 m
- Storey height: 2.8 m

Grid calculations

- Grid point distance: 10 x 10 m
- Calculation height: 4.0 m above ground (as in European Environmental Noise Directive EU-END)
- Extrapolate grid under building zones

Other settings

The following parameters were selected as further general settings in CadnaA in accordance with the "Rough" calculation setting:

> Maximum error	1.0 dB
> Maximum search radius	1000 m
> Minimum source-pollution point distance	5.0 m
> Grid interpolation	17 x 17 grid points
> Maximum vertex difference	5.0 dB
> Maximum centre difference	0.1 dB
> Grid factor	1.0
> Maximum section length	1000 m
> Minimum section length	10 m
> Projection of line sources	None
> Reflection order	0

A2 Data sheets (Extract)

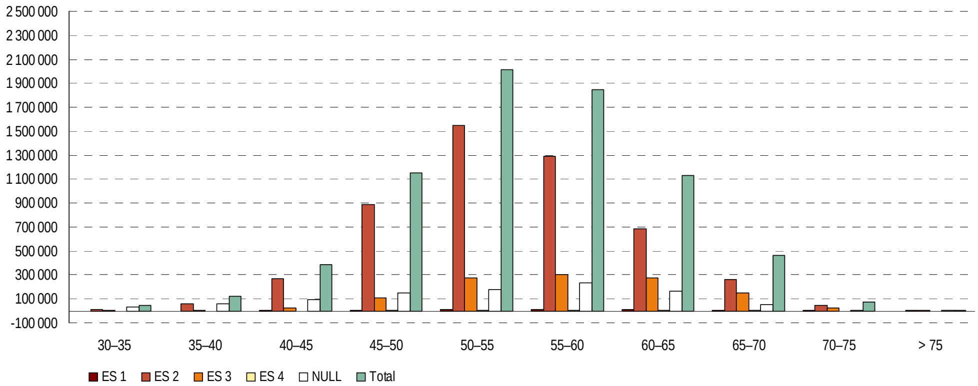
The analysis facilities programmed in SonBase automatically generate so-called data sheets providing statistical conclusions (histogram, exceeding of limits) for freely selectable regions and criteria.

Fig. 29 > Pollution affecting people (histogram)

Noise source: Road
Region: Switzerland
Time: Day

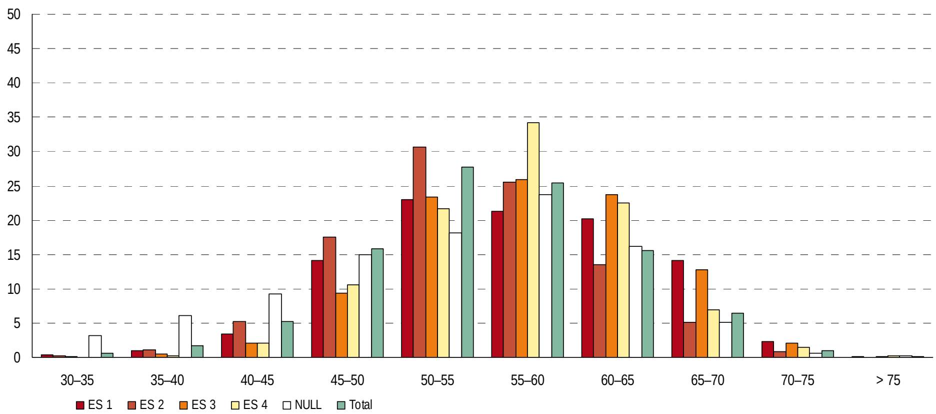
Number

Typ	< 30	30–35	35–40	40–45	45–50	50–55	55–60	60–65	65–70	70–75	> 75	Total
ES 1	156	163	458	1 589	6 500	10 620	9 826	9 327	6 525	1 051	34	46 249
ES 2	3 337	12 341	56 627	265 874	885 536	1 548 537	1 292 003	682 268	258 301	43 061	2 785	5 050 670
ES 3	355	912	5 540	24 672	109 181	271 983	302 780	277 025	148 303	23 864	1 421	1 166 036
ES 4	1	5	41	344	1 733	3 520	5 562	3 672	1 130	242	42	16 292
NULL	24 433	31 976	61 227	91 708	149 712	180 513	236 643	161 060	50 479	6 543	2 374	996 668
Total	28 282	45 397	123 893	384 187	1 152 662	2 015 173	1 846 814	1 133 352	464 738	74 761	6 656	7 275 915



Percent

Type	< 30	30–35	35–40	40–45	45–50	50–55	55–60	60–65	65–70	70–75	> 75
ES 1	0.34	0.35	0.99	3.44	14.05	22.96	21.25	20.17	14.11	2.27	0.07
ES 2	0.07	0.24	1.12	5.26	17.53	30.66	25.58	13.51	5.11	0.85	0.06
ES 3	0.03	0.08	0.48	2.12	9.36	23.33	25.97	23.76	12.72	2.05	0.12
ES 4	0.01	0.03	0.25	2.11	10.64	21.61	34.14	22.54	6.94	1.49	0.26
NULL	2.45	3.21	6.14	9.20	15.02	18.11	23.74	16.16	5.06	0.66	0.24
Total	0.39	0.62	1.70	5.28	15.84	27.70	25.38	15.58	6.39	1.03	0.09



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