Navcon Engineering Network
Noise & Vibration Consultants

SoundPLAN
Designing a Sound Environment

Environmental Noise Modeling Tools for Engineering & Planning Solutions

A&WMA Ontario Section
Air Quality and Environmental Acoustic Modeling Conference
October 22, 2013

Presented by
Hans Forschner
Navcon Engineering Network

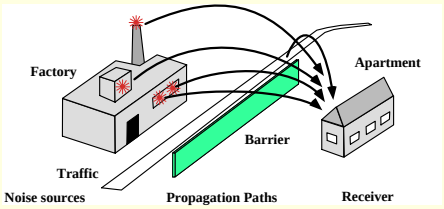
Trends North-America

- **Population Growth**
  - US 1950 – 150 M, 2012 – 315 M
  - CA 1950 – 15 M, 2012 – 34 M
- **Household Growth**
  - US 1950 – 43.5 M, 2012 – 115 M
  - CA 1950 – 3.5 M, 2006 – 12.5 M
- **Trend Urbanization**
  - US 1950 – 64%, 2010 – 81%
  - CA 1950 – 60%, 2010 – 81%
- **Increase Mobility (Cars)**
  - US 1950 – 74 M , 2010 – 260 M
  - CA 1950 – 4.5 M, 2010 – 29 M
  - US Total Monthly Vehicle Miles:
  - 190 billion miles (1988), 270 billion miles (2013) (ref. FHWA Traffic Volume Trends)

Parameters that change our Engineering Field

- Research shows how noise effect us:
  - ✓ At Work (Hearing, Communication, Productivity, …)
  - ✓ At Home (Sleep, Communication, Hypertension, Privacy, ...)
  - ✓ At School, Communication
  - ✓ Sources - Transportation, Industry, Sports, Entertainment, …
  - ✓ Effect on Wildlife (Endangered species)
- Government bodies (Global, Federal, State, County, City levels) develop legal frameworks with limits for sources & receptors in terms of Environmental Impact, Social Fairness, Cost for Society, …
- Research, Technology advances the characterization of noise sources, the modeling and the noise assessment parameters
- Funding

Environmental Noise Modeling Tools
for Engineering & Planning Solutions



- Modeling w/ Ruler & Calculator before area of Personal Computer
  - ✓ Inverse square law (e.g., Doubling Distance 3 dB, 4.5 dB, 6 dB)
  - ✓ Octave frequency (e.g. 500 Hz Industry, Road, Rail)
  - ✓ Peak traffic / loudest sources
  - ✓ Simplified Geometry (Rule of Thumb)
  - ✓ Simplified Directivity (e.g. Roof -5 dB, Opposite Wall -20 dB)
  - ✓ 0 or 1st order of reflection

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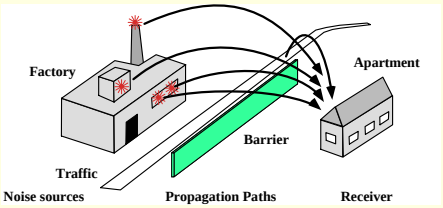

- **Pro's**
  - ✓ Very Quick Initial Results
  - ✓ Small Data Amount
  - ✓ Great tool for project with small number of noise sources
- **Con's**
  - ✓ Too much or too little safety margins
  - ✓ No Detail (Spectral, Usage, Reflection, Flanking Paths, Local Shielding,…)
  - ✓ Labor Intensive / Manual input effects study detail
  - ✓ Result Tables, No Graphics

Environmental Noise Modeling Tools for Engineering & Planning Solutions

Technology highlight's of the recent 30 year …

- 1981 IBM introduces 1st Personal Computer (PC)
- 1983 IBM PC/XT Technology Intel processor & DOS
- 1984 Apple Macintosh
- 1985 IBM 386 microprocessor
- 1986 64 million PC's Shipped Worldwide
- 1986 Toshiba introduces T1000 laptop
- 1988 CD discs
- 1989 120 million PC's Worldwide
- 1991 WWW
- 1995 DVD discs, Windows 95
- 1997 Pentium II, 1999 Pentium III, 2000 Pentium 4
- …. Windows 98, 2000, XP, Windows 7, Windows 8
- 2012 Global Sales 350 Million PC & 30 Million Tablets….

Environmental Noise Modeling Tools for Engineering & Planning Solutions

Noise Modeling Software

- Basic Need
  - Digitizing Geometry of sources, receiver, path objects (barrier, elevation,..)
  - Implementation of Prediction Algorithms (ISO, Road, Rail Models,…)
  - Automatic Acoustic Model Processing
  - Basic Noise Assessment
  - Documentation
- Expanding Features
  - 1/1 & 1/3 Octave Band
  - Graphic Features / Visual QC Input Geometry, Parameters, Results
  - Cost Optimization
  - Data Interfacing & Reduction (ACAD, GIS)
  - Project / Data Management
  - Distributed Network
  - Software Updating via Internet
  - Quality Assurance (QA) ISO 9001
  - Quality Control (QC)

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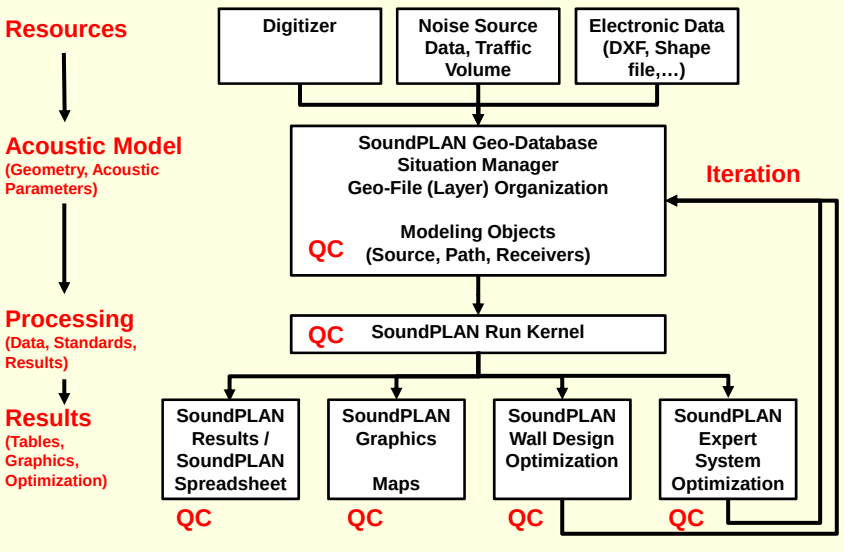
SoundPLAN Software & Noise Project Flowchart



Environmental Noise Modeling Tools for Engineering & Planning Solutions

Environmental Noise Modeling Tools for Engineering & Planning Solutions

- **Quality Control – Geo-Database**
  - ✓ Consistency of Geometry (location, height/elevation, width,…) via 2D and 3D Graphic visualization
  - ✓ Data Organization & Documentation
  - ✓ Review Object Acoustic Parameter, Pre-flight
  - ✓ Aerial Photography
  - ✓ …
- **Quality Control – Calculation**
  - ✓ Setup Default Settings (Run, Standards, Assessments)
  - ✓ Review of Calculation Parameter, Standard Settings
  - ✓ Batch Processing, Recalculation
  - ✓ Error / Warning Log
  - ✓ …

Environmental Noise Modeling Tools for Engineering & Planning Solutions

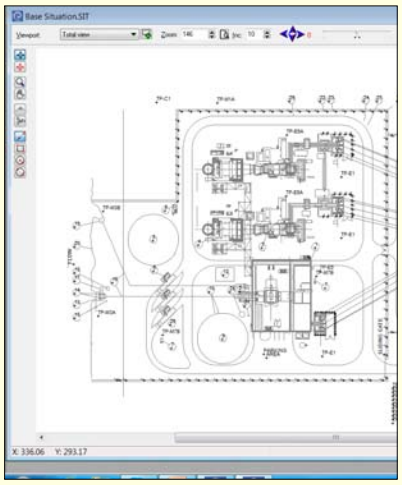
- **Quality Control – Result Documentation**
  - ✓ Documentation of Program Version, Calculation Settings, Source Input (Spectral, Usage)
  - ✓ Intermediate and detailed calculation steps
  - ✓ Assembly of Spreadsheet (multiple variants assessment)
- **Quality Control – Graphics**
  - ✓ 2D, 3D Graphic representation of Input Geometry
  - ✓ 2D, 3D Graphic representation of Results
    - ✓ Contour Map & Cross Section Maps (Noise Prediction, Difference, Conflict, Measured Data, Standard Deviation, File Operations, Façade Results, …)
    - ✓ Export Raw Data, Contour Lines (DXF, GIS)
  - ✓ Spreadsheet integration

Environmental Noise Modeling Tools for Engineering & Planning Solutions

- **Quality Control – Wall Design**
  - ✓ 2D, 3D Graphic representation of Input Geometry
  - ✓ Cost Optimization Control Features
  - ✓ Visualization of Optimization Steps
  - ✓ Documentation and Export of Results
- **Quality Control – Expert System**
  - ✓ 2D, 3D Graphic representation of Input Geometry (Receiver and Source Visualization)
  - ✓ Visualization of Optimization Steps
  - ✓ Overall, Spectral Mitigation
  - ✓ Saving Mitigation Measures

General Objects / Display / Documentation

- Generic Text for general Documentation
- Generic Point for general Layout
- Generic Line for general Layout
- Generic Area for general Layout
- Photo Spot for Documentation



Environmental Noise Modeling Tools
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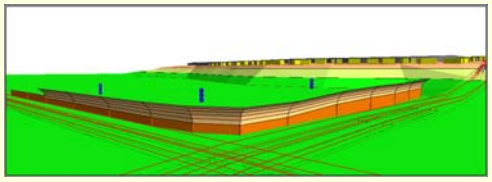
Noise Source Objects

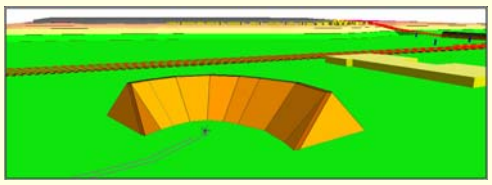
- Point Source -> Lw (f), Group, Time Histogram, Lmax,…
- Line Source -> Lw (f), Group, Time Histogram, Lmax,…
- Area Source -> Lw (f), Group, Time Histogram, Lmax,…
- Industrial Building
  - Building (Reflection, Shielding)
  - Source Indoor to Outdoor
  - Incorporate sub-source in façade
  - Lw (f), Group, Time Histogram, Lmax,…
  - Indoor Model
- Road -> Traffic Volume, Veh. Mix., Speed, Surface, Geometry
- Parking Lot -> Traffic Volume, Type of Parking Lot
- Rail Road -> Train Traffic, Speed, Geometry

Propagation Objects

- Noise Barrier Wall
  - Screening (over, around & under), reflection
  - Height, Absorption (front, back), on the ground, floating above ground



- Noise Barrier Berm / Embankment
  - Screening (over)
  - Height, Incline



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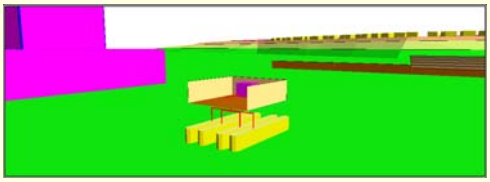
Propagation Objects

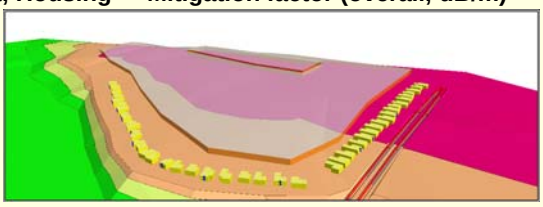
- Floating Screen
  - Floating platform with reflecting walls going up or down
  - Screening over, around & under



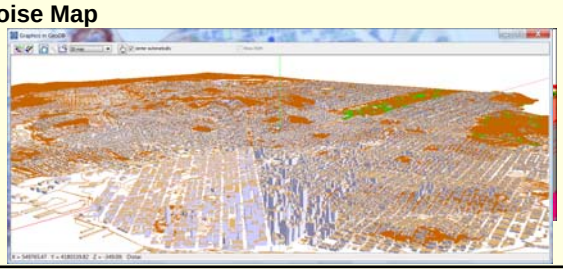
- Ground Definition
  - Ground factor / flow resistivity (g, rayle)
  - Define small to big area (Shoe Box System)

Propagation Objects

- Attenuation / Mitigation Area
  - Forest, Housing -> Mitigation factor (overall, dB/m)



- Building – Reflection, Shielding, Receiver Definition for Façade Noise Map



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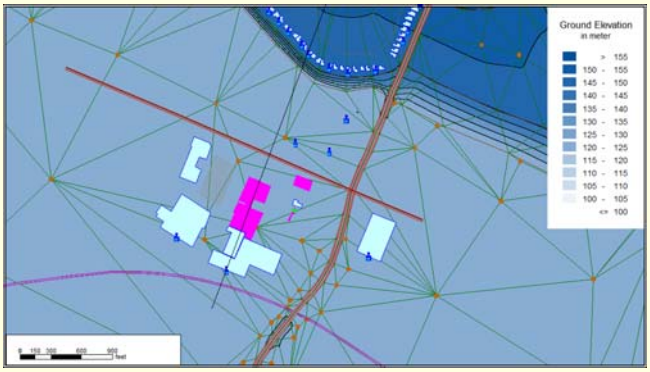
Propagation Objects

- Spot Heights, Elevation Lines – Ground Height DGM
- Provides elevation for grid receiver
- Provides elevation for objects w/ relative elevation input
- Used for Propagation Model (Shielding, Ground Reflection)



Receiver Objects

- Point Receiver (Name, Number of Floors, …)
  - Free Field, Building
- Line / Cross Section
  - Cross Section Contour Map
    - Grid Spacing, Interpolation, Ground to xx height
- Calculation Area
  - Grid Noise Map
    - Grid Spacing, Height above Ground, Interpolation
  - Meshed Noise Map
    - Triangle Mesh, Height above Ground
  - Recalculation Area
- Building / Façade Receiver are define by Building Name, Floor Heights and Façade Geometry

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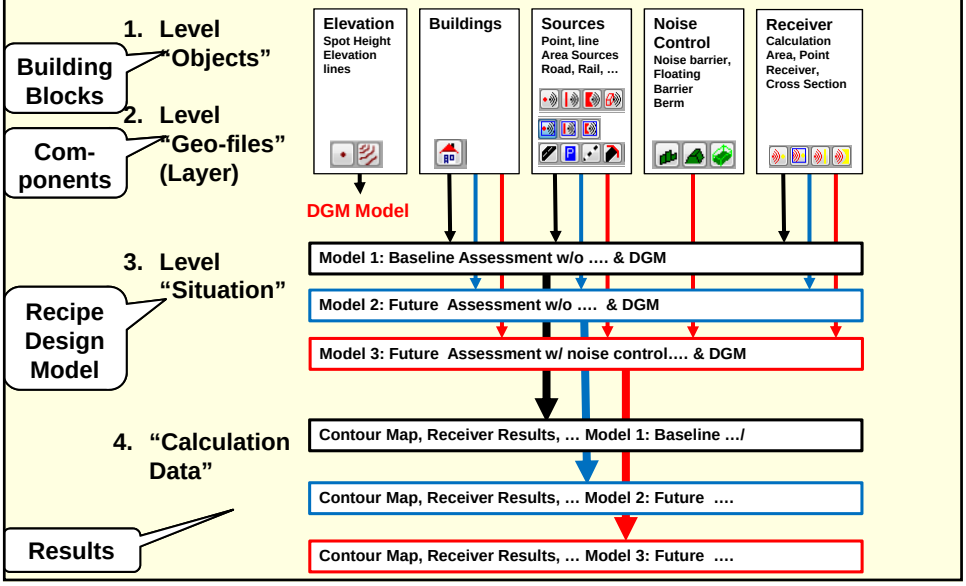
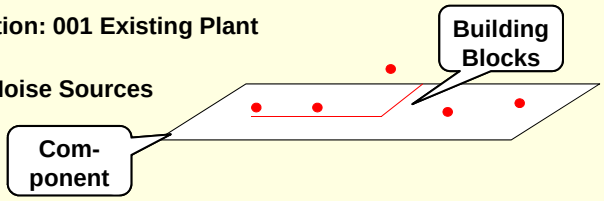
Data Flowchart & Management of Project Situation/Scenario



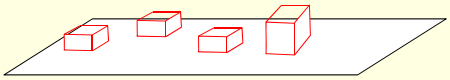
Environmental Noise Modeling Tools for Engineering & Planning Solutions

Scenario / Situation: 001 Existing Plant

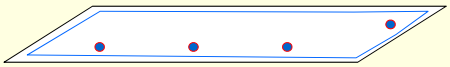
- 001 Plant Noise Sources



- 001 Plant Structures



- 001 Receiver



- DGM (Elevation)

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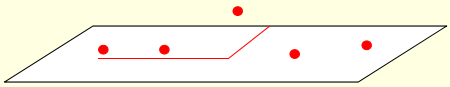
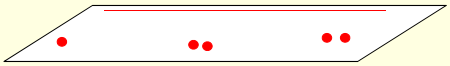
Scenario / Situation: 002 Future Plant

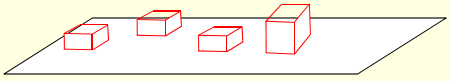
- 001 Plant Noise Sources



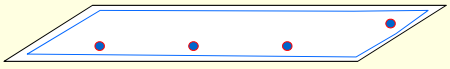
- 002 New Noise Sources (Road, Rail,…)



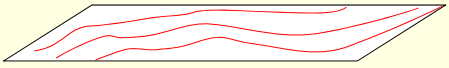
- 001 Plant Structures



- 001 Receiver



- DGM (Elevation)



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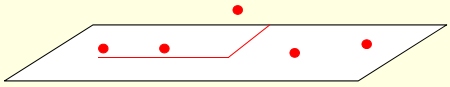
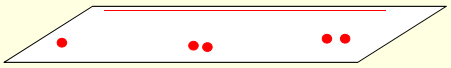
Scenario / Situation: 003 Future Plant w/ Noise Barrier

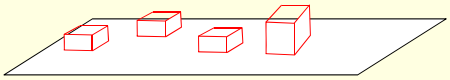
- **001 Plant Noise Sources**



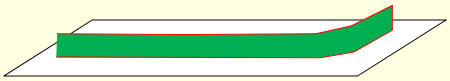
- **002 New Noise Sources (Road, Rail,…)**



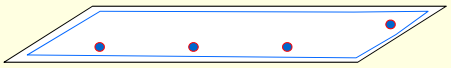
- **001 Plant Structures**



- **003 Noise Barrier**



- **001 Receiver**



- **DGM (Elevation)**

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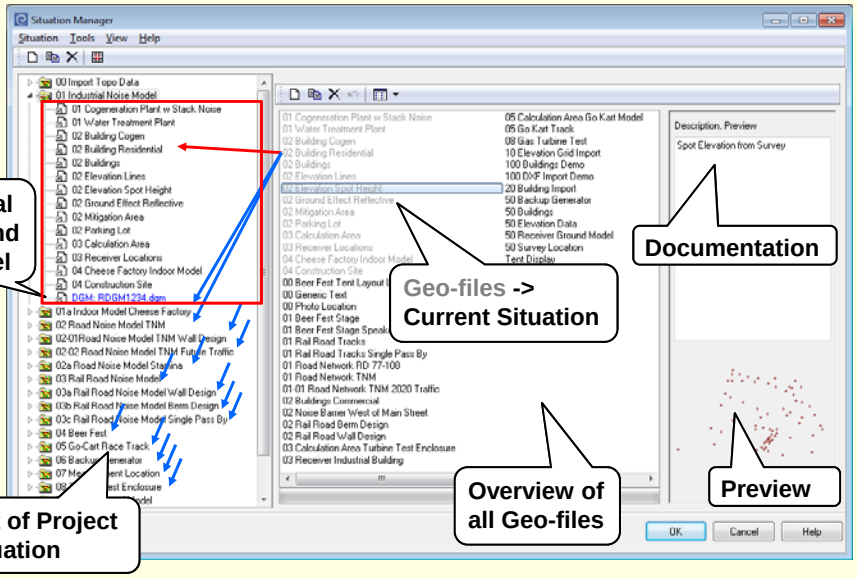
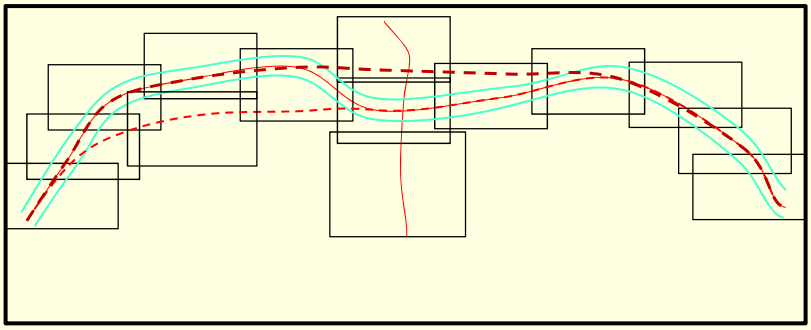
Project Planning & Organization / Situation Manager



Aerial Views & Usage

- Problem: Project Drawings usually do not extend to receptors locations
- Aerial Photography is easy way to add missing data
- Scaling with 2+ local or world coordinates
- Google Earth Interface via Coordinate and Reference System
- Geo-referenced Maps

Mooz & Zoom Aerial Section for Transportation Corridor Noise Study



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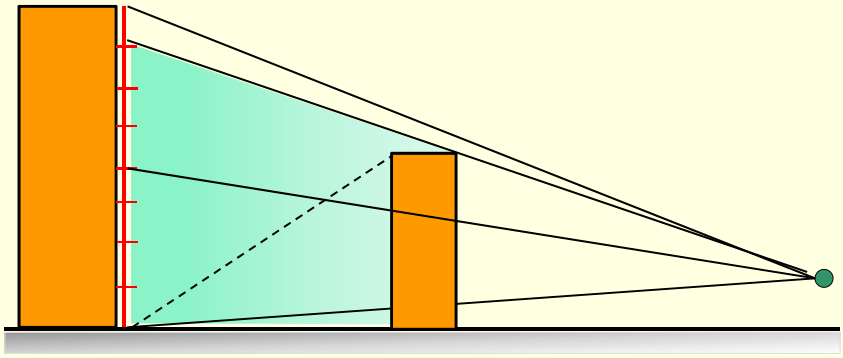
Noise Modeling Technique

SoundPLAN's Dynamic Search

- Search starts from receiver
- Find sources that are relevant for receiver (ranking by free field propagation) Tolerance Factor (Calculation Speed)
- Find obstacles (buildings, walls, berms,…), ground definition between source and receiver (line of sight, over/around/under)
- Find reflective walls close to receiver, close to source providing reflection contribution (Reflections)
- Iterative division of line and area sources to ensure adequate propagation (Accuracy)
- Consider propagation correction based on selected standard (Type of Source, Emission, Spectra,..)

Iterative Division Line / Area Sources



$D_{ground} + D_{shielding} > x$ dB

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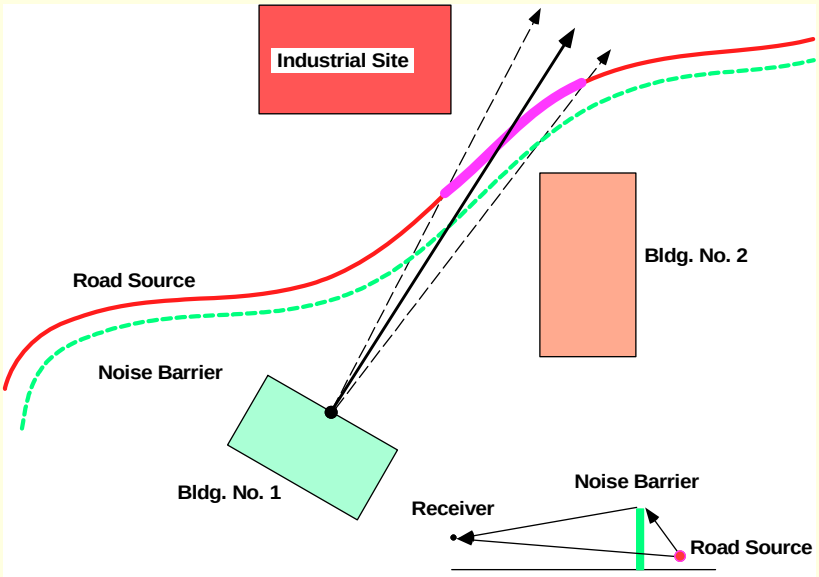

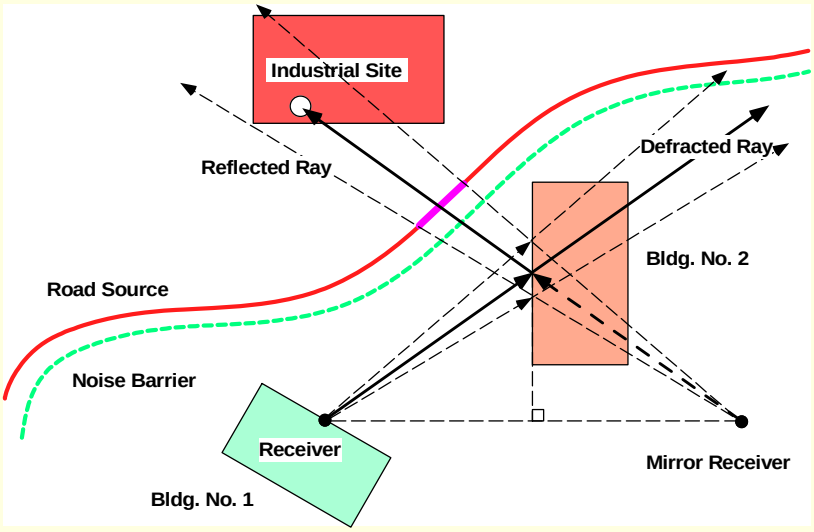

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Noise Modeling Technique Cont'd

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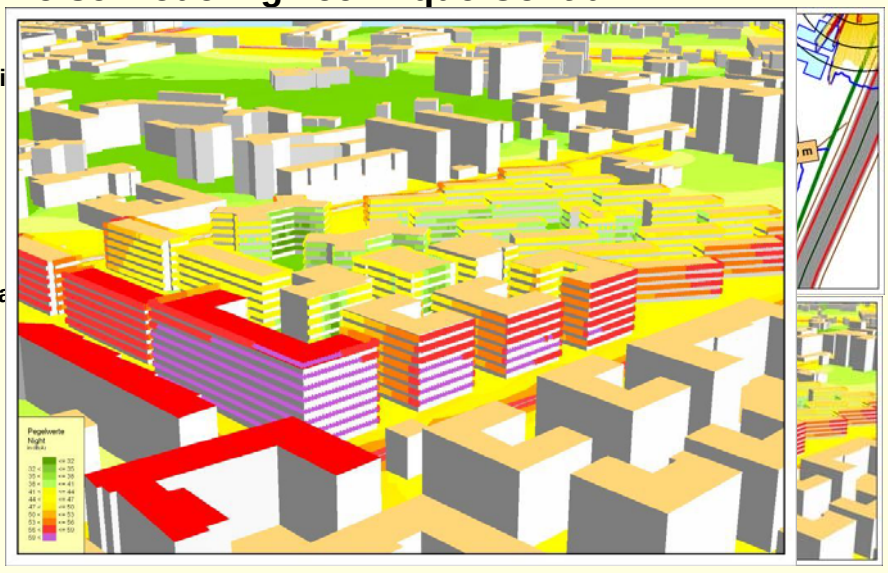
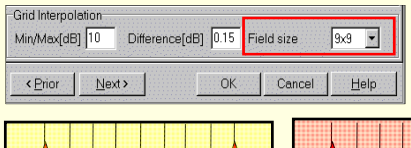


Noise Modeling Technique Cont'd

- Grid Noise Map (equal space distance, x m above ground)
  - ✓ Spacing effects computation time
  - ✓ Spacing effects spatial aliasing
  - ✓ Interpolation (Balance Processing Speed vs. Accuracy)



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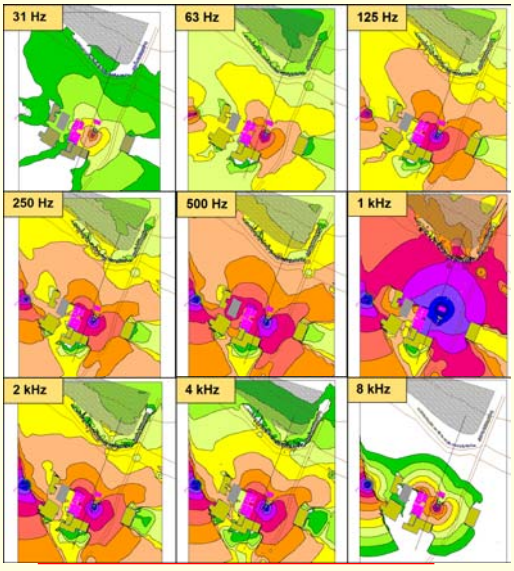
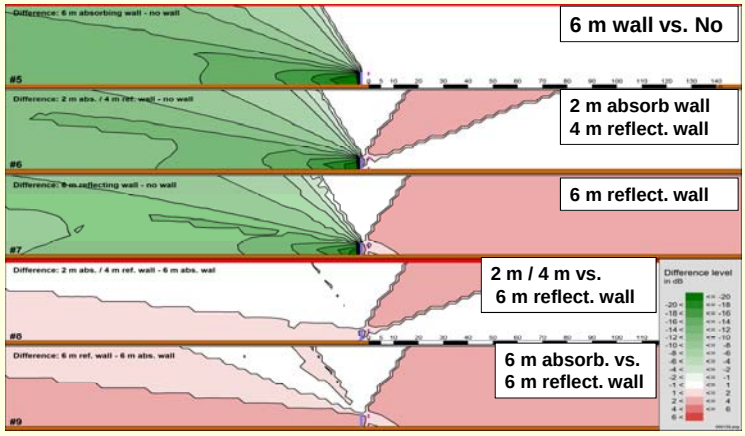
Noise Modeling Technique Cont'd

- Meshed Noise Contour Map
  - No Interpolation
  - Triangle Mesh
  - Points density is a function of acoustic activity
  - Every Point Calculated
  - Results – Overall & Spectra



Noise Modeling Technique Cont'd

- Cross Section / Vertical Noise Map
  - Overall sound level prediction
  - Grid spacing effects computation in regards to time & spatial aliasing



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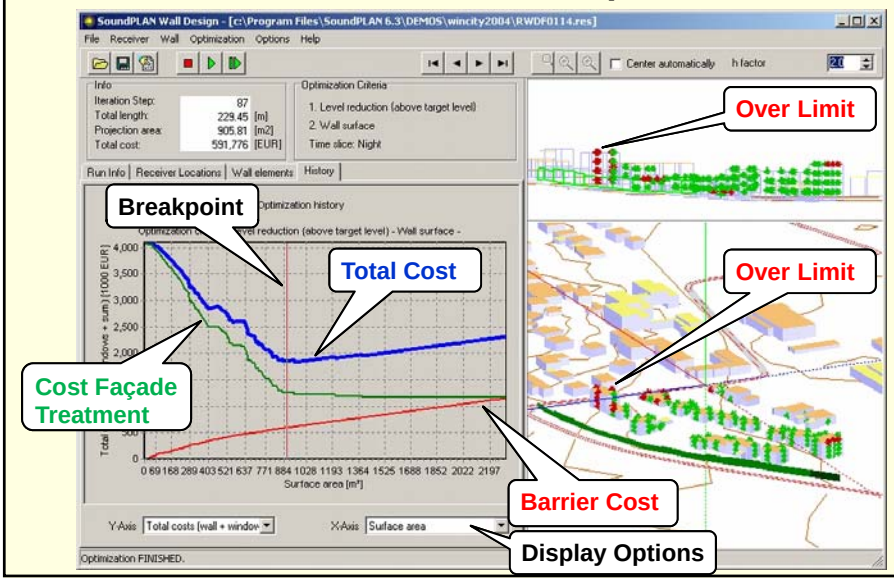
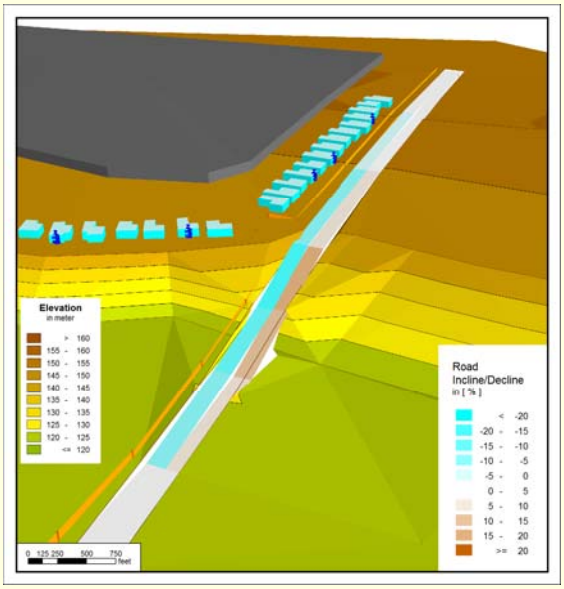
Barrier / Berm / Window Optimization





Visual Check

- Road Incline TNM
- Ground Model

  Topography

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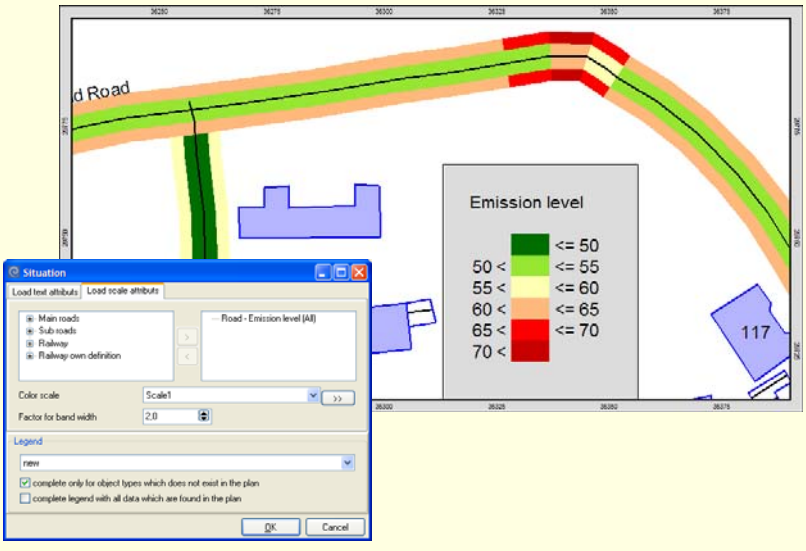
Visual Check – Traffic Noise Emission



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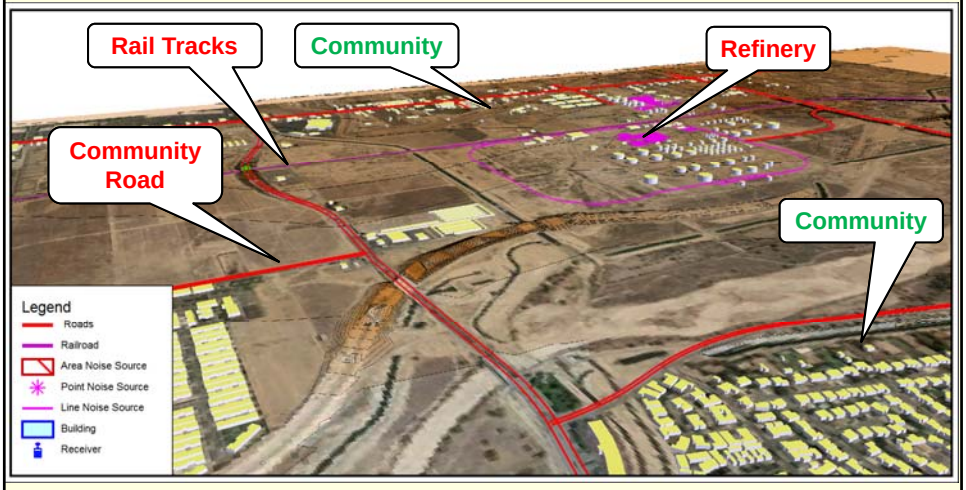
Visual Check – Topography / Aerial / Project Input



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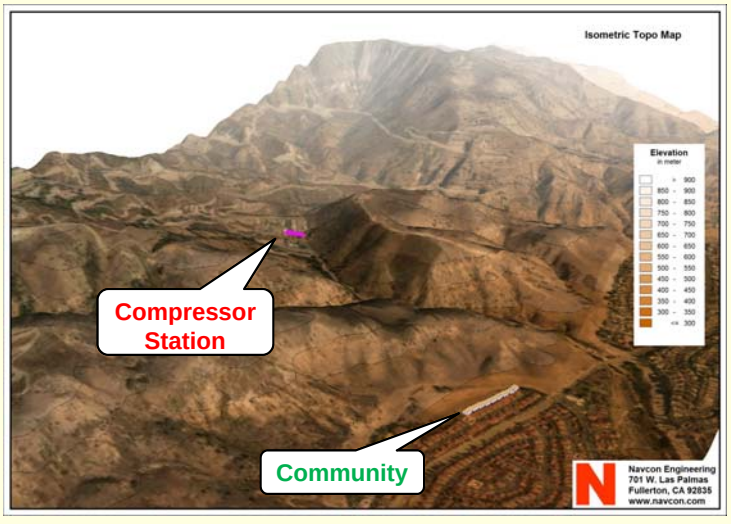
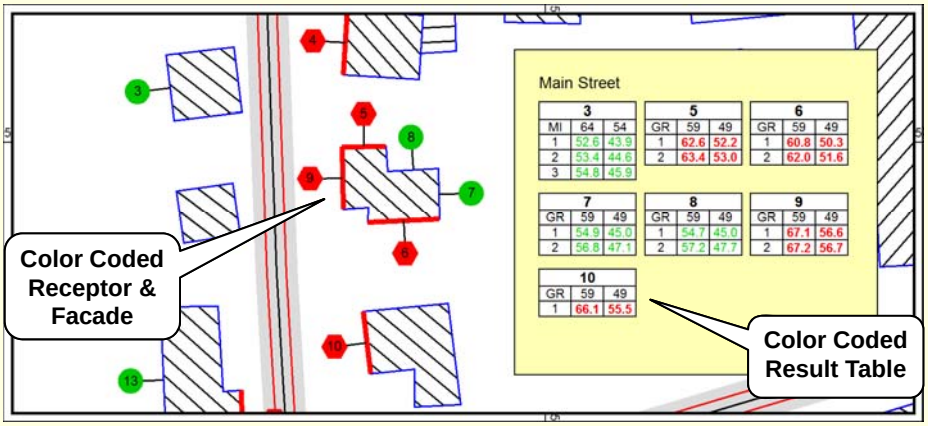
Visual Check – Topography / Aerial / Project Input



Visual Check Documentation



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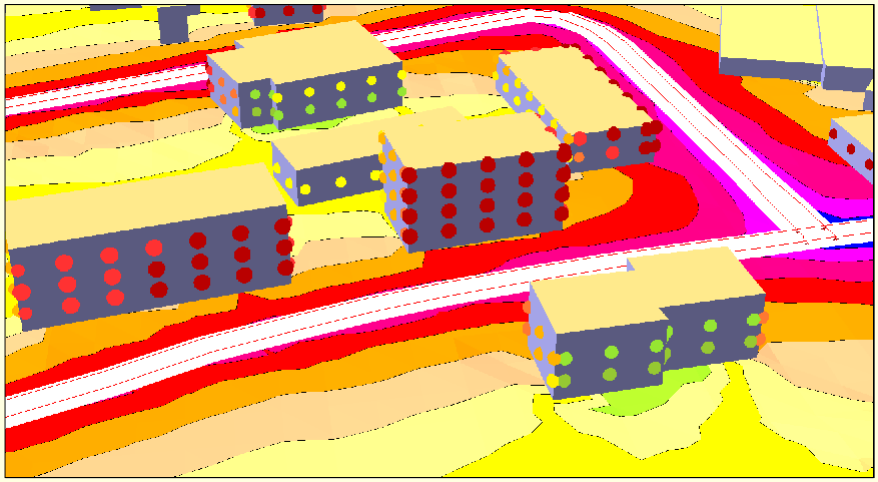
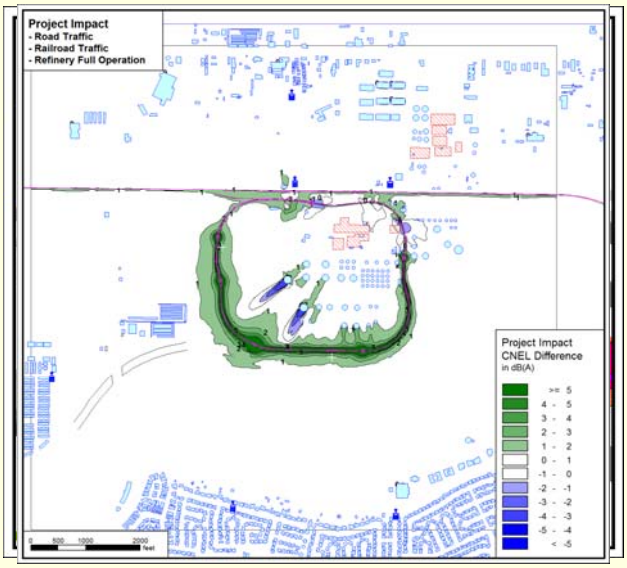
Façade Result – Graphic Representation



Contour Result – Graphic Representation



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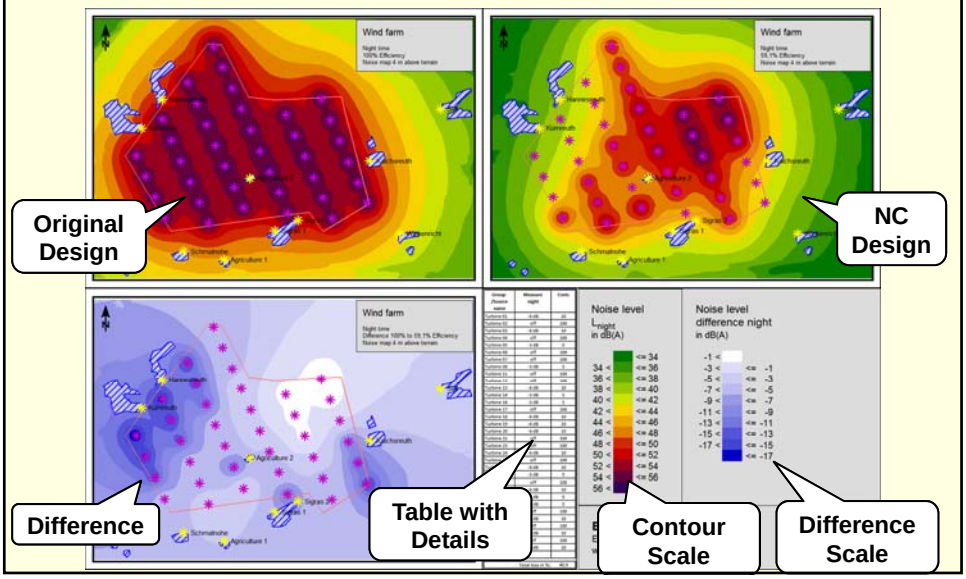
Contour Result – Graphic Representation



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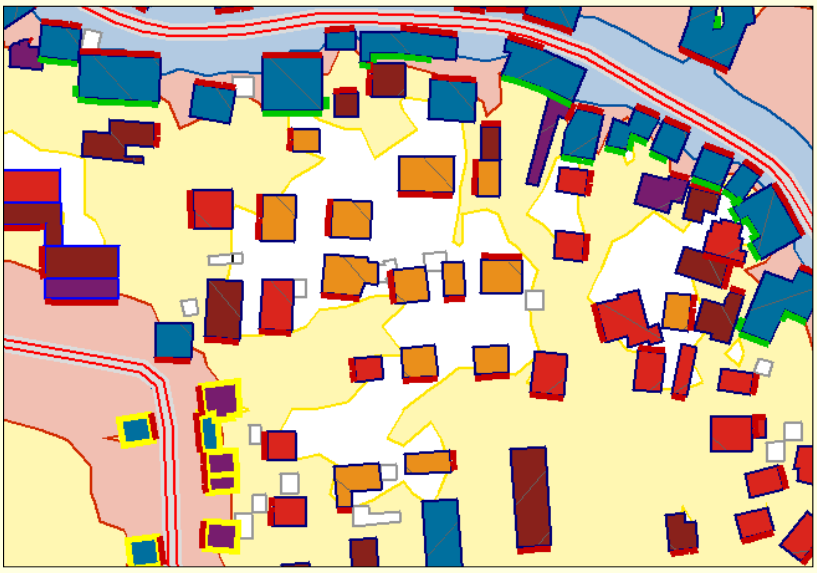
EU Directive – Graphic Representation



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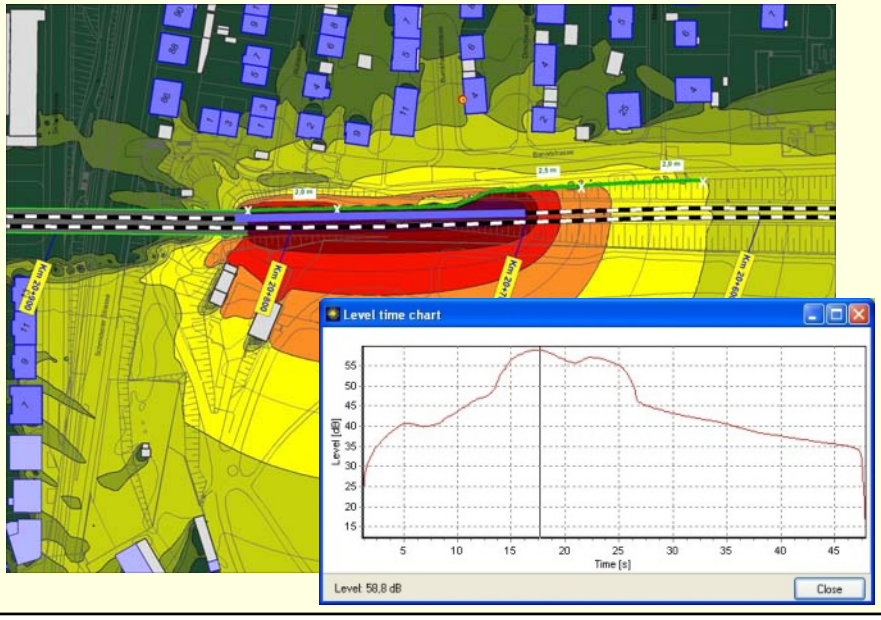

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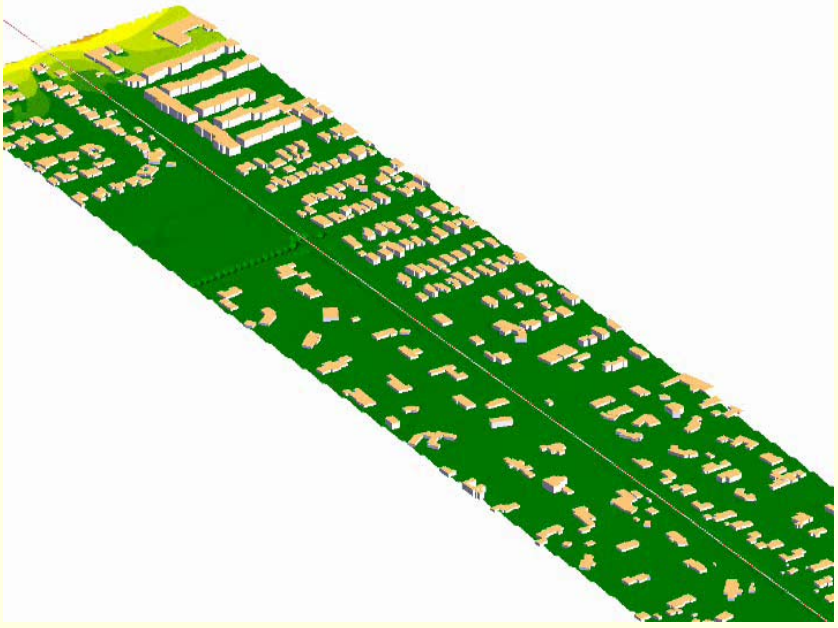

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Conclusions:

- Environmental awareness and regulation will increase with the population density and mobility.
- As acoustical engineers we will tasked with solving even more complex noise problems.
- We have to become multifaceted.
- In the 1970's & 1980's engineering technology was driven by the hardware manufacturers.
- Today engineering technology is driven by our software tools.
- These tools allow us to attack more complex problems with increased efficiency, accuracy, traceability and transparency.