A Comparison of ISO 9613-2 and Advanced Calculation Methods -- Predictions Versus Experimental Results

PART 1

Introduction

Overview

- A poll by Mediterranean Acoustics on LinkedIn showed that well above 50% of acousticians favour ISO 9613-2 for outdoor sound propagation.
- Nord 2000, Harmonoise, Concawe and other methods share the remaining 50% of those asked.
- Nord 2000, Harmonoise are advanced calculation models implemented in user friendly software.
- Some commercial software has several standards available in the same package.

Standards vs Independent Research

Standards

- Positive: standards can provide same answers by independent users
- Negative: perceived as dogma, and often provide inaccurate results
- By-products: provide widely accepted algorithms

Independent Research

- Detective work with lots of twists and turns in the plot
- It needs intuition and a stomach for the ups & downs
- By-products: unique algorithms – possibly less widely accepted

Software (SW) Based on Standards v. Independent Research

- SW based on standards provide: simpler code, fast and approximate results
- SW based on Research provides: complicated code, slower yet more accurate results than SW based on standards
What follows in this presentation

- Theoretical background of one software package - "OTL - Terrain" by PEMARD
- ISO 9613-2 background
- Presentation of comparison of results
- Discussions on results
- Conclusions

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The sound pressure at a receiver location in Terrain

The A-weighted sound pressure at a receiver location in Terrain

\[ 10 \log \left[ \sum_{i=1}^{N} \left( \frac{p_i \cdot e^{i \theta_i}}{R_i} \cdot a \cdot Q_i \cdot s \cdot Q_n \cdot D \right) \right] - A \]

**coherent summation**
- \( I \) is path loss of possible sound path between Source and Receiver
- \( P \) is a particular path's source sound pressure at 1m
- \( N \) is the number of paths between Source and Receiver
- \( n \) is the number of reflections within a particular sound path between Source and Receiver
- \( R \) is the total length of a particular sound path between Source and Receiver

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The sound pressure at a receiver location in ISO

\[ 10 \log \left( \sum_{i=1}^{N} 10^{0.1(A_i + B_i - A_{iso} - A_{iso} - A_{iso} - A_{iso} - A_{iso} - A_{iso} - A_{iso} - A_{iso} - A_{iso} - A_{iso} - A_{iso})} \right) \]

- \( A_i \) is the octave-band sound power level, in decibels, produced by the point sound source relative to a reference sound power of one picowatt (1 pW)
- \( B_i \) is the directivity correction, in decibels, that describes the extent by which the equivalent continuous sound pressure level from the point sound source deviates from a specified direction from the level of an omnidirectional point sound source producing sound power level \( P \). \( D \) is the directivity index \( D \) of the point sound source plus an index \( D \) that accounts for sound propagation into solid angles less than 4\( \pi \) steradians (for an omnidirectional point sound source radiating in free space, \( D = 0 \) db)
- \( A_{iso} \) is the attenuation due to geometrical divergence
- \( A_{iso} \) is the attenuation due to atmospheric absorption
- \( A_{iso} \) is the attenuation due to the ground effect
- \( A_{iso} \) is the attenuation due to a barrier
- \( A_{iso} \) is the attenuation due to miscellaneous other effects

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ISO 9613 – 2, background

- Empirical method adopted as a standard in 1996
- Lends itself for spreadsheet calculations
- There were good reasons at that time for adopting ISO 9613-2 as a standard

But
- There is ambiguity in its implementation
- Two different users can come up with different results

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Presentation of comparison of results among, OTL – Terrain, ISO 9613-2 and published measured data.
Published measured data used were also used for the validation of Nord2000 model.

- Cases selected from measured data are based on distance, with and without barrier. Also, chosen to be simple to be handled by ISO 9613-2.

Cases used for the validation of NORD 2000 (www.delta.dk) and implemented in ISO 9613-2 and OTL – Terrain.

<table>
<thead>
<tr>
<th>Distance S - R</th>
<th>Case 13</th>
<th>Case 17</th>
<th>Case 33</th>
<th>Case 36</th>
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• All results in Excess Attenuation (EA i.e. Transfer Function) which is the effect of the environment on direct sound.

• Results: Black dots represent measurements results, the blue curve OTL – Terrain results and the red curve ISO 9613-2 results

• Geometry
  - Sound paths between Source and Receiver up to 3rd order diffraction
  - Mapping, using OTL – Terrain, either on vertical or horizontal planes
  - Depending on the case, mapping shows EA of ground, EA of barrier, level with or without barrier
Case History

Traffic Noise and Residential Abatement
PART 4
Discussion on Comparison of Results

- Measurement data
- OTL-Terrain results
- ISO 9613-2 results

Measurement Data

- There is little information on methodology used to obtain results for the cases examined
- We were able to track down some of the cases where the methodology is given but which are not included in this presentation
- K.B. Rasmussen, the person who conducted some of the sound measurements, mentions that for some cases there was uncertainty about the choice of flow resistivity.

OTL – Terrain Results

- Fair match between OTL-Terrain & measurements
- Anticipated better agreement
- More information on measurements allows better modelling
- We have conducted measurements to simulate diffraction [scattering] from stone steps in ancient theatres.
- Lateral shifts of source or receiver with respect to the barrier produce significant change in results.
ISO 9613-2 Results

• Apparent deviations from measured data
• Lack of detail to interpret sound propagation mechanisms
• Ambiguity of the standard could allow different results

Discussion On Comparison Of Results

PART 5

Conclusions

ISO 9613-2

• Empirical method
• Simple in concept to be understood
• Simple to implement
• Widely used since its publication in 1996
• It has served the acoustical community well
But
• Inaccurate and imprecise

Advanced Calculation Methods offer

Sound rays in a 3D environment carrying information on how to:
• Reduce intensity with distance
• Interact with atmosphere, turbulence and refraction
• Reflect from objects
• Diffract around and scatter from objects
• In the near future, lose intensity through structures

In the future advanced calculation methods could offer...

One calculations engine for:
• Outdoor Sound Propagation
• Building acoustics
• Room acoustics
• Duct-borne sound transmission and others
But
• They are computationally expensive

Conclusions

• Nowadays technology allows the replacement of old empirical methods with new scientific methods
• Advanced calculation methods offer better results
But
• Their implementation in software applications should offer more answers than questions
• Users need a better understanding of the science behind them in order to properly interpret results
• They need to serve the user and not the other way round
We say,
"The less time one needs to use a software application the better the application is"