A Comparison of ISO 9613-2 and Advanced Calculation Methods Using Olive Tree Lab-Terrain, An Outdoor Sound Propagation Software Application: Predictions Versus Experimental Results

21st March 2012

Panos Economou

Mediterranean Acoustics Research & Development

Cyprus

Panos Economou's background

- Founder of Panacoustics Ltd an acoustics consultancy in Cyprus in 1982
- Between 1990 and 1992, Principal Engineer at Noise and Vibration Department Atkins-Epsom, UK, in charge of Architectural Acoustics
- Founder of P.E. Meditarranean Acoustics Research & Development (PEMARD) – developers of Olive Tree Lab - Terrain™, in Cyprus in 2009

Panos holds

- BSc in Mechanical Engineering
- MSc in Applied Acoustics
- Member of IOA, ASA, AES, HELINA, IEEE, and the Cyprus Technical Chamber (ETEK).

PART 1

Introduction

pemard
mediterranean acoustics research & development

Overview

- Mediterranean Acoustics Poll 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.

- How many ISO 9613-2 users are there in this room?

pemard
mediterranean acoustics research & development

Why is ISO 9613-2 still the favourite method?

This is a question you might help answer after the presentation during a brief discussion.

pemard
mediterranean acoustics research & development

Standards vs Independent Research

Standards

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

pemard
mediterranean acoustics research & development

Independent Research

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

pemard
mediterranean acoustics research & development

Software (SW) based on Standards vs 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 on standards

pemard
mediterranean acoustics research & development

What follows in this presentation

- OTL- Terrain theoretical background
- ISO 9613-2 background
- Presentation of comparison of results
- Discussions on results
- Conclusions

pemard
mediterranean acoustics research & development

OTL – Terrain is based on the work of :

- Salomon's ray model using analytical solutions
- Hadden & Pierce for spherical wave diffraction coefficients
- Chessel for spherical wave reflection coefficients
- Delany & Basley for finite surface impedance
- Clay on finite size reflectors with Fresnel zones
- Keller on his geometrical theory of diffraction
- Sound path explorer – an in-house model to detect and draw diffraction and reflection sound paths in a 3D environment
- Harmonoise for atmospheric turbulence

pemard
mediterranean acoustics research & development

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

pemard
mediterranean acoustics research & development

PART 3

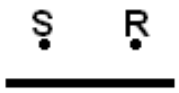
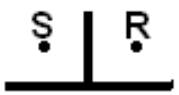
Presentation of comparison of results among, OTL – Terrain, ISO 9613-2 and published measured data.

pemard
mediterranean acoustics research & development

Published measured data used, was also used for the validation of Nord2000 model.

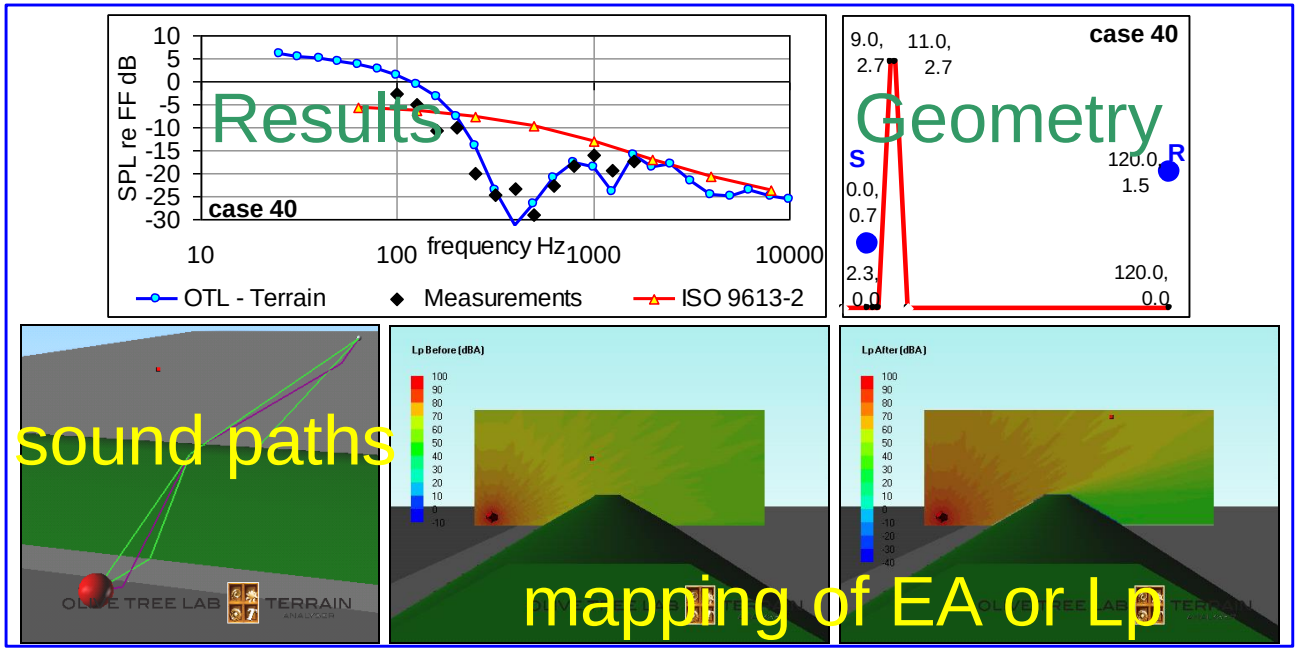
- Cases selected from measured data are based on **distance**, **with and without barrier**. Also, chosen to be **simple** to be handled by ISO 9613-2.

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

Distance S - R					
4.5 m	Case 13	Case 17	Case 33	Case 36	
50 m		Case 91			Case 92
100 m	Case 77				
120 m					Case 40

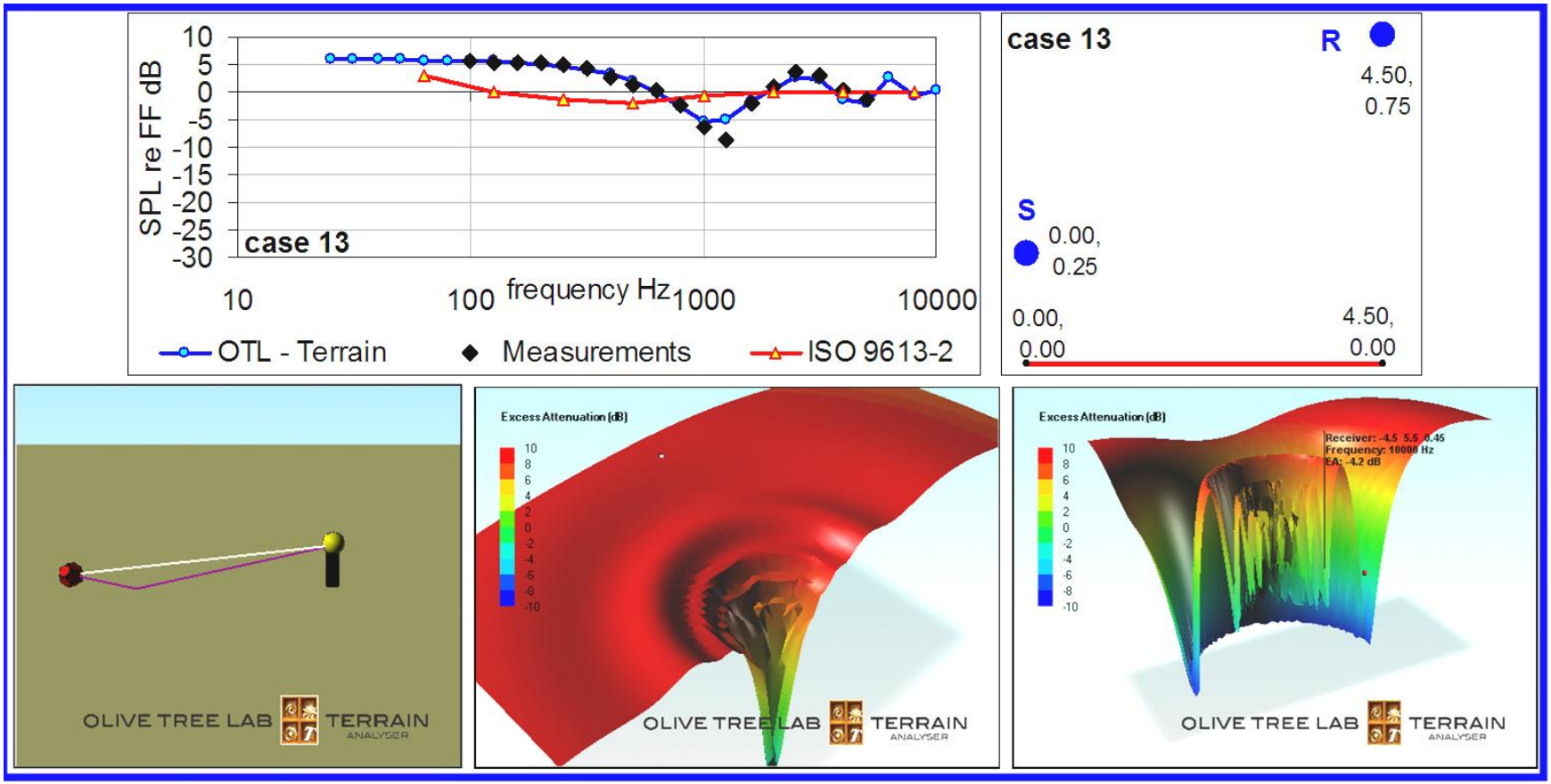
Presentation of results template

- 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

Distance S - R	S R	S R	S R	S R	S R
4.5 m	Case 13	Case 17	Case 33	Case 36	
50 m		Case 91			Case 92
100 m	Case 77				
120 m					Case 40

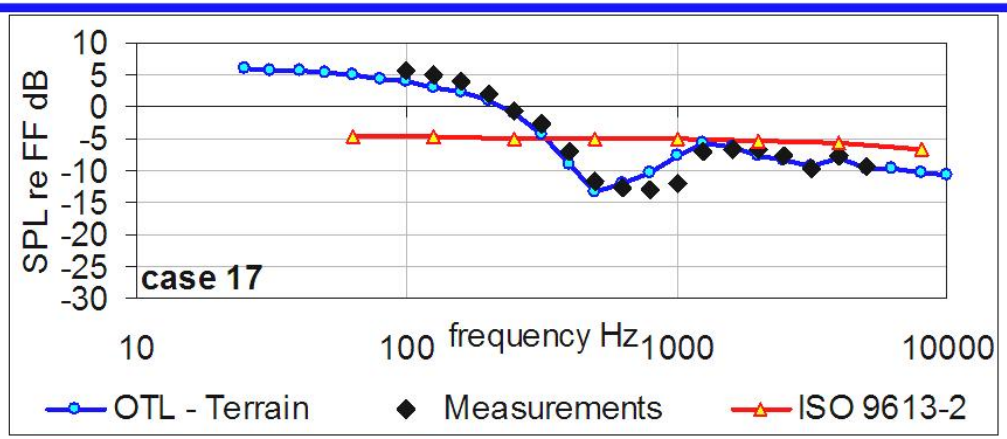


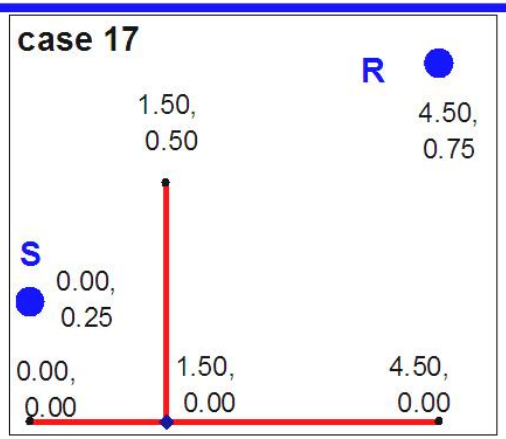
Sound paths between Source and Receiver

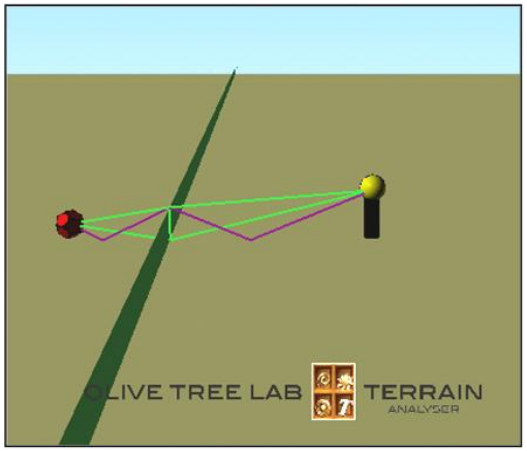
Mapping, on horizontal plane depicting EA of ground, broadband results

Mapping, on horizontal plane depicting EA of ground, 10 kHz

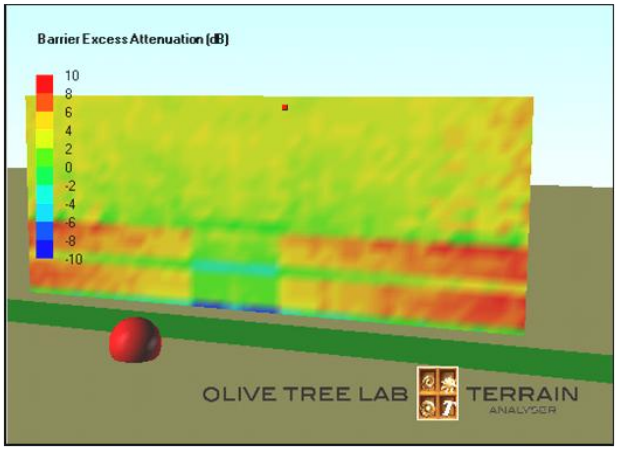
Distance S - R	S R	S R	S R	S R	S R
4.5 m	Case 13	Case 17	Case 33	Case 36	
50 m		Case 91			Case 92
100 m	Case 77				
120 m					Case 40



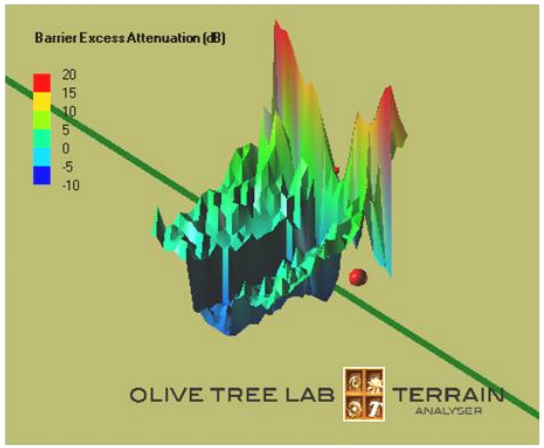




Sound paths between Source and Receiver

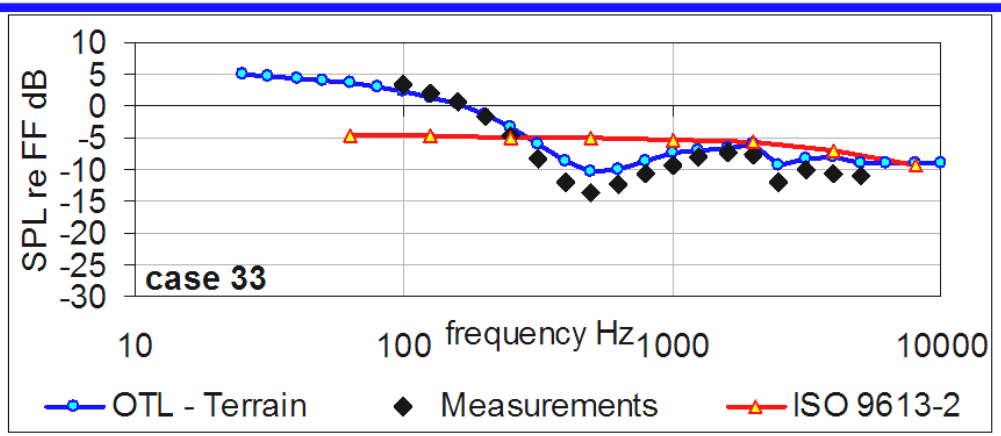


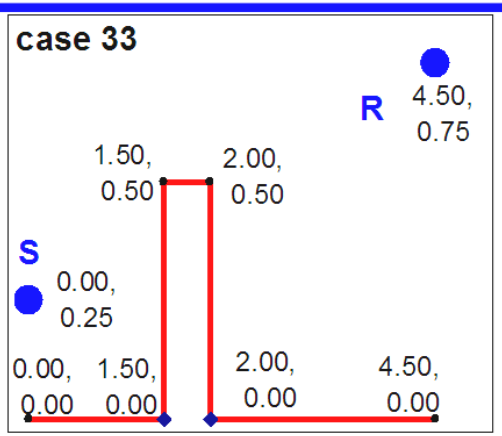
EA mapping, on vertical plane behind barrier

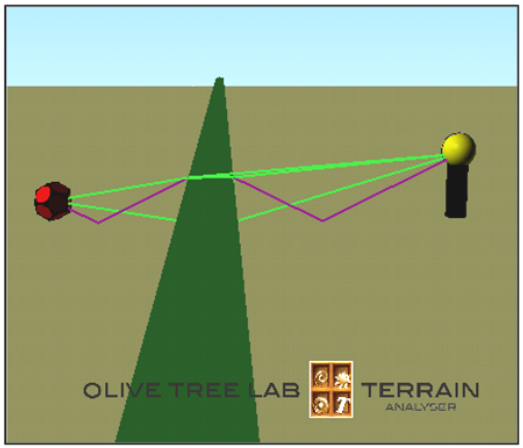


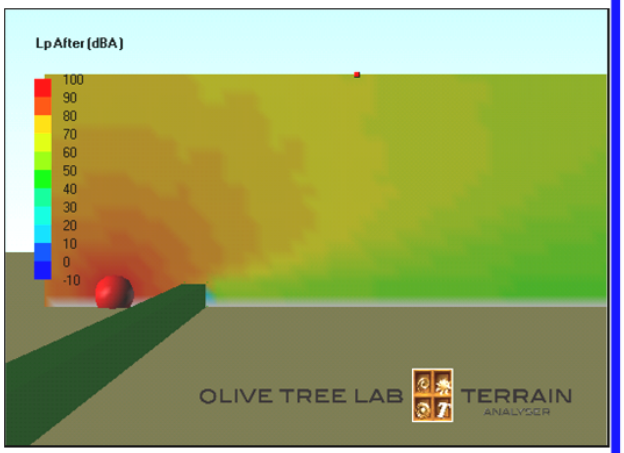
EA mapping on horizontal plane across barrier

Distance S - R	S R	S R	S R	S R	S R
4.5 m	Case 13	Case 17	Case 33	Case 36	
50 m		Case 91			Case 92
100 m	Case 77				
120 m					Case 40







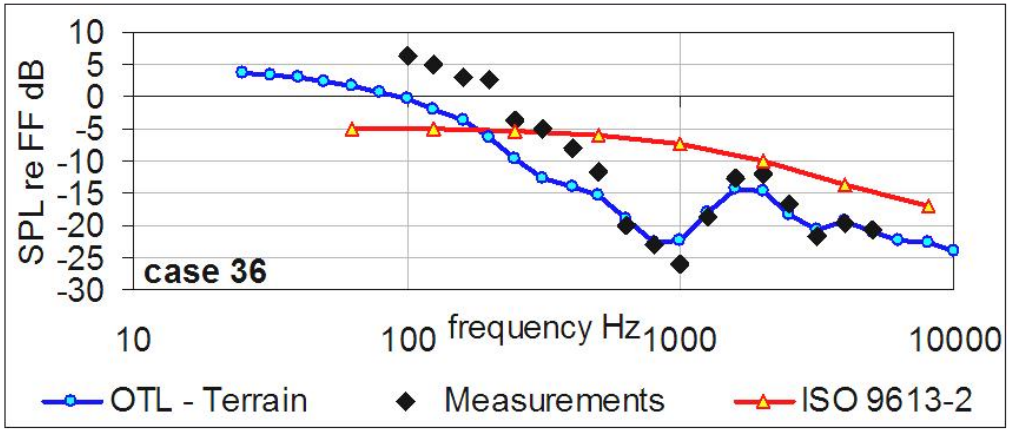


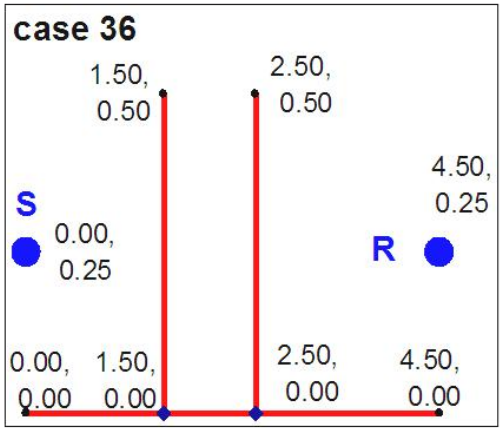
Sound paths between Source and Receiver

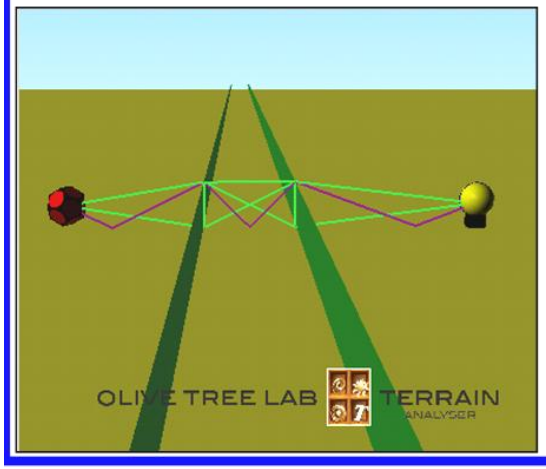
SPL mapping, on vertical plane across barrier BEFORE

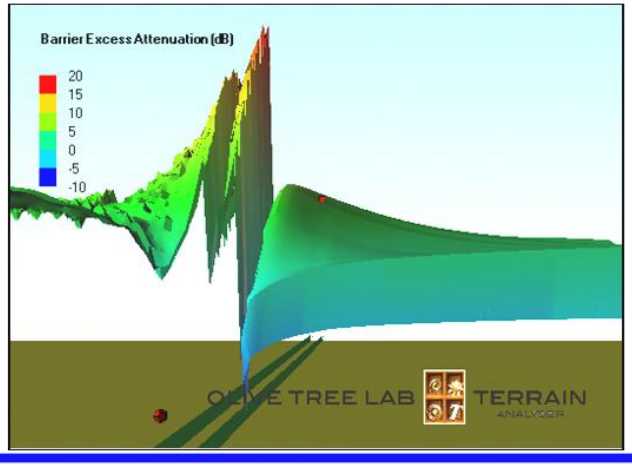
SPL mapping, on vertical plane across barrier AFTER

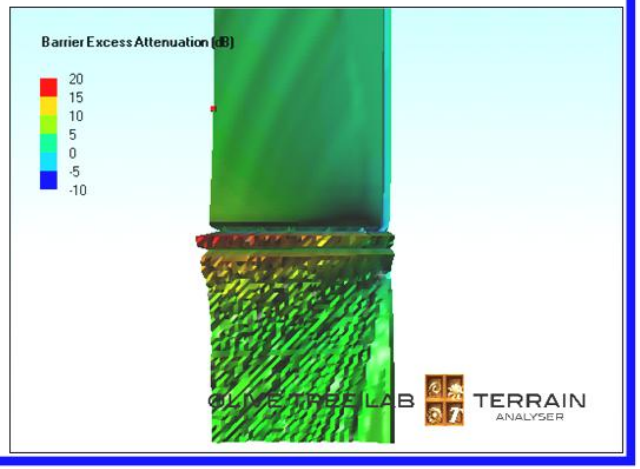
Distance S - R	S R	S R	S R	S R	S R
4.5 m	Case 13	Case 17	Case 33	Case 36	
50 m		Case 91			Case 92
100 m	Case 77				
120 m					Case 40









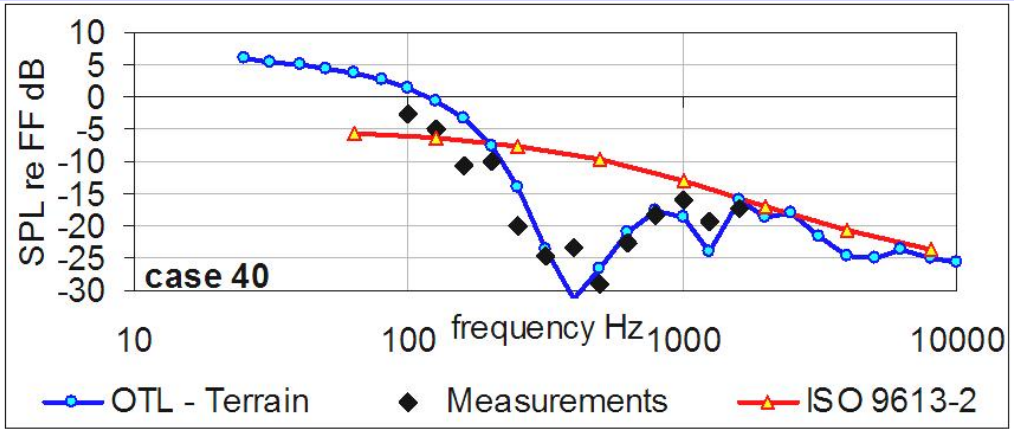


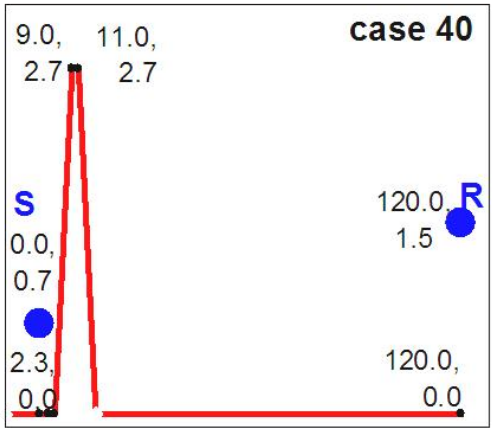
Sound paths between Source and Receiver

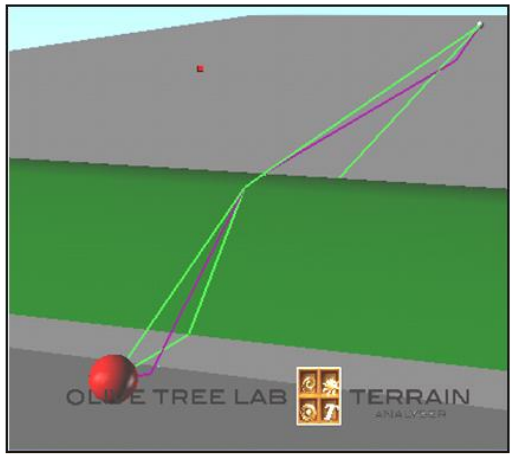
EA mapping, on horizontal plane across barriers, side view

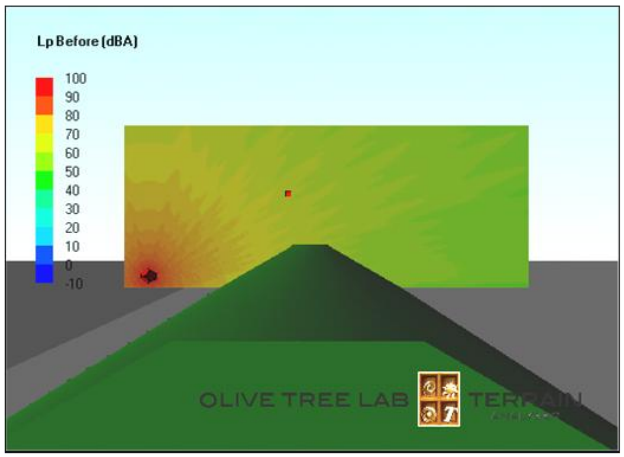
EA mapping, on horizontal plane across barriers, top view

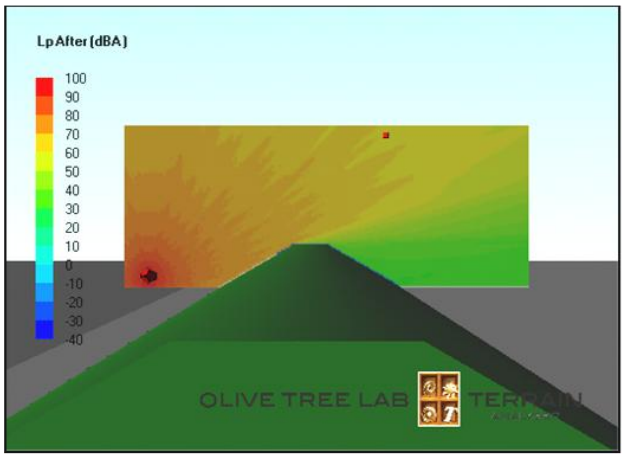
Distance S - R	S R	S R	S R	S R	S R
4.5 m	Case 13	Case 17	Case 33	Case 36	
50 m		Case 91			Case 92
100 m	Case 77				
120 m					Case 40









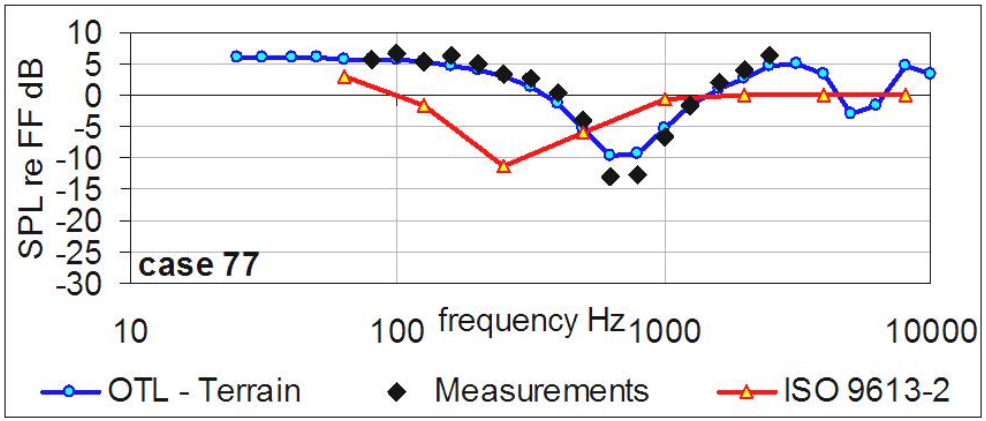


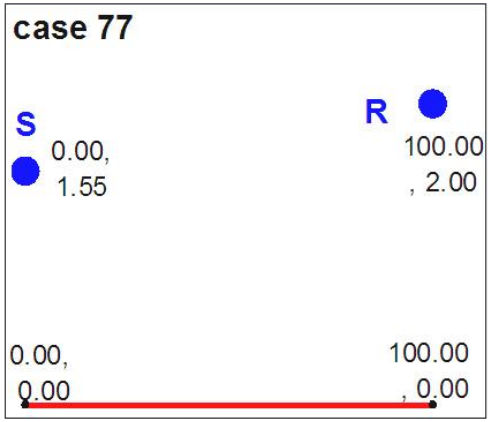
Sound paths between Source and Receiver

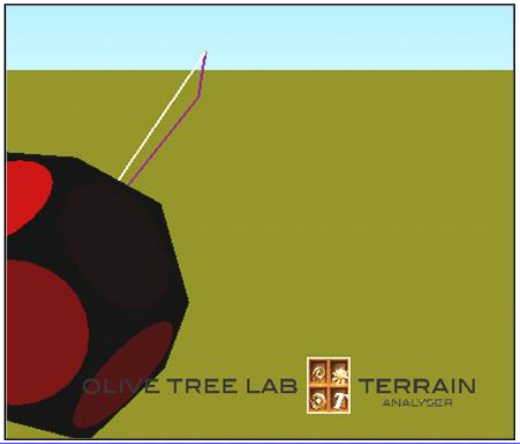
SPL mapping, on vertical plane across barrier BEFORE

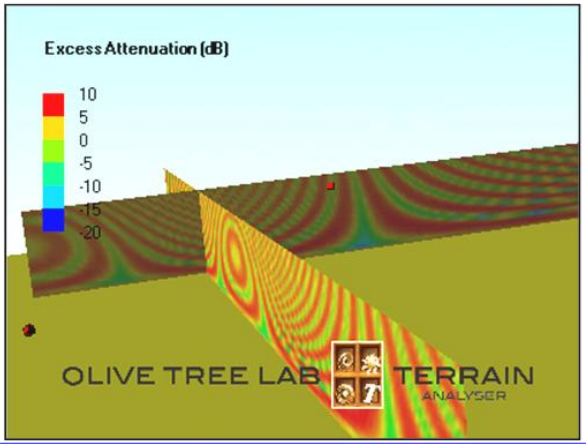
SPL mapping, on vertical plane across barrier AFTER

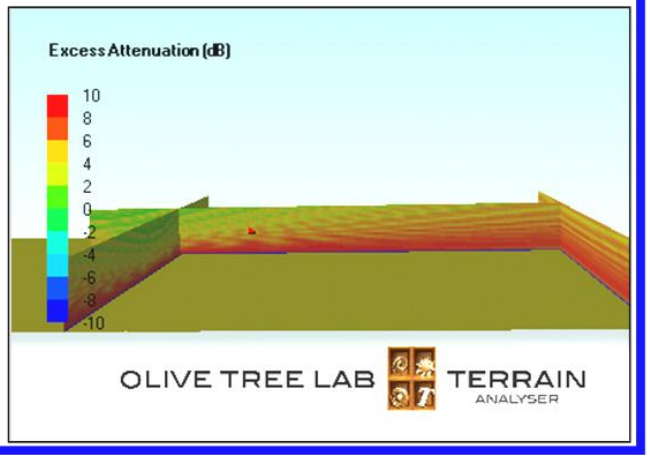
Distance S - R	S R	S R	S R	S R	S R
4.5 m	Case 13	Case 17	Case 33	Case 36	
50 m		Case 91			Case 92
100 m	Case 77				
120 m					Case 40









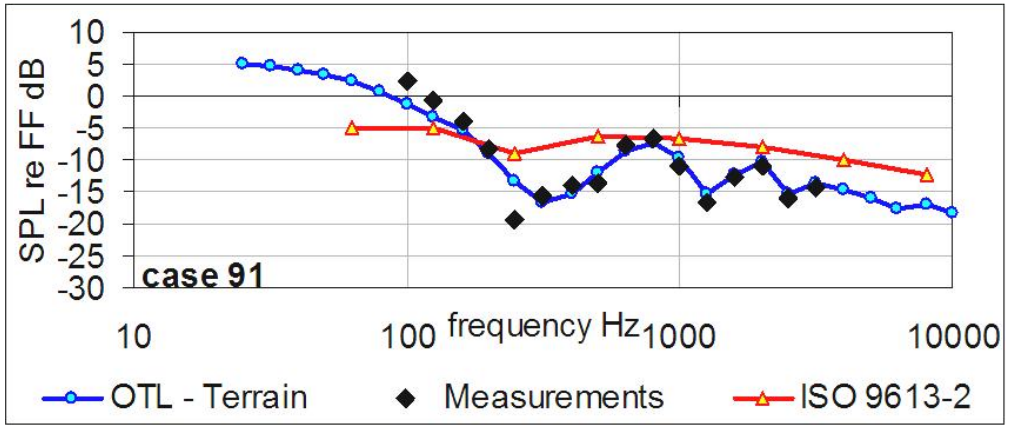


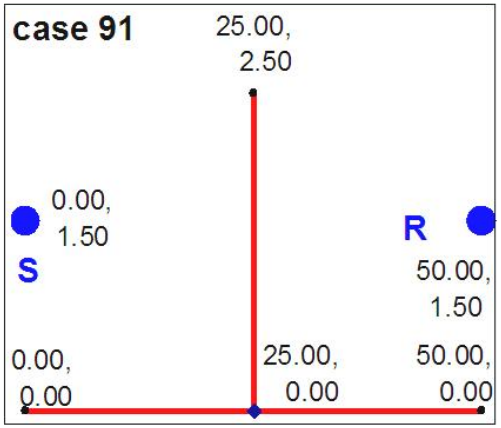
Sound paths between Source and Receiver

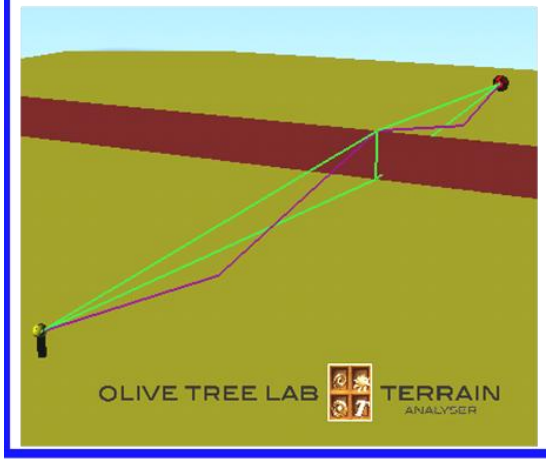
EA mapping, on vertical planes, 10kHz

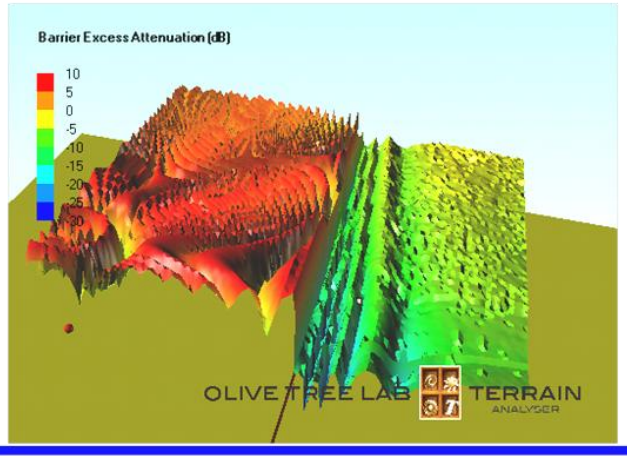
EA mapping, on vertical planes, broadband

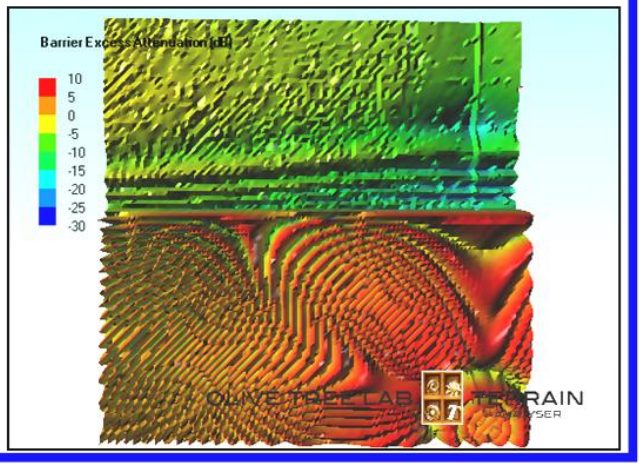
Distance S - R	S R	S R	S R	S R	S R
4.5 m	Case 13	Case 17	Case 33	Case 36	
50 m		Case 91			Case 92
100 m	Case 77				
120 m					Case 40









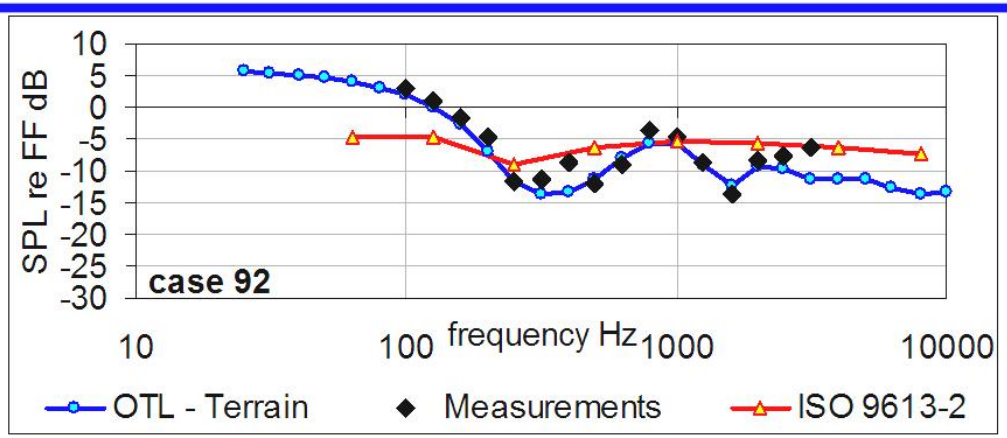


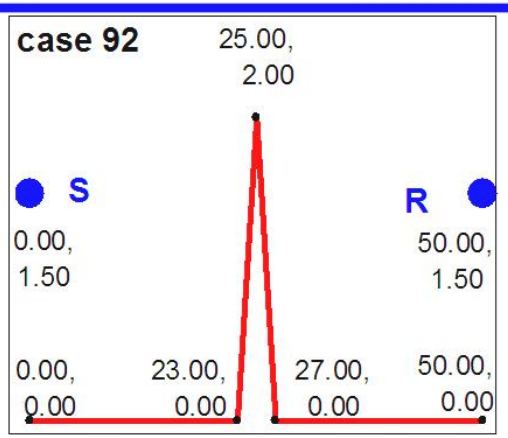
Sound paths between Source and Receiver

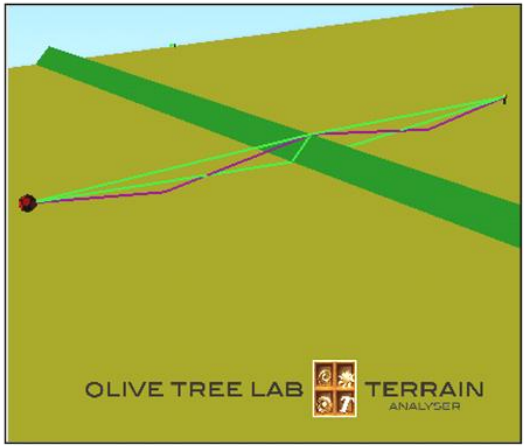
EA mapping, on horizontal plane across barrier, side view 10 kHz

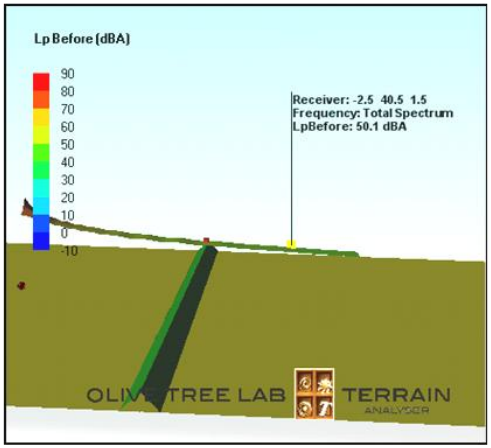
EA mapping, on horizontal plane across barrier, top view 10 kHz

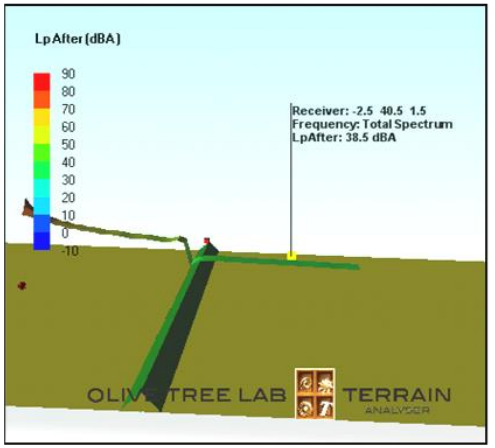
Distance S - R	S R	S R	S R	S R	S R
4.5 m	Case 13	Case 17	Case 33	Case 36	
50 m		Case 91			Case 92
100 m	Case 77				
120 m					Case 40











Sound paths between Source and Receiver

SPL mapping, on horizontal plane across barrier BEFORE

SPL mapping, on horizontal plane across barrier AFTER

PART 4

Discussion On Comparison Of Results

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

pemard
mediterranean acoustics research & development

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.

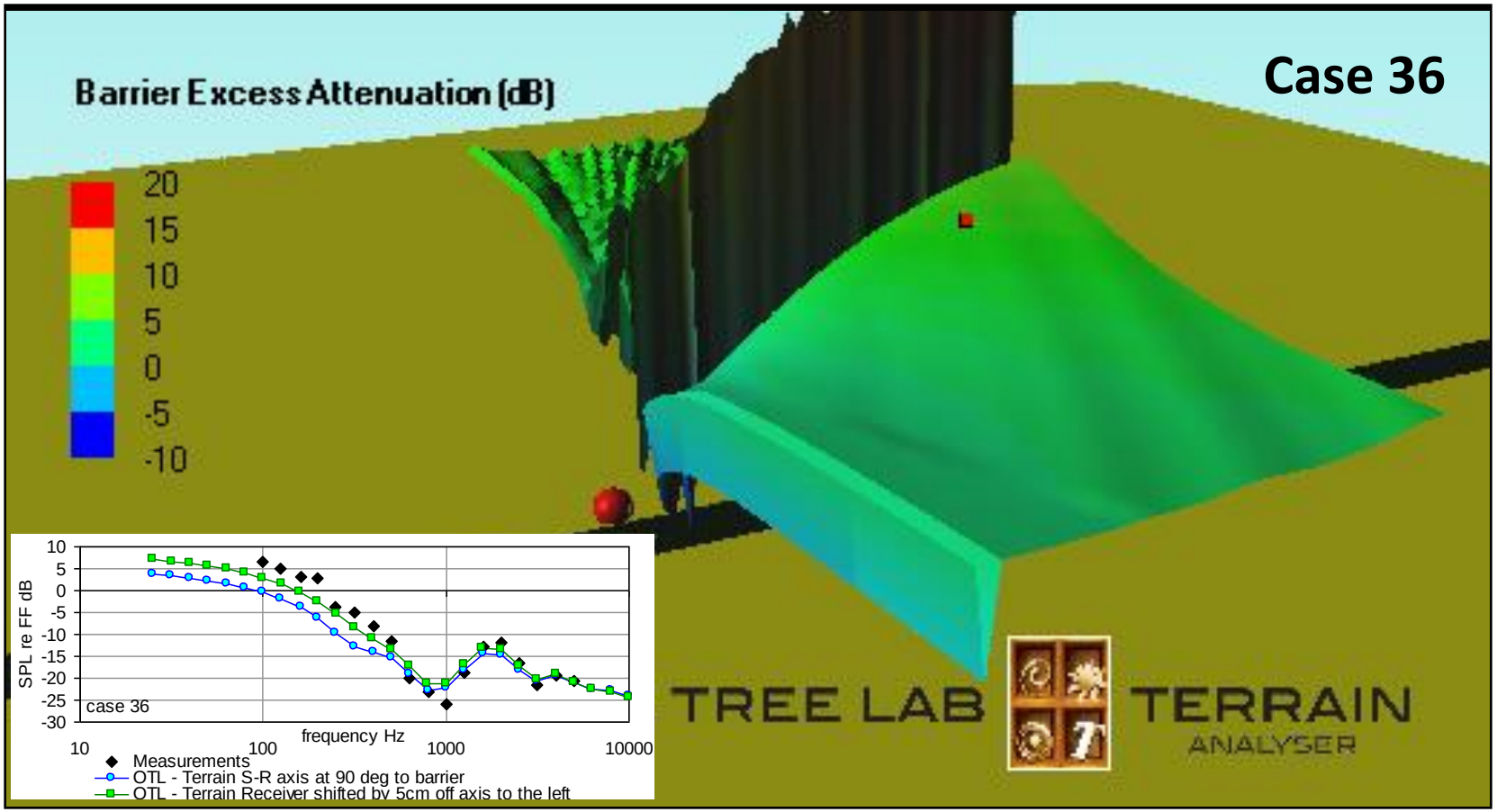
OTL – Terrain Results

- 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.

pemard
mediterranean acoustics research & development

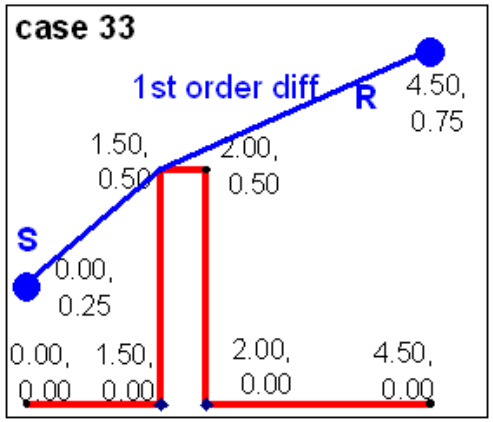
OTL – Terrain Results contd.

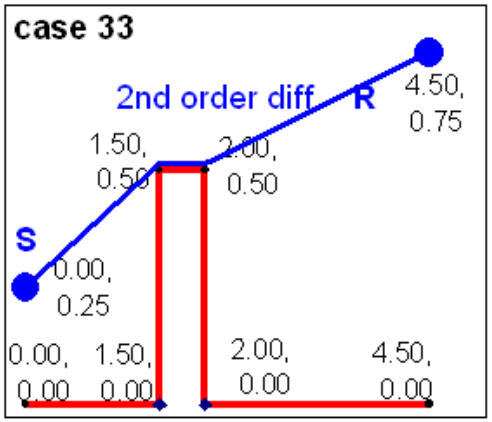
- Results are very sensitive to 3d modelling
- 5cm shift of receiver to the left, improves match between measurements & simulation

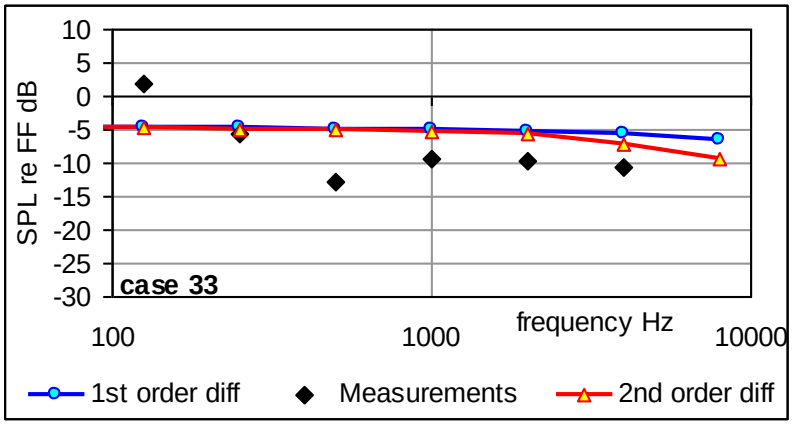


ISO 9613-2 Results

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







pemard
mediterranean acoustics research & development

PART 5

Conclusions

pemard
mediterranean acoustics research & development

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

pemard
mediterranean acoustics research & development

Advanced calculation methods offer

Sound rays in a 3D environment carrying information on how to:

- Lose intensity vs distance
- Interact with atmosphere, turbulence and refraction
- Reflect from objects
- Diffract around and scatter from objects
- In the near future, lose intensity through structures

pemard
mediterranean acoustics research & development

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

pemard
mediterranean acoustics research & development

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”

pemard
mediterranean acoustics research & development

Thank you for your attention.

The question still remains: Why is ISO 9613-2 still the favourite method?

I would welcome some answers, questions or comments.

pemard
mediterranean acoustics research & development