DAGA 2010, Berlin
Vorkolloquium: Soundscape and Community Noise

A Framework of Soundscape Design Potentials

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Outline

- EU COST Action on Soundscape of European Cities and Landscapes
- *Introduction: why soundscape design*
- A framework of soundscape design potentials
  - Sound
  - Space
  - Users
  - Environment
- *Design tools*

Soundscape of European Cities and Landscapes

http://soundscape-cost.org/

COST on

Soundscape of European Cities and Landscapes

COST (European Cooperation in Science and Technology) is one of the longest-running European instruments supporting cooperation among scientists and researchers across Europe [http://www.cost.esf.org/]

Aims

The main aim of the Action is to provide the underpinning science for soundscape research and make the field go significantly beyond the current state-of-the-art.

The Action will promote soundscape into current legislations, policies and practice, aiming at improving/preserving our sonic environment

Objectives

(1) Understanding and exchanging

- Foster interdisciplinary cross-breeding.
- Exchange technical know-how on an international/interdisciplinary basis.
- Examining cultural differences.

(2) Collecting and documenting

- Gather soundscape data to be reanalysed from inter-disciplinary perspectives.

(3) Harmonising

- Review and harmonise the current methodology, and develop a new indicators.
- Develop a standard protocol.
- Lay the foundations for future European/international standards.

(4) Creating and designing

- Provide practical guidance and tools for the design of soundscapes.
- Provide guidelines for preserving architectural heritage sites.

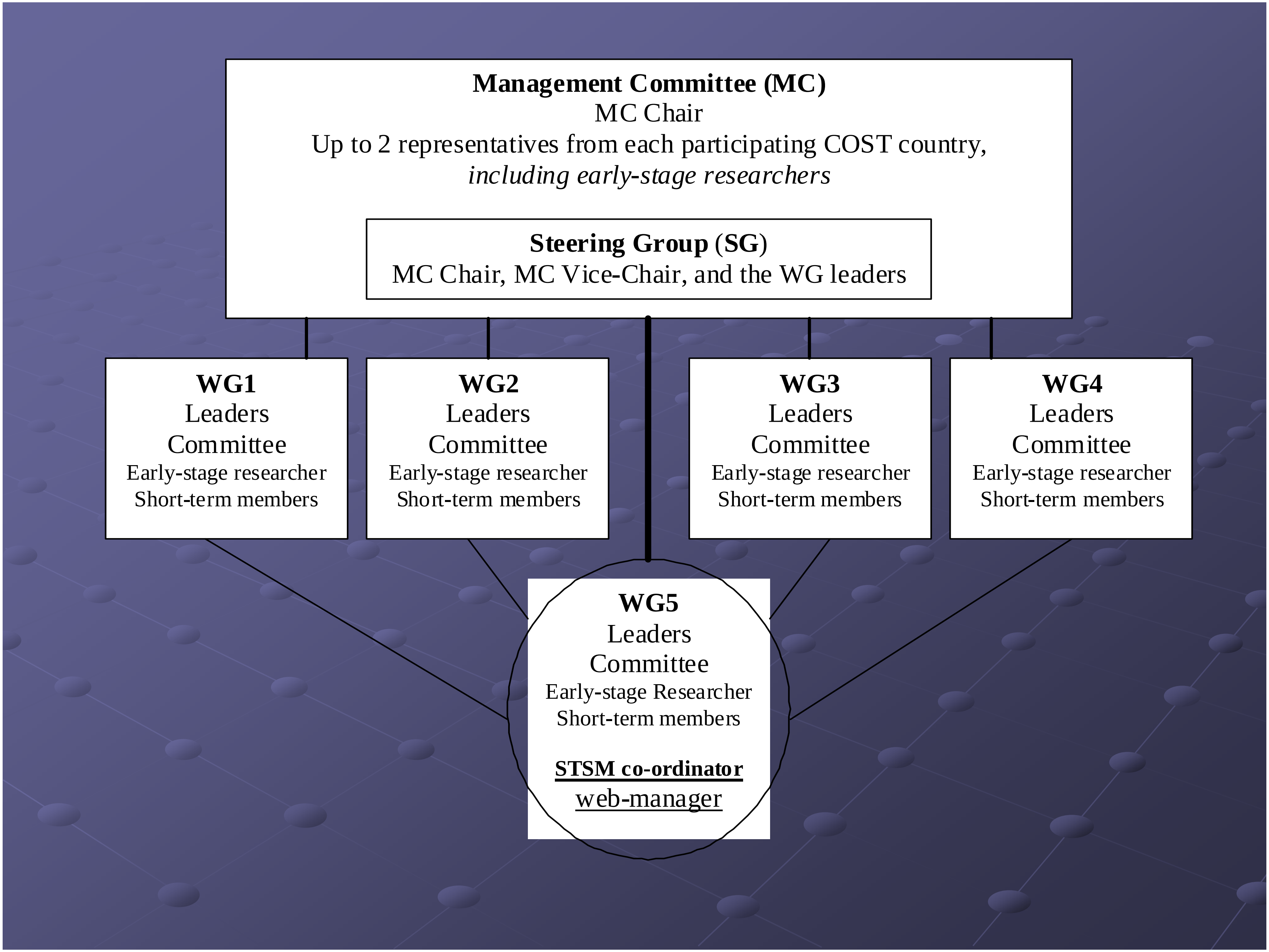
(5) Outreaching and training

- Create awareness among general public, stakeholders and policy makers.
- Provide training for early-stage researchers.

Activity timetable

Table 2

Tasks		Year 1		Year 2		Year 3		Year 4	
WG1									
WG1.1	European languages, vocabularies and terminology for soundscapes	y							
WG1.2	Sound source recognition for soundscape research		y						
WG1.3*	Contributions from cognitive science and auditory perception			y					
WG1.4*	Modelling and simulation of soundscape perception			y					
WG1.5^	Modelling different soundscapes: simulation versus real soundscape					y			
WG1.6^	Acoustical soundscape measurement					y			
WG2									
WG2.1	Brain-storm on documentation of soundscapes	y							
WG2.2	Soundscape data approaches/measures: data compiling/collecting		y						
WG2.3	Exchanges of early-stage researchers (co-ordinated with WG5.6)			y	y	y	y		
WG2.4*	Soundscape data approaches and measures: cities vs. landscapes				y				
WG2.5*	Soundscape data approaches and measures: field vs. lab setting				y				
WG2.6*	Verbal data collection and analysis vs. physical measures				y				
WG3									
WG3.1	Different definitions of soundscapes		y						
WG3.2*	Soundscape indicators: physical, physiological, human etc			y					
WG3.3*	Health and Quality of Life outcome indicators in soundscape			y					
WG3.4	Combination techniques (triangulation, methodological triangulation)				y				
WG3.5	Evaluation of common case studies					y			
WG3.6	Towards soundscape method standardization/harmonization						y		
WG4									
WG4.1*	Soundscape creation and improvement: cities			y					
WG4.2*	Soundscape creation and improvement: landscapes			y					
WG4.3	Preserving the soundscape of architectural heritage				y				
WG4.4	Adaptation of soundscape to enclosed spaces					y			
WG4.5	Deign guidance and application of soundscapes						y		
WG4.6	International standards for soundscape							y	
WG5									
WG5.1	*Awareness day on "Soundscape: new tendencies in urban design" >80 people*								y
WG5.2	*Awareness days: "Listen to your city"*							y	
WG5.3	*Web site*	y	y	y	y	y	y	y	y
WG5.4	*Training school for early-stage researchers, with a think-tank*			y					
WG5.5	*Future soundscape: early-stage researchers think-tank, for roadmap*								y
WG5.6	*STSM exchange visits across WGs, managed within WG5*	y	y	y	y	y	y	y	y
Management									
MC meetings (combined with workshops etc. whenever possible)		x		x		x		x	x
WG meetings (combined with workshops etc. whenever possible)		x		x		x		x	
Steering Group meetings (combined with workshops etc. when possible)			x		x		x		x
Reports									x


Management Committee (MC)
MC Chair
Up to 2 representatives from each participating COST country,
including early-stage researchers
Steering Group (SG)
MC Chair, MC Vice-Chair, and the WG leaders
WG1
Leaders
Committee
Early-stage researcher
Short-term members
WG2
Leaders
Committee
Early-stage researcher
Short-term members
WG3
Leaders
Committee
Early-stage researcher
Short-term members
WG4
Leaders
Committee
Early-stage researcher
Short-term members
WG5
Leaders
Committee
Early-stage Researcher
Short-term members
STSM co-ordinator
web-manager

Participants and open door policy

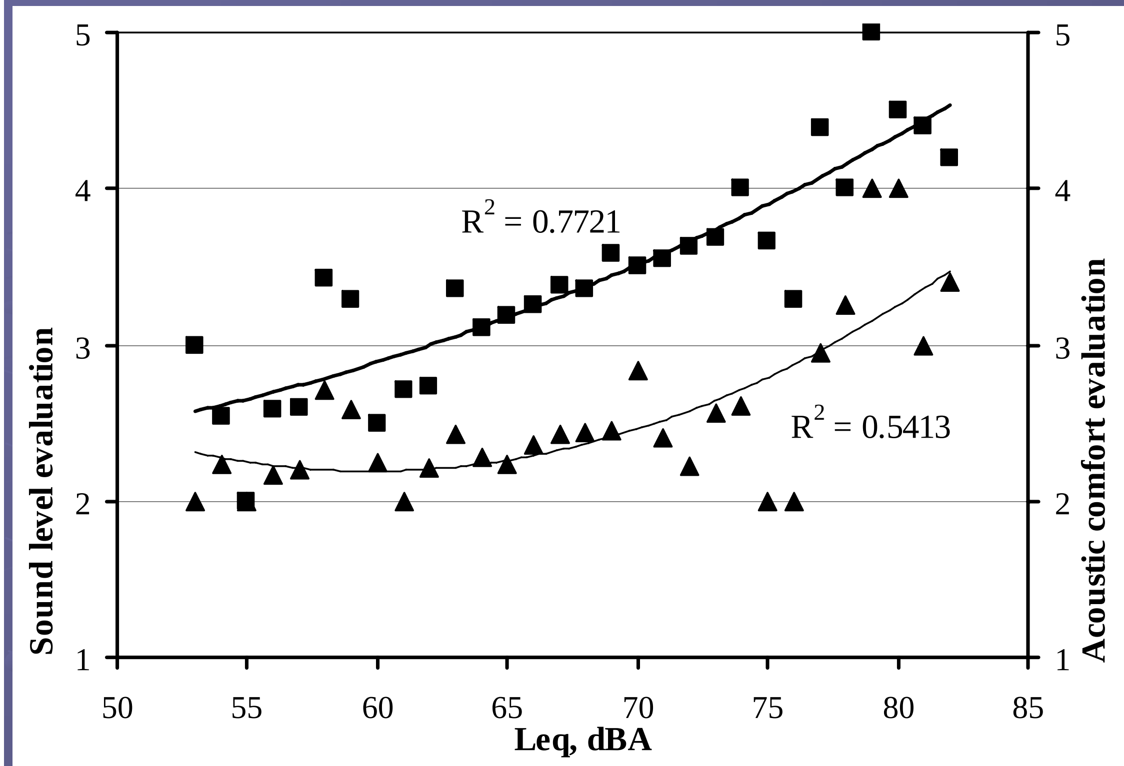
- Initially with 25 participants (MC members) from 16 COST countries and 7 partners outside Europe including USA, Canada, Australia, Japan, Korea, Hong Kong, and China.
- Now about 35 participants (MC members) (18 COST countries).
- Each COST country up to 2 MC members.
- Others can join WP, or just workshops etc, as invited experts or just attendees.

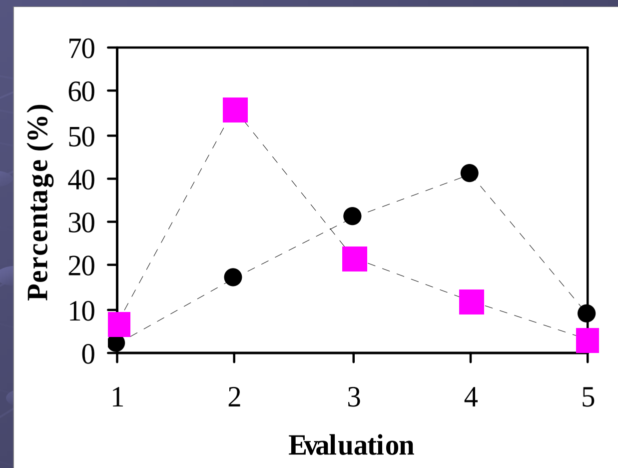
Coming activities

- Workshop in Gent, 29-30 April 2010 (with joint IOA/ABAV meeting).
- Training School, September 2010 (with EAA).
- Soundscape conference in Stockholm, September 2010.
- STSM

Introduction: why soundscape design

Evaluation of soundscape vs. sound level





Peace Gardens, Sheffield

1, Very quiet (very comfortable);
2, quiet (comfortable);
3, neither quiet (comfortable) nor noisy (uncomfortable);
4, noisy (uncomfortable);
5, very noisy (very uncomfortable).

SOUNDSCAPE

on relationships between ear, human being, sound environment and society

relating to acoustics, aesthetics, anthropology, architecture, ecology, human geography, landscape, linguistics, media arts, musicology, noise control engineering, philosophy, psychology, political science, religious studies, sociology, and urban planning

science, engineering, social science, humanity and art

From noise reduction to soundscapes creation

- Soundscape research will bring a step change in environmental acoustics by considering environmental sounds as a 'resource' rather than a 'waste'.
- This will support the design and implementation of urban sound environment that promote health, attract investment, convey cultural uniqueness and enhance quality of life.

EU

Sheffield China

Framework for soundscape design: designable factors to be considered

- Each source (type)
  - Sound pressure level
  - Spectrum
  - Temporal conditions
    - Variation (hour, day, season)
    - Duration
    - Impulsive characteristics
  - Location
  - Source movement
  - Psychological/social characteristics
    - Meaning
    - Natural or artificial sound
    - Relation to activities
    - Soundmark
    - Descriptive or holistic
- Effect of the space
  - Reverberation
  - Reflection pattern and/or echogram
  - General background sound
  - Sounds around the space
- Users
  - Social/demographic factors, activities and behaviours
  - Acoustic condition at users' home and work, experience, etc
- Other environments
  - Temperature, humidity, lighting, etc
  - Visual, landscape and architectural characteristics

Sounds

Active and passive sounds

- In addition to dividing sounds as keynotes, foreground sounds and soundmarks, sound sources in an urban open space can be divided into:
  - active sounds
    - relate to sounds from the activities in the space, e.g. group dancing
  - passive sounds
    - relate to the sounds from the landscape elements, e.g. fountains

Designable factors/potentials

Spectrum – also important when using psychoacoustic magnitudes
dynamic process
acoustic zones and scale - suitable aural space or source-listener distance for each zone
… …

Music: a typical active sound

- People are not only interested in the music itself, but are also attracted by the activities of the players.
  - *For live music, the type of music is not important.*
- When music is played using loudspeakers, the type of music and the sound level are important.
  - *Most people don't like loud music played from loudspeakers, or from passing car.*

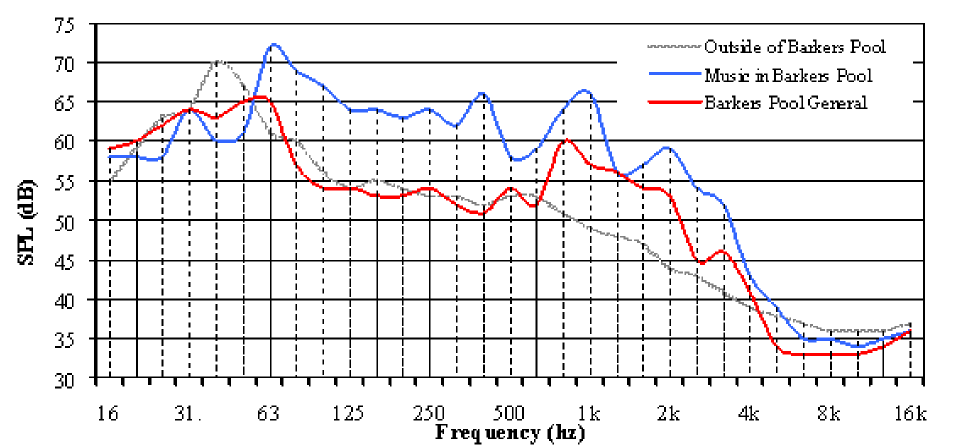


Figure 8.35 Comparison of sound spectra in the Barkers Pool

Spectrum analysis dynamic process

Acoustic zones

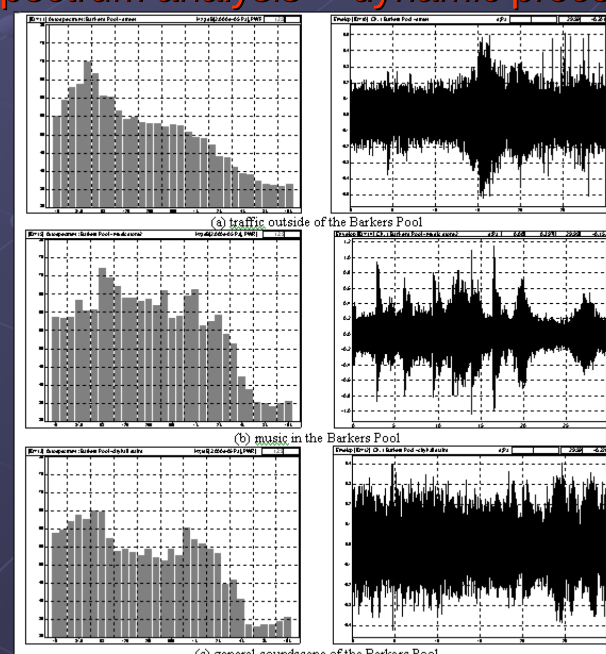


Figure 8.34 Spectra and dynamic range of the sounds in the Barkers Pool

Water: a typical passive sound

Endless effects in colouring the soundscape – ‘primary soundscape quality’

Landscape theory: ‘primary landscape qualities’ - water and foliage

- Spectrum: most water sounds have significant high frequency components around 2k to 8kHz and some of them also have notable low frequency components.

  making water sound distinctive from the background

- Dynamic: The flow rate of a water feature should not be constant.

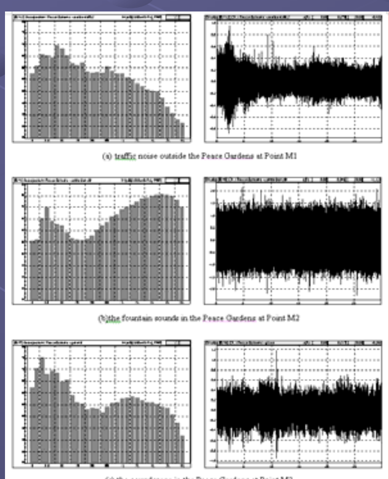


Figure 8.3 Spectra and dynamic range of the sounds in the Peace Gardens

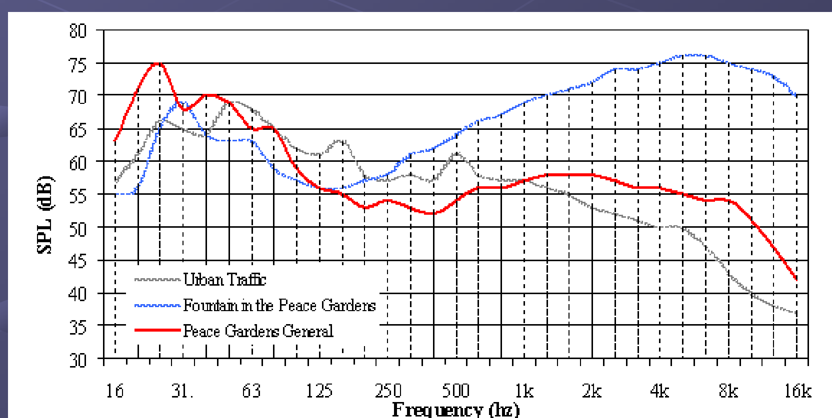


Figure 8.4 The comparison of the sound spectra in the Peace Gardens

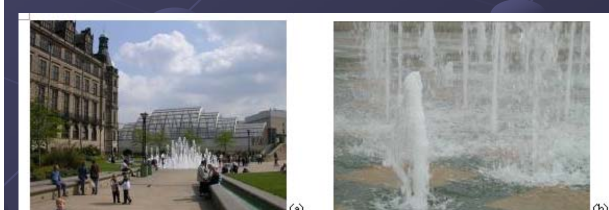


Figure 8.1 The Goodwin Fountain in the Peace Gardens

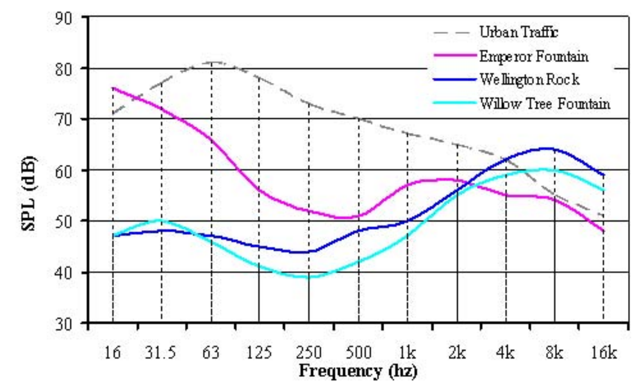
Examples showing design potentials:

- high frequency components come from the water splash itself,

- whereas when a large flow of water is raised to a very high level and then dropped to a water body or hard surface, notable low frequency components can be generated

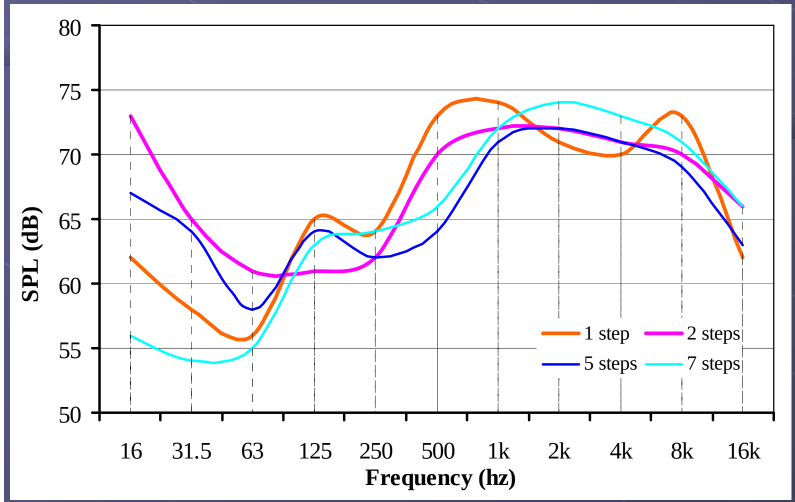
(a)·Emperor·Fountain .... (b)·Wellington·Rock .... (c)·Willow·Tree·Fountain¶

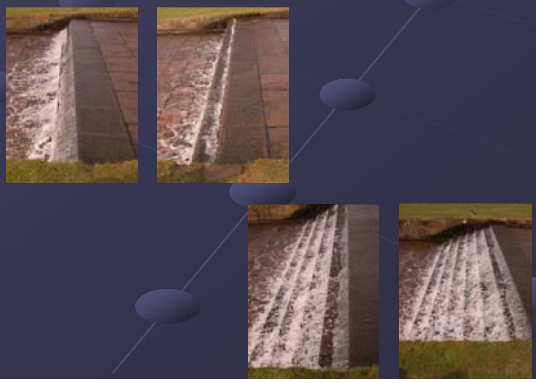
Figure·8.24··Fountains·in·the·Chatsworth·Garden¶



Comparison·of·the·spectra·of·the·sounds·in·the·Chatsworth·Garden·and·urban·traffic·noise¶

Cascade with Temple Pavilion in the Chatsworth Garden





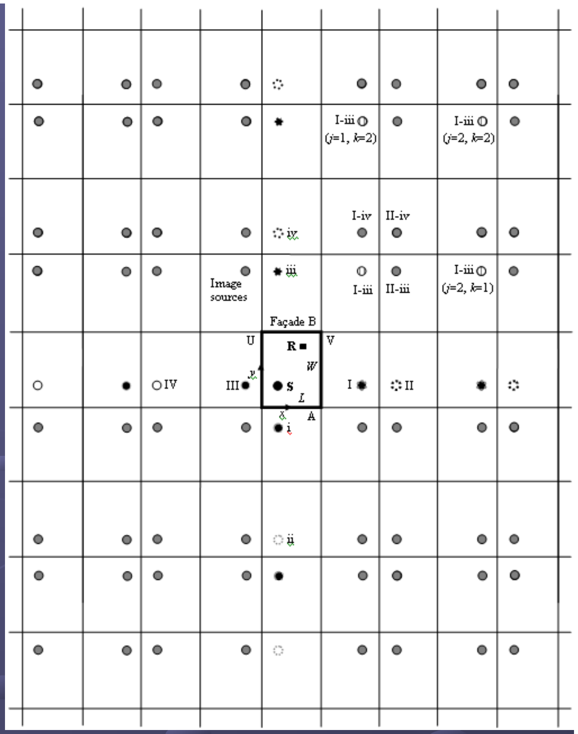
Bird sounds:
passive sound and then active sounds….

Interesting example in Berlin

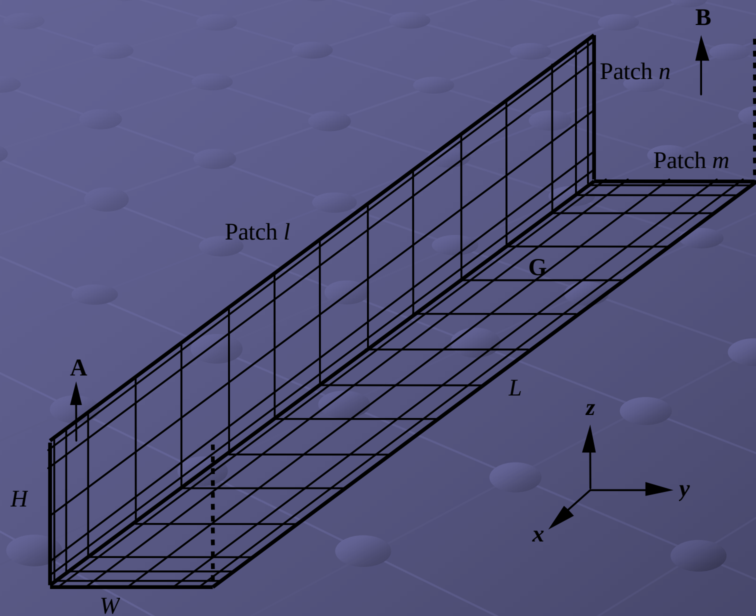
Also ecological issue

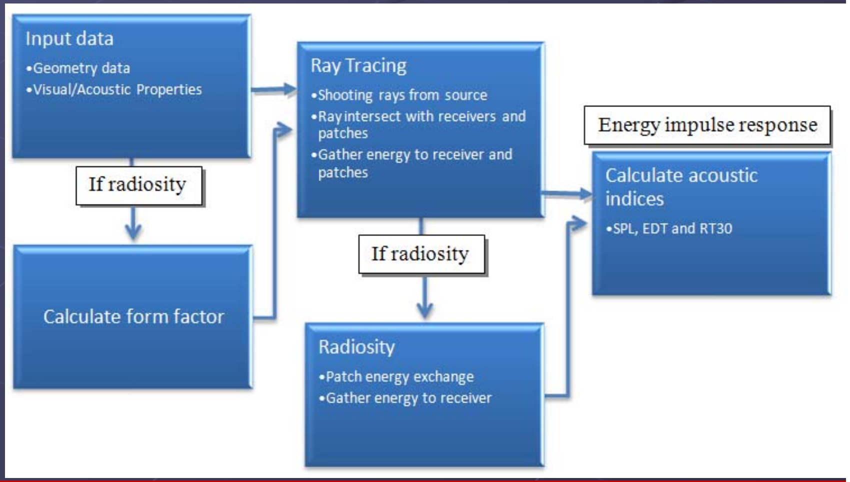
Space

IMAGE SOURCE METHOD



RADIOSITY MODEL





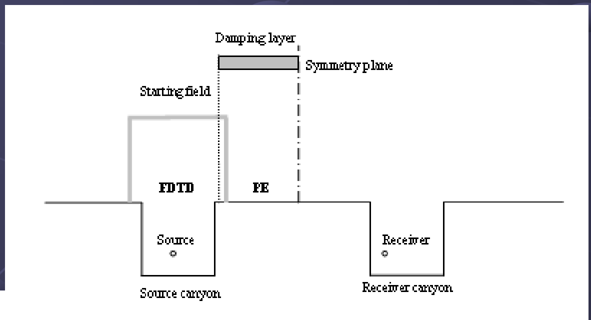
CRR – Combined Ray-tracing and Radiosity

- **IMAGE SOURCE METHOD WITH INTERFERENCE** (Li, et al)
  - Useful when a street is narrower than 10m.
  - When the boundaries do not reflect sound diffusely

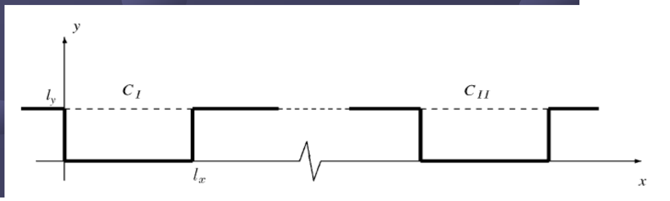
- **TRANSPORT THEORY** (Picaut et al)
  - Sound propagation is simulated by a beam that represents the path of a sound particle or phonon

- **BOUNDARY ELEMENT METHOD & FINITE ELEMENT METHOD** (e.g. work at Bradford, Reading)

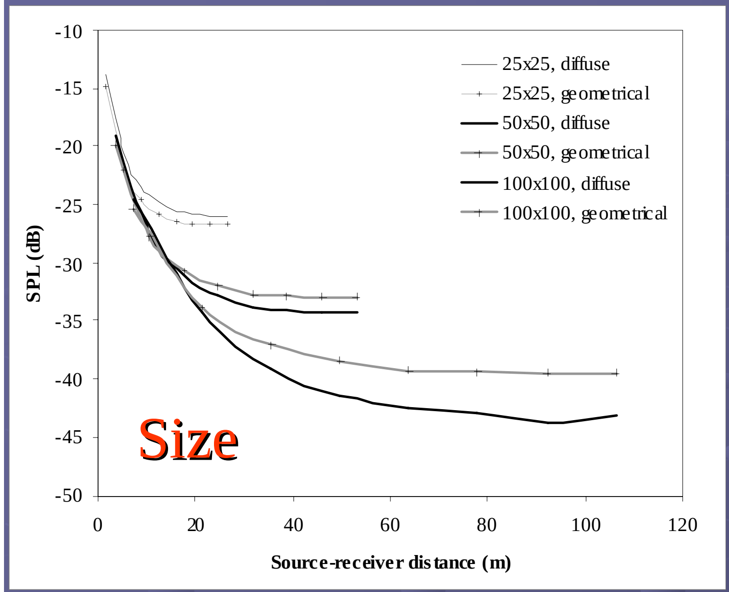
- **FINITE-DIFFERENCE TIME-DOMAIN (FETD) METHOD & PARABOLIC EQUATION (PE) METHOD** (Botteldooren et al)

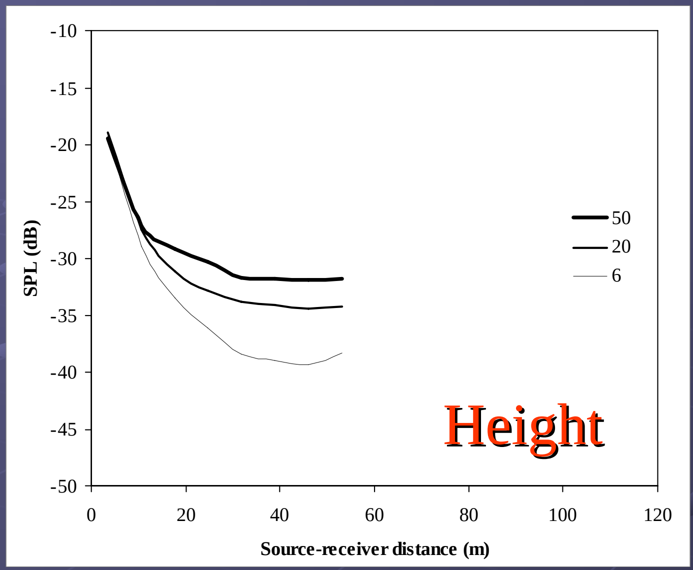


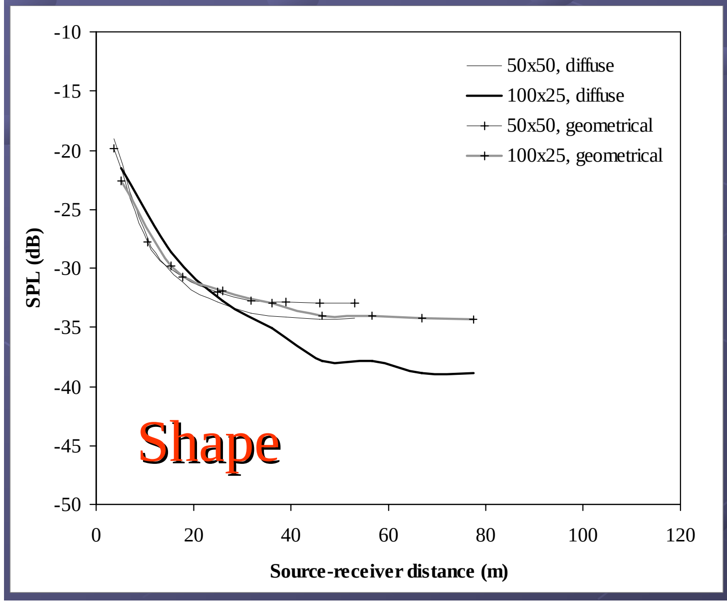
- **EQUIVALENT SOURCES METHOD** (Kropp et al)
  - For parallel streets

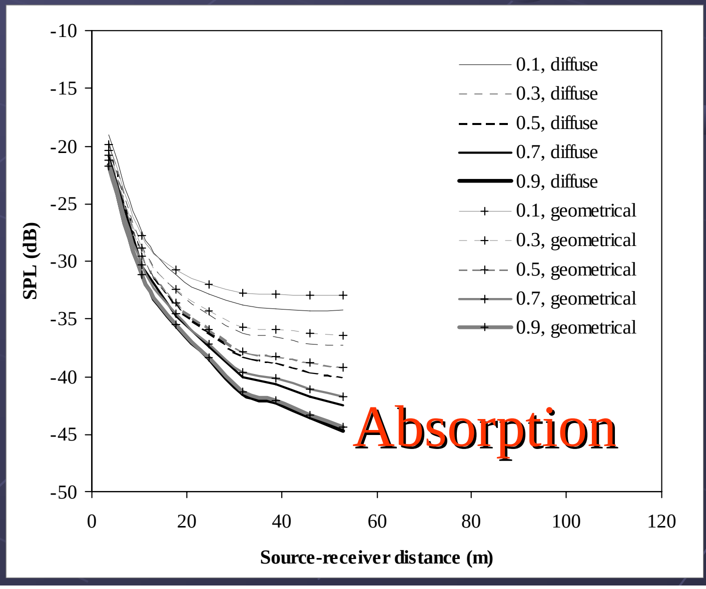


Parameter studies using the simulation models

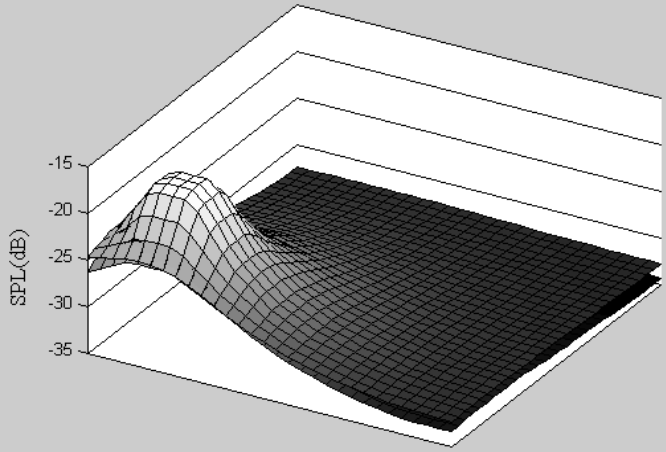


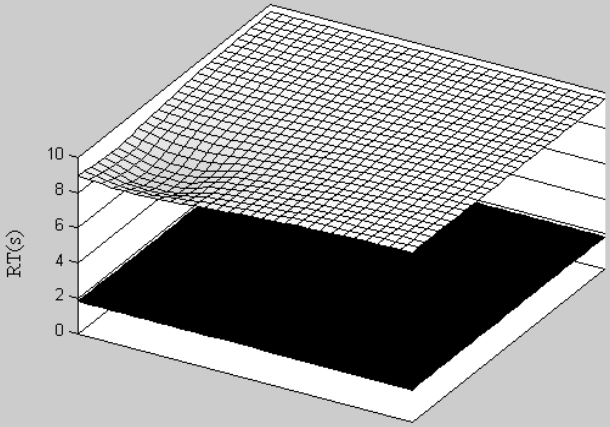


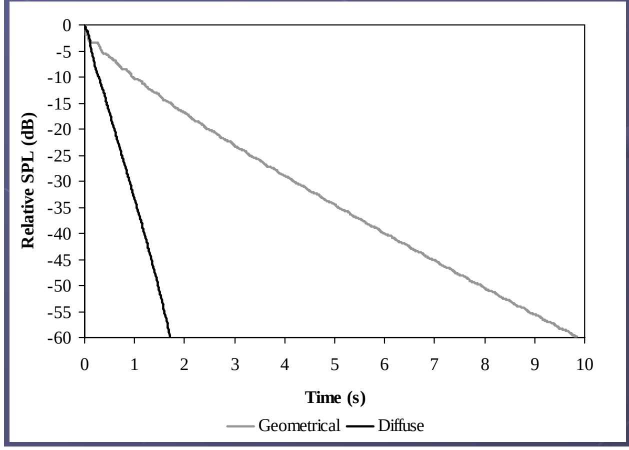


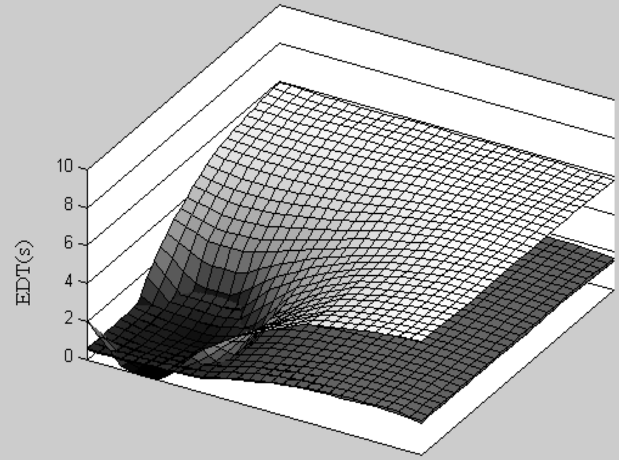


Boundary: diffuse vs. specular

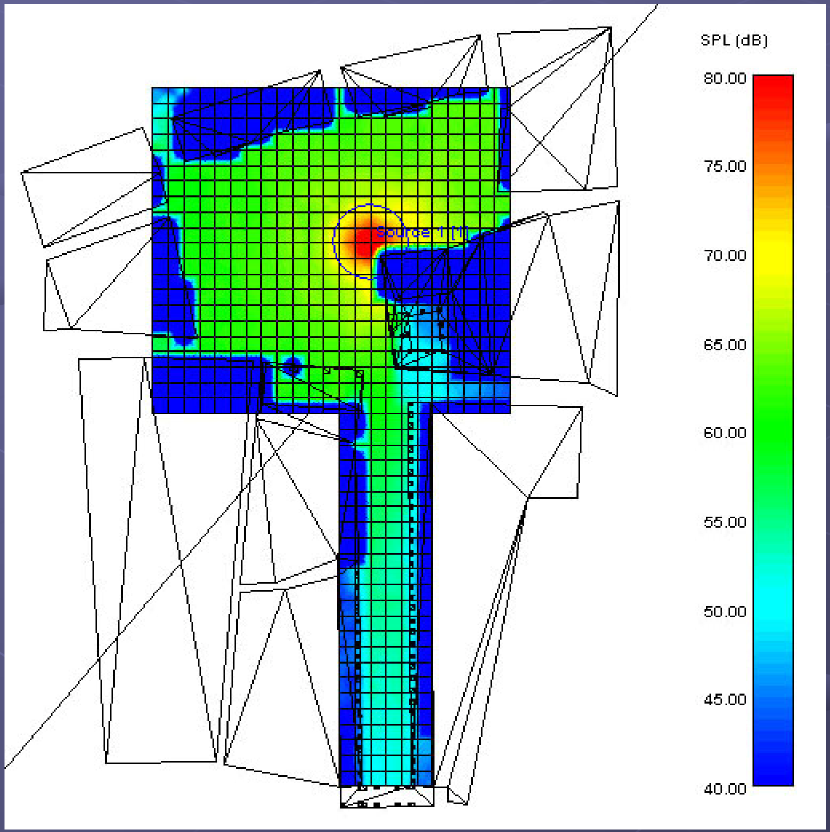


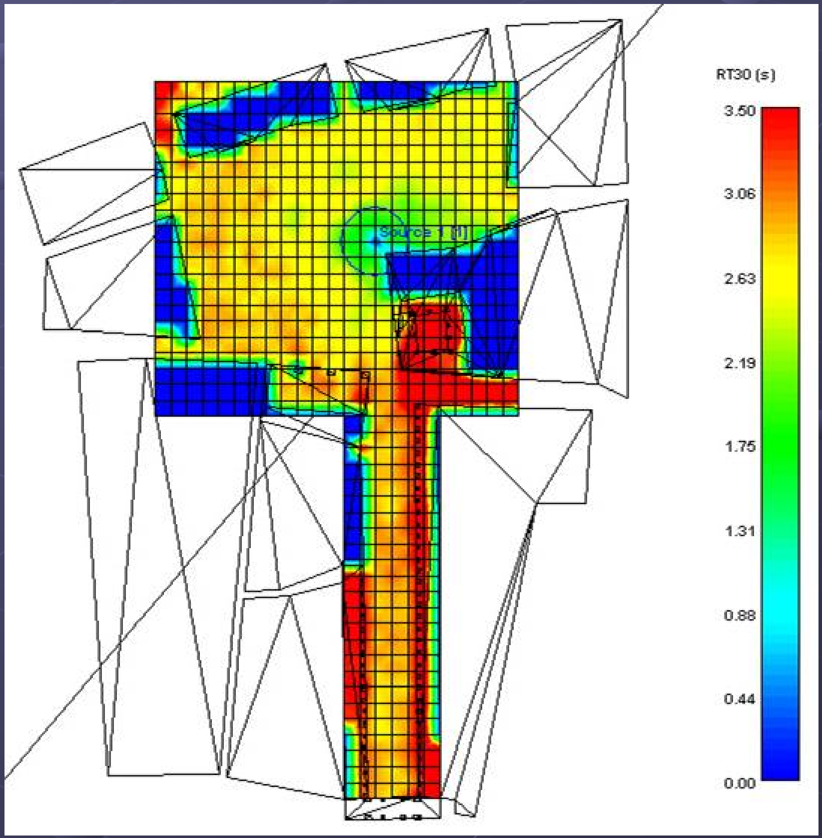




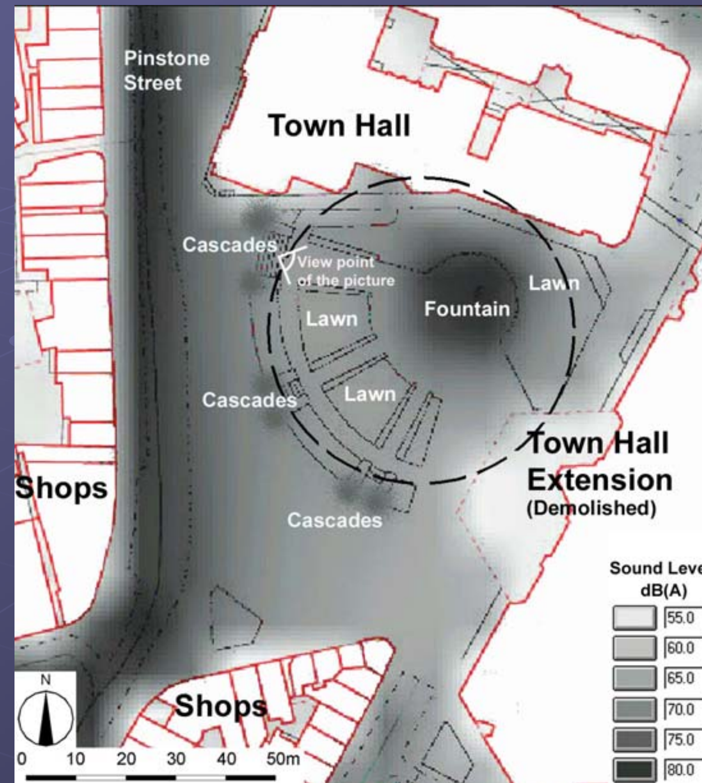


Combination of various types of space: for contrast and rich soundscape





Soundscape in different zones with/for different sounds



Design spaces for creating active sounds

An urban open space can be designed to encourage activities generating active sounds.

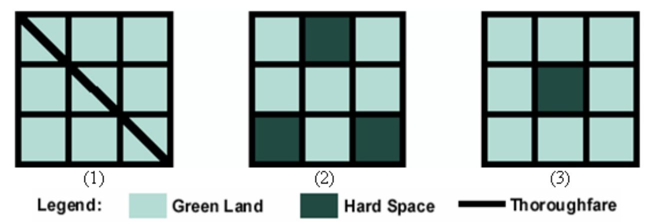


Figure 8.33 Three types of square form

People

Evaluation

- **Sound level evaluation**:
  - Occupation and education have more influence than other factors including age, gender and residence status.
  - The effects of some behavioural factors including wearing earphones, reading/writing, and moving activities, are insignificant.
  - The watching behaviour is highly related to the sound level evaluation, again indicating visual/aural interactions.

- In terms of acoustic comfort evaluation, the effects of view assessment and watching behaviour are even more significant.

The evaluation of acoustic environment at home, significantly affects the soundscape evaluation in urban open spaces.

- **People's noise sensitivity may differ considerably in different cities**
  - Kassel has the quietest home environment, whereas Alimos has the noisiest. With similar Leq, the evaluation score in Kassel is much higher than in Alimos.

- *People from a noisy home environment adapt more to noisy urban spaces?*
- *Cultural difference - people in Germany are more aware of urban noises?*

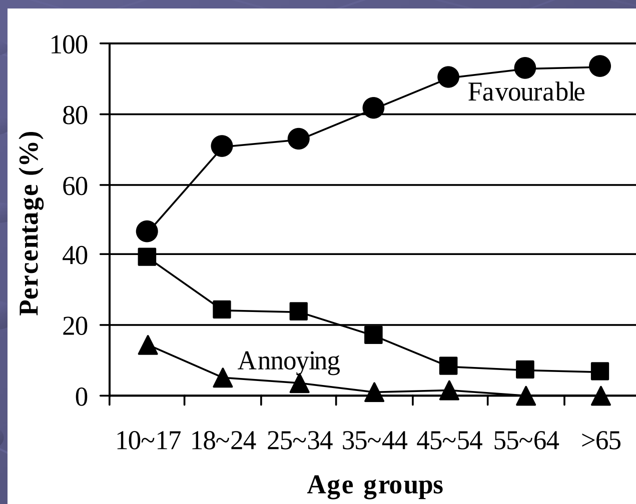
Sound Preferences

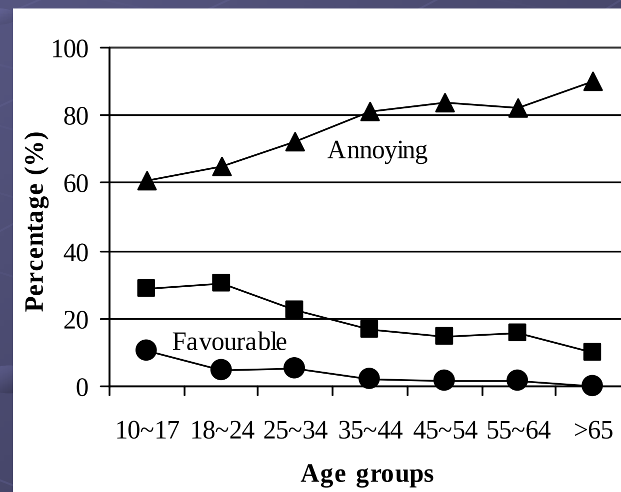
Essential preferences

- *Positive attitudes towards natural and culture-related sounds.*

Micro- preference

bird songs





car music

Difference in sound preference between age groups

Macro-preference

cultural background and long-term environmental experience play an important role in people's judgment of sound preference.

Significant difference exists for some sounds among the cities, likely caused by cultural factors.

		Alimos		Thessaloniki		Sesto San Giovanni		Sheffield		Kassel	
		Kara. Square	Seashore	Maked. Square	Kritis Square	Petazzi Square	IV Nov. Square	Peace Gardens	Barkers Pool	Florent. Square	Bahns-. platz
Water	F						27.7	84.0	74.7	80.3	74.5
	N						66.6	14.8	20.5	17.9	22.4
	A						5.7	1.2	4.8	1.8	3.1
Insects	F							37.7	33.2	34.0	23.5
	N							43.1	46.1	59.1	75.3
	A							19.2	20.7	6.9	1.2
Bells of church	F					31.1		56.8	47.9		
	N					68.9		35.4	37.6		
	A					0.0		7.8	14.5		
Music played on street	F							44.2	48.8	57.3	88.0
	N							38.3	28.8	27.2	12.0
	A							17.5	22.4	15.5	0
Surrounding speech	F	2.3	7.0		32.2	23.5	44.6	17.9	18.0	18.5	15.3
	N	77.8	77.6		17.0	69.8	47.2	68.3	69.3	80.5	84.7
	A	19.9	15.4		50.8	6.7	8.2	13.8	12.7	1.0	0
Children's shouting	F	20.3	25.5	54.1	29.5	27.4		11.7	6.9	1.7	1.0
	N	54.3	50.8	19.9	53.0	53.4		48.4	40.3	69.0	54.8
	A	25.4	23.7	26.0	17.5	19.2		39.9	52.8	29.3	44.2
Pedestrian crossing	F	5.5	8.0					8.6	12.9	7.1	
	N	89.9	84.7					62.0	58.4	17.9	
	A	4.6	7.3					29.4	28.7	75.0	
Passenger cars	F	0.6		3.5	31.3	2.7	1.6	2.4	1.0		
	N	26.0		53.0	16.6	59.8	35.4	38.7	43.6		
	A	73.4		43.5	52.1	37.5	63.0	58.9	55.4		
Passenger buses	F			3.4	1.3		1.6	3.7	2.1		
	N			52.3	84.3		39.2	38.9	37.9		
	A			44.3	14.4		59.2	57.4	60.0		
Vehicle parking	F							2.9	1.0	1.4	2.0
	N							32.2	35.3	57.9	54.7
	A							64.9	63.7	40.7	43.3
Construction	F			2.1	32.5			2.2	2.1		
	N			52.9	11.5			18.0	19.2		
	A			45.0	56.0			79.8	78.7		

Classifications for various sounds in urban open public spaces (%).

A comparative study between Sheffield, Taipei and Beijing about preferred sounds in their living environment (sound from outside)

Type of sounds	Sheffield	Taipei	Beijing	Sheffield (stage 2)	Taipei (stage 2)
Bird songs	1.30 (0.46)	1.68 (0.48)	1.75 (0.44)	1.28 (0.45)	1.70 (0.88)
Insect sounds	1.96 (0.19)	1.79 (0.42)	1.90 (0.30)	1.97 (0.18)	1.93 (0.80)
Water	1.69 (0.47)	1.89 (0.32)	1.90 (0.30)	1.73 (0.45)	1.93 (0.96)
Music from outside	1.96 (0.19)	1.74 (0.45)	1.57 (0.50)	1.96 (0.21)	1.65 (0.89)
Other Sounds	1.71 (0.46)	1.89 (0.57)	1.78 (0.42)	1.71 (0.45)	1.94 (0.65)

Bird songs as a preferred sound in their living environment:

70% in Sheffield, 32% in Taipei and 25% in Beijing.

Music from outside:

4% in Sheffield, 26% in Taipei and 43% in Beijing

Environment

if a place is very hot or very cold, perhaps none cares about soundscape…

Consider aural-visual interactions

	Factors		
	1	2	3
Temperature	.696		
Sunshine	.650		
Brightness	.599		
Wind	-.532		.521
View		.769	
Sound level		-.734	
Humidity			.828

Factor analysis of the overall physical comfort evaluation. Kaiser-Meyer-Olkin measure of sampling adequacy, 0.613; cumulative, 55.1%; extraction method, principal component analysis; rotation method, varimax with Kaiser normalization; N=9200.

Correlations

		sd_sati	lan_sati
sd_sati	Pearson Correlation	1	.265**
	Sig. (2-tailed)		.000
	N	598	592
lan_sati	Pearson Correlation	.265**	1
	Sig. (2-tailed)	.000	
	N	592	601

**. Correlation is significant at the 0.01 level

EU data

Landscape and acoustic satisfaction

Correlations

		sd_sati	vis_sati
sd_sati	Pearson Correlation	1	.289**
	Sig. (2-tailed)		.000
	N	598	591
vis_sati	Pearson Correlation	.289**	1
	Sig. (2-tailed)	.000	
	N	591	601

**. Correlation is significant at the 0.01 level

(Beijing data)

Visual and acoustic satisfaction

Beijing

Correlations

		Quiet	Views
Quiet	Pearson Correlation	1	.677**
	Sig. (2-tailed)		.000
	N	80	80
Views	Pearson Correlation	.677**	1
	Sig. (2-tailed)	.000	
	N	80	80

**. Correlation is significant at the 0.01 level

Taipei

Correlations

		Quiet	Views
Quiet	Pearson Correlation	1	.638**
	Sig. (2-tailed)		.000
	N	200	200
Views	Pearson Correlation	.638**	1
	Sig. (2-tailed)	.000	
	N	200	200

**. Correlation is significant at the 0.01 level

Sheffield

Correlations

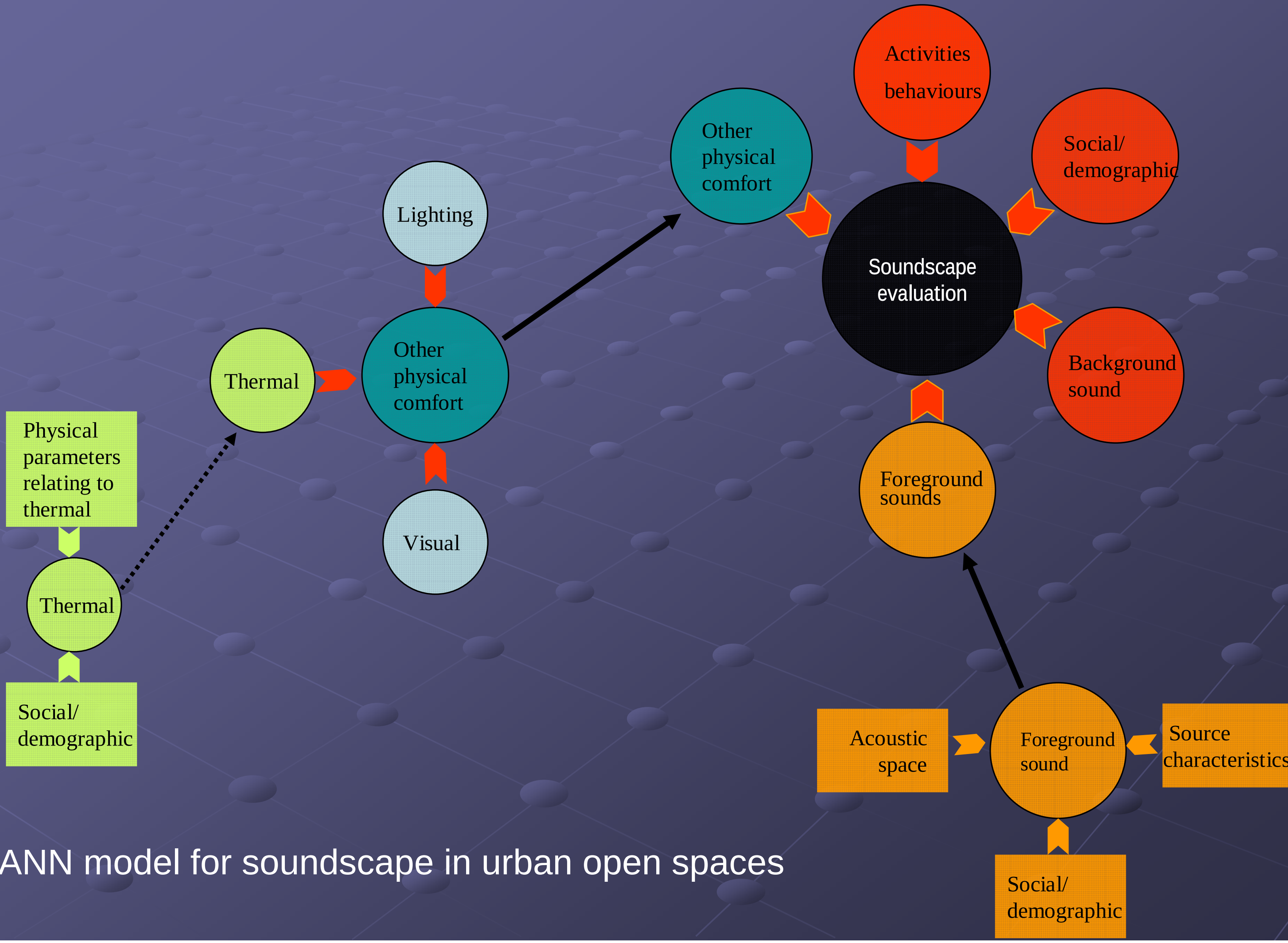
		Quiet	Views
Quiet	Pearson Correlation	1	.519**
	Sig. (2-tailed)		.000
	N	200	200
Views	Pearson Correlation	.519**	1
	Sig. (2-tailed)	.000	
	N	200	200

**. Correlation is significant at the 0.01 level

Correlation between quiet and view when choosing a living environment

Design tools

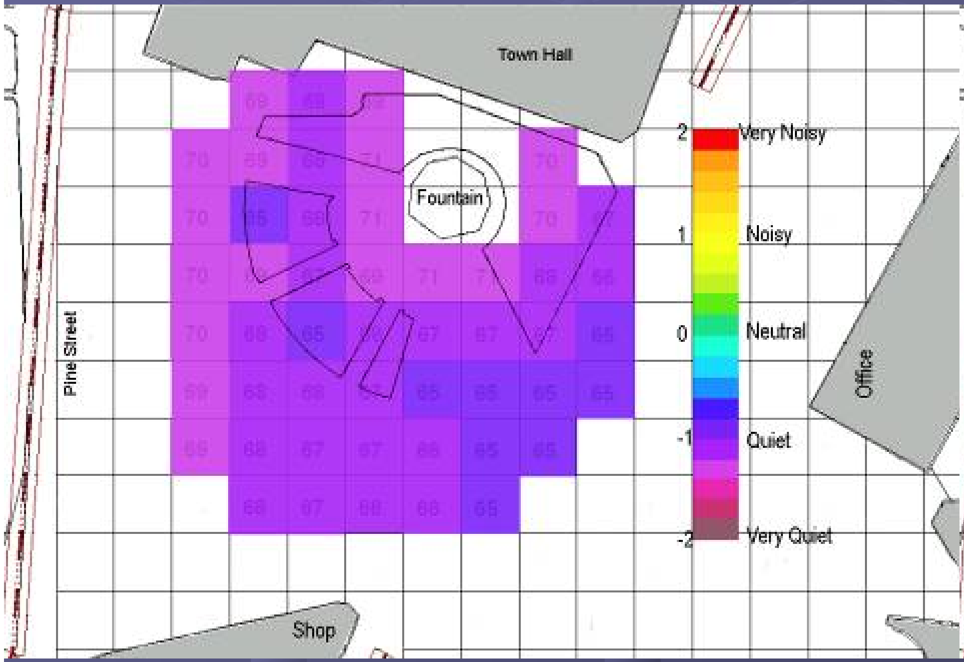
Artificial neural network (ANN) models



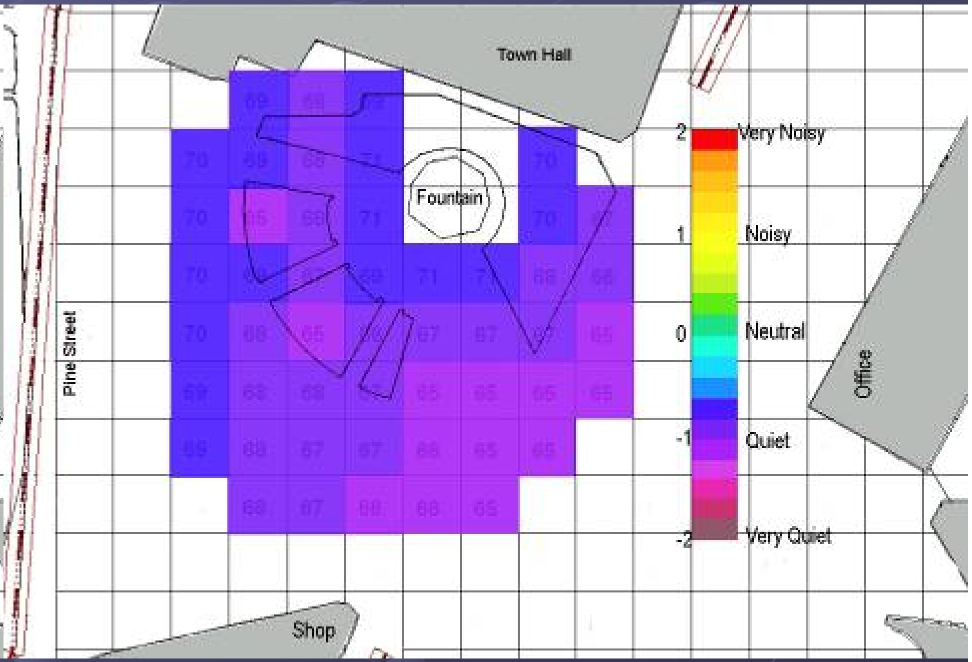
ANN model for soundscape in urban open spaces

MAPPING EXAMPLES based on ANN

- **Maps *of Sound Level Evaluation:* different age groups**



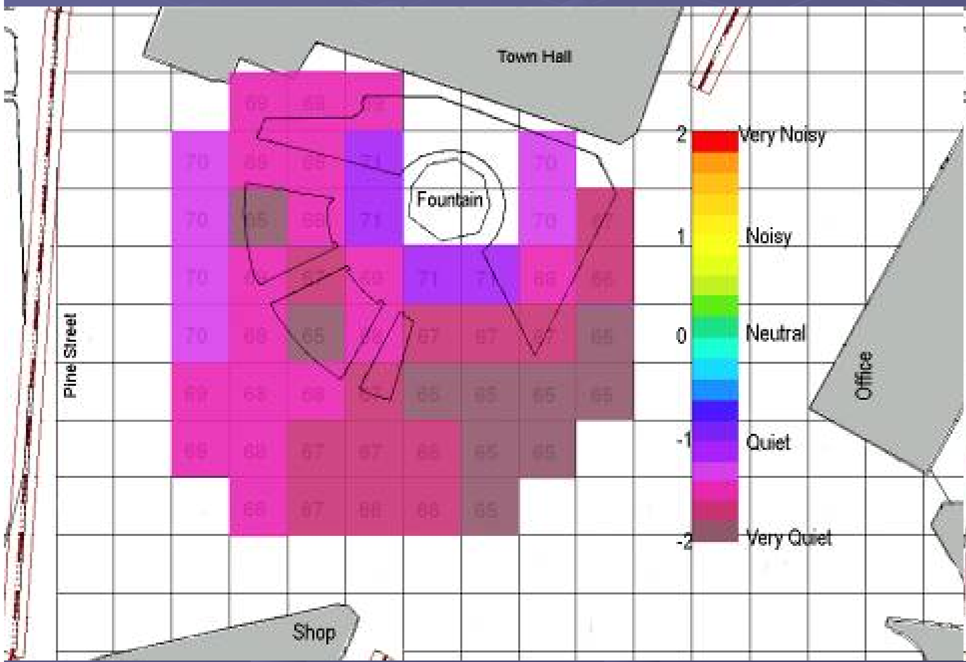
- Age Group 13-18



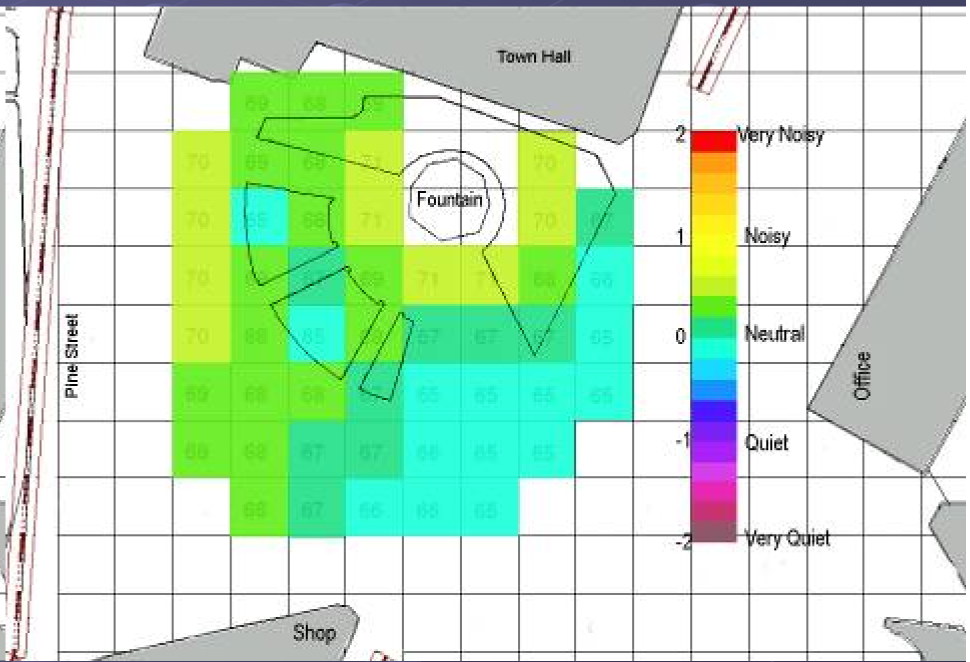
- Age Group > 65

- Young people feel the square quieter than old people

Maps *of Sound Level Evaluation:* different education groups



- Secondary education level group

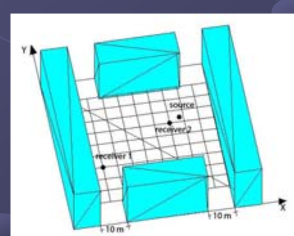


- High education level group

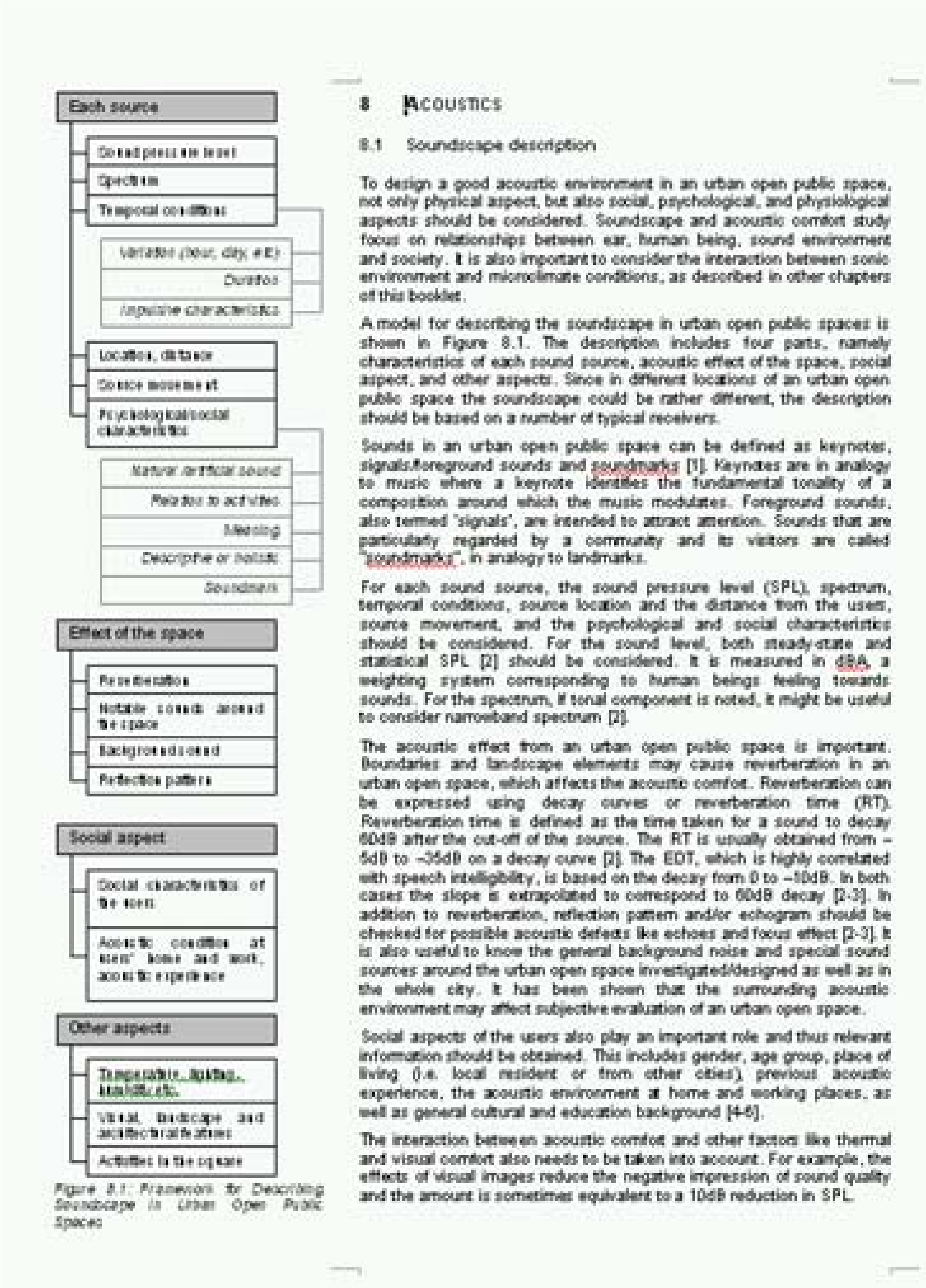
- Higher education people feel the square noisier than the secondary education level group

Acoustic animation and auralisation

- To aid urban soundscape design and for public participation, it would be useful to present the 3D visual environment with an acoustic animation tool
- Challenges
  - Multiple sources
  - Source and receiver all moving
  - Calculation speed fast
  - But: calculation accuracy less critical



Design guidelines



8 ACOUSTICS

8.1 Soundscape description

To design a good acoustic environment in an urban open public space, not only physical aspect, but also social, psychological, and physiological aspects should be considered. Soundscape and acoustic comfort study focus on relationships between ear, human being, sound environment and society. It is also important to consider the interaction between sonic environment and microclimate conditions, as described in other chapters of this booklet.

A model for describing the soundscape in urban open public spaces is shown in Figure 8.1. The description includes four parts, namely characteristics of each sound source, acoustic effect of the space, social aspect, and other aspects. Since in different locations of an urban open public space the soundscape could be rather different, the description should be based on a number of typical receivers.

Sounds in an urban open public space can be defined as keynotes, signals/foreground sounds and soundmarks [1]. Keynotes are in analogy to music where a keynote identifies the fundamental tonality of a composition around which the music modulates. Foreground sounds, also termed 'signals', are intended to attract attention. Sounds that are particularly regarded by a community and its visitors are called "soundmarks", in analogy to landmarks.

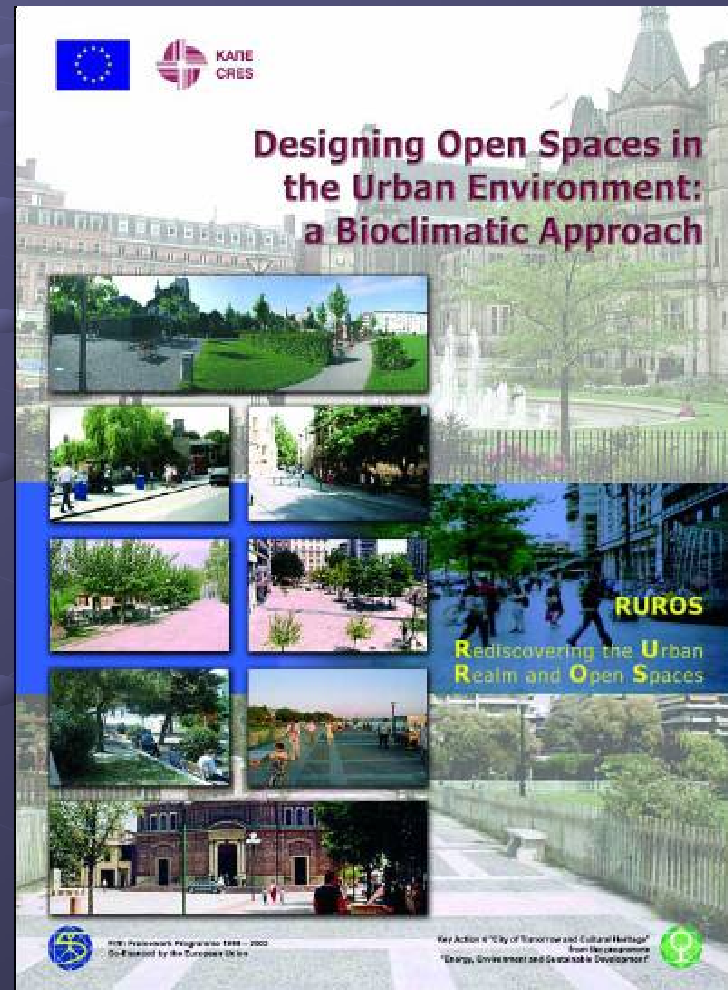
For each sound source, the sound pressure level (SPL), spectrum, temporal conditions, source location and the distance from the users, source movement, and the psychological and social characteristics should be considered. For the sound level, both steady-state and statistical SPL [2] should be considered. It is measured in dBA, a weighting system corresponding to human beings feeling towards sounds. For the spectrum, if tonal component is noted, it might be useful to consider narrowband spectrum [2].

The acoustic effect from an urban open public space is important. Boundaries and landscape elements may cause reverberation in an urban open space, which affects the acoustic comfort. Reverberation can be expressed using decay curves or reverberation time (RT). Reverberation time is defined as the time taken for a sound to decay 60dB after the cut-off of the source. The RT is usually obtained from –5dB to –35dB on a decay curve [2]. The EDT, which is highly correlated with speech intelligibility, is based on the decay from 0 to –10dB. In both cases the slope is extrapolated to correspond to 60dB decay [2-3]. In addition to reverberation, reflection pattern and/or echogram should be checked for possible acoustic defects like echoes and focus effect [2-3]. It is also useful to know the general background noise and special sound sources around the urban open space investigated/designed as well as in the whole city. It has been shown that the surrounding acoustic environment may affect subjective evaluation of an urban open space.

Social aspects of the users also play an important role and thus relevant information should be obtained. This includes gender, age group, place of living (i.e. local resident or from other cities), previous acoustic experience, the acoustic environment at home and working places, as well as general cultural and education background [4-6].

The interaction between acoustic comfort and other factors like thermal and visual comfort also needs to be taken into account. For example, the effects of visual images reduce the negative impression of sound quality and the amount is sometimes equivalent to a 10dB reduction in SPL.

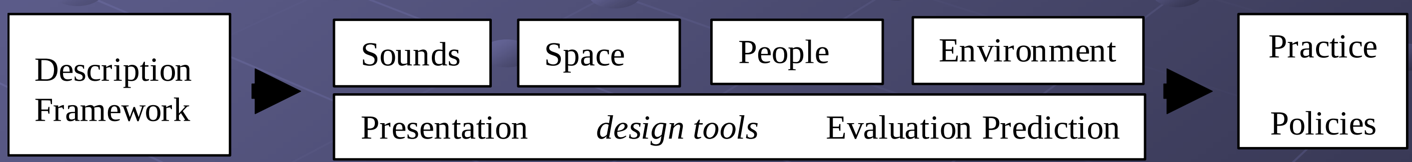
Figure 8.1: Framework for Describing Soundscape in Urban Open Public Spaces



Concluding remarks

Tendency from noise reduction to soundscape creation

- Great potentials of planning/designing soundscape has been demonstrated



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Summary

- Whilst much work has been carried out in terms of soundscape description and evaluation, it is important to put soundscape into the intentional design process comparable to landscape, and to introduce the theories of soundscape into the design process. In this paper a framework of soundscape design potentials is explored by considering four key factors, namely sound sources, space, environment and people, with a particular attention to urban open public spaces. In terms of sound sources, both active and passive sounds are discussed, relating to the sounds from the activities of users such as group dancing, and the sounds from the landscape elements such as fountains, respectively. Designable factors include sound level, spectrum, as well as temporal and spatial dynamic process. In terms of spaces, effects of architectural changes and urban design options on the sound field are studied based on parametric studies using a series of computer simulation. In terms of environment, multi-sensory interactions are discussed. In terms of people, since different users may have rather different soundscape preferences, a space should be designed accordingly.