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CAN WE CREATE SPACE BY MEANS OF SOUND?

– The Quest for the Spatial Dimension in Audio Arts –

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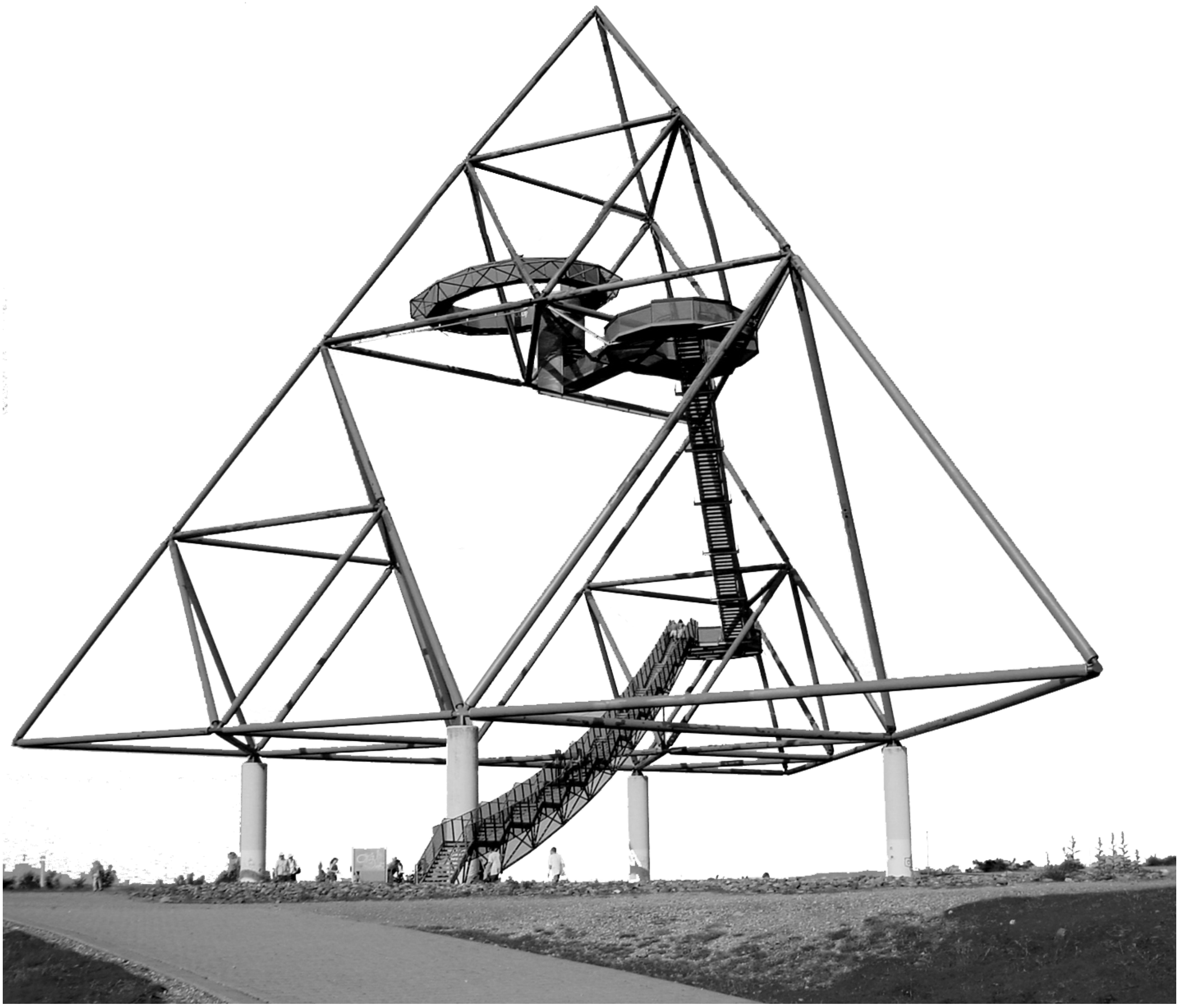

For Echo the Nightingale

_A_abstract

The paper discusses Sound Art at the intersection with Architecture. Coming from various musical backgrounds, a number of artists have specialized in the spatial treatment of sound with multichannel reproduction systems, and the discipline of Sound Architecture is emerging. Features of classical architecture, immaterial architecture and sound architecture are compared in order to answer the question, to what extent sound can take on functions usually attributed to the field of architecture.

As there is little literature and background on the subject, an empirical method is chosen for, starting from the analysis of the work of three pioneering artists: B. Leitner, B. Fontana, and A. Bosshard. Comparing and evaluating their work, a number of parameters are introduced as a starting set of terms by which to discuss qualities of Spatial Sound Installation.

The conclusion is that many of the functins of architecture - not the material but the social ones - can be fulfilled by sound, and sound as a supplement or complement to conventional architecture has a great potential only partly explored yet.

The idiom used in the paper is such that no specific in-depth knowledge in music, sound technology or architecture is presumed.

CONTENTS

_0_intro_ motivation, scope, method

Mr. Andres Bosshard's reports about the sound culture of the North-Indian tribe of the *Santal* were a seminal inspiration to my writing of this paper: a society that not only cultivates a collective awareness of hearing, but in which architecture, agriculture, religion, and social behaviour are all 'tuned' such as to create the most pleasurable collective soundscape permeating the whole village with a unifying vibration that orchestrates everything, from the wind in the trees to the household noises and the ritual musics to a perpetual musical performance! Such a concept was a sensation not only to the ears of a musician. This culture must have key knowledge on all acoustic issues to save our noise-polluted cities from chronic tinnitus and aural collapse.

Being myself an Audio Designer with a key interest in sound installations, the question about the social legitimation of such an art form kept me busy for a long time. How was electronic Sound Installation to be integrated in our urban environment? Happening in completely different contexts than conventional forms of musical practice in terms of medial, social, temporal and spatial presence, new relations with other disciplines had to be found. The step towards Architecture emerged as a logical one, as the space dimension becomes equally or even more important than the time dimension, which is usually considered the domain where sound and music have their place.

Architectural Acoustics uses building materials to influence the sound perception in space;
Electronic Sound Installation uses sounds as material to influence the space perception, acoustically.

So, to what extent can sound fulfill public tasks usually attributed to architecture? Where can sound help overcome recurrent problems of urbanistics and architecture? How can we tune sound so subtly that it will be tolerated by everyone and not be felt as intrusive? Is the model of the Santals appliable to our urban biotopes?

And: Can we, at all, create Space by means of Sound?

These are the questions I put myself to be answered in this paper, for anyone interested in this exciting intersecting field of music and architecture, sound and space, noise and the city; be it a musician, sound designer or any open-eared architect.

In order to keep this text accessible for a broad readership, I will aviod going into the specifics of sound treatment too deeply and rather refer the interested reader to the relative literature.

As the field is truly far-reaching and not (yet) cemented by a theoretical fundament, I think that the only feasible way to approach it is empirical, that is, by giving plenty of room to the observation and analysis of work done so far in the concern.

As a consequence, after some introductory sections for a basic understanding of important concepts, the main body of the paper will consist in a sort of inventory of what has been done in the field of spatial sound: *not from the side of the technical developers (there are countless projects going on at technological universities concerned with issues like WFS, ambisonics or surround sound, mostly for military or industrial use), but from the applied side;* reviewing a selection of artists with a representative portfolio in the regard of using techniques of electronic sound spatialization to investigate its communicative potential, while keeping a strong relation to the architectural domain of conceiving and realizing spaces.

Then, after carefully analyzing common and diverging features in their work, I will try to deduce some considerations useful for the future development of the discipline of designing sound and space.

Sounds guide Santal day-to-day activities. Certain sounds are treated as pointer[s] to time and season, some are prophetic, while others are auspicious or inauspicious for them. Besides, on certain occasions, silence (absence of sound) has great significance. In all of these, it is found that the Santal perception of sounds, specially of birds and animals, is directly or indirectly related to aspects of auspiciousness and inauspiciousness in life contextualized in terms of time, place, direction, and object. The call of the cock, for instance between the time of evening meal and midnight is inauspicious; the call of *curhin cere* from the mound of white ants is good omen, the cock crows food omen but the same from the dead branch of a tree is considered a bad omen;[…]

In 1994 and 1995, Andres Bosshard, together with a group of scientists from the Sanitiniketan University, India, held musicological and linguistic field studies in a village of the Santals. This small tribe lives in Northern Bengal at the foothills of the Himalaya, their language does neither belong to the indo-european nor to the persian group of languages, as it is the remainder of a culture that reaches far beyond the history of these people that dominate the Indian subcontinent in our days.

An outstanding feature of the Santali culture is the significance they attribute to sound and the sense of hearing. The web resource <http://ignca.nic.in/>, India gives an idea of how detailled their vocabulary is when it comes to sounds:

Santals classify sound into three categories: (a) *sade* (produced by different objects as a result of collision or stroke); (b) *aran* (created by human beings, or produced from musical instruments constituting the bases of its subdivision into the *ror*, and *rar*, respectively); and (c) *rak* (produced by animals, birds and insects) including sounds produced by human beings in pain.

The sound of birds and animals, which correspond to their names, are favourite repetition with children. Thus the Santals perpetuate the knowledge of and maintain the flow of information about different types of sounds.

Sounds, particularly that of birds and animals, perpetuate because of their multifarious functions in the society as (a) basis of classification of sound producing objects, (b) indicator of time and change in the seasonal cycle, (c) indicator of auspicious and inauspicious happening, (d) means of creating imagery of cosmic phenomenon, and (e) indicator of futurity. *(Onkar Prasad, Santal Perception of Sound, 2000, http://ignce.nic.in/nl_00511.htm)*

Bosshard researched the implications of this acoustical awareness in their daily life and found some spectacular facts:

Listening to different sounds is a practical daily exercise for every inhabitant of the village. Like the sound of the birds, also the sound of the wind in the trees has a function of communication to the divine entities, with different degrees of importance depending on the sort of the tree and the height level of the wind. To this purpose, the trees are planted in a special arrangement around and in the village. Similarly, the logistics and architecture in the village are all laid out according to acoustic demands: The two-storey buildings have their sleeping rooms at the upper level and are equipped with a narrow vertical listening slot to either of the four sides, so that any sounds happening around the house, and around the village (hence the elevated post) can be permanently monitored, also during sleep. The houses are arranged in parallel rows along the streets, which in turn are equipped with long rows of benches on which the inhabitants can sit during idle time. The straight parallel walls offer them a maximum of intellegibility for their conversations across the street. It is recommended that each villager take part in these conversations for at least two hours a day, for his psychological health. The notion of a *mumbling stream* denotes the perception of these human voices from afar, an experience of at least as great importance as the actual active participation in a discourse.

Even the household ‘noises’, such as the sounds emitted from the dishes being washed in one of the three ponds across the village, are to be orchestrated in a way that they sound ‘sweet’. If it does not sound good, then immediately a priest will intervene and have the women restart their work in a more harmonious way. The vibration that is to be achieved is referred to as *honey wind.* Good sound in the society means good conditions and health for each individual: musical harmony is interpersonal harmony.

_1_theory : space perception and sound

This chapter is dedicated to the understanding of some general concepts of how we perceive sound in a daily environment and how we extract spatial information out of that in various environments:

1.0_Spatial Hearing

One of our ear's best evolved functions is to spatially localize the source of a sound it perceives in terms of angle, elevation and distance. This is a survival feature of crucial importance, which is proven by the fact that it is independent of the position of the head, independent of the state of sleeping/waking of the subject and works over a wide radius which is not delimited by solid obstacles that might impair sight. All this suggests the importance of the ear as the primary alarm system that our auditory system took in its evolution.

As it is with the sense of sight, the presence of *two* sensors - ears in this case - is key to the spatial resolution of perceived sound. The equivalent to stereoscopic sight is called *binaural hearing*.
There are three cues on which spatial hearing is based. The first of them takes advantage of the so-called *interaural intensity difference*: A signal from my right side will appear louder on the right ear than on the left.
Then there is the *interaural time delay* cue. That means that the signal from the right will appear earlier than on the left ear, as sound takes about half a millisecond to travel the distance of a head's width. The auditory system can resolve time differences in this range with high precision.
The third spatial clue is based on spectral differences between the sound signals perceived from the two ears. The shape of the oute ear is mainly responsible for this; sounds appearing from the back of a listener are 'shadowed' by the outer ear and thus their frequency (spectral) content is altered. Without this effect, the time and level differences would be identical for front/rear sources.
See Roads, *The Computer Music Tutorial*, MIT press, 1996, pg. 459 ff. For a very detailled description of the psychoaoustical phenomenon of spatial hearing refer to J. Blauert, *Spatial Hearing*, 1965-82.

1.1_environmental sound spaces

1.1.1_ features of acoustic space experience

1.1.1.1_ inside/outside body

Sound, in its physical nature, is vibration, fluctuation of air pressure. The ears are the part of our outer membrane specialized in the task of sensing vibration. Nonetheless, all of our skin is, in a more limited way, reactive to it; as we know from very strong low frequency sounds: we literally *feel* those basses as we feel the vibration of a solid body in contact with our skin.
As such, sound is the medium that connects us with the space outside us by means of volatile air vibrations. But let's not forget that we also hear sounds from within our body. We hear ouselves speaking and, sometimes, we hear sounds produced by the working of our inner organs, bodily fluids and bones wich might or might not be audible to others. Sound, thus, also is a medium relating the inside and the outside of our body, a medium permeating the bounds of our body in both directions.

1.1.1.2_ a soundwalk, the concept of sonospheres

> From the perspective of sound, the listener is at the vanishing point. What for the eye is in the distance is, for the ear, the closest. The vanishing point is the point of starting out and is located at the centre, the centre of an expanding sphere which becomes a space that may contain other spaces. *(A. Moore, expanding, spherical waves and social space. in: Umzug ins Offene, Springer, Vienna, NY 1998)*

To understand the acoustic space outside our body, let's examine a couple of everyday listening situations[1]. From those, we may deduce some generalisations useful for the understanding of our sonic space, which is, in turn, an indispensible necessity for anyone interested in creating artificial sound-spaces.

setting a) in a café, indoor.

I am sitting around a table with two friends. We are talking and sipping our drinks; a waiter temporarily intervenes to take orders or serve drinks. The sounds emerging from the talk and the handling of cups, glasses and spoons form the inner radius of my surrounding sound-space. We can call it the **inner sonosphere**. This is where my attention is focussed, and consequently, also where my eyes are looking at: the faces of my friends, my cup, the menu and the waiter as he approaches the table.

Surrounding my table and delimited by walls and windows, the rest of the café forms the medium radius of my listening space. It is dominated by speech of other people, backed up by a layer of (background- or louder) music, and some mechanical sounds from the bar. Occasionally, the entrance door will open and a shadow of the sound-space outside the window will merge with the **meso-sonosphere**. In this case, my level of attention to this part of the sonosphere will be low, as it consists mainly of sounds that might distract my attention from the ones I want to focus on: my friend's speech versus the speech of the other guests [2].

At last, the sounds from the street form the **outer sonosphere**. Through the separation of the window/wall, there is a significant decrease in intensity related to the true distance of the traffic outside. Conversely, the window also functions as a protection against possible dangers from the traffic, so that I don't need to focus my attention on it for safety reasons.

A good complement to the urban indoor situation is the study of an outdoor setting, because it leads us to a soundscape more similar to what humans were used to hear for millenia before industrialization massively changed the acoustic world.

setting b) in the green, outdoors. open lawn with a forest close by.

Walking on a lawn in the open, my inner sonosphere is rather silent: I hear sounds of my feet stepping through the grass, grasshoppers evading these steps.

On the middle radius, I hear the multitude of insects chirping, jumping, flying over the green; birds in the wood and in the air; the wind that moves over the grass and through the trees.

The outer radius of the sonosphere seamlessly merges with the middle one; other birds more distant, behind the woods, wind from afar... An occasional airplane crossing the sky makes me aware of the present state of technology, and, if I didn't move out really far from the city, there will sure be some distant car traffic noise emerging from some direction, while I can feel quite safe about the presence of any wild animal.

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[1] simplified protocol of a 'soundwalk'; conducted with P.Kiefer and A. Bosshard in Cologne, 2002. 'soundwalks' are a listening practice common in the 'ambient' music scene led by the canadian composer Murray Schafer. His *Handbook for acoustic ecology* is a standard in the field of ambient sound theory and his initiative *World Soundscape Project* is an attempt to precisely protocol all acoustic events in selected urban, rural and un-inhabited areas over the world.

[2] My auditory system is well able to separate the inner from the middle radius, even if the distance relation is minute or even inverse: a person sitting to my back can be at a distance smaller than my friend on the opposite side of the table. Yet, if I don't *listen* to that person, I don't understand what s/he is saying, while I can perfectly filter out what my friend's speech is about. This ability of the auditory system is called the *cocktail-party-effect* and works at such an unconscious level that it is worthwhile to try and record such a situation with a microphone to realize how confusing the recording will sound.

These two short descriptions are just typical examples of our spatial sound experience. The introduction of the triad of sonospheres helps us keep apart different stages of our acoustical awareness. A scaling according to different radiuses, creating spherical spaces around the listener makes sense in multiple ways:

- Sound traveling through a medium (air) loses energy along its way. The more distant from the listener, the softer and less detailled a sound will be perceived. The spheres indicate gradients of sound level attenuation as a function of distance.
- A sound field emerging from a source propagates spherically. Bound by the constant of speed of sound (approx. 343 m/s at normal temperature and humidity), the further distance it reaches, the longer it takes. The same applies for the inversion of the model: the further away the sound source, the longer it takes it to reach the ear. Thus the spheres as graphs of distance and sound level are also temporal graphs.

When the inner sonosphere is about as large as the area within which we usually talk to people, the border of the meso-sonosphere can be approximately drawn at the range where detail and intelligibility of voice and other sounds drastically decrease. The maximum hearing radius of the human ear, thus the limit of our outer sonosphere, is at about 500 m, under ideal conditions and for sounds of normal loudness (else than aircrafts, motorways explosions). That corresponds to the timespan of 1-2 seconds that psychologists assume for the capacity of our short time memory, our "Present".
(<http://www.psychologie.uni-bonn.de/allgm/neu/publikat/abstract/buecher/kmk-95/kzg.htm>)

1.1.2_ urban sound experience

> Many densities of sounds occur at sustained high levels that have no quiet space in their acoustic shape. This traditional lack of designed sounds and sound relationships is largely influenced by the concept of noise. This concept assumes a hierarchical value difference between meaningful and meaningless sounds. It is a general fact that most people in our Western culture find little meaning in their everyday experience of ambient sound. Sounds are normally considered meaningful when they are part of a semantic context such as speech and music. Most ambient sounds exist in a semantic void, where they are perceived as being noises. *(B. Fontana, The Environment as a musical resource; <www. resoundings.org>, 1990).*

As we noticed in the first of the two hearing examples above, an urban environment heavily influences the range of our aural awareness. The presence of relatively loud broadband noise sources (traffic) pushes the 3 sonospheres to become considerably smaller: we don't hear as far as we could in a non-motorized environment. On the other hand, solid architectural structures such as walls and windows delimit the sonospheres as well. Sounds happening outside the walls surrounding my room have to be attributed to the outer sonosphere, even if the true distance is minute. The distance-level-relation of the sonosphere is broken.
We can notice something like a *circulus vitiosus* in the two phenomena mentioned above: because traffic noise is felt as annoyance by a majority of people, special architectural devices are developed to isolate those noises (sound-absorbing walls, isolating windows). The extent of the sonosphere is, paradoxically, reduced in order to fight its reduction.

When we read that more than half of the complaints being registered in the public complaints hotline of

New York City are related to noise pollution[3] it becomes evident that traffic noise is problematic. Besides the actual risks of hearing damage at very loud noise levels, the active process of filtering out these impulses causes stress to our brain.

This does not mean, though, that the absolute absence of these sounds would be desirable: after we've grown up in this environment, the presence of these sounds has aquired a stabilizing function. They communicate to us that everything is OK, functioning properly. Even if I am really annoyed by the squeaking of the tram in front of my window with it's steady quarter hour rhythm, an instant of absence of this noise would make me think of a delay or even an incident; both highly undesirable events.

The *mumbling stream*, that is, all the human voices reaching me from the meso- and outer sonosphere has a similar, if not more important, function. It gives me security and confirmation of my existence in a social and not an isolated environment. According to Bosshard, the Santalis employ a specialized caste of musician-priests, whose job is to 'tune' the stream of civilisatory sounds so that each individuum is acoustically connected to everyone else. Failure in this enterprise can have fatal consequences.

This phenomenon of consolidating sounds actually applies not only to civilised environments, but also to the animal world. The *quiet before the storm* with its dreadful implication is a notion common in many cultures.

1.1.3_acoustic ecology

> The first and principal difference between various sounds experienced by our ear, is that between noises and musical sounds. The soughing, howling, and whistling of the wind, the splashing of the water, the rolling of carriages, are examples of the first kind and the tones of all musical instruments of the second [...].
> *(Hermann Helmholtz, On the Sensations of Tone, first publ. 1863, Alexander Ellis, trans., New York: Dover Edition, 1954. p. 7.)*

While this statement of acoustics pioneer Helmholtz reads rather outdated, we understood from the previous chapter that unwanted exposure to sounds creates psychicological and social stress. The discipline of *Acoustic Ecology* made it their task to study the implications of *noise pollution* and find solutions to the problems created in consequence. We have seen that the origins of the pollution are to be traced back to industrialization and motorization.

Another task the *World Forum for Acoustic Ecology* (WFAE) has taken on is the documentation of soundscapes, soundworlds and –phenomena that are about to disappear, for whatever reason. Concerned phenomena may range from the idiom of an endangered bird species to the sounds produced by an old artisan practice that is not in use anymore. The same man that coined the term of *Soundscape*, the canadian composer Murray Schafer, also introduced this concept in his *Handbook for Acoustic Ecology*. To date, the association is presided by Barry Truax, another influential Canadian composer.

The reader interested in this field may refer to the website of the *World Forum for Acoustic Ecology* <http://interact.uoregon.edu/medialit/wfae/home/index.html>.

[3] source: Die Welt, weekly newsmagazine, Frankfurt ed. 20.05.2003

1.2_social spaces: architecture

1.2.1_ constituents, functions

Not only when it comes to *problems* related to space should we ask the opinion of the architects, who are commonly considered the specialists in dealing with space-related issues. More detailed, we can state that architecture is the technical-artistic discipline involved in designing space as an environment for human social interaction.

Richard Buckminster Fuller[4], one of the most influential innovators of architectural thought in the 20th century, defines architecture's role as to provide a controlled environment for humans. The parameter for it's efficiency is how little material is needed to achieve this goal. This theorem opens up ways for thinking about architecture not only in material, but also in immaterial terms; spatial sound conceptions would be a subset of this immaterial way of producing space:

Fuller's architecture is meant to create controlled environment for humans. That implies protection from certain undesirable atmospheric conditions such as temperature too high or too low, wind, moisture, precipitation and the like. These low-level material needs can of course not be fulfilled by the immaterial presence of whatever acoustic artifacts, but it seems evident that architecture also envisages other goals.

If we look at the architectural setting of a city, we can read it as a social score: there are spaces with defined functions of communication and others wich give shelter. Between the two extremes of marketplace and sleeping room, there is a great variety of spaces for each defined kind of social encounter, points of density and points of relaxation; points that bring together specific groups and others which cater for a demand varying rhythmically over time in a daily, weekly or yearly cycle.

The same as in the city, just on a smaller scale, can be observed in a well-designed house: spaces for meeting in groups, spaces for dialog, spaces for defined temporal functions, spaces for movement, for relaxing and for rest in isolation are distributed to form a subtle orchestration. The encounter of people in its broad lines is staged by the architect.

An example of an opposite understanding of architecture could be a building that is purely representative for an institution, a personality or a place and does not fulfill any other social function. Such a building is visited like a monument; a sculpture or historic relic whith the added extra that one can move inside the monument. If we look at Renzo Piano's ship-shaped *New-Metropolis*-building in the center of Amstedam and its short-lived fate as a technology museum, we get a plastic impression of such an interpretation of architecture. (<http://www.vitruvio.ch/arc/contemporary/1946-2000/newmetropolis.htm>)

1.2.2_ media, tools; acoustics

We understand that architecture is, generally, material. Before Buckminster Fuller, actually, the idea of immaterial architecture did hardly exist. Material architecture employs solid media - stone, bricks, wood, metal, concrete, glass – to realize structures. Whether space be the material architectural structure itself or the 'empty' space it delimits, is a question of philosophical concern, and has a long history:

> Already the baroque discovered that space is not surrounding the architecture, but is created by it. *(Giulio Carlo Argan: L'Europa delle Capitali, 1600-1700 Geneva 1967 p. 106).*

Now it is interesting enough to observe how the material medium shapes the quality of the immaterial in the space. In terms of sound, this is generally referred to as acoustics. This term is used for both the subjective experience of how sound is affected by an architectural space (dry, wet, reverberant, soft, hard), and for the

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[4] see <www.cjfearnley.com/fuller-faq.html>

science dedicated to the research of the interaction of materials and sound: physical and architectural acoustics. The research in this field has brought great advances in the analysis and simulation of how sound behaves in a given space, but less is yet known on how to interpret these data sets, i.e. what measures are to be taken to achieve a desired acoustic behaviour in a space. Further, it seems that more parameters are to be taken into consideration for a full understanding of spatial acoustics. While reflexivity/absorption of materials, diffusion and diffraction of surfaces are well studied, the influence of other factors such as temperature and humidity is mostly not taken into account in the mathematical models.

It is evident that this specialisation of architecture is extraordinarily interesting for our understanding of the interaction of space and sound. Yet, as indicated in the introduction, I will not go in depht about it here, as it would lead us far beyond the scope of one Thesis paper. Instead, I will keep the focus on the inverse approach: instead of tuning the materiality of the architecture to change the sound, I go for the use of electroacoustic means to change the space perception.

1.3_ immaterial spaces: light & sound architecture

A quote from V. Flusser - unfortunately no official translation to English could yet be found:

> Erfahrungen sind Geraeusche, die erst im Gewoehnlichen Bedeutung gewinnen (dort zu Informationen verarbeitet werden).
> [experiences are noises that gain meaning only in accustomation/normality (there, they are transformed to informations)]
>
> Es haeufen sich die Anzeichen fuer ein neues Unbehaustsein. Wahrscheinlich, weil unsere Haeuser der Aufgabe nicht mehr gerecht werden, Geraeusche zu Erfahrungen zu prozessieren. Wahrscheinlich haben wir die Haeuser umzubauen.
> [Signs become evident for a feeling of house-lessness. This is, perhaps, because our houses cannot satisfy the demand of processing noises to informations anymore. We may have to re-construct the houses.]

(V. Flusser, "Einiges ueber dach- und mauerlose Architektur mit verschiedenen Kabelanschluessen" [some considerations about roof- and wall-less architecture with various cable connectors], Basler Zeitung, 22.03.1989, Nr. 69)

1.3.1_ forms & media

> The invention of the loudspeaker could be compared to the invention of the light bulb. Suddenly it was possible to project sonic energy in spaces small and large, at any angle or intensity. But the use of loudspeakers - in movie theaters, stadiums, railroad stations, and home radios - remained for the most plain and functional. Only with the dawn of World War 2 era were the aesthetic possibilities of sound projection via loudspeakers exploited [...] (*C.Roads, The Computer Music Tutorial, MIT Press 1996, p. 452)*

How can immaterial architecture be realized? Fuller dreamed of a cloud-shaped entity whithin which the climate could be regulated. Protection for humans without any material enveloping at all. While we are only at the first experiments in creating artificial clouds, we have much more experience in the use of light and sound, the media for reaching the two senses that most acutely shape our awareness, not only spatially.

Light design mainly relies on the use of artificial light sources, displays, projectors and lasers. Conversely, it is only since we have electroacoustic devices at our hands, that we have sufficient control over sound to creatively engage in 'sound architecture': In the first place, it is the fact that our commands, electronically transmitted, can reach any place at light speed. Then, we have got loudspeakers that are apt to reproduce virtually any sound we imagine, and we can position them nearly anywhere in space. Finally, the modern digital equipment does so much work for us with more than sufficiently high definition, that we can keep ourselves busy with higher levels of sound organization.

1.3.2_ functions

Referring back to the social function of architecture mentioned in chapter 1.2.1, and having understood the basic features of sonic space, we can now deduce that the sonosphere carries or can carry many of the socially relevant elements attributed to architecture: nodes of density, concentrated fields, paths of movement, dispersed zones and places of relaxation; features of proximity and distance, areas stimulating communication and others inviting for meditation. These experience profiles are not necessarily bound to material architecture, and thus we might re-formulate Fuller's question in a musical way:

What (how little) sounds can be used to create a stable, communicative, emotionally transparent environment?

Instead of attempting to answer this question theoretically, we directly step over to the 'practical' part, where we will examine works done so far that could have been motivated by this question.

_00B_interlude_   Kyoto 1350

[...] The placement of the Temple Bells still left in Kyoto suggests that between Antiquity and the Middle Ages, a sound-project of large scale was realized, whose dimension would be hardly imaginable within present day urbanistics. Not that this was the emperor's will – the temples themselves adopted the aestetics of the time, in order to develop a harmonious masterplan. The centre and the four outer districts of Kyoto were, since then, guarded by fairies – Water God, Blue Dragon, Red Bird, White Tiger and Unicorn – while the Temple Bells sounded in five different modi. It was a cosmologically ideal city on Earth, a city as mandala, a premise of which was an acute sense of hearing.

[...]

From present-day's point of view, we can compare idea and spatial dimension of the sound-plan integrated in Kyoto's architecture with the Sound Installation, the avantgardistic form of contemporary sound art. The modern sound artists transmit the noises of the ocean waves to the land, creating acoustic environments in conjunction with phantastic, synthetic soundscapes; or they transmit sounds in realtime to other places. They open up ways for us to experience sounds in completely unusual manners, they directly confront us with our surrounding by means of the sounds, and let us re-discover our environment. In our present reality, barred by manifold obstacles that impede an intuitive direct approach to our environment, such sound installations [...] express the wish to re-gain the lost sensual exprience of the cosmos.

Of course, the correlation in meaning and background between the system of medieval Temple Bells and modern sound installations is not straightforward. If at all there is any point in explaining the former with the latter, then only from this point of view: reading the Kyoto sound-plan not only as an institutionalisation and realization of the [chinese] doctrine of the Five Elements, but as the creation of a sound-event. It's about a method to perceive the universe in the dimension of the sensual experience by means of the skin or the eardrum. The idea gets experiencable as a phenomenon, and sound plays the role of a medium that regulates the relations between humans and cosmos. The Kyoto Temple Bells also rang for those who did not know about the doctrine of the Five Elements, by telling them the time, conveying the dimension of the city through their sonic presence and invoking wanderlust [Fernweh]. Now, the sounds of the Bells and the modern sound installations start to collectively vibrate, breaking through the historical wall of several centuries.

(Shin Nakagawa, Kyoto - Klaenge des Kosmos, Merve, Berlin 2000)

_2_ praxis: works and analysis

2.1_ three exemplary personalities

The following chapter shall present a trio of artists that share a life-long dedication to the exploration of spatial sound phenomena, both conceptually as creatively, by means of electroacoustic media - mostly sound installations.

In awareness of the fact that the whole issue has a short history and no canonized theory, I think it is very instructive to observe and discuss these three men's achievements. Coming each of them from a different background, I found it interesting to see how they approach things from their own professional perspective and deal with recurrent problems in their own distinctive way: The architect, the composer and the performing musician.

2.1.1_ Leitner

Born 1938 in Austria and educated as an architect, Leitner is researching the intersections of sound and space since the late 1960's with a very distinctive, formal approach. We might sum up his activity as translation of architectonic space concepts to sound. The resulting works are described as sound architecture, sound/space-sculpture, -installation or –objects. His early resarch started from the assumption that sound could create an *inner space* that would be acoustically experiencable by the ears as well as by the entire body.
His pamphlet *Sound Architecture*, published 1971 in New York, presents results of his reearch in a very formalized way. It seems to be a good entrance point into his way of thinking and working, thus I will quote some parts that are of interest for us:

1. Definition
A line is an infinite series of points.
A line of sound is produced when sound moves along a series of loudspeakers, from one speaker to another.
Space can be defined by lines.
Lines of sound can also define space: space-through-moving-sound.

a trio of Leitner's sound/space-objects or –installation, 1996, 2001, 1987.

1.1. Space Through Moving Sound

In many examples a large number of loudspeakers have been used to distribute sources of sound in space. These examples are almost exclusively works by musicians and composers, i.e., the message is a musical one, whatever the definition of music is. The movement of sound in three dimensions, therefore space itself, is the message. Sound in space. *Music*.

Architectural space, however, is not a total message in itself. It makes something possible, but it becomes fully meaningful only when it is used in an appropriate way. The architectural space can be an indication of the content. Space created through moving sound is the frame for different kinds of activities and functions, a spatial experience for certain uses. The building material is sound, the abstract line of sound. Space through sound. *Architecture.*
[...]

2.1. Time

The fundamental phenomenon of sound is its development in time. Architecture is basically static; time is introduced through changes in daylight, periods of different intensity of noise and, above all, through the movement of people. Sound-architecture is in its essence an event of temporal development. Space is developed gradually in time. But it is not a space, it is a constant sequence of spaces.

2.2 Determinants of space
[...]

Pause – the duration of an interruption in the development of a space. Theoretically this interruption is a "spaceless" situation.

4. New conditions - new values
[...]Some subjects for research:

How do acoustical changes influence space perception? – The influence of acoustics on balance and orientation. – [...] Fast transformation from a narrow space into a wide one and vice versa. – Simulation of street experience. – Crowding versus openness. – Space created through traveling sound for medical purposes – Acoustical space perception overlapped with visual space perception. – Sound-architecture as therapy – Spaces for relaxation.

Note how the goals of sonic space stated here are overlapping the goals of architecture as stated in the previous chapter.
Part 5 describes an example of a realized sound-space; see the illustration below:

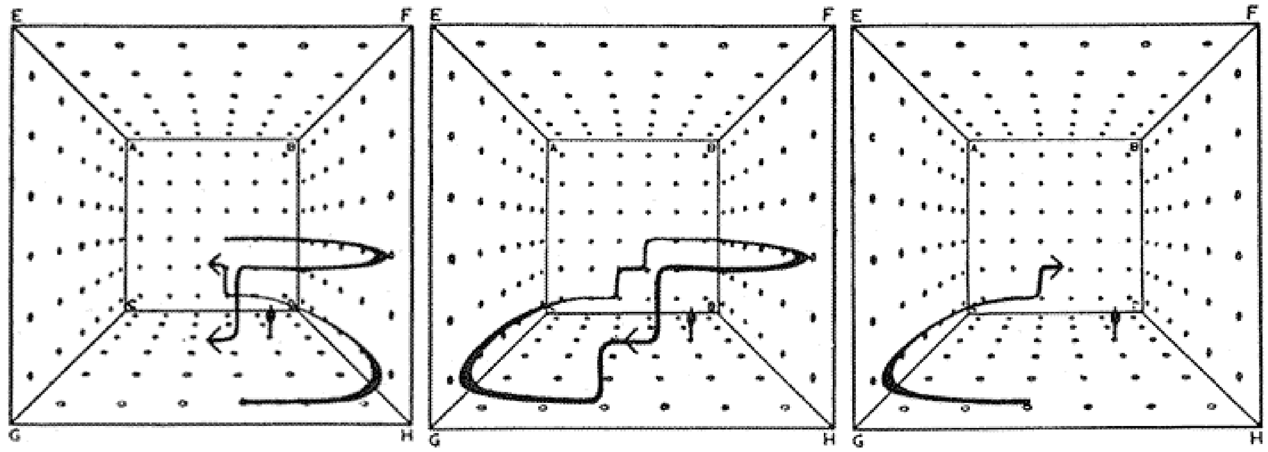
5. The Soundcube.

5.1. Description

The Soundcube has a grid of loudspeakers on each of its six walls. The dimension of the cube is ideally "neutral", visually speaking, i.e., without any specific spatial message. The sound is programmed to travel from loudspeaker to loudspeaker. An infinite number of spaces or spatial sensations can be created.

5.2. Function.
The Soundcube is not a space for producing music.
The Soundcube is an instrument for producing space (with sound).[...]

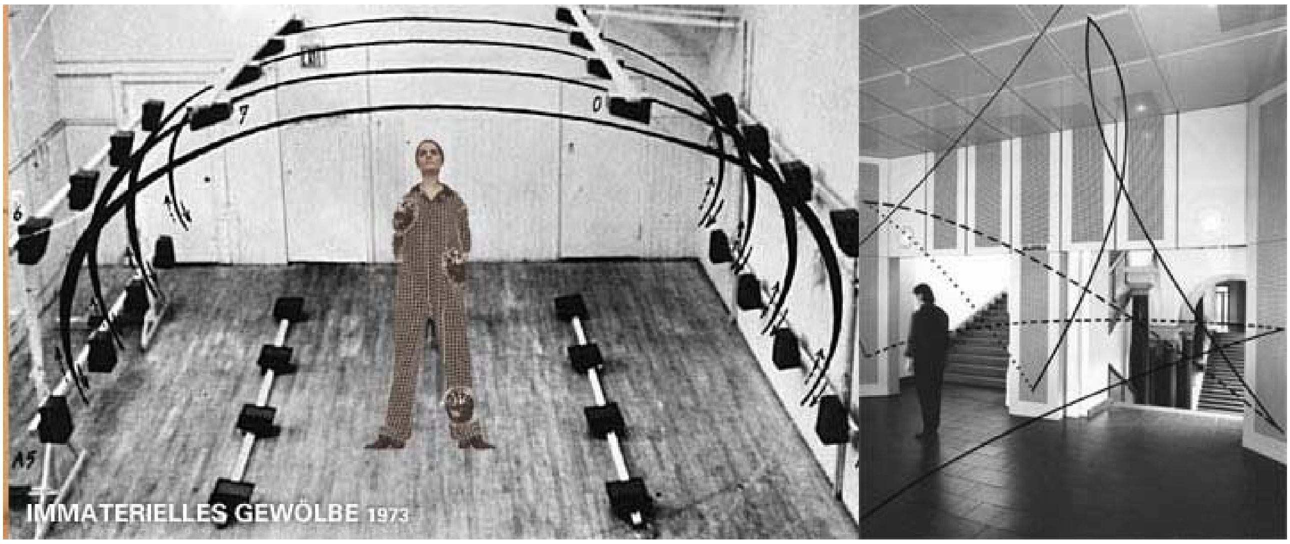
5.3 Spaces Created within the Soundcube
+ Timbre of sound has not been considered in the following examples. The main purpose here is to describe the principle of spaces created by traveling sound.
++ The notation of pitch follows classical notation. It should not be interpreted as a musical statement. It is an illustration of the simple but crucial relationship between pitch and definition of space.
[...]



SOUNDCUBE 1971

different space programs of the *Soundcube*, 1971, New York.

What follows in the text is a description of several sound-shapes to be achieved with different ways of moving a tone within the 3-D-array of speakers. It can coarsely also be understood on the basis of the illustration. The programming of the movements, by the way, was at that time achieved by means of a punch-card-system and allowed, cosequently, for a rather low level of complexity compared to present-day digital sound sequencing tools.



two of Leitner's Sound/space-objects with paths of sound movement superimposed as lines, 1973, 84

2.1.2_ Fontana

The Californian composer and sound artist Bill Fontana is making public Sound Installations since the 1970's. Starting out with a training in philosophy and classical composition, he got influenced by the ambient music movement of the time:

> [I] use the human and/or natural environment as a musical information system full of interesting sound events. [...] I am assuming that at any given moment there will be something meaningful to hear.

The step from recording soundscapes towards live sound installations is described as the way out from the dilemma that playing back recorded material would hardly have been accepted as compositional achievement. Fontana found his *modus operandi* in live transmitting a soundscape from one to another place, a concept as stringently powerful as it is simple to explain:

> One of the most useful methods has been to create installations that connect two separate physical environments through the medium of permanent listening. Microphones installed in one location transmit their resulting sound continuums to another location, where they can be permanently heard as a transparent overlay to visual space.

Up to the year 2003, where for the first time he employed synthetical sound modeling, he would actually develop mastership in 'composing' microphoned sound streams - without sonically altering them - in a highly musical way. The only change applied to the sounds was a temporal one, as sounds transmitted via cable travel many times faster than through air.

> Influenced by Duchamp's strategy of the found object, I began to realize that the relocation of an ambient sound source within a new context would alter radically the acoustic meaning of the ambient sound source. *(B. Fontana, The Relocation of Ambient Sound: Urban Sound Sculpture, 2001, <www.resoundings.org>)*

A concrete example of one of his live installations is given here:

> The sculptural placement of the live multiple audio streams in one space as a sound sculpture has been an important strategy for reconfiguring the acoustic sense of the body in relation to an environment. In my recent ACOUSTICAL VISIONS OF VENICE, which was installed during the [1999] Venice Biennale on the façade of the Punta della Dogana, live sounds from 13 locations in the visual panorama, acoustically wrapped this building with its amazing views. It created a situation that you could hear as far as you could see. This new multidimensional acoustic body of Venice was transparent and framed the actual acoustic events one would normally hear at the Dogana, so that whenever a bell rang or ship blew its horn, one heard it first at the speed of light and then at the speed of sound. A physicist visiting the sculpture remarked to me that I had created a reverberant zone. *(B. Fontana, The Environment as a musical resource; 2000, <www.resoundings.org>)*

The concept of *sound sculpture*, as he would call his works, alludes to the spatial dimension of a soundscape when it is transmitted and projected via multiple audio channels:

> I conceived such relocations in sculptural terms because ambient sounds are sculptural in the way they belong to a particular place. To make [music] out of an ambient sound, the act of placing this sound would have considerable aesthetic importance.
>
> In addition to their sculptural ability to belong to a particular space, ambient sounds are *re-sculptural* as volumes of space in terms of how a given sound source occupies its own sound field. Through multiple-perspective field recordings and live relocations of environmental sound processes, I have investigated this sculptural property of sound in many different circumstances. Real-time multiple-acoustic perspectives reveal qualities in sound sources that are not explicit in our typical perception of them. Such factors as acoustic delays, the Doppler effect and phasing reveal elegant musical structures in even the most simple of environmental sound sources. When a multiple-perspective rendering of the sounds of one place (either live or recorded) is installed in another space and played from a number of carefully positioned loudspeakers, dynamic and vivid relocations of the sound sources can be realized. When thinking about the transformed acoustic meaning that a familiar sound acquires when its whole sound field is considered, I ask myself, What is this sound that I am now hearing? The answer I give is that this sound is all the possible ways there are to hear it. *(B. Fontana, The Relocation of Ambient Sound: Urban Sound Sculpture, 2001, <www.resoundings.org>)*

Further than borrowing the notion of sculpture for his art form, Fontana employs other metaphors from the visual vocabulary (perspective, panorama, image) to describe the subtle interactions of sound and space difficult to explain otherwise. Actually, in many of his works he directly juxtaposes scope, limit and plasticity of the visual and aural domains in order to achieve the effect he desires. For his Kyoto installation he writes:

> At the sculpture site you have distant panoramic views, [...] where you can see much further than you can hear. This sound sculpture explores the experience of hearing as far as you can see, by borrowing the landscape for sound, by simultaneously bringing many live sounds from the Kyoto landscape to the hilltop. *(B. Fontana, The Environment as a musical resource; 1990, <www.resoundings.org>)*

Another motivation for Fontana's recurring allusion to sculpture and architecture is the factor of permanence:

> The most elemental characteristic of any sound is duration.
>
> Sounds that repeat, that are continuous and that have long duration defy the natural acoustic mortality of becoming silent..
>
> In the ongoing sculptural definition of my work I have used different strategies to overcome the ephemeral qualities of sound, that seem to be in marked contrast to the sense of physical certainty and permanence that normally belong to sculpture and architecture.

The factor of permanence explains his fascination for sound sources with no apparent beginning nor ending, i.e. river, ocean and wind sounds:

> [...]
> [This 8-channel recording of ocean waves] was also sculptural in another important way, the percussive wave action at Kirribilli Wharf had continuousness and permanence about it. This 8 channel tape was not a recording of a unique moment, [...] but was an excerpt from a sound process that is perpetual. Twelve years after this recording was made, I returned to Kiribilli Wharf and placed microphones there which transmitted live sound to the Art Gallery of New South Sales in Sydney, as part of a sound sculpture.

Paradoxically, what musicians and composers dreamed of for ages, to get ever-lasting sound at their hands, soon turned into the major issue of the acoustic ecology discourse: it is the the permanence of the sounds emitted by motors and machines that makes them so stressful to our ears.

2.1.3_ Bosshard

Born in 1955, Zuerich-based musician and sound architect Andres Bosshard is a passionate advocate of spatially moving sound in all its musical and acoustic aspects. With his background as a flutist, he has kept a focus on live music throughout his career, which shifted from the concert halls over industrial sites to spectacular outdoor locations – reservoirs dams, mountain tops, forests, mines, glaciers or lakes. He has developed a capacious multichannel sound distribution setup, which he employs both for sound installations and for live mixing of various sound sources – be it recorded material, musicians playing live or realtime streams from other places, transmitted via telephone, radio or - as in *Moon Echo,* his collaboration with Pauline Oliveros - to the moon and back.

Unfortunately, there is no written biography about Bosshard available, so I can only render what I learned from personal interviews with the artist – it might be due to his unorthodox approach to sound and architecture that he is not yet canonized like the other artists portrayed above.

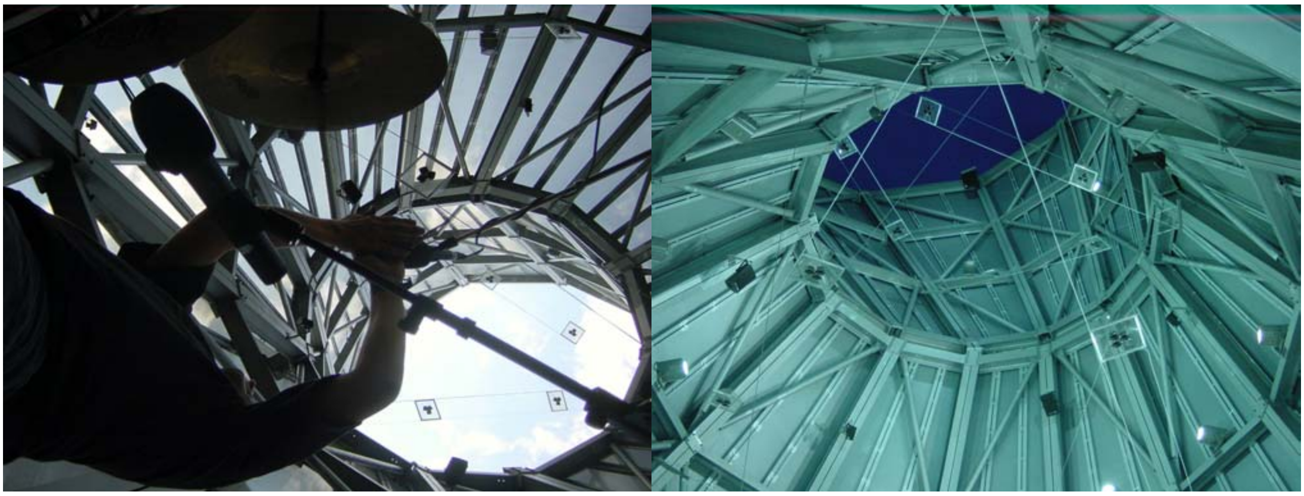
Perhaps it is best to have a look at his latest work, *Klangturm*, that brings together all his musical ideas, technological development and social vision:

The Sound Tower from outside

Klangturm, the 'Sound Tower' (<www.klangturm.ch>) was a project realised for the Swiss *EXPO 2002*, the national showcase that takes place every 25 years. This event has a major importance, nationally, and represents all cultural and economic lobbies of the country.
The main representative building was a tower of some 40 m height, planned by *Coop Himmelblau* Architects, and situated on the shore of Lake Biel/Bienne. The tower was a roofless metal structure with a semi-transparent aluminium skin such as to allow light, - and sound - to permeate the building from inside out and vice versa. Bosshard had the direction over a 22-week daily continuous music programme.

The open, nearly immaterial architecture of the tower was an ideal framework to house a complex sound architecture, as it did not inscribe any marked acoustic character to the inner space, as it usually happens with architectures realized by solid materials. The open space is, theoretically speaking, acoustically neutral for its absence of reflective surfaces; so all sonic spaces could be realized by means of the building blocks best suited for this task: loudspeakers.

The sound architecture was implemented as a 40-active-channel system comprising PA-speakers with subwoofers, custom frame-speakers hung at height from ropes, and high-frequency horns on flying balloons. In accordance with the concept of the sonospheres, the sound system was divided into several sub-systems with a distinct spatial direction each: a lower ring of speakers for the direct-field, 2 arrays of speakers spiraling up and down the vertical axis of the tower, and 2 horizontal rings at higher levels, which would, thanks to the acoustically transparent lining of the tower, also project sound to the exhibition area outside. Thus they provided for the far-field of sound, casting acoustic shadows around the range of about 50m around the building.



two views from inside the tower towards the sky

The loudspeaker system was controlled by a twin set of PCs equipped with multichannel audio interfaces and running a standard commercial harddisk-recording software. Being of a newer generation and initially designed for surround media production, Bosshard 'abuses' it for live mixing and spatialisation to multiple channels. To create spatial sound from the (monophonic instrumental) sources, a number of different approaches are employed, which are worth going into some detail here:

- conventional panning. Similar to what we saw in the illustration to Leitner's *Soundcube*, lines of traveling sound are created by panning. The panning system of the software allows for freely positioning the speakers on a virtual plane, between which the sound sources can be arbitrarily moved. The resulting paths can be recorded and re-used as automation data.
- what Bosshard calls 'pixeled playing' of the speaker array, a direct targeting of each speaker without gradually distributing energy between adjacent pairs. With the use of time delays, one sound can *successively* appear in any sequence on the speakers. This way, different spatial effects can be obtained:

-- with sufficiently long delay times, a percussive sound appears to 'jump' from one speaker to the next. That can yield a strong effect when geometrical shapes are 'drawn' with the temporal and topological sequence of sounds on the speakers. The upward and downward speaker spirals in the tower were attributed such playing technique. Sounds with a smooth starting and ending envelope appear to glide between the speakers, an effect similar to the panning described above, but different in its temporal evolution.

-- By using shorter delay times in the same setting, sound sources can be made to appear being located in a distinct position in space. This position can also be outside the actual circumference of loudspeakers. Like this, the frame of the actual space is not the limit of the experienced sonic space. (This method exploits *interaural time difference* localization and the *law of the first wavefront*, which determines the apparent direction of the sound source).

-- With yet a smaller, more dense scaling of the delay times between the loudspeakers, an impression of reflections of the sound can be achieved. The early reflections of a room, as it were, can be individually modeled. It is evident, that that way a multitude of enclosed or reflective outdoor spaces can be simulated. With the additional aid of some equalization, we can understand it as a 'hand-made' version of what a reverb processor does; with the difference that the reverb processors commercially available offer 8 channels, at best.

The total-recall-functionality of the sequencing software allows for instantly switching from one setting to another, which is to say, from one space to another. What we remember Leitner having stated 30 years earlier, is now within reach so immediately that a musician can 'improvise spaces' at will.

Operation of the whole sound distribution system in the *Klangturm* was managed from a box floating at 4m above the ground. One of 14 *sound-directors* was present at all times of the day throughout the 22 weeks, coordinating the sonic events and their spatial behaviour. A preconceived score structured the timespan of the whole exhibition in weekly and daily rhythms, where an instrumental concert at a certain time of the day would change with periods of reduced activity where the *sound-director* could improvise with pre-recorded material or signals from one of the 7 live-feeds, which included different layers from atmo microphones to underwater hydrophones and sonified data from seismic and solar activity.

The sound architecture was in use for the period of 22 weeks, housed 40 concerts with musicians of different styles including a classical orchestra, and had an audience of more than 750 000 people.

For the social aspect of the work, the times between official concerts are of particular interest. While the concert situation is still a traditional context for music consumption, even in this specific environment, the times when no live musicians were on stage offered a more neutral, quasi context-free situation for the *sound-directors* to play the sound tower. The fact that this way of live playing was not perceived 'as music', actually allowed for a fresh and free way of perceiving the sounds without relating the heard sounds to any learned listening habit. Being free of any function for the rest, the tower proved an ideal area for experimenting with the audience interaction. The entire array of social musical functions as described above could be played: attraction and repulsion, activity and relaxation, concentration and distraction.

The floating *Sound Directors' Box* during a concert

2.2_ deductions

This second part of the present chapter will analyze common aspects of the works presented and give some impulses on how to distinguish qualititive charcteristics of spatial sound installations. The method used here will be comparative and deductive, thus trying to stick to the facts learned from the work discussed above rather than to speculation.

2.2.1_ an architect, a composer, a musician.
planning, hearing, playing

Now that we've seen the work of three artists of sonic space, we can acknowledge how different their approaches are, which might be explained by their provenience from different artistic/scientific backgrounds:

Leitner, in his investigation of sonic space, remains an architect in the way he *plans* spaces; not using concrete building blocks anymore, but substituting them by sounds. Certain sounds take certain 'constructive' functions, and a speaker setting is designed for a certain number of sonic spaces it can produce. Although it can contain 'a sequence of dynamic spaces', the concept solidifies again, as the planning of the sound-space happens on a purely conceptual level and, once realized, it is not intended to be changed in interaction with the audience, just like a building is once built and then 'used' by it's inhabitants in the way it fits them best.

Fontana, then, shows a similar conceptual strength in preliminarily conceiving location, content and techniques of a sound sculpture. Yet, the subjective thought of the composer has high value; he thinks much less functional than aesthetic. As a result, the sonic space, once realized, has one specific layout that will not be changed, and one set of sources that will not alter. Still his work is very lively, because the sound sources are live streams, thus subject to all sorts of natural modulations and interferences: in effect, what the audience hears is unpredictable.

Bosshard’s approach of creating complex multichannel sound architecture and then playing it like an instrument allows for a degree of liveliness even higher than Fontana's: The musician can sense the momentary emotional condition on the location and directly react to it, so as to either follow the tendencies or try to evoke new stimuli. Although concept and approach are directly rooted in musical tradition, the live playing with the spatial perception is not 'heard' as music by most of the audience, as Bosshard states. It is, of course, immediately perceived, but not as concretely as the saxophonist's playing, for instance. The unseizable, 'airy' dimension added to the music has a strong harmonizing and hypnotizing, thus truly musical potential, but as it is such a new feature to our experience, we have no words to describe it (yet...)

In the following paragraphs, I want to introduce some parameters by which, in my opinion, fundamental characteristics of sonic spaces can be described, or rather, discussed. Some of them are dualistic pairs of terms which demarcate the extremes of a continuum, such as hot/cold or large/small.

2.2.2_ reproduce/create

A common notion in electronic music and signal theory, the distinction between reproducing existing and creating/synthesizing new signals, can also be applied to the spatial sound discourse. Most of the audio-electronic media, from the grammophone via the telephone to the tape recorder, were initially developed to reproduce music and speech, and later musicians learned to use these devices to manipulate the mediated sounds, which yielded unheard new sonorities. Even later the idea of synthetically creating sounds emerged, again first with the intention of replicating existing instrumental timbres, and only then exploiting the full sonic potential of these devices that would reach far beyond the scope of imitation.

In architecture, the idea of reproducing spaces has less of a meaning – except for documentary purposes, perhaps. What is asked for, instead, is the concrete creation of spaces for various functions.

Now, in the field of spatial acoustics, right on the intersection between sound/music and architecture, can sonic spaces be reproduced at all, in a fashion beyond replicating the reverberation halo? As Fontana's example shows, it is possible. In his work this is achieved by means of the spatially distributed sensor network, the signals of which are projected in a spatially congruent pattern. Of course, as with every transmission, distortions occur, and these are to a great extent due to the spatial deficiencies of both the microphones and the loudspeakers: they have directional characteristics, i.e. a loudspeaker projects its energy in a non-radial way. High frequencies form a beam along the axis orthogonal to the speaker membrane, while low frequencies radiate to all sides of the enclosure. This behaviour is far from the radiation pattern of physical sound sources and it would take great technological effort to compensate for it, in order to achieve 'spatial fidelity'.
Another cause of distortion in the representation of space is the overlay with the actual acoustic space in the place of reproduction. We will discuss this issue later on in this chapter.

In spite of its technological shortcomings, acoustic space reproduction reveals a very strong potential, an almost magical impact, if two conditions are met.

One is the relation of the transmitted space to the space of reception. As we can observe, Fontana often feeds sound sources from places too remote to hear, but well within the visual horizon of the installation site. At other times, the relation is a historical or social one, as in *Distant Trains* (Berlin 1983), where he transmitted the sounds of the busy Cologne main station to the ruin field of what used to be the *Anhalter Bahnhof* in pre-war Berlin. In yet another situation, the relation between source and target sound-space is of purely sonic nature, as in *Sound Island* (Paris, 1994), where he 'sonified' the Arc de Triomphe with sounds of the ocean off the Normandy coast. While there is no intrinsic connection evident between these two spaces, the white noise of the wave sounds had the effect of partially masking the traffic sounds in downtown Paris and so to create an island of apparent silence. (Indeed, there is also a striking political/historical subtext implied in the work: the Normandy coast as the scene of D-Day, and the Arc, symbol of the power of the 'Grande Nation').

The second aspect of the success of Fontana's installation is that the transmissions are *realtime*. Compared to the playback of a comparable space-source from tape, this gives us the feeling of a true extension of the senses, when we can hear what is happening in another place *right now*. Also, the slightly vague and vanishing quality of the acoustic medium unfolds its full effect here; similarly to our custom of 'tele-communicating' by means of the telephone and not by sending each other moving pictures (although it would be possible, technically). Perhaps we *want* this last remainder of uncertainty, this gap of psychological distance kept by the fact of being invisible.

2.2.3_ outdoor/indoor

The 4 border cases of hearing spaces are
-a). the dead room
-b). the endlessly reverberant room
-c). the anechoic outdoor situation
-d). the perfectly echoic outdoor.
Approximations of the first two are found in departments of physical acoustics at universities, where measurements of absorptive and reflective behaviours of materials are made. All real indoor situations are somewhere along the continuum between these two extremes; the more hard and smooth surfaces, the more reverberant, and vice versa. An approximation to the ideal anechoic outdoor situation can be found in a very

large open field with no buildings, trees or landscape elevations; and the closest to a perfectly echoic outdoor site should be a rocky canyon in a mountainous landscape. Situation a) and c) are sometimes confused with situations of perfect silence. Besides the fact that at least since Cage we know that perfect silence is literally utopic, the definition of *anechoic* does not imply the absence of sound, it merely implies the absence of reflections to any given sound. That would be, theoretically, an ideal precondition for the creation of artificial sound-spaces, because any desired spatial behaviour, any reflective pattern could be modeled on this acoustical *tabula rasa.* The ideal means for it would be a system for *Wave Field Synthesis*, the physical method which states that with an infinite number of infinitely small sound sources (loudspeakers) placed in a 360 degree sphere around the listener, sounds can be realistically placed in all thinkable positions and virtually *all* spatial sound situations can be recreated[5].

Given that these conditions are virtually never met for the purpose of a spatial sound installation (and if they were, the location would probably look else than pleasant), the following problem emerges:

An artificial sound-space is always trapped in another, real, sound-space.

The acoustics of the artifact, no matter how they were designed, will inevitably be 'colored' by the acoustics of the real space in which they are presented. This problem particularly holds in indoor situations, but it also applies to outdoor sites, as most of them will be surrounded by some reflective surfaces that color the acoustics.

Another related problem pertains more to the outdoor situations; it emerges from Cage's dogma of the non-existence of silence:

Any acoustic signal induced in a space will inevitably be overlaid by a soundscape already present in that space.

A writer writes on sheets of blank paper; how could a sound-architect or musician deal with this reality that there is neither a nowhere nor a nothingness in acoustic space where to start from scratch? While I thought that this apparent dilemma should be of great concern for people making sound installations (as it does for physicists), I noticed that the artists reviewed above all had found an elegant solution to it, or didn't even realize it as problemetic:

Leitner, with his architecture background introduces the terms of *Primary Space* and *Secondary Space*. Section 6 of his *Sound Architecture* reads as follows:

```
6.Primary Space and Secondary Space overlaid.
  Primary space is visually clearly determined.
  Secondary Space, created through traveling sound, defined by lines
  of sound, is continuously changeable.
```

5 The technology is based on Huygens' principle which states that any point of a wave front of a propagating wave at any instant conforms to the envelope of spherical waves emanating from every point on the wavefront at the prior instant. While it is not practicable to position the acoustic sources on the wavefronts for synthesis; by placing the loudspeakers on an arbitrary fixed curve and by weighting and delaying the driving signals, an acoustic wavefront can be synthesized with a loudspeaker array.
Werner de Bruyn at the Technical University of Delft has realized a prototype of a WFS system with over 250 active channels in a 2-dimensional plane. As the notion of *Wavefront* suggests a linear cut through a 2-dimensional plane, this theory was not initially conceived for 3-dimensional models. These are, though, mathematically easily derivable , resulting in a far more complex system, which was, to my knowledge, not realized yet. See <http://www.lnt.de/LMS/research/projects/WFS/index.php?lang=eng> for more on the matter.

The terminology suggests that the sound-space will always be subordinate, *secondary* to the 'real' space that exists *a priori*. He does not mention, though, the acoustic nature of the *Primary Space*, but we might guess that he wishes it to be as *neutral* as in the indication for the visual design of the primary space in his *Sound Cube*. For the rest, he investigates the interaction of primary and secondaty spaces and uses that as a creative resource, as Fontana does. Bosshard and Fontana, both environmentalists who share a preference for outdoor sites, often use a strong characteristic feature – be it a key sound or a situation with special acoustics – of the *Primary Space* as a source of inspiration for an entire work. Let me just point to Bosshard's *Staudamm-Konzert*, a live performance centered around a huge reservoir dam in an alpine valley of the *Tessin*, whose concave outer façade was used as a giant reflector for loudspeakers (a picture of the set is available at <www.soundcity.ws>).

2.2.4_ outline/reflections

A more technical distinction regards the instrumental use of loudspeakers. While both Leitner and Fontana do not mention the loudspeakers in their writings and supposedly consider them as a medium that should ideally be neutral, Bosshard emphasizes that they are to the sound-architect what the violin is to the violinist: the instrument, whose possibilities and limitations determine the spatial/musical result of the performance; the instrument that needs to be tuned before the concert begins (here in terms of accurate positioning in space) and mastered by its virtuoso player.

Further we can observe how the different artists consider creation of a sonic space, instrumentally. Leitner clearly formulates that "lines of traveling sound demarcate space". This implies that these *outlines* of a sonic space are bound to the physical positions of the loudspeakers and, consequently, from one speaker layout a number of movement path variations can be deduced, but the resulting acoustic spaces can not surpass the dimensions of the static space as demarcated by the speakers.

Bosshard, on the other hand, refers to the sound from the speakers as *reflections* of the sonic space he intends to create. By doing so, he avoids being bound to the topology of the speaker layout with his sound sources; if he masters the distribution of the reflections over all of his speakers, he can get sound sources from all locations, also inside and outside the grid of the speakers. This technique, better described in the *Klangturm* section above, may actually be thought of as a creative reduction of the Wavefield Synthesis principle.

2.2.5_ fill/open; take/make

Another interesting psychological dimension of sound is, whether it subjectively creates space that was not there before, or occupies existing space by filling it with sound. That is to say, when every sound has a spatial dimension, we can distinguish whether its relation to the space it happens in is possessive or open.

But it is very difficult to set objective parameters for this quality of sound. Of course, the number of sound sources plays a certain role – a single monophonic source seems to be less apt to make spatial impressions than a set of eight or more speakers – but while the complexity of sound treatment rises in direct proportion to the number of speakers used, the degree of spatiality does not.

'Opening space' has also a social connotation; the drastic example of a discotheque may illustrate this from the opposite point of view: Entering a disco, we immerge into something like an sonic bath. High levels of sound are equally distributed all over the place, massive basses permeate our body; the whole space vibrates in an unifiyng, inevitable beat. Ideas of a liquid that surrounds us, or a heavy mass we are all part of, come to mind; much more than the notion of airy spatiality. (If ever, the space appears to shrink, acoustically). The consequence of this dominance in filling out acoustic space is, that there is literally no space left for other acoustic events: verbal communication is not possible (and, presumably, also not wished for).

Sound Installation has other goals. A leading idea is, actually, to leave the audience as much freedom as possible, giving them the choice about when to enter and leave the piece, allowing them to move freely in the space and to communicate and talk at will. The concept of creating an open space to be filled by unpredicted happenings and audience interaction is intrinsic in the idea; the step further to translate the concept to the sound-space itself is evident.

Sound Sculpture, a term often mentioned along with Sound Installation, suggests a yet different interpretation of spatiality: sculptural objects equipped with loudspeakers. In the visual world, a sculpture is a 3-dimensional object with, therefore, well defined spatial properties. But it usually does not give the impression of opening up a space – it constitutes a space on its own, but mostly even neglects the *Primary Space* in which it is located: a sculpture is nomadic and can move from one place to another.

Interestingly enough, Fontana chose exactly the term *sound sculpture* for his work of acoustic relocation. Although the aspect of spatial presence is not his primary preoccupation, I think that his sound installations have a much higher degree of spatiality than the term would suggest.

A quality of an opening sound space, on the other hand, seems to be that it constitutes a transparent framework that has a spatial character regardless of *what* sound is fed into the system. Bosshards sound-architecture that was played with instrumentalists as varying as Alphorn, dulcimer, jazz drums, lithophones and with a symphonic orchestra is a pristine example for it. We remember also that Fontana's networks of microphones and speakers are open for any sound that occurs near them.

For those concerned with acoustic ecology, this quote of W. Herzogenrath with a reference to 'muzak' might be of interest:

> [... in our] public world, music is 'composed' for spaces in order not to be perceived as such, but merely to deliver a sound that atmospherically fills out space. *(W. Herzogenrath, About B. Leitner. in Sound:Space, 1998, Cantz, Stuttgart)*

2.2.6_ visuality

With all the dedication to the realm of the sounds, I noticed how all of our three specialists recurrently use metaphors from or references to the visual domain. Leitner frankly states that "our hearing is dominated by our sight", so the hierarchy is once forever fixed.

Bosshard, in most of his lectures, uses visual aids, diagrams and images to illustrate his spatial/musical thought. According to him, he does it to aid the understanding of the ephemeral phenomena of the acoustic world, as many thinking patterns are laid out along visual paradigms.

Fontana shows a tendency to reconcile visual and aural sense when he develops devices to extend the acoustic horizon of his audience to the visual one.

_3_ conclusion

It is time to resume what we have found and review the questions asked initially.

Can we create space out of sound?

Implicitly, the question is already answered: *positive*!

Having seen the results of Leitner's research and the work of the other artists, we can take it for granted that the medium sound can be treated in a way such as to induce a distinctly spatial experience. It can create an emotional space, which, just like a real architectonic space, one can enter and leave, experience from different perspectives and distances, and, above all, socialise in. That distinguishes sonic space from the majority of 'virtual spaces', which many times need special encapsulated environments to exist, and, acoustically, are designed such as to offer the intended spatiality for the one person in the 'sweet spot' only. Many other virtual environments are based on the use of headphones and are thus not very social, either.

Of course, we can hardly argue that sonic space can be an equivalent of or replacement for architectural space as we know it. There is still a number of basic human needs (controlled temperature, humidity…) that require the employment of other than sonic media. But beyond those needs, - for which material architecture still seems to be the most adequate medium - when it comes to social and emotional tasks attributed to architecture, sonic space can be a great complement. Furthermore, it has a few unique qualities unrivalled by conventional architecture. Among these are the temporal flexibility and the relocatability of acoustic space.

It was proven by Leitner that one sound installation could evoke a multitude of different spatial experiences, a feature that is also employed in certain commercial applications (theme park etc.) where a high degree of flexibility with a minimum of temporal and material expenses is required.

Relocatability is a quality with an enormous potential not fully understood yet. Being able to put a person into a reality that is simultaneous but in another place is a faculty that sure had belonged to the domain of magic at other times.

The social potential of acoustic space has many facettes.
To the question whether his sound-spaces were works with a demand on the private art market, Leitner answered, significantly, that public space proved to be the forum best suited for his work [6]. Not the private space, thus, but the space intended for social interaction is the space for sound architecture. Fontana's and Bosshard's numerous permanent public installations suggest the same.

What seems a minor detail at first glance, the employment of open microphones as constituent permanent sources for the public sound space, is actually a generous democratic gesture: the artist offers a channel of public adress to anybody. He creates a forum in the literal sense of its historical example. Not only does he more or less explictly provide a public tool for the freedom of expression, he also takes the responsibilty for the sounds that are broadcast via this channel. To ultimately let let go of full control over the content of his work, must require a good deal of courage from any artist. Yet, this reminds one the sitiuation of an architect, who plans a building and has no control over what will happen in it. (In the sound installations that were accepted by the audience, abuse of the open microphone channels was virtually never registered.).

In those fields where urbanistics and architecture struggle with problems of noise overload, the expertise of sound space specialists can help resolving some of the trouble; not only passivly. As we saw, the measures aimed at isolating noises do not always keep their result within the desired frame: they tend to isolate people, too. The alternative is active noise abatement. Under technologically ideal circumstances, this would mean noise *cancellation:* feeding the same noise, but with inversed phase (polarity), into an environment, results in silence. Unfortunately, at present time this is possible only in one point in space (sweet spot). Until we get

[6] from: Dialog between W. Drechsler and B. Leitner, in: „Ansichten", Residenz, Vienna, 1992

complete control over the entire *phase space*, we can help out with some poetic adaption of the concept of active noise reduction. Fontana gives us an example with his work at the Paris Arc de Triomphe. This strategy of feeding 'composed' sounds into a 'polluted' environment and thus revaluating the soundscape, or even managing to mask part of the undesired noises with other sources without excessive levels, surely deserves some further investigation before we understand their full potential.

The specific capabilities of spatial sound projection might also find their application in public spaces that traditionally lack orientation. Just think of a multi-storey car park. By assigning it different zones with specific acoustics qualities - a silent area, a 'wet' zone, one with sounds of birds or sheep or bells, a pop storey or a classics-lane - orientation could be made easier without bothering people to remember numbers, colours or codes. Obviously, such a project would not only involve specialists in sound spatialization but also acousticians to shape the materiality of the different parts of the building, accordingly.

The situation is similar to other fields where visual and sound people work in a team: sound people often feel frustrated because they are taken into account only when most of the conceptual and aesthetic decisions are already taken. Just like in the film industry, where the best results are achieved when director and composer work together from the beginning of the project, in a situation ideal for the acoustic hygiene of a place, architect and musican should collaborate from the beginning. That way, the architect can employ his available means of building acoustics, and the musician can use the technologies of sound spatialisation to achieve optimum synergetic results.

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