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SCENIC AND SONIC STRUCTURE:
ACOUSTICS WORKSHOP

Text by Sabine von Fischer

How does a building for electronic music have to look like? Electronic music in its many forms has become the most popular sounds of a new generation, also of young architects. Under these circumstances, we have decided to investigate the creation of a prototype for electronic music during a semester of architectural design in the winter of 2002-3 at ETHZ: Object Semester 1.

Space perception and the technological basis
The acoustics workshop started with a visit to EMPA (Swiss Federal Laboratories for Materials Testing and Research www.empa.ch). Kurt Eggenschwiler, expert for acoustics in architecture and lecturer at the architecture department of ETH (www.arch.ethz.ch/eggenschwiler), gave both a theoretical introduction into the parameters and procedures of acoustic science, and guided an experiential ‘sound walk’ through the indoor and outdoor spaces of the complex and into the anechoic and the reverberation spaces of EMPA.

Kurt Eggenschwiler and students in the reverberation room of EMPA
(concrete floor and ceiling, tile walls and plexiglass reflectors: 8-9 seconds of reverberation time)
The idea of using room acoustics software derived from the thought that, in architectural practice, we are just-so familiar with visual simulations: No architectural project is presented without images rendered from 3D models, including surface structures, lights and reflections. While this visual virtual reality is becoming perfected, we have to remind ourselves how we perceive space: not only with our eyes, but also with our ears, hands, feet, by smell and by touch. One proof for the perception of space as a multi-sensory process is the uneasiness one experiences in an anechoic space: The feeling of an obscure ‘pressure’, a headache has no objective source. The zero reverberation of an anechoic space is identical with the sound on a mountain top, as Kurt Heutschi pointed out inside the anechoic chamber at the electroacoustics department of ETHZ. Yet, the discrepancy of hearing no echo while the eyes perceive a wall seems wrong, as it is artificially created with sound absorbing materials and shapes.

**Grid diagrams and auralisation with Odeon**

The goal of the acoustics exercise was two-fold:
- First, we wanted to inspire the students to think of their projects in terms of sound, not only as a space for the reproduction of sound, but as a space where sound is produced by the architecture itself.
- Secondly, we wanted the students to measure their ideas against the results of a technical experiment, in this case the simulation of sound in an interior space through the use of the software ‘Odeon’ which was provided by the company Brüel und Kjær (www.la.dtu.dk/~odeon).

The volumetric and material concepts of the student’s projects were developed during the previous weeks under consideration first of a general strategy and then of structure, yet with little consideration of the auditory quality of the space.

Following the general introduction on the first morning of the acoustics workshop, Kurt Eggenschwiler had explained the possibilities and limitations of sound simulations from CAD-generated computer models, and the basic parameters as an introduction.

In the acoustics exercise, a 3-dimensional dxf model of an interior space was to be imported into the Odeon software. This part of the project was assisted by the chair for Building Physics of Prof. Dr. Bruno Keller (www.bph.hbt.arch.ethz.ch) under the guidance of Matthias Kissling and supported by the departments’ IT department. The two possibilities for sound simulation which Odeon software offers are:

a) auralization
b) grid calculation

Following the advice of Mr. Eggenschwiler, we asked the students to focus on grid calculation results of:
- T30 : reverberation time (Nachhallzeit): time, until the sound pressure level has decreased by 30 dB after the sound signal has terminated; a general value for the entire space, calculated according to the Sabine formula.
- EDT: early decay time (Anfangsnachhallzeit): time of the sound pressure decrease over the initial 10dB, correlates more closely with the perceived reverberation time of different spaces, multiplied by 6 for comparison to T30.
- STI : speech transmission index (Sprachübertragungs-Index): calculated after the RASTI-model of syllables developed by Brüel und Kjær

![example of Odeon grid calculation](example_of_odeon_grid_calculation)

![reflexions_and_reverberations_diagram](reflexions_and_reverberations_diagram)
The potential of auralizations is that they are able to simulate a sensory (spatial) experience. (This can best be heard over headphones. Playing sound files from an average sound system often cannot represent subtle differences). Because the wav-files provided by the Auditorium Version of Odeon are taken from classical music, music samples were extracted from Techno CD’s, and Christopher Sauder (sound technology, ETHZ) provided a CD with a range of electronic sounds.

Grid calculations are a representation of data calculated after room and sound parameters for multiple receiver points on the audience area. The appropriate values are coded with colors where red references high, blue low values. Measures as times and sound levels are shown in the Odeon grids; for measures depending on frequencies (as reverberation times), there is a grid-map of each octave frequency. Imagining an architectural design for music, a certain amount of reverberation was desirable, however it could be predicted that most projects – by the extensive use of concrete and metal - would exceed the scope of acceptable reverberations and would much rather produce disturbing echoes.

For a ‘full’ or ‘warm’ sound, the ideal reverberation time for an orchestra performance in a large auditorium is approx. 2 seconds (ca. 2.2 seconds for early decay time). Meanwhile, the desirable reverberation time for speech is shorter (0.3 – 1.2 seconds) which is also expressed in the speech transmission index. For electronic music, reverberations should be as short as possible, as the music already contains a ‘sense’ or simulation of space (analogous to cinema). The focus of the design discussion of the first tests with Odeon was then the choice of materials, the volume of the space as well as the position of the sound sources.

Some references on the use of acoustics in architecture

Looking at contemporary references in architecture and the choice of materials, the congress center in Lille by OMA features a slanted wall of blue soft padding on one side of a smaller auditorium: Here an absorbing wall is not hidden, but spectacularly staged in space. One might wonder though which frequencies are actually absorbed, does sound absorption happen as visual trick here? The transparent reflectors suspended from the ceiling of the main auditorium are sound reflecting surfaces which have become a main feature of the interior design: Architectural space at the end is merely a function of reflections and absorptions.

In practice, the difficulty to employ acoustic measures as an integral part of the architectural design seems to remain. The ingenious invention to maintain the visual transparency but provide acoustic absorption of the Plenarsaal in Bonn, Germany was only made after a problem appeared. The auditorium was meant to be enclosed by glass walls exclusively, the result being that no public events could be held there as the speaker was not understood. The solution, developed by the Fraunhofer Institut für Bauphysik in Stuttgart, was a layer of microperforated acrylic glass which acted as an absorbing yet transparent material.

The question which architecture needs to confront, even before the use and application of materials, is the one of geometrical form. Preconceptions that a space for music has to adopt a wave-form, imitating the forms of sound waves, were propelled by the architectural visions of architects like Ålvar Aalto, and they last. It seems more obvious when thinking mathematically to avoid focal points in favor of an even sound distribution. Then, instead of the visual impression of a wave form, the auditory sense of standing in a field of reflected sound signals can inform the design of the architectural space.
The moment when aural and visual criteria start to merge is with the question of the performer – audience relationship.
A prototype in its kind, the innovation of the Berlin Philharmonic (architect: Hans Scharoun, 1956-63) was that of bringing the music in the center of the space, of breaking the tradition of the frontal arrangement of orchestra versus audience.

Contemporary music clubs, often, have no center. Furthermore, the disc jockey, at least in early techno culture, was an ‘anonymous’ figure, a person without a face and without a central position in the club. As club curator Phillip Meier (Metastar) describes it, only very few DJs today reach ‘star status’ of the kind of pop musicians; the DJ is usually not the source of the event, much rather is the sound amplified from all four sides of the space. The most interesting might be how „dance, show and entertainment elements merge into a single scenery.“

The image of a discotheque in Nagoya (Japan) illustrates how a space for dancing at times needs to be a space without orientation, without boundaries. The disappearing lights, diffused into infinity, suggest that it is a space of total absorption, a near-to-virtual environment of changing and disappearing lights and sounds, a space of oblivion, without echoes.
Results and conclusion of the sound exercise of Object Semester 1:

On December 17, following a lecture by Dr. Kurt Heutschi on circular spaces, the students presented results of the sound analysis of their spaces to a jury of experts (K. Eggenschwiler, Dr. K. Heutschi, Prof. Dr. B. Keller) and Prof. Dr. Josep Lluis Mateo.

It had become clear during the first week that the use of the ‘Odeon’ software was a challenge for the students, and their investments into the technique had varied. The best results were either produced by students who were enthusiastic with the computer generated sound analysis and successful in handling Odeon (which in some cases had given problems when importing dxf files), or students who translated the questions of sound transmissions and reflections into conceptual models and drawings.

Producing an appropriate acoustical space for electronic music (quite obviously not a chamber orchestra) might be a paradox inherent in the entire program. Can architecture really define sounds, or is the ideal space for electronic music space a non-space?

To simulate an environment of total absorption, Odeon is not an ideal tool. Further, the dimensioning of an electroacoustic system (like Dolby Surround) quite obviously needs to be laid into the hands of an expert. Yet if we work under the scenario that the sound of a space has real qualities, and not only virtual perceptions, it is the responsibility of the architect to connect physical and geometrical space, visual stimuli and sound impressions. It is not a coincidence that the most interesting of the students’ projects had worked with the conscious acceptance and the engagement of auditory interferences.

The projects presented on the following pages have taken different strategies to articulate the acoustic approach: modelmaking, description and division of sound zones in plans or sections, construction detailing and even ideas for unusual amplifying devices.

These and other projects are documented at: www.arch.ethz.ch/mateo
Michele Majerus: Strata of core and skin
The project of Michele Majerus has evolved from the concept of weaving and wrapping in the attempt to create a, fluid space which passes through different conditions. The main music hall and the music event spaces are distinct both in their spatial structure and in their aural qualities: The upper hall is a conventional large space, with penetrations from the lower floor which at the same time are platforms for the DJs. The lower floor is a labyrinth through which we navigate mostly by auditory orientation from sounds piercing through the perforated walls. The body of these spaces for music is wrapped with a 'dense' layer of service cores and secret niches, and with a 'diffusing' layer of moving cars on the parking ramps at the outside of the building.
Stefano Garbani Nerini: A circle loudspeaker array candelier

The main music space is a large hall, surrounded by galleries which connect it to the other parts of the building. The sound is reinforced over a PA (public address) system from a large central speaker, hanging over the hall like a candelier. This 360 degree loudspeaker has yet to be invented, or could be simulated with a radial series of 60 degree speakers.

Zentrale Schallquelle (Circle loudspeaker array) an einem Event in London

© L-Acoustics
Franziska Bächer: A sleeping animal
The building section connects the main space by a fennel-like circulation area to a small music space which is part of a composite and stacked structure. The idea is that the change in proportion creates not only a spatial transition, but also acoustical.

A proposal by the acoustic experts during the discussion was to place additional walls parallel to the circulation direction. Without blocking the visual connection between two spaces, they will absorb the low frequencies by channeling and absorbing the travelling sound waves. The walls were then thickened into staircase elements.

early decay time diagram
Dorothy Holt Intestines and intensities

In the project of Dorothy Holt, transparent polystyrene insulation is used as a sound absorbing surface at the interior of the building. A strange solitary object from the outside, the building turns into ‘soft’ space, like the bowels of an unfamiliar body, in its interior. Lights and sounds reflect and disappear in the large plastic surfaces of the deep layer of the building’s skin.
Ramias Steinemann + Florian Sauter: Unidentified grounded object (UGO)

Like a meteorite, the sonic and scenic structure has landed anywhere on the ground. Inside we find one single open space, with no visible partitions. Light and sound shape the different areas. Contemporary technological devices like light curtains and earphones create separations when necessary. The floor is organised with different platforms that can be raised separately creating spatial topographies for the dance floors where the “see and be seen” is performed.

We can look at this object as a contemporary tent, a techno-circus, a place to celebrate the ephemeral ritual of today’s techno party.

A wall of light.
A laser scans this plane of light into the space by projecting its blue-green laser ray via glass fibre light conductors onto a highly reflective surface mirror positioned at a 45° angle and rotating at 2,000 rpm.

Electronic sensors communicate the rate of people passing to the system. The signal can synchronize the sound in the headphones through which the visitors hears the soundscape. This effect is unlike stereophonic sound in that the intensity and placement of the sound surroundings alter depending upon the actual position of the visitor in the space.
Gunter Klix: Parking lot
The parking garage as a space of spontaneous music events borrows from urban nightly activity rather than from entertainment typologies. Gunter Klix in his project enters an area of no-design, where architecture seems to observe rather than to interfere. Stacked horizontal parking levels with 3.20m floor to floor height, a creek over the entry ramp creating a vast vertical space and a dance hall under the roof compose a box that at first sight is just another prefabricated concrete structure. Yet we discover that the functionalist rationale of the parking layout has incalculated the sizes, even the sounds, for a dance performance space.

Gunter Klix has demonstrated in computer-generated sound simulations and in graphics how the sound pressure levels of different frequencies of the dance music originating in the large hall travel differently within the building: at the entry ramp to the parking garage, only distorted low frequency sounds are audible.