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## Stage Acoustics: Paper ISMRA2016-59

# Transforming a rehearsal stage into an experimental music venue using active acoustics

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## Abstract

In 2014 the San Francisco Symphony launched a new venue and concert series in which to program a wide range of repertoire, drawing upon a variety of ensembles comprised of musicians from the symphony. They envisioned a venue more intimate and flexible than the 2,743 seat Davies Symphony Hall, able to support both pre-Baroque choral music as well as contemporary works for percussion ensemble. The symphony created “SoundBox” by utilizing San Francisco’s “Zellerbach A,” which has been the rehearsal room for the San Francisco Opera since 1981. This 700 square meter space accommodates 500 people, and has a nominal reverberation time of only 0.9 seconds, lower than preferred for the repertoire presented. An active acoustic system was installed both to increase the room’s reverberation time and strength and to create early reflection patterns from the two performer locations both back to the performers as well as to the audience. Acoustic settings are selected for each piece during rehearsals. Music has been performed that utilize both musicians as well as pre-recorded elements spatialized by the acoustic system’s loudspeakers and integrated signal processing. The design, acoustic performance, and subjective impressions of the resulting acoustics from the point of view of the music directors, musicians, and press will be described.

**Keywords:** reverberation, active acoustics, stage acoustics

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## 1 Introduction

American orchestras are acutely aware of the shifting demographic of their audiences. This has provided a challenge for many to remain economically vital in the 21st century [1]. Jesse Rosen writes that:

"At the League of American Orchestras' 2010 national conference in June, an overwhelming majority of the more than one thousand attendees agreed that orchestras need to change in significant ways to remain a vibrant part of twenty-first-century American life. Across the nation, orchestras are working to grow and deepen their relationships with their audiences despite economic pressures, by developing programming that stretches taste and reflects community heritage, making new connections outside their concert halls, incorporating new entry points into the musical experience through multimedia and other contexts, and inviting new forms of audience participation through texting and social media."

Orchestras have taken creative approaches to engage their audiences with special events and programming. These have included classical repertoire interspersed with electronic dance music, concert simulcasts in parks, guest artists from popular music genres, movie scores performed simultaneously with video presentation, and even invitation-only cannabis-friendly fundraising events [2,3].

In 2014, the San Francisco Symphony, under the guidance of music director Michael Tilson Thomas, introduced the new concert series 'SoundBox' in which to showcase chamber music from all eras in an intimate setting with amenities and visual aesthetic more akin to a rock concert or dance club than to a classical music concert. Patrons enter from a side door of the building and then walk down into the venue, past an orchestra pit that is often transformed into a smaller pre-show performance area with performance artists or musicians. They are greeted by a full bar in the performance area itself, large video screens with creatively commissioned works that accompany each piece, cocktail tables, and lighting that overall provide a more 'underground' aesthetic. The show begins at 9 pm, later than the typical starting time for concerts at Davies Symphony Hall. The ticket price is significantly less than San Francisco Symphony Concerts at Davies Hall.

SoundBox is a 'pop-up' venue built using the rehearsal stage of the San Francisco Opera. Adapting and sharing an existing space provided significant materials, energy, and cost savings over building an entirely new venue [4,5]. This space accommodates three distinct stages and an audience of approximately 500 patrons. Seating is not available for all in attendance; some will sit on the edges of the stage, encouraging connection with the artists. Between sections of the program, musicians mingle with the audience.

The commercial active acoustic system, Constellation by Meyer Sound, enables the wide range of acoustics optimal for the varied repertoire of each program [6]. The acoustics are set during rehearsals for each piece in the program, and then recalled by an operator. Often, the same

system loudspeakers that deliver acoustics are used to play back pre-recorded elements, sometimes on their own, and sometimes as accompaniment to performers.

For the inaugural SoundBox program entitled "Extremities," the shortest reverberation setting was for Steve Reich's percussive "Music for Pieces of Wood," while the 16th century choral work, Josquin Desprez's "Missa Pange lingua," utilized a longer reverberation time more appropos for the cathedral setting in which it was orginally performed, augmented by large visual projections of stained glass windows. The contemporary works Varèse's "Intégrales" and Monk's "Panda Chant II" utilized intermediate reverberation settings.

# 2 Acoustics and architecture

## 2.1 Active Acoustics

A room's physical reverberation time is proportional to the volume of the room, and inversely proportional to the absorption. Architectural or passive acoustic systems employ both adjustable volume and absorption to change room acoustics. Regenerative active acoustic systems may be thought of as analogous to a coupled space, in which an electronic room is coupled to the physical room by microphones and loudspeakers [7]. Sufficiently high density of loudspeakers are used to ensure that acoustic signals are not localized to any given loudspeaker, and sufficient number of microphones separated by the decorrelation distance are used to provide coverage of the entire room and a provide sufficient number of acoustically independent channels for the necessary multichannel power gain.

Constellation is based upon Variable Room Acoustic System (VRAS) algorithms and methodologies [8]. This system provides control over room reverberation as well as strength, density and propagation pattern of early reflections. System processors are set either to provide regenerative room reverberation or non-regenerative early reflections. Multiple processors are often used to treat various areas, or 'zones' of a room, such as stage, orchestra seating, under-balcony, and balcony. Early reflections processors may be sub-divided into either two or four sub-zones for greater granularity of control.

## 2.2 Architecture and system design

SoundBox is held in the "Zellerbach A" rehearsal space, which is approximately 33m x 13m wide x 15m high. The nominal mid-band reverberation time (unoccupied) is 0.9 seconds, resulting in a reverberation radius of approximately 4.7m. Microphone and loudspeaker placement is guided by this value. A series of four pipes are suspended above the floor on which overhead microphones and loudspeakers are suspended. In addition, additional loudspeakers are mounted permanently on the walls. At the time the system was designed, the stage locations had not been determined. Therefore microphones were distributed uniformly over the entire space. The system was tuned to accommodate multiple stage configurations, providing additional early reflections gain for the various stage locations. Most of the performances have utilized stage east and south stage locations, as shown in Figure 1. In addition, small groups of musicians have performed from the center of the room, and singers have performed in the entire room, including surrounding the audience.

The system uses 28 compact cardioid microphones suspended from the pipes at an elevation of 4.6m. These pipes also support 24 full-range wide-dispersion loudspeakers at an elevation of 6.9m. At the beginning of system tuning, the physical location and channel number of all speakers and microphone are verified to match the drawings. The speaker and microphone coordinates are then extracted from the drawings and used to calculate appropriate delays. During system calibration, reference signals are played through every speaker one at a time and recorded at all microphones simultaneously. These recordings are analysed to determine appropriate input, bus, and output equalization. These recordings are also used to measure the physical acoustics of the room and to determine a complementary starting point for the reverberant processing. The gain between the microphones and speakers reduces the effective absorption of the room. The reverberation added between the microphones and speakers increases the effective cubic volume of the room [9]. Active acoustics can only simulate a larger, less absorbent room, not a smaller room.

The system uses 49 loudspeakers mounted on the walls at two elevations in order to provide lateral energy to performers and audience, and an additional 12 low-frequency loudspeakers for acoustic reinforcement of energy below 100 Hz. System loudspeakers are numbered, below, and system microphones are shown as red circles.

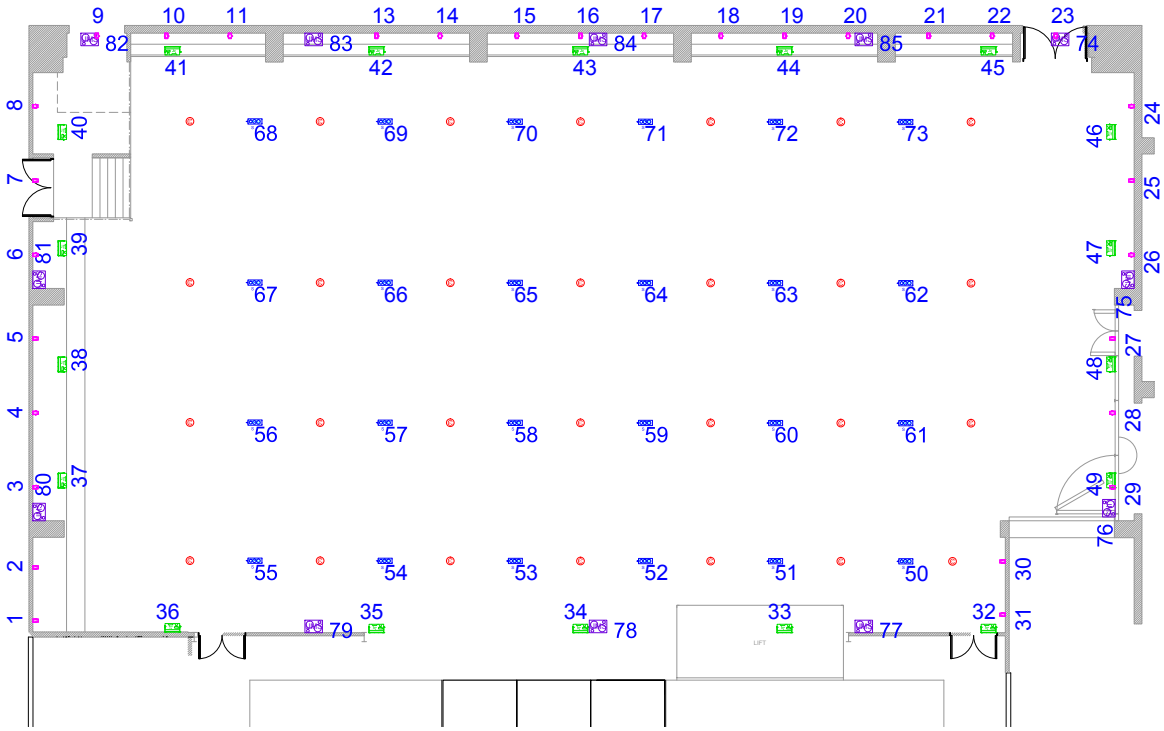


***Figure 1: SoundBox transducer layout***

## 2.3 Audio playback and diffusion

The signal processing hardware that performs the acoustic processing also incorporates the SpaceMap algorithm to provide multi-channel sound diffusion [10]. This algorithm allows for a custom panning to be designed that enables sound trajectories to be pre-recorded and played back on cue. Sound sources that are from audio signals external to the system or internal via the system's multi-channel audio file playback can be moved and distributed in real time. SoundBox's inaugural season utilized a pre-recorded audio file of Steve Reich's "Clapping Music" that was panned throughout the room as a dynamic "chime" to indicate to the audience that the program was about to begin. The February 20-21 performance of Reich's "Electric Counterpoint" in the concert "Sticks and Stones" featured a solo marimba player performing with pre-recorded tracks played back using the acoustic system's overhead loudspeakers. The pre-recorded marimba tracks were each distributed to loudspeakers on distinct overhead pipes, so that the entire audience experienced a statically spatially distributed accompaniment to the solo performer. Thus the loudspeakers in the system help enable the performance of contemporary works. Acoustic settings were selected for each of these works.

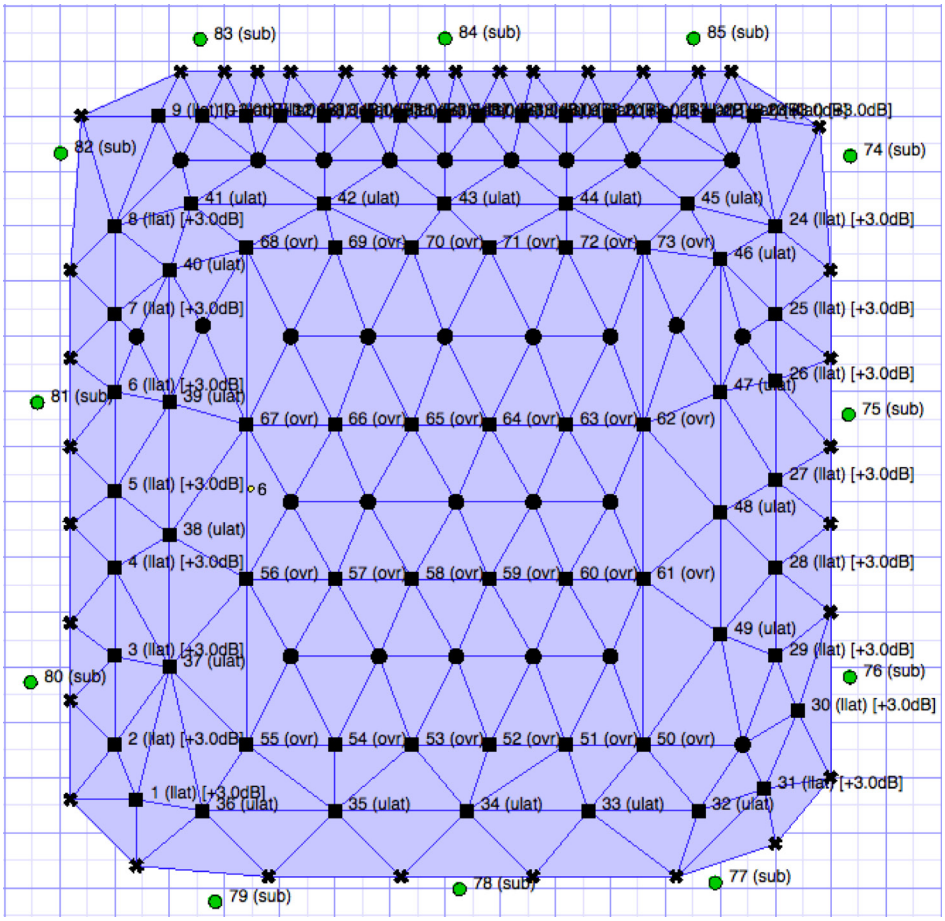


***Figure 2: SoundBox SpaceMap***

The initial SpaceMap created for SoundBox is shown in Figure 2. Panning from left to right on the mid-point of the SpaceMap, the sound will be silent, then fade in to the lower lateral loudspeaker (5), then to the upper lateral loudspeakers (38,39), then to the overhead loudspeakers (56,67) and through the overhead speakers, etc.

# 3 System performance

## 3.1 System Tuning

The system tuning process included both objective and subjective stages. System verification and onsite and offsite calibration is performed based on acoustic and positional measurements of all loudspeakers and microphones. The room acoustics are measured after this calibration to confirm broadband power gain, balanced power distribution, and regenerative reverberant gain. Adjustments were made to early reflection strength for stage locations. During system voicing, a variety of music ensembles and music directors auditioned settings and made subjective recommendations for system strength, early/late energy ratio, reverberation time, and warmth. These settings provide starting points for the varied ensembles and repertoire for the concerts.

## 3.2 User interface

The primary user interface is implemented on a webpage (accessible only on a local network) as shown in Figure 3. The webpage is divided into tabs such as “Home”, “Details”, “Tools”, etc. The Home Tab contains what are referred to as “Performance Presets”. Performance presets are typically named after a type of ensemble such as “String quartet”, “Percussion”, and “Choral”. Of course, the optimal acoustics for a given performance depend not just on the type of ensemble but also on the piece being performed. The performance presets serve as a suggested starting point that will get an operator of any skill level close to the optimal acoustics for a given performance. The acoustical properties can be further refined in the Details area, which is normally hidden from view.

The Details buttons are given names that describe how they will affect the perception of the acoustics: Reverberation Length, Strength, Warmth, Brightness, etc. Reverberation Length is a set of buttons with labels that range from “shortest” to “longest”. Strength, Warmth, and Brightness are given numerical labels. The numerical labels are not intended to be interpreted literally as decibels. Because the system is regenerative the effect of these controls is not linearly independent. For example, when the reverberation length is set to “medium” the resulting reverberation time in the room will be longer when Strength is set +1 than when Strength is set -1. Similarly, the effect of the warmth control will be more dramatic when the Strength is set higher rather than lower. Of course, it is always possible to measure the resulting objective acoustical properties of a given set of “details” and store it as a named Performance Type. But in practice, all users have chosen to make their final settings decision for each performance by ear. Performance Presets are simply a particular combination of settings from the Details area.

For each installation, these sets of parameters are determined based on the active acoustic system architecture, the modes of use of the room and system, and the skill set of the user

base. During the voicing of the system, sets of these acoustic details are grouped as "Performance Presets" that provide a starting point during rehearsals. Musical ensembles are brought in to audition the system settings and determine the initial Performance Presets. This collaborative process between artists, system engineers, and consultants is critical to ensuring both musically satisfying result and buy-in from the artists involved. Acoustic measurements are typically made as reference points at various times during this process.

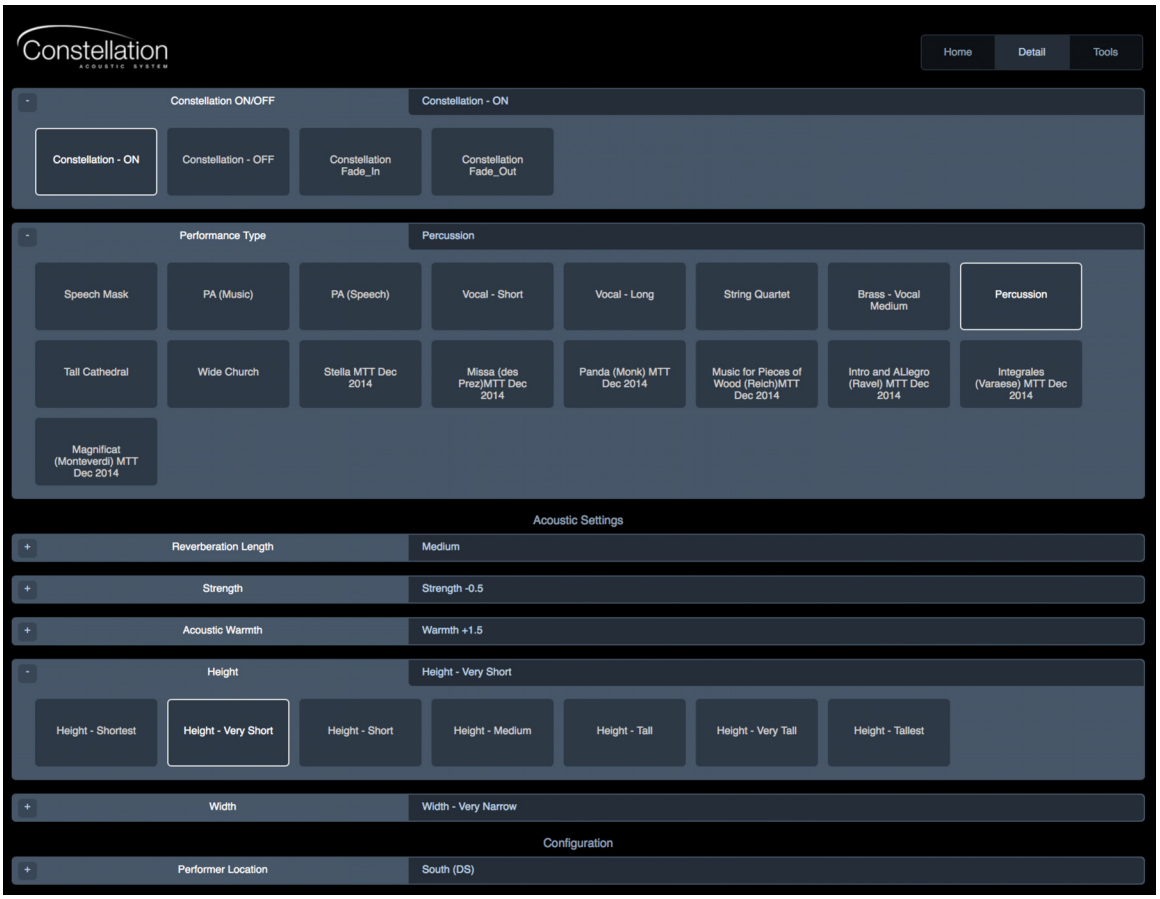


***Figure 3: Constellation user interface and settings, "Percussion" preset***

The parameters "Width" and "Height" refer to how soon the energy is delivered to the room. Qualitative values such as "Tallest" and "Narrowest" are used to describe this in architectural terms. In time these parameters become less abstracted as the users work within a performance preset and adjust a single parameter to gauge that parameter's influence on the system's performance and resultant acoustic.

### 3.3 Measurements

Because of the number of acoustic details adjustments available, a very large number of acoustic settings are possible. The author was present for rehearsals for the March 25, 26, 2016 performance "Outré" that featured French works drawing from the 12th through 20th centuries and made impulse response measurements after two of the pieces were rehearsed. Both pieces were performed from the South stage location. The "Baroque" setting was used for REBEL Chaos, Tambourin I & II, Caprice from *Les élémens.* The "Percussion" setting was used for MILHAUD Concerto for Percussion and Small Orchestra. The settings are shown in Table 1.

| **Setting** | **Length** | **Strength** | **Warmth** | **Height** | **Width** | **Stage** |
|---|---|---|---|---|---|---|
| *Parameter (min, max)* | *(Shortest, Longest)* | *(-4.0, +2.0)* | *-1.5, +1.5* | *(Shortest, Tallest)* | *(Narrowest, Widest)* | *All, East, South, North, West* |
| Baroque | Long | +0.5 | +1.0 | Medium | Medium | South (DS) |
| Percussion | Medium | -0.5 | +1.5 | Very Short | Very Narrow | South (DS) |

***Table 1: Preset acoustic settings***

The measurements shown in Table 2 were made in the unoccupied room, with stands and chairs on stage, from an average of six balloon pop measurements, after each rehearsal.

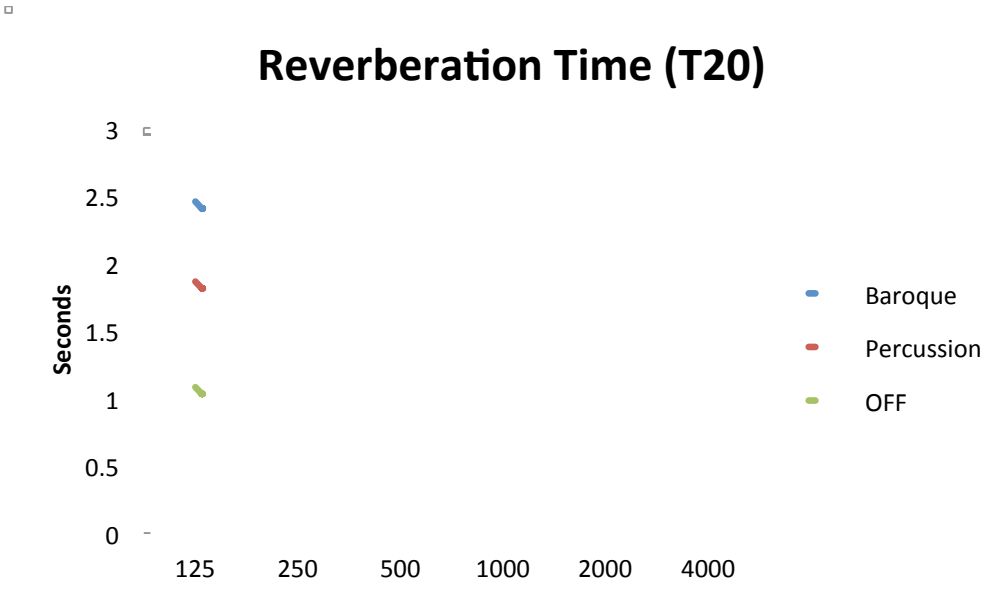


***Table 2: Reverberation measurements, SoundBox***

### 3.4 Critical and artistic response

SoundBox has been well received by musicians, concertgoers, and the press. Concerts throughout the first two seasons have sold out [11], and the SoundBox website provides references to over 20 positive reviews from media outlets including the New York Times, SF Weekly, San Jose Mercury News, and KQED television station. Emblematic of these, guitarist and musicologist Giacomo Fiore, who teaches at the San Francisco Conservatory, University of San Francisco, and University of California at Santa Cruz, writes in SF Classical Voice that:

"Zellerbach A, one of the San Francisco Symphony's on-site rehearsal spaces, used to have a sinister reputation as one of the deadest halls on earth. I had the privilege of testing that claim a few months ago, when I participated in a rehearsal and experienced my own sounds disappear in the vast and surprisingly non-reverberant space.

Yet the Symphony has now harnessed these negative qualities to make the hall into a sort of acoustical blank canvas, a tranformation made possible through the installation of Meyer Sound's multi-speaker 'Constellation' system." Regarding the opening concert, 'Extremeties', he writes that "the music transported the audience into a timeless plane — reminding us that, more so than any technological and innovative elements, programming and performance must deliver. And they did [12]."

In a cover article for "The New Yorker," Alex Ross writes that the technology behind SoundBox has "had a democratizing influence, allowing ensembles to obtain pleasing results in problematic spaces" and helping "to make classical music a more mobile, adaptable beast, one that is freer to roam the entire cultural landscape [4]."

Jacob Nissly, Principal Percussion with the San Francisco Symphony says that "SoundBox lends itself to a lot more experimentation. (With the acoustic system) we can make notes last forever, or end immediately… It's liberating the percussion section." Percussionist Raymond Froehlich likens SoundBox to a rock or jazz club, and says that "I love picking up on what the audience is feeling [13]."

## 4 Conclusions

The San Francisco Symphony created the concert series SoundBox to expand their audience and perform works not ordinarily performed at their home, Davies Symphony Hall. By creating a visual aesthetic and concert-going experience more akin to a nightclub than a concert hall, they have appealed to a younger audience than makes up the majority of their subscription series. They secured the rehearsal space of the San Francisco Opera to accommodate this new endeavour. While the room provides the size necessary to support a chamber orchestra 500 patrons, and a bar area, the room's physical reverberation time of 0.9 seconds is shorter than desired for the wide range of repertoire and ensemble envisioned for the series. The repertoire varies from early vocal music through contemporary electronic and features solo artists, small and large ensembles, and pre-recorded electroacoustic music. The active acoustics system Constellation was selected to provide the flexibility and sound quality desired.

Loudspeakers in the system are sometimes used for pre-recorded and live sound elements, and may incorporate integrated sound spatialization algorithms to dynamically pan sound elements throughout the room. SoundBox has been an artistic success, as evidenced by ticket sales, critical response, and artist comments. San Francisco Design Week 2016 included a session on SoundBox and dissected how "breaking down performance conventions could lead to a new path forward for the traditional concert experience." [14] This, in turn, may provide a model for other symphony orchestras to create engaging, flexible venues capable of supporting a wide range of music and engaging new audiences.

## References

[1] Rosen, J. Reports from the Front: League of American Orchestras, Grantmakers in the Arts, GIA Reader, Vol 21, No 3 (Fall 2010).

[2] Lee, D. Symphonies are playing a new tune to lure younger audiences, June 29, 2011. http://www.thelinemedia.com/features/orchestraaudience062911.aspx.

[3] Wenzel, J. Colorado Symphony Orchestra rolls out first cannabis-linked concert, The Denver Post, May 23, 2014.

[4] Ross, A. Wizards of Sound, The New Yorker, February 23 and March 2, 2015.

[5] Schwenke, R. W., Duty, J. R., Electroacoustic Architecture: Is it Green?, *INTER-NOISE and NOISE-CON Congress and Conference Proceedings, NoiseCon10*, Baltimore MD, pages 982-2000 , pp. 1813-1818(6).

[6] Ellison, S. and Schwenke R. The Case for Widely Variable Acoustics, *Proceedings of the International Symposium on Room Acoustics*, 29-31 August 2010.

[7] Poletti, MA. Active acoustic systems for the control of room acoustics. *Building Acoustics*, 18 (3,4), pp 237–258, 2011.

[8] Poletti, MA. The performance of a new assisted reverberation system. *Acta Acustica*, 2 December 1994, pp 511-524.

[9] Schwenke, R., Ellison, S., Objective Assessment of Active Acoustic System Performance, *Proceedings of the International Symposium on Room Acoustics*, 29-31 August 2010,

[10] Ellison S. SpaceMap: 20 years of audio origami. *Lighting and Sound America*. April 2013.

[11] Lam, M. Playing in the SoundBox with the San Francisco Symphony, KQED, March 27, 2015.

[12] Fiore, G. SoundBox Debut: Sound and Space Sensation, San Francisco Classical Voice, December 14, 2014.

[13] Video interviews provided to the authors by the San Francisco Symphony, July 2016.

[14] SF Design Week program notes, Playing in the SoundBox: The Performance Space as Laboratory, June 9, 2016.