

SpaceMap: 20 Years of Audio Origami

By: Steve Ellison

The evolution of an audio technology across two decades—and several product platforms

SpaceMap is a Meyer Sound software technology embedded in the D-Mitri digital audio platform; it lets sound designers use a dynamic graphic interface to fly sounds through space using any loudspeaker layout. Initially developed by myself in 1986, SpaceMap was commercially introduced in 1993 as part of the Analog Series by Level Control Systems (LCS), a company acquired by Meyer Sound in 2005. SpaceMap has now been implemented on four hardware platforms and been heard by millions of listeners in live entertainment venues such as theatres, theme parks, planetariums, cruise ships, parades, special-format films, and others.

In this story, we will retrace SpaceMap's footsteps. Along the way, we'll hear from some of the designers who have used it in their work.

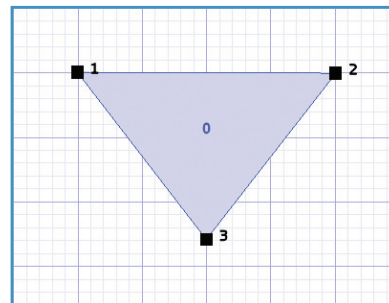
What is SpaceMap?

SpaceMap allows sound designers to create two-dimensional maps of loudspeakers in a space, customize the power distribution to them, and record paths of sound trajectories that can be recalled as part of a sound cue or mapped to incoming time code. This provides a flexible system for defining surround-sound mapping techniques, regardless of the loudspeaker layout. Three-dimensional sound fields can be explored by using multiple concurrent SpaceMaps and the concept of audio "divergence." Through its lifetime, SpaceMap has been refined and

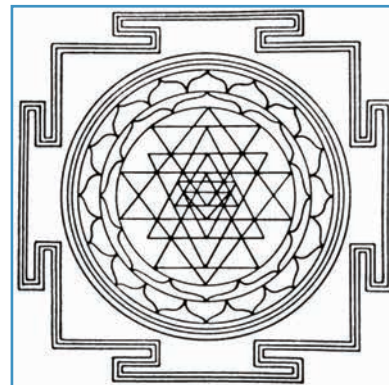
evolved, but the fundamentals are unchanged from its inception.

In the beginning, there was a triangle. In 1986 and 1987, I had the opportunity to work with Floating Exceptions, a group of computer artists in Canberra, Australia, who built a portable polymedia performance space. The venue was a geodesic dome, 22' in diameter. While 16 loudspeakers were suspended with an arrangement of three offset groups of five, a single loudspeaker was hung directly above. I was one of a small group developing an algorithmic musical vocabulary for this space. One task involved distributing sound to the loudspeakers in a simple, elegant way. An efficient way of representing a sound on the surface of the dome was to use the three closest loudspeakers. Once these were identified, we could distribute power to them to locate the sound. This solution was certainly inspired by the architecture of the venue. Unfortunately, the hardware technology available to us at the time was not sufficient to fully realize this. We were using early Macintosh computers and MIDI technology to control synthesizers that were dedicated to each loudspeaker. This provided a low-resolution look at what was yet to come. However, the concept of the triset, the fundamental building block of SpaceMap, was born.

In late 1992, LCS shipped its first multichannel audio control system, affectionately known as R2D2, for



The triset concept of SpaceMap.



The Tibetan Yantra.

George Lucas's *Super Live Adventure*, a touring theatre show developed by Feld Productions. The late, great show control designer Damon Wootten referred to *Super Live Adventure* as "a cross between a tractor pull and a Megadeth concert." It was an enormous undertaking, requiring that the audio hardware platform and control software be developed in just a few months. SpaceMap didn't make it in, but the system did feature a fully automated analog matrix and hierarchical cueing engine that set the stage for SpaceMap's entrance.

After the show completed its tour of Japan, the hardware was redesigned to be more cost-effective and expandable, and the software was further

developed. Enter SpaceMap. When developing it for this hardware platform in my small office, I used an arrangement of four loudspeakers in the corners of the room and one overhead. Theatrical sound designers have used overhead loudspeakers for years to extend the auditory experience around and above the audience.

It didn't take long to realize that not all systems would include loudspeakers in overhead positions. Further, when a sound was dragged off the edge of the map, the sound unceremoniously cut out. This led to several improvements. First, the concept of the virtual speaker was introduced. This would be a point, or node, in the map that would send sound to a group of user-specified loudspeakers. Now we could remove our overhead speaker node and replace it with a virtual node. When sound was dragged overhead, it would be distributed to the four corner loudspeakers. Second, the concept of the silent node was added. This let designers place nodes of the SpaceMap around the outside edges so that power could be distributed to these null loudspeakers and generate smooth fades. Derived nodes were introduced to create regional subwoofers or under-balcony feeds. The means to record a sound trajectory and place it in a cue associated with a mix bus completed the auditory picture.

Las Vegas, the family entertainment capital?

The 1990s saw an uptick in the number of the Las Vegas casinos attracting more families as a vacation destination, leading to extended-run entertainment extravaganzas. In 1993, two Las Vegas shows would be the first to use LCS' new second-generation Analog Series hardware and cue control software. *Starlight Express*, Andrew Lloyd Webber's roller-skating musical, opened at the Hilton, and Cirque du Soleil's *Mystère* opened at Steve Wynn's Treasure Island.



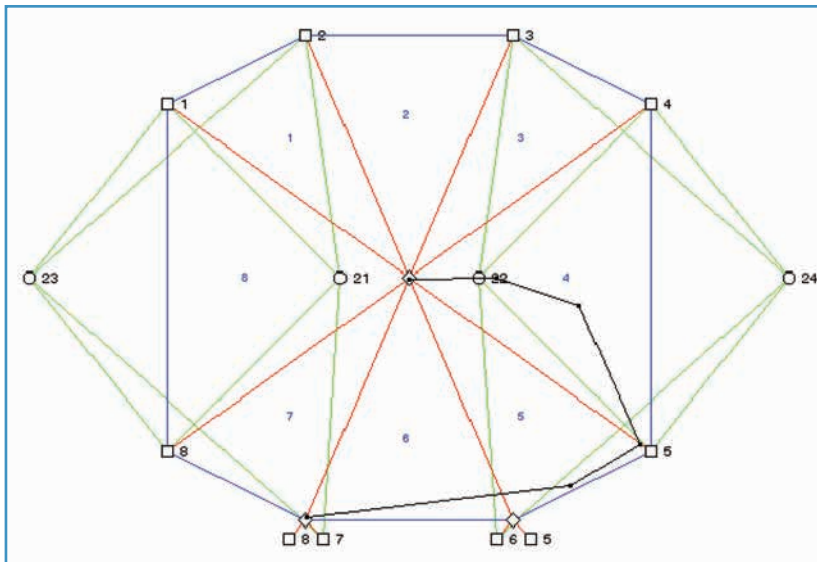
Walt Disney Concert Hall.

“Buying a ticket to see a live event, I should have a unique experience with sound in the same way as I do when sitting, standing, or traveling to the performance. Having sound delivered to me in a manner that I can recreate at home or in my car is not interesting to me. What is the point of going to an event if it is not a unique experience? Designing a sound system that is unique is one step, and then applying the audio sources to the system for that particular venue and/or event is crucial. If not, it is utility sound. Using SpaceMap can make an event truly special, as each passing moment of audio is unique and cannot be reproduced in any way other than at that particular event.” –Jonathan Deans

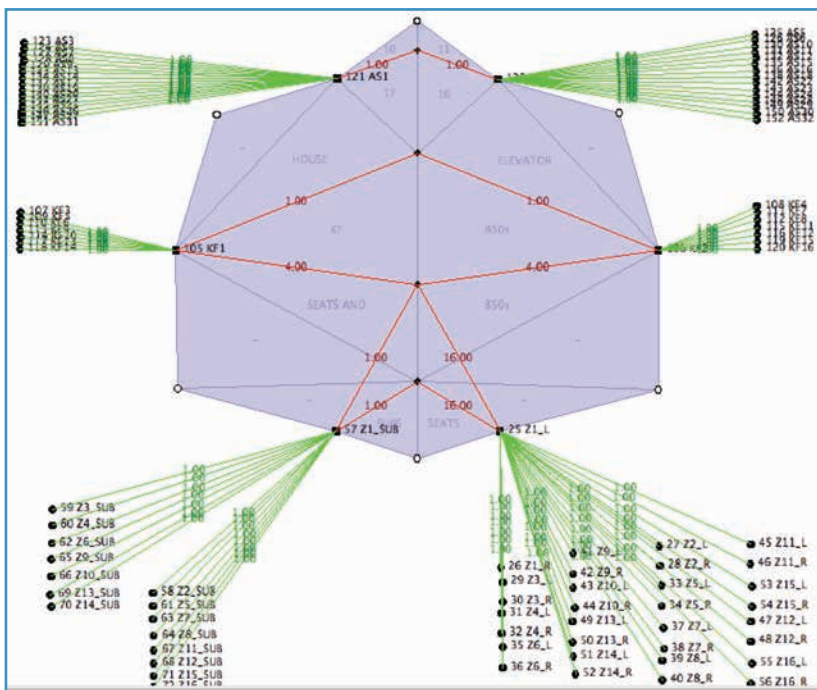
Starlight used SpaceMap effectively, if not predictably, to pan surround sound effects overhead as the “engines,” played by actors on skates, raced around the arena. *Mystère* sound designer Jonathan Deans took this several steps further, using his surround system with SpaceMap more as an instrument,

bringing voices over and around the audience, soaring with the trapeze. *Mystère*, like SpaceMap, has performed for nearly 20 years and recently completed its second major audio upgrade, still using the sound cues developed nearly 20 years ago.

Deans says, “Buying a ticket to see a live event, I should have a unique



SpaceMap from Walt Disney Concert Hall: A prerecorded flute responding to a flautist onstage by moving up to the ceiling and then around the room, ending at house rear left.



SpaceMap from KA: Three levels of vertical pan moving sound from the seats to overhead point sources to ambient speakers in the ceiling.

experience with sound in the same way as I do when sitting, standing, or traveling to the performance. Having sound delivered to me in a manner that I can recreate at home or in my car is not interesting to me. What is the point of going to an event if it is not a unique experience? Designing a sound system that is unique is one step, and then applying the audio sources to the system for that particu-

lar venue and/or event is crucial. If not, it is utility sound. Using SpaceMap can make an event truly special, as each passing moment of audio is unique and cannot be reproduced in any way other than at that particular event.”
 As part of the LCS Analog Series, SpaceMap broke ground in several areas in the early ‘90s, including theme parks (Universal Studios Hollywood’s *Flintstones* show), reper-

tory theatre (South Coast Repertory in Costa Mesa, California), and higher education (Colby College, Yale University). The Analog Series’ last hurrah would be for the Fremont Street Experience, a multi-block installation in the original Las Vegas strip where special software was written to create a system with twice as many mix buses (16) as the original; sound designer Alan Howarth used the system to help automate and pan sounds in synch with the light and animation display.

Going digital—LD-88, Matrix3, D-Mitri

SpaceMap really came into its own with the advent of digital audio technology, beginning with LCS’ LD-88 SuperNova series in 1996, Matrix3 in 2000, and D-Mitri in 2010. This platform evolution provided successive improvements in audio quality, control resolution, and programming software. All three supported the ability for the SpaceMap trajectories to be stored in the hardware itself, providing the more robust embedded automation required for large-scale integrated systems, including theme parks.

François Bergeron, a sound designer and principal with theme entertainment specialist Thinkwell Group, has worked with SpaceMap since its inception on various platforms in venues in Asia, North America, and Europe. He appreciates how the work flow required for designing sound for large-scale multichannel systems has been streamlined by SpaceMap. “As paradoxical as this may sound,” he says, “having a visual representation as the audio moves throughout the space has been an essential element of our soundscape creations since the late 1990s.

“Without visual cues, the majority of our time would be spent running around the space, trying to listen for each move. With SpaceMap, we are able to see where we place the sound, record multiple iterative moves, and then walk around the theatre for a final confirmation.”

Repertory theatre

While playing to more intimate audiences than the big Vegas productions, sound designers like Jim Neil, of Toronto, Ontario's Stratford Festival, now had a tool to help them solve design problems and take their productions places they couldn't have gone otherwise.

Neil recalls, "At the Grand Theatre in [London, Ontario] a few years ago, we did a *Peter Pan* that included a twist in the normal telling of that story. Tinker Bell's onstage image was achieved by using a moving light focused on the set pieces, and an actor was in the wings speaking the lines on a microphone. Sometimes the lines would happen when Tinker Bell was in one spot, but other times it was when she was flying about the room. I used SpaceMap to match the voice to the light image on the stage. It was truly amazing as we developed the trajectories for both the lights and sound. As the lighting department refined their positions, I was able to keep the voice coming from wherever Tinker Bell was positioned. When I did the show again a few years later in Stratford, I knew exactly how I was going to match Tinker Bell's sounds to her positions on the stage. Once again, it worked just how I imagined it would."

This is one of SpaceMap's key strengths: The move is rendered in real time during the performance. So if a touring show moves from one venue to another, the move can be recreated by creating a new SpaceMap to correspond to the new loudspeaker layout. The cues and trajectories don't need to be rewritten.

Audio origami: from virtual nodes to virtual worlds


While SpaceMap is adept at representing arbitrary surround-sound loudspeaker layouts and creating audio trajectories, it also provides a more abstract potential that some artists have tapped into. Zachary Seldess, a research associate at University of California at San Diego's CALIT2 laboratory, where multichannel audio panning is a prime area of research,

helped facilitate the integration of SpaceMap into the CORNEA virtual reality system at King Abdullah University of Science and Technology (KAUST) in Thuwal, Saudi Arabia.

Seldess says, "It is quite common for sound spatialization techniques (e.g. VBAP, DBAP, wave field synthesis, and Ambisonics) to deal in real-space metaphors by providing methods for composers and sound designers to choreograph sound as a virtual extension of the listening space. This approach to thinking about sound as

existing in and moving around the 3-D space of the listener in the same way that real objects move can facilitate both powerful artistic expression and realism, to be sure. However, I am convinced that there are powerful artistic advantages to abstracted spatial mappings when thinking of sound localization, and this conviction grows primarily out of my work with Meyer Sound's SpaceMap system.

"By abstracting the speakers away from their 3-D origins and providing an environment for flexibly resituating



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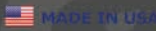
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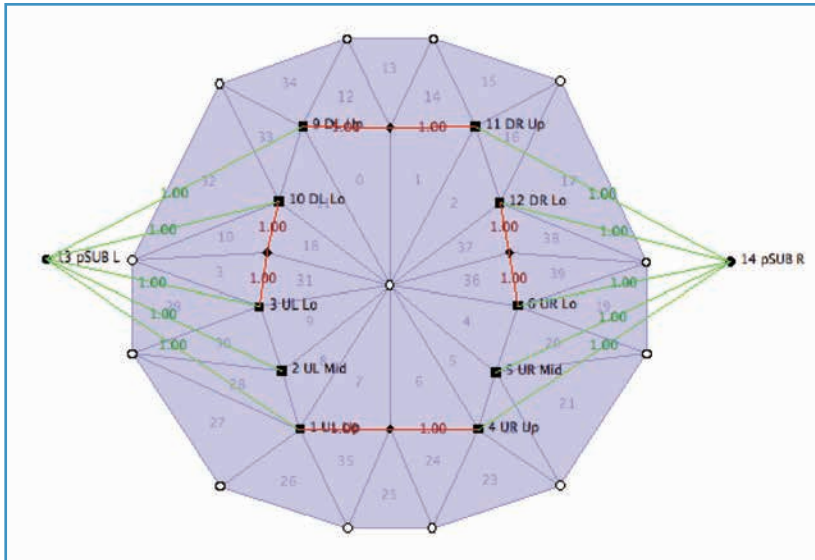
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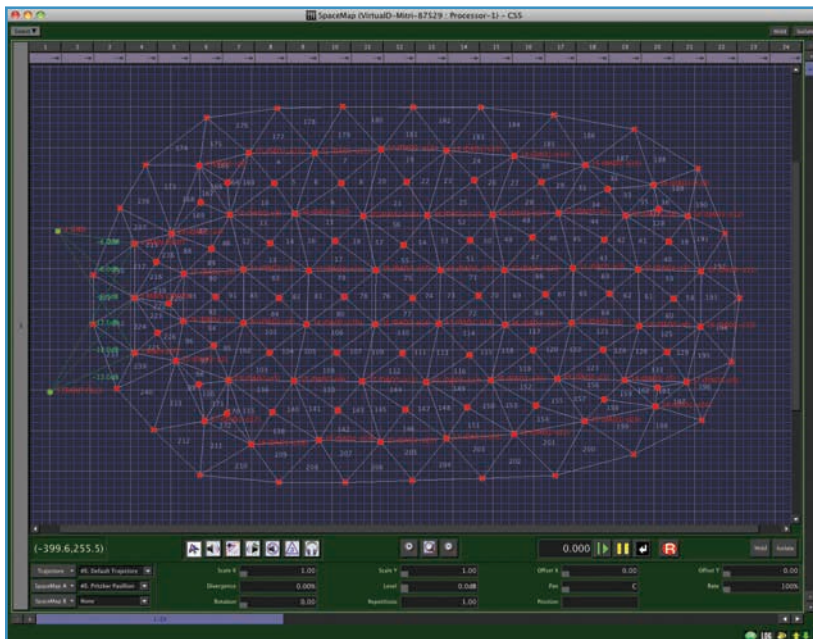
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The SpaceMap from *KĀ* snakes up and down the line arrays; sound shimmers when mixed with a stationary signal.



The main SpaceMap created for Bill Fontana's "Soaring Echoes" installation in Chicago's Millennium Park.

them within one or more 2-D spatial maps, SpaceMap allows sound designers to construct their own unique physical rules and constraints for the way sound moves in space," Seldess says. "Using SpaceMap, one can, of course, still quite easily design maps that allow intuitive 'realistic' movement within a listening space. But it is the flexibility in choice between realism, abstraction, and the space in between that allows for the creation of sonic gestures that would

not be possible otherwise."

Sound artist Naut Humon pioneered the use of multichannel audio in artistic events where art and technology intersected in many unexpected ways. His collaborative, Sound Traffic Control (STC), utilized multiple LCS platforms with SpaceMap throughout the '90s to help realize its sonic adventures.

Scot Gresham-Lancaster, now a lecturer in sound design at the University of Texas at Dallas, worked with STC early on and spent time

exploring SpaceMap's possibilities.

"My favorite SpaceMap experiment," Gresham-Lancaster says, "only saw the light of day (or night, in this case) inside a small performance. Using a map of the Tibetan Yantra [just the center part of the classic image, as shown on page 92] I decided which of the intersections in the diagram were the points that represented the eight channels in this case, and then every other point of intersection on the Yantra was a virtual speaker. This made for an amazing and unpredictable set of sheets and planes of sound that would collapse into the point that was the actual speaker. This is hard to describe and like nothing I have been able to do without SpaceMap. The interesting thing about this approach was that it was not concerned with trying to make a representation of the smooth movement of a sound from point A to point B, but rather to make a type of sound density from any material that was played through the SpaceMap that was a dynamic representation of the space itself and the multidimensional folding of space represented in the Yantra."

Walt Disney Concert Hall sings

In 2003, John Williams was commissioned to write a piece to be performed by the Los Angeles Philharmonic on the occasion of the opening of Walt Disney Concert Hall. Williams says: "As I admired the hall and studied its interior, I wondered what it might be like if the building's brilliant exterior surfaces could be sounded and the hall actually 'sang' to us. These thoughts suggested the third section, 'The Hall Responds,' in which the hall itself becomes a partner in the music-making. The orchestra sounds a vibrant low D, and the hall reverberates and responds. Three other great sails are sounded as the orchestra, led by the solo flute, sends messages, which are returned to us from various locations in the hall."

To bring the hall to sonic life, Williams enlisted the help of scoring mixer Shawn Murphy, whose back-

ground in theatre sound design led him to consider the appropriate tools.

"We used ProTools to record and assemble the basic tracks," Murphy explains. "But I realized that, since the loudspeakers were not going to be placed in a 'traditional' surround sound format, we needed a system to mix the sources that could adapt to the layout."

Using Matrix3, Murphy created SpaceMaps that allowed sounds to be preprogrammed to move seamlessly within the concert hall, utilizing eight discrete full-range loudspeakers and two subwoofers. In order to support the illusion of the hall "singing", loudspeaker positions were selected that indirectly reached the audience, with sound reflecting off interior surfaces first. This helped to create a natural, diffuse movement of sound that effectively surrounded the audience without overpowering the orchestra.

Mark Swed, music critic for the *Los Angeles Times*, wrote, "John Williams'

'Soundings,' which premiered Saturday night, tested the possibilities for spatial effects in the hall: Mission accomplished ... The hall, through Williams' score, quivered, trembled, pulsed, throbbed. There were eerie and extravagant effects I couldn't quite identify. Once, it sounded as if a battery of glass harmonicas surrounded the audience. Williams cleverly created the amazing illusion of instruments traveling about this listening space. A deep electronic organ note made the ground on which we sat feel alive."

Perspective and possibilities

SpaceMap has made it possible to address large-scale systems in ways that would be nearly impossible without it. In 2010, the Dutch musical *Soldaat van Oranje (Soldier of Orange)* was mounted with the entire audience situated on a large rotating platform. There were 14 main loudspeaker arrays in fixed positions, and the

action moved as the audience was rotated to the next set. Sound designer Jeroen ten Brinke used D-Mitri to maintain the audience's proper audio perspective. As the platform rotated, rotational coordinates were sent to a D-Mitri system that used SpaceMap to decode them and create the proper mix. Without SpaceMap, it would have been impossible to pan the complete multichannel surround image while the audience was moving.

In Cirque du Soleil's *KÀ*, which opened in 2005, Deans used SpaceMap in what the *Los Angeles Times* referred to as what "may well be the most lavish production in the history of Western theatre. It is surely the most technologically advanced." The theatre, with a capacity of 1,950 people, is equipped with a total of 4,774 loudspeaker drivers in 2,139 cabinets, including a pair of speakers at ear level in every seat in the auditorium. In addition, there are distributed loudspeakers overhead, conventional sur-

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rounds, and upstage and downstage line arrays. KÁ assistant sound designer Leon Rothenberg built more than 30 SpaceMaps to create unique panners to sculpt the highly cinematic score and sound effects. This allowed sound to fly smoothly between the higher-powered arrays, seat speakers, and everything in between.

“We sat in that massive theatre one night and brainstormed all the different ways we could move sound around the space,” Rothenberg says. “Which, on that system, was no small number.

It was like exploring a really big cave; we kept turning corners and thinking of more cool stuff to do. Then Jonathan [Deans] tasked me with making a sound system demo, which I did with a ‘megamix’ of different kinds of music to show off the different aspects of our massive PA. The demo ran off an iPod—the idea was to show how you could fill the space, be totally immersive with just two tracks of audio. To be thrown in the deep end like that was a lot of fun, like everything up to that point was time in the

simulator, and this was the first big mission. The composers, directors, and producers were duly impressed. We were off and running.”

Rothenberg adds, “We developed SpaceMaps for very specific moments. The bubble map [effect] had the position of gurgling bubbles mapped to a fader on the console. This allowed the operator to mix the position of the sound to match the position of the performer swimming in the ocean during [the sequence known as] ‘The Deep.’ Other maps had more subtle functions. One of my favorite things to do with SpaceMap in KÁ is to move sound through parts of a PA and mix it with a stationary signal. It creates a great shimmering effect, a subtle sense of movement without being intrusive. We did this a lot for the guitar, giving it a great sense of space and life.”

Sound artist Bill Fontana has explored the relationship between place, structure, and sound in installations throughout the world. He has brought sonic life to public spaces and museums including San Francisco, New York, Paris, London, Berlin, Venice, Sydney, Tokyo, and, most recently, Chicago. In 2012, Fontana created the public sound installation “Soaring Echoes” that, he says, “dislocates the viewer within its host environment, transforming perceptions of time and space.” The Jay Pritzker Pavilion, an outdoor music band shell designed by Frank Gehry, is the centerpiece of Chicago’s Millennium Park. Threshold Acoustics’ Jonathan Laney integrated D-Mitri with the pavilion’s existing sound system, a steel trellis equipped with 102 loudspeakers that arcs above the Great Lawn.

Fontana says, “I created a series of spatial compositions with SpaceMap that expands the act of listening while reframing our everyday experience of the city. Multiple layers of moving trajectories of sound float through, above, and around the lawn.” The sounds in the compositions were recorded in Chicago’s natural, urban, marine, and historical environments.

“Using SpaceMap to achieve this

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“In 2010, the Dutch musical *Soldaat van Oranje* (*Soldier of Orange*) was mounted with the entire audience situated on a large rotating platform. There were 14 main loudspeaker arrays in fixed positions, and the action moved as the audience was rotated to the next set. Sound designer Jeroen ten Brinke used D-Mitri to maintain the audience’s proper audio perspective. As the platform rotated, rotational coordinates were sent to a D-Mitri system that used SpaceMap to decode them and create the proper mix.”

result was an amazing experience that could not have been realized with any other interface, as I could stand under the trellis and create individual trajectories upon individual trajectories by moving a cursor through the interface,” Fontana concludes.

With his outdoor installation at the Pritzker Pavilion, SpaceMap has gone full circle; from a 16-channel system suspended in a geodesic tent in Canberra to a 102-channel system suspended in a trellis in Chicago. So what does the future hold?

Perhaps Reggie Watts can provide a clue. Watts is a staple of the international performance scene, and his improvised musical sets are created on the spot, using only his formidable voice and a looping machine. He recently explored SpaceMap in Meyer Sound’s Pearson Theatre at Berkeley.

“The experience I had using SpaceMap exceeded my expectations and helped me realize a lifelong dream,” Watts says. “I had always imagined the ability to position/move sound anywhere in a room at will using an intuitive interface. Hearing it in reality as opposed to hearing it in my imagination was quite a surprise, and it presents me with a whole host of possibilities.”

How will these possibilities be realized? New productions using SpaceMap that, as Deans says, can only be experienced at one place and one time will continue to motivate us to leave the comfort of our home with a few people and enjoy a shared experience with many people. For the last 20 years, SpaceMap has extended sound designers’ sonic vocabulary, evolving along with the audio platforms on which it has been hosted. How high the bar will be raised in the next 20 years will be up to the artist’s creative vision.

Steve Ellison is applications director for digital products at Meyer Sound.



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