INTERACTIVE OUTDOOR THEATRE

USING THE TIMAX2 SOUNDHUB TO LOCALIZE PERFORMERS IN AN IMMERSIVE SOUNDSCAPE

by Alan Hardiman

To mark the bicentennial of the outbreak of the War of 1812, Toronto's Water's Edge Festivals & Events mounted a four-day immersive-interactive theatrical extravaganza outdoors at the city's lakefront Harbour Square Park last June. Entitled *The Wharf at York: where folklore gets Interactive,* the production featured three dramatic historical scenes interspersed with as many as fourteen vignettes enacted within and among the surrounding audience. Period-accurate activities were designed to maximize audience involvement and participation between dramatic scenes.

Part of the annual free-admission Redpath Waterfront Festival, the performance ran three times daily, attracting up to 30,000 visitors per day, including busloads of middle school students and teachers for whom the War of 1812 was a curriculum item. It featured sixteen costumed performers portraying historical figures, along with twelve costumed tradesmen specific to the period, teaching their trades to "apprentices" from the audience.

Adding to the excitement of the first scene was the arrival of one of three tall ships that served as set pieces for the drama. The schooner *Challenge* sailed in to the wharf with half the cast and news of the imminent outbreak of war. A little over two hours later, the show wrapped up with a rousing sword fight leading to the capture of an enemy spy and the departure of the *Challenge* amid tearful goodbyes from friends and loved ones remaining behind.

Krista Slack, artistic director of *The Wharf at York*, developed the creative concept and contracted me as sound designer to create a period-appropriate soundscape to transform modern day Toronto back into the Muddy York of 1812, blanketing the park in a nineteenth-century sonic environment.

Talking this over with Bill Coons, whose company Contact Distribution markets TiMax audio technology in Canada, I saw the potential to be more creative with the sound design as well as for increasing the intelligibility of the actors. I took him up on his generous offer to lend me a TiMax2 SoundHub for the show. I was familiar with TiMax and had written about it in the industry press, but I had never had occasion to use it before.

Adhering to my number one rule for success—hire the best people you can find and stay out of their way—we recommended that the producers engage Frischkorn Audio Visual as our sound system supplier, with veteran sound system designer Chris Baron leading the team because of his familiarity with TiMax. Well aware of Frischkorn Audio Visual's reputation for technical know-how and attention to detail, Slack readily agreed.

Setting the Stage

The field of play in Harbour Square Park measured about 400 feet by 100 feet, oriented lengthwise from east to west. The grass was edged on the long south side by a generous boardwalk running along the lake-side wharf. The northern edge was fenced off by a seven-foot-high stockade painted on canvas that concealed the parking lot where the production trucks, off-stage facilities, and generator were located.

In addition to a forty-foot by forty-foot tent situated near the western end of the park, a dozen or so small shelters dotted the landscape, each housing a practitioner of a historically accurate trade, including a cooper, coppersmith, sword master, sail maker, cobbler, lumber jack, leather worker, wood turner, potter, games master, and two blacksmiths. During the intervals between scenes, audience members were invited to participate in the activities and possibly earn their "Journeyman's Ticket" by making some small souvenir for themselves.

Four stages were integrated into this landscape: the wharf platform, where characters disembarking from the schooner *Challenge* were met by local officials and townsfolk in Act One; the large tent, home to the games master and site of Act Two, a "town meeting" to discuss raising a militia, featuring a large dose of audience participation; a gazebo roughly in the center of the field of play that provided convenient staging for a number of vi-

Opposite page, The brigantine *Playfair* tied up at the wharf at Toronto's Harbour Square Park. Photo by Annie Runciman.

Left, Members of the Rapier Wit theatrical stage combat troupe provide the excitement of a real sword fight and, *above,* doomed lovers realize the impending war will put an end to their dreams. Photos by Catherine Bacque.

The wharf platform, one of four stages in the park. A Renkus-Heinz PN82 hidden in a burlap sack atop a barrel provides a localization anchor.

PHOTO: CATHERINE BACQUE

PHOTO: JDVAILLANCOURT.COM

Audience members surround the cast. The production attracted up to 30,000 visitors each day.

PHOTO: CATHERINE BACQUE

gnettes; and a couple of rough benches situated near the eastern edge of the park suitable for one or two "private conversations."

Several times during the two-hour cycle, characters walked through the set of the town speaking among themselves while making an entrance or exit. More than once, enthusiastic audience members were observed interrupting these conversations, with questions on background or historical context for some aspect of the drama as seen from the perspective of someone from the early nineteenth century.

There was no underscore or other musical accompaniment to the drama, music being reserved for the intervals between scenes and vignettes. Unamplified in the tent, the Hardtackers Shanty Crew sang historically appropriate sea shanties and other work songs that were used on the square-rigged ships of the Age of Sail, their timings and rhythms designed to coordinate the efforts of many sailors hauling on lines or heaving the anchor. In addition, acoustic instrumental music was supplied by the string trio Freshwater Trade and by itinerant fiddler Kelly Lefaive.

The Soundscape

Based on the few contemporary paintings of the settlement that I was able to find, I chose to make it sound much the way cottage country north of Toronto sounds today (minus the motorized intrusions): ambient crickets, birds, and animals on land, and gulls, loons, cormorants, ducks, geese, bullfrogs, and lapping water coming from the direction of the lake. To this I added occasional sounds of domestic fowl (geese, hens, and a rooster) and animals (cows, sheep, goats, and hogs) emanating from areas behind the structures in the park, where settlers would likely have penned their livestock.

These tracks were augmented with the sounds of horses and carts rolling though the village from time to time, as well as dogs running around sporadically, barking in reaction to scripted events and other sounds, such as the bosun's whistle from aboard *Challenge*. Rope creaks, pulley squeaks, oars in oarlocks, and other dock sounds helped to flesh out the wharf.

It was important that all these sounds be kept in natural perspective, without becoming intrusive or drawing undue attention to themselves. The obstacle to creating this more natural sounding environment, of course, was the omnipresent roar of the city, especially given the park's proximity to the Gardiner Expressway, a major east-west artery running close to the waterfront, and to Billy Bishop Airport on Toronto Island less than a mile away.

The brigantine Playfair was one of three tall ships that served as set pieces for the drama.

As it turned out, cricket tracks came to the rescue, the kind of sizzling crickets with substantial high frequency content that you hear on a hot summer day, distributed throughout the park. While they couldn't mask the roar of the city, the crickets sat well above it in the frequency spectrum where our hearing is most acute, and thus diverted attention away from the mechanized din of our twenty-first-century world, allowing it to more or less fade into the background of awareness, much like the hum of the refrigerator that you seem to hear only when it shuts off. Coupled with the willing suspension of disbelief, it seemed to do the trick. An unforeseen benefit was that the crickets apparently made people happy.

Because of the number of loudspeakers, their spacing around the park, and the fact that the audience would be wandering around and not sitting in one place, I cut the effects in mono, so that the sense of stereophony or spaciousness would be rendered naturally, as with almost any outdoor sound reflecting off the ground and other surfaces.

Alongside a thirty-minute bed of crickets destined for every loudspeaker in the park except those at the water's edge, I laid tracks of wind in leafy trees and a variety of summer birds, all recorded in the woods and fields near the shore of Georgian Bay, and routed them out of the loudspeakers located near trees. To this I added a number of individual bird tracks—blue jays, cardinals, woodpecker, song sparrow, meadowlarks, chickadees, crows—along with a few squirrel chucks and screeches, and distributed these in a random, alternating fashion to the loudspeakers near the trees, moving them around so the same birds didn't always appear to be perched in the same trees.

At my studio, David Sutherland and I programmed these tracks to loop indefinitely, since we knew the duration of the performance would be highly variable. We didn't worry about the shorter bird tracks sounding loopy because birds tend to produce very repetitive sounds to begin with. And with so much going on, I was banking on the fact that no-one would be listening intently even once, let alone twice in a row, when a looping point came around, provided that there were no easily identifiable, idiosyncratic elements in any of the sound effects.

We routed the aquatic birds and marine sounds to the single loudspeaker on the wharf as well as to a pair of shipboard loudspeakers. Once the schooner *Challenge* had tied up a few minutes into Act One, we had three loudspeakers at the water's edge for the rest of the show.

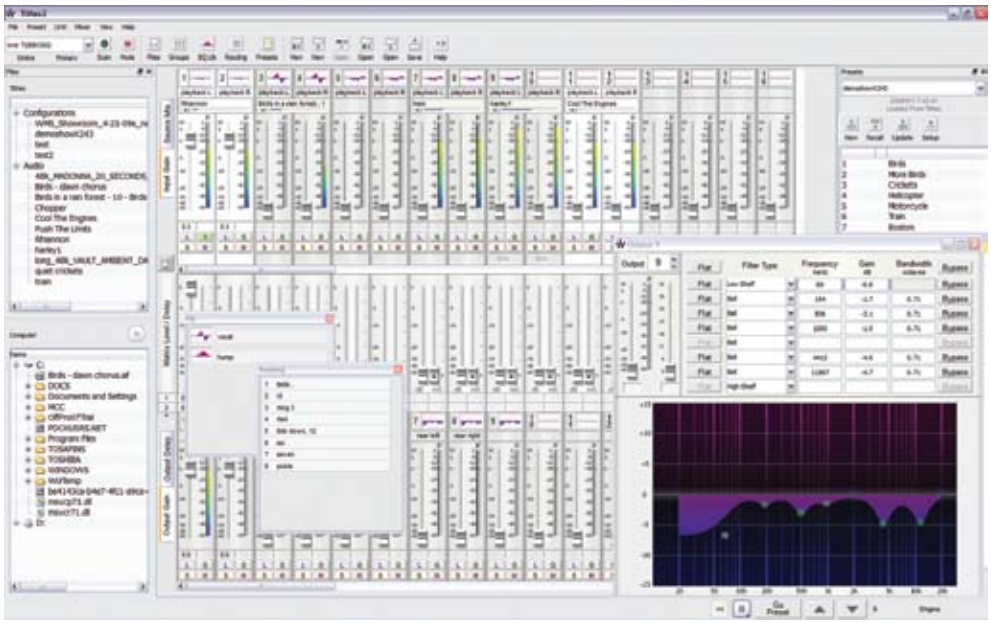
The final component of the soundscape consisted of prerecorded commands ostensibly shouted by a couple of the ship's crew, to be replayed from Renkus-Heinz PN82 loudspeakers strapped to the main mast and cockpit arch of the schooner. As she approached the wharf, the audience would be able to discern, if at first only faintly, vocalizations from across the water that would be suggestive of maritime adventure. Fortunately, the production's historical consultant, Gord Laco, had written such dialog for the 2003 epic feature film *Master and Commander: The Far Side of the World,* and was on hand to help maintain accuracy in this department.

A few weeks before opening day, I went into the studio with the show's writers, Terry Hart and Rick Kunst. Assuming the roles of captain and first mate, they yelled heartily back and forth, exchanging such chestnuts as, "By the mark, five fathom!" and "Handsomely on the yard's tackle!" We recorded 160 such lines which, when sequenced at a fairly natural pace, filled the eight minutes from the time *Challenge* was in range of our Shure ULX wireless transmitters about 600 feet offshore, until she had sailed past the wharf once and come around again to dock. The voices were underscored by ship's creaks and augmented by the occasional well-timed clang of the ship's bell and high-pitched bosun's whistle.

Routing Matrix and Source-Oriented Reinforcement

The soundscape and live actors' dialogue had to be distributed in various combinations that changed over time to the loudspeakers on the ship, along the rear fence, inside and outside the tent, and on the gazebo and wharf. This called for a dynamically programmable routing matrix.

Further, it was crucial that we be able to direct the audience's attention quickly to the focus of the action, wherever that might be at any given moment, given the potential for audience members to become distracted from the drama or unaware of its imminent resumption after an interval. Therefore, instead of simply distributing the actors' wireless microphone signals



The TiMax GUI for PC and Mac provides a familiar environment for programming input, output, and matrix levels and delays, as well as parametric EQ, group faders, snapshots, and show libraries.

to every loudspeaker for the sake of complete coverage, we elected to take advantage of source-oriented reinforcement techniques to ensure that the actors would be localized more or less accurately and immediately.

Source-oriented reinforcement is based on the Haas (or precedence) effect—the localization of a sound by a listener in the direction from which it first arrives at the ears. By carefully programming signal delays to each of the fourteen loudspeakers around the site and ensuring that the level of the reinforcing audio was no more than 6-8 dB greater than the level at an actor's position, we were able to assist the audience in localizing the actors, rather than the nearest loudspeaker. Because the cast was not confined to a single performance stage, however, this meant dynamically varying the levels and delays according to the actors' movements throughout the park.

In addition to a programmable routing matrix, we clearly needed some hefty digital signal processing (DSP) power, and this is where the TiMax2 SoundHub stands alone. Like a Swiss Army knife for audio, the SoundHub combines a number of extremely useful functions in a single package: a routing matrix available in multiples of 16 inputs x 16 outputs up to 64 x 64, with sufficient DSP to afford control of level and delay at each of the 4,096 crosspoints, as well as four-band parametric EQ on each input and eight-band parametric EQ plus delay on each output. An integrated hard disk is also included for sound effects replay, the number of available tracks being equal to the number of inputs. All of this is packaged in a 2-RU enclosure.

For our purposes, a 16 x 16 SoundHub with 16 tracks of random access playback was adequate. We used ten inputs for sound effects playback and reserved six for dialog groups. Sutherland and I loaded the SoundHub's hard drive with the individual, edited effects tracks that would make up the soundscape. Even though the SoundHub allows loops to play within loops playing within loops almost *ad infinitum,* I elected to edit and produce the individual effects tracks in ProTools, simply because of my familiarity with it, and then import the finished tracks into the SoundHub for routing and playback, programming loops as necessary.

Localizing Performers

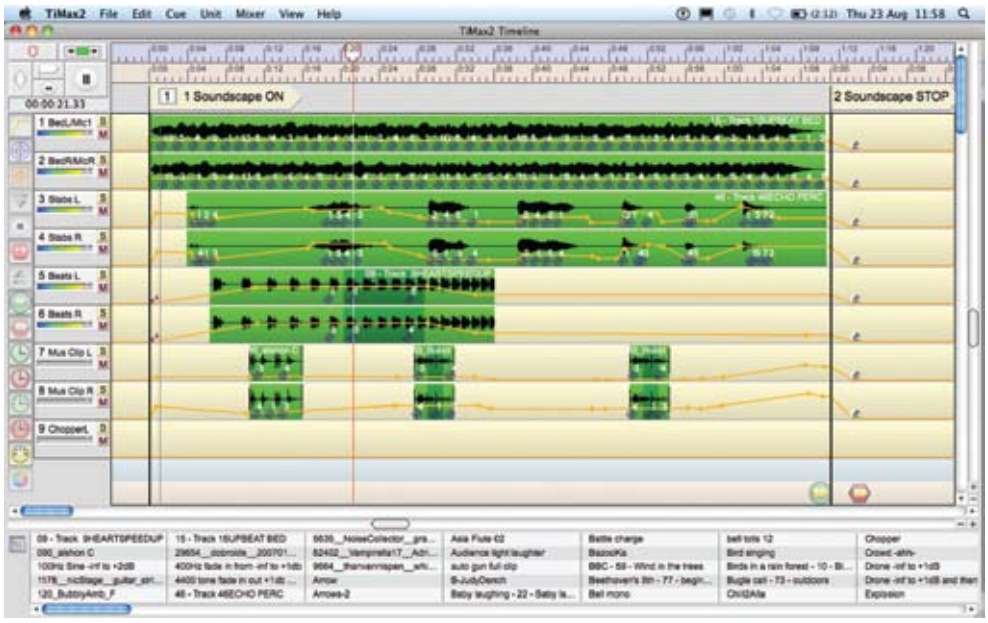
For accurate localization, every audience member should receive an acoustic wave front from each performer about ten to twenty milliseconds before receiving the reinforcing energy from the loudspeakers. Within this short time difference, the brain integrates the two arrivals together as one sound, but causes the listener instinctively to localize to the slightly earlier sound arriving directly from the performer.

TiMax2 achieves this by setting up multiple unique delay relationships between the performers' wireless microphones and each loudspeaker reinforcing them. These relationships are changed every time a performer moves to a different location in order to maintain the acoustic precedence that makes the audience localize to the performer and not to the loudspeakers.

The TiMax2 software simplifies the process by allowing localization zones to be predefined as image definitions, which are simply tables of level and delay instructions preprogrammed into the SoundHub, instructing it to place the performer's audio image in the appropriate zone.

"There's no black magic involved," said Dave Haydon, director of Out Board, the UK company that developed TiMax2. "TiMax is based on psychoacoustics and the physics of sound, primarily the Haas effect that allows us to localize a sound source in space using interaural cues based on time difference of arrival of a sound at each of our two ears."

After programming the image definitions with routing and level for each of the soundscape tracks, we shipped the SoundHub to Chris Baron at Frischkorn Audio Visual so he could begin programming image definitions for the actors.



The TimeLine offers a highly intuitive GUI for multichannel playback and sound effects editing, object-based delay-panning and show control programming.

OUTDOOR

The PanSpace graphical object based pan programming screen integrates with the TimeLine.

In designing the performance sound system, Baron sought to achieve high intelligibility at relatively low volume levels, as opposed to mere brute force amplification of the actors. Increased intelligibility at lower levels is an inherent benefit of source-oriented reinforcement, which enables our auditory cortex to focus on each part of the total sound field as we wish. By processes of cross-correlation between time differences of arrival between our two ears, we can filter out almost everything else. This is sometimes called the "cocktail party effect," and stands in marked contrast to the conventional center-cluster approach in which all of the different elements of the mix are sitting in the same place spatially, limiting the ability of the auditory cortex to discriminate based on binaural cues relative to spatial position.

With this in mind, Baron designed a system with Renkus-Heinz and Meyer Sound components, chosen primarily on the basis of coverage, detail in the vocal range, and ruggedness in an outdoor waterfront environment where the weather was changeable from hour to hour.

"I was quite pleased with the way the Meyer and Renkus-Heinz performed together," he said. "Obviously mixing different models and brands of loudspeaker is not a typical approach, but given the circumstances, I think the results were superb."

Baron's task of refining image definitions on site was complicated by the fact that it took longer than scheduled for the construction crew to build the huts, gazebo, and other structures in the park, which cost us a day that had been set aside for a tech rehearsal. All he had to go on were the rough dimensions of the field of play and scripts for the three main acts.

"Time was a huge challenge on this event. I did some pre-

liminary programming of rough delay equations to test out the theory of how we would approach localizing the actors," Baron said. "In the little time we had once we arrived at the site, I programmed the routing of the mics on the Yamaha LS9 console into logical groups for each scene, and then bussed these groups to the SoundHub for routing to the various loudspeaker outputs. Then during the first performance, we refined our preprogrammed image definitions, tweaking the levels and delays at each crosspoint by ear to ensure that the actors would be localized to the various stages correctly."

Fortunately, the logical groups for each scene invariably included almost all the actors in the scene, the exception being the town crier, whose fixed place was beside the wharf platform next to a large bell that he would ring vigorously, signaling an imminent announcement.

"Unfortunately, we didn't have enough information to complete the programming in advance, and had to do it on site once the show developed," Baron said, noting that not all vignettes were included in every performance, nor were they always in the same order. Director Terry Hart would occasionally cut scenes, call them out of order, or select a different stage for a scene, depending on the weather, overall timing of the show, and whether or not a group of special guests or sponsors had arrived in time to see a particular scene, or had to leave early. In fact, the show was rarely performed the same way twice in a row. As artistic director Slack explained, "We are not a theatre company that rehearses for weeks in a fixed environment with a show that doesn't change."

Baron chose the Yamaha LS9 console for its programmability, which was essential in executing the job. "Mix engineer Joe Zeagman and I programmed parallel cues for each scene in both the LS9 and the TiMax2 SoundHub. The console would control the TiMax2," he explained, "by sending MIDI commands to step it though the cues that contained the various image definitions for each scene." They had initially envisaged advancing cues in the console with an iPad wirelessly over Wi-Fi. "Our iPad app worked wonderfully in the shop," Baron said, "but on-site we discovered we needed more hands-on with the faders, so we ended up leaving the iPad in the box."

Ideally, in a theatre with fixed seating, the different delays to the various channels are preprogrammed for multiple onstage zones using laser measuring devices and Smaart software, the data outputs of which are entered into a custom spreadsheet that yields the requisite level and delay data for each audio channel. During a show, a performer's position in three dimensions can be tracked manually by the operator, or automatically using the TiMax Tracker radar tracking system. As the performer moves from one zone to another, the input-output matrix is switched with soft crossfades, so that audio levels and delays remain appropriate to the performer's position for accurate psychoacoustic localization according to the Haas effect.

We didn't need to use the Tracker system for *The Wharf at York* because once a scene had begun the blocking did not change significantly. The use of dynamic crossfades, however, helped create the illusion in our soundscape of dogs running around barking, and of horse carts clattering through the settlement.

Localization Needs a Direct Sound Anchor

The accuracy of localization depends to a large degree on a performer's ability to project direct sound adequately in order to provide a strong direct sound anchor that the audience can unconsciously correlate with the delayed sound reinforcement emanating from the loudspeakers.

"You must have a good anchor," Haydon explained. "In opera, for example, the anchor is putting out 130 dB_{SPL} at one meter—an opera singer is as loud as a 12-and-a-horn box. But for weaker voices, one of the tricks you can use is to build first-wave front reinforcing speakers into the stage or the set to create an artificial time zero somewhere near the performer. While the ideal would be to strap a loudspeaker to the performer's chest, in reality you can accomplish almost the same thing by positioning a loudspeaker above the head, halfway back up the stage, which is virtually at time zero as far as the audience is concerned."

So," Hayden continued, "as well as feeding the voice though the PA with appropriate delays, you run it undelayed through the speakers above the performers' heads, which helps the audience hear it as the anchor reference. That's been done in a number of theatre spaces, including the Royal Danish

EQUIPMENT SUPPLIED BY FRISCHKORN AUDIO VISUAL

LOUDSPEAKERS
Renkus-Heinz PN82 (2 aboard *Challenge,* 1 on the wharf)
Renkus-Heinz PN61 (2 for coverage in front of the tent)
Renkus-Heinz SG81 (2 at rear of the tent for coverage inside the tent)
Renkus-Heinz PN81 (1 at the rear fence)
Meyer UPM-1P (4 on the gazebo)
Meyer UPA-1A with Ashley FTX 2001 amplifiers and Meyer M1-A processing (2 at the far end of rear fence)
MICROPHONES
14 Shure UHF-R wireless systems (plus 2 spares)
14 Countryman H6 micro-headsets
TRANSMITTERS TO THE SHIP 2 Shure ULX transmitters and ULXP receivers
CONSOLE Yamaha LS9-32 digital console
PROCESSING TiMax2 SoundHub-S16 (16 analog I/O with 16 tracks of hard disk playback)

Theatre, as well as in large outdoor venues, where it has helped localize the first arriving wave front."

The theory proved sound, particularly on the wharf where the anchor was a Renkus-Heinz PN82 loudspeaker hidden in a rough burlap sack sitting casually amid some barrels and crates. In the vignettes staged in the gazebo, there were four slim Meyer UPM-1Ps mounted just under the roof edge at each of the four points of the compass.

"The gazebo worked particularly well because of the loudspeakers in line with the performers, acting as reinforcement to a point source," Baron noted. "We had mono audio coming from the gazebo 360 degrees around it. The UPM-1P has a 100 degree conical dispersion pattern, so the coverage was excellent, and those speakers are unbelievably good sounding. For people who were further away, we had a little bit of delayed fill coming from some of the other loudspeakers on the wharf and along the rear fence."

Proof of how well our concept was working came early in the run when I was standing beside one of the producers watching the drama unfold on the wharf platform. Glancing behind her, the producer whispered, "The speakers in the back of the tent aren't on!" I assured her that they were on and working. "The speakers in the tent aren't on," she insisted. "I can't hear them." Again, I assured her that they were on and working properly. She turned and walked back to check the rear loudspeakers, stopping abruptly about fifteen feet in front of them where she could first hear them as a distinct source. "That's the magic of what this is all about," I explained, her smile broadening as she began to understand how the sound system was imperceptibly and unobtrusively reinforcing the actors.

Configuring TiMax2

Multiple TiMax2 SoundHubs can be cascaded for scaling beyond a 64 input x 64 output configuration for operation in multi-zoned theme parks and other large venues.

Each matrix input can be selected from among three sets: analog or AES-3 digital audio, Cobranet or Ethersound audio, and playback from the internal hard disk drive. Alternatively, these three inputs can be mixed together or crossfaded from one to another into a single matrix input.

"We expect most people to select between these submix inputs," Hayden said, "but it's not unusual for some live shows to have playback backup, which could be used to thicken up the backing vocals if the band is having a slack night."

Balanced analog audio interconnect is via groups of eight channels on DB25 connectors in the now familiar Yamaha pinout. Digital I/O with sample rate conversion is provided for sixteen channels on DB25 connectors, with an option to sync automatically to embedded word clock, or to lock to external word clock on a BNC connector. Digital audio on Cobranet or Ethersound networks is provided in pairs of thirty-two on Cat5 cable. MIDI, SMPTE, and GPIO connectors round out the rear

panel. Optional dual power supplies, dual cooling fans, dual mirrored audio hard disk or flash drives, and input relay bypass provide for fail-safe operation.

In a multi-user environment, single or multiple SoundHub units can be programmed from one or an indefinite number of computers in any mix of PCs and Macs on 100 Base-T Ethernet, while a front panel control pad and color LCD screen with simple push-button switches and menus permit stand-alone operation of the system for show and cue recall. Alternatively, presets and cues can be recalled remotely from AMX/Crestron, MIDI, SMPTE, GPIO, or TCP/IP controllers.

Level, delay adjustment, and parametric equalization are provided for every input and output, with eight bands of EQ and output delay (in addition to the crosspoint delay) available on each output channel to allow for conventional loudspeaker system alignment. "If you need to 'move' a particular loudspeaker a little further back, the additional output delay allows you to do that without having to rewrite all the image definitions," said Out Board director and TiMax2 developer Robin Whittaker. All levels, EQs, delays, and routing paths can be stored in libraries and recalled to additional channels as required.

Each cue or preset can be crossfaded between different routing, level, delay, and EQ settings for seamless operation as performers move from one zone to another during a show. Operation of the TiMax2 software GUI is extremely intuitive, with drag-and-drop functionality, and familiar console features such as control group faders, signal meters, and EQ displays.

A list of preprogrammed cues or presets is stored as a show or configuration, which can be stored on hard disk or flash drives in the SoundHub. Via a series of simple front-panel screens, soft switches, and a rotary encoder, the user can recall a show and execute its cues. In addition, the user has access to pre-assigned level and mute groups to make adjustments across multiple zones and sources. Input-output metering, solos, and mutes permit localized zone control, source switching, and diagnostics. Needless to say, access is password protected.

During *The Wharf at York,* we backed up the entire TiMax2 configuration to a USB flash drive every time we made a change to cues or individual image definitions. In addition, we had a backup of the entire show, including all the 48 kHz, 16-bit audio for the soundscape, on two additional USB flash drives as well as on the laptop running the user interface. Happily, we never had to use it. ❖

*Veteran sound designer **Alan Hardiman** works with sound for large scale events and exhibits. Other recent projects include the original score for the dramatic film* Joy *and producing and composing the soundscore for the documentary* Osprey Family Life on Georgian Bay. *He previously wrote about the electro-acoustic support system in Toronto's Four Seasons Centre for the Performing Arts in the fall 2006* TD&T.