Who will turn the knobs when I die?

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This paper addresses questions regarding the performance of interactive music compositions through an examination of the author's own works. The questions emerge from the compositional impetus and the subsequent technical design of each of the works. The paper also examines some of the forces impacting the performance, preservation and long-term viability of interactive works and non-interactive electroacoustic compositions.

1. INTRODUCTION

I clearly recall that in the early 1980s, after labouring with non-real-time computer synthesis systems, primarily of the music-x category, many young electroacoustic music composers became excited by the idea of real-time interactive composition and performance. Composers such as myself that had worked with pre-computer music electronics and perhaps played in rock, jazz or experimental live electroacoustic ensembles were suddenly able to connect these experiences with the precision and formality of computer programming. The first MIDI interfaces for portable personal computers opened an entirely new domain of musical thinking. Composer–perfomers such as Roger Dannenberg who developed the CMU Midi Toolkit (Dannenberg 1986) and trombonist George Lewis at UC San Diego who created a unique personal performance tool called *Voyager* (Lewis 2000) demonstrated the promise of software-based real-time performance.

I too jumped into this new world. As a performer, I found the idea of developing real-time systems for myself very compelling. As a composer, I found the idea of integrating real-time electroacoustic resources into a solo or chamber ensemble setting even more alluring. However, the practical realities of creating, supporting and circulating this genre of works has indicated that for the vast majority of these kinds of pieces few performances have occurred without the presence of the composer. All but a few of the interactive pieces I composed over a 15-year period required my personal intervention at each and every performance. Thus, the question: who will turn the knobs when I die? Even though the computer system requirements to mount these works have diminished (thanks in part to Moore's Law), other electroacoustic elements are lost or obsolete, leaving little more than the scores and audio recordings as long-term artefacts. While reviewing my own work, the following paragraphs explore some of the forces that affect the longevity of interactive music including the role of performers, teachers, venues and music technology experts.

2. THE MIDI PIECES

2.1. *Preascio-I* (1987)

In 1986 I embarked on the *Praescio* series of compositions for one or more performers and interactive electronics beginning with *Praescio-I* for saxophone and MIDI system. This piece, first performed by me at SUNY Buffalo in April of 1987, utilised an entire station-wagon-full of gear. The system consisted of two IBM-AT Intel 286 computers, which at that time were the fastest personal computer on the market. One was essentially a MIDI file player that sent data to an external rack consisting of Yamaha FM synthesisers, an Ensoniq *Mirage* sample player and a MIDI-controlled reverb/delay unit. The software for this part of the system was a port of Alex Brinkman's Score-11 (Brinkman 1982), developed at the Eastman School of Music, which itself was a port of Leland Smith's venerable Score program developed at Stanford in the 1970s as a compositional front-end to the CCMRA Music-10 language (Smith 2003). (Not to be confused with Smith's music notation engraving product called Score, but originally called MS when it was under development in the 1970s.) As a group project with students in computer science at Queen's University in Kingston, Canada, I added a MIDI player to Score-11 using a Roland MPU-401 MIDI interface. This system permitted me to create tracks of MIDI data and then send them to arbitrary MIDI channels along with program changes, pitch-wheel data and other controller data. The second PC in this piece received MIDI data from a now obsolete IVL Pitchrider that converted the saxophone pitches to MIDI signals and ran a small program developed using the CMU-MIDI Toolkit that provided routines for reading and processing the saxophone's MIDI data stream. After performing this

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work many times, I streamlined the saxophone player's actions by designing an extension to the soprano sax. Built by McGill University EMS technician Eric Johnstone, the saxophone harness provided both sustain and trigger using two micro-switches as shown in figure 1.

In 1990 I reconstructed this piece reducing the technologies to a stereo audio track on CD plus a MIDI-controlled synthesiser. The audio track was a mixed recording of all the materials generated by the MIDI files in the original version. A Max program replaced the second PC in the original system receiving pitch data from the saxophone and controlling the outboard MIDI gear. I recorded this compact Max version at McGill University and it appears on Pennycook 1991a.

If I were to faithfully preserve this work, I would need to create a completely new software system – most likely in Max/MSP – that could interpret all the original MIDI data and also emulate all the functions of the original. Predictably, recent performances of this piece have omitted the Max component entirely thus eliminating all interactivity and reducing *Praescio-I* to a work for instrument and tape.

2.2. *Praescio-II*: amnesia (1987)

Praescio-II: amnesia was commissioned by Jeffrey Wright at the Peabody Conservatory of Music as part of the celebration of the twentieth anniversary of the Peabody Electronic Music Studio founded by Jean Eichelberger-Ivey in 1967. For this commission a new software system was devised called MIDI-LIVE as described in Pennycook 1991b. The primary objective of the MIDI-LIVE system was to eliminate the static structure of tape playback by forming accompaniment passages from short segments of MIDI data (such as fragments of tape) that could be initiated by a performer. Observing that in the performance of traditional repertoire one cannot alter pitch content or the relative rhythmic elements – leaving dynamics, tempo and overall pacing as the primary variables for personal interpretation – my approach sought to free the player from the time-invariance of tape playback allowing the piece to breathe at the performer's pace. Of course, more then 20 years later this all seems rather simplistic but I was convinced that performer control of temporal elements would enhance the spontaneity of the performance, allowing the player to vary the pace of the piece by controlling event entrances during a given performance.



Figure 1. Saxophone Harness for *Praescio-I*.

Praescio-II: amnesia is scored for soprano, flute, violin, cello, DX-7 synthesiser and computer system. In the original system, both the soprano and flute audio signals were fed to a pair of pitch-to-MIDI devices and, like *Praescio-I*, data from stored MIDI files was intermingled with the incoming data and the acoustic and synthesised sounds from the players on-stage. Reconstructing this work today would be possible but very difficult. The original MIDI data files are archived on CD-ROM but none of the PC software is functional, nor are the DX-7/TX-802 synthesiser patches readily recoverable. With a Herculean effort, all the necessary systems and technologies could be reconstructed in Max/MSP but the performance of the piece would still require substantial on-stage and off-stage resources. Even if a new system were to be constructed, it is highly unlikely that the work could ever be performed without my being present to oversee the installation and operation of the technologies. The last performance of the piece with all the gear intact was in Montreal for the 25th Anniversary of the McGill University Electronic Music Studios, held in December of 1990, and this performance was recorded and released with other works from the McGill studios on Pennycook 2001. I have recently orchestrated an acoustic version of this piece under the title *amnesia*, for soprano, flute, harp and string quartet. Though the electronic components are completely absent in this version, the piece can again be performed.

2.3. *Praescio-III* (1989)

Praescio-III was commissioned in 1988 by Montreal-based harpsichordist Vivienne Spiteri. In addition to significant enhancements to the MIDI-LIVE software such as more elaborate record/play functionality, this work included the design and building of a custom MIDI interface for the upper manual of her two-manual instrument. The first version of the interface utilised gold contacts on each key similar to the key mechanisms of commercial synthesisers of the day. The contact wires were attached to a simple MIDI interface device manufactured by a small firm in Ottawa, Canada. The

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interface worked quite well but, perhaps like the harpsichord itself, it required constant minute adjustments to ensure good contact from each and every key. Sadly, this hand-made device was lost or stolen somewhere in Europe. Eric Johnstone, who had constructed the first interface, designed a new system based on optical switching rather than wire contacts. With only a few mishaps, this new system proved more reliable and less susceptible to the variability of the key/plectrum mechanics of the instrument.

The compositional benefits of the extended harpsichord system were, for me, significant. The software permitted several different approaches to the integration of the MIDI system and live performer such as unison and parallel 'colorising' of the harpsichord notes with MIDI-generated sounds, performer-initiated file playback, MIDI data recording, and playback with a variety of modifications such as harmonisation, transposition and time delay. It also supported sustain and volume pedals, which provided the performer with a new dimension for her instrument. All of these capabilities were explored in *Praescio-III* and can be heard on Spiteri's CD, *Vivienne Spiteri – comme si l'hydrogen/the desert speaks* (Pennycook 1994). Given that the interfaces are now lost or inoperative, I do not expect *Praescio-III* to be performed at any time in the future. Thus, the score and the Spiteri recording form the only surviving archive of this piece.

2.4. *Praescio-IV* for extended clarinet and MIDI system (1991)

Praescio-IV was commissioned by Jean-Guy Boisvert and premiered at the 1991 International Clarinet Conference held in Quebec City and recorded on Pennycook 1993. A new version of the MIDI-LIVE software was developed to better handle input data from the triggers and the pitch-to-midi converter. A custom clarinet extension was constructed by Eric Johnstone that provided three additional keys made from extremely lightweight micro-switches and small aluminum pads enabling cross-fingered triggers and sustain (Pennycook 1991b). As in the harpsichord piece, a volume pedal was also part of the rig and it was connected to the harness cables along with wiring from a reed frequency sensor made of vibration-sensitive plastic. The objective of the harness was to minimise the number of unfamiliar actions that the clarinettist needed to learn to perform the work. By mounting the harness on the lyre post of the clarinet, players could conveniently reach and operate the triggers and sustain actions. As shown in the score fragment in figure 2, I utilised a system of symbols to indicate triggers, sustains and volume pedal controls such that they could be readily learned. All the clarinettists who performed this work with the harness, and even those that used the alternative foot pedal version, seemed very comfortable with the process. More importantly, the players reported that having direct control of entry times for

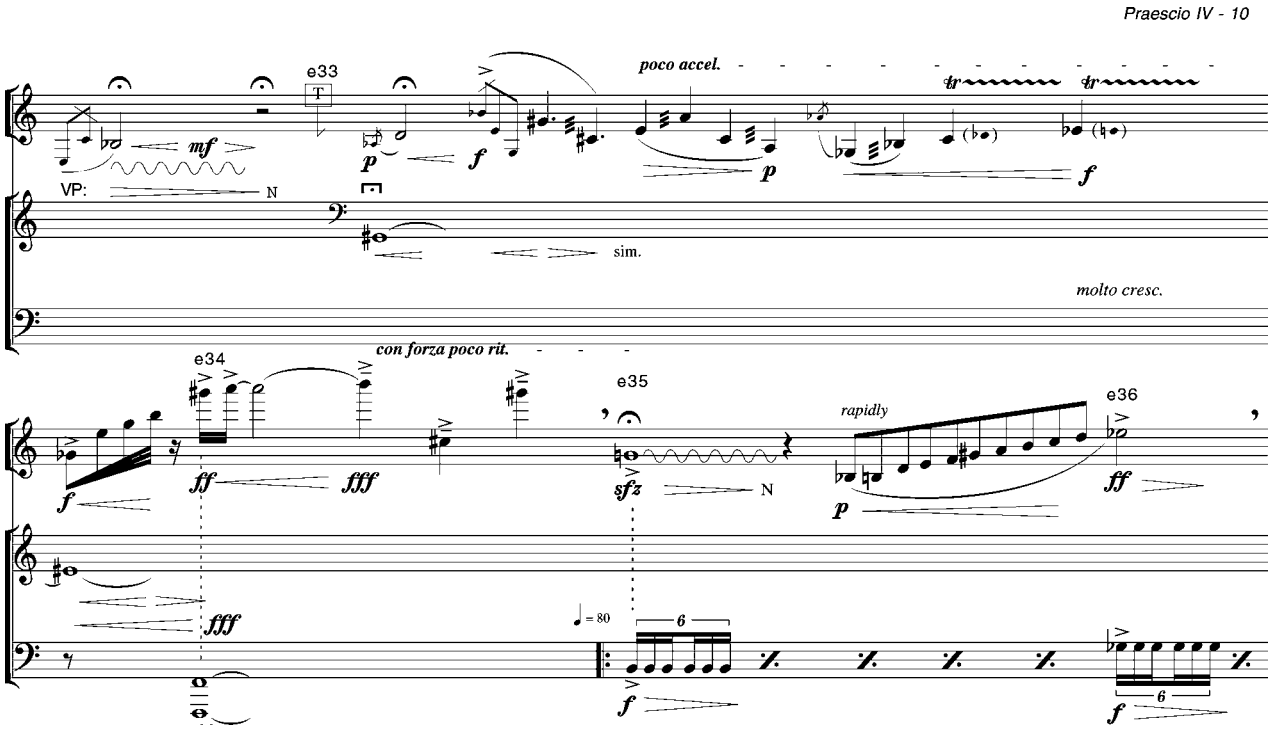


Figure 2. *Praescio-IV* score fragment showing event notations.

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the more than 60 unique events in the piece gave them a satisfying sense of control and expressivity.

In 1994 a few Canadian composers teamed up to design a portable touring rack for Boisvert, enabling him to perform on tour several different interactive works. For this system I rewrote all the MIDI-LIVE software in Max and adapted the sound sets for a small collection of devices that were agreeable to the other composers for their pieces. This version was used for numerous performances and proved to be a reliable touring rig but, unfortunately, is now obsolete.

In 2004 David Wetzel implemented a new version of *Praescio-IV* for his doctoral recital on clarinet at the University of Arizona. Using my original MIDI data to play sounds he acquired from various synthesiser sources, Wetzel ported my piece to Max/MSP. But as he correctly states (Wetzel 2006) a direct port or transcription 'is itself subject to the possibility of technological obsolescence' and I am painfully aware of this fact, having myself made four unique versions of this clarinet piece. I re-scored *Praescio-IV* in 2006 for clarinet and marimba under a new title, *Concert Piece*. I am not at all troubled by rewrites such as this as there is a long tradition of chamber music transcription. For example, both of Brahms clarinet sonatas, Opus 120 no. 1 and 2, were re-published for viola and violin, and practically every instrumentalist has played transcribed versions of eighteenth-century pieces of Bach or Handel – even saxophone players! When Wetzel completes his latest version of *Praescio-IV*, two versions of the work will exist, one with electronics and one with marimba, and I suspect that the latter will have a longer life span.

3. THE MIDI AND AUDIO PIECES

One of the vexing problems of learning and performing interactive pieces I observed during the course of the MIDI-LIVE works was that during complex moments in the score, especially when the instrumental part was very demanding, it was very difficult for the player to know exactly what the system was doing. The questions that frequently emerged, especially during rehearsals included: Were triggers and other messages received and processed correctly? How many seconds are left in this section? Which event number is next and at what tempo? My solution to the feedback problem was to develop a MIDI-controlled visual display device that could inform the player as to the state of the software throughout the piece.

3.1. The MIDI Time Clip

In 1991, Eric Johnstone and I teamed up and designed and implemented a device we called the MIDI Time Clip (figure 3) that could send signals and text-based messages to a small display 'clipped' to a music stand. The original version of the device had four independent displays connected to a control box. Each visual display unit consisted of one large red LED and six, 16-segment addressable LEDs for ASCII character display. Johnstone wrote a low-level software system that responded to MIDI SysEx byte streams and I constructed a set of Max patches based on these codes to instantly send messages such as 'lamp-on' and 'lamp-off', which could be used for beat cuing, and 'write text', which would display alphanumeric data such as event numbers. Perhaps the most useful feature was the display of time as clock time, SMPTE time or simple measure counting.

The original version was replaced by a compact single unit (figure 4) that we called the Unified MIDI Time Clip (Pennycook 1992a). For this version, then McGill University PhD candidate Dale Stammen encapsulated all the Max functionality from the first system into a single Max external, thus simplifying the process of sending the MIDI messages to the device. The new version housed all the electronics and the display in a single box and included a microphone stand thread-mount. Both versions of the MIDI Time Clip provided a MIDI-in port to pass data to the computer from a



Figure 3. original Time Clip with one display.



Figure 4. Unified MIDI Time Clip.

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MIDI controller supporting the player's foot pedals and triggers. The Time Clip capabilities strongly influenced the composition of both *Praescio-VI* for flute and electronics and *Praescio-VII (piano and then some…)* for piano, electronics and eight loudspeakers.

3.2. *Praescio-VI* (1993) and *Praescio-VII* (1994)

Toronto flautist Christine Little, a specialist in contemporary and electroacoustic flute music, commissioned *Praescio-VI* in 1993. *Praescio-VII* was commissioned by the Association du création et recherché electro-acoustique du Québec and was composed for my friend and colleague, Montreal composer–pianist alcides lanza. In addition to using the Time Clip for timing and message display, these pieces shared a number of other technological developments especially my abandoning my PC-based MIDI-LIVE software for Opcode's Max software.

The arrival of faster Motorola 68040-based Macintosh computers coupled with the availability of affordable CD-burners permitted me to significantly expand my acoustical language within the framework of real-time interactive composition. I created sets of two-channel audio tracks using various non-real-time software resources such as csound, then burned CD-audio disks to be played under Max software control. Both the audio tracks and sets of pre-composed MIDI tracks were triggered by the performer, and the Time Clip played an important cueing role here. During audio track playback, the system converted the absolute time from the Max CD object into clock time and posted the data to the Time Clip enabling the player to readily synchronise score events with the displayed clock time. The system also informed the player that triggers or certain pitches had been correctly sent and received by the software. All the event information and time values throughout these pieces were presented to the player using the Time Clip Max objects to write to the external display system. This combination of messages, beat flashes and clock time proved to be a highly effective visual feedback, and performers who worked with the Time Clip stated that the visual information was extremely helpful giving them confidence with the temporal progress of the piece, especially during rehearsals.

Praescio-VI and *Praescio-VII* shared a variety of MIDI technologies available at the time such as the Digidesign Sample-Cell, a sample player housed on a Macintosh-II bus card. *Praescio-VII* also used a MIDI-controlled multi-channel audio level controller to enlarge the acoustic to space eight discrete channels of sound. Interestingly, this multi-channel playback configuration would be the least difficult part of the piece to reconstruct using current digital multi-channel audio interface technologies. A recording of *Praescio-VII* using all of the original hardware and software was released by alcides lanza (Pennycook 1996). However, the resources and software needed to present these two works in their original form are obsolete and, of the two, only a piano and fixed-media audio version of *Praecio-VII* continues to be performed. I am now working on a new acoustic version of *Praescio-VI* for flute and chamber ensemble and look forward to giving this work a new life.

3.3. *The Black Page Tropes* (1996)

The last piece in the set of MIDI-plus-audio pieces is *The Black Page Tropes*; my homage to Frank Zappa. This 21-minute piece is scored for drum kit and percussion and was begun shortly after Zappa's untimely death. The piece is based on *The Black Page #1* (Zappa 1978) plus fragments of *The Black Page #2, The Easy Teenage New York Version*(Zappa 1978) as transcribed by Montreal composer Walter Boudreau. Boudreau was the conductor and arranger for the Montreal-based Zappa cover band *The Dangerous Kitchen* (named after one of the Zappa pieces in the show), in which I played soprano saxophone and Yamaha WX-7 wind controller.

There are several components to the live, interactive performance system in *The Black Page Tropes*. Audio tracks were created from a collage of more than 25 Zappa CDs, and these incorporate famous Zappa lines such as 'Suzy Creamcheese? What's got into you?' (Zappa 1968), with numerous re-mixed elements extracted from many sources throughout his recorded repertoire. These audio collages appear throughout the piece, forming an important part of the overall acoustical fabric. Within the Max software for this piece, real-time processes conditionally select data from tables of small fragments (2–3 beats long) from *The Black Page #1* drum rhythms. These data sets get merged with incoming MIDI data from the on-stage drum pads then are all sent to a drum sample unit. The best illustration of this aspect of the work was during a lengthy drum-kit solo: the drummer had to select from any of six different patterns generated in real-time by the software by striking one of the midi drum pads. In response, the software generated new rhythmic patterns played by an external drum sample device. The outcome was a very spontaneous and powerful mix of rhythmic accompaniment, leaving the drummer free for some 'over the top' soloing.

The musical structure of *The Black Page Tropes* is a set of expanding variations based entirely on Zappa's original musical materials. The variations are articulated by synthesised interjections of a 'band' playing selected bars from the *Black Page #2*. Both the drummer and the percussionist must play along in time with these brief interjections as if a part of a larger ensemble, thus presenting some tricky synchronisation problems that were only resolved by my serving as both

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a conductor and system operator at every concert. Thanks to two superb soloists and several opportunities to present the work in Montreal and then in Mexico City, this piece did receive excellent performances, including a broadcast and recording by Radio-Canada. However, the complexities of the software, hardware and other materials make repeat performances highly unlikely. Even if I were to completely reconstruct the entire system today using contemporary devices it would be impossible to perform this work without a highly skilled operator/conductor as part of the ensemble.

In summary, the MIDI-plus-audio group of pieces all require very specific hardware and software that cannot be readily reconstructed. I no longer have a functioning OS-9 computer that will run the necessary collection of Max externals written over the course of several years, and although I could re-code everything using current hardware and software this would take many months of effort. Fortunately, all of these pieces have excellent recordings by the players for whom they were written.

4. THE AUDIO PIECES

After hearing some of the exciting new pieces being composed in the early 1990s for the IRCAM ISPW (Lindemann et al. 1991) such as those by Cort Lippe and Zack Settel (Lippe n.d.) it seemed that aesthetically, interactive MIDI pieces were passé and that the new sensibility was real-time audio processing. Availability of the expensive NeXT-ISPW platform was a limiting factor for most composers including myself, but Moore's Law again came to the rescue and a number of affordable audio processing systems emerged: real-time implementations of csound for both Wintel and Mac configurations, James McCartney's SuperCollider programs and Max/MSP. The integration of audio recording, signal processing, mixing and a real-time control into a unified programming language and hardware platform engendered the same kind of compositional excitement in the mid-1990s as had the arrival of MIDI in the mid-1980s. Composers weary of the limitations of MIDI-controlled hardware synthesisers and sound processing devices were drawn to 'audio only' pieces capitalising on powerful new computer technologies and real-time audio software packages. In short, we all moved on.

4.1. Panmure Vistas (2000)

Panmure Vistas, composed for solo violin and real-time audio signal processing, is the first of my 'audio plus instrument' group of pieces. It was inspired by the rugged maritime beauty of Canada's Prince Edward Island I experienced while camping with my family at Panmure Island Provincial Park. The sounds of the seashore coupled with Celtic traditional music performed at summer festivals on the island invoked the lively dance-like violin materials and well as the electroacoustic environments. The piece has been performed many times, primarily by Canadian violinist Gascia Ouzounian, who also recorded it on Pennycook 2003.

Like many other works of this genre, the relationships between the soloist and the computer component can be divided into the following general categories: instrument alone, instrument with signal treatments, instrument with pre-recorded or computer-generated accompaniment, instrument with all of the above, and computer-generated audio alone. These changes of texture or 'states' are central to the formal organisation of the piece. As shown in figure 5, a screenshot of the operator's user interface, the software presents a set of states, each of which invokes a subset of the available processes and loads tables of parameter data to initialise all the parameters including audio levels.

Panmure Vistas has proven to be an easy piece to set up and install, requiring nothing more than a two-channel digital audio interface to receive the violin signals and send audio output from the computer to the sound reinforcement system. Though most of the output levels for each state or process are automated, during the first performances it became apparent that the huge expressive and dynamic range of the violin demanded a more subtle and responsive control of the dynamics than could be fully pre-programmed. Thus, *Panmure Vistas* became a kind of duet for violin and computer operator requiring a continuous interplay between the two and, like any chamber music duet, both performers must listen and respond to each other's contributions. Frankly, I do not know how to successfully automate the subtle control of timing, mixing and overall level control that this piece requires, as this would require some form of intelligent listening system able to respond to complex audio conditions and make

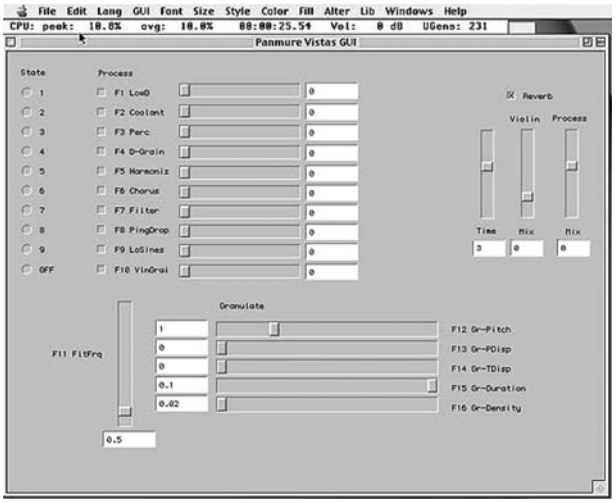


Figure 5. *Panmure Vistas* – operator screen.

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the appropriate adjustments to the mix. For now, I continue to travel to the performances and to provide the technical and operator support this piece requires.

4.2. Frontenac Axis (2001)

In 1996 I received a commission from the woodwind trio *Nova Musica* in Sherbrooke, Quebec for a work with electroacoustics. This multi-movement work used much the same software structure as *Panmure Vistas*: a series of states with processing of the live instruments plus real-time synthesis routines. With three players in this ensemble, it was apparent from the onset that managing the audio input would be a significant issue. My solution was to compose a work with solo movements for each player, thus isolating some of the audio processing routines to individual instruments. Even so, this work requires that all three players have microphones that can be mixed and routed to the computer and that the subsequent computer audio output be mixed and balanced with the live and processed signals. Unfortunately, these technical requirements far exceed the normal performance capabilities of *Nova Musica*. In addition to needing a very skilled operator who can install, test, debug, run and mix the piece, the group must own or rent all the sound reinforcement gear plus the digital audio interface and computer. For a rock or live 'techno' band, these requirements seem trivial. For a small chamber ensemble with a limited touring budget they are effectively insurmountable. For example, after careful testing and documenting of my software on my own G4 laptop in preparation for a concert in Montreal which I could not attend, I learned that at the first rehearsal the piece did not work despite the fact that there were several highly skilled computer music graduate students helping the players. I am absolutely certain that had I been present the piece would have worked flawlessly as it had on previous occasions. If this were merely an embarrassing anomaly I would be less concerned, but the reality is clear: real-time interactive music is very difficult to present with the same consistency and reliability as other genres. More often than not, the composer has to be present.

4.3. *Club Life* (2002)

The final work in this group was commissioned by *Quark*, a chamber trio consisting of two saxophone players and one piano player. *Club Life* has much the same technical requirements as the previous two works: a sound reinforcement system including microphones for the saxophones, a laptop computer with a digital audio interface, and my SuperCollider 2 program. For this piece I added the option of a small on-stage keyboard to allow the software states to be triggered by the pianist. However, each time this piece has been presented, including a superb performance at the 2004 ICMC at the University of Miami, I have been able to be present to install and run the system during the performance. It is of interest to note here that Dale Stammen, the leader of Quark, was one of the original team of developers at Real Networks and a highly skilled audio signal processing and media software expert. I cannot imagine any computer- or audio-related issue that he could not swiftly resolve. Even so, during the course of performing a very difficult saxophone part, it would be challenging and possibly distracting for him to be worrying about technical matters at the same time. There are other hurdles with this work: the ensemble or the venue must provide a multi-channel audio system and, until I rewrite the software, the performers will need a suitably configured OS-9 Macintosh computer. Alternatively, *Club Life* can be performed without the computer audio and this, I suspect, will be the likely future of the piece. Fortunately, there is an excellent recording made by Stammen's group at the Banff Center for the Arts in 2003, which is scheduled to be published sometime in the near future.

In summary, these audio only pieces pose nearly as many difficulties as the earlier MIDI pieces: the computer needs to be configured appropriately, the performance software needs to be updated to run on current operating systems, the audio system must be able to accommodate the channel configurations and, finally but most important, someone with sufficient technical knowledge and musical training must be present to make it all work correctly.

5. CURRENT WORK

Over the past few years I have been composing acoustic works, electroacoustic music for video and for multi-channel works for acousmatic diffusion. As these are by definition 'fixed media' formats, there has been no need for real-time interaction considerations.

However, in 2005 I received a commission from Susan Tomkiewicz for a piece for English horn to be premiered at the 2006 International Double Reed Society Conference held at Ball State in Muncie, Indiana. Discussions with the commissioner led to the question of real-time interactivity versus a tape piece and, for all the reasons cited in the preceding paragraphs, she and I determined that the piece should be for English horn and a two-channel audio track. For the premiere, Ball State University provided a superb audio system in a small and very intimate recital hall. The combination of tape and amplified English horn mixed perfectly in the space and, more importantly, this first performance by Tomkiewicz affirmed that the tape-plus-instrument format remains a powerful and convincing combination.

Despite all my previous efforts to construct systems that enable players to exercise their own individual

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temporal pacing and dynamic expression, Tomkiewicz successfully demonstrated stunning temporal accuracy including some very tricky entries that are unprepared rhythmically by the accompaniment. Credit for this most go primarily to the soloist – a remarkable double reed virtuoso. However, learning the piece was simplified by my producing a score with precise timings for both the instrumental and the tape parts.

Composers of instrument-plus-tape pieces know that aligning the instrumental notation, especially metered materials, with the absolute clock-time of the audio track can be very tricky. Having performed numerous pieces for saxophone and tape, I can attest to the difficulty of understanding from the notated part precisely where the tape and notes are to be synchronised. Of course, once a piece is truly learned and memorised these problems largely disappear, but during the first encounters with tape pieces temporal issues are always the most troublesome. My solution was to convert the finished audio track into Quicktime movie and then to import this into Sibelius using the movie synchronisation feature of the software. By precisely synchronising the audio track with a concurrent sample playback of the notated version, I was able to ensure that the clock time matched exactly the times in the score. From the point of view of the performer, I would highly recommend that other composers investigate this process as it assures truly precise synchronisation of the instrumental notation, the symbolic or timed tape cues in the score and the audio.

Tomkiewicz has performed this work several times now and, I suspect, is no longer so concerned with the temporal issues. In fact, like most fine players, she is able to make the combination of fixed pre-recorded materials and her live performance appear to be a unified and spontaneous musical whole. This leads me to consider that perhaps the real-time temporal control systems in the *Praescio* series described above were beneficial primarily as a learning tool and were less critical during actual performances. It is also clear that the instrument plus tape format for *Fastdance* solves the problem of longevity requiring only the score and a copy of the fixed-media audio to be learned and performed. With current archiving and storage methodologies I can assume that this piece and my other fixed media works could remain performable indefinitely.

6. DISCUSSION

Having abandoned composing for tape plus instruments and voices in the 1980s to explore issues of temporal flexibility in real-time performance, I have now gone full circle and returned to composing for fixed-media format. This re-thinking has been profoundly influenced by all the difficulties of performance longevity outlined in the preceding paragraphs.

Perhaps the most important observation is that expert performers of instrument and tape pieces can successfully 'fake' the kind of spontaneity and flexibility that interactive works are designed to ensure: meaning, for the audience, there is no perceptible difference between a powerful and moving electroacoustic performance whether for fixed-medium or for live electronics. The innovations of real-time interactive composition and performance systems certainly have a positive impact on learning and rehearsing a new work, but in concert are less significant for both the performers and the listeners. In fact, the presence of computer and audio technologies on the stage may interfere with the drama of live performance distracting both the performer and the audience. From my own experiences as a performer and from attending countless electroacoustic performances, I cannot help but conclude at this time that fixed-medium pieces may prove in the long run to be the more durable and effective electroacoustic format.

As I have argued elsewhere (Pennycook 1992b, 1997), it is evident that the burden of presenting and disseminating interactive electroacoustic works has rested primarily with composers and, unlike other chamber music idioms, has not been integrated into the chamber music idiom. Nor has it been integrated into the teaching practices of the vast majority of instrumental music teachers. The intimate relationship that exists between the teacher and the student while learning to master an instrument necessarily requires the young instrumentalist to absorb much of the principal repertoire for their instrument and, during their college degree in performance, instrumental students strive to demonstrate in their recitals their expertise with works selected from hundreds of years of masterpieces. Including even one electroacoustic work on a student's recital not only displaces some other piece they should probably have mastered but adds significantly to the complexity of the teaching and rehearsing process. Teaching and rehearsing an interactive work that demands the use of complex technologies is clearly outside the scope and capacity of the vast majority of instrumental instructors. The high quality of current stereo audio playback systems in teaching studios (and in most concert venues) combined with the simplicity of playing a CD or audio file readily supports the performance of works for instrument and fixed media. Given that performers of chamber music generally provide all their own supporting materials, the ubiquity of good audio systems relieves the soloist or ensemble from providing anything more than a CD or an iPod. Any technical requirement beyond 'stereo audio in' is very likely to be problematic.

Overall, there are simply too many factors that limit the learning and presentation of technology-based interactive music performance. Outside of the electroacoustic music festivals or university-based new music concerts, few of these works are performed on a regular

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basis. Conversely, the simplicity and effectiveness of fixed-media pieces has allowed the tape format to become a reasonably well understood part of the overall repertoire for many instrumentalists.

7. PRESERVATION AND RESTORATION

There have been several important initiatives to preserve recordings of electroacoustic music such as the IDEAMA Project initiated by Max Mathews (Goebel, Chowning and Wood 1990) and The McGill University EMS Archive (McGill n.d.). There have also been efforts to house and maintain historical collections of electronic and digital music devices including (Davies 2001), the MUSTICA Project at IRCAM (Blanchette 2004), the ongoing work of the Electronic Music Foundation (Chadabe 2001) and the extensive International Documentation of Electroacoustic Music (Hein 2006). One may also wish to look at the work of Li (2007), whose team is investigating the reconstruction of audio waveforms from high-resolution photo-microscopy of historic stereophonic recordings.

But the more general issue of the preservation of digital artefacts poses very serious issues for us all. As UCLA Information Studies researcher Jean-François Blanchette states on his research web pages:

> Cultural industries are today massively turning to digital media as the primary medium for the production and distribution of their products, either through digitization of cultural artifacts, creation of new forms of cultural expressions (e.g., videogames), or reliance on digital tools in the creation process itself (film production). Yet, there are today no known solutions to the problem of preserving over time complex digital objects. (Blanchette 2007)

Ultimately a general solution to digital media preservation must come from experts in the field of informatics such as Blanchette. What *is* certain is that the complexities of long-term preservation and restoration of electroacoustic music far exceed the capacity and skills of composers and performance system developers such as myself.

My interest in the problems of restoration and preservation is much more personal: what are the mechanisms beyond the archiving of the notated score and the audio recording that could enable future performances of my interactive pieces? One answer may come from Wetzel (2006), who has proposed a generalised approach to the formal description of data lists, events and processes. Though Wetzel is primarily concerned with sustaining his own performance repertoire, his research is intended to extend to a broad variety of interactive, real-time pieces and may prove to be an important contribution. Of course I am very grateful to him that he has included *Preascio-IV* in these efforts and look forward to future performances of my piece using his general solution. Another effort for which I am equally grateful is the adaptation of *Praescio-VII* by pianist Chrissy Nanou, at the Center for Computer Research in Music and Acoustics, Stanford University, who has also constructed her own personal performance system for my piece in Max/MSP. Both Wetzel and Nanou have performed these works without my presence or intervention, offering a ray of hope that at least some of the real-time pieces might persist.

8. CLOSING COMMENTS

Perhaps installation artists have the right idea; they create a production for a specific site, run the show and create a thoroughly documented permanent record of the event. Thus the expectation of repeat performances is minimised or even eliminated. But this is not how the majority of composers and musicians understand their art form; we become musicians through the performance of notated works that have remained more or less intact since they were composed and have been played by many performers before us. As composers, we expect other performers to repeat our works anticipating future performances by unknown performers through the traditional modes of music publishing and word of mouth dissemination. For electroacoustic music to comfortably and permanently integrate into the traditional flow of chamber music composers may have to adopt very simple and robust technology platforms, and at the same time performers will need to acquire some basic technical know-how.

I have tried to show that for the most part the knobs for my pieces and for many other interactive compositions by my colleagues simply do not work any more. While I have no special insight into whether or not my interactive works will be restored, reconstructed or even preserved in some archival format, I can state that more than fifteen years of designing and composing real-time interactive pieces was, for me, creatively exciting and intellectually fulfilling. But for all the complex and difficult reasons described in this paper and until such time as I acquire or devise a more durable approach to interactive compositions, I am currently focusing on acoustic and fixed-media works that have fewer knobs to turn.

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