Ecoacoustic and shamanic technologies for multimedia composition and performance

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The author's close connection to traditional Alaskan culture has inspired the creation and implementation of new multimedia instruments based on the use of ritual objects in shamanic cultures of the far north. Simultaneously, the musical processes articulated by this music are structurally tied to environmental systems in a technique discussed here as 'ecoacoustics'. In this work, performer/composer interaction, musical composition theory, multimedia performance, and musical instrument design have been transformed in response to these influences.

1. OVERVIEW

In the recent multimedia performance artworks discussed here, formal and informal Alaskan anthropological and ecological research has been merged with my ongoing work in computer music and composition. The large-scale multimedia artworks *Ukiuq Tulugaq (Winter Raven)* (2001) and *Kuik* (2004–2006, in progress) involve the integration of specially designed computer interfaces based on traditional shamanic objects into an ecoacoustic compositional process. The specially made techno-shamanic interfaces are used to evoke the mythic powers of traditional rituals and their close connection to environmental forms. An attempt is made to create a new kind of staged musical work informed by traditional Alaskan performance art. Technology serves as a bridge between physical and virtual movement and sound, exploring a contemporary manifestation of a non-Western-European art form in which culture and nature are closely linked.

These new pieces were created in the context of a composer working primarily for the concert stage in a tradition of experimental, technology informed music borrowing heavily from the structures, procedures and instruments of the Western-European classical tradition. In the Western-European musical tradition there is a precedent for appropriating non-Western musical materials to reinvigorate its own forms. For this reason, it is worth noting that rather than borrowing from Alaskan music, in this work the compositional process and performance modalities themselves have been transformed in terms of a shifting artistic approach influenced by natural systems and sounds. As opposed to a Western-European music borrowing from Alaskan culture, I view this music rather as Alaskan music using a Western-European framework.

Central to the discussion is the group of pieces making up *Ukiuq Tulugaq* or *Winter Raven*, an evening-length multimedia work for instrumental ensembles, surround computer sound, multiple video projections, dance and movement art, and dramatic staging. Earlier compositions are considered as formative to the techniques employed in this large-scale piece, and more recent pieces and works in progress are discussed as building on techniques implemented in *Winter Raven.*

2. INTRODUCTION: THE SYMBIOSIS OF TECHNOLOGY AND ENVIRONMENTALISM

The complex relationship between the persistence of natural systems and human technological development deserves a special mention in a paper devoted specifically to forming a close connection between the two. Western social conditioning often posits opposing stereotypes of the 'environmentalist' and the 'technocrat', the two inhabiting mutually exclusive contexts. In Western culture, political conditioning also gives us opposing stereotypes of the 'developer' for whom nature stands in the way of progress, and the 'conservationist' who views technological development as an oppressively encroaching force. These over-generalisations are complex and not invalid, the result of generations of Western culture's relationship to its natural surroundings. While prevalent, these stereotypes are also not by any means universal. We find, for example, groups of eco-friendly technocrats or techno-paranoid anti-environmentalists.

Non-Western-European cultures, by contrast, can have strikingly different relationships to the interplay of human technological development and the natural environment. In extreme environments such as the far north, the necessity of seeking a symbiosis between technology and environmentalism is more pronounced. After being born into and living many years in such environments, I observed another kind of relationship particularly evolving from the collision of Western technology and an indigenous approach to the environment. Such a symbiosis can be illustrated

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through the development of any number of tools that allow people to exist in harsh environments.

3. BACKGROUND/FOREGROUND: MULTIMEDIA IN ALASKAN SHAMANIC CULTURE, AND SHAMANISM IN MULTIMEDIA TECHNO-CULTURE

Over thousands of years, the indigenous cultures of Alaska have cultivated a strong tradition of multimedia performance including dance, music, drumming, masks, costumes, story telling, and more. In practice, long before any encounter with European and Russian explorers, this unique art form was highly tied to an ecological awareness shared in the culture, relying on a calendar of seasonal subsistence living. The design principles for the new instruments discussed here draw on a perceived mutability of physical objects in traditional shamanic cultures. The mythology of Alaska, for example, reveals fluidity between the human, animal, natural and spiritual worlds. The shaman negotiates the relationships between these worlds by means of carefully orchestrated rituals. At the centre of these rituals, characteristic objects such as masks and other adornment actuate the ceremonial joining between the metaphysical and physical worlds.

3.1. Description of the traditional Alaskan multimedia artwork

The ceremonial performance tradition of the Inuit people of Alaska was an elaborate theatre (Kaplan 1982). As the primary interpreter of the spirit world, the shaman would prepare the people by guiding them through a variety of ceremonies. Through these activities the cosmological views of the people were expressed. The creation of special masks was an important part of this ceremonial preparation. The Inuit tradition of mask building and the presentation of these masks in a multimedia artwork involving music, dance, story and art can only be understood in the context of the subsistence culture that gives rise to the art. The celebration season during which these multimedia events were performed comes within an annual cycle, scripted by nature, and including a subsistence season lasting from approximately February until September (see figure 1).

As the long harvest season ends the people prepare for the ceremonial season, a time of spiritual reflection and renewal. The shaman was often inferior in traditional hunting skills but his or her strength came rather from his/her coupling with a *Tuunrat*, a supernatural helper visible only to the shaman. Indeed, the word for shaman, *angalkuq*, means 'the one who can see'. The Tuunrat is the personification of various natural forces or objects, or the spirits of animals. In masks carved by shaman, the Tuunrat was often depicted as a contorted human face.

Figure 1. The Inuit harvest festival was an elaborate multimedia theatre supported by dance, drumming, music, story telling, masks and costumes. In this image, taken by Alfred Milotte in 1946, a pair of masked dancers representing walruses and another elaborately costumed dancer perform with drums on a stage. In the foreground, the audience sits, facing the stage (from Alaska State Museum, Juneau, neg. no. 1103).

3.2. Techno-shamanism in art

The rich possibilities of integrating new technology with principles derived from traditional shamanic practices has been addressed by artists such as Lawrence Paul Yuxweluptun in the *Inherent Rights, Vision Rights* installation (Yuxweluptun 1996), and Diana Domingues' *TRANS-E, My body, My blood* installation, among others (Domingues 1999). These pieces reveal a tradition of merging biological and virtual reality as a means of exploring the relationship between body and spirit. Yuxweluptun's installation places the audience within a smokehouse ritual, and Domingues' work points to a post-biological world where electronic rituals engulf bodies into a space mitigating the transcendental physical and the embodied virtual. This post-biological artistic vision is set in relation to the shaman's 'supra-biological' metaphysical state; the most apparent difference between the two is the mediating force of computer technology.

Like visual art, music has experienced similar embodiment trends in recent years. Physical modelling sound synthesis and human computer interaction have

developed to the point where highly sensitive interfaces can control equally responsive synthesis algorithms in real time (Burtner and Serafin 2002, Cook 2001). Using computer controllers and sound synthesis facilitates a fusion between the embodiment of a performer on the physical stage and a disembodied counterpoint of forms in the virtual stage. Abetting the exchange between virtual and physical systems, advances in sonification allow for the analysis and remapping of complex data systems from one medium to another (Kramer *et al.* 2004). This has opened the possibility for new structural forms derived from natural systems.

4. DEVELOPING A TECHNO-SHAMAN MUSICAL CONTEXT

The theory of liminality, proposed by anthropologist Victor Turner (1974) refers to an ambiguity arising from everyday tasks being reinterpreted as symbolic activities. The transformation from common activity into ritual activity is paramount to an understanding of shamanism. Ethnographically, rituals are described as 'the collectively patterned performance forms through which processes of cultural or sacred signification are integrated into consciousness and social practices' (Tomaselli 1996: 50). Liminality describes this passing from common reality, into a symbolic understanding that enacts a change in an individual's personal relationship with herself/himself and with society. The symbolisation of common reality through orchestrated ritual creates the sense of transcendence experienced by the participants.

Shamanic traditions in Alaska employ the use of special objects to manifest spiritual understanding. Face and hand masks, staffs or clothing can act as the symbolic axis around which liminal transformation occurs. In the case of human-computer interaction (HCI), any common object can act as a computer controller. The mouse and keyboard are two simple HCI interfaces, but the type of data communicated between the human and computer can be housed in a variety of instruments. This aspect of HCI, called 'modulated object theory', has been discussed in Burtner (2004).

My research into traditional Alaskan culture has inspired multimedia works that take advantage of expressive interfaces to construct virtual reality worlds evoking the transformative rituals of shamanic exploration. The controllers themselves create a real-time interface between the artist and the media, analogous to the shamanic ritual object's interface with the spiritual world. Here technology is used as a means of representing the magic observed in mythology. *Taruyamaarutet* is a formative example of this approach, defining certain characteristics. The masks and staff in *Ukiuq Tulugaq* and Kala Alak's Shaman Hands of *Kuik* are then examined as applications of the liminal technology.

4.1. *Taruyamaarutet (Twisted Faces in Wood)* (1995)

Taruyamaarutet for voice, bass clarinet, marimba, percussion, computer, dancer and projected images was my first attempt to incorporate shamanic Alaskan ritual into a musical context. This piece focuses on a special kind of 'twisted face' mask sometimes called 'Taruyamaarutet'. I first came into contact with the Yupik twisted-face masks in Unalakleet, Alaska. Further research on the masks drew on the seminal work by Ann Fienup-Riordan (1996), and the extensive mask collection of the Anchorage Museum of Art.

In collaboration with actress and movement artist, Melanie Anastasia Brown, dance, lighting and projected images of the masks were combined with music on the concert stage to create a multimedia spectacle. In *Taruyamaarutet*, the instrumentalists and computer share the stage with the movement artist and are integrated into the theatrical context. The vocal part in particular, sung by Haleh Abghari, pairs with the dramatic movement of the dancer. Brown's choreography emphasises the vocal part allowing it to affect her movement.

The projected images change slowly, creating a shifting staged context for the more active dance. While the singer connects with the dance, the computer is closely related to the projected images. The computer part, performed live and conducted like the other instruments, uses my polyrhythmicon computer hyper-instrument to articulate the formal structural unity of the composition (Burtner 1997). Twisting polymetric systems, underlying the highly rhythmic texture, are used as an analogy to the mask images.

Taruyamaaarutet exhibits an approach to mixed-media composition that has served as a model for the works discussed below. In terms of technology, the integration of the computer into the ensemble, and its close connection to the media, suggested a deeper interactive relationship between the mixed media. *Ukiuk Tulugaq (Winter Raven)* introduced the notion of ecoacoustics and increased the level of interactivity between the computer, dance and video.

4.2. *Ukiuq Tulugaq (Winter Raven)* (2001)

Ukiuq Tulugaq (Winter Raven) is a large-scale multimedia work for instrumental ensemble, surround sound electronics, interactive video, dance and theatre. The piece draws on an Inupiaq myth in which the world is created by Raven from snow. As the story is told, in the beginning of the world only Raven existed flying through the darkness of space in the falling snow. As the snow gathered and fell from Raven's wings, some of it clumped together into a small snowball. Raven threw the snowball into space and it gathered more snow until it was large enough to stand on.

Winter Raven (Ukiuq Tulugaq) metaphorically connects this story with the ecological seasonal approach of winter. Snow was present originally along with Raven, and so winter is taken as a symbol for renewal and genesis.

The dramatic form of *Winter Raven* is a change from fall into winter. This linear structure is filled with nonlinear narratives, as if stories or dreams are experienced along the way. The movements use widely divergent media. Each of the three acts explores a different ontological state based on the juxtaposition of time in relation to the seasonal change. At the first performance of *Winter Raven* at the University of Virginia on 18 March 2003, the programme described the plot of the piece in this way:

> Act I takes place before winter. It is fall. The family is preparing wood, leaves are falling, and there is abundant sunlight.
>
> Act II presents the psychological transformation into winter. It is the most dramatic section of the piece, in which the stark northern landscape represented by *Kunikluk* becomes a backdrop for the juxtaposition of the spirit/flesh and the industry/voice in the *Speaking Flesh* and *Industrial Garden*/*Lost Voices* movements. The coming of ice and the freezing of everything break industry suddenly.
>
> In Act III it snows. The wind blows, leaving impressions on the snow. The light changes and shadows emerge. The animals seek shelter, their fading prints creating another type of pattern on the snow. While the act is predominantly about moving forward into a still place of winter, it also revolves around the notion of memory and cyclical processes in general. The focus on wind itself is a memory of Act I, and Raven appears, invoking the memory of the family preparing wood for the winter. We are reminded of the continuation and cohabitation of humanity and nature. While the music is still and cold at the end it is pregnant with the possibility of rebirth and resurrection; ideas that give hope for the future.

Each of the three acts contain an ecoacoustic chamber ensemble piece with video (discussed in the next section and excerpted on the *Organised Sound* **10**(3) CD as *AV4-Tingnivik, AV5-Kunikluk* and *AV6-Snowprints*), and an unipkaaq 'story' involving music, dance/movement art, interactive video, and a specially constructed mask (excerpted on the *Organised Sound* CD as *AV1-Siknik, AV2-Siku* and *AV3-Anugi*). There is another type of movement in each act, more loosely defined in terms of media, involving some aspect of the human voice or body such as a wood cutter humming, a human body played as a percussion instrument, layers of spoken texts and construction, and the final *Ukiuq Tulugaq* movement in which Raven appears. At the end of the piece when Raven appears, his arrival is articulated by three representations; the 'Voice of Raven' played by an electric violin triggering raven audio samples, the 'Memory of Raven' invoked by the masked dancer using an FM radio transceiver, and the 'Spirit of Raven' sung by the soprano voice.

In *Ukiuq Tulugaq*, a dancer portraying the Shaman character personifies the natural forces of sun, ice and wind. A desire to evoke the shamanic relationship between human and nature on the stage inspired the creation of the masks and a shaman staff. The shaman staff allows the dancer to capture the detailed changing movement of the masks she wears. A computer receives and processes the video signal, projecting it onto a stage screen. Video tracking technology is used as an analogy of the shaman's ability to effect reality by entering a dream-like spirit world.

Figure 2 shows the performance setup for the shaman masks and staff; figure 3 shows the different masks used. Affixed to the top of the wooden staff formed from interwoven dried vines are a light and a wireless camera. The dancer holds the staff and performs a 'mask video choreography', moving the camera and mask to change the image. The signal is received and processed by a computer. The processed image is then projected onto a screen behind the performer. Signal processing of the wireless video feed is accomplished by a combination of automation and interaction from the staff itself.

Aniseh Khan Burtner created the video choreography. In talking about how she created the choreographic movements, she said:

> Each of the masks signified an element or a spirit, and what I tried to do in the choreography is channel that element or spirit. The Sun movement was flowing, round and warm in the dance; and Ice was the opposite – slow, cold, frigid and tight movements. The last one was Wind and it used grand and quick movements. The choreography was very organic.
>
> I saw the masks before I heard the music, so at first the movement was inspired by the masks. Then it changed because it was the music I was actually dancing with, and putting on the masks intensified it. The video wasn't a large part of the choreography because it was behind me in rehearsals and performance. During the Speaking Flesh movement I was watching the video during the performance, and I was lost in it. It was very profound to watch those faces and hear my body as the music. (Khan-Burtner 2004)

The movements were mapped into software by processing the incoming signal and modulating it with other video. In *Siknik Unipkaak* (Sun), a video of sparkling light gives a changing sheen to the colourised and blurred input signal. In *Siku Unipkaak* (Ice), an accumulating fractal algorithm of the processed input signal gradually spreads from the centre of the screen outwards, as if crystals are being generated throughout the piece. Finally, in *Anugi Unipkaak* (Wind), the screen is split, one side is a turbulent shifting grey texture and the other side gives space for the mask to be seen moving in and out of the turbulence. Figure 4

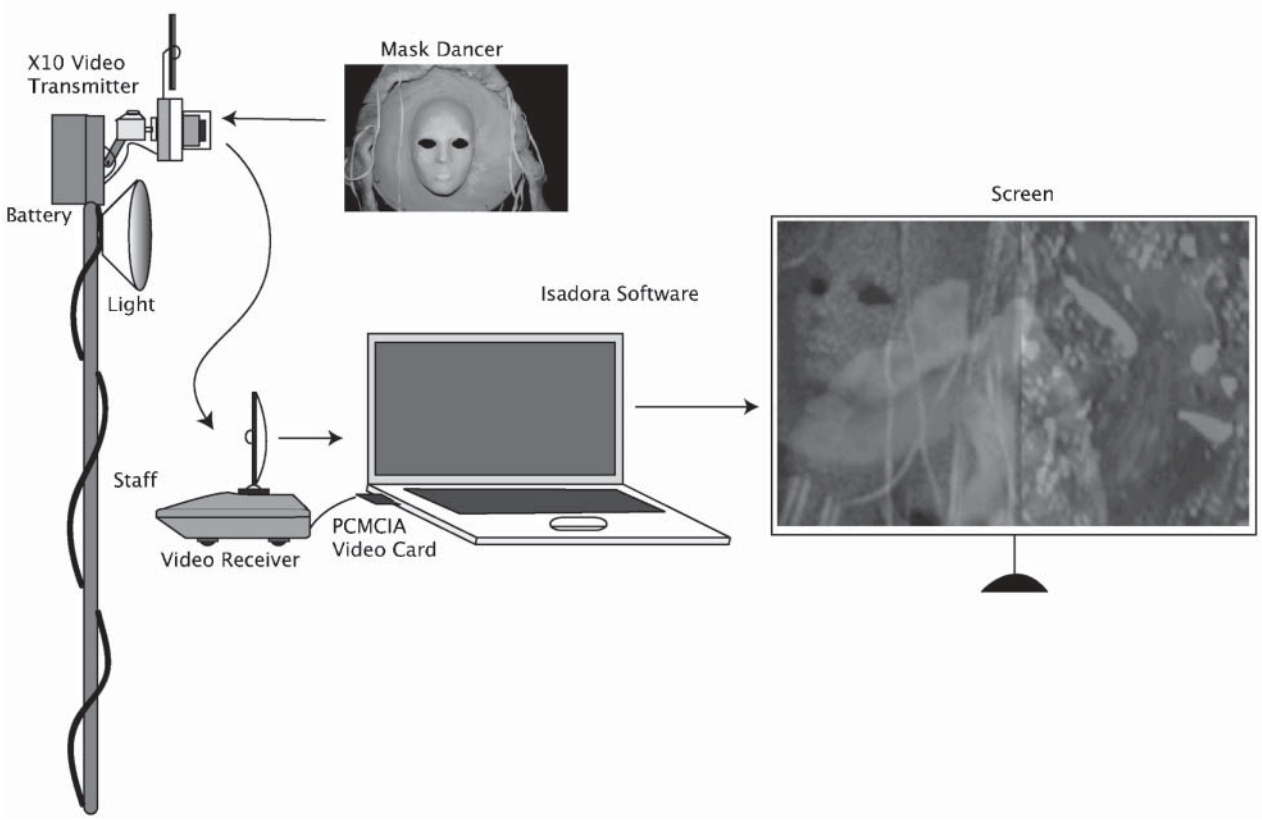

Figure 2. Diagram of the shaman mask / shaman staff concert setup for interactive video.

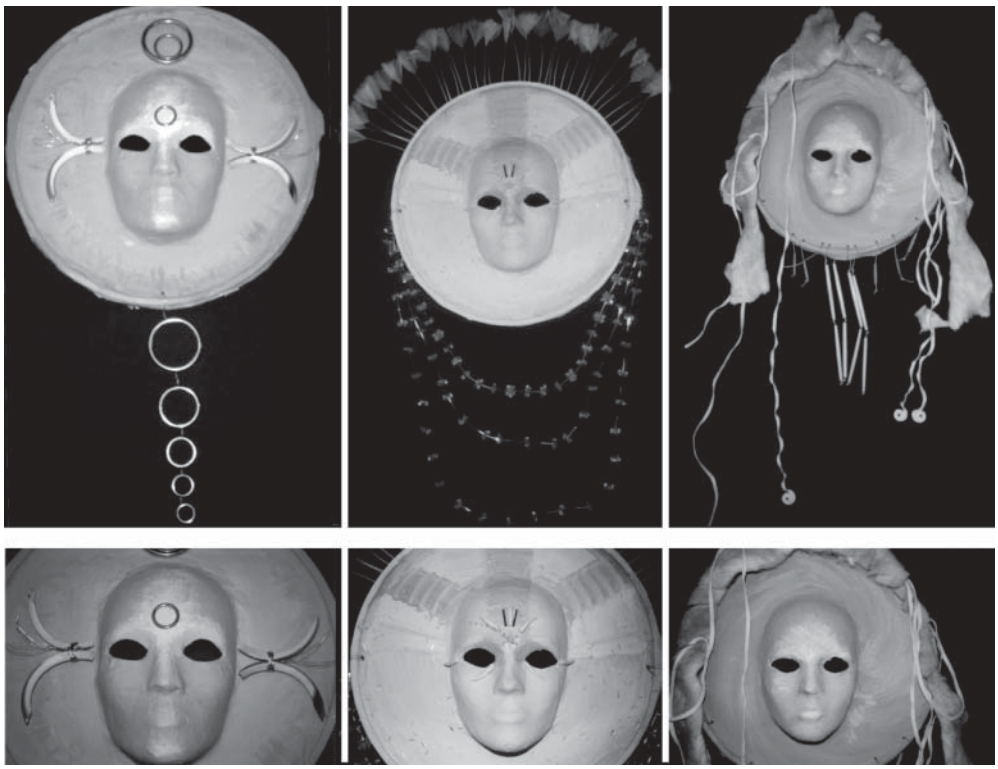

Figure 3. Each shaman mask is supported by its own choreography, music and video processing (Aniseh Khan Burtner created the video choreography).

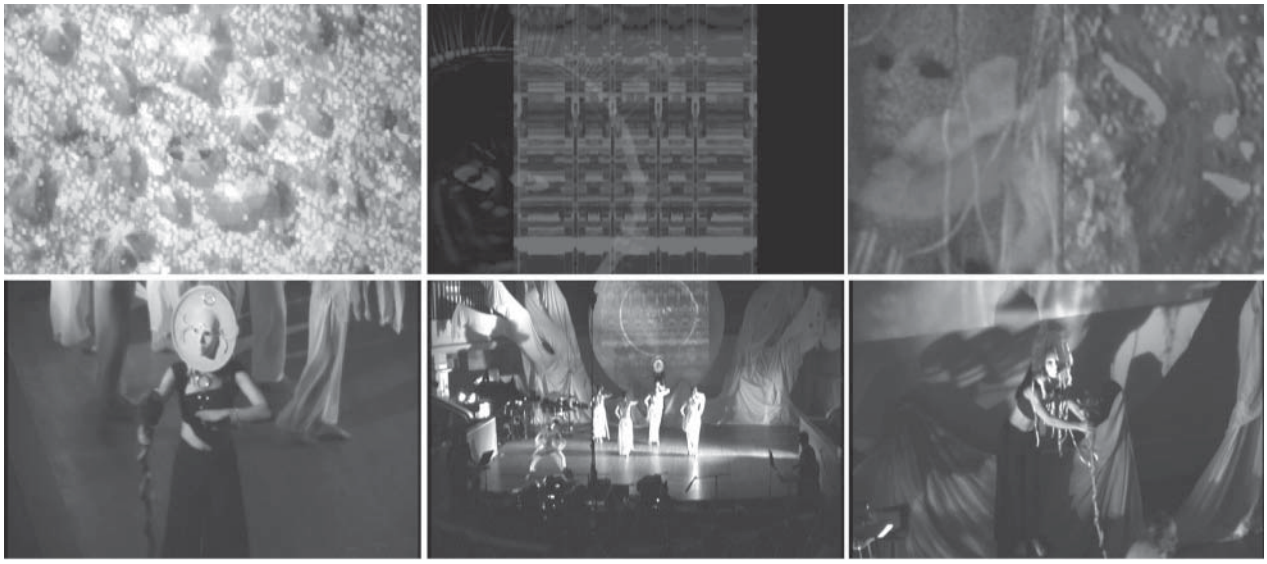

Figure 4. Each column above shows the processed video (above) and mask dancer (below). The rows from left to right show: Sun (*Siknik Unipkaaq*), Ice (*Siku Unipkaaq*) and Wind (*Anugi Unipkaaq*).

shows each of the three video choreography movements. The top of each column is a still from the resulting video and the bottom shows the corresponding staged movement of the dancer. The first three audio-video excerpts on the *Organised Sound* CD, *AV1-Siknik*, *AV2-Siku* and *AV3-Anugi*, show examples from each of the staged movements. The video shows the staged action with interactive video projected on the screen behind the dancers. Aniseh Khan created the video choreography and Sage Blaska created the dance choreography for this production. The footage is from a live performance on 18 March 2003 in Old Cabell Hall at the University of Virginia.

In *Siku Unipkaaq*, the dancer's mask image is colourised by removing all the reds and greens. It is then slightly blurred with a Gaussian algorithm, and filtered to allow only the changed pixels to pass through. The mask appears brighter if it is moving faster, and dimmer if it is still. A movie of ice is layered with the live mask. This image is first colourised by enhancing the blues and removing reds, then played back in a manner that continuously scrolls a single line of the source video horizontally outwards from the centre to the edges. The result is a continuously expanding blue and green lattice texture, changing organically but forming a crystal-like structure (figure 4, centre; audio-video excerpt 2, *AV2-Siku*).

For *Anugi Unipkaaq*, the dancer's input video is processed by taking the preceding two frames of video and retaining randomly selected pixels. This signal is then sent through a Gaussian blur to the output mixer. The source video is repositioned on the right side of the screen partially obscuring the mask when it moves into the same side of the screen (figure 4, right; audio-video excerpt 3, *AV3-Anugi*). *Siknik Unipkaaq* uses two independent streams of sunlight on water, combining the first with the live mask input and layering this mix into the second. The videos are colourised and blurred differently to create an effect of warmth (figure 4, left; audio-video excerpt 1, *AV1-Siknik*).

Although simple, the wireless video staff and mask choreography of *Winter Raven* were successful in establishing an interactive media context. Encouraged by the results, I began developing more sophisticated instruments that could give greater control to the dancer. *Kuik* is a multimedia opera based on the flow of water from mountain glaciers to the ocean in Western Alaska. A Dena'ina legend about the flow of this water forms the basis of a libretto made up of place names along the Kvichak river system. The natural process of transformation observed in the flow of water creates the form of the piece, and the diverse cultures that have made their home along the river contribute stories and mythologies about the water. The work involves anthropological and ecological field research in an attempt to communicate through music the harmony between environment and culture expressed in native Alaskan cultures.

This idea creates a setting for the multimedia composition using new technologies to communicate the magic expressed in the mythology of the culture. In *Kuik*, new interfaces allow theatrical gesture of the characters to control sound synthesis and video processing. The first of these instruments to be completed were the 'shaman hands', worn by the Kala Alak character. Like the shaman staff and masks, these hands are theatrical costume objects designed to function as technological instruments.

Figure 5. Three of the many glove controllers in use: Reality Quest N64 NGlove (left), P5 3D Virtual Glove (centre), and the 5DT Data Glove (right).

4.3. Shaman hands of the *Kala Alak* character from *Kuik* (2004)

Hand-based costume objects are commonly used in traditional Alaskan dance forms. From the women's 'dance fans' to the giant shaman hands, the accentuation of hand movements contributes to the unique choreographic forms of these performances.

In the field of human-computer-interaction (HCI), interfaces that extend the human hands are prevalent. Michel Waisvisz's *Hands*, Laetitia Sonoma and Bert Bonger's *Lady Glove*, Butch Rovan's *SoundGlove*, the Reality Quest N64 NGlove (figure 5, left), the P5 3D Virtual Glove (figure 5, right), and the DT Data Glove (figure 5, centre) are just a few of the many 'glove' controllers in use.

The shaman hands controller is based on my contact with a pair of wooden hands in southwest Alaska. These particular hands, in use approximately 100 years ago, are heavy, dramatically oversized, and visually striking (figure 6). The stories of hands with magical properties, including healing and travelling powers, inspired me to use them as a model for a multimedia controller interface.

The shaman hands differ from other hand-based computer interfaces in that they make no attempt to be ergonomic. On the contrary, they are unwieldy and heavy objects. Physically, these hands are designed for broad rather than subtle movements. They imply large-scale theatrics. The size of the hands influences the approach to audiovisual mapping in several ways. Micro-level control mappings are not idiomatic for these hands in the way they are for many hand-based controllers. These hands would not be idiomatically employed as a video game controller, for example. Rather, the use of broadly articulated gestures suggests macro-level control mapping strategies. As a result, the performer works with individual contrapuntal layers of rich material, controlling broad relational interdependencies. Subtle gestures are also mapped to signal processors, but because small movements are difficult to reproduce with the instrument, such movements are relegated to reactive fluctuations within larger interactive contexts. Spatial audio processing mappings are idiomatic since the shaman hands visibly traverse large areas.

Figure 6. Picture of a Togiak shaman (*ca* 1906) in Bristol Bay, Alaska, showing the hands sheltering a sick boy (photo by John E. Thwaites, Alaska State Library/Thwaites Collection/PCA-18-497).

Following traditional principles of ritual object design, special wood was gathered to construct the shaman hands. This involved carefully choosing materials based on symbolic meaning as well as functionality. The use of 100-year-old Bristol Bay cannery salt-fish barrels was intended to draw focus to the complex socio-political history of the fishing industry

Figure 7. Outside view of completed shaman hands. The white dots are fingerprints as seen on the original hands.

on the Kvichak River, and its relationship to the salmon that traverse the river each year. Three fitted slats of a barrel were used for each hand. The slats were attached together with leather strips and wood glue. Following the pattern from the photographs, the boards were then cut into the shape of the hands, sanded and the wood treated. This process yielded a thin curved hand shape (see figure 7). Leather arm straps and handles on the back of the hands allow the dancer to strap the hands to her arms. Despite their weight and size, the hands feel surprisingly freeing due to the dramatic exaggeration of arm movements they provide (see figure 8).

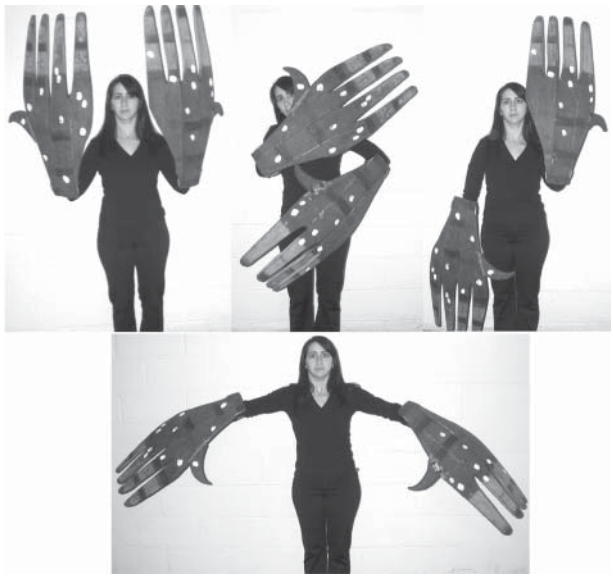

Figure 8. Several distinct shaman hands movements.

The controller is designed to capture touch, turn and bend information from the performer (see figure 8). Two Memsic 2125 dual-axis accelerometer chips, mounted on small circuit boards, are embedded in the hands. The accelerometers measure movement in two dimensions independently for each hand. Earlier work in tilt sensing used an Analog Devices ADXL 202-series accelerometer employing a mass and spring technique to sense tilt (Burtner 2002). By contrast, the Memsic 2125 senses tilt by heating a pocket of air that passes by thermopiles and is detected as it moves inside the sensor (Williams 2002).

Bend sensors attached to the wrists of the hands measure the elbow joint movement of the dancer. The bend sensors are connected through an RC circuit design to convert analogue voltages to digital signals from each pin. Force sensing resistors on the fingers provide the hands with a sense of touch. The shaman hands software runs on a Parallax BIISX microprocessor converting the signal to a MIDI message (figure 9).

5. ECOACOUSTIC AND IMMERSIVE AUDIO ENVIRONMENTS

Ecoacoustics is the name used here for an approach deriving musical procedures from abstracted environmental processes, remapping data from the ecological into the musical domain. In the most general sense, ecoacoustics is a type of environmentalism in sound, an attempt to develop a greater understanding of the natural world through close perception. In the field of composition, this takes the form of musical procedures and materials that either directly or indirectly draw on environmental systems to structure music.

The data from nature may be audio information from wind or ocean waves, for example, but it may equally be some other parameter such as temperature, geological change, etc. Ecoacoustics draws heavily from the related areas of soundscape composition (Truax 1978/99, 1994; Westerkamp 2002) and sonification (Kramer *et. al.* 2004). It embraces the sonification of ecological models, a technique well articulated by Damian Keller as acoustic ecology (Keller 1999, 2000).

The approach I took to ecoacoustics in these pieces began as procedurally causal such that data is mapped simply and directly. The point was first to achieve a perceivable sonic representation of the environmental system. The limitations of such sonification mapping strategies in music are clear. Mapping temperature changes to frequency changes, for example, is an arbitrary assignment that disregards the inherent perceptual differences between the senses. As a result, it could be said that such mappings *fail* because the listener does not perceive the original data construct through a new medium in the same way. This failure, however,

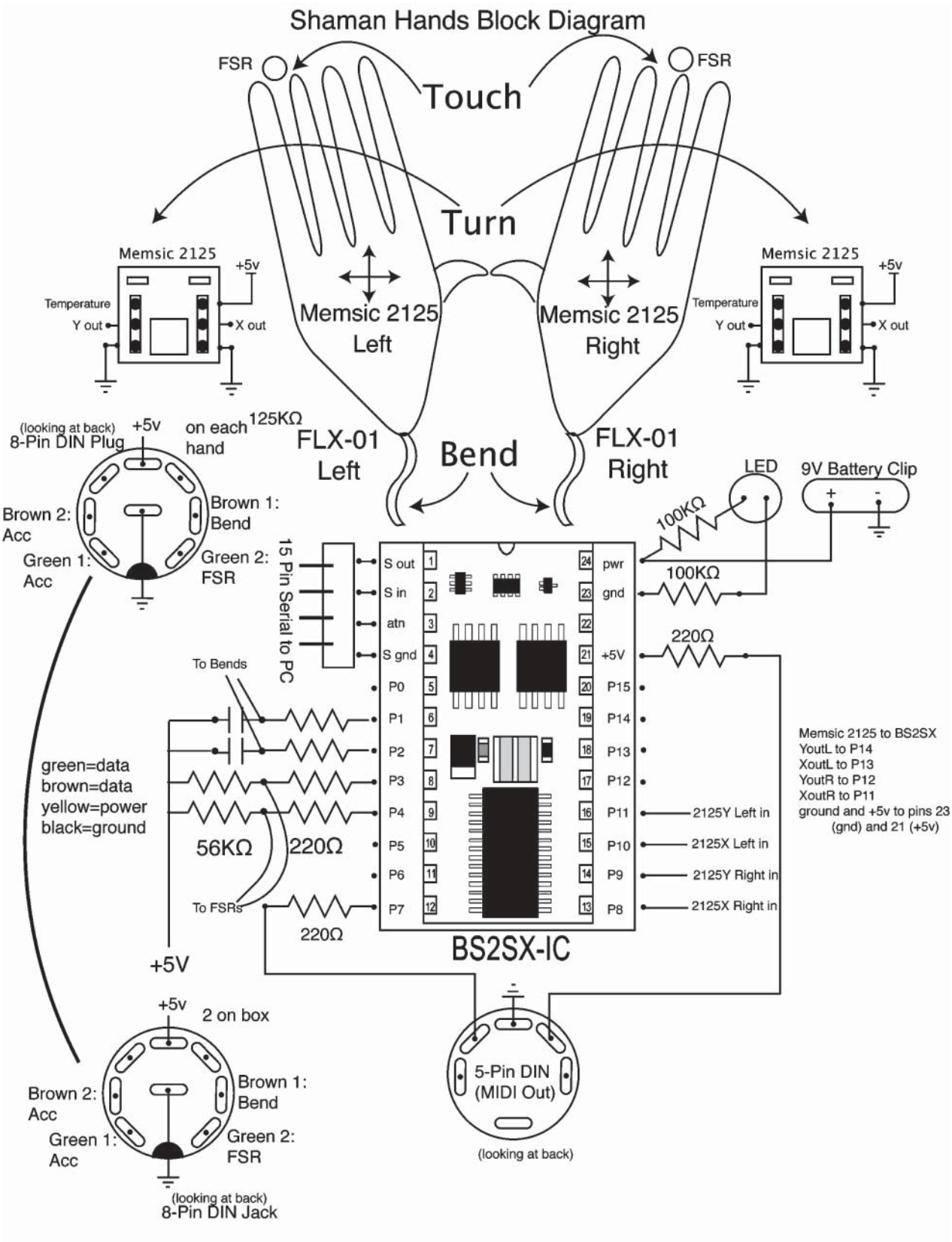

Figure 9. Shaman hands block diagram showing sensor placement on hands.

is precisely what makes this process compelling. In this sense, the sonification is seen as a compositional *distortion*, rather than a failure. Composing with sonification is thus a process of controlling the degree of distortion, mapping it in a way that maintains characteristics of the source data while simultaneously functioning as compelling music.

5.1. Sonification strategies in chamber music

Sonification of environmental systems has proven successful in forming a close link between the natural world and musical structure. Giacinto Scelsi (1905–1988) devised a new kind of harmonic language, now commonly called spectralism, by building musical structures on the natural overtone series. His compositions, written for acoustic instruments, opened up the rich world of timbre as a harmonic language for musical formal exploration. By employing signal analysis technology, composers such as Gerard Grisey (1946–1998) and Jonathan Harvey (b. 1939) were able to extend the specificity of the spectral structures by drawing on a more finely varied array of harmonic differentiations and transformations (Bundler 1996; Harvey 1999). Other composers such as Iannis Xenakis (1922–2001) utilised complex sonification strategies to map physical behaviours of natural, often chaotic phenomena into instrumental music (Xenakis 1992). Real-time tracking and computing methods have allowed composers to design systems in which the computer directly interacts with the environment. Sound installations such as Garth Paine's *Reeds* for lily pond, or Judith Shatin's *Tree Music* are two fine examples of a number of real-time sonification works (Paine 2004; Shatin and Topper 2004).

My own chamber music regularly makes use of ecoacoustic structures to organise large-scale form. Patterns from wind, tides, waves, seasonal transformation, melting ice, snow, etc. are common musical resources for my chamber music. The chamber music and video movements of *Winter Raven – Tingnivik*, *Kunikluk* and *Snowprints* develop a number of ecoacoustic structural techniques. In these pieces, the music is not meant to be heard as overtly *environmental*. Rather, its structure is infused with environmental modalities of time and texture. It is intended to communicate to the listener through shared experiences of natural systems. Like the changes in environmental systems, such as temperature, light, air pressure, etc., this music changes slowly and does not necessarily fit into predictable musical forms. The pieces attempt to capture the experiential rituals of environmental natural processes, imbuing the music with a sense of engagement we experience when coming into contact with natural systems. Three audio-visual excerpts on the *Organised Sound* CD, *AV4-Tingnivik*, *AV5-Kunikluk and AV6-Snowprints*, correspond to these three movements.

Tingnivik for viola, alto saxophone, piano, noise generators and video, from the first act of *Winter Raven*, maps the shifting of daylight and temperature as the season of fall approaches into the musical material. The title is an Inupiaq word meaning 'the time of leaves falling and birds flying'. In this way, the piece explores the ecological changes of 'fall' as an acoustical system. Each instrument is assigned a specific parameter of the environmental system. The evolution of each of these components generates the development of the instrumental lines. Like experiencing an environment, the musical macro timbre is the result of the summation of these parameters. The viola represents temperature, the saxophone, light, the piano is wind, and the noise generators move throughout the hall, creating a context in which the piece sounds. The sampled environment tracks changes over mid-day into evening, extrapolating this into an acoustical representation of the coming of fall.

A page from the score of *Tingnivik* shows the viola's rising glissando as a result of the environment cooling (figure 10). The saxophone's changing multiphonics represents the intermittent light through the trees, and the piano is bowed, fluctuating like the wind. Three or more additional performers carry wireless noise generators, and move about the audience creating an environmental context through filtered noise.

Figure 11 shows three still images from the video of *Tingnivik.* The video underscores the musical process by changing from warm browns and yellows to cooler blues, by transforming from images of leafy to leafless trees. The video becomes increasingly windy and distant, evoking the onset of winter. The audio-video excerpt *AV4-Tingnivik* on the *Organised Sound* CD corresponds with the above music.

In *Kunikluk* for ensemble, computer noise generator and video, the accompanying image of a horizon line slightly obscured by blowing snow or ice ('kunikluk' in Inupiaq) creates a real-time still life within which the dramatic music sounds. At one point in the video a raven flies across the field of vision but other than that moment, the video appears as if it is a still image. This poised stillness of the flat, permafrost-covered arctic landscape contrasts with the extreme annual fluctuation of temperature and light. *Kunikluk* explores this ecological texture as a musical system. Audio-video excerpt five, *AV5-Kunikluk*, corresponds to the score excerpt in figure 12.

The computer noise part, created in Common Lisp Music, uses a type of granular noise generator that allows the density of randomly generated components to be controlled along with their distribution in a band-limited field. The result is a quiet granular noise sound, analogous to the granular ice mists visible in the arctic landscape.

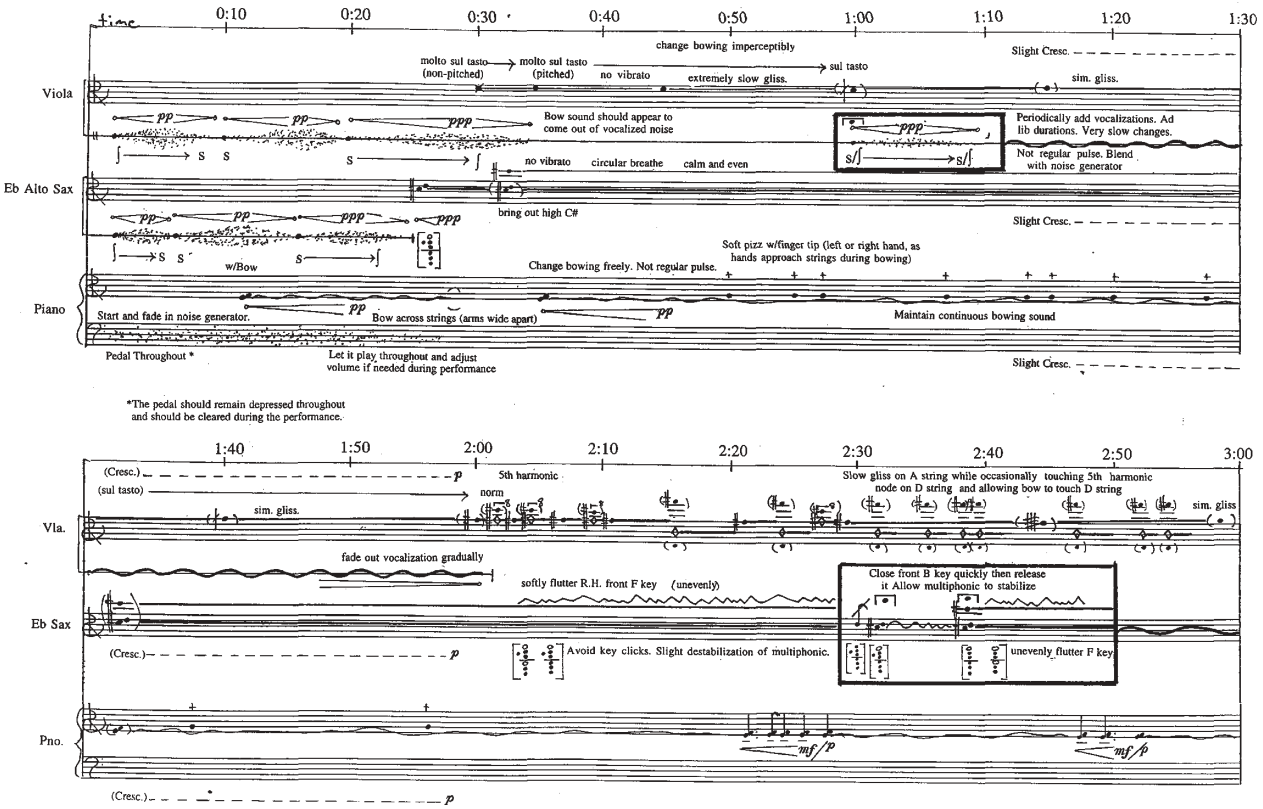

Figure 10. Score excerpt from *Tingnivik.*

Figure 11. Video stills from *Tingnivik.*

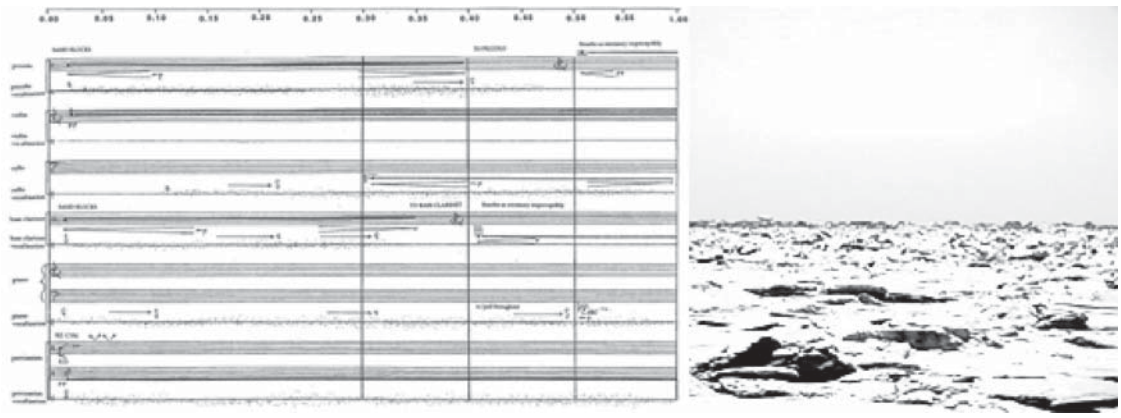

Figure 12. Score and video still excerpt from *Kunikluk*.

Snowprints for flute, cello, piano, electronics and video explores snow both metaphorically and sonically. In this piece, a recorded walk in the snow above Anchorage, Alaska, serves as a departure for a composition utilising a wide array of snow sounds and snow forms. Photographs of snow formations correspond to audio recordings of snow sounds and the layering of these 'print' images and sounds created the musical structure. In snow, prints of bodies are captured and transformed by wind and changing temperature. The wind leaves impressions in the form of drifts; changing light creates shadow prints on its surface; and animals leave their own fading tracks (figure 13).

Many types of movement in different kinds of snow were recorded. The sounds were then mixed directly into the electronic part, combined with three 'digital prints' of the acoustic trio. The digital prints were created from a scanned synthesis string, a physical model of a flute, and granular synthesis piano. The orchestration of the composition is thus an acoustic trio of flute, cello and piano; and a digital trio of virtual flute, cello and piano. The noisy sounds of the snow bind the sonic world, creating a background environment for the instrumental/digital prints.

In the video, three types of 'prints' are used in the piece: wind formations, animal tracks, and shadows. All images in the video are naturally occurring and were not digitally enhanced in any way. A corresponding audio-video excerpt, *AV6-Snowprints*, is provided on the *Organised Sound* CD. The score from *Snowprints* (figure 14) shows the instrumental parts, a graphical representation of the snow sounds, and the

Figure 13. Video stills from *Snowprints.*

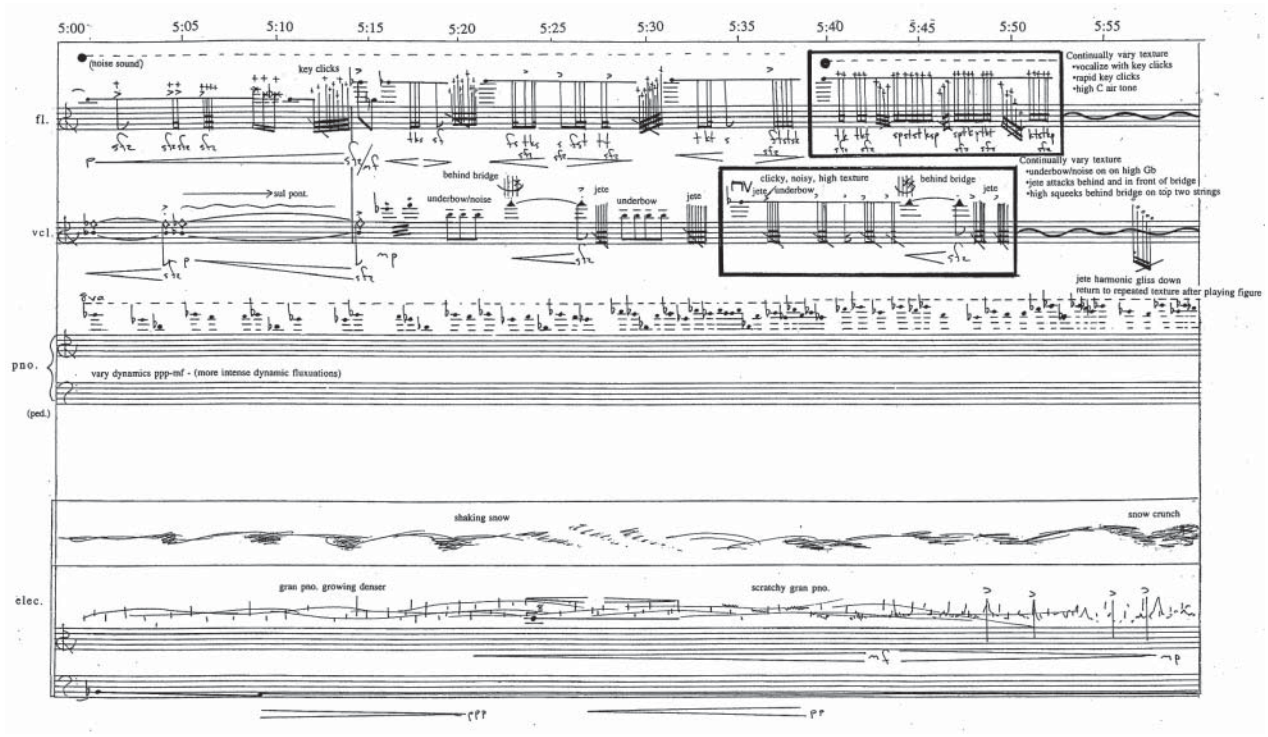

Figure 14. Score excerpt from *Snowprints.*

electronic digital prints. As in the video, there are three types of digital prints corresponding to each of the three instruments.

The musical form also falls into three sections corresponding to different approaches to the 'print' metaphor. This form is articulated in the video by photographs of the three kinds of prints appearing at key points in the music, modulating from the surface of the snow to shadow effects, which reveal the presence of external bodies and a directional light source. This transformation is supported in the music, which moves from an abstraction of the print metaphor into a kind of soundscape composition at the end where the footsteps of the recording engineer are heard. Here, the music reveals its source, bringing the sound walk into focus and drawing the listener out of environmentalism and abstraction into the presence of human intention.

5.2. Ecoacoustic and multichannel composition using SOS synthesis

Like ecoacoustics, multichannel composition has a basis in acoustic ecology through soundscape composition. Multichannel soundscape compositions reconstruct sonic environments through the sampling and redistribution of distinct sounds to construct externally referential environments. In the approach to immersive audio environments taken here, natural systems are mapped into the multichannel domain as a way of creating structure, but not as an attempt to reconstruct the environment figuratively.

Spatio-operational spectral synthesis, or SOS, is a signal processing technique developed at the VCCM by myself and David Topper (Burtner, Topper and Serafin 2002). SOS is based on recent research in auditory perception on audio objecthood as a result of streaming theory (Bregman 1999; Kubovy and Valkenburg 2001). The technique breaks apart an existing algorithm (i.e. additive synthesis, physical modelling synthesis, etc.) into salient spectral components treated independently in the spatial domain. Due to the inherent limitations of audition, the listener cannot readily decode the location of specific spectra, and at the same time perceive the assembled signal. In this sense, the nature of the auditory object is altered by situating it on the threshold of streaming, between unity and multiplicity.

When spectral parameters are spatialised in a certain manner, the components fuse and it is impossible to localise the sound. Yet when they are spatialised differently, the localisation or movement is predominant over any type of spectral fusion. Creatively modulating between fusion and separation is where SOS comes into being.

SOS explores the nature of sonic unity and multiplicity through spatialisation of the frequency domain. The technique exploits what can be described as a 'persistence of audition' insofar as the listener is aware that auditory objects are moving, but not always completely aware of where or how. This level of spatial perception on the part of the listener can also be controlled by the composer with specific parameters. Figure 15 illustrates the basic notion of SOS as demonstrated in the example of a square wave.

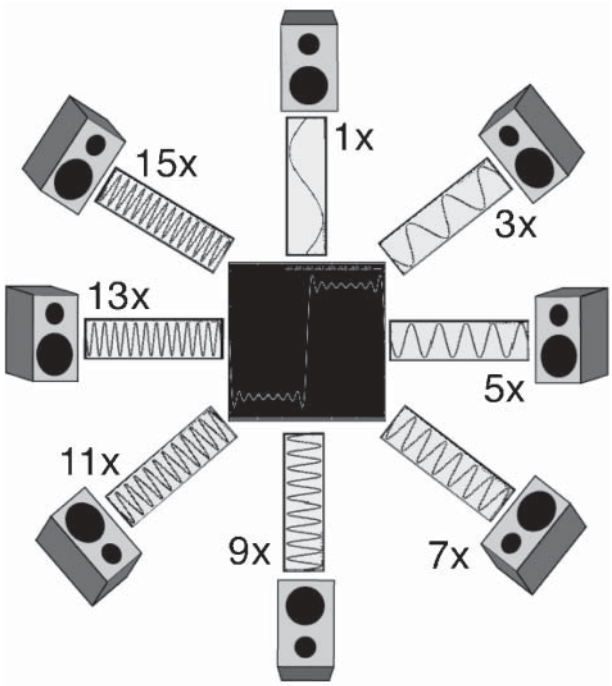

Figure 15. SOS recombinant principle.

5.3. SOS ecoacoustic immersive environments

In practice, SOS has proven to be a flexible and interesting addition to available synthesis tools. Figure 15 describes a basic procedure, but this principle is variable when the individual components become spatialised independently. In the examples described here from *Winter Raven*, SOS techniques were implemented for a multimedia ecoacoustic context. The electronic parts for the three *Unipkaaq* movements discussed above are each supported by percussion and eight-channel computer-generated sound diffusion using SOS techniques. In the first of these three pieces, *Siknik Unipkaaq (the story of sun)*, a group of interlocking concentric paths were created (figure 16).

A tempo ratio of 1 : 2 : 3 : 4 : 5 : 6 : 7 : 8 was applied to spatial modulation for the eight independent paths of audio. The base tempo of the structure is modulated globally, accelerating from a time base of 1 = 120' to a time base of 1 = 20'. This yields a time structure of 120' : 60' : 40' : 30' : 24' : 20' : 17' : 15', gradually compressing into ratios of 20' : 10' : 6.7' : 5' : 4' : 3.3' :

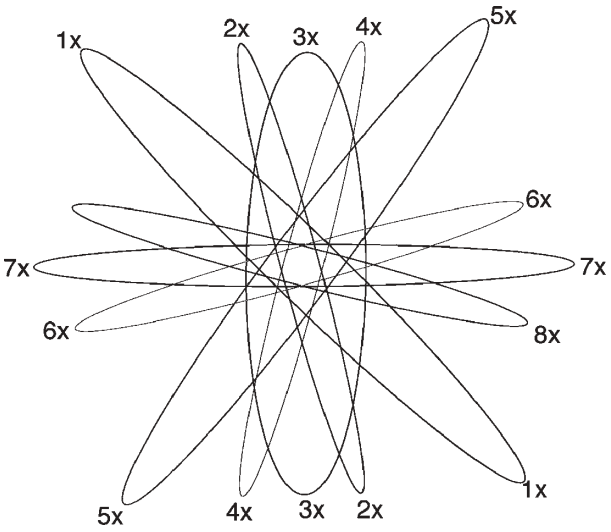

Figure 16. *Siknik Unipkaaq* SOS processing.

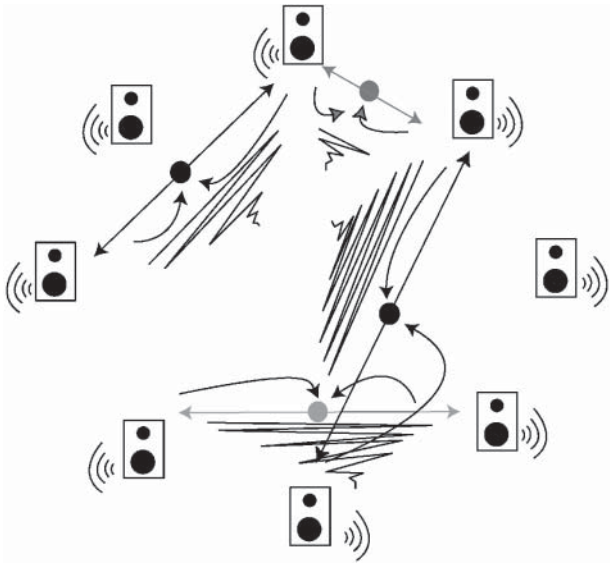

Figure 18. *Siku Unipkaaq* SOS 'shaking' algorithm.

2.8' : 2.5'. A percussion ensemble helps articulate this process (figure 17).

In *Siku Unipkaaq (the story of ice)*, a 'shaking' algorithm was employed to model the freezing of motion in the spatial domain. Each component of the ice sound pans between two randomly selected points very rapidly and gradually reduces movement, increasing frequency. The panning occurs in the order of 600 to 20 milliseconds, varying for each particle of sound. The result is a feeling of gravity pulling the sound towards a single point between the two spatial anchors. Thus the sound is 'frozen' into multifaceted crystals, continually spawning new paths that are again frozen. At any given time there are four simultaneous spatial paths. Figure 18 depicts this motion type.

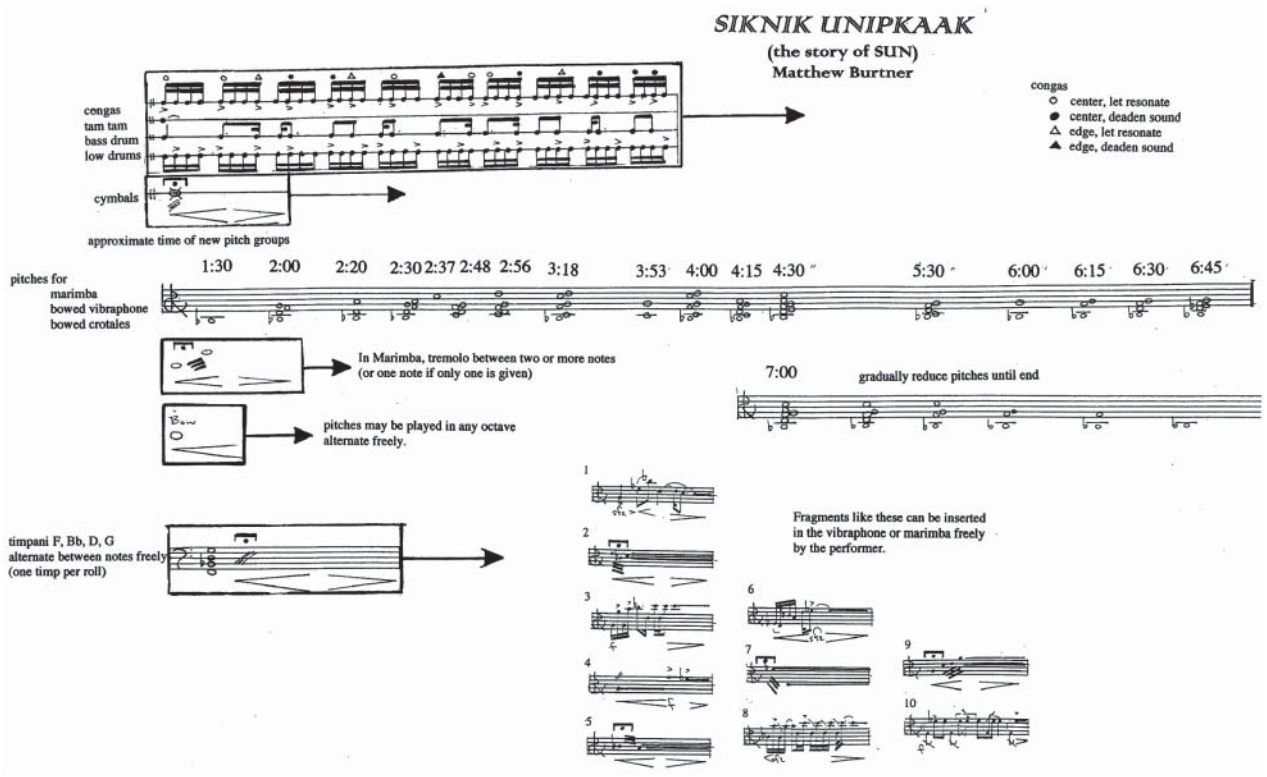

Figure 17. Instrumental score for *Siknik Unipkaaq.*

A gradual reductive process is articulated by four glockenspiel performers. Gradually the density and variety of pitches are reduced, focusing the frequency energy into increasingly reduced bands of sound. Finally, the voices slow and stick onto individual repeated notes (figure 19).

Anugi Unipkaaq (the story of wind) utilises the sound of wind recorded in Alaska and band-pass filtered into four discrete frequency regions. Each excerpted wind channel is panned rapidly between groups of randomly selected speakers, accelerating logarithmically as they approach the target point. In figure 20, each straight line represents this accelerating curve. Amplitude is linked to spatial change such that the wind sounds crescendo into each new location. The bands of wind rush simultaneously around the space, creating a kind of 'SOS blizzard'.

The piece is scored for a solo percussionist playing a battery of tom toms and drums, and three players playing a single large bass drum. At the end of the piece, as the rhythmic structure concentrates into a single common rhythm, the solo percussionist joins the other players at the large bass drum and the group ends together (figure 21).

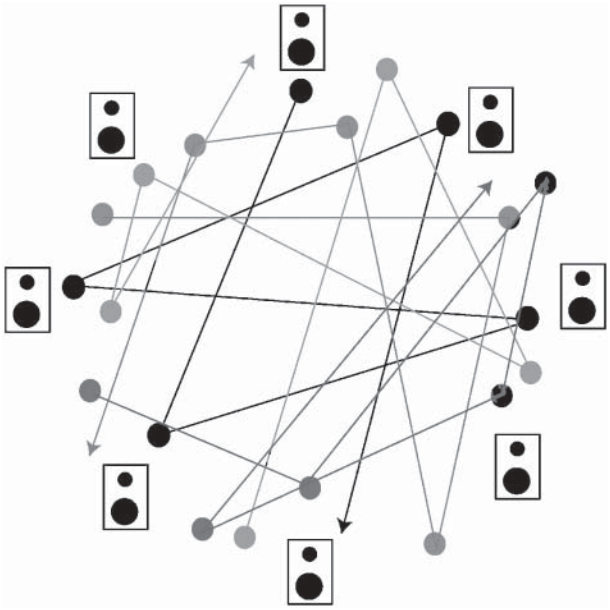

Figure 20. *Anugi Unipkaaq* SOS spatial motion 'blizzard' algorithm.

6. CONCLUSION

The work described here is one example of an artist rethinking the implementation of new technologies through a non-Western-informed perspective. My experiences growing up close to traditional Alaskan culture have altered my approach to performer/composer interaction, musical composition theory, multimedia performance, and musical instrument design. Through the design and implementation of shamanic and ecoacoustic multimedia technologies, this influence is brought to the forefront of the musical artwork.

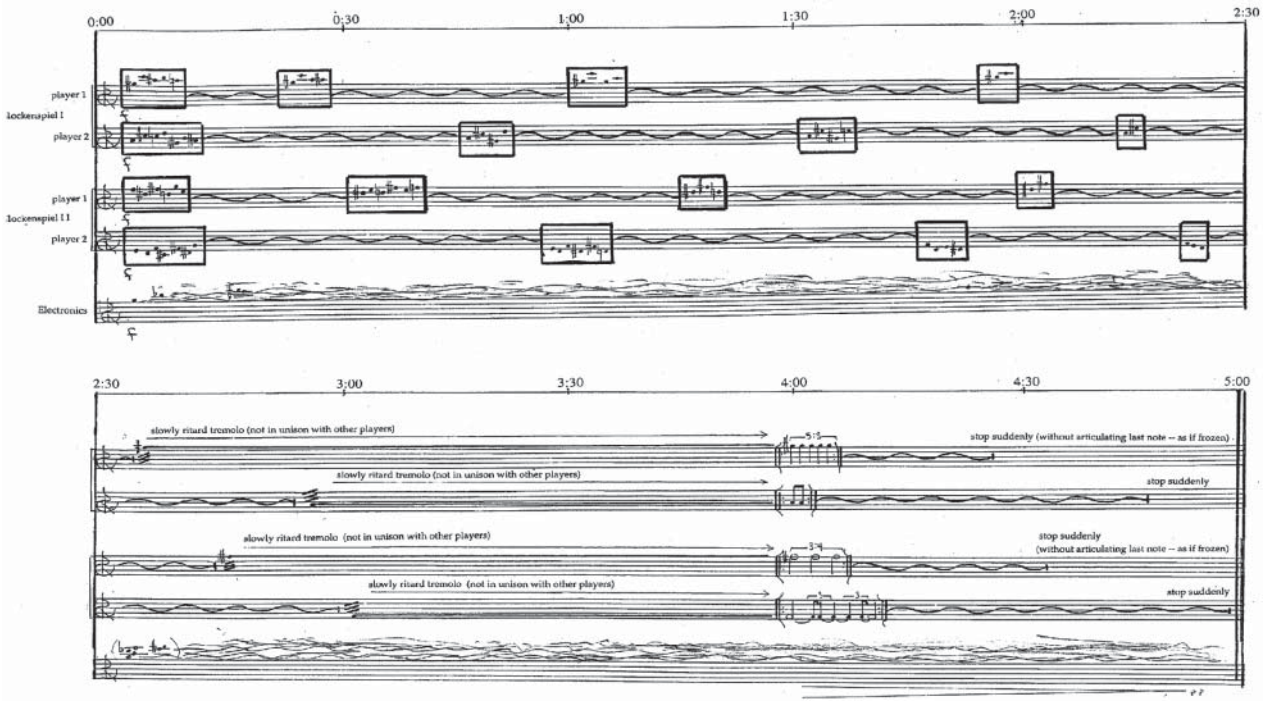

Figure 19. Instrumental score for *Siku Unipkaaq.*

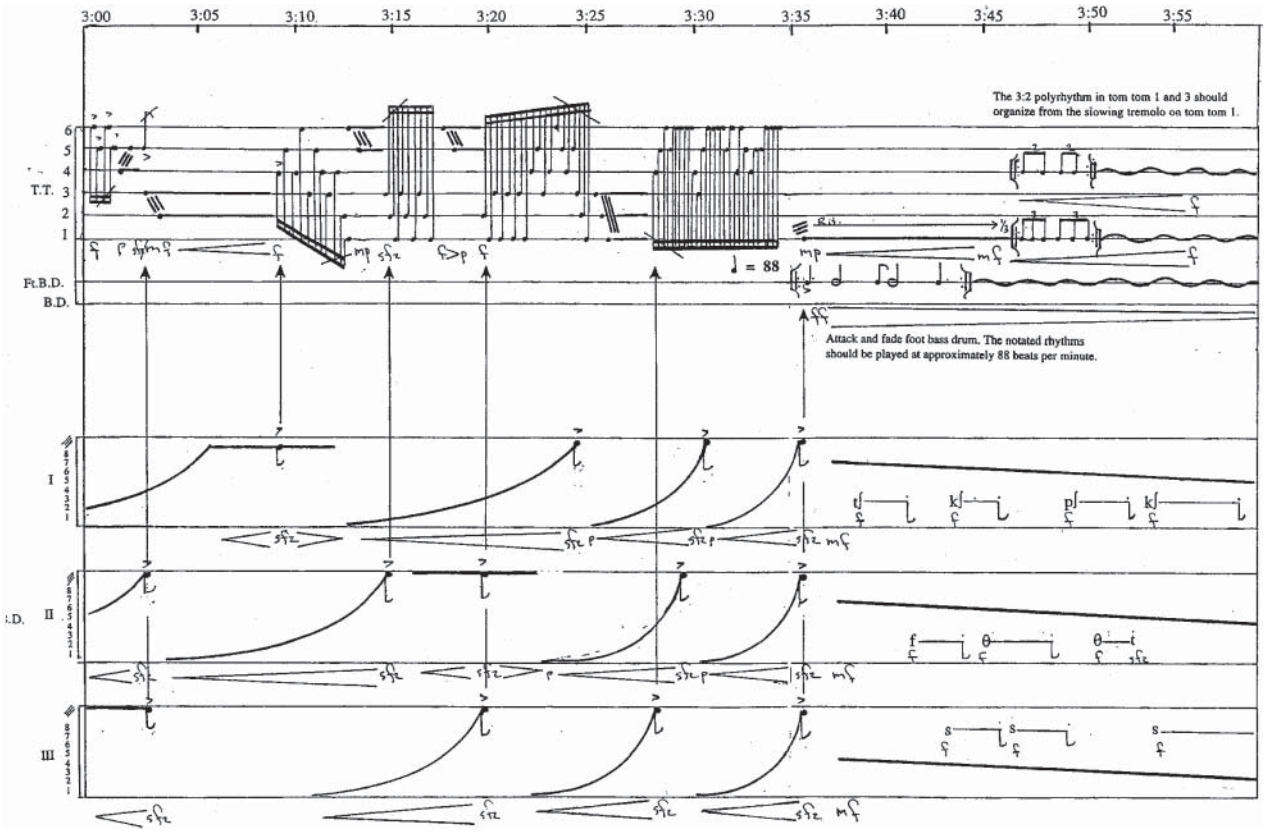

Figure 21. Instrumental score for *Anugi Unipkaaq.*

At the beginning of *Formalized Music*, Iannis Xenakis describes a successful work of art:

> Art, and above all, music has a fundamental function, which is to catalyse the sublimation that it can bring about through all means of expression. It must aim through fixations which are landmarks to draw towards a total exaltation in which the individual mingles, losing his consciousness in a truth immediate, rare, enormous, and perfect. If a work of art succeeds in this undertaking even for a single moment, it attains its goal …

This transcendental truth reminds us of the shamanic approach to liminal transformation discussed above. Xenakis continues by challenging artists to strive to attain the 'meta-art' while still being able to trace its mechanisms:

> But this transmutation of every-day artistic material which transforms trivial products into meta-art is a secret. The 'possessed' reach it without knowing its 'mechanisms'. The others struggle in the ideological and technical mainstream of their epoch which constitutes the perishable 'climate' and the stylistic fashion. Keeping our eyes fixed on this supreme meta-artistic goal we shall attempt to define in a more modest manner the paths which can lead to it from our point of departure, which is the magma of contradictions in present music.

This ambition for art to transcend mere expression, is at the core of the Inuit subsistence festival, led by the shaman, who bears a strong resemblance to Xenakis' description of the artist. Edward William Nelson, the explorer/anthropologist who travelled throughout Western Alaska, and preserved many indigenous artefacts, describes the qualities of a successful festival: 'A good festival must not only please the spirits; it must also be long remembered so as to guide the future actions and thoughts of individuals'.

Beyond the naturalist meta-art lies the realm of cultural memory and spirituality.

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