Interpreting Data: Re-contextualizing Data to Develop Approaches to Musical Composition

Roger Alsop
Department of Performing Arts (Production). VCAMCM, University of Melbourne, Australia
ralsop [at] unimelb.edu.au
http://vca-mcm.unimelb.edu.au

Vincent Giles
PhD Candidate: Faculty of the Victorian College of the Arts, University of Melbourne, Australia
Lecturer in Composition, Australian Institute of Music, Australia
vin@vgiles.net
http://www.vgiles.net

Proceedings of Korean Electro-Acoustic Music Society's 2015 Annual Conference (KEAMSAC2015)
Seoul, Korea, 2-3 October 2015

This paper discusses ways the authors use data from the science in the creation of musical works, *Silver With Carbon Bond*, by Giles and *Flow 2000* by Alsop described below.

Silver With Carbon Bond, created while in-residence at the Bio 21 Institute, is a musical representation of mass spectrometry data. It takes experiment results, which describes the mass to charge frequency, and the true and relative intensities of each frequency of atomic mass of silver bonded with carbon. It relates the mass/charge frequency to specify sound frequency, and the relative intensity to specify amplitude, and a Max patch is used to synthesise output. SPEAR was used to do a spectral analysis and onset detection of the synthesised sounds, and to export that data as SDIF. The SDIF file is then used in a patch developed using IRCAM's OpenMusic that reads the spectral analysis file and outputs notation. This raw notation then formed the basis for the piece Silver With Carbon Bond.

Flow 2000 represents the theoretical behaviour of imaginary fluids as represented through varying the elements of velocity, density, tube length and width, and dynamic and kinematic viscosity. These elements are sonically represented as: frequency, timbre variation based on altering phase of sine waves, positioning within a binaural space, amplitude, and duration. A varying imagined Reynolds number based on randomly generated seed values for the six elements is used to generate the numeric values of these elements.

The paper details the processes used to create the two works, the influence of the composers' aesthetic preferences in the creation of each piece, and potential ways in which the processes may be used in the development of other works that exemplify the music/science nexus.

The intersection between science and music can be an extraordinarily fruitful place to work from, and allows so many approaches to music-making that range from the trivial (such as the fact that a great quantity of music made today utilises computers in some way) to the much more interesting (such as observations made by people like Thomas Watson that sound carries via the ionosphere and can be received by radio! (Kahn 2013)) Giles' interest in science is reasonably broad, and stems from an ideal to – as much as possible – objectively understand everything in our environment. Of course, this is not necessarily possible at any given point in our history, but it is an ideal to strive for. More specifically, organised sound[1] as a function that necessarily comes from physics and biological evolution. By necessity, looking for a way to creatively engage with this wider understanding of the world, and thus attempt to understand the world more thoroughly, is important to Giles. This was highlighted when he attended a lecture by composer Richard Barrett, and he discussed the notion that perhaps art (including music) might reflect an intuitive understanding of some natural phenomenon that we are otherwise unaware of: in particular, by observing the role of memory, imagination, and expectation when listening to music and relating that to a possible multi-dimensional (or multi-directional) time, that flows forwards and backwards (Barrett 2014).

Alsop considers the recontextualizing of data from a wide variety of disciplines, modes of thought and systems; looking at the process for gathering, interpreting and using data across many fields in the creation of art works. He initially looked at processes of interpreting speech systems into systems for music/sound art creation (1999, Pedersen and Alsop 2013, Burke and Alsop 2014, Alsop 2014, Alsop 2007, Cox and Alsop 2014, Alsop 2013, 2010, Alsop 2011, Alsop 2003) creating a number of audio works, and then developed these conceptual and technological processes to generate interactive audio visual works. In these works Alsop developed the algorithms and formulae for interpreting data idiosyncratically and without direct reference to specific or already used approaches.

Discussed in this paper are the computer-based approaches to data re-contextualization employed by Alsop in his work: *Flow 2000* (2015), and by Giles in *Silver With Carbon Bond* (2014-2015). The paper will briefly describe the contexts of these two pieces, explore the techniques used in developing them, and contrast the two approaches, with the expectation that such explorations yield innovation in the arts, and a novel way of exploring data in the field of origin.

Giles in residence: context for the work

Giles is one of six artists-in-residence (and the only composer) for a period spanning approximately 15 months, with an anticipated end date of December 2015. The residency has been facilitated by the Victorian College of the Arts and the School of Chemistry, both faculties within the University of Melbourne, in Victoria, Australia. These works take the form of instrumental and electronic work, some for installation, some for live performance. In particular, Giles has been working with a chemist who specialises in mass-spectrometry[2], as there are some obvious parallels between spectral analysis in sound and mass spectra analysis in chemistry.

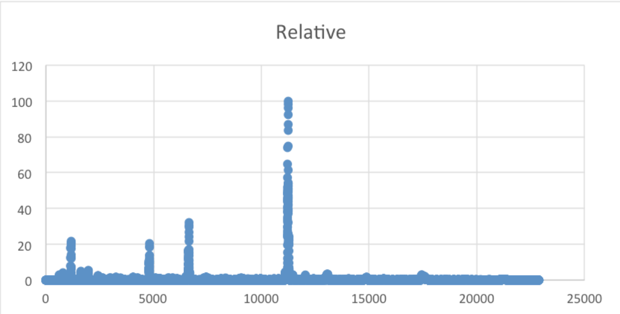

Figure 1: m/z spectra data of silver bonded with carbon. Provided by Zavras (2014).

The work under discussion in this paper: *Silver With Carbon Bond* is for solo baroque violin with either a classical or modern bow; it is a sonically demanding work requiring the performer to execute somewhat complex rhythmic gestures with fine motor control in the bowing arm. It is one of a number of works being developed during the residency. An instrumental piece was decided on, not only to be an interesting challenge, but also an interesting juxtaposition: translating data from mass spectrometry into notation. Not simply being descriptive, but finding novel ways of treating the data as a material basis for the development of a piece that, when looked at in the context of Giles' total output from the residency, can be seen as inter-connected by their source material.

Using the formula for deciding a Reynolds number to create a sound work develops Alsop's conceptual approach discussed above. Here the formula is simply taken as way to develop outcomes to be reified sonically, in this case via live flute performance augmented by technology.

Aesthetic Considerations

The work under discussion as with others (Giles 2015) created by Giles over roughly the last four or so years has forced him to consider an aesthetic stance, and thus context, suitable to partially generative music. This aesthetic stance is built on an intersection of ideas, ideals, values, and a degree of poetics, the primary points of which are detailed below.

The first is an ongoing interest in 'complexity', which is seen as not only musical complexity (complex compared to what? – refer to (Barrett 1992) and (Toop 1993) for in-depth considerations on complexity) but an ever-expanding understanding of complex systems: biological, electronic, social, and so on. This interest in complexity has lead to a great fascination with the 'micro' in sonic works; tiny fragments of sound or material that exist at the edge of human perception (Roads 2001) – a facet of sound that has been at the core of works developed during Giles' Bio 21 Residency.

The second is the recognition of an attitude of 'experimentation' (Cassidy 2012) in musical composition: a practice driven largely by the question 'what happens if…?' and the procedures and works that result from that question (mondayeveningconcerts.org 2011). There are other forms of experimentation also, from systems of constraint to systems of indeterminacy, and so on. But for the most part, experimentation is procedural and generative, and once the music is committed to, it becomes determinate.

These aesthetic considerations may simply be described as the prioritisation of structure and logic, and of unity between material and form, which the above-mentioned ideas and values encapsulate.

Alsop's approach has many similarities to Giles', particularly an interest in the complex systems mentioned above and their behavior. While concepts of artistic frameworks, such as 'the new complexity', 'minimalism', 'abstract' and so on are considered when interpreting his works they are not when creating them. Instead there is a strong focus on improvisation, time, cross-modality and inclusiveness in the creation of the works. These terms may take a variety of interpretations while creating the works; for example, 'improvisation' may refer to the development of an improvised performance, machine improvisation, or improvised interpretation – where the work is listened to and considered through a variety of concepts and contexts, or 'time' may be considered as the temporal relationships between events inherent to the work being made, not considering the work complete until it has been listened to and considered over an extended time period – a year for example. He sees each creation, reification and experience of an artwork as unique to the ephemeral moment of creation, reification or experience, and considers collaboration and improvisation as essential to his approach.

Alsop views understanding per se as a prime human need and that this is created through exploring the structure and logic, materiality and form of things, and when these aspect are interrogated though new, differentiated, or diverse paradigms an aesthetic experience is created that may disrupt or expand current aesthetic norms in both the composer and the listener.

From Data to Notation: Silver With Carbon Bond

In developing the piece titled *Silver With Carbon Bond* (Giles 2014-2015) the composer needed to make tools that could transfer, sonify, and then notate the data that received from the Bio 21 Institute. The goal was to move beyond simple sonification – which could be perceived as somewhat trivial – into artistic territory that thoroughly interrogates the provided data, illuminating a new view of data. The primary generative software used by Giles is MaxMSP (Max) and OpenMusic (OM), along with Sibelius 6 for typesetting.

From data to notation: generation and interpretation

The raw mass spectrometry data is provided as a large Microsoft Excel spreadsheet, consisting of up to ~22,000 individual rows, depending on the sample, and three columns: *m/*z (mass to charge), *absolute intensity* and *relative intensity*[3]. This data plotted as a graph can be seen in **Figure 1**. The relative intensity data is the most interesting and usable, partly because the numbers are much smaller and thus constrainable, and partly because they are what the scientists prefer to use in their tests.

The first stage was developing software to sonify the data, taking the *m/z* and its relative intensity as frequency and amplitude data in the sound domain. Using a patch designed in Max MSP which performs the job of separating the columns and attaching the *m/z* and relative intensity as a pair, to be sent to oscillators for synthesis. The result of one such sonification can be seen in **Figure 2**[4]. This process is fundamentally a gradual additive sequence of one oscillator being assigned a frequency and amplitude, then the next, and so on.

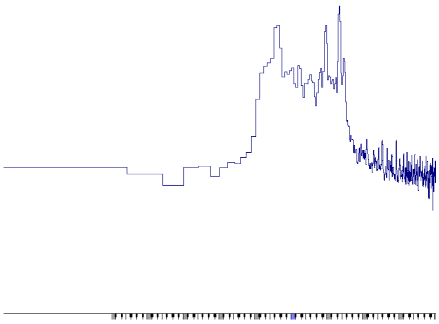

Figure 2: Cumulative frequency data generated using MaxMSP.

This generated audio is the most rudimentary of materials with which to work, acting as the unifying basis from which all other materials are derived[5]. SPEAR[6] provided the functionality of being able to perform spectral analysis on the source audio and to output an SDIF[7] file that can then be used within OM. The SDIF file is the source of generative pitch and rhythm, with pitch being approximated to any division of the octave that is desired: in this case, 1/4 tones or the division of one octave into 24 equal-tempered (24TET) parts. Once this data is within the OM environment it exists in the form of lists, which have the flexibility of being subjected to variation of any degree of complexity through procedures that reflect those employed by serial composers: inversion, retrograde, and so on, alongside other manipulations such as randomized rhythm or rest insertion, polyrhythmic nesting of tuplets, and much more. Given the quantity of data (and subsequent material that would be generated), no such permutations or manipulations were employed other than quantizing the onsets as rhythms to a 13-tuplet at any rhythmic division of a quarter note (8th, 16th, 32nd, 64th, and so on). **Figure 3** (below) shows the patch and its generated pitch and rhythmic material.

Once quantized, the rhythm part became stretched well beyond the time of the original audio, which led to the decision to make the piece – for solo baroque violin with classical or 17th century bow – in four short sections, each corresponding to a part of the parent audio. In this way, the piece will coalesce in an additive way, similar to the sonification process, resulting in the final section that contains as much of source sonic information, spread over time, as is possible on a fundamentally monophonic instrument.

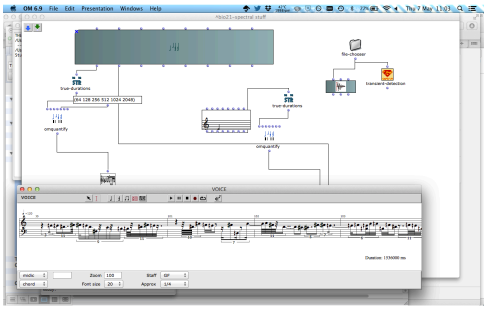

Figure 3: Combined pitch and rhythm generation using OpenMusic.

Having generated the raw material, the actual composing could begin. This process involved taking the raw notation generated by OM and getting it into the typesetting software Sibelius[8], and then working with that raw material to turn it into a piece of music. **Figure 4** (below) shows the first page of the completed, typeset composition with much more detail, rhythmic division and formal organization, various performative parameters such as glissandi, bow pressure, and harmonics, and so on.

This process of working with generative material forces a response to the material that is intuitive, and becomes almost like a performer responding to a score without the restriction of time. It stimulates the imagination and forces, as Cassidy (Cassidy 2013) discusses, the composer into a metaphorical corner from which they must push against the imposed restraints, stimulating imagination and invention that would otherwise not occur. In this sense, this method of composing can be considered experimental, in that the outcome is not known due to the generative procedures, but once those procedures have run, it is up to the composer (and then the performer) to respond.

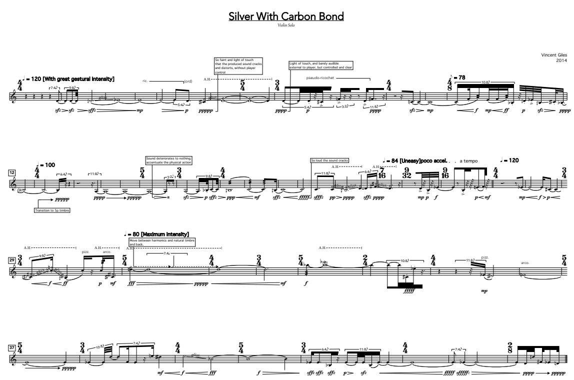

Figure 4: Score for first page of Silver With Carbon Bond. (Giles: 2015)

From Data to Notation: Flow 2000

The data used to create Flow 2000 is imaginary; the process of using the Reynolds number equation to create a sonic output offers a very different approach to Giles, who took existent data from an analysis of an object to for a basis for his composition. The Reynolds number equation has a variety of iterations depending on the properties of the object being tested, as this version of its use is to be performed with a flute the iteration based on pipes is used, this can be seen in the equation $R = \frac{\rho \upsilon D}{\mu}$ (Ahern 2007), this variation of the equation $R = \frac{\upsilon \rho L}{\eta}$, which provides "a more general approach to turbulence when objects move through a fluid" (Nave 2012) does not form a substantive difference in outcome when used in the creation of sound.

The equation provides ten potential numbers to be generated, one for each symbol and one for the inverse of the outcome of the equation. These numbers provide the score as is shown in **Figure 5**.

This is a dynamic score, created in the Max environment, that responds to the performer and performance as it is taking place. The performer is able to interpret the score within a few paradigms; for example: air pressure 1 - 10 refers to the pressure the performer should apply to exciting the playing the note indicated below, the angel of embouchure indicates the position the performer should angle the flute in relation to their mouth, key depression indicates the amount to which the performer should depress the keys in order to play the note, and units of time refer to the number of beat the performer should take to play the particular note. The performer can set the unit of time prior to performance in relation to their experience of the dynamics and reverberation time of the room.

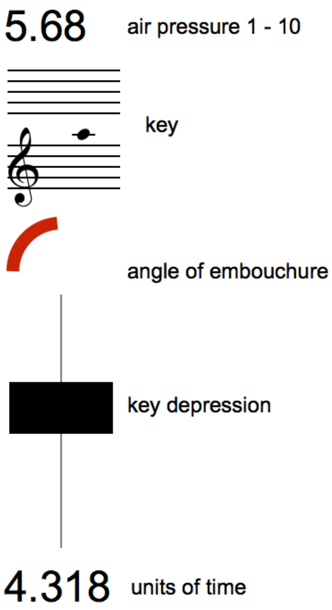

Figure 5: Flow 2000 score example

The music made is generated from using the $R = \frac{\rho \upsilon D}{\mu}$ equation based on the frequency of a flute note (in this example a recording of a flute performance was used to generate the data), as shown in **Figure 6**.

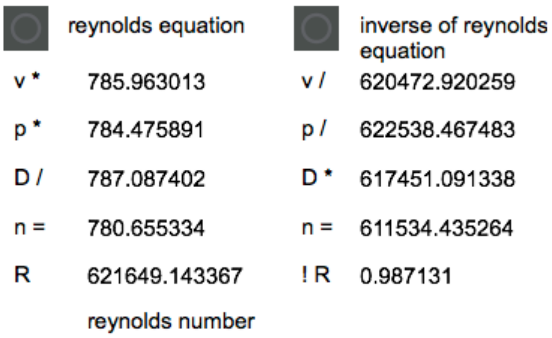

Figure 6: Reynolds equation based on changing frequencies

These numbers are mediated to fit the ranges appropriate to the score element displayed, for example the relating to *v* s scaled t fit between 1 and 10, the number relating to *p* scaled to fit between integers 60 and 96 so that is can be represented as a MIDI note, the number relating to *D* scaled to fit between integers 0 and 180 to represent an angle, the number relating to *n* scaled to fit between integers 0 and 100 to relate to percentages of depression of the keys, an the number relating to *R* multiplied by 0.00001 to indicate a duration. It is understood that any performer and performance venue may require alteration to the scaling process and this is built into the Max patch.

The inverse of the resulting number, created by reversing the operations used to get the Reynolds number, is used to effect the reverb time, bandwidth, damping, early reflections, and reverb tail time parameters of the gen~ gigaverb patch. This creates a virtual sonic space that responds to the performance in situ. The entire control surface is seen in **Figure 7**, this presents all relevant data but only the score, seen in **Figure 5** is visible to the performer.

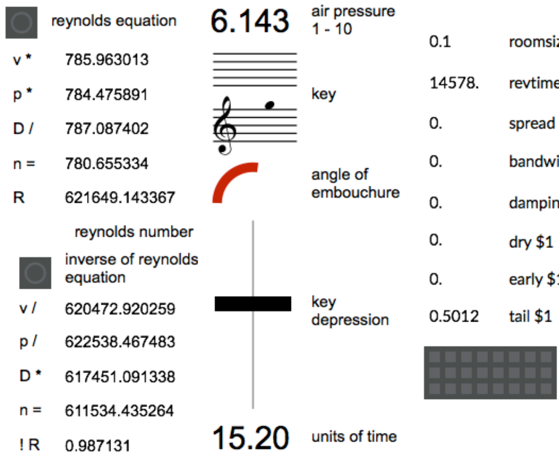

Figure 7: Flow 2000 control surface

Flow 2000 integrates Alsop's interests in collaboration, improvisation, the ephemeral nature of sound art and performance, and the importance of location in the creation of an artwork.

Comparison of Approaches and Concluding Remarks

Data is often seen as exclusively the domain of the sciences, understandable only in the context from which it comes or which it describes. However as both Giles and Alsop have shown, data interpretation can be very fruitful ground for artistic expression in musical activity and the sonic arts, providing the artist (composer) moves beyond sonification and into interpretation.

The aesthetic considerations and goals of Alsop and Giles are different, as are their approaches to data interpretation. Giles prefers an 'experimentation-as-material-generation' approach, which once generated becomes extremely deterministic at a performance level, while Alsop takes an interactive approach where the performer becomes part of a pre-designed system of data interpretation with indeterminate outcomes. Both approaches reflect an experimental approach to music making that is based on intransigent approaches, generated data in Giles' case and a mathematical formula in Alsop's.

One novel connection that arises between the two approaches is Alsop's notion of a virtualised sonic space. In

Alsop's approach the virtualised sonic space exists within a computer system, and is both a score-generator and performer-interpreter, that exists only in the virtual world. The Reynolds number, which is dimensionless and at best creates an indication of an outcome, provides a metaphor for the constant fluid motion of a performance.

The score in Giles' approach appears to function in a similar role, being the artefact around which the virtualised sonic space (the data interpretation systems built by Giles) and the performer interact – a sonic mediator of sorts.

References

Ahern, Judson L. 2007. "Reynods Number (optional material)." Accessed August 15. http://geophysics.ou.edu/geol1114/notes/running_water/Reynolds_number.html.

Alsop, Peter R. 2011. "Mapping Gestures in the Creation of Intangible Art Objects."PhD by Project, Media and Communication, Royal Melbourne Institute of Technology.

Alsop, Peter R. 2014. *Ambit Improvisations One*. Melbourne: Tilde New Music. Recorded Music.

Alsop, Roger. 1999. "USING ASPECTS OF LANGUAGE IN COMPUTER BASED COMPOSITION: THREE APPROACHES TO CURRENT AUSTRALIAN TEXTS."Master of Arts, Music Dept, La Trobe University.

Alsop, Roger. 2003. "Compositional Processes in Developing Poly-Media Performance Works." Australasian Computer Music Conference, Perth.

Alsop, Roger. 2007. "INTEGRATING TEXT, SOUND, AND VISION IN AN INTERACTIVE AUDIO-VISUAL WORK." *Proceedings of ICoMCS December*:11.

Alsop, Roger. 2010. "Action A/V: An Improvisatory Process For Translating Movement To An Audiovisual Outcome." Australasian Computer Music Conference 2010, The Australian National University Canberra, Australia 24th-26th June 2010.

Alsop, Roger. 2013. "Fluidity - We Are Water: The development of an improvised audiovisual performance." In *Water Issues Relating to Environmental Landscape Sustainability*, edited by Med Amin Hammami Hichem Rejeb, James Cunningham, Suzon Fuks 7 - 11. Tunisie: University Sousse.

Barrett, Richard. 1992. "'Complexity', one last time." http://richardbarrettmusic.com/Complexity.html.

Barrett, Richard. 2014. "Multi-dimensional time." RMIT University/SIAL.

Burke, Brigid, and Peter R Alsop. 2014. Motion5. Melbourne: Australasian Computer Music Association.

Cassidy, Aaron. 2012. "I am an experimental composer." Accessed 8/1/2015. http://aaroncassidy.com/experimental-composer/.

Cassidy, Aaron. 2013. "Constraint Schemata, Multi-axis Movement Modeling, and Unified, Multi-parametric Notation for Strings and Voices." *Search: Journal for New Music and Culture* 10.

Cox, Travis, and Roger Alsop. 2014. "Sublime: An Open Approach To Collaborative Performance." Harmony Australasian Computer Music Conference, Melbourne, July 9 - 13.

Giles, Vincent. 2014-2015. Silver With Carbon Bond (solo violin).

Giles, Vincent. 2015. Bits & Pieces/Put Together To Create/A Semblance of a Whole.

Kahn, Douglas. 2013. "Earth Sound Earth Signal Energies and Earth Magnitude in the Arts."

mondayeveningconcerts.org. 2011. MEC Music Talk: Aaron Cassidy and Michael Pisaro. edited by Monday Evening Concerts.

Nave, Carl R. 2012. "Hyperphysics." Accessed August 12. http://hyperphysics.phy-astr.gsu.edu/hbase/pturb.html.

Pedersen, Mark, and Roger Alsop. 2013. "Gesture, sound and place." International Symposium on Electronic Art, ISEA2013, Sydney.

Roads, Curtis. 2001. *Microsound*. Cambridge, Mass.: MIT Press.

Toop, Richard. 1993. "On complexity." *Perspectives of new music*:42-57.

---

[1] *Organised Sound*: acts as an umbrella term for sound art, sonic art, music, and so on. I will interchangeably use the terms *sound art* to mean work in which the visual element and the sonic element in an installation context are equally important; *sound art* will also encompass radiophonic work. *Music* will be used to describe works which come from the Western art music (classical) tradition, including variants such as: computer music, acousmatic music, electroacoustic music, and so on.

[2] Electrospray ionization mass spectrometry (ESI-MS) is an analytical method allowing transfer of molecules in the liquid-phase to the gas-phase where they can be analysed according to their mass-to-charge ratio (*m/z*). The ionization process (ESI) can transform neutral molecules into charged species (ions) classified as positively charged cations or negatively charged anions. The mass analyser allows the mass of the molecule to be revealed by information in the *m/z*. The analysis produces a mass spectrum that displays the relative intensity (Y-axis) vs. the *m/z* (X-axis).

[3] Relative intensity is the electron charge per spectra relative to the sample currently being tested.

[4] Audio of this wave file is available here: https://soundcloud.com/vince-giles/firstsynth7000

[5] Indeed, this method of 'material restriction' has been part of my composition practice for many years. It provides a way of unifying a piece across any amount of time, and is for me a great way of inducing creativity. It means that the starting material can be explored in great detail over the course of one or many pieces of music. In this case, the parent material – the data – becomes the unification across multiple works, while at the localised level of *Silver With Carbon Bond,* only the generated waveform acts as the unifying material.

[6] **SPEAR:** Sinusoidal Partial Editing Analysis and Resynthesis. http://www.klingbeil.com/spear/

[7] **SDIF:** Sound Description Interchange Format. http://sdif.sourceforge.net

[8] Giles has since switched to Finale, making the process of porting from OM to typesetting much quicker. At this stage however, the OM output needed to be transferred to Finale Notepad to be re-exported as an older format of MusicXML that Sibelius could recognize.