

SUSTAINABLE LIVE ELECTRO-ACOUSTIC MUSIC

Nicola Bernardini
Conservatorio di Padova
Padova, Italy

Alvise Vidolin
Conservatorio di Venezia
Venezia, Italy

ABSTRACT

Real-time/performed electro-acoustic music (also known as *live electro-acoustic* music) is currently facing a serious sustainability problem: while its production is indeed considered very recent from the music history point of view, several technological generations and revolutions have gone by in the meantime. Thus, most of these works can hardly be performed because the technologies used have gone lost since a long time and no long-standing notational precaution was taken. This paper presents some typical case studies and examples and introduces some techniques that might lead to a partial – when not completely adequate – solution to the sustainability problem.

1. INTRODUCTION

Digital preservation and archival of cultural assets is now a widely-studied and active research problem everywhere (cf.[11, 13, 14, 9]). The music domain is no exception to this rule, ranging from the preservation of score manuscripts to that of antique musical instruments, old recordings¹, electro-acoustic music on tape (cf.[15, 5]), etc. In general, from these studies it appears that digital preservation of *dense* documents² coupled with symbolic representation of linguistic elements (where available) would be sufficient to preserve most artistic works in the music domain.

There is a specific music field, however, which presents many more problems in the preservation of its works: live electro-acoustic music. Most, if not all, live electro-acoustic works are endangered today because their sustainability in time is extremely low (cf. Sec. 2) – there is an urgent need for research and solutions to face an otherwise inevitable loss of many masterpieces of last century. Furthermore, if the sustainability problems of live electro-acoustic music are not tackled, current and future works may well face the same fate of their predecessors.

2. PROBLEMS

Live electro-acoustic music is indeed a “performance-intensive” art form which may somehow relate to

other similar musical formats: jazz, popular music or “performer-centered” interpretations are the first that come to mind. These may include, for example, the jazz standards performed by an extraordinary artist, rock-band concerts and records, sublime interpretation of classical works by legendary singers or players, etc. In general, preserving these formats implies preserving the recorded documents that contain them. While that is not the performance *per se*, its high-quality reproduction is deemed acceptable for memory preservation.

Live electro-acoustic music is different in that we seek to preserve not only a single, memorable performance but rather the ability to perform, study and re-interpret the same work over and over again, with different performances proposing different interpretations. A recorded document of the first (or indeed, of any) performance of a live electro-acoustic music work is instead completely insufficient and inadequate to the re-creation of the work itself.

Of course, this would call for a score capable of providing the necessary performance indications to the complete re-construction of the piece. Symbolic notation, abstracted from practical implementation and the underlying technology, is extremely important here. In this case, notation should be both descriptive and prescriptive to some extent (it should define *which* result is sought and *how* to get it — always in device-independent terms). However, live electro-acoustic music currently possesses notational conventions and practices that can be compared at best to middle ages tablatures. This is due to several factors, the most important being the availability of recording technology which has been considered, for years, as the proper way to preserve the details concerning the electro-acoustic performance. This, in connection with

a) use of end-user configuration patches using proprietary software and hardware technologies (cf. Sec. 4.1 on the next page);

b) use of binary and especially proprietary file formats

has lead to huge losses in performance information of many live electro-acoustic music works. It is now time to think about the sustainability of these past, present and future works.

3. POSSIBLE SOLUTIONS

Scores are essential to *speculative* (i.e.: non-commercial, non-programme) music to preserve two fundamental mu-

¹ cf.<http://www.aes.org/technical/documentIndex.cfm#ardl>

² the term *dense* is taken from early semiotic studies (cf.[6, p.241 and sec.3.4.7], [7, III, 3] and [3]). It basically means documents that carry all the information within themselves, i.e. they are not symbolic representations to be further interpreted and converted into a final artifact.

sical functions, namely reproduction and interpretation of the works; most live electro-acoustic music is no exception to this requirement. Full-blown audio-video recordings are not appropriate, because

- a) recordings do not convey any of the necessary instructions (descriptive and prescriptive) that are required to re-interpret the work, and
- b) they give a “reference” interpretation to mimic, thus seriously jeopardizing the possibility of new interpretation.

Furthermore, the score representation must resist time degradation and technological revolutions, so it must rely on lower level standard common denominators (such as paper, widely diffused sound file formats, standard metric units, etc.).

These considerations have led to the following solutions that should be adopted to for any sustainability-aware live electro-acoustic score — it should be augmented with

1. a multimedia glossary covering all live electro-acoustic processing found in the work; every item should have:

- an algorithmic description
- an impulse response
- an audio example

these items should be provided in an ASCII-based standardized format (such as XML).

2. a computer-assisted notation system based on the orchestra/score paradigm (i.e. a description/prescription of *how* sounds are build, and a description/prescription of *when* they should be built in time).

We maintain that a multimedia glossary provides indeed completely different information than a full-blown recording of a passage or an entire piece. A glossary such as the one devised above allows performers to verify if single elements are in place while leaving most of the interpretation (e.g. quantities, speeds, etc.) to them. Furthermore, while the impulse response of a processing system possesses the abstraction qualities that we seek, it would probably be too hard, in most cases, to trace back the (usually complex) system producing it. The impulse response should then be complemented by an accurate algorithmic description of each electro-acoustic process and the impulse response (or its transfer function) should rather serve as a checking tool (much like the test-tones were used on electro-acoustic tapes in the analog era).

The orchestra/score paradigm is still relevant because it allows

- a) good separation of *system* data from *performance* data;
- b) lowering of the complexity barrier during performance;

- c) seamless integration with traditional instrument performance.

True, the orchestra/score has a number of serious drawbacks (cf. for example [8]), the most important being that of promoting a mind-set which separates processes from events. This separation is often very weak, if not utterly non-existent, in electro-acoustic music as well as in much contemporary music thinking. However, the lack of a distinctly better model and the advantages enumerated above suggest that this paradigm can still find its use in live electro-acoustic music.

The adoption of sustainability-aware score models may be considerably facilitated by computer-assisted notation software applications that should be devised to:

- a) pick up automatically internal data of electronic devices such as mixers, effects, DSPs, etc. *and* convert it to a common format (such as XML) using ASCII, standard metric units, etc.;
- b) provide objective representations such as time-local impulse response plots;
- c) provide assistance to the composer in devising the performance notation related to the above elements.

Along the same lines, live electro-acoustic music transcription and documentation should be an integral part of the creation of a work (just as writing a score is essential to most contemporary music) and it could/should become an editorial profession just as professional music copying is.

These elements should provide long-standing sustainability to live electro-acoustic music works.

4. CASE STUDIES

Live electro-acoustic music is quite an abundant field which provides many examples with much diversity of contexts and settings. Unfortunately, most of these examples are problematic: the way the scores are realized do not allow the performance of the score any longer or will not allow it in the very short future (we must always think that in music 50 years is a *very short* future). Of course, a “problematic” example of live electro-acoustic music scoring has nothing to do with the quality of the music itself. However, a “problematic” example of scoring of a great piece will not allow its performance any longer and that makes it even more problematic — if at all possible.

Luckily, a few “positive” examples exist. No example is really perfect and many problems still need to be solved, but these positive examples are very important because they create a foundation that can be taken over and enhanced.

4.1. Stockhausen – *Oktophonie*

A good example is provided by *Oktophonie* by Karlheinz Stockhausen [16]. *Oktophonie* is a 69-minute multi-channel tape piece which, in theory, could also do without a score. However, faithful to his long-standing tradi-

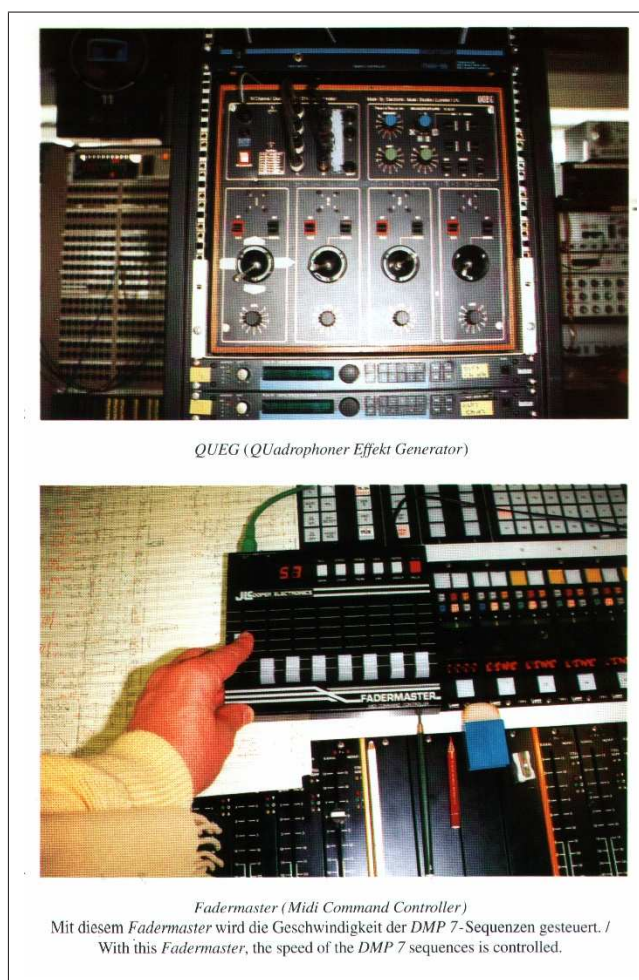


Figure 1. Stockhausen, *Oktophonie* — Some pictures of Page O V

tion of creating beautiful realization scores, Stockhausen has carefully notated every musical and technical detail of *Oktophonie* to an excruciating definition level. The score has also a long introduction (32 pages almost entirely repeated twice, in German and in English) in which the process of creating and reproducing the music is described at length. Thus, we may think that this is a good example of an electronic music work sufficiently described to reconstruct the piece forever and ever. However, a deeper look (and even more, an attempt at reconstructing the piece) will unveil a few dark spots like the passing references to technology and software such as the now-legendary “Atari 1040ST”, the “QUEG (Quadraphonic Effect Generator)” and the “Notator version 2.2” sequencer software. These references are completed only by photographic evidence – cf. Fig. 1, which unfortunately will not say much about the inner workings of these devices. The rest of the technical introduction contains a schematic description of the production system (cf. Fig. 2 – please note the reference to the “Notator diskettes”, with no further information of their contents), and the timings and dynamics of every track in every section. We are at a loss concerning the description of how the “QUEG” used to handle sound spa-

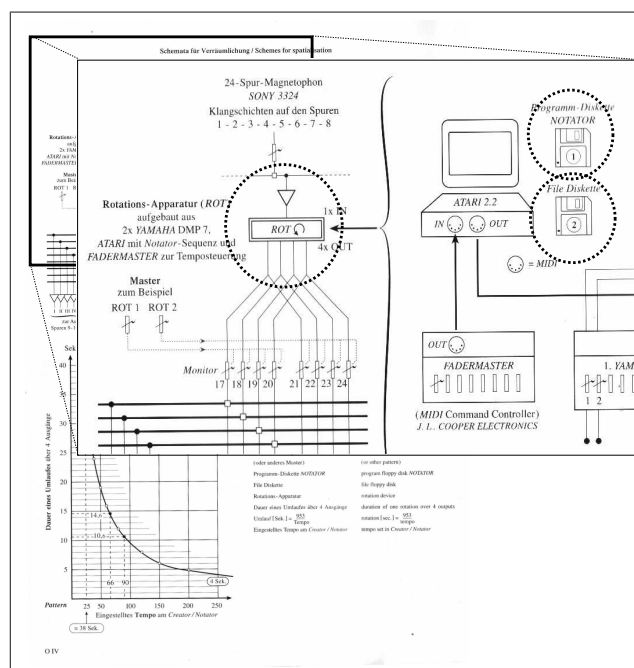


Figure 2. Stockhausen, *Oktophonie* — Page O IV, Details of the Schematic Description

tialization (inter-channel interpolation, measured amplitude ranges, etc.). The only reference on the web³ does not help much either. The “Atari 1040ST” has become a true museum piece⁴ and the company itself has long since gone into more profitable businesses. Emagic GmbH stopped supporting the Atari platform at the beginning of the new century and has been bought by Apple Inc. in 2002. The company has refused to release the source code or the binaries of the “Notator” program claiming that “it could steal potential Notator Logic customers”⁵ – so any form of data based on the “Notator Sequencer” running on an Atari platform is basically lost. Concerning this last point, there is only one chance: there is a (possibly still on-going) voluntary community of affectionate “Notator” users⁶ which may help out with the diskettes (this is important because it shows a clear case on a central issue in memory conservation – the power of communities versus the unreliability of companies).

In a case like this, we can only be very happy that a tape exists, because until that tape exists *Oktophonie* will exist. A faithful reconstruction is really difficult, if at all possible, because some essential information is missing.

This work is indeed the most significant we could find under several aspects.

1. *Oktophonie* provides a sufficient time perspective to show the main problem of live electro-acoustic music performance. Judging by music history time scales, *Oktophonie* is a very very recent work (it

³ <http://www.ems-synthi.demon.co.uk/emsprods.html#queg>

⁴ cf. for ex. <http://www.atarimuseum.com/computers/16bits/stmenu/atarist.htm>

⁵ http://www.notator.org/html/notator_faq.html#17 (“Notator Logic” being a completely different software running on Macintosh platforms)

⁶ <http://www.notator.org>

is dated 1990/1991) — musicologists would indeed consider it totally *contemporary*.

2. it shows quite clearly that time scales of technology and software are very different: the technology described in the score has been obsoleted by *several generations* now. It is hardly available or in working condition anywhere on the planet. If the realization of the score relies on the presence of this technology, then the work is irremediably lost unless a re-edition of the realization score is worked out, itself obsoleting the first edition.

Thus, while we acknowledge that Stockhausen and his collaborators have worked very hard on the score of *Oktophonie* to provide all the information required to reconstruct the piece, the score itself is the perfect example of how hard the problem of sustainability of electro-acoustic music is. The main point being: a reference to the technology used is simply not enough to reconstruct the piece.

However, *Oktophonie* is certainly not the most endangered work. The current trend of many live electro-acoustic music leads to many disconcerting examples. In constant seeking for precision and detail, composers produce scores which do include “the live-electronic part” saved digitally (often using proprietary non-disclosed format) on some media fitted to the purpose, using some (often proprietary) software application fitted to the purpose which runs on casual operating systems and hardware. live electro-acoustic performers are being told “You just press “Play” and everything starts”, and that seems to be the ultimate solution. It is in fact the ultimate grave for these works. Just consider that many of these works save the data/application on Iomega Zip Drives (now being discontinued) or non-industrial masterings on CD-ROM. As far as media go, the latter ones may last much longer through several backward-compatible editions, but will they last 50 or 100 years? will they last longer than that? We still consider Arnold Schönberg’s *Pierrot Lunaire* “recent”, don’t we?

4.2. Battistelli, *The Cenci*

Other examples may be less problematic. Here, “less problematic” does not mean that the authors are absolutely sure that these scores are indefinitely performable. All the score listed below still carry sustainability problems which we will try to point out. However, these scores show some successful attempts at sustainability. “Successful” means that attempts to perform the score without non-score hints from the composers and or her/his technical assistants do actually succeed⁷.

Giorgio Battistelli’s *The Cenci*[1] (1997) provides another good initial example. The score possesses a detailed initial legenda both for the symbolic notation used for the actors’ voices and for that used for the live electro-acoustic processing of orchestra and voices. As an example,

⁷ Often the problems are experienced by the composer herself/himself and/or her/his technical assistants when they try to pick up the work for another performance years later the première.

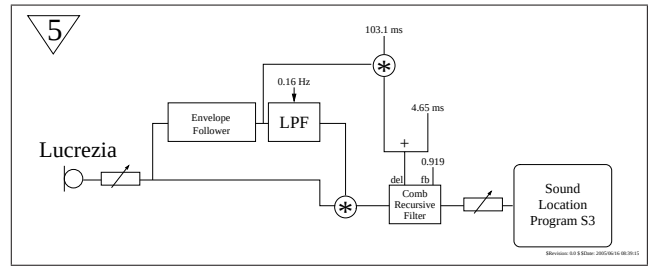


Figure 3. Battistelli, *The Cenci* — Processing definition (example)

fig. 3 describes processing n.6. The graphical description shows:

- the input/output flow
- the algorithm (in abstract terms)
- the properties of the object (i.e. the values) expressed in conventional units (i.e. Hertz, dB, etc.)

In the score, the processing is called on and off by a very simple and visible graphic device (shown in fig. 4). Score

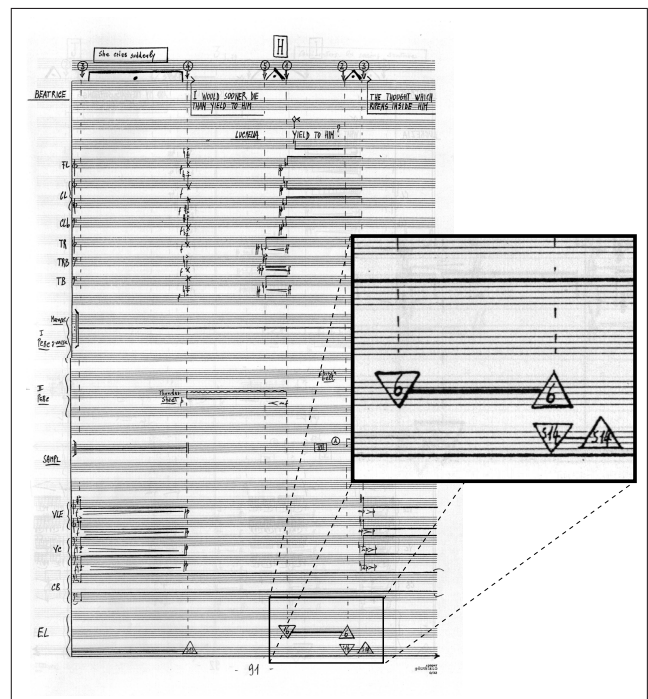


Figure 4. Battistelli, *The Cenci* — Processing calling (example)

and live electro-acoustic instructions are completely provided in technology-independent terms within the sheet music. The score explains in detail *how* to create every single processing device used within the work⁸, and then it shows precisely *when* it is to be performing in the music. As such, Battistelli’s *The Cenci* is fairly sustainable. Of course, the addition of impulse responses and isolated

⁸ there are 11 descriptions similar to that shown in fig. 3 and a glossary of 27 vocal effects in the score.

audio examples for each processing would indeed complete the picture, but the composition may already be reconstructed by the score alone as in fact it has been done at least once after the première performances with the original technical staff⁹. To be completely precise, a member of the original production team (Alvise Vidolin) was asked by the composer to join the sound crew towards the end of this latter production to help him (the composer) out with some final loose ends, but that had hardly anything to do with the way *The Cenci* was scored.

Later scores by Giorgio Battistelli are developed along the same lines, with a varying degree of detail and definition (cf. for example [2]).

4.3. Boulez, *Dialogue de l'Ombre Double*

Pierre Boulez's *Dialogue de l'Ombre Double*[4] (1984) for solo clarinet and live-electronics provides another brilliant earlier example. The electro-acoustic setting implies in this case some special miking of the clarinet, a natural reverberator built out of the resonances of a piano and the performance of a (recorded) "shadow" clarinet in a spatialized context in transitional passages between (real) clarinet solos.

19

Transition de 5 à 6

DMic	dc	IMic	di	PMic	reverb.	reverb. time
yes	1.5 m	no	---	yes	yes	1.8 - 2.0 sec.

comments: The sound from the DMic is sent to the digital reverberator and to the speaker under the piano. The transformed sound is picked up by the PMic. All levels should be set at 9/10.

Single final

DMic	dc	IMic	di	PMic	reverb.	reverb. time
yes	1.5 m	yes	5.5 m	no	yes	2.0 sec.

comments: The sound from the DMic is sent to the digital reverberator. During this section the levels vary. During measures 1 to 65, DMic remains at 10/10 while IMic plus digital reverberation increases gradually from 1/10 to 10/10. IMic remains at 0/10. During measures 66 to the end of the section, DMic decreases gradually from 10/10 to 0/10, DMic plus digital reverberation stays at 10/10, and IMic increases gradually from 0/10 to 10/10. Special attention should be given to the recurring high D's which, although played loudly, should sound more and more distant.

Figure 5. Boulez, *Dialogue de l'Ombre Double* — Transition description (example)

Each passage is described in plain words in a separate part of the score (an example is shown in fig. 5). Levels and volumes of each element are expressed in proportional form in tenths (i.e. 1/10, 2/10, ...), timings are in seconds, and sound location is expressed in terms of speakers going on or off at given cues in the score (again, in orchestra/score functional distribution — cf. fig. 6). No references to specific technologies are made.

Dialogue de l'Ombre Double is a difficult virtuoso piece both for the clarinet part and for the live-electronics part. However, it can be easily picked up, studied and re-interpreted from the score alone¹⁰. There are indeed

⁹ notably at the Hebbel-Theater in Berlin in 1999, under the sound direction of sound direction of Mark Polscher.

¹⁰ here too, there are many performances by several different players and teams.

4.2.1 Data for: version aux chiffres romains

Single Initial cue number	speaker(s) ON	speaker(s) OFF
1	1	-
2	3	1
3	5	3
4	2	5
5	5	2
6	4	5
7	6	4
8	3	6
9	5	-
10	2,5	3,6
11	4	5
12	1,6	2,4
13	2	6
14	4,5	1,2
15	3,6	4,5
16	2	6
17	4	-
18	5	3
19	1	4
20	6	2
21	-	1,5
22	4	-
23	1	-
24	3	-
25	2	-
26	5	-
27	-	1,2,3,4,5,6

comments: The data above indicates which speaker(s) should be turned on, and which speaker(s) should be turned off at each cue. This implies that sometimes speakers will remain on from one cue to the next. The transition from off to on, and on to off, should be as fast as possible. When the speaker is on, the level should be mezzo-forte to forte.

Figure 6. Boulez, *Dialogue de l'Ombre Double* — Sound location description (example)

a few problems in the correct interpretation of dynamic balances (the scales are neither scientific — such as *0dB*, *-12dB*, etc. — nor musical — such as *mf*, *fff*, etc.), but the overall scheme is very well thought out and it enforces sustainability.

4.4. Nono, *das Atmende Klarsein*

Luigi Nono's scores of his late electro-acoustic works have always been seriously endangered: the early scores derived from his manuscript were really too scarce in providing information to reconstruct a work from that repertoire. These works could only be performed by an extremely small group of gifted musicians which were personally trained and instructed by Nono for each work, and the electronics were no exception to this.

However, musicians and technicians along with the *Archivio Luigi Nono* have collected abundant notes and documentation over the years to reconstruct the late works in every details, and when publisher BMG-Ricordi decided to provide a new edition to each of these works, they were ready to answer the call.

Nono's *das Atmende Klarsein*[10] (1987) is one of the first examples of this daunting endeavor, and it is indeed the "closest-to-optimum" example so far.

Here too, the score is provided with a detailed description of each processing (cf. fig. 7 on the next page) along with a graphic pattern for performance (cf. fig. 8 on the following page). In addition, the 2005 edition of score comes with a DVD which contains:

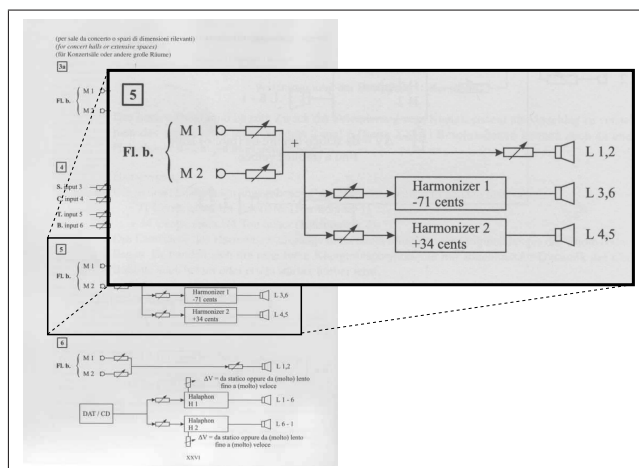


Figure 7. Nono, *das Atmende Klarsein* — Processing description (example)

- a historical introduction to the genesis of the work
- a commented performance (both for the flute and the live-electronics parts)
- an audio glossary of flute effects
- an introduction to the performance of the live-electronics part
- an overview of the performance practices of the choir

Most comments and introductions are provided by the première performers who have actually worked with Luigi Nono to the creation of the work.

It should be noted that the DVD does *not* carry a simple recording of the complete performance. As stated above (cf. Sec. 2 on page 1), a simple recording would probably jeopardize the possibility of other interpretation.

das Atmende Klarsein is the closest example so far to an optimum scoring system for live electro-acoustic music. A useful addition could be, here too, the presence of impulse responses for each processing element, and the replacement of references to specific hardware (i.e. the *Halaphon* — which is a well described instrument though) with the abstract functionalities of that hardware.

4.5. Harder Problems: spatialization

Representation of sound location in space still remains a harder problem to solve. Solutions such as the one adopted in Boulez's *Dialogue de l'Ombre Double* (cf. fig. 6 on the preceding page) work for relatively simple movements and settings. When things get more complicated, the space-time characteristic of sound location still poses great challenges to concise symbolic notation that can be learned by performers out of the score alone.

Figure 8. Nono, *das Atmende Klarsein* — Score excerpt

5. CONCLUSIONS

We hope to have raised with this paper the attention over a problem whose solution is ever more urgent as the time goes by: that of the sustainability of live electro-acoustic music works.

Since the first draft of this paper we have noticed at least another paper devoted to this precise issue (cf.[12]) in a knowledgeable and documented way. The authors provide interesting case studies of work reconstructions of two complex works by Luigi Nono (*Quando Stanno Morendo*, *Diario Polacco No.2* and *Omaggio a György Kurtag*). However, these studies concentrate on the technology needed *today* to reconstruct the pieces, and they fail to consider that the real “infinite” reproduction can only be obtained by creating adequate notation and transcription methods. The authors rely on specific current technology and hardware, thus simply postponing the problem to a later stage, maybe ten, twenty or thirty years from now.

Instead, we strongly maintain that live electro-acoustic works will stand a better chance of sustainability if their score will rely upon:

- low technology or no technology at all (paper, ink, standard measure units, etc.)
- redundancy of sources (wider diffusion, perhaps obtained via P2P technologies and open licensing)

schemes)

- isolated audio and impulse response examples recorded following standardized codings on sufficiently diffused media (such as the CD or the DVD media, though we acknowledge the problems which these media may encounter fifty years from now)
- last but not least, active communities of co-operating performers which will be conscious enough to share and document their experiences (implying of course the on-going performances of the works themselves)

In particular, any dependency from any form of computing platform and software should be strongly avoided in the scores.

6. REFERENCES

- [1] Giorgio Battistelli. *The Cenci — Teatro di musica da Antonin Artaud*, 1997. Text by Giorgio Battistelli and Nick Ward from the English Version by David Parry — Literal Translation by Myriam Ascharki.
- [2] Giorgio Battistelli. *The Embalmer — Monodramma Giocoso da Camera*, 2001-2002. Text by Renzo Rosso.
- [3] Nicola Bernardini. *Musica Elettronica: problemi e prospettive*. *Tempo Presente*, (89), 1989.
- [4] Pierre Boulez. *Dialogue de l'Ombre Double*, 1984.
- [5] S. Canazza, G. De Poli, Mian G. A., and A. Scarpa. Comparison of different audio restoration methods based on frequency and time domains with applications on electronic music repertoire. In *Proceedings of the International Computer Music Conference*, pages 104–109, Goteborg, Sweden, 2002.
- [6] Umberto Eco. *Trattato di Semiotica Generale*. Bompiani, Milano, 1975.
- [7] Nelson Goodman. *Languages of Art*. Bobbs-Merrill, 1968.
- [8] Victor Lazzarini. A proposed design for an audio processing system. *Organised Sound*, 3(1):77–84, 1998.
- [9] Michael Lesk. Preserving digital objects: Recurrent needs and challenges. In *Second NPO Conference on Multimedia Preservation*, Brisbane, Australia, 1995.
- [10] Luigi Nono. *Das Atmende Klarsein*, 1987 (1st edition), 2005 (2nd edition). Per piccolo coro, flauto basso, live electronics e nastro magnetico.
- [11] Deanna Marcum and Amy Friedlander. Keepers of the crumbling culture - What digital preservation can learn from library history. *D-Lib Magazine*, 9(5), May 2003.
- [12] Richard Polfreman, David Sheppard, and Ian Darden. Re-Wired: Reworking 20th century live-electronics for today. In *Proceedings of the International Computer Music Conference*, pages 41–44, Barcelona, Spain, 2005.
- [13] Henk J. Porck and Renee Teygeler. Preservation science survey: An overview of recent developments in research on the conservation of selected analog library and archival materials. Technical Report ISBN 1-887334-80-7, Council on Library and Information Resources, 2000.
- [14] Jeff Rothenberg. Avoiding technological quicksand: Finding a viable technical foundation for digital preservation. Technical Report ISBN 1-887334-63-7, Council on Library and Information Resources, 1999.
- [15] Canazza S., Coraddu G., De Poli G., and Mian G. A. Objective and subjective comparison of audio restoration methods. *Journal of New Music Research*, 30(1):93–102, 2001.
- [16] Karlheinz Stockhausen. *Oktophonie*, 1990/1991. Electronic Music of Tuesday from LIGHT, sound projection.