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On the Documentation of Electronic Music

Abstract: In a concert performance of *musique mixte* (i.e., music combining electronics with acoustic instruments), the documentation accompanying the score is of great importance. But this information is often missing or, at best, incomplete. Moreover, there has never been a systematic study of this subject. For these reasons, we decided to examine the documentation practices of the electroacoustic repertoire, with the goal of proposing a documentation model allowing for a better transmission and conservation of this repertoire.

If we consider the evolution of musical scores from a historical point of view, we can identify three periods. During the middle ages, music was notated in the form of manuscripts. After Gutenberg's invention of the printing press, music was printed, and from the Renaissance up to the modern era we lived with printed material. Now, in our computer age, we use electronic files. Even if we cannot find a computer to run Music V, the files used with Music V are still printable and readable, and they can even be copied by hand. But what about things that are not printable—such as multimedia files, interactive installations, live-coding performances, and even Web art, current art forms interacting with big data, cloud files? We are now becoming aware that this progressive dematerialization of the medium conveying musical information yields serious problems of preservation.

Anyone whose job it is to replay electronic music with computer technologies knows the importance of documentation. Each particular piece of music may have its own specific documentation. To interpret electronic music, the expertise of a computer music designer is often required (also known in French as a *realisateur en informatique musicale*). This term (Zattra 2013, 2018), which originated at the Institut de Recherche et de Coordination Acoustique/Musique (IRCAM), refers to a person with dual skills, artistic and technical, who realizes the electronic part of a piece (in particular for live

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performance, but also in the studio), usually in collaboration with the composer. The computer music designer not only has to read the score, but also other documents possibly accompanying the score. He or she can also listen to recordings, watch videos, and examine drawings, graphics, and photos. A telephone conversation with the computer music designer who played the piece at an earlier performance is likely to help. The job of a computer music designer is a global interpretation of an ensemble of disparate documents.

First, we have to quickly find how to start the "patch" in the documentation. Second, we must refer to the documentation and recordings to identify how the music should sound. Third, because of functional obsolescence, documentation has to answer to the question, "what do we do when it stops working?"

We will see in this article how historical pieces of music that were well documented enable anyone to play them from scratch, without prior knowledge. For example, documentation that was edited by Marc Battier at IRCAM between 1991 and 2002, called *cahiers d'exploitation* and *cahiers d'analyse*, are good examples of precise descriptions of how a piece should sound and how it is made to sound as intended. These days, the Sidney database at IRCAM offers a model of an environment allowing collective contribution to electronic music conservation.

Related Work

Considering day-to-day practices, we realize that documentation of electronic music is rarely an object of study collectively taken into account. Moreover, there is very little research in this domain. Although there is an emerging and growing literature on the subject of preservation of digital documents since the beginning of this century (see, e.g., Canazza and Vidolin 2001; Chadabe 2001; Teruggi 2001; Lee 2006; Wetzel 2006; Bonardi and Barthélemy 2008; Boutard, Guastavino, and Turner 2013), to the best of our knowledge the subject of studying the documents accompanying a score does not yet seem to have been addressed. It is, however, a vital subject for the preservation of the music of our time. A close, but slightly different, subject is the study of "e-sketches" recently covered by Twila Bakker (2017). Electronic music documentation studies can be related to the notion of paratextuality in the literary domain (Genette 1987).

User Manual and Musical Scores

The score plays a central role in the transmission of the Western music tradition. To play a classical or modern instrumental, orchestral, or vocal piece, usually the score is sufficient (except perhaps for medieval or early Baroque music). Everything becomes somewhat more complex when we want to perform a musical work involving an electroacoustic part: Several other documents are required, and these are often not included with the score. These are the *heterogenous* objects that are the object of this study.

To play such a work, the performer can use different types of information found in numerous kinds of documents, such as a "Read Me" text file, user manuals, technical riders, audio or video recordings, photos, pictures, drawings, scores, or even oral transmission. Structured and complete documentation of the pieces is very seldom found in this repertoire.

Unlike a conventional score, whose medium is paper, the information required to perform works involving recent technologies makes use of several kinds of media data storage.

In the absence of a standardized score for this kind of music, the question of a faithful transmission of the repertoire—allowing for the possibility of playing the music in a historically informed manner and preserving it for posterity—is not easy to answer. As of today, the transmission of this repertoire depends highly on the knowledge of the performers and computer music designers who are able to interpret these disparate elements. They also know how the music "should sound," but this knowledge is not easy to transmit.

As the electroacoustic repertoire has now matured sufficiently to arrive at its "Age of Reason," we believe that the time has arrived to propose a documentation model equivalent to traditional musical notation. This documentation should be sustainable, because we have seen that for data preservation over time paper always seems to be a better solution than digital archives. The latter cannot always guarantee physical integrity or content intelligibility.

The goal of this research is to examine the practice, in terms of notation and transmission, of the electroacoustic part of contemporary works, to detect any emerging consensus on good practices. In a second stage, we will be able to propose a more standardized model emerging from these disparate documentation models, in order to find a common language for the transmission of this repertoire. As with traditional musical notation, this language should also be useful for the creation of new works.

Historic Models of Documentation

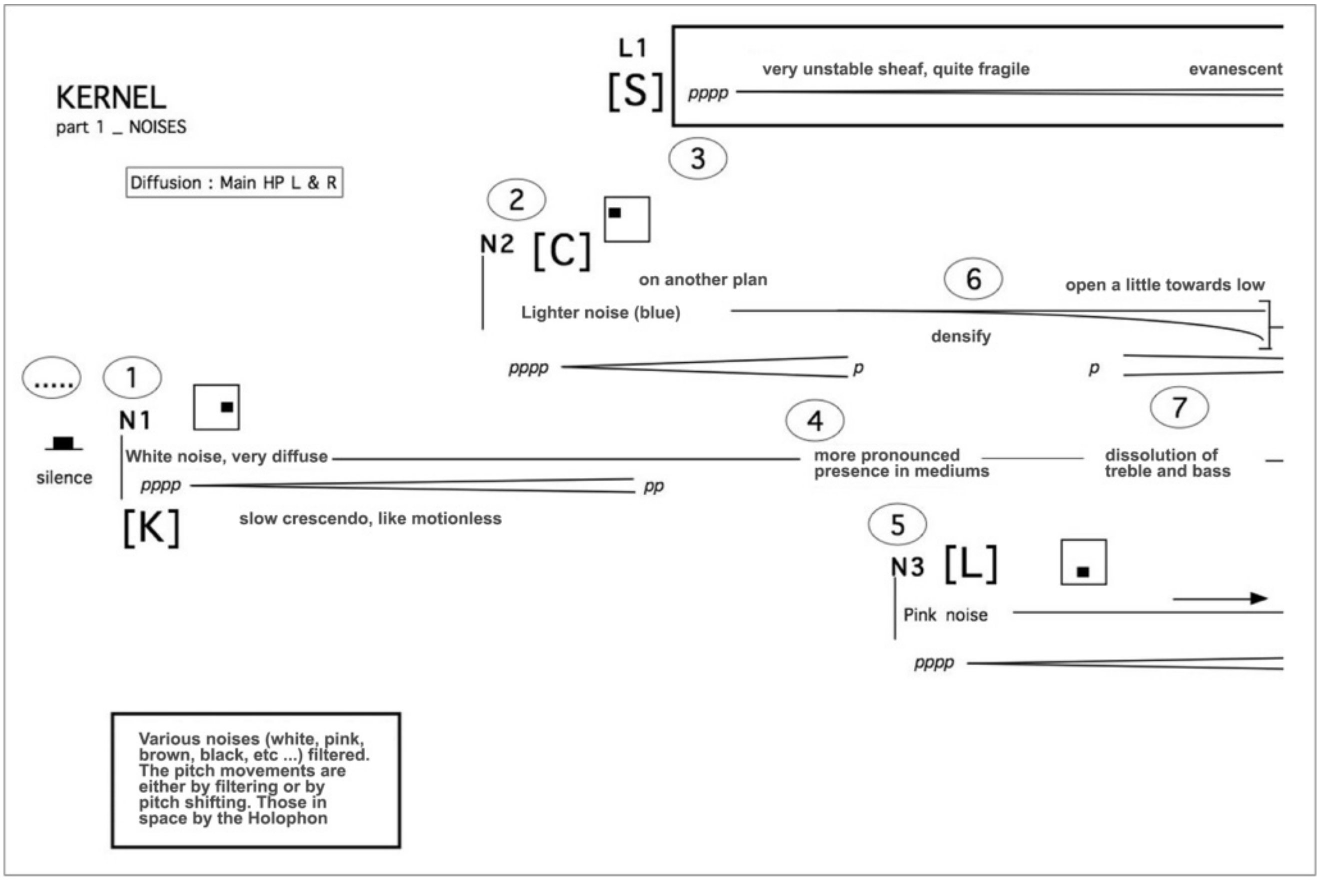
To obtain a better understanding of the documentation process, we have studied a large corpus of electroacoustic musical works from the point of view of documentation. These works span several periods, some recent and some more historical, and from diverse geographic and aesthetic spheres (and going beyond the IRCAM repertoire). We will present here are only a small selection of these items in detail, to show different typologies of and strategies for documentation.

Classic Works of the Electronic and Tape Music Repertoire

Karlheinz Stockhausen was one of the most well-known composers and pioneers of electronic music. He was also a composer who detailed the approaches he took in his work, often fully documenting each sound produced to realize his electronic works. For example, the piece *Studie II* (1954) has been described both by mathematical formulas producing the relations between the partials composing each of the sounds (which were nonharmonic), and by precise diagrams of the amplitude and register envelopes, which later allowed researchers to reconstruct the piece with software such as Max/MSP (Hajdu 2011) or Csound (Sousa Dias 2007). Stockhausen's techniques were not digital, however—rather, they were based on the use of analog tape recorders and long reverberation to mix sounds, thus giving them a particular timbre that is relatively difficult to achieve with digital technologies. Newer versions of *Studie II* do not sound exactly like the original, and consist of clearer, more precise sounds. Do the results perceived by the listener with these new versions correspond to what the composer expected half a century earlier?

In the field of computer music production, John Chowning has produced several well-known pieces, including *Turenas* (1972) in which he implemented two major innovations he had recently theorized: synthesis using frequency modulation and the spatialization of sounds. Made exclusively by synthesis with the Music IV program provided by Max Mathews' research, *Turenas* also used high-level composition functions, routines used to generate whole sets of sounds, according to arithmetic, random, or combinatorial processes. Until the end of the 20th century, *Turenas* was only documented by the sketches produced by the composer. It is only recently that Chowning handed over all the files that had been used to produce the piece. Because the Music IV family of programs are well documented (cf. Mathews 1969), these files give precisely the structure of each of the synthesis instruments used to produce the sounds, as well as the parameters of each of the sounds produced by these synthesizers. Thus, it is now possible to reproduce exactly all the sounds of the piece and synthesize them entirely with these data, using for example the Csound or the Max programs (Pottier 2007). Chowning also produced other files, however, showing how each type of file was produced and what compositional processes were used to make timbre interpolation or to move sounds into space, and so on. So the documentation is available at two levels: the sound synthesis and the compositional levels. A live arrangement of the piece was also made in 2011 to allow four percussionists to perform *Turenas Live* from a score and real-time gesture devices (Pottier 2013). Different versions (2011–2016) of *Turenas Live* are now available on IRCAM's Sidney Web site. Chowning's *Stria* (1977) also benefited from integral

Figure 1. *First page of the score to Kasper T. Toeplitz's* Kernel *(2002).*



reconstruction in environments more recent than the original ones (see Baudouin 2007; Dahan 2007; Zattra 2007).

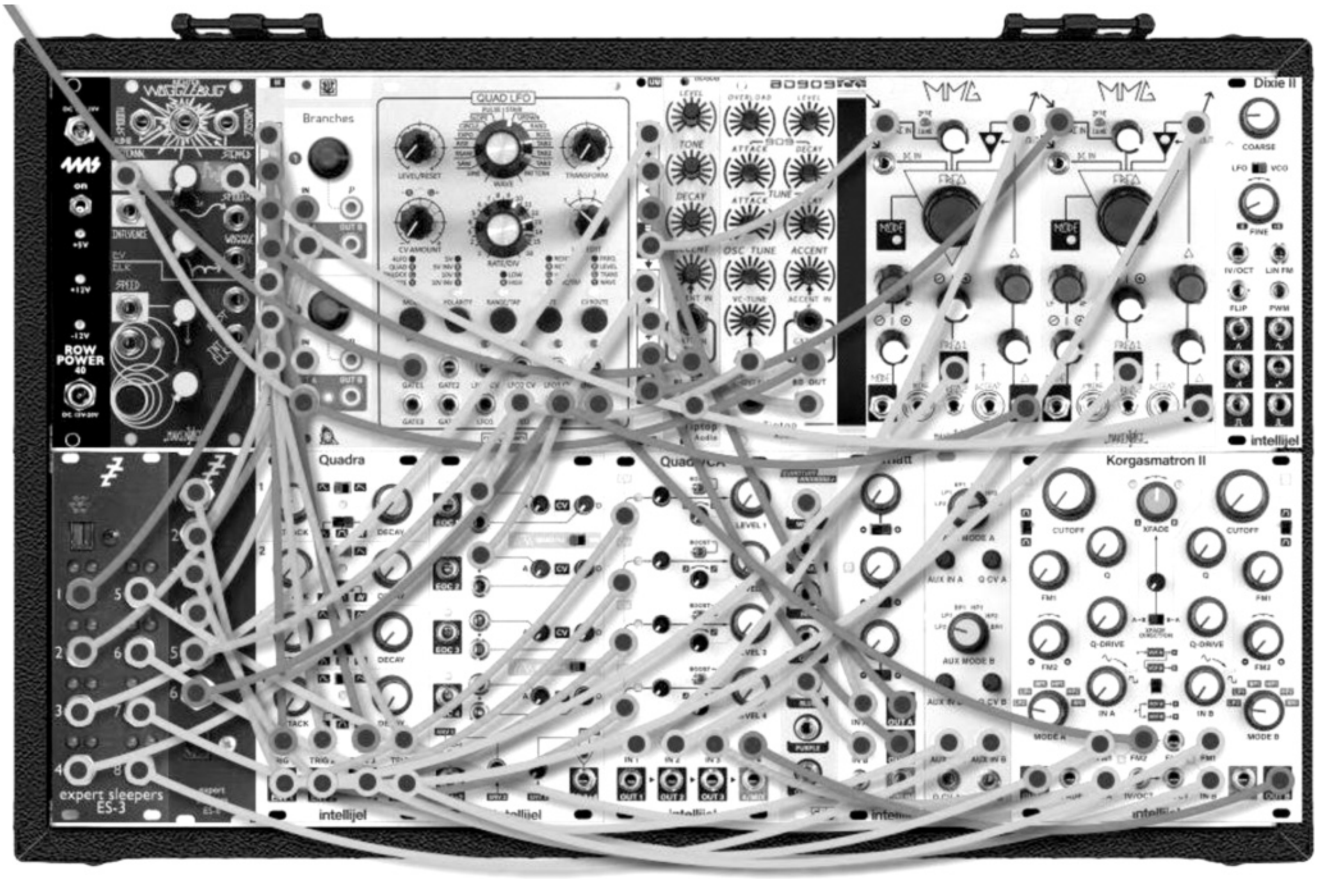
These examples by Stockhausen and Chowning are relatively rare exceptions in the world of electronic music for the quality of information stored in the documentation. Moreover, they concern music for fixed sounds. Real-time electronic music presents problems that are more complex.

Real-Time Electronics

In the case of interactive music, there are electronic instruments for synthesizing and processing sounds that need to be documented, but how to play and control these instruments should also be documented. The maintenance of analog synthesizers and real-time devices from the 1960s can be problematic, but digital real-time musical systems tend to be even less robust and more subject to obsolescence than other technologies.

The case of the French composer Kasper T. Toeplitz is rather distinctive. The various pieces he has composed as interactive *musique mixte* (i.e., music combining electronics with acoustic instruments) or purely electronic real-time music are all fully noted on graphic and textual scores (see Figure 1). They give no information on the DSP techniques necessary to produce or process sounds, they only indicate the sonic results to be produced, indicating the progression of time and the acoustic characteristics of the sounds to be produced. It is up to the instrumentalists to

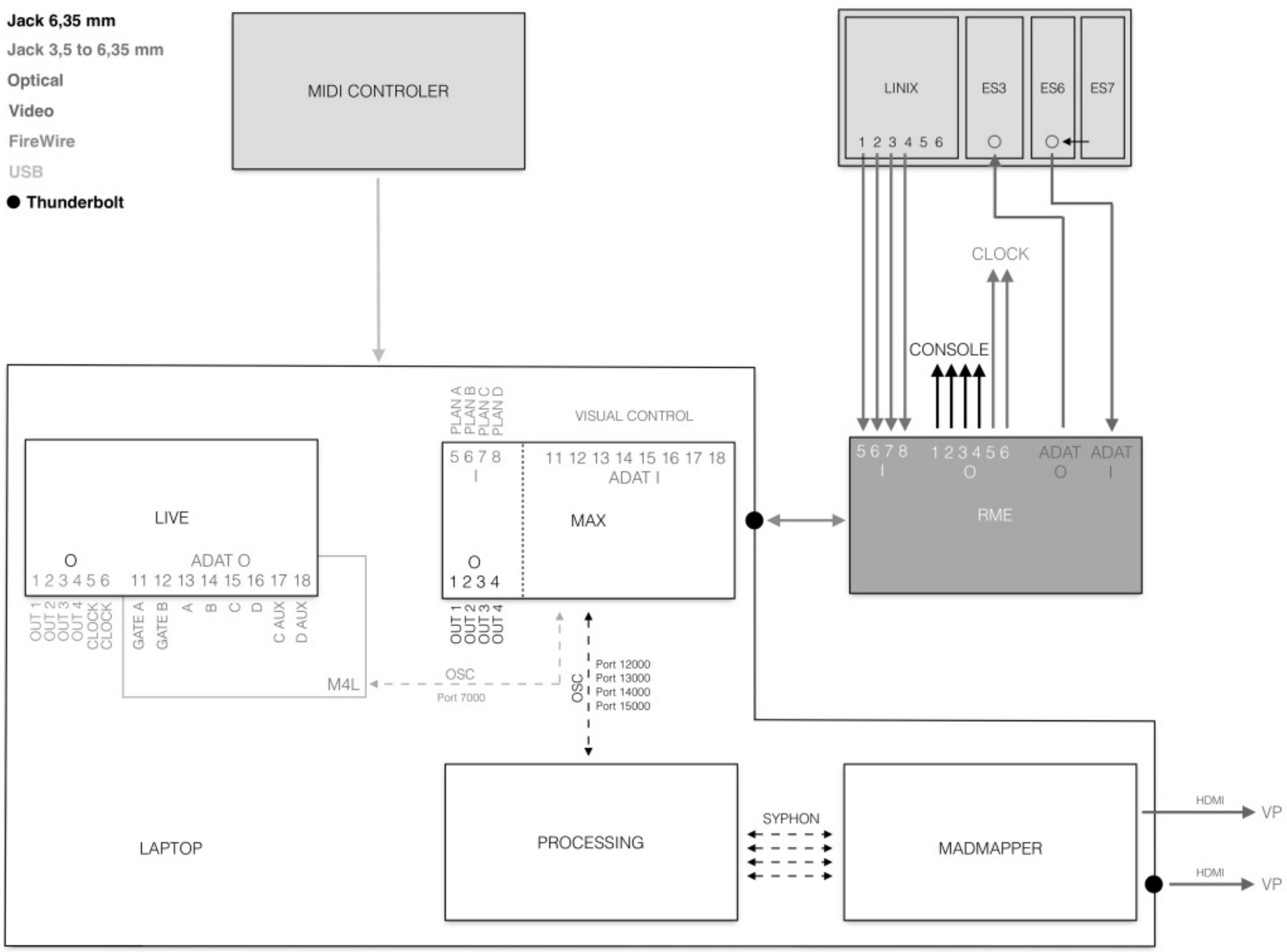
Figure 2. Graphical backup of the Linix synthesizer patch used in Alexandre Augier's _nybble *(2017).*



build their own instruments (usually using the Max program) and to play with them in concert. This assumes musicians have good programming skills, and are able to understand the composer's language and instructions. In fact, Toeplitz works regularly with the same performers. It might be interesting to make these scores available to other performers, who have not been "trained" by the composer, to appreciate what kinds of music might result.

In electronic music, many musicians use the program Ableton Live. How long can works made with this program, whose source code is unavailable, continue to be performed? According to the French musician Alexandre Augier, this question is a major concern. He works simultaneously with Live, Max, Processing, Madmapper, and an analog synthesizer based on a Eurorack module called Linix. Whereas the settings of the analog synthesizer are fairly easily preserved by photos or by connections made using the Modular Grid site (see Figure 2), the software part is much more complex to preserve. For each version of a piece, a document is written including a diagram of connections (see Figure 3), a checklist, and an indication of the versions of each piece of software used. The computer's operating system (Mac OS X) is updated as rarely as possible (it remained at the version Snow Leopard 10.6.8 for a long time at and is, at the time of writing, still at Yosemite 10.10). Despite this, with the latest version of Max, some external objects are no longer recognized, depending on whether 32- or 64-bit mode is being used. All older versions of the software (Max and Live) are archived on an external drive.

Figure 3. Software and hardware configuration of Augier's _nybble *(2017).*



In interactive music produced with Max, is it possible to program patches that are sufficiently well documented so that screen copies specify both exactly how the DSP scheme works and how the settings should be made in different parts of the piece, allowing them to be readily reprogrammed from scratch and generating the desired results?

For example, the patches made for the Tana String Quartet to perform Juan Arroyo's work *Smaqra* (see Figure 4, cf also Maisonhaute 2017). This is a work in which there is no computer music designer present during the concerts, all electronics are managed only by the musicians without any intervention in Max. The musicians must, however, know the precise DSP operations made by the program—the program was designed such that all the features are clearly documented to the extent possible.

We can indicate the way the Portuguese composer António de Sousa Dias and his team maintain important pieces of real-time *musique mixte*. They create new versions of these pieces, transferring works produced under an older technologies to use more modern technologies, adapting existing works with guidance from the composer, redesigning Max patches, etc. The resulting versions are stored on a GitHub session, making the tools to produce the piece accessible to any interested parties. Sousa Dias considers that with this practice—as is the case of Jorge Peixinho's works *Harmónicos* for piano and tape delay (1967–1986) and *Sax-Blue* for

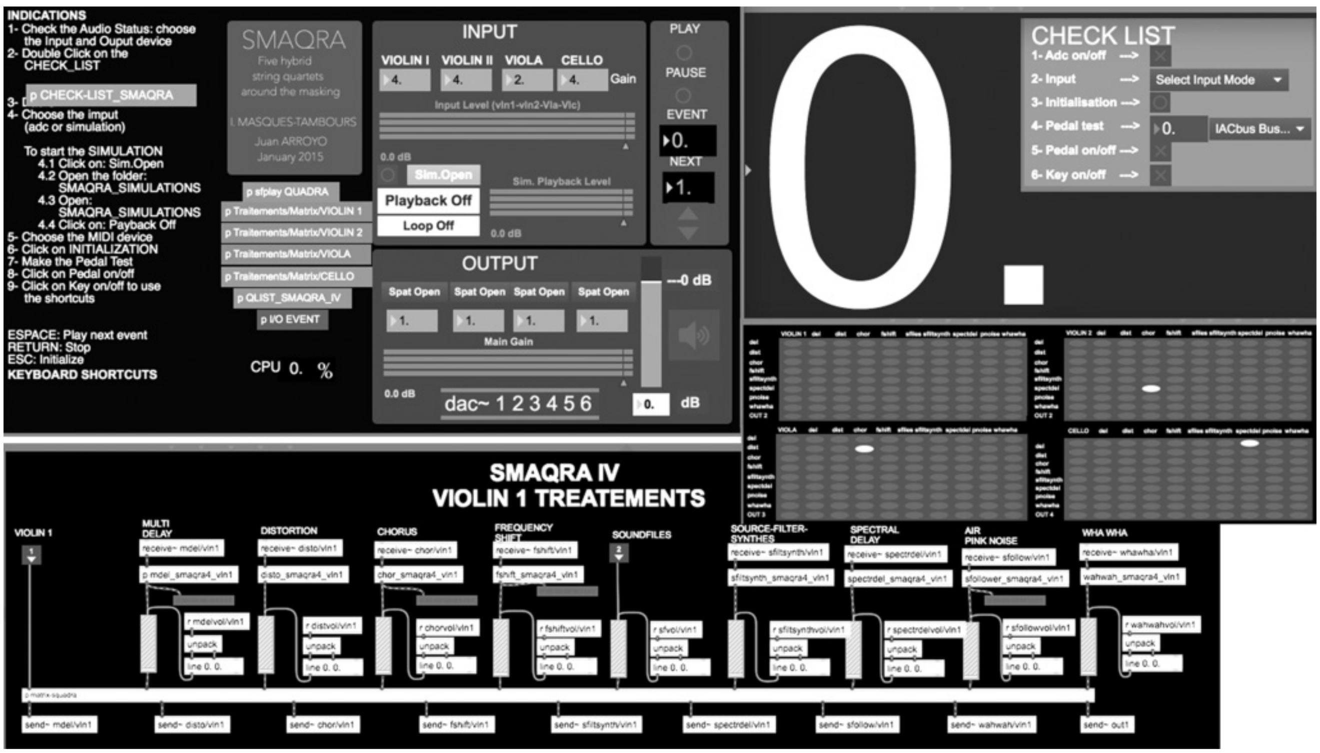


Figure 4. The main window of the Smaqra *(2015) patch for hybrid string quartet by Juan Arroyo.*

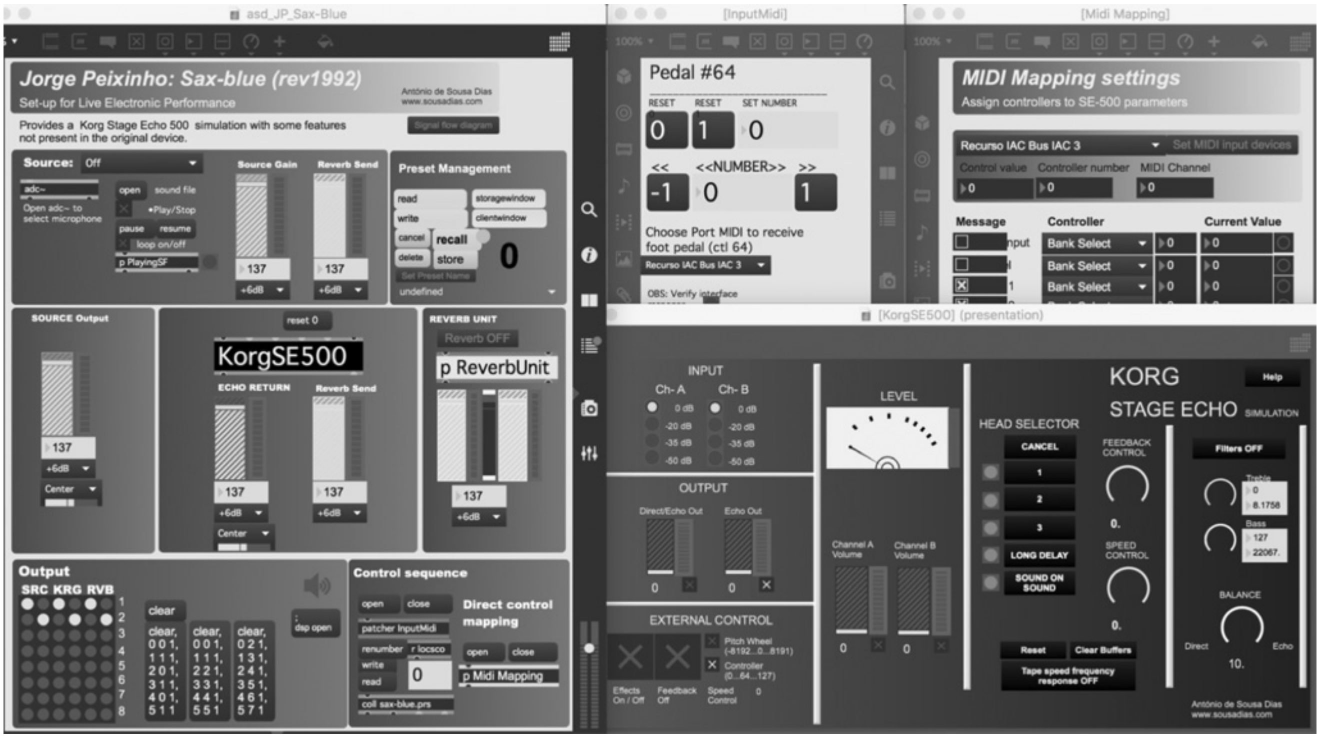
saxophone and echo chamber (1984–1992, see Figure 5), ported to new Max version environments by Sousa Dias (2009, 2011), or Jonathan Harvey's *Ricercare una melodia* (1984) ported by José Luis Ferreira (2016, pp. 141–147)—he has observed an increase in the number of performances of these pieces in Portugal. The GitHub sessions for the works by Peixinho can be found at https://github.com/asousadias/Peixinho_Harmonicos1967 and https://github.com/asousadias/Peixinho_SaxBlue1982.

French National Centers for Music Creation

A recent study conducted by our working group looked at work in the French National Centers for Music Creation (CNCM). These include the Grame center in Lyon; the Groupe de musique expérimentale de Marseille (GMEM); the Centre international de création musicale (CIRM) in Nice; Césaré in Reims, La Muse en circuit-Paris in Alfortville; and the Studio de Création et de Recherche en Informatique et Musiques Expérimentales (SCRIME) in Bordeaux. Our study showed that there has been neither a concerted action nor any rigorous practice concerning the long-term preservation or documentation of live computer music at these centers. We have contacted the computer music producers of each of these centers and collected their answers to the following question: How are the electronic archives of the real-time pieces developed in your center collected and preserved?

The most common response was that the lengths of composers' residencies for creating works are often so short (only a few weeks) that there was not sufficient time for any documentation. As a general rule, files are saved, works are recorded, sometimes filmed, and electronic parts are sometimes recorded separately as audio files. The trend is for composers to avoid closed commercial tools for real-time works

Figure 5. Patch schematics for an updated version of Jorge Peixinho's Sax Blue (Sousa Dias 2009, 2011).



as much as possible. Additionally it was noted that, for Max patches, composers limited themselves to standard objects.

The question of backups concerns the problem of the programs' DSP architecture, the management of the events (triggering, presets, score following), and the interfaces for gestural controls.

Documentation in Previous Preservation Projects

The Mustica Research Initiative was an international project led and coordinated by the University of Technology of Compiègne, built on a collaboration between two contemporary music institutions, IRCAM and the Institut national audiovisuel, Groupe de recherches musicales (INA-GRM), by performing research on the topic of contemporary music preservation between 2003 and 2004 (Bachimont et al. 2003; Douglas 2007). Although this project was a collaboration between institutions, the preservation prototype was developed and hosted at IRCAM. At the end of October 2006, the project had referenced 54 IRCAM works. It provided access to many sources of information: a PDF document generated on the fly (including the main patch, the loudspeaker implementation, and the audio and MIDI setup), audio excerpts (generally in MP3 format), pages in the Base relationnelle d'articles hypertextes sur la musique du 20e siècle (BRAHMS) database about the composer and the work, various publications, and the possibility of purchasing the CD.

The project Analyse et synthèse de traitements temps réel (ASTREE, 2009–2011) brought together IRCAM, Grame, the Centre de recherche en informatique (CRI) Armines, and the Centre interdisciplinaire d'etudes et de recherches sur l'expression contemporaine (CIEREC) at the University of Saint-Etienne. The project focused on the explication of live electronic processes using Faust (a programming language developed at Grame starting in 2000), the generation of documentation, and the constitution of knowledge based on these processes. It provided the opportunity to create Faust code and documentation for Chowning's *Turenas* and *En Echo* (1993) by Philippe Manoury (cf. Bonardi 2013). The documentation generated consists mainly of the elicitation of the live sound processes. With a basic knowledge in mathematics, anyone can regenerate the electronic sound transformations, although temporal control values are not represented. In a way, the generated document can be included in the musical score to indicate the electronic content.

IRCAM Repertoire

The institute created by Pierre Boulez in Paris more than 40 years ago is the birthplace of a great number of musical works using technology. The corpus represents more than 800 musical works, not counting all the pieces composed and produced by the young composers from the pedagogy department.

Les Cahiers d'exploitation

From 1991 to 2002 the musical pieces commissioned by IRCAM and realized in their studios were documented under the editorial responsibility of Marc Battier. He often wrote these manuals in collaboration with the musical assistants responsible for the realization of each work. These manuals were called *cahiers d'exploitation*; about 100 IRCAM-commissioned works were documented in this way. Figure 6 shows the table of contents for a typical *cahier d'exploitation.*

As implied by the document name, *cahiers d'exploitation* (literally, operation manual), each contained all the information required to perform a specific piece. Also during the period 1991–2000, a few musical works were documented in greater detail using so-called *cahiers d'analyse.* These documents contained many interesting details about the creative process behind the production of a work, including computer-assisted composition systems used, design of the interactive part, score followers, aesthetic and theoretical considerations, etc.

Sidney

Sidney is the name of the online database used in the IRCAM production department to store all the elements required to perform the institute repertoire pieces (Lemouton 2016).

Sidney is part of the BRAHMS database (www.brahms.ircam.fr, see Figure 7), which intends to document all contemporary music since 1945. Sidney contains data about almost every work created at IRCAM. Its goal is to archive and to document the technological part of all electroacoustic pieces produced at IRCAM, from the technological state of the work when it premiered to its latest public performance. Because Sidney is an evolution of the MUSTICA project, whose data model was developed by Bertrand Cheret (Sirven 2004), the main concept is the *work version.* The idea here is to document not only every work but also every version of each work. As we are in a technological context that is evolving at a rapid pace, it is not possible to preserve a work as such, simply because each new performance with real-time or interactive systems requires updates or modifications. The "musical work" object is stored in the BRAHMS database, whereas each "version" object is stored in Sidney (inheriting from BRAHMS content). This idea of focusing the documentation not on the work but on each version of it is unique among all existing preservation projects.

The main technology used for the development of this site is the Django Framework (https://www.djangoproject.com).

The data are structured in a MySQL database, through the Object Relational Mapping provided by Django. The underlying data model is shown in Figure 8.

The Sidney model has proved to be sufficiently effective to be adopted by almost every IRCAM computer music designer. The whole community uses it systematically to document and to store patches after every new performance. It is a kind of archive: Every successive version of the work is kept, and it is also a digital repository of the performance material of contemporary repertory of *musique mixte*.

Figure 6. Table of contents for a typical cahier d'exploitation, *a format used at IRCAM for over a decade for the documentation of works realized there.*

Contenu

The target users of this site include all the contemporary music actors: computer music designers, composers, publishers, producers, concert organizers, sound engineers, scholars, students, etc. Each time concert organizers plan to program pieces created at IRCAM, they ask us for a list of required materials. With Sidney it is easy to respond to these requests quickly. The documentation in Sidney can be created in a relatively free form.

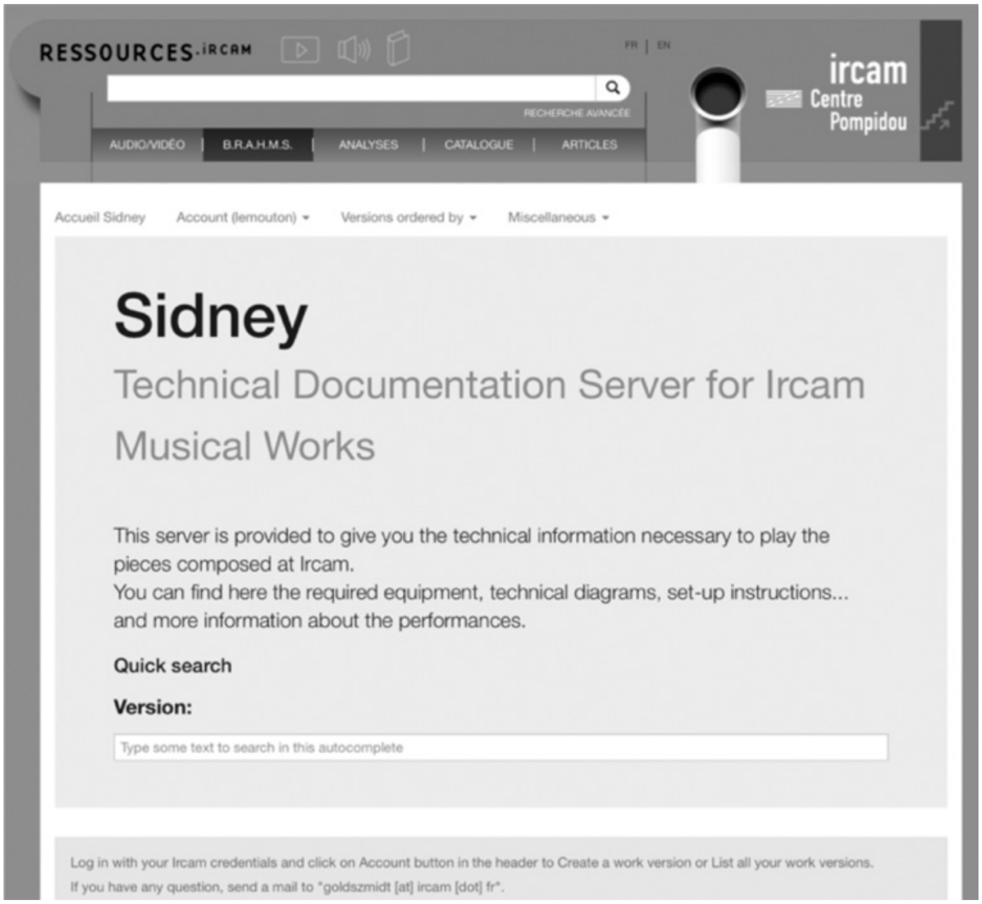
During the system design, the decision was taken not to put too many constraints or verifications on the ways data are entered. The idea was to make data input a fast and easy task. Before being marked as Valid (potentially available for distribution outside of IRCAM), a version can go through the following states (see Figure 9): Unknown, Archive, In Progress, Documented, and Valid.

The validation phase, performed a posteriori, is essential to verify that all the information required for proper documentation is provided. When a version has been validated, it means that the work is ready for use at the time of the validation and for a duration dependent on the rapid evolution of the technologies involved.

The estimation phase consists of an evaluation of the resources required to update a piece that is no longer performable in its current state.

A documentation charter exists (albeit it in a permanently evolving state), and is given to each Sidney user. Every contributor should conform as

Figure 7. Sidney home page.



much as possible to this chart, summarized in Figure 10, so all the documentation elements are complete. This allows for a new performance and possible future ports. This document lists all the elements that should be present in the documentation: instructions, things to be done to play the piece, performance notes, etc.

The validation step consists of verifying that the documentation conforms to the different points of the charter.

As of the time of this writing, there are almost 1,000 versions of 550 different musical works documented in Sidney. Of these, 122 versions have the status Valid.

Each Valid work documentation in Sidney contains detailed written instructions, in English, on how to perform the piece.

This exceptionally large corpus of documented musical works could be an object of musicological study in and of itself. For instance, the first author proposed an automatic analysis of the contents of Max patch of a subset of this base to classify the role of the electronics in the *musique mixte* (Lemouton 2016).

Theoretical Considerations

After having studied, ported, and performed a great number of works, we are now able both to find some common rules and to express certain generalities about the documents accompanying musical scores from the computer music repertoire.

Figure 8. A simplified representation of the Sidney data model.

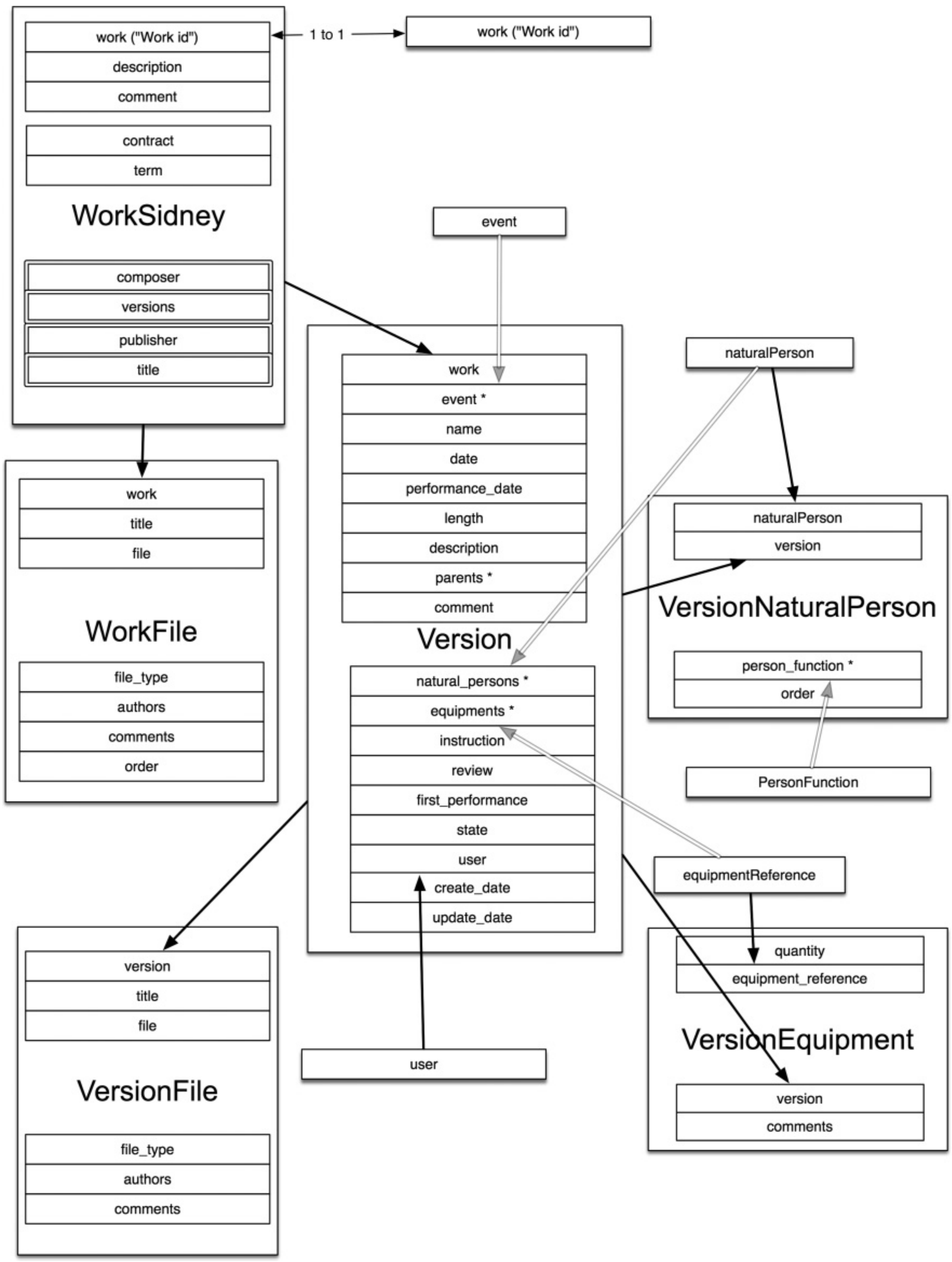
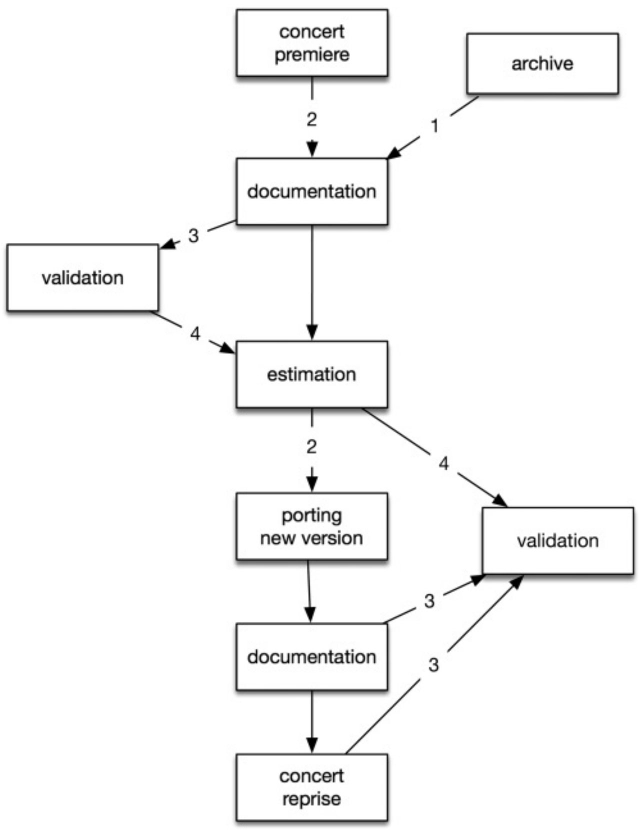


Figure 9. Lifecycle of a Sidney work version, showing the different states of the documentation. The numbers indicate different states: 1 for Archive, 2 for In Progress, 3 for Documented, and 4 for Valid. The Sidney model includes an additional state, 0 for Unknown, not displayed in the figure.



Documentation Classifications

The documentation of electroacoustic works is very heterogeneous; it does not consist only of textual documents. We find drawings, diagrams, tables, sound files, pictures, etc. This heterogeneous nature has some consequences for the possibilities of storage and preservation, and it has to be taken into account when designing a digital repository.

The information contained in accompanying documents may be of several natures: what is described can be the composer's intentions or the result. It can also be a description of the way to realize the work. In other words, the why, the what, and the how.

If we draw a parallel with traditional music notation, the what-versus-how dichotomy corresponds in a certain way to the difference between a transcription (a notated description of a musical event) and a tablature (prescribing what to do to produce the music).

To illustrate this dichotomy, we can compare the score of two electroacoustic pieces of the 1950s: György Ligeti's score to *Artikulation* is a "listening score," realized a posteriori (a kind of visual transcription of the music), whereas Stockhausen's *Studie II*, discussed earlier in this article, is an extremely detailed description of the way to produce the piece and can even be used to reconstruct it.

The composer's intentions can be expressed as text (spoken or written), as graphic sketches, more or less precise drawings or music notation. On the final product side, we can find computer code (Csound score files, Max patches, etc.), sound files, but also traditional musical notation and graphic notations.

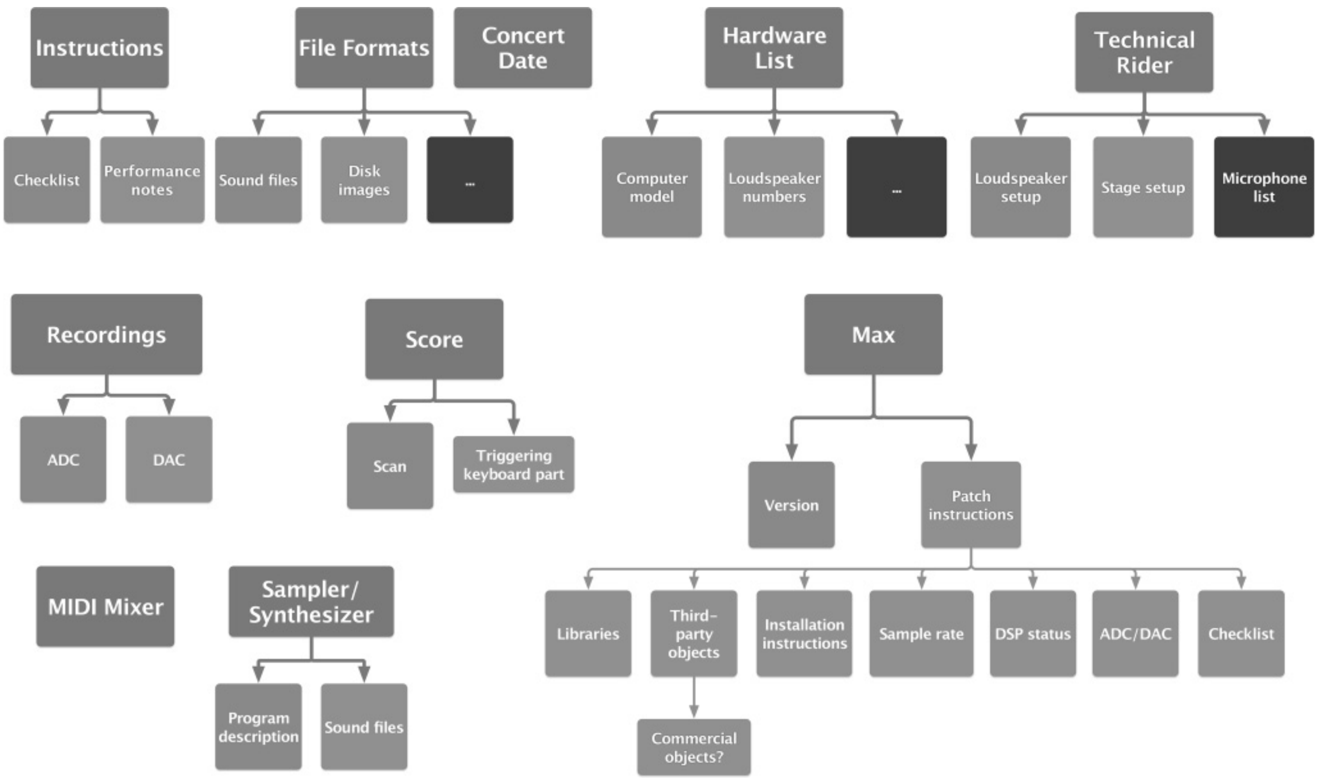
The documentation accompanying an electroacoustic work can be either descriptive or prescriptive. It can be a description of how the piece should sound and how it is constructed, or a step-by-step list of instructions telling the electronic musician how to prepare the complete setup and to perform the work. These two categories correspond to the *cahier d'analyse* and *cahier d'exploitation* discussed previously.

We can find performance instructions, in textual or oral form. These instructions, often related to general levels of volume, acoustic balance between the layers, actions to be made during the performance, or more aesthetic recommendations, can be more or less precise, but are nevertheless always essential documentation of the composer's intentions.

Less often, instrument specifications can be found. For example, a precise description of the content, functionality, and architecture of a Max patch can be invaluable in understanding its operations, without having to reverse engineer the patch in its entirety. Formal, standardized specifications of sound-processing modules are highly desirable to facilitate porting and sustainability of the music using such modules.

An overwhelming majority of works in interactive computer *musique mixte* are programmed in the Max environment. As in any programming language, each author has an individual style. A patch can be

Figure 10. Chart showing the information data types that should be present in a Valid Sidney documentation.



easily readable, or less so. Some developers include extensively informative and useful comments inside the patch, whereas other patches are entirely bereft of self-documentation. The patch structure can be more or less intelligible. The differences in the styles of several computer music designers programming in Max can be identified by automatic analysis of the patch structure (Lemouton and Goldszmidt 2016).

A good Max patch can contain its own documentation, and all the steps necessary to set up the performance (audio routings, loudspeaker tests, calibrations, etc.) can be directly performed from inside the Max patch before the concert. But do we know of an ideal Max patch that can be run without any supplementary written or oral explanations, without any contact with the composer or the computer music designer?

The programming of the electronic events can be done in several ways. Events can be stored as Max patches or software programs; they can be stored on the computer as more-or-less readable proprietary file formats; or they may be stored as text files (Max qlists, Csound scores, Antescofo scores, etc.). Text files always seem to be preferable, as they can be more easily ported, read, and stored. The electronics part of Pierre Boulez's *Anthèmes 2* was recently reprogrammed from Max patches to Antescofo scores. It was the occasion to make a more readable electronic score, closer to the printed musical score, as well as the occasion to correct some errors ("wrong notes") that were difficult to detect in the original Max programs.

A programming environment allowing the visualization of the electronic score in the form of a timeline adds some readability. Such systems fill the gap between the computer score and the musician's score. In Figure 11, showing an excerpt of a piece for viola and electronics written by Julia Blondeau (Fober et al. 2015), we can see, gathered together in the same window, a representation of

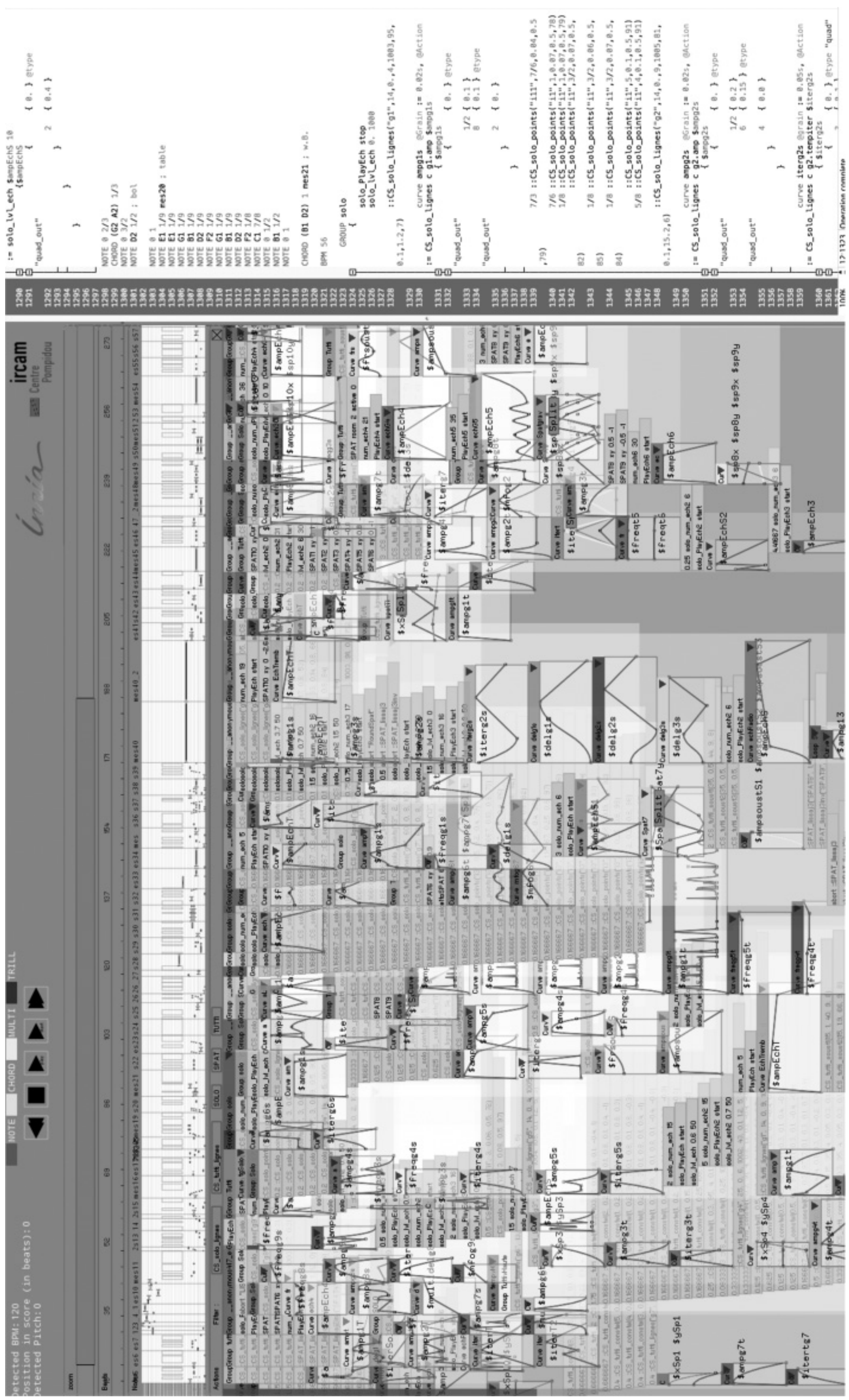
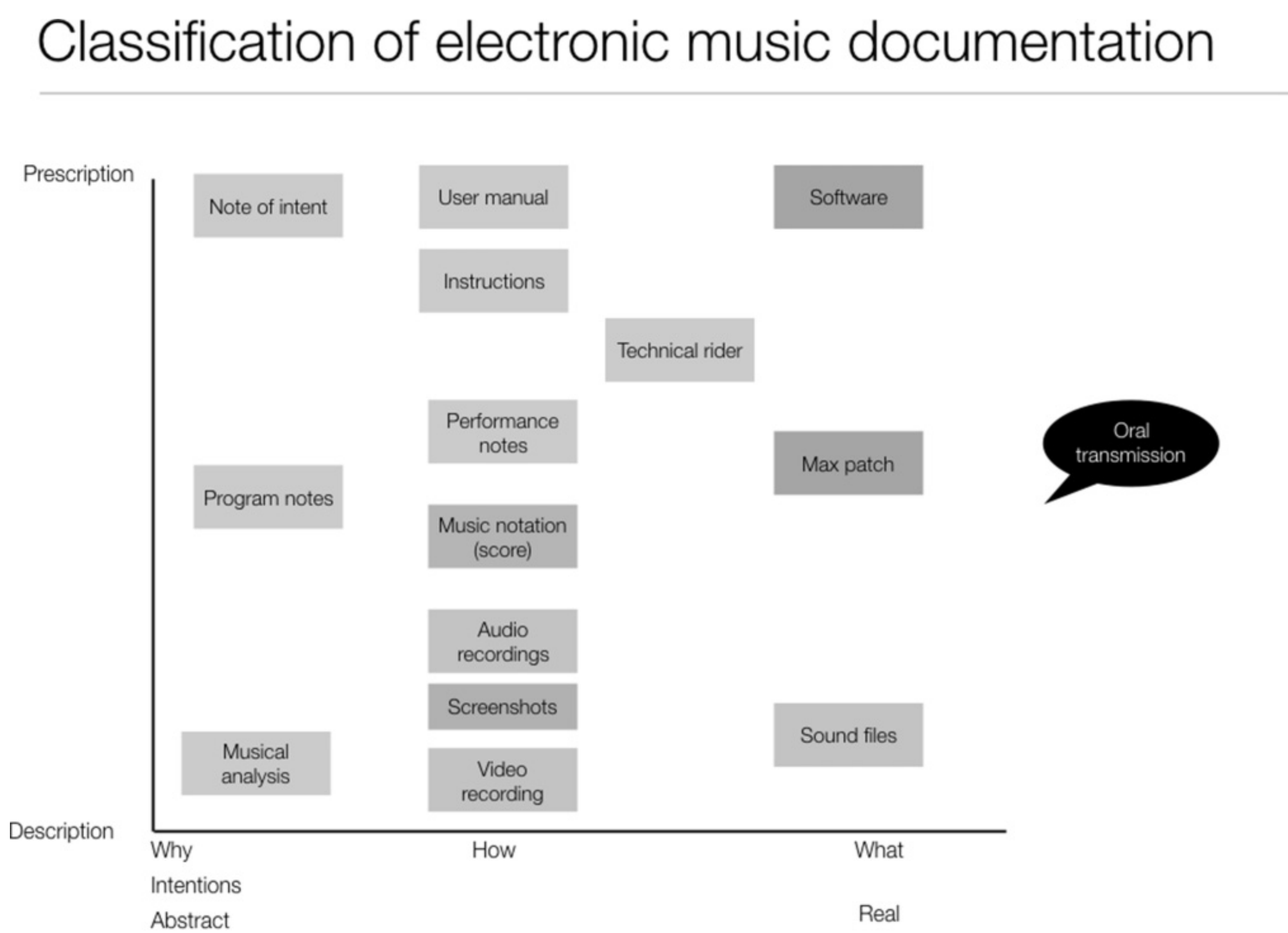


Figure 11. Ascograph representation of Julia Blondeau's Tesla.

Figure 12. A classification for all the kind of electroacoustic music scores paratexts.



the performance score (top left), the electronic score as text (on the righthand side) and a visual representation of the computer part at the lower left (below the performance score).

Thanks to the Ascograph software (Coffy, Giavitto, and Cont 2014), and to Ascograph's graphical user interface, this representation is more than a visual depiction—it is an operational score in the sense that it can be played by the computer. To have this kind of operational representation of an electroacoustic composition proves to be invaluable in understanding, debugging, and performing the piece. Unfortunately, the development of the Ascograph software has been discontinued.

A useful element when a work of *musique mixte* using real-time transformation is received for performance is the presence of an audio recording of the instrument or instruments that are to be transformed. This recording of the acoustic part of the work, called an "ADC recording" or a "simulation," can be used to test the Max patch before the performance, to rehearse the piece without the presence of the musician, and to test the score-following system, if necessary. It is also a crucial element when the software environment requires porting. The practice of systematically recording the input of a concert Max patch and distributing the audio recording is highly recommended.

We are now able to synthesize our study of the different types of documents (*paratexts*) into a proposed classification, illustrated in Figure 12.

What Should Be Done to Improve the Situation?

We have seen that proper documentation is crucial for the interpretation, transmission, and sustainability of works of *musique mixte*. Since the establishment of this repertoire, several practices have emerged. We are now able to identify and classify the different information elements found in documentation of works. It is now possible to identify what can be considered as best practices to develop digital data systems for storing this information and for proposing methods toward standardizing such documents. When implemented and adopted, this standardization of computer music notation will be an important step in the history of electronic music.

Conclusion and Perspectives

Museums put together international groups of research, such as the International Network for the Conservation of Contemporary Art (https://www.incca.org), to gather answers on the subject of cultural heritage. Their aim is to be able to show their collections of contemporary artwork in the future.

A working group called Archivage collaboratif et preservation créative [Collaborative Archiving and Creative Preservation], gathering several French institutions, is supported by the Association Francophone d'Informatique Musicale (AFIM). This working group started its activities in the beginning of 2018. Its goal is to network our ideas and to find the best ways to document the music we play today so that we will also be able to play it in the future. The group will also work on the question of long-term preservation of databases in reliable digital repositories. It will also have to work on legal issues concerning rights of collaborative multiauthor documents in a technoartistic context. The main goal of this group is to propose a model and to develop a functional preservation system allowing all parties concerned in the writing of electronic scores (composers, computer music designers, sound engineers, publishers, etc.) to collaborate on the elaboration of a common, shared documentation database.

To conclude, we would like to add a few words on the works of Jean-Claude Risset, who passed away in November 2016, and say that the question of documenting and preserving his digital music should be envisaged in collaboration with GRM, the Perception, Representations, Image, Sound, Music (PRISM) research center in Marseille, the Groupe de recherches expérimentales sur l'acte musical (GREAM) research center in Strasbourg, the CIEREC research center, IRCAM, Stanford University, and perhaps other partners. Two recent conferences in Paris examined this subject (see "Hommage à Jean Claude Risset" at https://musinf.univ-st-etienne.fr/recherche2.html).

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