The Computer Realization of John Cage's *Williams Mix*

Tom Erbe
UC San Diego
tre@ucsd.edu

ABSTRACT

This paper describes the process of creating a new performance of John Cage's early tape music piece Williams Mix (1952). It details the features of the score, the sound library, and the process used by Cage and his group of friends (David Tudor, Earle Brown, Louis and Bebe Barron, etc.) to construct the piece. The construction of a new version of the piece is then described, discussing the problems interpreting the score, the collection of sounds according to Cage's specification, and the creation of a computer music patch to perform Williams Mix.

1. INTRODUCTION

In the summer of 2012, I decided to attempt a new version of John Cage's second piece for magnetic tape, *Williams Mix*. My intent was to create performance software that would vary the unfixed elements and make each playing of the piece unique. As no-one had performed *Williams Mix* directly from the score since the original realization[1], I was interested in what would come from a strict adherence to the original score and notes – to find whether a new performance would resemble Cage's original rendition.

The main impediment in creating a performance of *Williams Mix* is the length and detail in the score [1]. Each of the 192 pages depicts 20 inches of 8 tracks of magnetic tape. The entire piece contains over 3000 tape splice shapes, and each shape requires at least 8 measurements. As I have recently worked on several large and complex recording projects (Lucier's *Slices* and Berio's *Duetti per due violini*) I felt ready to take on the task.

My approach was to manually record all of the information from the graphic score onto a spreadsheet. I collected a new sound library of 500-600 sounds of "all audible phenomena"[1] by making new field and other recordings, and by asking around 20 of my friends and colleagues to contribute. Finally I created a computer program in the music language Pure Data that reads the event data and selects, sequences, edits, fades, spatializes and processes the sounds according to the score markings.

[1] It should be noted that both Larry Austin [8], and Werner Dafeldecker & Valerio Tricoli [9] composed new interpretations of *Williams Mix* adopting Cage's compositional methods (although not following the score).

Copyright: © 2016 Tom Erbe. This is an open-access article distributed under the terms of the Creative Commons Attribution License 3.0 Unported, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

2. APPROACHING THE SCORE

The first task in performing *Williams Mix* was to convert the score into a form that could be read by computer software. This required identifying, measuring and noting all of the sonically relevant features on the score. I worked initially with my colleagues in computer graphics to see if the measurement process could be expedited, but it soon became apparent that the noise and complexity of the score made an automated process more of a computer research project than a solution. After scanning the score at high resolution, and adjusting the scans to match the original size of the score, I then proceeded to measure *Williams Mix* manually.

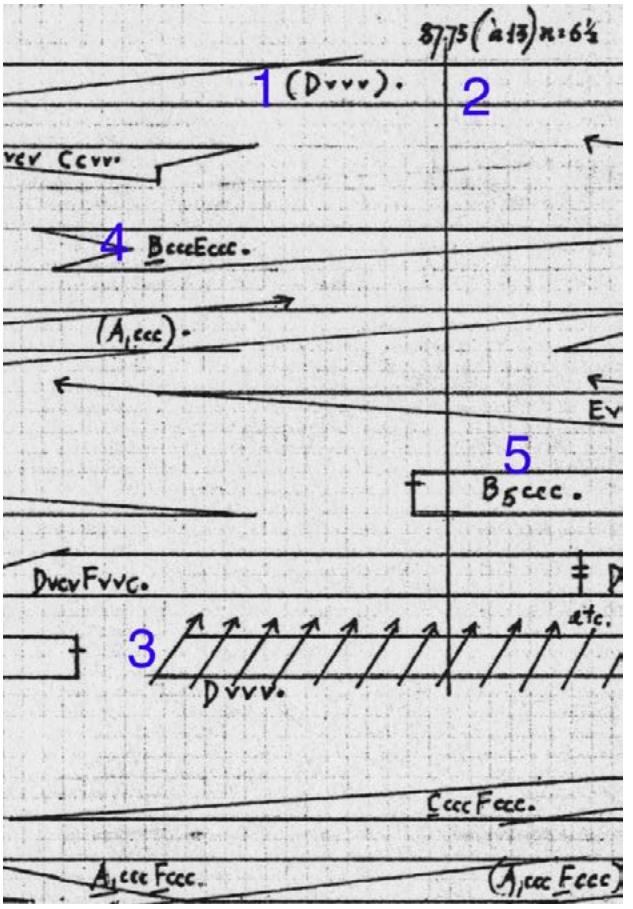

Figure 1. Features in the score: 1) Parentheses around category, 2) Section markings, 3) Crosscut splicing, 4) Looped double sound with double fade in, 5) Hash mark indicating indeterminate fade type, number indicating specific Bccc sound .

The score for Williams Mix is a diagram of the pattern of edits of 8 channels of magnetic tape. The tape is shown at 100% scale, so one could lay the tape on the score to cut the tape "like a dress-makers pattern" [2]. Each page represents one and one third of a second of sound (twenty inches per page divided by a tape speed of fifteen inches per second) and the score is 192 pages for a total length of 255 seconds (the piece ends in the first half of the last page).

Before I started work, it was important to determine what features to measure and record. Each tape splice segment has a shape, a channel (from 1 to 8), a start and end position, one or two sound categories, and several marks indicating particular editing techniques which result in various sonic transformations. This includes: a horizontal dash at the beginning and/or end of the splice; cross-hatched arrows throughout or at the beginning or end of a splice, and an underline under either of the sound categories.

Cage describes most of these marks in the note to the score. There were two other marks with no explanation. First, the category is sometimes noted in parenthesis. This seems to indicate a continuation of the category previously noted following an editing technique change. Second, the category sometimes appears with an additional number. As the original tapes developed for Williams Mix also contained these numbers, I believe that this indicates that a specific sound of a given category is to be used.

Finally, there are sectional notations in the score, such as that on the top of page 5: "87.75 (á13) n=6 1/2". The first number indicates the number of inches from the start, the second - "á" - indicates the density of the section from 1 to 16, and the third - "n" - is the time base of the section (in this case, 6 1/2 inches). These numbers determine the length and densities of the splices created for each section, but are not needed to perform the score.

2.1 Splice shape feature details

Several of the splice shape features - track number, page number, start position and end position - are noted plainly. Track number ranges from 1 to 8, page from 1 to 192, start and end from 0 to 20 inches (from the start of the page). One point of interest is that measurement accuracy does affect the timing accuracy. As the line width in the score varies from 0.01 inch to 0.03 inch, a 0.03 inch accuracy is probably the best one can hope for. At the tape speed of 15 inches per second this corresponds to a 2-millisecond accuracy.

The shape of each splice is more complex. At the start of my project, I was recording the full dimensions of the polygon that made up each splice shape. I soon found that this was too time-consuming (I was not making quick enough progress to complete the piece by the debut concert date). From a quick inspection of the score, I found that almost all of the splice shapes could be reduced to a pair of trapezoids by dividing the shape with a horizontal line (parallel to the direction of the tape). With this simplification, only 8 numbers need to be recorded per shape; the horizontal position of each point in the two trapezoids. The vertical measurements are always 0 and 1/8 inch. Shapes that do not fit the two-trapezoid simplification were treated separately.

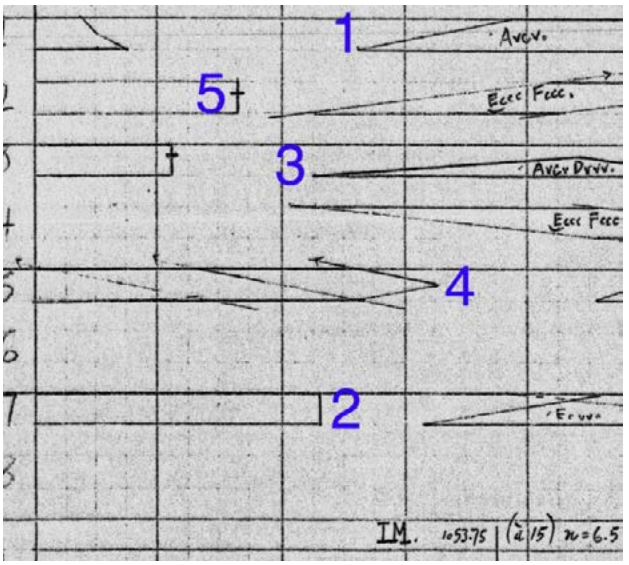

Figure 2. Fade types: 1) Simple fade in, 2) Blunt cut, 3) Fade that does not reach full volume, 4) Double fade. Note the section marking on the bottom that indicates the piece is now immobile "IM." *Score images Copyright © 1960 by Hanmar Press, Inc. Used by permission of C.F. Peters Corporation. All Rights Reserved.*

Diagonal lines indicate crosscut tape across the tape splice shape with arrows indicating the original tape direction. In the original realization of Williams Mix this required cutting the tape into rhomboids with a 1/4 inch distance between the slanted sides so that the rhomboids can be rotated and connected together. This splicing technique can cause sound fragmentation, filtering and reversal. I simply noted the angle of the arrows on the score and whether the crosscut is repeated, or only occurs once at the beginning or end of the splice shape.

Sound type is indicated with a set of four letters, and each sound type may also have a number and/or an underline. Each tape splice shape may have one or two sound types. If there are two, then two sound types are to be mixed together. The underline indicates sounds that are looped or repeated. There is no indication how quickly the looping is to be performed. As stated earlier, the number may indicate that a specific recording in the given sound type should be used. In the original sound library created by the Louis and Bebe Barron, the source tapes were similarly numbered [3].

The first letter of the sound type designates the sound category: A - city sounds; B - country sounds; C - electronic sounds; D - man-made sounds (including the literature of music); E - wind-made sounds (including song); and F - small sounds requiring amplification to be heard

with the others. The subsequent three letters are c or v, and indicate whether the pitch, overtone structure and amplitude are constant or variable. The six categories and two states for pitch, timbre and amplitude result in a set of 48 sound types.

There is no indication in the score for the amplitude of any given sound. The description for category F (small sounds requiring amplification to be heard with others) implies that the recorded material should be at a similar amplitude, and that the number of tracks that are active and whether one or two sounds are mixed in a track will determine the overall amplitude (this corresponds to the "á" number for the section).

3. THE SOUND LIBRARY

When recording and collecting sounds for *Williams Mix* one needs to determine the category and variable or constant aspects of each sound. Examination of the categories soon reveals that many sounds could fit in multiple categories. A wind-produced sound could be a manually produced sound, a country sound and a small sound at the same time. In my version, I decided to give preference to more specific categories – separating small sounds first, wind and electronically produced sounds second, manually produced sounds third, and finally city and country sounds. Similarly there will be different interpretations of "constant" or "variable" for pitch, timbre and amplitude. I decided to use similar guidelines to those David Tudor used for interpreting "simple" and "complex" in *Variations II*. [4] "Constant" describes either a fixed value or simple repetition in frequency, timbre or amplitude; "variable" describes change and unpredictability in those parameters.

Cage does not say much about the sound library in the score notes besides describing the categories, and stating "The library of sounds used to produce the *Williams Mix* numbers around 500 to 600 sounds". From an analysis of the score one can see that the sounds are fairly evenly distributed among the A, B, C, D, E and F categories and that ccc and vvv occur more often than other combinations. However, the score does not say how much repetition is allowed for a given category. If Accc occurs more than once, it could be a foghorn, then a helicopter, then a drill; or it could be a foghorn each time. In Cage's composition notes on *Williams Mix* [5], one can find more detail on the methods used to populate the sound library. Cage initially used a deck of 1024 cards to select the sounds. In this deck, for single (unmixed) sounds, there are 4 sounds with 3 variable aspects (vvv) repeated 32 times, 8 sounds with 2 variable aspects (cvv, vcv and vvc) repeated 16 times, 16 sounds with 1 variable aspect (ccv, cvc and vcc) repeated 8 times and 64 sounds with no variable aspects (ccc) repeated twice. There is a similar distribution of double source sounds - a greater variety of constant sounds, and more repetition of variable sounds. So a sound like a fog horn, with constant pitch, timbre and amplitude, will not be repeated more that twice; but a completely variable sound - like the ambience in an outdoor market - can be repeated many times. With this repetition of more variable sounds, 1024 sounds can be chosen with only 222 source sounds.

This method must have expanded before the original realization of *Williams Mix*. The score calls for sounds that are not in the 222 sound cards. Also, the collection of the Barrons' tapes for *Williams Mix* in the David Tudor archive [3] contains nearly three times the number of source sounds specified in the deck (although with the same distribution). One possible answer for this divergence is that sounds are replaced with new sounds after being selected from the deck when the score is "mobile". A full analysis of the original Williams Mix tapes and comparison to the score is needed to verify this.

For my version of Williams Mix, I asked a group of my friends to help collect the sounds for the sound library. I did not want the library to be the reflection of a single aesthetic, but rather an aggregate of many people's judgments and methods of sound collection.

Cage suggested processing sounds through filters or reverb to add variant sounds [6] (which might account for the many cricket sounds in the original). I applied 24 different sound processing treatments, with eight affecting frequency, overtone structure and amplitude respectively. These were selected by throwing the I Ching. By processing existing sounds I was able to both increase the size of the sound library and adjust its proportions to match the constant to variable ratio given in Cage's notes. By keeping careful watch on the size, categorization and proportion of aspects in the sound library, I feel I have achieved the same density of variation as is in the original while maintaining the structure of the piece.

PROCESSING TREATMENTS

FREQUENCY
1) Varispeed
2) Chorusing
3) Pitch Shift
4) Ring Modulation
5) Granular Pitch Shift
6) Frequency Shift (SSB Ring Modulation)
7) Phonogene Pitch Shift (Eurorack Module)
8) Brassage (Large Window Granular) Pitch Shift

OVERTONE STRUCTURE
1) Phasor (Swept Notch Filters)
2) Bandpass Filter
3) Spectral Compression
4) Spectral Expansion
5) Convolution
6) Delay
7) Phase Nulling
8) Granular Delay

AMPLITUDE
1) Tremolo
2) Time Domain Brassage
3) Gating
4) Bit-depth Truncation (Decimation)
5) Chebyshev Polynomial Wave-shaping
6) Compression
7) Analog Clipping (Fuzz Factory Guitar Pedal)
8) Granular Sample Playback

Figure 3. Sound library processing treatments for new realization.

4. COMPUTER REALIZATION

The performance software strictly follows the score, and allows only minimal performer interaction during the piece. However, it does not result in a fixed realization, but a new version each time. Cage left much room for variation in the score, and I chose to implement chance

procedures whenever a choice is needed. In the original there was similar freedom in the creation and categorization of sounds.

"This is a very free way of permitting action and I allow the engineers making the sounds total freedom. I simply give a list of the sounds needed, e.g.Evcv Fvvv (double source). If a source is ccc by nature, then v means a control. I do not specify how a sound shall be interpreted (in this regard) but leave it to the engineers". [6]

And although he was working with fixed media and creating a single concrete realization, Cage did not want a fixed, repeatable performance of the piece. *Williams Mix* was created for eight tape machines, and the lack of synchronization between machines allowed some variation. Cage states "...my idea all along was to have each track be individual, so that the relation of the tracks could be independent of one another, rather than fixed in a particular scorelike situation." [2]

4.1 Playback engine

The database created from measuring all of the splices was exported to a text file, with a splice on each line, and parameters separated by spaces. Each line is read by the *textfile* object, and scheduled up to 50 milliseconds before it's playtime. When a given splice is played, the next splice is read from the score and scheduled. As there can be up to 8 tracks active at any given time, and splices often overlap, 16 separate splice playback voices are needed to play the sounds.

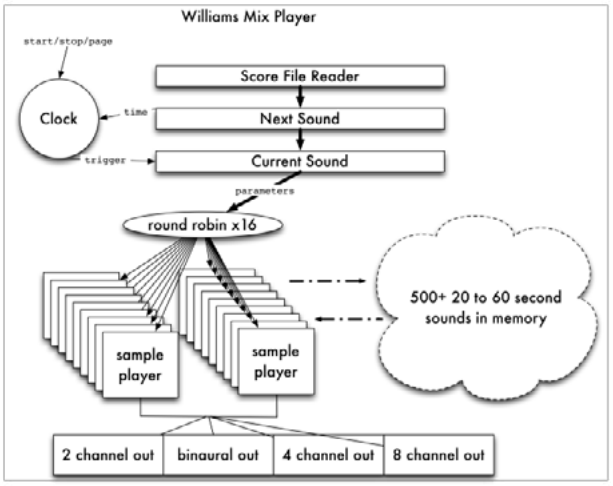

Figure 4. Overall diagram of *Williams Mix* player.

Each splice playback voice is designed to playback any of the splices in the piece, with all of the variations and processing separated into parameters. These parameters include: the channel number, sound category or/ categories (for double sounds), looping, fade shape, and crosscut angle (or lack or crosscut).

Sound selection is rather straightforward, there are around 500 sound files, and the correct one or two files need to be selected for every splice. As there are more sound files than there are categories and aspects, I am able to randomly select the file. If the next sound is a DvcvFvvc, my program will pick one of the 15 Dvcv sounds and one of the 5 Fvvc sounds that I have collected. When Cage adds a number to the sound, like the A1ccc on page 5 of the score, I select the first Accc in the sound file library. Thus there is a mix of fixed and indeterminate sound selection. Cage did not designate in the score what part of a given sound should be selected. As the sounds in the library range from 8 seconds to 60 seconds, and the splice lengths range from 0.01 to 1.66 seconds, I am also able to pick a random start time within each sound file for every splice.

4.2 Looping, crosscutting and pulverization

In the original *Williams Mix*, the tape loops were assembled and transferred to linear tape before they were edited into the master tapes. These loops were typically 1/2 to 2 seconds long in the original sound library. As the splice length in the score is often shorter than the loop length, the repetition that Cage probably expected was usually not heard. In my version, I chose to determine the loop length as 1/2 to 1/12 of the note length, picked at performance time. For very short notes this can produce a ring modulated effect.

The fades are also rather straightforward. In the case of a fade being designated as indeterminate with the horizontal dash in the score, a random fade length is chosen from 0 to twice the length of the splice. When the fade is longer than the splice length, the sound never comes up to full volume. Cage also suggests in the case of indeterminate fades that anything can be done in the editing, even "pulverization". Although I didn't implement "pulverization", I could add a type of time domain randomization to a future version of the piece.

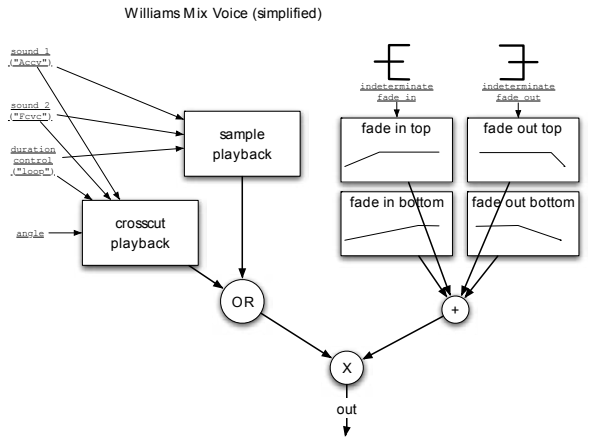

Figure 5. Simplified diagram of *Williams Mix* voice.

The crosscut splicing is one of the more interesting techniques Cage created for *Williams Mix*. Cutting the tape on an angle, rotating the tape, and reassembling has two effects. First, it has the potential of reordering the tape. This early tape technique is very similar to granular sample playback, complete with overlapped trapezoid ampli-

tude envelopes (from the rhomboid shape of the tape splice), and grains that are as short as 20 milliseconds. Second, playing the tape at a respliced angle causes low pass filtering. The angled tape produces the averaged amplitudes for a section of time; similar to a boxcar FIR lowpass filter. These two effects produce one of the characteristic sounds of Williams Mix, a rumbling, granular, bass-heavy timbre. This is implemented in PD with typical granular playback, and low-pass filtering calibrated to match the response of angled tape.

4.3 Spatialization and Performance

Williams Mix is to be performed by eight loudspeakers, surrounding the audience. I have created an output patch which will allow me to use any number of loudspeakers from 2 to 8, mapping virtual loudspeakers using vector based amplitude panning. The virtual speaker positions can be brought to more central locations, for a more monaural playback. This is especially important when in less ideal or more reverberant concert halls. A binaural output is also available.

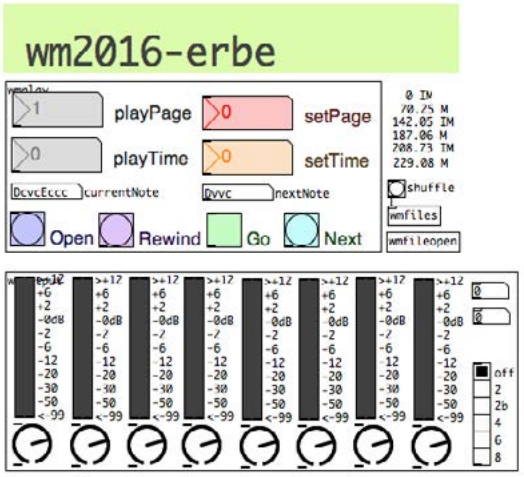

Figure 6. Pure Data main control patch.

The performance controls are simple: *start*, *overall volume*, *individual volume* and *stop*. There is an additional *shuffle* control that randomly reloads the sound library during the performance of the piece. This is only allowed during the sections of the piece when the score is "mobile", and highlights the structure by introducing a new set of sounds to be played and repeated.

5. CONCLUSIONS

Since the competition of the software, I have performed *Williams Mix* nine times, and have released one performance on CD. The most notable difference between the original piece and my version is that of audio fidelity, and possibly the higher fidelity is more capable of making audible the rhythms, structure, spatialization and diversity of material that exists in Cage's score. In retrospect, I do feel that I have been successful in creating a faithful and rich version of Cage's piece. And this realization shows that *Williams Mix* is fully described in the score. Hopefully my score data and other findings can open the way to other researchers and musicians.

I have placed the software and score data for *Williams Mix* at http://tre.ucsd.edu. I have omitted the sound library, leaving the collecting of sounds to the enterprising musician(s).

Several of my versions of *Williams Mix* can be heard at https://soundcloud.com/tomerbe/sets/williams-mix and on the recording *CLPPNG* by Los Angeles experimental hip-hop group clipping. [7].

Acknowledgments

I would like to thank Laura Kuhn of the John Cage Foundation for giving me access to the score, and Jonathan Hiam of the New York Public Library for providing a copy. I would like to thank Larry Polansky, Amy Beal, Anthony Burr, Michael Trigilio, Volker Straebel, and Elizabeth Edwards for comments, critique and research assistance; and Miller Puckette for guidance with Pure Data. Finally, I would like to thank my many collaborators in creating the sound library: Cooper Baker, Bobby Bray, Clay Chaplin, Kent Clelland, Greg Davis, Daveed Diggs, Greg Dixon, Tom Djil, Samuel Dunscombe, Christopher Fleeger, William Hutson, Jeff Kaiser, Scot Gresham-Lancaster, J Lesser, Elainie Lilllios, Stephan Mathieu, Rick Nance, Maggi Payne, Margaret Schedel, Jonathan Snipes, Carl Stone, Michael Trigilio and Doug Van Nort.

6. REFERENCES

[1] J. Cage. *Williams Mix*. 1952. Edition Peters, 1962.

[2] R. Kostelanetz, *Conversing With Cage*. Limelight Editions, 1987.

[3] The Getty Research Institute. The David Tudor papers. Audio Recordings.

[4] J. Pritchett, "David Tudor as Composer/Performer in Cage's *Variations II*", Getty Research Institute Symposium, "The Art of David Tudor", 2001.

[5] J. Pritchett, "The development of chance techniques in the music of John Cage, 1950-1956", Ph. D. Thesis, New York University, New York, 1988.

[6] J. Nattiez, *The Boulez-Cage Correspondence*. Cambridge University Press. 1993.

[7] Clipping., *Clppng*, Sub Pop Records, 2014.

[8] L. Austin, "John Cage's *Williams Mix (1951-3):* the restoration and new realisations of and variations on the first octophonic, surround-sound tape composition," *A Handbook to Twentieth-Century Musical Sketches*. Cambridge University Press. 2004.

[9] V. Tricoli, W. Dafeldecker, *Williams Mix Extended. http://www.dafeldecker.net/projects/pdf/WME_Audio%20copy.pdf* . 2011.