

DIGITAL AUDIO PRESERVATION FORMAT REPORT

4 June 2008

Submitted by Dan Noonan

CHARGE: To investigate the standards for digital audio preservation.

INTRODUCTION: As part of the Digital Initiatives Steering Committee's re-focusing in CY2008, we are investigating establishing standards and best practices for the OSU Libraries and associated university communities. This report will look at those standards associated with digital audio files.

METHODOLOGY: Various leading digital library websites were investigated for the existence of digital audio format and preservation standards and best practices from which to draw conclusions. These included the California Digital Library, Bibliographical Center for Research's (BCR) Collaborative Digitization Project (CDP – formerly the Colorado Digitization Project), the Library of Congress's (LOC) NDIIPP, Rutgers University and the New Jersey Digital Highway, and the Sound Directions Project. General recommendations for sample rate, bit depth, file formats, and tools have been distilled here. More in-depth, detailed information can be gleaned from following the resource links at the end of this report. The three most useful resources in the order of simple to complex are:

- RUcore and NJDH Standards Analysis for Audio Objects
- CDP – Digital Audio Best Practices Version 2.1
- Sound Directions Best Practices for Audio Preservation

For an in-depth review of file format specifications, visit the LOC's Format Descriptions for Sound.

RECOMMENDATIONS:

- **Sample Rate** – The Sample Rate is described in the number of times per second (measured in kHz or thousands of samples/second) that an audio file is sampled. Since audio files are waves, the higher the sampling rate the greater the accuracy in capturing a true copy of the original audio source.
 - It is agreed that most humans cannot hear pitches above 20 kHz. This is the rationale for the selection of the 44.1 kHz sampling rate for audio CDs. [CDP]
 - The highest frequency pitch that a digital audio sample can record is one-half of the sampling rate; therefore, the highest frequency one can sample and record from an audio CD is 22.05 kHz. [CDP]
 - Further, recording at a sample rates higher than 44.1 kHz may not be effective in preserving more information for particular source materials, such as vinyl records or analog audiocassette tapes, which are not capable of recording frequencies above 22.05 kHz. [CDP]

OSUL-DISC: DIGITAL AUDIO PRESERVATION FORMAT REPORT

- **Bit Depth** – The “bit depth” describes the range of numbers used to represent each wave amplitude measurement. Sample size is measured in bits:
 - 8-bit numbers range from 0-255
 - 16-bit numbers range from 0-65,535
 - 24-bit numbers range from 0-16,777,215

Since human ears are sensitive to the volume of sound, higher bit depths result in a “smoother” or more realistic representation of the audio source, or greater “dynamic range.” All audio CDs are 16-bit recordings. Most experts also agree that the human ear can only resolve between 15 and 17 bits per sample. Thus, some people may not be able to differentiate between a 16-bit recording and a 24-bit recording. Curiously, though, some listeners, and especially experienced audio engineers, report a clear difference in the quality of a 24-bit recording compared to a 16-bit recording from the same audio source. [CDP]

- **High Resolution Copies** –
 - However, higher sample rates and bit depths do have benefits:
 - Many musical instruments are capable of producing information in higher frequency range, including inaudible higher frequency harmonic content that also affects our perception of sounds. [SD]
 - They provide improved timing of the arrival of sounds that in turn improves spatial imaging (the locations of sounds from within a stereo or surround sound-field). [SD]
 - Creating high resolution digital audio files is analogous to practices employed in the still image preservation world, where the term “rich” is sometimes applied to high quality preservation masters. Although there are obvious differences between the media that are the targets of preservation, there are some overlapping issues. According to one imaging tutorial, creating a rich digital master provides enough information to eliminate the user’s need to use the original; satisfies all research, legal, and fiscal requirements related to use; supports creation of higher quality derivatives especially if they are processed; accommodates future applications as user expectations. [IASA]
 - A standard should set forth the minimum sampling rate and accepts it as a minimum, while recommending a higher level whenever the opportunity to sample at a better rate presents itself. [Rutgers]

INSTITUTION	MINIMUM		RECOMMENDED		OPTIMAL	
	SAMPLE RATE	BIT DEPTH	SAMPLE RATE	BIT DEPTH	SAMPLE RATE	BIT DEPTH
CDP	44.1 kHz	16 bit	44.1 kHz	24 bit	96 kHz	24 bit
RUCore/NJDH	44.1 kHz	16 bit	96 kHz	24 bit	192 kHz	24 bit
Sound Descriptions	44.1 kHz	16 bit	44.1 kHz	24 bit	96 kHz	24 bit

POTENTIAL FILE SIZE					
SAMPLE RATE	BIT DEPTH	# OF CHANNELS	SIZE MB	SIZE GB	
44.1 kHz	16	2 (stereo)	591	0.59	
44.1 kHz	16	1 (mono)	296	0.30	
44.1 kHz	24	2 (stereo)	887	0.87	
44.1 kHz	24	1 (mono)	444	0.44	

OSUL-DISC: DIGITAL AUDIO PRESERVATION FORMAT REPORT

POTENTIAL FILE SIZE				
SAMPLE RATE	BIT DEPTH	# OF CHANNELS	SIZE MB	SIZE GB
96 kHz	24	2 (stereo)	1,931	1.93
96 kHz	24	1 (mono)	966	0.97

<http://www.bcr.org/cdp/best/digital-audio-bp.pdf#page=18>

- **Formats** – The primary issues to consider in selecting a file format are to select non-proprietary formats with a high potential for future readability, and uncompressed formats for maximum audio fidelity. The CDP, Rutgers, and Sound Directions all agree upon Wave file format as an appropriate preservation format. Sound Directions notes, *“There is general agreement in the audio preservation field that the Wave file format (.wav) or, as more specifically recommended by IASA, AES, and the National Academy of Recording Arts and Sciences, the Broadcast Wave Format (abbreviated BWF or BWF), is the best target preservation format.”* The CDP and SD also agree upon the AIF format for preservation, while Rutgers notes that MP3 is acceptable for presentation. CDP did caution, *“Please note that WAV and AIF are uncompressed file formats, while MP3 is a compressed format. An additional consideration is, while in common use, WAV, AIF and MP3 are not open source file formats. Their specifications are owned by MicroSoft, Apple, and the Fraunhofer Institute.”*

POTENTIAL TOOLS:

- **FACET** – The Field Audio Collection Evaluation Tool (FACET) is a point-based, open-source software tool that ranks audio field collections based on preservation condition, including the level of deterioration they exhibit and the degree of risk they carry. It assesses the characteristics, preservation problems, and modes of deterioration associated with the following formats: open reel tape (polyester, acetate, paper, and PVC bases), analog audio cassettes, DAT (Digital Audio Tape), lacquer discs, aluminum discs, and wire recordings. This tool helps collection managers construct a prioritized list of audio collections by condition and risk, enabling informed selection for preservation. Using FACET provides strong justification for preservation dollars.
- **Harvard Sound Directions Toolkit** – The Harvard Sound Directions Toolkit consists of a large number of command line interface tools, each of which is targeted to a very specific application. Command line tools are initiated by typing commands directly into a terminal window and specifying an input file, an output file, and the appropriate options. You can think of these tools as the pieces of a jigsaw puzzle with very regular shapes. Through scripting these can be pieced together into multiple configurations to generate different automated workflows.

RESOURCES:

- **CDP** – Digital Audio Best Practices Version 2.1 (October 2006)
<http://www.bcr.org/cdp/best/digital-audio-bp.pdf>
- **CLIR** – Capturing Analog Sound for Digital Preservation: Report of a Roundtable Discussion of Best Practices for Transferring Analog Discs and Tapes (March 2006)
<http://www.clir.org/pubs/reports/pub137/pub137.pdf>

- **International Association of Sound and Audiovisual Archives** – IASA-TC 03: The Safeguarding of the Audio Heritage: Ethics, Principles and Preservation Strategy Version 3 (December 2005) http://www.iasa-web.org/IASA_TC03/TC03_English.pdf
- **Library of Congress:**
 - Sustainability of Digital Formats Planning for the Library of Congress, Format Descriptions for Sound (December 2007) http://www.digitalpreservation.gov/formats/fdd/sound_fdd.shtml
 - Sound Quality and Functionality Factors (March 2007) http://www.digitalpreservation.gov/formats/content/sound_quality.shtml
- **RUcore and NJDH** – Standards Analysis for Audio Objects <http://www.njdigitalhighway.org/documents/njdh-audio-object-standards-analysis.pdf>
- **Sound Directions:**
 - Best Practices for Audio Preservation (2007) http://www.dlib.indiana.edu/projects/sounddirections/papersPresent/sd_bp_07.pdf
 - FACET <http://www.dlib.indiana.edu/projects/sounddirections/facet/downloads.shtml>
 - Harvard Sound Directions Toolkit http://www.dlib.indiana.edu/projects/sounddirections/papersPresent/sd_app5_v1.pdf