CDP
Digital Audio Working Group

Digital Audio Best Practices

Version 2.0

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1. Introduction

Prepared by the CDP Digital Audio Working Group

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1.1. Purpose and Scope

The transfer of original recordings to digital formats is a process that helps protect the original analog recordings from unnecessary handling, can serve as a preservation process, and can provide access that might otherwise be unavailable. These digital duplicates may be copied without noticeable signal loss and safely accessed without concerns about the destruction of original material. This transfer process, when handled properly, can prove to be both easy and cost effective for most historic collections. As the technology continues to improve, this alternative will become even easier and more cost effective, helping to preserve and make accessible the historic audio collections of museums, libraries, and archives.

The purpose of this document is to provide guidelines and a set of best practices for cultural heritage institutions interested in converting analog audio recordings to digital formats. Recording audio directly into digital formats is also addressed. There are many historic audio collections in museums, libraries, and archives that may be in poor condition and are becoming increasingly fragile due to their age or storage history. We hope this information will help to preserve these collections and make them more widely accessible.

If you are unfamiliar with audio terminology, or the terminology related to digital media, please refer to section 11 for a glossary of terms. We recommend that you familiarize yourself with these terms before continuing.

1.2. Recommendations Strategy

Taking into consideration all of the items discussed in this document, our goal is not to provide absolute recommendations, but rather to provide guidelines for making informed decisions about best practices for particular projects. We offer a tiered approached to best practices that takes into consideration the nature and quality of the audio source material, the intended use of the resulting digital audio files, and the nature and available resources of the institution conducting the project

1.3. Updating the Colorado Digitization Program Digital Audio Best Practices

In the fall of 2004, the Collaborative Digitization Program (CDP), formerly known as the Colorado Digitization Program, received funding from the Institute for Museum and Library Services (IMLS) to create an infrastructure for the delivery of digitized audio recordings. As part of this project, the CDP Digital Audio Working Group began the long process of reviewing and updating the Colorado Digitization Program's *Digital Audio Best Practices, Version 1.2, May 2003.* This document, *Version 2.0*, replaces the earlier version. It is expanded to include best practices for a wide range of audio collections held by cultural heritage institutions, and to reflect the current state of best practices for digital audio in a field that is rapidly evolving.

1.4. Acknowledgments

We would like to thank all of the members of the CDP Audio Working Group for volunteering their expertise and hard work to complete this document. We would like to especially thank Richard Urban, former CDP operations coordinator, and former chair of the CDP Audio Working Group, for his work on *Version 1.2* and for his hard work on the early stages and direction of the current document. We would also like to extend special thanks to the Institute for Museum and Library Services for providing funding under the CDP's Sound Model Grant.

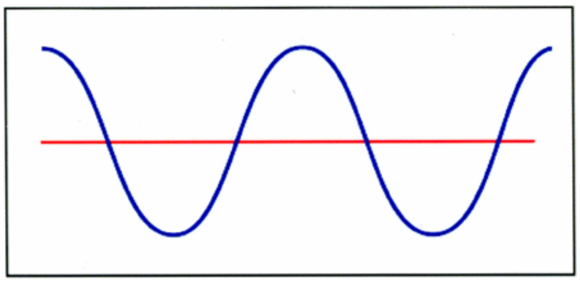
1.5. Supporting Documents

A number of supporting documents are provided as supplementary materials. They are available as separate documents in PDF format on the Collaborative Digitization Program Web site, www.cdpheritage.org.

2. Understanding Audio

2.1. A Brief Overview

What we call “audio” is actually a continuous series of air pressure waves. When these waves strike the eardrum, nerves are stimulated within the ear, nerve signals are transmitted to the brain, and we “hear sound.” In early sound recordings, such as wax cylinders, the pressure waves were converted on the cylinder into grooves that mimic the high and low pressure, or amplitude, in the air waves. The grooves are analogous to the pressure waves, so we call that an analog recording. Similarly, the airwaves striking the diaphragm of a microphone produce an electric current that varies with the air pressure waves. When this current is recorded on magnetic tape it is also an analog recording.



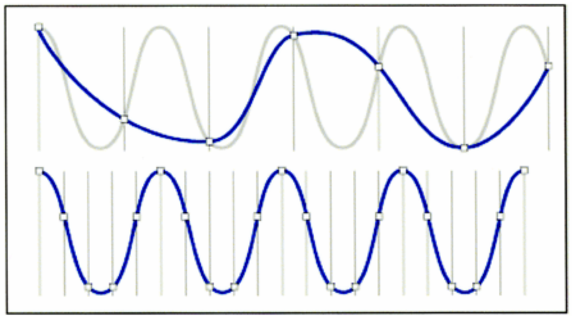
A sound wave shown as a waveform with low and high pressure points, or “amplitude.” Imagine that the wave is flowing past you as the pressure on your eardrum changes.

When audio is digitized, an analog recording is played back through an electronic device, and the variations of the electric current generated by the device are sampled at very fast time intervals. The amplitude of the current, corresponding to the amplitude of the original sound wave, is recorded as a number at each sampling point.

The quality and resolution of digitized audio is determined by two factors:

1. The number of times per second the amplitude of the wave is measured
2. The range of numbers used to record each measurement

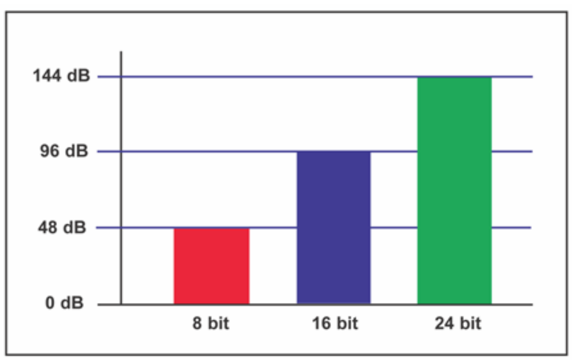
The first value, the "sampling rate," is described in kilohertz, or thousands of samples per second. Consumer audio CDs are recorded at a sampling rate of 44.1 kHz. That means that each second of audio is represented as 44,100 separate amplitude measurements as the wave flows past a point.



Visual representation of two sample rates

- **A. The top wave represents a low sample rate, which distorts the shape of the original sound wave.**
- **B. The bottom wave represents a high sample rate, which more accurately reproduces the wave.**

The second value, the "bit depth," describes the range of numbers used to represent each amplitude measurement. For example, if each measurement were represented on a scale of 1 to 10, that would be a rougher measurement than a scale of 1 to 1,000. Sample size is measured in bits: 8-bit numbers range from 0 to 255; 16-bit numbers range from 0 to 65,535; and 24-bit numbers range from 0 to 16,777,215. Since human ears are sensitive to the volume of sound, measured in decibels (dB), higher bit depths result in a “smoother” or more realistic representation of the audio source, or greater “dynamic range.” The standard for audio CDs is 16 bits.



Higher bit depths can represent a wider volume range because they possess a greater “dynamic range.”

2.2. Additional Considerations

- The highest frequency pitch that a digital audio sample can record is one half of the sampling rate. For example, 44.1 kHz audio CDs can record frequencies only up to 22.05 kHz.

- Most experts agree 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.

- Most experts also agree that the human ear can resolve only 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.

- Recording at a sampling rate higher than 44.1 kHz may not be effective in preserving more information for particular source materials, such as vinyl records or analog audio cassette tapes, because those sources are not capable of recording frequencies above 22.05 kHz.

- Recording equipment may not be perfectly matched to a particular audio source. Sampling at the higher depth of 24 bits significantly offsets any imperfections in equipment configurations, and also offers additional “headroom” for additional audio processing on computer-based audio editing systems.

- In addition, sampling rates and bit depths should be considered in relation to the nature of the original audio source, not only in relation to the range of human hearing. Many sounds exhibit a frequency range much higher than 22.05 kHz, and a 24-bit depth clearly records more audio information than a 16-bit depth. Our recommendations take these facts into consideration, recognizing that there are unknown future uses for digital audio files, and unknown potential for digital audio in this rapidly advancing technological field.

- A guide for choosing the best practices for your project is included in Section 6.

3. Planning and Implementing an Audio Digitizing Project

Planning and implementing an audio digitizing project should include a thorough period of analysis and planning. It is important to clearly articulate the goals of the project, identify the audience for the audio products, have a thorough understanding of methods and processes for completing the project, develop a realistic work plan, identify staffing or outsourcing needs, and create budgets and funding to support the project through a series of stages.

As a guide to answering questions relevant to all phases of planning and implementing an audio digitizing project, please refer to the Supporting Document *Questions to Ask Before Beginning an Audio Digitizing Project*

4. Legal, Copyright, and Intellectual Property Issues

It is necessary to address the complex issues surrounding intellectual property before undertaking a project to digitize audio recordings. Whether it is a commercially produced recording of a musical performance or an oral history taped by the local historical society, any audio recording that is a creative expression fixed to a tangible medium is protected by copyright and subject to restrictions if signed release forms are not available.

As a guide to answering questions relevant to all aspects of intellectual property issues for an audio digitizing project, please refer to the Supporting Document *Legal, Copyright and Intellectual Property Issues for an Audio Digitizing Project.*

5. Metadata for Digital Audio

The creation of quality metadata is a key component for the responsible management and long-term preservation of the digital files produced by your project. Metadata is the term used to describe traditional descriptive cataloging applied to digital files, in addition to information needed to retrieve, access, and manage those files. Frequently, metadata creation begins with preexisting descriptive cataloging, finding aids, or accession records that are extended by adding information about the digital files. Some projects will need to create new metadata as part of the project's overall work flow.

There is no one standard for metadata creation that meets all the needs of all types of collections and repositories, however most common metadata schemes include the following sets of information:

Descriptive Metadata	Metadata that describes the intellectual content of a resource.
Administrative Metadata	Metadata that includes information about ownership and rights management.
Structural Metadata	Metadata that describes relationships between multiple digital files, such as the order of audio files that together form a series or set.
Technical Metadata	Metadata that describes the features of the digital file, such as file type, bit depth and sample rate.

5.1. Audio Metadata Standards

Several professional organizations are working to develop metadata standards that specifically deal with the description of digital audio files. Many of the emerging schemas recognize the importance of recording the technical aspects of digital audio files and original formats. References to specific audio metadata standards can be found in the Resources section of this document.

5.2. Audio Metadata in Dublin Core

Including technical metadata about the digital audio file is important because not all audio file formats are supported in current browsers. Providing information about file size and the duration of the audio helps users determine if they have sufficient bandwidth and time to access the resource. In addition, including the technical details of the master file will inform users about the conversion process and availability of higher-quality recordings.

Examples of Format and Digitization Specifications metadata are shown below.

5.2.1. Format

Duration: the playtime of the audio recording.
Example: 1 hour, 14 minutes, 40 seconds

5.2.2. Digitization Specifications

Digitization process: hardware and software used to digitize the original recording, particularly if any optimization was applied during the conversion.
Example: Nakamichi Dragon Cassette Deck; Digidesign Digi002 Analog-Digital Converter; Pro Tools version 3.0 audio software; WAVES XNoise noise reduction.

5.3. CDP Dublin Core Metadata Best Practices

A complete discussion of metadata best practices for digital audio is beyond the scope of this document. Projects planning to use the Dublin Core metadata scheme for describing digital audio files should refer to the *CDP Dublin Core Metadata Best Practices, Version 2.1,* available on the CDP Web site.

6. Guidelines for Creating Digital Audio

6.1. History of Audio Recording Devices

Audio recording began in 1888, with the introduction of the wax cylinder recorder by Thomas Edison. Since that time, audio recording devices have gone through a series of technological advances. Commonly encountered recording media are summarized below. Please refer to the Resources section for links to more detailed information.

History of Audio Recording Devices

Format	Description	Years in Use
Wax Cylinder Records	2- or 4-minute formats, wax or wax compound	1888–1929
Recordable Disc Records (Direct or Acetate Discs)	7”, 12”, or 16”, recorded at 33 or 78 revolutions per minute (rpm). Generally vinyl on a paper, glass, or metal base.	1929–1960s
Recording Wire	Spooled wire, usually in 15- to 30-minute lengths, one direction only	c. 1945–1955
Open reel recording tape	1/4”–2”, 3”–10 1/2" reels, 1 7/8–30 inches per second (IPS) speeds	c. 1945–Present
Compact Cassette	1/8” tape in hard case, 1 7/8 IPS format	1965–Present
Microcassette / Minicassette	Very small 2-4 cm cassette tapes	1977–Present
Digital disk, MP3, and other digital recorders	Audio recorded directly in digital files to optical disks or internal hard drives	2000–Present

It is possible to digitally reformat any of these audio materials. Audio quality will vary based on the type of device and the quality of the original recording, but with modern computer-based audio editing software it is possible to “clean up” the audio within limits determined by the original audio quality and the software employed. A primary consideration in reformatting older audio formats is the limited availability of satisfactory playback devices.

6.2. Modes of Capture

The transfer of existing analog audio to digital media is, in its simplest form, a basic process. The computer hardware and software required for digital reformatting are readily available and decreasing in cost as the technology advances. The end result is audio in a format not prone to signal loss or the generational degradation of analog audio formats.

Since most of the commonly encountered recordings exist on either audiocassette or open reel tape, this document will primarily address those formats. However, the processes described are applicable to any analog audio format, assuming that the proper playback equipment is available.

Before beginning any tape conversion project, the condition of the original materials should be checked to make sure they will not be damaged in the conversion process. Magnetic tape is made up of two layers: the base and the binder. The base is a strip of material on which ferromagnetic particles are held by a binder layer to make up the complete sound copy. The most common problem with magnetic tape is hydrolysis. This is a condition in which, over time, the tape absorbs humidity from the air, which causes the base and binder layers to stick together back to front. The result is that the tape becomes sticky and sheds material when it is played back in a recording machine. Hydrolysis can also cause the bond of the base and binder to detach and shed. This problem surfaces most often in polyester tape manufactured between 1972 and 1982, but can occur in any tape that has been improperly stored.

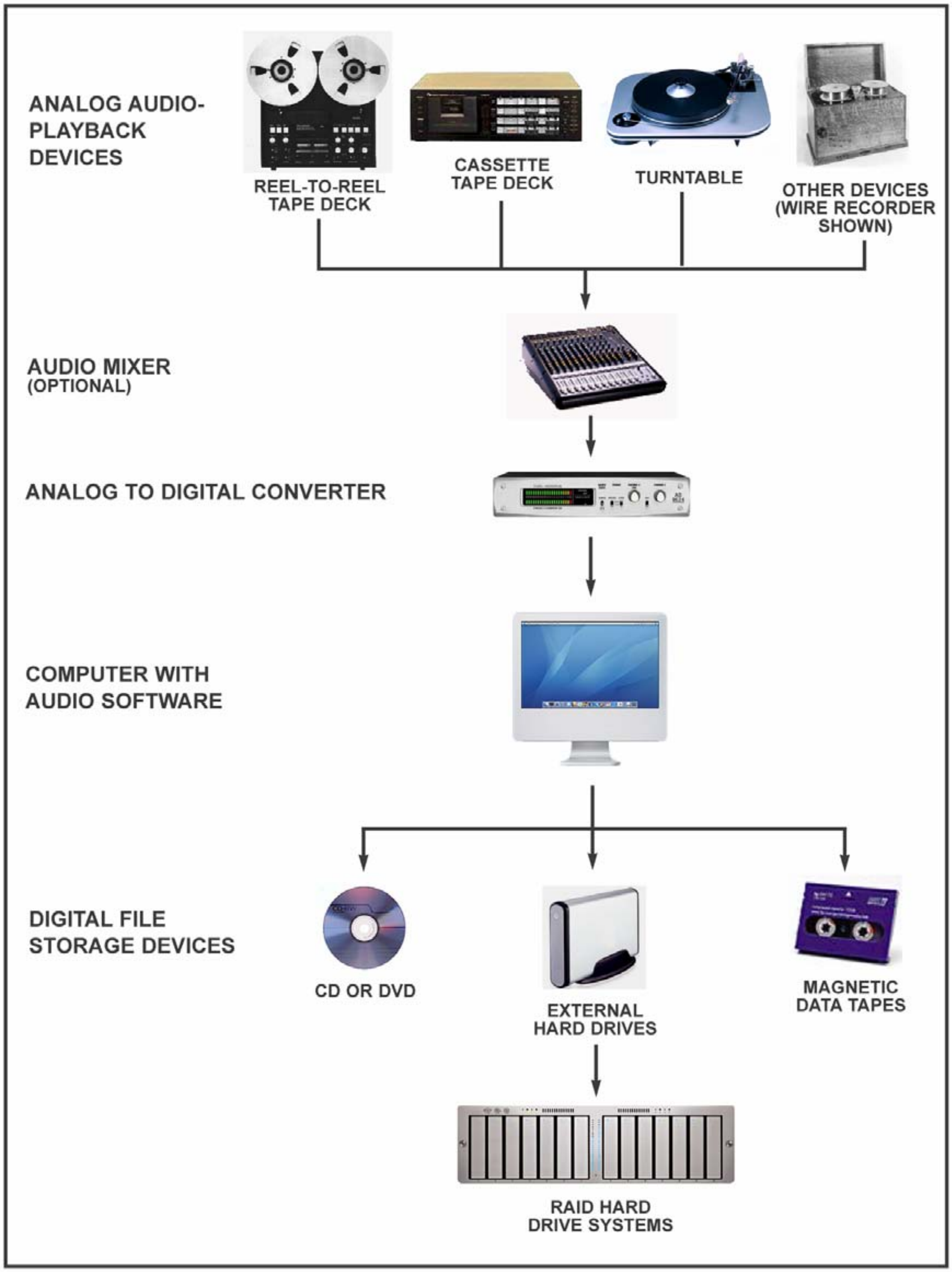
If a tape has any signs of stickiness or shedding, consult with a conservator before proceeding. Be aware that recovery methods for hydrolysis are temporary and serve only to restore tape so that it can be duplicated or transferred. Sources for information on other common problems with original audio materials are included in the Resources section at the end of this document.

The basic digital reformatting process typically involves four devices: an analog audio playback device, an analog-to-digital (AD) converter, a computer to process the digital signal, and a device for digital file storage. Optionally, a mixing device, such as an audio mixing board, can be utilized between the analog audio playback device and the AD converter to enhance the audio signal before any digital processing takes place, or it may be used to connect multiple analog audio playback devices to the system.

Audio software programs, such as Pro Tools, Sound Forge, or Adobe Audition (formerly Cool Edit Pro), among others, allow the user to manipulate the audio files with processes like volume adjustments, tracking, equalization, noise reduction, and compression, all methods to enhance the original sound or create surrogate files. For digital preservation efforts these methods are used sparingly, if at all.

Digital files can be recorded in many formats, with common examples being WAV, AIF, and MP3 audio files. The primary considerations in selecting a file format are to select nonproprietary formats with a high potential for future readability, and to choose uncompressed formats for maximum audio fidelity.

The final step is to write the digital audio files to digital storage media. Commonly utilized storage media generally consist of a combination of CD/DVD; external hard drives, including RAID hard drive storage systems; and/or magnetic data tape backups.



Common components of a modular audio digitizing system

6.3. Sample Rate

As previously described, the selection of a sampling rate is one of two critical factors in determining the audio fidelity of the digitally reformatted audio.

The two acceptable choices for sampling rates are 96 kHz and 44.1 kHz. The 96 kHz sample rate is rapidly being accepted as the archival preservation standard. If resources are not limited—in particular, if computer processing power, staff time, and digital storage space are not limited—then we recommend adhering to the 96 kHz standard for preservation master files.

For institutions that are limited by funding for digital storage, staff, or computer processing resources, we recommend that a sample rate be selected based on an analysis of the audio qualities of the analog materials. These factors relate to the frequency ranges of the original audio material, and also relate to the source type of the original audio. The nature of source types is addressed in more detail in Section 6.5.

6.4. Bit Depth

The selection of a bit depth is the second critical factor in determining the audio fidelity of the digitally reformatted audio. In general we recommend adhering to the current professional standard of 24-bit depth.

However, 24-bit audio files are not playable on many consumer audio devices, a situation that requires an additional step to convert 24-bit files to16-bit files as user copies. Therefore, exceptions to the 24-bit standard could be made in cases where institutional resources are limited. Limiting resources could include, but might not be limited to, the lack of adequate storage space required for larger 24-bit files, or the lack of adequate staff and/or equipment to create resampled user copies.

The charts below summarize the pros and cons of bit depth and sample rate selections, and file storage requirements for each selection.

Audio File Storage Requirements

Requirements	Sample Rate	Bit Depth	Pros	Cons
Minimum	44.1 kHz	16-bit	No file format conversion needed for audio CD. Maximizes storage space. Appropriate for lower-quality source files. Lowest level of processing time. Ubiquitous home-audio standard. International standard for Compact Disk (Red Book Standard).	Lowest frequency range acceptable. May not provide sufficient quality for future formats. May have limitations for publication or broadcast and migration to future digital formats. Limits ability to enhance source file for delivery.
Recommended	44.1 kHz	24-bit	More accurately reproduces sound of source material. Increased capability to enhance source file for delivery. Increased dynamic range. Acceptable for publication and broadcast. Reflects current professional audio standards.	Lowest frequency range acceptable. Requires 50 percent additional storage space. Requires conversion to 16-bit for delivery on Red Book Audio CD. Requires additional processing time and thus additional costs.

Requirements	Sample Rate	Bit Depth	Pros	Cons
Optimal	96 kHz	24-bit	Standard for DVD/HD audio. Increased frequency range. More accurately reproduces sound of high-frequency, high-quality source material, such as musical recordings. Increased potential for enhancement of source file for delivery. More potential for future applications. Potential recommended benchmark for future. Highest recommended current quality. Rapidly growing acceptance. Reflects emerging professional audio standards.	Increased storage space. Increased processing time. No perceptible improvement in sound quality for some source files. Requires conversion to 16-bit for delivery on Red Book Audio CD. May require frequency compression for delivery.

File Sizes for One Hour of Audio

Sample Rate	Bit Resolution	No. of Channels	File Size: Megabytes	File Size: Gigabytes
44.1 kHz	16	2 (stereo)	605.6 MB	0.61 GB
44.1 kHz	16	1 (mono)	302.8 MB	0.30 GB
44.1 kHz	24	2 (stereo)	908.4 MB	0.91 GB
44.1 kHz	24	1 (mono)	454.2 MB	0.45 GB
96 kHz	24	2 (stereo)	1977.5 MB	1.98 GB
96 kHz	24	1 (mono)	988.8 MB	0.99 GB

This table represents the file sizes for one hour of digitized audio at different sample rates and bit resolutions.

6.5. Source Types

As previously discussed, considering the source type of the original sound can also be helpful in making decisions related to sampling rates. Frequency ranges of assorted sounds can vary greatly. Considering these frequency ranges can be helpful in selecting either the 44.1 kHz or 96 kHz sampling rates. Remember that the range of frequencies recorded for each sampling rate is one half the rate, either 22.05 kHz or 48 kHz, and that the 96 kHz sampling rate will require more than double the storage space of the 44.1 kHz sampling rate. Following are some recommendations for basic source types:

Spoken language: Virtually all human voices fall within the 20–50 kHz frequency range, so the recommended sampling rate for spoken language is 44.1 kHz.

Field Recordings: We are generally referring to spoken language recordings occurring in the field, so the recommended sampling rate is, again, 44.1 kHz. For field recordings that include music or sounds such as insects, birds, or other natural sounds, the 96 kHz sampling rate should be considered.

Musical Recordings: Musical instruments produce a wide range of frequencies, some above the 22.05 kHz capabilities of the 44.1 sampling rate. Although 44.1 kHz may be more than adequate for many musical recordings, in general we recommend the 96 kHz sampling rate, which will record frequencies up to 48 kHz, and provide additional information that may be useful during audio processing.

6.6. File Types

As with other digital media, a number of file types are in use for storage of digital audio files. In selecting a file type, it is important to consider the universality of the file type and thus its readability by a variety of software programs. File types that are proprietary and not likely to be supported in the future should be avoided. File types that compress the audio file should also be avoided for preservation masters.

The WAV file type was developed by Microsoft, is in widespread use, and is readable by virtually all audio software programs. The AIF file type was developed by Apple Computer and is also in widespread use. Both of these file types are uncompressed and acceptable for long-term file storage. The WAV file type has become a standard and is recommended. In addition, the WAV file type is also available in a professional format, broadcast WAV (BWF), which has the capability to store metadata in the file header. Although not all audio software programs are currently capable of reading or writing to the metadata header, the BWF format is emerging as the WAV file type of preference for archival audio projects.

With the emergence of compact hand-held digital recording devices, a number of other formats have become very popular. The MP3 format has become the file type of choice for many applications requiring downloads or uploads to the Web. This format has the advantage of being highly compressed for electronic transfer, but also has the disadvantages of compressed formats. Other popular compressed formats include Windows Media, RealAudio, and QuickTime for streaming downloads. Caution should be taken to avoid the proprietary formats of many of the hand-held devices. Converting the files to WAV or AIF files for long-term storage is recommended. Although compressed file types are ideal for Web applications, none are recommended for long-term storage.

6.7. Digital Audio Toolbox

The selection of the proper equipment for digital transfer should be made with quality and not price in mind. The purpose of the Digital Audio Toolbox is to provide a basic level of familiarity with the hardware necessary to create a digital audio workstation (DAW). We do not endorse particular brands, but will mention them in cases where key equipment is nearing obsolescence and has been discontinued by the manufacturer.

Much of the equipment required for playback of analog audio recordings may be difficult to find, and likely only available through used equipment outlets. For assistance in locating this equipment, and in learning its operation, we recommend taking advantage of all available local resources. Sound engineers at local radio stations may be very helpful, as well as other local audiophiles or music collectors. It may be necessary to consult the phone book, make calls, or simply find local experts through word of mouth. You can also contact national experts by consulting the Web site for the Association of Recorded Sound Collections, http://www.arsc-audio.org/, or the Society of American Archivists Recorded Sound Roundtable, www.archivists.org.

Of course, it is also possible to purchase quality used equipment through a number of online resources. If you are unfamiliar with the equipment, however, we still recommend that you consult audio experts before making significant purchases. After purchase, all used equipment should be professionally inspected and maintained before use, and maintenance should continue on a regular timetable.

Reel-to-reel Tape Decks

Most systems for recording open reel tapes are either monophonic—one track in each direction—or stereo—two tracks in each direction. It is important that the proper machine is selected with this in mind, as monophonic machines will give inferior reproduction of stereo tapes, with the separation of the two channels being lost, and stereo units will sometimes lose part of the audio information due to the space normally present between tracks. In the absence of a mono deck, the problems created in playing back monophonic recordings on stereo decks can be corrected by duplicating the mono track on the second stereo track using computer audio editing software.

Also, the proper speed must be determined. Modern open reel consumer decks play back at 3 inches per second (IPS) and 7 IPS, whereas many older machines can also play at 1 7/8 ISP, a common speed for many oral history recordings. Professional units often play back at only 7 IPS and 15 IPS. Many older recordings will need to be played back on vintage equipment, if only to achieve the correct speed. Tapes played at improper speeds will be quite apparent, either exhibiting the slow dragged-out voices many of us have heard in improperly played recordings, or the fast squeaky pitch of a recording running too fast.

It is important to recognize the difference between consumer-grade and professional-grade tape decks. Atari, Revox, Studor, and Tandberg were a few popular manufacturers of professional reel-to-reel tape decks.

Cassette Tape Recording Decks

Although most cassette tapes are recorded at the speed of 1 7/8 IPS, some half-speed examples do exist. Also, cassette decks are subject to the same restrictions concerning mono versus stereo reproduction. Almost all portable decks prior to modern boom boxes are monophonic. As with playback considerations on open reel tapes, the problems created in playing back monophonic recordings on stereo decks can be corrected by duplicating channels in computer audio software.

Also, as with open reel decks, it is important to recognize the difference between consumer grade and professional grade tape decks. Pro decks will include features such as azimuth adjustment, which allows the machine to adjust tension on the tape as it plays. Some popular manufacturers of professional cassette decks are Nakamichi, Teac, Tascam, and Sony.

Turntables

Turntables are used to play audio most commonly recorded on 33 1/3 rpm and 78 rpm vinyl disks. Early disks were also manufactured with other materials. With the recent resurgence in the popularity of the “DJ,” turntables have become widely available. Special attention should be paid to the quality of the cartridge and other features such as the availability of weight, tracking, and skating adjustments. Many high-end models are currently available.

Mixers

Mixers are optional devices that can serve multiple purposes. They can be used for “equalization,” or adjusting the input levels on multiple channels. In systems requiring multiple inputs, such as a combination of tape decks, turntables, etc., the mixer can be used to connect all of the devices to a single input into the computer’s analog-to-digital converter. Macky, Grace Designs, Beringer, and Sabine all manufacture a number of popular models.

Analog-to-Digital (AD) Converters

The analog-to-digital converter is a key hardware component. The quality of the digital signal from the AD converter to the computer system is a key factor in the quality of the digital audio created. In general, external AD converters are recommended, although internal sound cards are rapidly evolving. Low-cost sound cards will, however, introduce noise into the audio system. External AD converters will isolate this noise from the system. When purchasing an AD converter, pay special attention to the technical specifications. In particular, note the noise levels, shown in dBs, the sampling rates, shown in kHz, and the bit depths. All high-quality AD converters will include both 44.1 kHz and 96 kHz sampling rates, as well as 16- and 24-bit depths.

Computer Systems

Many different computer systems can be utilized for a digital audio workstation. Virtually all computers currently marketed can be connected to an AD converter through USB or FireWire ports, and a variety of excellent audio software is available for both the Windows and Macintosh operating systems.

Two key specifications to consider in purchasing a computer for a DAW are the processing power of the computer and the quantity of RAM installed. As in all high-end computer applications, more is better. A 1-GHz processor and 640 KB of RAM is a minimum requirement. A 3- to 4-GHz processor with 1-2 GB of RAM will show a considerable improvement in performance. Working files should be stored on a separate external hard drive, with a minimum size of 40 GB recommended.

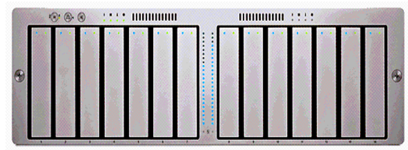
Because audio editing software requires considerable power, and can be affected in negative ways by other computer applications, it is recommended that the DAW be a stand-alone machine with no other programs running during the digitizing process. Virus protection programs can be particularly problematic. It is also recommended that the DAW be disconnected from any Web or network connections.

Monitors, Headphones, Microphones, and Cables

It is important that the audio technician be able to accurately *hear* the quality of the sound as it is digitized and played back through the audio workstation. For this reason, a good pair of professional headphones and/or studio quality monitors (speakers) are another critical component of the system.

If the DAW is used for recording as well as digitizing functions, then a high-quality microphone is a necessity. For high-quality recording, a high-quality microphone will be a critical factor in the final sound quality, and these can now be found at relatively low cost. For instance, a microphone that cost $1,000 just a few years ago can now be purchased for under $300. There are a number of major brands with good track records, including Shure and AKG.

Cables are a component of the DAW that are often overlooked but can make a drastic difference in audio quality. Inexpensive cables can be microphonic, picking up noise and introducing it into the system. Quality cables will include shielding, non-oxygenated copper, and gold-plated connectors. Price is generally an indicator of quality. High-quality cables are a good investment.


Digital Storage Devices are discussed in Section 9: Storage and Preservation of Digital Audio

Software

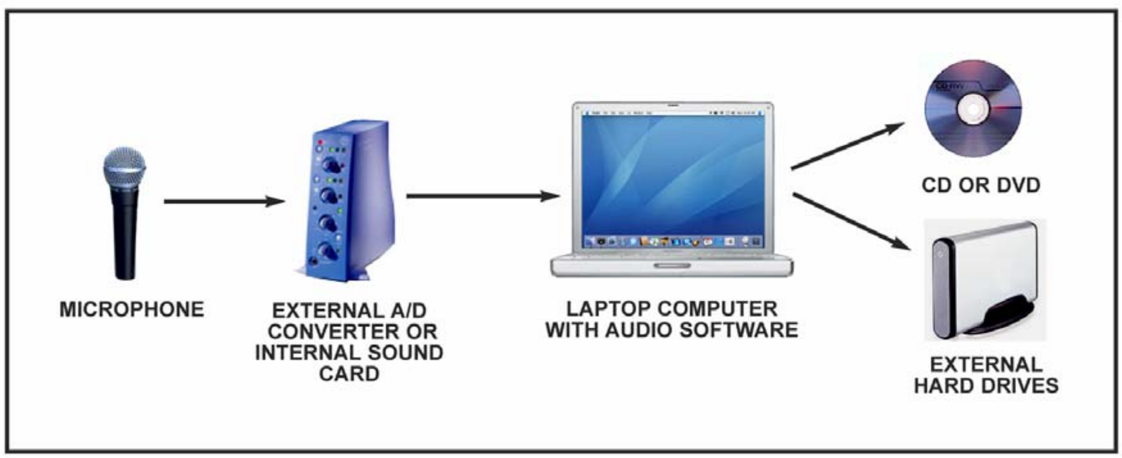
A digital audio workstation may utilize a number of software programs. The primary program is the audio editing software, used to import the audio files into the system, and to make adjustments to the audio signal for optimal recording. This software can also be used in the creation of “optimized” listening copies—digitally enhanced files with volume levels adjusted and “normalized” across stereo channels, silent gaps deleted, noise reduction accomplished to eliminate hiss and hums, and more. Some commonly used programs are *Pro Tools*, *Sound Forge*, and *Adobe Audition* (formerly *Cool Edit Pro*)*,* but there are many others. Please refer to the Resources section for additional information on audio programs and their functionality.

If you choose to store your files on CDs, then a program to write the files to CDs may be required. For converting your files from 24-bit master files to 16-bit files playable in common audio players, or for converting WAV files to compressed MP3s or other formats for download from the Web, a file-conversion program will be required. There are a number of such programs available, most of which allow mass file conversions in batches. In addition, much audio and other related software is available as Freeware. Additional information related to these types of software is listed in the Resources section as well.

6.8. Born Digital Recording

With rapid advances in digital audio technology the phenomenon of “born digital” recording is gaining ground. There are many advantages to recording with born digital systems, including the excellent sound quality of the high-end systems, and the capability to make digital audio files immediately accessible. As with the process of converting analog audio to digital, we recommend a tiered approach to born digital recordings, which should also encompass all of the previous recommendations related to sampling rates and bit depths.

Three types of born digital audio recording systems have emerged into the marketplace in the past few years, each with strengths and weaknesses. At the high end are modular systems that typically employ a laptop computer with a CD/DVD writer; an external compact AD converter that may also serve as a mixer, or a high quality internal sound card; hard drives for storage of files; and microphones or other input devices. Mid-range systems are self-contained units with all of the components housed in a single case, primarily marketed for on-site recording and audio CD production at music venues or, more recently, for podcasting. Low-end systems are the hand-held recording devices.



Common components of a modular born digital recording system

The modular high-end system is recommended for archival born digital recordings. These have the advantage of recording at both 16- and 24-bit depths, at 44.1 or 96 kHz sampling rates—providing the highest quality audio of the born digital systems; serving as an audio editing workstation with software that can be easily updated; being easily updated with new hardware due to their modular nature; and possibly also serving as a separate computer workstation in the field. Disadvantages are their high cost and bulk; they require expertise for assembly, operation, and maintenance; and they may intimidate subjects because of their professional appearance.

We offer a few words of additional advice on internal sound cards for modular systems. Although we are hesitant to recommend these at this time, we recognize that this technology is changing rapidly and a number of satisfactory internal sound cards have entered the marketplace. If you choose to employ an internal sound card in a modular system we recommend the selection of a card that is specifically designed for audio capture, as opposed to cards employed for many gaming applications, which are designed primarily with audio playback in mind. Specifications requiring particular attention include sampling rates, bit depths, and software compatibility.

 Mid-range integrated recording systems have the advantage of being smaller, self-contained systems that include recording functions in a single case, many with CD-writing hardware; they are turnkey systems that require minimal setup; and they are less expensive than modular systems. Their disadvantages are that they offer limited sampling rates and bit depths, most recording only at 16-bit depths; they may store files on portable proprietary media; and the hardware and software cannot be updated.

 Compact hand-held digital recording devices are not recommended for born digital recording. They have many disadvantages, including that files are stored in compressed, often proprietary formats; built-in microphones that users often employ may be very low quality; the units are prone to rapid obsolescence; and their sound quality cannot compare to the high-end or mid-range systems. Their advantages are that they are inexpensive; they are small and very portable; they require no setup time; and they are easy to learn. This said, we understand that the use of these devices has become very widespread. In cases where recordings are received from these devices, it is highly recommended that all files be converted immediately to standard WAV or AIF files, which should then be integrated into the organization's standard digital storage system.

7. Outsourcing Audio Reformatting

It is often not practical for a cultural heritage organization to digitize its audio collections in-house. Audio digitization equipment is specialized and can be expensive, and the technical expertise to create acceptable digital audio master files and derivatives may not be available. This is especially true if the materials to be digitized are fragile, deteriorated, or are recorded on rare or unusual media. For small- to medium-sized audio digitization projects, or projects involving materials needing special handling, it will likely be more feasible to contract with a third party experienced in digitizing audio materials.

Managing an outsourced project involves monitoring schedule, budget, and the quality of the products created by the digitization vendor. The process has to be flexible, but also has to conform to schedule, budget, and quality constraints. For more information on outsourcing audio digitizing projects, please refer to the Supporting Document *Guidelines for Outsourcing Audio Reformatting.*

8. Quality Control

Quality control is an important, and sometimes overlooked, issue. The simple recommendation for quality control of digital audio is to just listen to it, but this may be easier said than done. The fact is that human ears exhibit great variations in what we hear, but our ears *can* be trained to hear better, especially if we know what to listen for. And this is also greatly aided by using a good set of professional headphones.

All digitized audio files should be sampled for sound quality. Technicians charged with quality control should listen for consistency in the audio quality at a number of points in the recording, listening for distortions in the sound, for proper playback speeds, and for artifacts such as hiss and hum. Technicians should specifically check that the volume levels are set correctly. Recordings should also be checked for completeness. Any distortions in the sound or other inconsistencies in the recordings should be noted in the metadata. Metadata should also be checked for accuracy and completeness, with special attention paid to accuracy of file names, which can lead to the effective loss of files when recorded inaccurately.

It is important to understand that quality control of audio can be a very subjective process. It is recommended that technicians performing this process be selected on the basis of their familiarity with a variety of types of recorded sound, and preferably have experience in a field that has already helped train their ears. Staff with previous audio experience, such as audio engineers, are a natural selection, as are staff with formal musical training.

9. Storage and Preservation of Digital Audio

The significant resources institutions devote to the creation of digital collections have increased awareness of the need for careful planning for their storage and long-term preservation. Successful digitization projects should include planning and documentation for the responsible sustainability of these collections.

The process of transferring recorded material to digital media is usually approached from an archival standpoint. This means that every effort is made to transfer the material exactly as it appears on the original media without any sort of alteration, creating as “exact” a copy of the recording as possible. This approach is recommended particularly in cases where the original recording is in danger of destruction, as might occur in a fragile transcription disc or wax cylinder.

Systematic file naming is important for system compatibility, interoperability, and to demonstrate ownership of the digital asset. File naming conventions specific to an institution may be used. These might include protocols that incorporate institutional acronyms, collection identifiers, or part designators, among others. In general, it is recommended that the characters in the file names be alphanumeric and lowercase, and not utilize spaces, tabs, commas, or any other characters reserved for computer system use, such as slashes, asterisks, or question marks.

It is highly recommended that organizations utilize a strategy employing multiple redundant copies of digital files in separate locations, as a fail-safe strategy for the failure or destruction of the digital media. Acceptable media may be optical disks, hard drives, or magnetic data tapes—all of which have particular strengths and weaknesses.

Optical Media Storage

Optical media types include CD-ROM (Compact Disc Read-Only Memory), CD-R (Compact Disc-Recordable), and DVD-ROM (Digital Versatile Disc Read-Only Memory). All employ a laser to read data from a metallic or dye coating over the disc, with a clear acrylic coating covering the recording layer for protection. Optical discs are a popular medium for transporting files and as a publication medium. Their integrity for storing digital masters is currently a matter of debate, primarily due to concerns about their longevity.

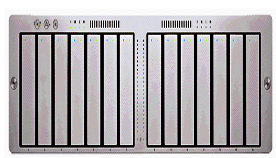
Issues of cost, convenience, speed of retrieval, and security all factor into decisions regarding optical discs as a file-storage and retrieval medium. It is recommended that digital assets be stored on CDs that conform to ISO 9660, the 1988 standard for volume and file structure of CDs for information interchange.

Optical discs can provide a relatively low-cost storage medium, but they can incur significant costs for accessing and managing the digital assets stored on them. These costs are related to slow writing and reading speeds that can be a burden on both staff and equipment, and costs associated with managing and migrating collections of discreet objects. Storage and retrieval costs will escalate as CD collections become larger and more challenging to manage. Digital collections stored on CDs may work well for small collections, but using this media as a long-term solution can present major challenges.

CDs have a limited physical life span and the files stored on them are vulnerable because of physical deterioration, mishandling, improper storage, and obsolescence. Studies have indicated that the physical lifetimes of the media range anywhere from 3 to 20 years, and obsolete equipment for reading the media poses a threat in the long term. Proper conditions can prolong the life of the discs, with optimal environmental levels at 72° Fahrenheit, with a relative humidity between 20 and 50 percent.

Both adhesive labels and permanent ink markers can cause early failure of CDs through chemical interaction with the CD's recording layer. Best practice is to not write or label CDs directly on the body of the CD. Some projects have placed small identification numbers in the central plastic hub of the CD, and some more long-lasting brands of gold and silver CDs are manufactured with individual serial numbers.

Projects considering CD-Rs for storage of master files should pay attention to the burning speed of the media they purchase and the maximum speed of the CD burner. Like the hardware used to create them, CD-Rs have a maximum burn speed that should not be exceeded even if the hardware is capable of higher speeds. Projects should also use the verification utilities in most CD burning software to ensure that there are no errors in the disks. Burning multiple copies of CDs from master files rather than copying a previously burned CD also decreases the possibility of introducing errors.



Hard Drive and RAID Storage

Storing digitized audio "live" on hard drives is a viable option for those wishing to store digital audio on a stable platform that offers sustainability, easy storage and retrieval, and ease of migration to new media. To prevent the loss of data, projects need to properly configure hardware and software, develop responsible backup and disaster recovery policies and procedures, create realistic plans to deal with technological obsolescence, and plan migration to new media as drives reach their natural life span.

Hard drive systems may be configured with a distributed system of individual hard drives, or RAID arrays may be utilized. RAID arrays (Redundant Array of Independent Disks) are self-contained collections of disk drives that act as a single large hard drive storage system. These configurations are designed to enable a system to operate when an individual drive within the array fails, thus minimizing the loss of data. Currently, there are ten types of RAID configurations. Each configuration has unique strong and weak points. Some configurations are best suited for rebuild speed, some are designed to maximize disk capacity, and others are well-suited for fault tolerance.

Hard drive storage systems may be maintained locally by organizations with technical expertise on staff, they may be maintained by an organization's IT department, or hard drive storage may also be outsourced to local vendors. Projects considering outsourcing should consider the costs of ingestion and ongoing maintenance fees, metadata requirements for outsourced files, work flow requirements, and accessibility requirements.

Magnetic Data Tape

For years, magnetic data tape has been the tried-and-true backup of choice by corporations storing massive amounts of data. Data tapes, properly stored and handled, have proven to be an extremely durable, economical, and reliable backup medium. For archival purposes they are commonly used as the medium of choice when all other media fail.

Like analog audiotape, magnetic data tapes are prone to wear and tear and the effects of improper storage. Additionally, they depend upon the availability of tape playback devices, and more importantly, some are dependent upon proprietary software programs to retrieve the digital data from the tapes. Generally, data tapes are not used for frequently accessing files, as they do not have the random access capabilities of hard drives or CDs—that is, they must be cued to a point in the tape to retrieve data. However, as the final stage in a fail-safe system, magnetic data tapes should be considered.

Refreshment and Migration

Regardless of which storage technique your project chooses, migration of files to new media is one of the most important aspects of a sustainable project. Migration is the transfer of digital files from one storage medium to another, to ensure that the files remain retrievable as technology advances. Do you still have floppy disks with files that you cannot retrieve because you do not have a computer with a floppy drive? Obsolete digital media is a common occurrence and will continue to be an issue as computer technology evolves. Software obsolescence is also an important issue, since the longevity of the storage media may not be as important as the ability to access the information. To avoid this problem in the future, transfer files to new media as they become widely available. Considering the amount of time and money invested in your digitization project, it is worth the effort and cost to migrate your files frequently, and at the very least every five years. Every sustainable digitization project should include the costs of data migration as a yearly budget line item

10. Delivery of Digital Audio

Once analog audio is digitized, institutions have the option of delivering the audio files through the Web for listening or downloading, and/or they may want to provide delivery to on-site patrons. Institutions should consider the needs of their user groups before deciding upon delivery options; such planning could result in adopting both the Web and a public terminal computer that can play compact discs, WAV, or MP3 media files.

10.1. On-site Delivery

For public listening stations, think in terms of disposability: public units suffer much wear and tear. Generally, purchasing and maintaining a computer is more costly than using "personal" style CD or MP3 players available at discount stores for less than $100 per unit. A good unit will come with a power supply and headphones, and will also have a display capable of showing some of the basic text metadata embedded into the MP3 files.

For personal computers, a variety of equipment is necessary to listen to the digital files, whether the patron is accessing the audio from a CD or via a link from your online catalog. Headphones generally provide the most manageable way for patrons to listen to the audio without interrupting other users, and patrons will need access to a software panel to control the volume of the audio. Audio workstations should be outfitted with these basics:

- Hardware: Each audio workstation requires a sound card, a CD-ROM drive, a network connection of some type—for audio accessed via a local network or the Internet—and headphones.
- Software: Each workstation should have a software audio player, such as Windows Media Player (http://www.microsoft.com/windows/windowsmedia/), QuickTime (http://www.apple.com/quicktime/), Winamp (http://www.winamp.com), or RealPlayer (http://www.real.com), etc., that is capable of playing a wide variety of audio formats, including CD audio, MP3 files, and streaming media.

10.2. Online Delivery

It is important to note that the needs of your users should drive the technology decisions, and not the other way around. While it is also important to consider the technology support that is available from your institution, the needs of your users should drive format decisions. If support is not available internally, consider outsourcing or partnering with another organization that can support the desired format. There are presently two predominant ways of distributing audio via the Internet: streaming and downloading.

Streaming Audio is available in a number of proprietary formats, including Real media (http://www.real.com), Windows Media (http://www.microsoft.com/windows/windowsmedia/), QuickTime (http://www.apple.com/quicktime/), and others. To provide streaming media, an authoring package, available through one of the above vendors, is needed to prepare the audio for streaming. Also available is the server software and hardware that is capable of providing the number of "streams" users will demand. The software vendor will determine specific server hardware specifications. Although there are shortcuts to providing streaming media and some institutions skip the "streaming server" route and simply make the files available as simple downloads, be sure to consider the needs of your users when making server decisions.

Downloading the complete audio files is the simplest way of making your audio files available over the Internet, perhaps as MP3 files. By making the files available as a download, access is needed to a basic Web server—either in-house or via an Internet service provider—but no other special server hardware or software requirements are necessary. The primary requirement will be adequate server bandwidth to meet the needs of your users, and adequate disk space to store the audio files.

10.3. Podcasting

Although downloading audio files over the Internet has been available for years, the explosion of portable MP3 players—particularly Apple's iPod—that allow users to play files at their convenience, has created a demand for online distribution of audio files.

A podcast is simply an audio recording posted for download, and can be coupled with RSS (really simple syndication) to allow users to subscribe to desired Web content and automatically receive updates that are downloaded to portable music players. More information on RSS is available at the RSS Specifications site (http://blogs.law.harvard.edu/tech/rss).

The breadth of available podcasts can be found through several online directories, including Podcast.net (http://www.podcast.net), Podcasting News (http://www.podcastingnews.com), Podcast Alley (http://www.podcastalley.com), and iPodder (http://www.ipodder.org). There are also several free software programs such as Doppler (http://www.dopplerradio.net) and iPodder to assist users in subscribing to and downloading podcasts. Once the address of a podcast is located, the Web address can be added to a user's list of subscriptions. Apple also makes available, for free, its iTunes software—

available for both PC and Mac—that handles searching, subscribing, and downloading of audio files.

11. Digital Audio Glossary

8-track: Tape cartridge invented in the early 1960s. Became popular because major automakers began including an 8-track player as an option in cars in the late 1960s. The 8-track format remained popular throughout the 1970s until overtaken by the cassette tape. For a detailed history, see http://www.8trackheaven.com/early.html.

AIFF (Audio Interchange File Format): Digital audio file format widely used with the Macintosh platform. AIF format is Windows-compatible.

Analog: Analog transmission is a method of sending signals in which the transmitted signal is a wave of reflection similar ("analogous") to the original signal.

Audio restoration: The process of restoring an audio source to its original form on a different medium (e.g., transfer of data on a cassette tape to a compact disc).

Bit: A bit is the smallest unit of data in a computer. A bit (binary digit) represents 0 or 1 to the computer. Eight bits make a byte.

Bit depth: In digital audio, bit depth describes the range of numbers used to represent each amplitude measurement of a sampled sound wave. In general, the more bits that are available, the more accurate the resulting output from the data being processed. From http://whatis.techtarget.com/definition/0,289893,sid9_gci213497,00.html.

Born digital audio: Audio recordings created with digital computer recording systems, with no analog media involved in any stage of the recording process.

BWF: File extension for Broadcast WAV File, a professional WAV file type with the capability to store metadata in the file header. (See also WAV.)

Cassette: Audio tape format introduced by Philips in 1962 as the "compact cassette." The format rose to popularity in the late 1970s and early 1980s.

CD-ROM (Compact Disc Read-Only Memory): This is an adaptation of the CD that is designed to store computer data in the form of text and graphics. Philips and Sony defined the original data format standard. Format of the CD-ROM is the same as for audio CDs: a standard CD is 120 mm (4.75 inches) in diameter and 1.2 mm (0.05 inches) thick, and is composed of a polycarbonate plastic substrate (underlayer—this is the main body of the disc), one or more thin reflective metal layers (usually aluminum), and a lacquer coating. From http://whatis.techtarget.com/definition/0,,sid9_gci211759,00.html.

Codec (compressor/decompressor) algorithm: As the name implies, codecs are used to encode and decode (or compress and decompress) various types of data—particularly those that would otherwise use up inordinate amounts of disk space, such as sound and video files. Common codecs include those for converting analog video signals into compressed video files (such as MPEG) or analog sound signals into digitized sound (such as RealAudio or MP3). Codecs can be used with either streaming (live video or audio) or files-based (AVI, WAV) content. From http://www.cnet.com/Resources/Info/Glossary/Terms/codec.html.

Compact disc: A compact disc (CD) is a medium for electronically recording, storing, and playing back audio, video, text, and other information in digital form. CDs have generally replaced cassette tapes and LPs for playing back music. Initially, CDs were read-only, but newer technology allows users to record as well. CDs will probably continue to be popular for music recording and playback. A newer technology, the digital versatile disk (DVD), stores much more in the same space and is used for playing back movies. From http://whatis.techtarget.com/definition/0,289893,sid9_gci507072,00.html.

Compact disc book standards: These standards refer to the color-coded books devised by CD manufacturers that address the types of data for encoding compact discs. For example, the Yellow Book standard (1988) covers CD-ROM, and the Red Book describes those physical specifications for audio CDs. (See also Red Book.)

Compression: The process of compacting binary data into a smaller whole. Compression can be lossy, in that certain types of data are intelligently removed, or lossless, in that no data is removed during the process.

DAT (Digital Audio Tape): DAT is a storage format for data or music, originally developed in the 1980s for music. Audio units and computers can use the same media but data is stored in the DDS format. DAT can be recorded on one side and is generally 120 minutes long.

Density: Density describes how tightly or loosely data is packed onto a storage medium. A higher density level means a device can store more data.

Digital: A description of data encoded in a binary format that is capable of being read or manipulated by electronic devices.

Digital audio data: This refers to sound that has been digitized into binary code. The code can be stored in a variety of formats. (See WAV, AIFF, etc.)

Digital reformatting: The process of converting an item (physical, audio, or video) into a binary format capable of being read or reproduced by a computer.

Error correction: The use of algorithms to correct corrupted data or blocks of data while receiving or processing.

Frequency: The rate or speed of a repeating sound wave.

Gain: Audio level. Also referred to as volume.

IPS (inches per second): The standard for measuring tape speed.

KHz (kilohertz): A unit of measure representing 1,000 hertz. KHz and mHz (megahertz) are often used to describe the bandwidth required to transport data.

MP3: MP3 is the file extension for audio files in MPEG Layer 3 format. MP3 files are tightly compressed but preserve the original quality of the recording. These files are small and travel easily via the Internet. MP3 audio files are popular not only because of size and playback quality, but also because a wide variety of players and downloadable audio files are available. See http://whatis.techtarget.com/definition/0,,sid9_gci212600,00.html.

Print through: Print through is the process in which data is transferred to a new location through physical contact. This occurs primarily with magnetic tape. For example, data may transfer to a new spot on a cassette tape that has sat idle for a long period of time.

Red Book: Red Book is the standard for audio compact disks, named after one set of color-bound books that contain the technical information on CD and CD-ROM formats. The physical parameters and properties of the CD are specified in the standard, including the encoding of the digital audio file, error rates, modulation systems, channels, and graphics.

Release forms: Release forms release the content of an audio recording to the owning institution or individual. Such forms should include a wide variety of details, including the intended use of the recording and permissions to copy or reformat.

Sample size: Larger sample sizes reproduce higher-quality sounds. See sampling rates, below.

Sampling rates: The sample rate is the number of samples of a sound that are taken per second to represent sound digitally. The more samples taken per second, the better the reproduction of the sound. The current sample rate for CD-quality audio is 44,100 samples per second.

Sound card: A sound card is a board installed in a computer, allowing it to play and manipulate audio files.

Sound pressure/amplitude: Sound pressure levels are measured in decibels, notated as dB, and determine the level of volume created by a sound wave.

Streaming: A method of transferring data so it can be processed in a steady or continuous stream. RealAudio, Windows Media, and QuickTime are examples of streaming media players. Data can begin playing before the whole file is downloaded with a browser or plug-ins.

Transcript: A word-for-word written copy of an audio recording, or may also be written as summary transcripts.

WAV file (Waveform Audio File Format): An audio file format for Windows developed by Microsoft and IBM. WAV support was built into Windows 95 and has become an industry standard since. A variety of applications now support WAV files, as do additional operating system platforms, such as Macintosh.

12. Digital Audio Resource List

Audio History, Preservation, and Reformatting

Conservation On-Line, “Preservation of Audio Materials,” 23 April 2003, http://sul-server-2.stanford.edu/bytopic/audio/.

Gibbs, John R., “Audio Preservation and Restoration,” University of Washington Music Library, 23 April 2003, http://www.lib.washington.edu/music/preservation.html.

History of Sound Recording Technology, n.d., http://www.recording-history.org/.

Library of Congress, “Project Documents from the First Phase of the Recorded Sound Digital Preservation Prototyping Project,” 2005, http://www.loc.gov/rr/mopic/avprot/avlcdocs.html (accessed 20 July 2005). Of particular interest are the “Audio transfer and image scanning specifications”—a sample statement of work for contractor selection—and the “Additional Early Project Documents” section, which contains several attachments from LC’s Request for Quotes for this project, particularly for in-house projects. Section IX, “Working with Others,” contains a subsection on outsourcing.

National Initiative for a Networked Cultural Heritage, “The NINCH Guide to Good Practice in the Digital Representation and Management of Cultural Heritage Materials,” 2002, http://www.nyu.edu/its/humanities/ninchguide/index.html.

Section VII, “Audio/Video Capture and Management,” covers technical issues in digitizing audio and video, and Section VIII, “Quality Control and Assurance,” contains a subsection specifically on digital audio and video. Section II, “Project Planning,” addresses general project management issues.

National Library of Australia, Preserving Access to Digital Information (PADI), “Audio and Audiovisual Material,” http://www.nla.gov.au/padi/topics/48.html.

Newton, Graham, “Frequently Asked Questions about Audio-Restoration,” n.d., http://audio-restoration.com/faq.php. Graham Newton owns a company that transfers older analog media to digital media. He keeps an FAQ page about restoration and transfer, as well as links to equipment suppliers

Porck, Henk J., and René Teygeler, *Preservation Science Survey: An Overview of Recent Developments in Research on the Conservation of Selected Analog Library and Archival Materials,* Council on Library and Information Resources (CLIR), December 2000, http://www.clir.org/pubs/Abstract/pub95abst.html.

Research Libraries Group, “Tools for Digital Imaging,” 2005, http://www.rlg.org/en/page.php?Page_ID=408. While this page is oriented toward large imaging projects, it points to several good project-planning resources, including guidelines to creating an RFP, and a sample RFP and RFI (Request for Information).

Safe Sound Archive, Links and Resources, http://www.safesoundarchive.com/links.cfm.

Schoenherr, Steve, “Recording Technology History,” 6 July 2005, http://history.acusd.edu/gen/recording/notes.html.

Seadle, Michael, “Sound Practice: A Report on the Best Practices for Digital Sound Meeting, 16 January 2001, at the Library of Congress,” http://www.rlg.org/preserv/diginews/diginews5-2.html#feature3.

St-Laurent, Gilles, “The Care and Handling of Recorded Sound Materials,” Council on Library and Information Resources (CLIR), 1996, http://palimpsest.stanford.edu/byauth/st-laurent/care.html.

Van Bogart, John W. C., “Magnetic Tape Storage and Handling: A Guide for Libraries and Archives,” National Media Laboratory, June 1995, http://www.clir.org/pubs/reports/pub54/index.html.

Vidipax, a collection of articles regarding different issues on restoring and archiving magnetic media, http://www.vidipax.com/articles/.

Digital Audio Collections and Related Projects

The Arhoolie Foundation's Strachwitz Frontera Collection of Mexican and Mexican American Recordings with the UCLA Library, http://digital.library.ucla.edu/frontera/. This collection of commercially produced Mexican and Mexican-American Recordings (the Frontera Collection) is the largest repository of Mexican and Mexican-American vernacular recordings in existence.

British Library, "National Sound Archives," n.d., http://www.bl.uk/collections/sound-archive/nsa.html.

Harvard University Library Digital Initiative, "Audio Reformatting," n.d., http://hul.harvard.edu/ldi/html/reformatting_audio.html. LDI procedures are being developed as part of the Eda Kuhn Loeb Music Library's project. The site has links to industry standards and project guidelines.

Library of Congress, American Memory, "Technical Notes by Type of Material: Sound Recordings," http://memory.loc.gov/ammem/dli2/html/sound.html. General comments on digital reproductions of sound recordings for American Memory.

National Gallery of the Spoken Word, http://www.ngsw.org/.

Metadata

Audio Engineering Society (AES), "Report of the meeting of SC-06-06 Working Group on Audio Metadata of the SC-06 Subcommittee on Network and File Transfer of Audio" held in conjunction with the AES 115th Convention in New York, NY, 10 October 2003, http://www.aes.org/standards/b_reports/b_meeting-reports/aes115-sc-06-06-report.cfm.

Audiovisual Archives, 1999, http://www.iasa-web.org/icat/icat001.htm.

Encoded Archival Description (EAD), 2002, http://www.loc.gov/ead/.

IASA, "IASA Cataloging Rules: A Manual for the Description of Sound Recordings and Related Audiovisual Media," Stockholm: International Association of Sound and International Symposium on Music Information Retrieval, http://ciir.cs.umass.edu/music2000/.

Library of Congress, American Memory, "Technical Notes by Type of Material: Sound Recordings," http://memory.loc.gov/ammem/dli2/html/sound.html. General comments on digital reproductions of sound recordings for American Memory

Library of Congress, “AV Prototype Project Working Documents: Extension Schemas for the Metadata Encoding and Transmission Standard,” http://lcweb.loc.gov/rr/mopic/avprot/metsmenu2.html and http://lcweb.loc.gov/rr/mopic/avprot/avprhome.html.

Oral History Techniques

Matters, Marion, *Oral History Cataloging Manual,* Chicago: Society of American Archivists, 1995.

Oral History Association, n.d., http://www.dickinson.edu/organizations/oha.

Smithsonian Folklife and Oral History Interviewing Guide, http://www.folklife.si.edu/resources/pdf/InterviewingGuide.pdf.

Professional Societies

Association for Recorded Sound Collections
Founded in 1966, the Association for Recorded Sound Collections (ARSC) is a nonprofit organization dedicated to research, study, publication, and information exchange surrounding all aspects of recordings and recorded sound.
http://www.arsc-audio.org/

Audio Engineering Society
The Audio Engineering Society is devoted exclusively to audio technology. Its membership consists of engineers, scientists and other authorities. It encourages and disseminates new developments through annual technical meetings and exhibitions of professional equipment, and through the *Journal of the Audio Engineering Society*, the professional archival publication in the audio industry.
http://www.aes.org/

Society of American Archivists, Oral History Section
The Oral History Section of the Society of American Archivists is composed of members of the Society and others who are interested in or are actively engaged in conducting oral history interviews and/or teaching oral history methodology. The Oral History Section provides a forum for news, for discussion of issues and developments, and for establishing and maintaining communication and cooperation with other professional organizations.
http://www.archivists.org/saagroups/oralhistory/index.asp

Society of American Archivists, Recorded Sound Roundtable
Serves as a forum for discussing the role, needs, and care of sound recordings in archival collections.
http://www.archivists.org/governance/handbook/section10.asp#description

Software

Adobe Audition (formerly Cool Edit Pro)
http://www.adobe.com/products/audition/main.html

Apple QuickTime
http://www.apple.com/quicktime/

Digital Audio Recorder
http://www.dartpro.com/

Mackie Tracktion 2
http://www.mackie.com/products/tracktion2/index.html

Microsoft Windows Media
http://www.microsoft.com/windows/windowsmedia/

Pro Tools
http://www.digidesign.com/

RealAudio
http://www.real.com

Sound Forge
http://www.sonymediasoftware.com/

Related Articles and Source Material

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