DIGITAL REFORMATTING OF MAGNETIC AUDIO RECORDINGS

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Preservation Reformatting
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PURPOSE

This paper is a review of administrative, philosophical and technical decisions encountered in the reformatting of analog audio materials to digital formats. The purpose is to provide an overview and reference handbook on analog-to-digital audio conversion for preservation administrators, curators and archivists of sound recordings of enduring value.

The historic and cultural record is made up of many categories of sound recordings of enduring value (including but not limited to: oral histories, studio recorded music, live performances, public speeches, meetings or events, radio broadcasts) and they are recorded on a range of media formats (e.g., wax cylinder, wire, analog disc, magnetic tape). Broad philosophical issues and technical information on the digital reformatting media discussed in this paper may be extended to the entire range of the formats of recorded sound (e.g., wax cylinder, wire, analog disc, tape) but for the purposes of focus and brevity, *discussion on the original source media will be limited to magnetic tape*.

It is hoped that this paper will be a useful supplement to general digital reformatting planning guides and a supplement to older manuals on the management and preservation of recorded sound collections.

INTRODUCTION

Sound recordings on magnetic tape may need to be reformatted for a variety of reasons; the underlying prime consideration is usually to ensure and/or enhance access to the record. For the purpose of this overview, *ensuring access* to the record is usually an effort to migrate the information from a failing or damaged media substrate to one that is known to be more reliable and by making service copies to protect preservation masters. *Enhancing access* can also include reformatting for wider distribution (by making service copy products on a variety of media), and audio restoration (reengineering sound to create a more "listenable" product, or one estimated to be more faithful to the original event). At the risk of being divisive, one might describe *ensuring access* as a preservation goal and *enhancing access* as a curatorial goal, both contributing to the overall access that is so important in the management of library and archival materials.

Both of these goals may be achieved by reformatting to the only accepted preservation medium, archival reel-to-reel magnetic tape, in an environment that provides for appropriate storage, handling and a migration plan. *Why then should one consider reformatting digitally?* As will be seen in the text of the paper, digital reformatting offers increased, continued and/or enhanced access through 1) the development of user-friendly service copy products and, 2) the preservation of information via copying without generational loss as is found in magnetic tapes. Information supporting these statements will be found in the text of the paper.

Major subject areas covered include:

- **Overview of Administrative Decisions** - in which background information is covered including deterioration of magnetic media, historical and current reformatting options, ethics, authenticity and characteristics of digital surrogates
- **Program Planning, Design, Implementation** - in which procedural and technical information is covered including selection and identification, preparation of materials, conversion, bibliographic control and access, storage and handling of the original and the new digital surrogates, and budget planning.
- **Our Conversion Project with Karl Miller** - which reports a practical exercise with a professional audio restorer
- **The Future of Magnetic Audio Preservation: Current Indications** - in which case studies are examined, trends and future developments are discussed
- **Appendices** - in which are included materials designed to be helpful procedural tools including a sample examination and survey tool, and an outline of the elements related to planning a reformatting project**.**

OVERVIEW OF ADMINISTRATIVE DECISIONS

Many of the administrative decisions in digital reformatting are not new and have been encountered before by preservation and curatorial professionals.[1] There are issues of selection, workflow, staffing, vendor relations and contracts, production method and end product types, quality control, costs and funding, integrating, publicizing and maintaining the end products. The institution's collection needs must be examined together with its financial and staffing ability to commit to short or long-term projects to

[1] Many of the necessary components in a reformatting program are found in: Nancy E. Gwinn, editor, *Preservation Microfilming: A Guide for Librarians and Archivists* (Chicago: American Library Association, 1987).

see whether it is more feasible to begin an in-house program or to contract with vendors on a project basis. The above considerations are discussed elsewhere in general manuals on planning reformatting projects; this paper will present factors unique to magnetic tape, which impact the decision to reformat to digital media.

DETERIORATION OF MAGNETIC MEDIA

There are several ways in which magnetic media deteriorates. The primary cause of magnetic media deterioration is failure of the binder. "The binder is responsible for holding the magnetic particles on the tape and facilitating tape transport. If the binder loses integrity—through softening, embrittlement, loss of cohesiveness, or loss of lubrication—the tape may become unplayable."[2] The binder is subject to hydrolysis, a chemical reaction in which atmospheric water reacts with chemicals in the binder causing long molecule particles to break up, thereby weakening the chemical structure of the binder. Binder hydrolysis causes "sticky shed syndrome," a condition characterized by the magnetic particles separating from the substrate during playback. The heads of the playback equipment will clog and portions of the recorded sound will "drop out," rendering the information inaccessible. Sticky shed is also detectable when a magnetic tape squeals during playback.

It is difficult for scientists to study the chemical components used in magnetic tapes because "the composition of most of the constituent materials is considered an industrial secret"[3]; this is especially true for binder chemical formulation. Manufacturers frequently change the formulation of binders, often within the same batch or lot of tape products.[4]

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[2] John W. C. Van Bogart, *Magnetic Tape Storage and Handling: A Guide for Libraries and Archives* (Washington, DC: Commission on Preservation and Access, June 1995), 3. Published with the National Media Laboratory, St. Paul, MN.

[3] Henk J. Porck and René Teygeler, *Preservation Science Survey: An Overview of Recent Developments in Research on the Conservation of Selected Analog Library and Archival Materials* (Washington, DC: Council on Library and Information Resources, December 2000), 45.

[4] Leslie E. Smith, "Factors Governing the Long-term Stability of Polyester-based Recording Media," *Restaurator* 12: 4 (1991), 202.

Other means by which magnetic media degrade include demagnetization of the pigment and loss of lubrication. “Magnetic particles differ in their stability.”[5] The most stable are iron oxide and cobalt-modified iron oxide; the least stable are metal particulate and chromium dioxide. When information is recorded on magnetic tape, an electric signal rearranges the position of the magnetic particles. The nature of magnetic polarity is such that, over time, the particles tend to revert to their original position.[6] “Print through,” the effect of magnetic particles in one tape layer essentially re-recording over particles in adjacent layers, is another condition typically exhibited by magnetic media stored improperly. Demagnetization can be slowed by cooler temperatures, “however, by-products of binder deterioration can accelerate the rate of pigment deterioration, so lower humidity would also be preferred to minimize the degradation of the magnetic pigment.”[7]

Lubricant is necessary “to reduce friction of the magnetic top coat layer of the tape. Lower friction will facilitate tape transport through the recorder and reduce tape wear.”[8] The amount of lubrication is reduced inevitably over time by tape use, evaporation, or hydrolysis.

The magnetic media’s substrate is another potential source of degradation. The earliest tapes have a paper base, and are in extremely fragile condition today. During the 1940s and 1950s, magnetic tape was produced with a base of cellulose acetate. The acetate plastic is subject to hydrolysis, which eventually causes a volatile condition known as “vinegar syndrome.” A tape afflicted with vinegar syndrome emits acetic acid as a by-product of the hydrolytic reaction. The plastic becomes brittle and shrinks dramatically, causing catastrophic failure to the magnetic pigment.

Since the early 1960s, polyester, or Mylar, has been used as a tape substrate. While polyester is much more stable than cellulose acetate, the binder used with polyester, most commonly polyester polyurethane, is still subject to hydrolysis.[9] Furthermore, stresses on polyester tape during storage can cause distortions and

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[5] Van Bogart, *Magnetic Tape Storage and Handling*, 5.
[6] Karl Miller, class lecture at the University of Texas at Austin, Austin, TX, 28 February 2001.
[7] Van Bogart, *Magnetic Tape Storage and Handling*, 6.
[8] Van Bogart, *Magnetic Tape Storage and Handling*, 4.
[9] Gilles St-Laurent, *The Care and Handling of Recorded Sound Materials* (January 1996). http://palimpsest.stanford.edu/byauth/st-laurent/care.html [Accessed 12 April 2001].

dimensional changes. "Polyester-based tape has a high tensile strength that can cause it to stretch irreparably (instead of breaking cleanly and reparably as does acetate-backed tape)."[10] Deformation is commonly caused by poor pack wind "as indicated by . . . strands of tape protruding from the edge of a wound roll of tape."[11] Serious structural changes to polyester tape can be prevented by maintaining proper storage and stable environmental conditions.

The effects of extreme temperatures and fluctuations in relative humidity on shortening the life of magnetic media are well documented.[12] Magnetic tapes that receive high use will also have a lower life expectancy due to handling, playback, and variation between ambient conditions in the storage facility and the listening area. Fingerprints, dust and debris are problematic because these "foreign matter deposits" attract and absorb moisture, which can initiate hydrolysis and promote mold growth; additionally, deposits can cause dropouts during playback. Gaseous pollutants and mold, which feeds on the binder polymer, can also adversely affect the life of magnetic media.

HISTORICAL & CURRENT WAYS OF REFORMATTING MAGNETIC MEDIA

Problems with magnetic media were published on at least as far back as 1959, and addressed in the report to the Library of Congress by the research scientists A.J. Pickett and M.M. Lemcoe at the Southwest Research Institute. The report was begun in 1954 in order to provide information for the librarian "comparable to that which had been evolved for paper and film . . . and to develop suitable techniques for the preservation of disc and magnetic recordings."[13]

The findings were to be the basis for many manuals on the management of sound recordings. The variety of substrates of magnetic tape media, (including Kraft paper, and a variety of plastics – cellulose nitrate, cellulose acetate and polyester) and their problems (dimensional instability, binders and plasticizers) are discussed. Many of the standards

[10] St-Laurent, *The Care and Handling of Recorded Sound Materials*.
[11] Van Bogart, *Magnetic Tape Storage and Handling*, 6.
[12] For a thorough compilation of sources, see: *Audio Preservation: A Selective Annotated Bibliography and Brief Summary of Current Practices* (Chicago: American Library Association, Association for Library Collections and Technical Services, Preservation and Reformatting Section, 1998).
[13] A. J. Pickett and M. M. Lemcoe, *Preservation and Storage of Sound Recordings* (Washington, DC: Library of Congress, 1959), 1.

for preservation one sees today, such as using a 1.5 mm thick Mylar base tape, cleaning, rewinding, and regular inspection are addressed in this report, with recommendations for environmental control, storage, best available substrate, avoiding print-through and creep, demagnetization, etc.

Between the 1960s and 1980s, many articles and several manuals on the management of recorded sound archives were written, but the chief focus was on storage and handling as a means of preservation. Where reformatting was addressed, it was simply a matter of copying from an unstable to a stable medium via low-tech commercial machines or sophisticated reel-to-reel arrangements with variable head sizes and tracking mechanisms. It was also recommended that for long-term storage only 1.5 mm Mylar or polyester base should be used. In some manuals, equalization, noise reduction and speed of dubbing are discussed in terms of restoration of sound quality.[14] The problem of sticky-shed began to appear in articles in the 1990s, and was the subject of a new burst in publishing activity on the potential catastrophic loss of magnetically recorded information, sound or otherwise.

Beyond the continually accepted 1.5 mm Mylar or polyester magnetic tape, recent available options for reformatting include digital audio tape (DAT), digital linear tape (DLT), printed compact disc (CD), optical recordable compact disc (CD-R), optical rewritable compact disc (CD-RW), and server-based storage systems. These all have characteristic drawbacks and some are more reliable than others. Future and projected developments include a movement away from media based information storage ("medialess" systems)[15], faster than real-time direct transfer to mass digital storage systems[16], quantum mechanical impulses, holographic systems, and live systems involving continually refreshed electronic impulses.

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[14] See Jerry McWilliams, *The Preservation and Restoration of Sound Recordings*, Nashville, American Association for State and Local History, 1979. Also, "*State of the Art Equipment in the Guide to the Basic Technical Equipment Required by Audio, Film and Television Archives*", ed. by George Boston.

[15] James Lindner, "Let's just get rid of tape and optical media entirely." Discussion thread on AV Media Matters listserv, begun 6 April 2001, 11:45:36 -0700. http://palimpsest.stanford.edu/byform/mailing-lists/av/ [Accessed 25 April 2001]

[16] "Report on the 5th Joint Technical Symposium, Paris, January 2000," *IFLA Journal* 26, no. 3 (2000): 230-232.

Written Transcription of Oral History Tapes[17]

Having a written transcription of the contents of an oral history tape is a major part of the oral history technique. When oral histories were first developed, the written transcription of the tape was the only record that was kept from the interviews. After transcription, the tapes were discarded or used to record other interviews. Later, it was recognized that the oral features of the interviews (tone, rhythm, pauses, volume, and accent) were one of the most important characteristics of the records. Thus, the need to preserve the tapes was also acknowledged.

Historians are used to working with written transcripts and almost all oral history archives provide access to both, the oral and the written materials. Taking into consideration the differences between the oral and the written communication, an adequate transcription of an interview is a great challenge in itself. The written transcription involves a number of techniques with varying amounts of details. Ideally, transcriptions are done immediately after the interview takes place by specialized technicians. Although a transcription is not meant to replace an original recording, there are many cases in which the original no longer exists or is badly damaged, and thus the transcription becomes as important as the original.

"Ceçi n'est pas un pipe"

In considering the values and ethics of reformatting, it is helpful to consider for a moment the contribution of the Surrealist painter René Magritte. His painting, *La Trahison des Images*, of a large wooden pipe with the caption "Ceçi n'est pas un pipe" ("This is not a pipe") painted below reminds us that we cannot always believe in the information that is presented to us, no matter how framed, documented or institutionalized.[18] Magritte's statement is even more relevant when the image is copied onto transparencies, postcards, Web sites, etc. This representation is not a pipe, nor even is it a painting any longer.

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[17] The information about current practices for oral history written transcription was extracted from an interview with Dr. Dora Shwartstein (20 March 2001) Oral History Project Director, Facultad de Filosofía y Letras, Universidad de Buenos Aires, Argentina.

[18] René Magritte, *La Trahison des Images*, oil painting, 1929, Los Angeles County Museum of Art.

In audio (and video) recording, it cannot ever be stated that the recording is a true representation of the original performance or event. Sound is a phenomenon based on time, distance, frequency, size and shape of sound waves. Perception of sound is variable between listeners and recording devices, depending on distance, auditory capability, size, shape (mouth, speaker cone), and age of projection and sensory devices (eardrum, microphone).

An enormous number of variables in playback and recording equipment influence the audible features of both the original and secondary reformatted product. These include the subjective input, skill and control of the audio engineer or reformatting team member, the inherent capability of a secondary media to capture and record, and for different equipment to playback the "same" information. The above example is used to show that there can be no such thing as a "true copy" in any reformatting project. Change is unavoidable, and must be acknowledged as an inherent characteristic of reformatting.

An excellent description of how a digital surrogate differs from the original recording is provided by David M. Levy, asks:

> What is a copy? . . . It is worth comparing print with analog audio or video recording…in the case of printing the source is used to produce a definite number of copies, an edition. Each copy in an edition is a stable physical object whose existence is independent of the source. But in the case of recording, when the tape is defined as the source, there is no notion of a definite number of copies (i.e. replayed performances); rather, once you have the tape and an appropriate player, you can produce a (relatively) unlimited number of copies or performance . . . unlike the products of print, the copies are completely dependent on the source for their existence. . . . This gives the source a greater importance in the case of recordings.[19]

Once the above realities are acknowledged, one can begin the serious business of implementing a reformatting program. Specific issues affect many decisions that will be made in the processes of selection and conversion. They are listed here in the form of questions to be considered:

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[19] David M. Levy, "Where's Waldo? Reflections on Copies and Authenticity in a Digital Environment," in *Authenticity in a Digital Environment* (Washington, DC: Council on Library and Information Resources, May 2000), 24-31.

Questions to ask when considering reformatting originals to digital format:

- Is reformatting necessary? What is the motivating factors for migration of the information?
- Can the original withstand playback? If not, can it be treated to allow reformatting? Is the risk worth taking?
- Is the previous storage and amount of use of the original known that could indicate the quality or reliability of the existing original versus another copy?
- Is the original still valuable, usable, and accessible to users in its original format? Can the original be maintained alongside the digital product?
- Does the repository/owner have the analog technology available to play the tape and is it maintained/maintainable? Is there a commitment to maintain staffing and equipment?
- Are there records of the creation and provenance that should also be considered for reformatting or inclusion in the metadata?
- How can you guarantee to the user authenticity of the record in a digital product? What is authenticity for the purposes of the users and the archive?

AUTHENTICITY

Authenticity and/or credibility are issues that are too complex to be anything but touched on here. More commonly addressed in regard to intellectual property rights, the subject of authenticity in digital collections for libraries, archives and cultural institutions has already been the focus of conference proceedings and publications.[20] Nancy Brodie, describing the approach of the Canadian Association of Law Libraries (CALL), puts forth an example of defining and protecting authenticity:

> **Authentication provided by libraries, archives or other depositories**
> . . . Libraries and archives are trusted intermediaries that protect the documents they hold and assure anonymity of users. Library and archival procedures are based on professional standards and practices and are documented. Institutions such as the National Archives of Canada have decided not to preserve encrypted documents but only to preserve the contents in unencrypted form. The Archives

[20] See *Authenticity in a Digital Environment*. (Washington, D.C., Council on Library and Information Resources, May 2000). http://www.clir.org/pubs/reports/pub92/pub92.pdf, 32-44 [Accessed 21 April 2001]

> will use its status as a trusted repository and custodian to achieve authentication through other means.[21]

Encryption, which the National Archives of Canada have decided against, is a standard component of computer security. Encryption does not necessarily mean that a password is needed to open a particular file or site - it can also take the form of digital watermarking or steganography. Digital watermarking can be performed by running a programmed algorithm on a file, leaving a visible or essentially invisible mark that may or may not appear on the output file. This can be achieved for any type of media file including, audio, graphic and video.

Chief among the problems for archival or cultural property is that digital watermarking and steganography, as Clifford Lynch states, "deliberately and systematically corrupt objects to which they are applied . . . changing bits within the object, but in such a way that they change the object only slightly."[22] He summarizes by stating, "The watermark may have some value in forensic examination of digital objects, but it does not seem to be a good tool for the management of digital objects within a controlled environment such as an archive or repository system that is concerned with object integrity."[23]

The obvious subtext here is that when developing products for an *uncontrolled* environment, such as the Web, digital watermarking would be useful to controlling the end use of the repository's object, by requiring the usual request for rights and permissions for access to an unwatermarked version of the digital object. Authentication may be more readily achieved by the attachment of a digital signature, which identifies the sender and does not affect the integrity of the record.

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[21] Nancy Brodie, "Authenticity, Preservation and Access in Digital Collections," paper delivered at *Preservation 2000: An International Conference on the Preservation and Long Term Accessibility of Digital Materials*. York, England, December 7-8, 2000. Conference papers available at http://www.rlg.org/events/pres-2000/brodie.html [Accessed April 18, 2001]. Brodie includes a helpful Appendix: "Components of authentication in an electronic environment."

[22] Clifford Lynch, "Authenticity and Integrity in the Digital Environment: An Exploratory Analysis of the Central Role of Trust," in Authenticity in a Digital Environment (Washington, DC: Council on Library and Information Resources, May 2000). http://www.clir.org/pubs/reports/pub92/pub92.pdf, 32-44 [Accessed 21 April 2001]

[23] Lynch, *Authenticity and Integrity in the Digital Environment*.

Thus far, we have discussed authenticity as credibility of the document. The authenticity of the *sound* of the recording is an issue that raises questions of ethics regarding manipulation, fidelity, historical accuracy, artist's intent, etc. In every type of reformatting, there is loss of the information inherent in the "source original", or the primary container of the information.[24] In analog magnetic-to-magnetic reformatting, there is always generational loss from first to second generation, and losses or enhancement of particular sounds can occur through intermediary devices. In analog to digital conversion and digital-to-digital copying, there is no generational loss but the input and changes applied to the sound wave patterns with intermediary devices can be infinitely more controlled by use of graphical user interface sound engineering tools.

The danger in maintaining credibility for the library and archive is in the liability of decision-making. The curator/administrator is in a position to decide how much information to keep or to lose, through manipulation of the technical equipment by a knowledgeable engineer or technician. In the case of analog audio recordings, information that might not be carried over in migration to digital formats includes:

- sounds that are not desired (noise, hiss, pops, coughs, rumble)
- the original physical recording medium (record, tape, wax cylinder, etc.)
- accessories (transcript sheets, housings, ephemera such as price tags, inclusions)
- annotations (labels, annotations on housings, or on the medium itself)

It is an ethical imperative for decision-makers to make a conscious decision about whether or how to maintain the information contained in the analog format. In order to maintain the authenticity of the document, much of the information can be transcribed as metadata or imaged and saved as parallel files. Metadata should also include a record of changes made to the document if possible. Schemes for entering metadata will vary between projects and vendor product; consider this caveat noted in the report of a recent technical symposium:

> In transfer/migration operations it is necessary not only to transfer the recorded contents, but also to manage the information on these contents (metadata). There are a number of vendors offering a variety of solutions to manage the contents and

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[24] *The Evidence in Hand: the Report of the Task Force on the Artifact in Library Collections, Draft* (Washington, D.C.: Council on Library and Information Resources, March 9, 2001). http://www.clir.org/activities/details/artifact-docs.html [Accessed 18 March 2001].

> metadata. The functions that the vendors built into their software often reflect the business processes they have worked most closely with (prepress; newspaper publishing; stock photo sales). Vendors are generally more concerned with adapting the solutions they have already developed to new needs than develop specific software.[25]

Options for maintaining artifactual information and metadata include: making a commitment to preserve and retain access to originals for possible comparison to the reformatted product or maintaining and/or creating access to an unmodified ("straight") version of the end product

- reformatting accompanying visual materials
- making accessible the above by including them in finding aids or by including them on reformatting media, such as by using extra tracks on CDs, creating hyperlinks on Web pages, etc.[26]
- making available multiple identical sound files products using differing compression ratios
- making sure that playback and reformatting, recording equipment are calibrated to an agreed upon standard[27]

Another option to maintain the authenticity of the document is to include a disclaimer regarding the conversion. Consider this example for *oral histories* from the Library of Congress' American Memory Web site "Digitizing the Sound Recordings for the Quilts and Quiltmaking in America 1976-1996",

> The sound recordings presented in the online collection were taken from the original seven-inch reel-to-reel tape recordings in the Library's collections. The analog audio from the tapes was transferred to Digital Audio Tape (DAT) to produce a master source for digitization. Some background noise may be apparent on the recordings. The audio files have not been digitally enhanced or altered in any way from their original state. WAVE, RealAudio, and MP3 versions have been supplied for each recording.[28]

[25] "Report on the 5th Joint Technical Symposium."
[26] Gwendal Auffret, "From TV and radio archives to digital libraries: the digitization of audio-visual cultural heritage," Paper presented at *Tenth DELOS Workshop on Audio-Visual Digital Libraries*, Greece, 24-25 June 1999. http://www.iei.pi.cnr.it/DELOS/WORKSHOP/Auffret.html [Accessed 18 March 2001]
[27] George Brock-Nannestad, "Calibration of audio replay equipment for mechanical records," Paper presented at " Image and Sound Archiving and Access: the challenges of the 3rd Millennium," Joint Technical Symposium, Paris, January 2000. Abstract available at http://www.cst.fr/jts2000/en/index.htm#res [Accessed 18 March 2001]
[28] The Library of Congress, American Memory. *Quilts and Quiltmaking in America*. "Building the Digital Collection, Digitizing the Sound Recordings" http://memory.loc.gov/ammem/qlthtml/qltbuild.html#digs [Accesssed 21 April 2001]

Whereas for another project of *recorded music* on the American Memory site,

> The sound recordings in Fiddle Tunes of the Old Frontier: The Henry Reed Collection were transferred from the original 7-inch, 7.5 ips (inches per second) analog tape reels to digital audio tape (DAT) to produce a master source for digitization. Transfers of AFS 13,034b29-36; 13,035a31-b14; and 13,037a1-27 and b1-3 were made by the American Folklife Center. AFS 13,033b, 13,703b, and 13,705a32-57 and b were transferred from a 1/4-track reel-to-reel machine to DAT by the Motion Picture, Broadcasting and Recorded Sound Division Laboratory, using their customary and conservative practices of level, equalization, and noise reduction. WAVE Form (.WAV), MPEG 2, Layer 3 (.mp3), and RealAudio (.ra) versions have been supplied for each recording. The WAVE files were created from the DAT tape at a sampling rate of 44,100 Hz per second, 16-bit word length, and a single (mono) channel. The RealAudio files were derived from the WAVE files through digital processing and were created for users who have at least a 14.4 modem (8-bit). The RealAudio - G2 files were created for users who have at least a 24 modem. The MP3 files were derived from the WAVE files in a batch-conversion process using the MP3 plug-in of Sonic Foundry's SoundForge software. Some surface noise may be apparent on the recordings, and tracks may start or end abruptly, as on the original recordings. Minimal adjustments to volume were made to certain tracks, and, on the advice of the consultant-collector, some snippets of conversation and fragments of music have been deleted.[29]

CHARACTERISTICS UNIQUE TO DIGITAL SURROGATES

When creating Web products, or if considering bypassing physically usable media such as cassettes and CDs for service copies, a responsible decision-maker must consider compliance with the Americans with Disabilities Act. While lesser or non-sighted persons can use physically recorded formats, they need assistive devices to use virtual playback equipment as for any computer-based tool. For persons with hearing and sight difficulties, alternative equivalent information should be made available in Web-based content. For example, if reformatting oral histories, efforts should be made "to provide text equivalents for non-text content since text may be rendered as synthesized speech for individuals who have visual or learning disabilities, as Braille for individuals who are blind, or as graphical text for individuals who are deaf or do not have a disability."[30]

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[29] The Library of Congress, American Memory. *Fiddle Tunes of the Old Frontier: The Henry Reed Collection.* "Building the Digital Collection, Digitizing the Sound Recordings" http://memory.loc.gov/ammem/hrhtml/hrbuild.html [Accesssed 21 April 2001]

[30] World Wide Web Consortium (W3C). Web Content Accessibility Guidelines WCAG 1.0 [WCAG10]. see definitions: "Alternative Information" and "Equivalent Alternative". For guideleines, see also: Jutta, Treviranus, Charles McCathieNevile, Ian Jacobs, and Jan Richards, eds. *Authoring Tool Accessibility*

The responsible decision-maker must also recognize that CD-Rs, CD-RWs are susceptible to decay and mutability, and that the hardware to support them may not continue to be produced, repaired or available. These media, as well as optically printed CDs, are vulnerable to light, pollution, oxidation, heat, phasing out of reliable supplies by vendors of equipment.[31] Backup systems and migration schemes should be planned for these as well.

PROGRAM PLANNING, DESIGN, IMPLEMENTATION

SELECTION AND IDENTIFICATION

As the field of preservation in libraries and archives has grown, institutions have developed sophisticated systems for selecting materials for reformatting. Gertz writes, "The decision process [of selection for traditional preservation reformatting] is not linear. No single selection criterion suffices; it is only valid in combination with others, as the decision-maker steps through a series of complex, interconnected questions where each answer influences the others."[32] Factors which must be considered in the selection process include: physical condition of the original materials, intellectual value, relationship of the material to other collections within the institution or to those of other similar institutions, user demand, availability of financial and technical resources, availability of staff expertise, the mission of the institution, and copyright.

Examples of decision matrices for either selection for preservation or selection for digitization are widely available both in print and electronic form.[33] There are notably

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Guidelines 1.0. World Wide Web Consortium, 3 February 2000. http://www.w3.org/TR/2000/REC-ATAG10-20000203 [Accessed 18 March 2001].

[31] For recent technical research, see: Jacob Trock, "Permanence of CD-R Media"; Jean-Marc Fontaine, "Initial Quality and CD-R Aging"; Dave MacCam "The Universal Preservation Format-A Recommended Practice for Archiving Media and Electronic Records". All presented at 5th JTS Paris 2000, "Image and Sound Archiving and Access : the challenges of the 3rd Millennium", abstracts available at http://www.cst.fr/jts2000 [Accessed 18 March 2001]

[32] Janet Gertz, "Selection for Preservation in the Digital Age," *Library Resources and Technical Services* 44: 2 (April 2000), 98.

[33] For an example of the traditional preservation decision-making process, see Gwinn, *Preservation Microfilming*, 39. For a select but representative bibliography of print and Web resources on selection for digitization, see Harvard University's "Selection Criteria for Digitizing Library Collections" at: http://preserve.harvard.edu/bibliographies/selection.html.

fewer descriptive models of the process of selecting for preservation digital reformatting, due in part, no doubt, to the fact that digitization as a method of preservation remains a controversial topic within the library and archives community.[34] The few examples that do exist do not explicitly discuss audio digitization. Instead, they are aimed primarily at the conversion of textural and graphic materials, since by far the bulk of the conversion work undertaken by libraries and archives has involved materials such as brittle books, photographs, maps, and drawings.

This section will explore how the traditional process used in the identification and selection for preservation relates to magnetic media as well as how selection criteria for digitization apply to magnetic sound recordings. The physical nature of magnetic media is such that reformatting is the only viable preservation option. Due to the inevitable instability of the medium, physical condition as a criterion may be less important than other criteria in the preservation selection process.

Reformatting: The Only Preservation Option

Traditionally, the options available in the remedial preservation decision-making process are to repair, replace, or reformat. In the case of audio recording on magnetic media, however, reformatting is the prevailing solution. Van Bogart explains, "For information that must be preserved indefinitely, periodic transcription from old media to new media will be necessary, not only because media are unstable, but because the recording technology will become obsolete."[35] Most often magnetic audio recordings of enduring value are rare or unique, so replacement is irrelevant. Repair as an option is only applicable to a handful of mechanisms apt to failure, such as detachment of the magnetic tape from the cassette hub or breaks in the tape, which inhibit playback. The problem of sticky shed can be "repaired" by baking, but this fix is only temporary. The need to perform repairs, serves as an indication that reformatting must be carried out. Any mechanical failures are overshadowed by the predominant problem, the inevitable deterioration of the magnetic tape itself. Reformatting is the only option because the physical condition of the medium demands it.

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[34] See the Preservation Reformatting Division of the Library of Congress' "Selection Criteria for Preservation Digital Reformatting" at: http://lcweb.loc.gov/preserv/prd/presdig/presselection.html.
[35] Van Bogart, *Magnetic Tape Storage and Handling*, 1.

Identifying Collection Items in Need of Reformatting

There are several ways to identify materials for preservation reformatting. A use-based approach is often advocated in the case of printed materials in a circulating collection. However, this approach would not be effective for magnetic media-based collection materials for several reasons. Typically, early audio recordings are not circulated because of their intrinsic and artifactual value. Furthermore, audio recordings are not used as frequently as other collection materials because they can be difficult and time-consuming to catalog and therefore they remain bibliographically inaccessible to the public. Because magnetic audio-based materials in libraries and archives do not pass over the circulation desk with any regularity, problems with their physical condition go unnoticed.

In many cases, the most effective way to assess the condition of a collection of magnetic media is to conduct a survey. A focused, systematic inspection on an item-by-item basis or by random selection can be implemented in order to gather data about the condition of the media, such as when it was manufactured and its physical makeup. An evaluation of the housings in which the media are currently stored should be included in the inspection process. Other metadata about the collection that should be gathered if available include: 1) the name or title of information recorded on the media; 2) time and place of recording; 3) the provenance of the materials; and 4) how the materials were acquired by the institution. Appendix I provides a sample data collection instrument, which can be used in the inspection process. During the assessment, it is also important to record the current environmental conditions in which the tapes are stored.

Selection Criteria

<u>Physical Characteristics and Condition</u>

Because preservation budgets are limited, setting priorities has always been necessary. All magnetic media of long-term value will require reformatting at some point in its lifetime, so it becomes necessary to be especially selective. One way to approach the selection process is to evaluate the physical condition of a set of magnetic media-based materials relative to that of others within the collection. The ability to differentiate between the various types of magnetic media is therefore crucial. Often magnetic audio tapes are stored in their original housings, and information about the tape, such as the name of the manufacturer, the kind of magnetic particles used, the type of base used, and thickness and length of the tape, may be printed on the box. If the type of tape is not recorded on the box, it is possible to identify the tape substrate by other means. For instance, light will shine through a reel of cellulose acetate tape.[36] Acetate-based tape also tears easily, while polyester is resistant to tearing and more likely to stretch. Other information useful in the identification process includes any dates recorded on the box by the creator. It can be very difficult; however, to determine with certainty if the date is that of the recording on the tape in question and the proximity of the tape's date of manufacture to the date of the recording.

Once the type of tape is identified, certain tests can be employed to assess the extent and degree of deterioration. In the article, "Factors Governing the Long-term Stability of Polyester-based Recording Media," Leslie E. Smith suggested the use of a "semiquantitative" roll test to determine if polyester tape binder is failing. The test involves creasing the tape in the long direction and then rolling or "translating" the crease back and forth between the thumb and forefinger. Weak binder will visibly flake off. During tests at the National Institute of Standards and Technology, this technique revealed that "no unaged tape lost binder in many such translations. Aged tapes often lost binder, sometimes when creased and sometimes after several passes between the fingers."[37] Smith notes, "Even when the binder flaked off in the first creasing, the tape could often be successfully read by a clean transport and head mechanism. This test is conservative in that respect but tape in such condition is clearly at risk and should be copied promptly."[38]

In the case of cellulose acetate-based media, testing for the presence of vinegar syndrome can be used to establish reformatting priorities. The first sign of acetate degradation is a vinegar odor, so a simple sniff test will detect the presence or absence of this distinctive smell. Testing with A-D strips will reveal the extent and degree of vinegar syndrome. A product of extensive research on the deterioration of cellulose acetate motion picture film carried out by the Image Permanence Institute, the small

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[36] Van Bogart, *Magnetic Tape Storage and Handling*, 6.
[37] Smith, *Factors Governing the Long-term Stability of Polyester-based Recording Media*, 209.
[38] Smith, *Factors Governing the Long-term Stability of Polyester-based Recording Media*, 209.

strips change color in the presence of acetic acid. The extent of vinegar syndrome is indicated by the degree to which the color of the strips changes from blue (good condition) to yellow (severely degraded). A program of testing reels of acetate tape with A-D strips is an inexpensive and quick way of assessing the relative need for reformatting within a collection.

Ideally, comparative data on the life expectancy (LE) of different brands or formats of tape could be useful in establishing priorities for reformatting. "Unfortunately, media life expectancy (LE) information is largely undocumented, and a standard method for determining magnetic media lifetimes has yet to be established. . . . According to manufacturer's data sheets and other technical literature, thirty years appears to be the upper limit for magnetic tape products, including . . . audio tapes."[39] In National Media Lab tests, the LE of a magnetic tape was defined as the point at which 12% of the tape's binder has hydrolyzed, causing failure. However, failure of magnetic tape can be defined in terms of any of the causes of its deterioration, including substrate deformation, sticky shed, loss of magnetic signal, or loss of lubrication. And, as Van Bogart explains, it is extremely difficult to accurately quantify the LE of a given audio tape because other critical factors, such as the conditions under which it has been stored prior to its acquisition and the chemical makeup of the binder, are often unknown.[40] Furthermore, the information recorded on magnetic media is dependent on technology to be accessed. Changes in format pose as great a threat to magnetic media as its physical instability; therefore, the LE of any given recording is meaningless without a machine available to play it back.

Because physical instability is common to all magnetic media, a host of other factors must be considered in the selection process for preservation. These additional criteria are important because they take into account the larger preservation decision-making context. Gertz suggested that "many of the same [selection for preservation] criteria hold for selection for digital conversion but with changed emphasis."[41] The predominant selection criteria for audio digital reformatting—user demand, research value, intellectual control, technical enhancements, and costs—are individually

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[39] Van Bogart, *Magnetic Tape Storage and Handling*, 11.
[40] Van Bogart, *Magnetic Tape Storage and Handling*, 28.
[41] Gertz, "Selection for Preservation in the Digital Age," 98.

addressed. Long-term concerns that arise are outlined as well. The matter of copyright will be addressed separately thereafter.

<u>User Demand and Research Value</u>

Recordings on magnetic tape of long-term value that are currently in high demand are prime contenders for digital reformatting. Because analog derivative copies of recordings deteriorate as they are used, the original must be duplicated periodically, thereby subjecting it to repeated use over time. A digital master copy, on the other hand, need only be made once, thereby drastically reducing wear on the original. Derivative digital copies can be made with little to no generation loss.

However, many sound recordings of long-term value are currently underutilized by researchers. Without a transcription or other means by which the recorded information is logged or indexed, finding specific information on a tape is a time-consuming and cumbersome process (see "Intellectual Control" below). Often tapes are not catalogued in online public access catalogs. Documentation of their existence may be limited to archival finding aids on paper or an outdated, non-standardized means of collection description and access specific to the institution. Furthermore, lack of operational equipment and staff expertise in machine use, as is often the case with reel-to-reel tape players, may inhibit the ability to play back recordings. For these reasons, current level of use may not be a helpful criterion in the decision-making process.

Subject specialists as well as other archivists and librarians can help to evaluate the research value of the materials and to determine if the sound recordings will find "a new community of users" and "more active scholarship"[42] once access is enhanced by digitization (see "Participants in the Selection Process" section below). As digital audio technology develops and lowers in price, coupled with the current popularity in accessing and distributing audio files on the Internet, interest in the use of audio materials in research may be expected to increase in the future.

<u>Intellectual Control</u>

Existing intellectual control of magnetic audio materials is often limited. The process of digitizing materials that have never been catalogued forces the issue.

[42] Dan Hazen, Jeffrey Horrell, and Jan Merrill-Oldman, *Selecting Research Collections for Digitization* (Washington, DC: Council on Library and Information Resources, August 1998), 5.

Depending on the nature of the recording, gaining adequate intellectual control over the digitized product may require a great deal of time and work, therefore adding to conversion costs. Indeed the overwhelming advantage of digitization is the access it affords; adequate control over the intellectual information in the converted recording is fundamental to the success of a digitization project. In many cases, it will be a matter of striking the appropriate balance of creating effective access points at an affordable cost.

Technical Enhancements

The information recorded on aging magnetic tape is often difficult to hear. Commonly the acoustical conditions under which recordings were created were poor. In addition, the aging process can introduce noise into the recording, including distortion, hiss, print-through, or pre-echo. These impediments can be extremely frustrating to listeners. Digital technology offers the ability to improve the listening experience by eliminating noise and other aural distractions recorded on the tape. However, these restoration enhancements are considered invasive procedures, and any digital copy that contains alterations to the recording cannot be considered an authentic copy of the original. A digital copy intended for preservation must be recorded "flat" without any modification of the sound. However, patrons of library and archives will appreciate having the opportunity to listen to a restored version of an audio recording given the choice. These "value-added" features can provide substantial justification for digital conversion of magnetic analog recordings.

Costs

The individual components that contribute to the expense of digital conversion must be considered in the selection process. For example, the rate of sampling can affect costs drastically. If the financial resources are not available to ensure that the goals of the project are met, the digitization project should be scaled back appropriately providing that the quality of the final product is not compromised as a result. "Those with very small collections or greater access to funds can use higher sampling rates without serious consequences, but large collections and less well endowed institutions may face a choice between higher sampling rates and reformatting some portion of their holdings."[43] The

[43] Michael Seadle, "Sound Practice: A Report of the Best Practices for Digital Sound Meeting, 16 January 2001 at the Library of Congress," *RLG DigiNews* 5:2 (15 April 2001). http://www.rlg.org/preserv/diginews/diginews5-2.html#feature3 [Accessed 16 April 2001].

question of cost is one of the most difficult to answer satisfactorily during the selection process because "hard numbers are not easily available and are in any case difficult to compare across institutions and across projects."[44] Specific cost considerations will be addressed in detail below.

<u>Concerns Beyond Conversion</u>

The use of digital technology in preservation introduces concerns extending beyond the conversion process itself. Specifically, technological infrastructure, user and staff training, and the management and preservation of the new surrogates have direct bearing on the effectiveness of a reformatting project. While these issues are not new to archivists and librarians who have participated in analog reformatting activities, the concerns are heightened in complexity in the context of digital information. The task of file management and the need to migrate data as new media and formats emerge require long-term commitment of the part of the institution. These concerns should be addressed in the course of planning and designing an audio conversion project.

Copyright

Very few sound recordings are in the public domain. On 1 January 2003, some early sound recordings—those created by authors who died before 1933—will enter the public domain. However, magnetic recording technology was not available at that time. "Substantial numbers of U.S. sound recordings will not enter the public domain until the year 2043,"[45] and on 15 February 2067, "all music recorded before 1972 will enter the public domain."[46] Given the estimated life expectancies of magnetic media, librarians and archivists cannot wait for copyright protection to expire before duplicating these deteriorating materials. Fortunately, they no longer have to.

Only very recently has the matter of copyright in respect to preservation reformatting been resolved adequately. Long-standing, nationally accepted standard practices in the preservation reformatting of library and archives materials dictate that three copies of an item of enduring value should be produced. Each of these copies has a

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[44] Gertz, "Selection for Preservation in the Digital Age," 100.
[45] Stephen Fishman, *The Public Domain: How to Find and Use Copyright-free Writings, Music, Art and More* (Berkeley, CA: Nolo Press: 2000), 44.
[46] Fishman, *The Public Domain*, 44.

distinct purpose: 1) a preservation master, which is a high-quality reproduction of the original item, thereby eliminating the need to "use" the original object further; 2) a copy master from which access copies are produced; and 3) a service or access copy for use by patrons. Many funding agencies such as the National Endowment for the Humanities require that, in grant-funded reformatting projects, three copies of each original item be produced. However, until Public Law 105-304, commonly referred to as the Digital Millennium Copyright Act (DMCA), was passed in 1998, Title 17 did not include provisions for libraries and archives to make more than one copy of any item, even if it was for preservation purposes.

The latest revisions to Section 108 specifically state that "the rights of reproduction and distribution under this section apply to three copies or phonorecords" of unpublished works "duplicated solely for purposes of preservation and security" and of published works "duplicated solely for the purpose of replacement of a copy or phonorecord that is damaged, deteriorating, lost, or stolen, or if the existing format in which the work is stored has become obsolete."[47] Another important change is that, for the first time:

> It is absolutely clear that Section 108 applies to digital formats – through the deletion of references to "facsimile form," through specific references to digital formats in subsections referring to preservation of both unpublished and published works, and through the addition of the new concept of preservation because a format has become obsolete.[48]

However, the law also states that, in the case of preservation replacements of unpublished works, "any such copy or phonorecord that is reproduced in digital format is not otherwise distributed in that format and is not made available to the public in that format outside the premises of the library or archives."[49] This statement means that repositories are limited in the extent to which they can distribute some digitized materials. The great promise of decentralized, "virtual" collections touted by the digital library community

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[47] 17 United States Code, Sections 108b and 108c, 1998.
[48] American Library Association Washington Office, *Library Preservation: Changes Incorporated into H.R. 2281, The Digital Millennium Copyright Act of 1998 (PL 105-304)*. Prepared by Carol C. Henderson, 12 November 1998. http://www.ala.org/washoff/preservation.html [Accessed 15 March 2001].
[49] 17 United States Code, Section 108c (2) 1998.

can only be realized by using materials in the public domain (if permissions from appropriate copyright holders cannot be obtained).

Librarians and archivists should be aware that, in respect to copyright law, sound recordings as a genre encompass intellectual property in many distinct and complex forms. For example, speeches, interviews, musical works, musical compositions, public performances, and private performances are some of the qualifications applicable to sound recordings and which ultimately affect how copyright protection is applied to them. An understanding of these distinctions will help librarians and archivists to determine fair use of sound recordings by patrons as well as how and to what extent their institutions can make digitized sound recordings still protected by copyright available to the public.

Participants in the Selection Process

Traditionally "the responsibility of making preservation decisions about individual items may rest on a variety of people . . . This process is known as the curatorial review and is critical to ensuring that preservation funds are spent wisely."[50] Both the number of persons who participate and the kind of expertise required in the curatorial process depend on the size and nature of the institution as well as the size and nature of the collection under review. It is common for the opinion of subject specialists, whether they are faculty members, collection curators, bibliographers, scholars or others from outside the institution, to weigh heavily in this process. The contributions of each of these individuals are equally crucial in the case of digital reformatting of magnetic audio materials.[51] Furthermore, the input of other additional specialists should be enlisted in the selection process. For example, audio engineers can provide technical evaluations of the original source materials and personnel representing the information technology department can evaluate the plans for digital conversion and provision of access to the files.

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[50] Gwinn, *Preservation Microfilming*, 30.
[51] Amanda Maple and Tona Henderson, "Prelude to a Digital Music Library at the Pennsylvania State University," *Library Resources and Technical Services* 44:4 (October 2000), 194.

Preservation and conservation staff supports this decision-making process commonly by providing information on available reformatting options and their relative costs.[52] In the case of magnetic media-based collections, preservation librarians and archivists should take a more active role in initiating reformatting programs. The dramatic problem of brittle books in libraries was relatively easy to demonstrate and therefore it was easy to gain wide support for traditional reformatting projects such as microfilming. The digitization of photographs and other graphic materials is very attractive to administrators. The matter of magnetic media deterioration, on the other hand, is less known by the general public, less apparent to library administrators, and less understood by scientists. This combination makes for a volatile situation which archivists and preservation librarians can help to alleviate by acting as advocates for reformatting the magnetic media of long-term value in their collections.

PREPARATION OF MATERIALS FOR AUDIO REFORMATTING

It should be noted that currently there are no standards to follow in the preparation of magnetic tapes for audio reformatting. Each institution designs its own guidelines, many of which are not published. The National Digital Library Program at the Library of Congress has prepared guidelines that describe the overall process followed to digitize all types of media, including audio materials.[53]

Planning the Reformatting Scheme

In order to organize the workflow and prepare the materials and equipment, the reformatting sequence, and thus the final product of the project, should be determined first. There are two general principles related to preservation reformatting.

1. Two digital files should be created and saved:
    - A flat file that registers the sound as it comes off the original tape.
    - An enhanced or re-mastered file used for access purposes.[54]
2. A preservation analog copy should also be created because its life span may be longer than the life expectancy of CDs or digital files.[55]

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[52] Gwinn, *Preservation Microfilming*, 31.
[53] Carl Fleischhauer, *Steps in the Digitization Process* (National Digital Library Program, Library of Congress, 1996). http://lcweb2.loc.gov/ammem/award/docs/stepsdig.hmtl [Accessed 28 February 2001].
[54] Karl Miller, Music Librarian, Fine Arts Library, The University of Texas at Austin, interview by Maria Esteva, March 2001.

Institutions follow a number of reformatting schemes. Examples of different types of work sequences are shown below[56]:

- Analog original → creation of preservation analog (magnetic tape or DAT) → transfer to hard disk → creation of a backup or working analog copy → creation of an access copy (CD or cassette)[57]
- Analog original → transfer to hard disk → creation of preservation analog → cassette for patron access
- Analog original → transfer to hard disk → creation of preservation analog → CD for access
- Analog original → creation of preservation analog → saved as an audio file and placed on a hard disk, CD, or server for access.[58]

Types of Documentation

From both technical and administrative perspectives, documentation is a fundamental component of the reformatting project. The following types of documentation should be considered: 1) conservation documentation, 2) administrative documentation, 3) transfer documentation and metadata, and 4) technical documentation.

1) Conservation Documentation

This type of documentation can be collected during the conservation assessment (See Appendix I). It includes information about the physical condition of the original materials, and the amount of material to be transferred. If each of the original tapes have not been thoroughly inspected and documented before transfer, their physical condition will have to be recorded during the preparation process.[59]

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[55] National Endowment for the Humanities, Grants for Reformatting Projects. http://www.neh. fed.org [Accessed 2 March 2001].

[56] Christa Maher Digital Conversion Specialist, American Folk Life Center, Library of Congress. Washington D.C. interview by Maria Esteva, 7 March 2001, by phone.
Terra Nova Digital Audio Inc., Austin, TX. Interview by Maria Esteva, April 2001.
Stinson, Austin, TX, interview by Maria Esteva, April 2001.
Colin Webb and Kevin Bradely, *Preserving Oral History Recordings*.
http://www.nla.gov.au/nla/staffpaper.cwebb4 [Asccessed 2 March 2001].
Columbia University Libraries, Audio Preservation.
http://www.columbia.edu/cu/lweb/services/preservation/audio.html [Accessed 7 April 2001].

[57] The option, which keeps two analog copies, is similar to the one followed for preservation microfilming.

[58] This scheme is followed at the Columbia University Libraries. A preservation copy is created first because some information may be lost during digital capture. A digital copy is created exclusively for access purposes.

[59] For a comprehensive magnetic tape inspection procedure, see: *Basic Inspection Technique to Sample the Condition of Magnetic Tape*, Specs. Brothers, 1988. http://www.specsbros.com/whitepaper.html [Accessed 10 February 2001].

2) Administrative Documentation

Information pertinent to the management of the reformatting project is included in the administrative documentation. These records involve keeping track of the production and finances and provide an efficient way to monitor the entire process.

- Production records: Request For Proposals (RFPs), contracts, invoices for tracking materials as they progress through the workflow either in house or at the vendor, as well as for receiving original materials and new surrogates from the vendor, time sheets which record labor required for each step of the process.
- Financial records: budget for vendors and suppliers, bills from vendors and suppliers, and salaries.
- Statistics related to production and costs that are important to provide to the overseeing administration and/or funding agency.

3) Transfer Documentation and Metadata

Transfer documentation involves recording detailed information about the materials, equipment, software, and steps followed during the transfer of audio materials from one format to another. Information about the transfer process is a form of preservation metadata, and it is critical for preservation purposes, especially in the case of digital reformatting. Currently there are no guidelines as to what type of preservation metadata needs to be registered in an audio digitization process. The different reformatting schemes will dictate the type of documentation that needs to be generated. According to Karl Miller, when digitizing audio files, a way of registering the changes that have been done to the original audio material is to compare the flat file, with the re-mastered file. The drawback is that the information can only accessed through the software that generated those changes.

The matter of preservation metadata standards is not resolved within the library and archives community. "What is right depends on the collections, the uses, and the costs involved. Ultimately the ability to map from one format to another is what matters."[60] In the meantime, administrators, librarians and sound engineers should decide together on the format in which transfer documentation and metadata pertaining to each reformatting project should be compiled and stored. Since the generation of this information is time consuming, project managers should be very specific about this requirement with vendors and in-house professionals from the outset.

[60] Seadle, Sound Practice: A Report of the Best Practices for Digital Sound Meeting.

Preservation metadata is only one part of the metadata that comprises a digitization project, and will need to be integrated with the structural metadata that allows access and the data that describes the audio piece. As stated by Payette and Lagoze, "Preservation metadata does not exist in isolation. Actually, it can be thought of as the union of all metadata that pertains to the continued discovery, use, and integrity of an object." [61]

Preservation metadata may include the following data:

- File size
- Sampling rate
- Sound resolution
- Pitch changes
- Amplitude changes
- Equalization changes
- Other editing changes
- Indication of index points
- Prohibition to copy
- Type of file compression
- Name of the person in charge of the transfer
- Dates of file creation, modifications and migrations
- Copyrights

4) Technical Documentation

Technical documentation includes reference materials pertinent to all the aspects of a reformatting project. Below are listed some examples of this type of documentation.

- Information about original recording technique and materials
- Reproduction, transfer and digitization guidelines
- Equipment, hardware and software operating manuals, instructions and catalogues
- Guidelines and standards for intellectual control of audio materials
- Standards for storing master and archival audio files, audio file formats and compression file formats
- Guidelines and reference materials for preservation and conservation
- Standards for retrieval of audio materials, file naming conventions, file formats
- Product evaluation results for tapes, CDs and server files
- Dictionaries and glossaries, monographs and periodical articles.

[61] Carl Lagozze, and Sandra Payette, "Metadata: Principles, Practices, and challenges", in *Moving Theory into Practice, Digital Imaging for Libraries and Archives*, editors and principal authors Anne R. Kenny and Oya Rieger, 84-100 (Mountain View, Calif.: Research Libraries Group, 2000).

Photographic and Curatorial Documentation Related to Audio Materials

The inclusion of any textual and visual materials related to a sound recording will allow for better interpretation of the recording. Types of archival materials related to sound recordings include: final scores, work sketches, photographs, labels and indexes contained on the cover, graphic analyses of musical materials, video segments of performances, rehearsals and interviews, written transcript of oral history, and biographic texts. Digital Library Projects, such as American Memory at the Library of Congress[62] provide Web access to the sound files along with related text and images. The inclusion of associated materials may enhance access and add research value to the reformatted collection

Work Space, Handling and Playback Considerations

The following recommendations should be considered during preparation, transfer and conversion of magnetic media.

<u>Studio conditions</u>

- The studio should be acoustically isolated.
- When removed from archival storage, the tapes should be allowed to equilibrate to the temperature and humidity of the studio before they are played. The studio should maintain temperature and relative humidity conditions recommended for the access storage of magnetic media.[63]
- The studio and the equipment should be kept clean and dust free. It is recommended that the work area be equipped with a filtered HVAC system.

<u>Handling</u>

- It is important that the recorded surface of the tape not be touched because fingerprints may attract dust and debris. Lint-free cotton gloves may be worn whenever magnetic tape is handled.

- The tape should be inspected to identify the type and to determine its condition before any major handling and playback is done.

- Open reel tapes, should only be handle by the hub. Pressure on the flanges will cause damage to the tape edges.

- Cassettes should only be handle by the outer shell. Do not place any materials into openings.

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[62] The Library of Congress, *American Memory, Historical Collections for the National Digital Library*. http://memory.loc.gov [Accessed 19 April 2001].
[63] Van Bogart, *Magnetic Tape Storage and Handling: A Guide for Libraries and Archives*, 19.

- Do not drop the tapes. The shock could partially rearrange the ferromagnetic particles, effectively attenuating high frequencies.
- To reduce the amount of exposure to particles in the air, items should be returned to their container whenever they are not in use.

Tape Playback and Rewinding

Although conservation literature praises the benefits of rewinding the tape before playback, it is first necessary to evaluate the condition of the tapes before carrying out this procedure. The more times a deteriorated tape is subjected to handling, and winding or rewinding, the worse its condition will get. Having said this, the following recommendations should be considered before tape playback.

- Tapes and cassettes should be played to the end, leaving the tape wound smoothly with only the leader or unrecorded tape exposed.
- Any tape that has not been used in a long time should be carefully rewound two to three times before reproducing in order to relieve any tension and to reduce the effect of print-through.
- Wind tapes slowly to avoid the formation of air pockets resulting in an uneven wind, which can make tapes susceptible to damage.
- Fast winding encourages loose oxide to adhere to the back of the previous layers of tape, and old splices to come apart. If this begins to happen, slowly bring the tape to a stop.
- In order to create even tape pack, wind at play speed backwards first and then forward.
- Closely monitor for squealing during tape playback; if noticed, stop the process immediately.
- Check the alignment of the guides to prevent uneven rewinding.
- Loose tapes can fold over resulting in cinching, creases, and signal losses called dropouts.

Preparation Guidelines for Magnetic Tape Reformatting[64]

Splicing

Splicing is performed to repair broken or snapped tape, to join two or more recorded programs onto one reel of tape, or to add leader tape. Only a trained professional should splice. This process is done on the splicing block that is located on the playback equipment. Two pieces of magnetic tape are joined together with a short length of non-magnetic pressure sensitive tape. If the original magnetic tape has any splices or leaders showing signs of deterioration, they should be replaced.

Baking

Tape baking is an unstandardized procedure that has only been experimentally tested and conservation literature provides only a handful of home recipes as guides. Audio professionals use home ovens and food dehydrators for the baking process. While at times successful, the procedure can be potentially catastrophic, causing irreversible blocking or fusing of the reel, and dimensional change of the substrate, causing further drop-off of magnetic particles. Volatile organic components that may be driven off during procedures are unquantified, and may endanger human health through ingestion, inhalation or combustion. The decision to bake is not to be taken lightly. To undergo tape baking is an irreversible commitment in time and risk, but not attempt it is a default acceptance of the loss of the record. However, there are no known alternatives for the repair of tapes suffering from sticky shed syndrome. If the decision to bake is made, the material must be reformatted promptly, as the rates of decay have been accelerated.

Cleaning

If the tape container is dusty, it is advisable to vacuum it before removing the tape. The Canadian Conservation Institute recommends using 3M tape cleaning fabric, to

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[64] This guidelines had been compiled from the following resources:
Van Bogart, *Magnetic Tape Storage and Handling*.
Graham Newton, *The Preservation of Recorded Sound Materials*, (1998). http://www.audio-restoration.com/menu.htm#info [Accessed 28 February 2001].
Terra Nova Digital Audio Inc. interview with Esteva.
Stinson interview with Esteva.
National Library of Canada, *The preservation of Recording Sound Materials*, (3 June 1998). http://www.nlc-bnc.ca/services/erecsnd3.htm [Accessed 11 April 2001].
Lisa Fox, ed., *Preservation Microfilming: A Guide for Librarians & Archivists*, 2d ed. (Chicago: American Library Association, 1996).

pick up loose debris from the tape surface. When extensive mold damage and/or soot are present on a tape, it is recommended to contact a professional conservator.

CD Programming and Indexing

The process of CD programming is dependent on the contents of the recording and the intended purpose of the sound files. If the original materials had been already indexed, the programming is straightforward. Otherwise, the individual professional will do what makes the most sense in terms of breaks and side changes. Indexing audio materials requires the expertise of music librarians and oral history archivists. Indexing audio materials may require the input of subject specialists, curators or other archivists and librarians familiar with the collection and its users. Most audio software utilities facilitate CD programming because they display the contents of the tape on the computer screen, and thus help to determine logical stopping points.

Label Preparation

- The information about the content of each CD track is transferred to a label that is included in the jewel box.
- It is not recommended to place any label in the surface of the CD because the adhesive may damage the surface of the CD. However, it is acceptable to write with a fine-tip permanent marker on the clear, inner circumference of the CD. This space could be used to write a unique CD number determined by the institution. This identification number should also be printed on the jewel case label and transferred to the rest of the bibliographic documentation. Alternatively, each CD has a unique number printed in this area by the manufacturer. This number can be adopted into the project for identification purposes.[65]

[65] John Stokes, class lecture at The University of Texas at Austin, 18 April 2001.

Equipment Overview, Preparation and Maintenance[66]

Depending to the type of project, the following equipment should be considered. Equipment necessary for re-recording audio tapes includes:

- Tape recorder playback
- Tape recorder recording
- Amplifier
- Loudspeaker

Equipment necessary for re-recording audio tapes and producing CDs includes:

- Tape recorder playback
- Tape recorder recording
- Amplifier
- Loudspeaker
- Computer with digital audio conversion software
- CD recorder with automatic indexing tools

<u>Playback Equipment Maintenance</u>

The playback equipment should be in good operating conditions since a defective machine could damage the magnetic media. General recommendations are listed below:

- Clean tape heads, guides and rollers thoroughly with isopropyl alcohol and cotton swabs. Dust, oxide particles, and other contaminants affect both playback and recording performance.
- Cleaning of guides and rollers should be performed once per shift or whenever a problem is encountered. Read/write heads and tape cleaner blades should be cleaned twice per shift and before any critical operation.
- A technician should periodically demagnetize the tape decks.
- Professional calibration of the playback and recording equipment is regularly needed depending on the frequency in which the equipment is being used. Keep track of the dates of calibration and frequency of use.
- Guides that are not aligned will lead to uneven rewinding of magnetic tape. Tape heads and guides should be periodically checked for alignment.
- It is important that equipment is kept in a dust free environment and far from machinery, such as printers and photocopiers that generates debris and soot.
- A tape test that contains a series of test tones at a standard reference can be used to verify the performance of the tape recorder's playback system and to align and calibrate the tape recorder.

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[66] The reference materials used for this section include:
IASA Technical Committee, "The Safe Guarding of the Audio Heritage: Ethics, Principles and Preservation Strategy," LLGC/NLW, 1997. http://llgc.org.uk/iasa/iasa0013.htm [Accessed 15 March 2001].
Van Bogart, *Magnetic Tape Storage and Handling*.
Newton, *The Preservation of Recorded Sound Materials*.
Terra Nova Digital Audio Inc. interview with Esteva.
Stinson interview with Esteva.

CONVERSION

The conversion of analog sound recordings to digital sound files is dependent on the availability of specialized technologies (old and new) and specially trained professionals. The technologies range from the playback devices of historical analog recordings to very sophisticated software and hardware used in the conversion and editing of digital recordings. Additionally, a thorough knowledge of the history of sound recording, audio engineering, and music is vitally important in producing a digital reproduction of the original analog recording.

The conversion process involves accessing the analog signal from the source material and transmitting it to a computer where the analog signal is converted to a digital bit stream through a sampling process. The conversion process therefore involves historical playback devices or modern equivalents, audio equipment for receiving and transmitting the analog signal, and computer hardware and software for digitization, inspection and/or editing of the digitized sound.

Analog Playback Devices

The original media will determine the necessary playback equipment. However, the process is not so simple as choosing between a turntable and a reel-to-reel tape playback. A close examination of the physical media coupled with knowledge of recording history is necessary to determine the proper and best playback device and settings. One example would be determining the number of tracks on a magnetic tape recording. Magnetic tape recordings consist of linear tracks in which the analog signal has been captured by manipulation of the magnetized particles on the tape. Historical knowledge of magnetic tape and recording systems combined with trial and error will result in determining the number of tracks on an analog-recorded magnetic tape. In some cases, understanding the media that the analog sound signal has been recorded is vitally important in safeguarding the original artifact from irreparable damage. If track layout is improperly assessed it can result in accidental loss of information in the conversion process and possibly damage the original artifact. The importance of understanding the history of recording technology and processes cannot be overemphasized.

Once the correct playback device and the settings for the device are determined, the process of playing back the analog signal can begin. The playback device is connected to the computer via cables and may pass through a receiver with speakers before reaching the computer's audio card where the signal is converted to a digital bit stream through a sampling process in which points of amplitude are taken along the sound signal. The samples taken are encoded in a binary form which, when processed by the computer, will reproduce the sound signal that was sampled.

Computer Equipment

Hardware

The hardware components of an analog to digital sound conversion system include a computer with a processor that can handle the complexities of audio conversion at a comfortable speed. Additionally, the computer will need to have an audio card. Storage of the files can be accomplished either on CD or on a server. Further hardware for storage of the digital files might require a CD writer or a networked system linking the audio conversion workstation to a server.

Audio cards accept an analog signal and make it available to the computer in a digital bit steam through conversion circuitry in the card.[67] In his article, "For Audio that Awes, Get a DAW," Mark Fritz makes a distinction between common audio cards that are standard issue with most commercially sold computers (which he refers to as hobbyist cards) and more technologically advanced audio cards (studio project cards).

> The perceived problems with consumer and hobbyist audio cards begin with the fact that they are only 16-bit. Higher-level cards are 18-bit, 20-bit, or, ideally, 24-bit. Hobbyist cards also tend to emphasize MIDI[68] at the expense of digital audio. Hobbyist cards do not have enough analog inputs and few, if any, digital I/Os [inputs/outputs]. Additionally, they offer few if any digital effects like EQ [equalization], compression, or reverb. These then are the things that are conspicuously absent in the consumer/gamer/hobbyist cards, but conspicuously present in the project studio-level cards. Project studio audio cards start at about $2000 and go up to about $5000.[69]

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[67] Mark Fritz, "For Audio that Awes, Get a DAW (Digital Audio Workstation)," (February 2000). http://www.emedialive.com/EM2000/fritz2.html [Accessed 18 April 2001].
[68] MIDI is a type of file format more specifically designed for electronic musical instruments. See Format section below.
[69] Fritz, For Audio that Awes, Get a DAW.

Fritz continues by explaining the necessity of considering hardware (audio boards and computers) with audio hardware (receivers, turntables etc.) and software all together to configure an overall system that meets the demands of the conversion process. More sophisticated software can compensate in some ways for less technologically advanced audio cards, for example. In other cases, certain types of audio cards can only work with the software that was written specifically for that audio card. Some audio cards that are available on the market include: “Yamaha's DSP Factory, Ensoniq's PARIS, MTU's Microsound, and Lexicon's Studio, E-mu's APS and Gadget Labs' wave cards.”[70]

Software

A large amount of audio engineering software is available commercially. The cost of the software varies with each software package but generally the more advanced the software is, the more expensive it will be. Karl Miller of the Fine Arts Library at the University of Texas uses ProTools by Digidesign for recording, editing and manipulating digital sound files. Mark Fritz also ranks Digidesign’s ProTools as perhaps the most widely used digital audio software. Digidesign also has made available slimmed-down versions of its software at lower costs.

Quality Control

Conversion systems that are designed for audio restoration allow for on-going quality assurance at every step in the conversion process. This can take the form of determining the correct playback device and parameters, listening while the signal is being digitized for any skips or other obvious playback problems, and listening to the completed digitized sound file. However, for conversion of less special material, the process can be somewhat automated and the sound files can be listened to later. As with any reformatting project, a quality assurance plan should be developed. Quality assurance protocol will be determined by the collection that is being converted. Situations in which the original recording media is in poor condition may require 100% inspection while file converted from materials in good condition may not require that level of attention. Equalization is the process of manipulating the sound signal to produce results that are pleasing to the ear. Equalization in the conversion of analog to

[70] Fritz, For Audio that Awes, Get a DAW.

digital materials for preservation purposes is a double edge sword. In some cases, equalization is absolutely necessary to isolate the relevant information in a recording for the user to gain access to the desired information. For example, oral histories might require the manipulation so that the words of the person being interviewed can be heard over background noise. While preservation professionals may expect exact copies of historical artifacts to be made with no manipulation in the coping process, it is necessary to balance this concern with the issue of access. A "flat" (equalization) master file of the converted analog signal can provide an archive copy while derivative copies of this master file can be manipulated through equalization to provide better access for the user. Concern over equalization of converted audio signals is warranted. However, by maintaining flat conversions of files in a lossless file format, original information will be maintained for future technologies and users to reinterpret.

Outsourcing

There are companies that provide audio analog to digital conversion services. Considering the complexity of audio conversion, it may be too expensive to set up an in-house operation and thus outsourcing may be the only option without full commitment of the institution's administration to implement a sound recording preservation program. The decisions that have to be made in relation to this issue can only be considered on a case-by-case basis.

While the expense of outsourcing an analog to digital audio conversion project can be less than developing and implementing an in-house operation, the cost will still be high. Rates will vary from company to company, but it should be expected to pay anywhere from \$50-\$70 an hour for conversion services with hourly rates increasing with complexity of the original analog recorded media. For example, tapes experiencing sticky shed syndrome will require baking before being converted, which will usually be an added surcharge.

The process of finding a vendor who can provide analog to digital conversion will be time consuming. However, the importance of thoroughly knowing the quality of a vendor's work is very important. The relatively short life span of analog recording materials combined with the high cost of conversion in most cases will mean that the opportunity for conversion will occur only once. For this reason it is important to acquire the highest quality product (converted digital file) possible.

Standards

Currently, no standards exist in regards to the conversion of audio materials from analog to digital, however a committee has been established at the Library of Congress to investigate the possibility of developing standards. Perhaps the reason why standards have not been developed is because of the innumerable variables involved in audio conversion. Some of these variables include, but are not limited to: 1) subjectivity of the person performing the conversion, 2) the lack of high quality compression algorithms for sound files, and 3) the loss of information through the sampling process which generates the digital audio signal. To isolate each of the variables and establish standard protocol for each issue will require the coordinated effort of the many entities that are involved in audio matters.

Formats

File formats for audio files are numerous and each serves a different purpose. Uncompressed file formats are believed to be the most appropriate form for master or archive audio files since compression file formats always result in loss of information. The most widely used uncompressed (lossless) audio file format is the WAVE file format (.WAV). This file format is available in the public domain and not dependent upon proprietary software. Additionally, almost all audio software available is able to process WAVE files. Yet, uncompressed audio files are typically very large. The consequences of the size of WAVE audio files are that they require considerable storage space and are difficult to serve to users. Hence, there is a need for a file format with compression algorithms which can produce a file that is both manageable in terms of size and capable of acceptable aesthetic reproducibility of the sound signal. There are many audio compression (lossy) file formats available. A description of some file formats follows.

> **WAVE:** The WAVE format was developed by Microsoft for use on Intel-based computers. Professional PC-based digital audio recording and editing systems use

WAVE files as their standard, and on the Mac, many players including QuickTime can play WAVE files. It is an uncompressed file format.

MPEG: MPEG is a file format that offers good quality and compression. The MP3 format is a type of MPEG compression that offers near-CD quality audio that uses about 10% of the storage space of a CD-Audio file. MPEG is actually a video format, but is used widely for audio-only "movies". It is getting a lot of press lately because high quality recordings can be easily distributed over the World Wide Web

.RM: this is one format for streaming audio that is used by Real Networks. FM-radio quality is available at modem speeds, but the purpose of these files is not quality as much as it is the ability to use large files or do live broadcasting. These files are heavily compressed.

.MOV: Quicktime provides 2 compressors from QualComm that allow audio compression with high quality. The .mov suffix usually denotes a video file, but Quicktime can be used to delivery high-quality compressed audio. Developed by Apple, it is playable on both Macintosh and Windows machines.

.ASF: The Windows Media format was developed by Microsoft. It is quite common on the Web, but at Cornell is not supported. The main reason is that it can only be played using Windows Media Player, which until very recently did not exist on the Macintosh. These files are heavily compressed.

MIDI: MIDI (Musical Instrument Digital Interface) was designed so that electronic instruments of all kinds could exchange musical information between them. Unlike the other sound formats, MIDI does not capture and store actual sounds. Instead, it translates the sounds into a set of performance steps, steps that can be recreated by any sound synthesis device that understands MIDI. This can include your computer, an electronic keyboard, or a great variety of specialized sound synthesizers. Because it does not contain actual sounds, the file size of MIDI files is extremely small.

AIFF: The AIFF (Audio Interchange File Format) was developed primarily for use on Macintosh computers. Mac-based digital audio recording systems and multimedia applications such as Adobe Premiere and Movie Player allow importing and exporting of AIFF files. It is an uncompressed file type.[71]

[71] Cornell University Academic Technology Center, Digitizing Audio and Video Workshop, *File Formats for Digital Audio*, 16 March 2001. http://www.cit.cornell.edu/atc/materials/dig/audioformats.shtml [Accessed 21 April 2001].

BIBLIOGRAPHIC CONTROL AND ACCESS

Knowledge that an analog audio recording has been preserved though digital means is important to not only the scholar but also to other institutions considering an audio transfer project. Thus, it is important that both the original audio material and the new digital surrogate receive cataloging records following the Anglo-American Cataloguing Rules second edition (AACR2) standards for sound recordings. The cataloging department will have the expertise and tools to provide these records. Processing routines should be established for the new digital surrogates so they become part of the daily cataloging routine, and are completed in a timely manner. These records should be made available through OCLC, RLIN and the institutions online catalog. Further, the original audio material and any digital hard copies should be assigned a Library of Congress call number and then stored based on this classification. There is the option to use a different type of classification such as Dewey Decimal. The main point is that some type of uniform system must be followed. Using a standardized means of organization will allow for easier access when retrieving an item.

Access to the digital file encompasses two areas: local access and remote access. For local access, a digital CD service copy should be provided and if possible, additional access to a digital file would be beneficial to local off site users. For remote access, the same two options exist, with providing a digital file available via the Internet the preferable option. However, there are issues associated with this option, including having computer space to store large audio files, and copyright laws. Another option for national access is to provide interested institutions with a digital CD copy at a reasonable price. As with the digital file, copyright issues will need to be settled before the transfer process begins. The amount and type of access allowed would be based on the copyright laws that apply to the individual audio items.

For digital files, the issue of bibliographic control should remain the same, with the digital item receiving a cataloging record following AACR2 standards. However, access management for a digital file is very different. Storage and management of the new digital files will be discussed under “Storage and Handling of the New Digital Surrogates.”

DISPOSITION OF ORIGINALS

It is important to retain the original audio materials for several reasons. First, it is impossible to make an exact duplicate of the recording. Thus, any copy will be an alteration of the original. In order to retain the original information, the original material must be kept. Second, there are continual improvements in the transfer process. By retaining the original, one may be able to make a new transfer at a potentially higher digital resolution in the future.[72] Additionally one has the option of making numerous transfers using different types of technology to produce the best surrogate. The original materials should be placed in off-site storage that maintains a high level of control of the environmental conditions. Off-site storage is suggested because the original materials should not be accessed very often, if at all. In addition to retaining the original materials, suitable playback machines must be retained as well. The following section reviews the proper environmental conditions for audio materials.

STORAGE AND HANDLING OF THE ORIGINAL AUDIO MATERIALS

Proper environmental conditions are essential to extend the life of audio materials. For the storage of magnetic tape, it is important to maintain low temperatures and low relative humidity. A temperature range between 55°F and 60°F and a relative humidity range between 35% and 40% will provide appropriate storage conditions for most audio materials. One important factor is to maintain stable conditions. While some amount of fluctuation will be impossible to prevent, the conditions should be monitored and checked for major discrepancies. Variation in temperature and relative humidity causes stress to the media.

Air quality is another major concern in maintaining a proper storage environment. The biggest issue with air quality is "foreign matter deposits," including dust, smoke particles, grease from a fingerprint, and adhesives.[73] The storage area should be vacuumed or swept regularly and materials should be returned to their protective enclosures immediately after use.[74]

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[72] IASA Technical Committee, The Safe Guarding of the Audio Heritage.
[73] St-Laurent, *The Care and Handling of Recorded Sound Materials*.
[74] Philip DeLancie, "Master Preservation: Practical Tips for Long-Lived Recordings," *Mix* 23, no.10 (Oct. 1999).

Ultraviolet radiation is damaging to audio materials. They should be stored in the dark when they are not being used and, in the rooms where they will be used, UV filters should be placed on fluorescent lights. The storage area should be kept clean and free from food products to discourage the infestation of pests. An Integrated Pest Monitoring (IPM) program should be in place to identify problems. In general, lighting and pests are not a major problem for audio materials because they are normally stored inside some type of enclosure. This does not mean that these issues should be ignored. Often different materials will be stored together or in close proximity to each other. So maintaining a consistent storage area that meets general preservation standards is the best policy.

Finally, there are some storage issues specific to magnetic tape. The tape should always be stored in the tail-out position to reduce the effects of print through. Tape reels should be stored vertically to prevent the tape from slipping to one side. Improper tape tension can cause loose pack or stretching if it is too tight. Loose pack can result in the tape pack shifting or the tape layers could become folded. Exercising the tape periodically will ensure proper tape tension. Proper wind is also very important, and during exercising it is essential to make sure the tape is winding in a uniform line. If any part of the tape is not in line, it will cause problems during playback.

STORAGE AND HANDLING OF THE NEW DIGITAL SURROGATES

The storage conditions described above are also suitable for the storage of CDs. Currently the life expectancy of CDs is unknown, but testing is underway by several organizations to begin to determine lifetimes. Currently, it is suggested that the discs be regularly checked to assure the integrity of the data.[75]

The storage of computer files presents a completely new arena. Digital audio files can be stored in several different file formats including WAVE, MP3, and MIDI. Digital file issues including size, sampling rate, sound resolution, amplitude and equalization changes will be determined during the conversion process and will become part of the metadata related to audio item. Although only one part of the metadata, this information will still need to be maintained along with the actual sound file. Once all of the metadata

[75] IASA Technical Committee, The Safe Guarding of the Audio Heritage.

is gathered together with the sound file, the issues of access and maintenance must again be addressed. The individual institution must decide which metadata will be accessible to the researcher. If the audio file is going to be accessible online, copyright and download ability issues will have to be resolved first.

As for the management of the file, disk space will need to be designated to store the files and a system will need to be in place to maintain them. Developing a system for managing the files will be based on specific institution requirement and abilities. The department within the institution in charge of the computer system should play a major part in the decisions made about digital storage issues. Financial constraints will also play a major role in decisions about digitization, and the storage and maintance of the digital files. Issues related very closely to file storage and access include refreshing and migration. These topics will also need to evaluated and will be briefly discussed in a following section

REFRESHING AND MIGRATION

Refreshing and migration move beyond the scope of our paper on digital conservation of analog materials, and into the issues of the preservation of the new digital surrogates. However, it is still very important to address these issues during the planning phase of the project. Digitization is an expensive process; the ability to maintain and preserve the final product should be a goal of the project. The problem with digital technology is that there are no concrete answers. Technology changes so fast that it is hard to develop a plan to preserve the files. Although not all of the answer to the problems will be known, at least a rough plan should be developed. An additional benefit to having a proposed plan is that the need to refresh and migrate the digital files will not get lost in case of a change in staff. It is important to stress that time and money should not be wasted on an end product that will not last as long as the original media.

Part of the reason to switch to digital files is because analog transfers suffer increased degradation each time they are copied.[76] However, digital migration offers the possibility of "loss free migration."[77] The Library of Congress is currently working on a

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[76] IASA Technical Committee, The Safe Guarding of the Audio Heritage.
[77] IASA Technical Committee, The Safe Guarding of the Audio Heritage.

project to examine new approaches to the storage and maintenance of digital sound item.[78] There are also future possibilities of a "digital mass storage system" which would be "self-controlling and self-regenerating."[79] Such technologies are still in development but the idea is intriguing and it is important that librarians and archivists follow the technology as it develops.

BUDGET PLANNING

The implementation of an audio reformatting project is "time-intensive on an ongoing basis."[80] It involves the coordination of efforts between administrators, curators, bibliographers, cataloguers, audio experts, musicians, archivists, and information technology professionals. Institutional support is crucial for the continuation of the project. Whether reformatting initiatives are undertaken on a regular basis, or as special projects, they require a significant allocation of technical and human resources, a financial commitment and support to search for external funding.

Overview of Costs of Digital Reformatting Projects.[81]

In the future, it is expected that the costs of equipment and storage will decrease. However, the costs for preserving and maintaining the analog materials, and generated digital objects and files extends over a long period of time, if not forever. High costs are associated with both the lack of conservation standards for audio digitization, and with the short lifetime of the digital formats. Digital resources continually need to be migrated every time a software upgrade is available. The other option is to find a more permanent storage format. Below are some of the points that support the above discussion:

- Need to maintain the analogue materials.
- Need to maintain the analogue equipment for transfer to digital data.
- Regularly need to assess the analogue materials condition.
- Regularly need to assess the condition of digital media.

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[78] Library of Congress, *Digital Audio-Visual Preservation Prototyping Project* (23 March 2001). http://lcweb.loc.gov/rr/mopic/avprot/avprhome.html#coll [Accessed 7 April 2001].
[79] IASA Technical Committee, The Safe Guarding of the Audio Heritage.
[80] Maple, Prelude to a Digital Musical Library at the Pennsylvania State University, 194.
[81] Webb, *Preserving Oral History Recordings*.
Kelly Russel and Ellis Weinberger, *Cost Elements of Digital Preservation, Draft* (2000). http://www.leeds.ac.uk/cedars/documents/CIW01r.html#Annex [Accessed 2 March 2001].

- Need to determine the amount of information or metadata that must be stored with the bit stream to ensure accessibility of the object in the future.
- Costs of digital archive administration
- Invest resources to support the increased accessibility available through networks
- Investments in future technologies
- Staff training

Conservation Assessment

The information contained in the conservation assessment of the collection is crucial to planning the budget of a reformatting project. Among other things, this data helps the administrator to estimate time, materials, equipment, space, human resources and training needs. The following information should be considered for budgeting purposes:

Quantitative information: number of reels and hours of recording

Condition of the original materials: need for repairs and need for re-housing

Intellectual control over the original materials: Does the material need to be inventoried, catalogued, and/or indexed?

Project Scope

The following questions should be asked to help develop the projects scope. Will audio reformatting be an ongoing activity in the institution, or is this a one of a kind project for the institution? What is going to be the final product of the project? What are the steps of the project and what will be needed related to equipment and human resources? How much time will be invested in each of those steps? In order to make an estimated budget as accurate as possible, the scope of the project should first be defined. Appendix II shows an outline that details most of the elements that should be considered while planning a project.

Human Resources[82]

There is a strong agreement within the field of preservation that audio engineers, music librarians, sound archivists or professionals with sound and music backgrounds should be responsible for the actual transfer work in an audio reformatting projects. Music librarians and sound archivists should perform the indexing of the materials and, after conversion, expert staff should address the issues involved in the access of digital sound. According to the interviews performed, the estimated salary for professionals with this level of expertise approaches $40,000 per year.

In House Reformatting[83]

For an institution that is planning to start an audio reformatting program, the initial investment will approach $100,000. This amount is based on the cost of setting up an audio studio, including the acquisition of analog equipment, and the cost of a digital workstation. An additional benefit of creating an in-house facility is that the on going program will provide educational opportunities and experience in a field that is still in an experimental phase.

Contracting Services[84]

Vendors charge an hourly rate for conversion of magnetic tape to digital format. According to the information obtained from local studios, the cost per hour ranges from $50 to $70. Materials including CDs and Jewel boxes are charged separately. Some studios also charge one price for the first generation of the CD, usually around $25, and then a reduced amount for each additional copy, usually around $15. If the tape requires baking, there will be an additional charge of $10 to $30 per sessions. A baking session may accommodate either one or two reel of tape.

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[82] IASA Technical Committee, The Safe Guarding of the Audio Heritage.
Terra Nova Digital Audio Inc. interview with Esteva.
Stinson interview with Esteva.
Maple, Prelude to a Digital Musical Library at the Pennsylvania State University.
Miller interview with Esteva.
[83] Miller interview with Esteva.
[84] Terra Nova Digital Audio Inc. interview with Esteva.
Stinson interview with Esteva.

When handling original audio materials, vendors should follow handling instruction provided by the institution. The vendor and the institution should work together to clarify aspects about CD programming, CD labeling and materials shipment. The degree of intervention of the audio materials required by an institution should be established up front. Mastering audio files range from noise reduction to complete re-mastering. Generally, vendors will provide the client with a flat transfer of the audio material for evaluation, and then the client will come back with an enhancement proposal.

Things to consider when selecting a vendor:

- Professional background
- Previous experience
- References
- Facilities
- Equipment
- Guidelines and standards that they use
- Type of documentation that they will provide along with the project
- Time management
- Proposed work flow
- Guarantee – Insurance
- Type of contract
- Quality control program

OVERVIEW OF GRANTS AND PRESERVATION STRATEGIES FOR AUDIO MATERIALS[85]

A review of available grants and of national and institutional preservation strategies for audio materials reveals current trends, points to useful resources and suggests working and funding models to follow. Currently, the National Endowment of the Humanities offers small grants of up to $5000, to perform conservation assessments and housing of recorded materials. They also offer significant grants (up to $250,000) for reformatting projects of special collections. The latter requires the applicants should

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[85] National Endowment for the Humanities, Grants for Reformatting Projects.
Task Force on the Preservation and Enhanced Use of Canada's Audio-Visual Heritage, "*Fading Away: Strategic Options to Ensure the Protection of and Access to our Audio-Visual Memory*," (Ottawa: National Archives of Canada, June 1995).
Webb, *Preserving Oral History Recordings*.
Columbia University Libraries, Audio Preservation.

share 50% of the project's cost. A specific requisite of this grant is that the original magnetic tapes should be transferred to a more stable reel-to-reel tape before digitization.[86]

Save America's Treasures will give $750,000 for sound preservation projects to the Smithsonian Institution (SI) and the Library of Congress (LC), providing that both institutions come up with matching funds. In order to do that, SI and LC have created a fundraising strategy that includes a Web site with samples of sounds and interviews to major music personalities that support the project. Donations can be made through the Web site.

In 1994, the Task Force on the Preservation and Enhanced Use of Canada's Audio-Visual Heritage performed a survey of the audio-visual repositories in Canada. As a result, a nationwide strategy to protect and facilitate access to audio-visual materials was outlined. The plan includes the development of selection criteria, the distribution of resources according to preservation priorities, creation of regional storage facilities, provision of resources for scientific research, and the shared access to the materials through the network.

CONVERSION PROJECT WITH KARL MILLER

In our conversion project with Karl Miller, we transferred a piece of music written by Aaron Copland and performed by the Cleveland Orchestra. The performance was originally recorded in 1944. However, the disc itself was recorded later. Visual inspection and several trial playbacks with needles of varying sized revealed that the record was cut with "micro-groves," a format developed in the 1950s. The performance was cut at 33 1/3 rpm on an aluminum acetate disc. The following is an outline of the steps we followed during the conversion process with Karl.

[86] According to Karl Miller, as soon as the field develops preservation standards for digital audio files, the generation of reel to reel surrogates will no longer be required.

Steps of the Transfer Process from a Disc

1) Clean disc, preferably on record cleaning machine (which Karl has)
   a) soaked disc with Kodak lens cleaner (only suitable with acetate discs)
   b) washed with distilled water
   c) vacuum to remove dirt

Issues with the cleaning process: The dirt on the disc is often the binder seeping through the acetate coating. Therefore, the concern is whether the binder is still holding well enough so that the acetate does not wash or flake off.

2) Choose needle
   a) Is the record recorded hill and dale (up and down) or tide (back and forth)?
   b) Needle size: for our project, we first picked a 33 1/3 needle. We then tried a bigger needle to determine which sounded the best and thus fits better. Karl stated that we did not need to worry about damaging the record by trying different needle sizes because the grooves are relatively strong. A bigger needle will ride on top of grove, which results in more noise, and very big needle will ride across record making a scratching sound. A needle that is too small will not completely pick-up the signal.

Interesting fact from Karl: vinyl records should not be played more than once in a 24-hour period because the heat produced from playing the record several times can distort the grooves.

3) Adjust tracking and needle pressure
   a) Through a series of playing the record and then adjusting the needle pressure, we determined the best sound.
4) Ready to record to computer (exact set-up not discussed)
5) Used Protools software to record the piece on the computer. The sound files are saved in Red Book format, which it set at 44.1KHz and 16-bit.[87]

   One unaltered copy should be made for preservation purposes. A second copy, which may be manipulated by reduce noise, correct any WOW or flutter, which have to

[87] Robert A. Starrett, "Tools of the Audio Transfer Trade: Audio Utilities for CD-ROM and CD-R," *CD-ROM Professional*, (October 1996): 101-113.

do with unintended speed or frequency changes, and adjust the amplitude and equalization, can be made for access.

Variation in the Steps for Magnetic Tape

The primary difference in the transfer of an audio disc and magnetic tape is in the handling and cleaning of the original material. Once the recording is transferred to the computer, the process is the same.

1) Make sure the heads of the playback machine are clean, and machine is in good working condition. The majority of damage done to magnetic tape is the result of machines in poor condition.[88] Therefore, it is very important to maintain the equipment in the best condition possible.
2) If tapes show signs of sticky shed, bake before attempting transfer or even playing the tape for any length of time. If the tape has sticky shed, it will make a squealing sound when being played.
3) Figure out the head configuration of the tape recording. This process is usually done by trial and error, and per Karl should not damage tape.
4) The sound can now be recorded to the computer and the process is the same for all types of materials.

The main issues with tape is to have: 1) a clean and working machine, 2) tape in playable condition, and 3) a machine with the proper head configuration to play the tape.

THE FUTURE OF MAGNETIC AUDIO PRESERVATION: CURRENT INDICATIONS

Within the greater library and archives community, currently there is a groundswell of interest in the preservation of endangered sound recordings, which is fomenting action and progress in the effort. Evidence of this movement includes the Folk Heritage Collections in Crisis symposium held at the Library of Congress in Washington,

[88] Stacey Roth, "The Care and Preservation of Sound Recordings," *Conservation Administration News* 23 (Oct. 1985): 5.

D.C. in December 2000. The Photographic and Recording Media Committee within the American Library Association's Preservation and Reformatting Section (PARS) dedicated its 2001 mid-winter session to the topic of digital preservation of audio materials. Janet Gertz, Director of Preservation at Columbia University and member of the committee that hosted the discussion, explains the current position of the preservation community: "We don't have the technical information we would like to have. With audio I think we are at the stage we used to be in digital imaging about 10 years ago before any of the Cornell and other work on preservation-quality capture" was developed.[89] She continues, "The range of people interested in audio preservation is a mixed group: archivists, oral historians, ethnomusicologists, musicians, the music industry to an extent . . ., etc. Many of these groups have no experience with the concept of preservation in general, so there is a basic learning curve—and a lot of educating—that needs to be done."[90] One of the beneficial outcomes of this discussion includes the new topic page about audio materials on the Conservation Online (COOL) Web site.[91] Other educational programs will be planned in the future so librarians, archivists, audio specialists, and other interested parties can share information about the digital reformatting of audio as well as learn more about each other's needs.

A recently published report titled "Preservation Science Survey: An Overview of Recent Developments in Research on the Conservation of Selected Analog Library and Archival Materials" indicates that scientists continue to develop appropriate means for testing the mechanisms involved in magnetic media degradation. A project currently underway at ScreenSound Australia holds promise. "Their goal is to answer such questions as how to measure tape characteristics and performance, how magnetic tapes fail, how to study the aging process, and how to define end of life (EOL) and life expectancy (LE) of tape."[92] The report also notes that internationally the trend is to digitize information stored on magnetic tape and that "most of the financial resources for tape conservation are put into digital preservation."[93] Manufacturers of audiovisual

[89] Janet Gertz, email correspondence with Hannah Frost, 7 February 2001.
[90] Gertz correspondence with Frost.
[91] Gertz correspondence with Frost.
[92] Porck and Teygeler, *Preservation Science Survey*, 34.
[93] Porck and Teygeler, *Preservation Science Survey*, 45.

media and technology are focusing on "miniaturization and the improvement of performance and storage capacity. Factors such as permanence and durability, however, are neglected."[94]

In the United States, a facility under construction and new legislation will empower the Library of Congress to make great strides in the preservation of audio materials. The National Audio-Visual Conservation Center is scheduled to open in 2004 in Culpeper, Virginia. "While the Center is being designed, audio engineers, archivists, and information technology specialists at the Library are building the prototype of the Library of Congress Digital Repository for the preservation of audio and video. It will be the first digital preservation initiative for sound and video recordings undertaken by a major archives in the United States."[95] On November 1, 2000, President Bill Clinton signed a piece of landmark legislation. The National Recording Preservation Act calls for the creation of a National Recording Registry. A board of selected experts will advise the Librarian of Congress in the selection of "recordings that are culturally, aesthetically or historically significant"[96] to be added to the registry each year. Appropriations of up to $250,000 a year have been authorized to fund the preservation activities. "This legislation also creates a National Recording Preservation Foundation to encourage and accept private gifts to promote the preservation of recordings at the Library of Congress."[97] Similar in scope and function to the National Film Preservation Act of 1988—which spawned the National Film Preservation Foundation, an important grant provider to cashed-strapped moving image archives managing miles of degrading film—this federal legislative action indicates the high level of attention that audio preservation is likely to receive into the future.

[94] Porck and Teygeler, *Preservation Science Survey*, 45.
[95] Library of Congress. *Library of Congress Leads Audio Preservation Initiatives for the 21st Century*, 17 November 2000. http://www.loc.gov/today/pr/2000/00-180.html [Accessed 4 February 2001].
[96] *Library of Congress Leads Audio Preservation Initiatives*.
[97] *Library of Congress Leads Audio Preservation Initiatives*

CONCLUSION

This paper is the results of research into the current state of digital reformatting of magnetic audio materials in library and archival collections. The survey of literature revealed that much work remains to be done in order to address the outstanding questions regarding standards and best practices. The need to rely on the expertise of technical specialists coupled with high costs of digital audio reformatting complicate the matter further. It is understandable why institutions are hesitant to adopt nascent, evolving technologies in order to solve old preservation problems. The conservative approach is, in many cases, a responsible course of action. However, the experiences of institutions experimenting with digital reformatting show that digital technology offers new found hope for audio preservation. The new possibilities should not be rejected altogether because of the uncertainties that accompany them. Gertz articulates this notion eloquently:

> Instead of 'just' trying to solve the brittle paper problem, we now have the potential to convert other media we have avoided for many years, and to do it with technology that users actively like. . . . As we work with audio and visual materials, we will be constantly moving between what we traditionally have been able to achieve and what digitization offers, and making sure we continue to value the core concept of preservation—the primacy of quality and longevity—in both traditional and new technologies.[98]

As long as digital technology develops, the preservation field will be faced with new choices and questions. These choices and questions represent opportunities for librarians and archivists to collaborate with technical specialists and to participate in designing systems that meet the goals of preservation.

[98] Gertz, "Selection for Preservation in the Digital Age," 101.

APPENDIX I

SAMPLE DATA COLLECTION INSTRUMENT

APPENDIX II

ELEMENTS TO CONSIDER WHEN PLANNING A REFORMATTING PROJECT

The next list of items should be considered when budgeting for a reformatting project. It has been adapted from the Standards, Recommended Practices and Strategies. (1987). IASA-TC 03. The Safeguarding of the Audio Heritage: Ethics, Principles, and Preservation Strategy.

1. Current Maintenance Cost of the Collection
2. Personnel
    a. Cataloging
    b. Curatorial
    c. Technical
    d. Consultants
    e. Contractors
3. Conversion
    a. Studio
    b. Recording and playback equipment
    c. Data processing equipment and software
    d. Furniture
4. Intellectual Control and Metadata Generation
    a. Cataloging
    b. Descriptive, technical and preservation metadata generation
    c. Web interfaces
    d. Storage of metadata
5. Handling and Storage of Original Materials
    a. Space
    b. Shelving
    c. Containers
        - Audio reel tapes
        - Reel hubs
        - Audio tape boxes
        - Audio cassette storage boxes
        - CD storage boxes
        - CD spacer boards
        - CD identification labels
        - Polypropylene Media Cases: jewel boxes, audiocassette.
    d. Labeling and marking
    e. Climate control system
    f. Security
    g. Monitoring equipment

6. Storage and retrieval of digital files
    a. Server space
    b. Web interfaces
7. Estimated Time Requirement of the Project
    a. Short term
    b. Long term-definite
    c. Long term-indefinite
    d. On-going activity

    For every point above, the following should be considered

    - Hours of recording materials to be reformatted
    - Recording speed
    - Metadata generation time
    - Labeling and packaging time
    - Complications
    - Supervision
8. Nature of the Work
    a. Review, collate and analyze existing data
    b. Research and development of techniques, standards, products
    c. Physical analysis/testing
    d. Chemical analysis/testing
    e. Conservation work
9. Level of effort
    a. Single researcher with peer group review.
    b. Task group with peer group review
    c. Inter organizational coordination
    d. Negotiation and approval
10. Level of support required
    a. Project manager
    b. Full-time or part-time aids
    c. Consultants
    d. Manufacturers
    e. Routine office supplies, mail
    f. Travel-meetings

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