Journal of Western Archives

Volume 14 | Issue 1 Article 11

2023

Making Hay While the Sun Shines: Answering the Urgency in Audiovisual Preservation

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ABSTRACT

Many twentieth-century audiovisual formats are becoming obsolete or are physically degrading, warranting the need to digitize this content as soon as possible. Balancing efficiency and urgency with digitization and digital storage resources is a challenging endeavor. This article documents the efforts of the L. Tom Perry Special Collections (LTPSC) at Brigham Young University to begin a systematic effort to digitize audiovisual content found in manuscript collections.

Introduction

Three years ago, I published a case study on how the BYU Library Special Collections has taken action to address the audiovisual (AV) materials embedded in our manuscript collections.[1] That article focused on the first stage, which was to locate AV materials by collection and location, identify specific AV formats and tally each, individually label all AV items with unique identifiers, and prioritize their preservation.

This article will pick up where the other left off. Now that the AV materials in special collections have been identified, what are the next steps for preserving the AV content in digital file formats? In this article, I outline our approach to responding to the following AV preservation challenges and provide examples of the actions we have taken:

- Develop preservation strategies, policies, and practices
- Determine which reformatting should be outsourced, which should occur in-house, and the needs in building an in-house AV digitization system

1. Benjamin Harry, "Finding AV Needles in Manuscript Haystacks: Conducting an Audiovisual Assessment/Audit in Manuscript Archives," *Journal of Western Archives* 11, no. 1 (2020), https://doi.org/10.26077/288d-c484.

- Develop a workflow queue to get materials in their prioritized order delivered to internal labs or outsourced to digitization vendors
- Track the materials throughout the steps of the digitization lifecycle
- Engage with technical specifics of actually digitizing the materials
- Address patron access

One important lesson learned through the process of adapting procedures to a specific situation is to always check each decision against guiding fundamental purposes. Decisions both broad and specific can be susceptible to leading away from the original intended goal. Pitfalls can lead to mission drift in the direction of expediency or to strict adherence to traditional practices that don't hold up to reevaluation. We must also continue to reassess accepted practices as situations can change, especially when advancing technology is concerned. As is often the case, we inherit the reactions and traditions of the giants upon whose shoulders we stand. This article will attempt to demonstrate how I evaluated common practices in relation to our AV preservation program goals as I engaged with the systematic digitization of AV content from analog carriers to digital files.

AV archiving programs can easily get mired down in hesitation because the challenges invite a myriad of impactful decisions that require application and adaptation. It is easy to get lost in the weeds of the necessary practical and technical considerations of connecting the technology of yesteryear with that of today, and many archivists lack confidence in their ability to navigate these challenges. This article seeks to offer readers insight into the considerations that need to be addressed when engaging with the digitization of AV content that currently resides on physical media carriers. While I will not shy away from some quite technical discussion, my goal is to dispel some of the factors that breed hesitancy by distilling these decisions down to a level of comprehensibility to aid custodians who would consider themselves beginners and novices in AV archival issues and practices.

I will attempt to do this by moving step by step through the challenge of taking ideals and principles and applying them so that desired results are actually achieved. I hope to identify the necessary components to building an in-house AV digitization system and then illustrate this through our example. I hope to provide enough context so that our decisions can be comprehensible and this will support others in making decisions that are appropriate for their situations. I hope to outline digitization procedures so that others may feel that they can act with confidence. Finally, I hope to address some digital preservation issues many smaller institutions face and offer some solutions that may present a more stratified approach to AV preservation than traditionally recommended. Some portions of this article will be better understood and utilized as a reference document more than a reading article, as it can get quite technical. But the hope is to not only suggest actions but provide enough support for adoption or adaptation.

As with any endeavor, specific decisions reflect fundamental guiding principles. In this article, I do not elaborate on foundational principles, but the following assumptions or tenets support the subsequent decisions and preservation efforts discussed in this article:

- AV content is historically valuable.
- The physical media carriers are under threat of obsolescence and deterioration.
- Timely action needs to be taken as soon as possible to ensure the preservation of time-based AV content from the physical media carriers.

Resource Review and Recommendations

My career in this field has paralleled its development. The first foundational text I was exposed to dealt with the analog preservation (refreshing) of AV content. "Preservation Re-Recording of Audio Recordings in Archives: Problems, Priorities, Technologies, and Recommendations" by Christopher Ann Paton from 1998 outlined methods of rerecording content from aging media carriers to new magnetic tape stock.[2] At the turn of the last century, digital file technology was not able to adequately reproduce AV content, but the last 20 years have seen an absolute new era of technological advancement as file-based content is now streamed to ubiquitous devices around the world. Paton's article, while based in technology from the analog era, is still insightful to read particularly for laying the groundwork for preservation re-recording. If your institution engaged in preservation re-recording projects, this is helpful to give context to the environment and paradigm in which these previous preservation projects were undertaken. I have found my experience from living through these stages to be very helpful when encountering numerous copies of recorded content in various formats spread throughout archival collections. When multiple recordings were squeezed onto newer tapes to save cost and storage, it can leave a legacy of confusing conflation and identification. Understanding what came just a generation before us can be supportive and helpful.

With the development of AV digitization and preservation occurring largely in the age of the internet, there are a myriad of resources to consult and review. But this also presents most information divided up into smaller chunks. No one has written the comprehensive "book" on AV digitization and preservation. A very significant reason is that much is still in development and chapters would still need considerable regular revision. But another is simply that there is a great deal of topics and nuance to be discussed for each archival stage and with each format type. This has led most information on the topic to be available in various segments of information. In this

2. Christopher Ann Paton, "Preservation Re-Recording of Audio Recordings in Archives: Problems, Priorities, Technologies, and Recommendations," *The American Archivist* 61, no. 1 (1998): 188-219.

article, I hope to provide not just some more bricks of segmented information, but also some connective mortar to contribute to the collective information available.

A good reference to begin with is Anthony Cocciolo's *Moving Image and Sound Collections for Archivists*. With an AV-specific lens, Cocciolo deliberates on archival principles from appraisal through the final stages of access and the promotion of archival AV collections. I recommend his book as a great overview of how to approach these types of materials and content from an archival standpoint. Providing an overview of the issues and considerations, it hints at some of the nuts and bolts of actual digitization and preservation. This keeps it from being overwhelming with technical details, but without further research it likely will not sufficiently instill confidence to begin a robust preservation program.

Cocciolo is careful to build upon enduring principles in his book. The subfield of AV archival practice and the technology for preserving such content is consistently progressing. While the specific software and standards he discusses have shifted already since his book was published in 2017, his discussions of "arrangement and description" and "outreach and access" are helpful for the conceptual goals and some specifics regarding implementation. Cocciolo's chapter on legal and ethical issues in particular ought to be required introductory reading for those dealing with AV in collections.[3] His points are basically the same legal and ethical concerns that archivists engage with on a regular basis, but the particular examples with AV content are helpful. Although there are published articles that go into more detail and depth than this chapter, it provides a great overview that will help the reader when jumping into specific case studies surrounding these issues.

Most insightful, the book includes a chapter on appraisal and reappraisal, in which Cocciolo introduces a very important decision factor that an archivist must consider when preserving AV content: "keep in what form?"[4] Appraisal has always dealt with the question of "keep or not keep," but Cocciolo discusses the need to ask this follow-up question with regards to AV content. The AV archivist must decide not only *what* to keep but also at *what level* to preserve it. "The form a record is stored in should be determined with respect to the mission and collecting scope of the archives and evidential and informational values inherent in the record."[5] Video files can be preserved in formats that maintain high fidelity to the original recording, but which will require a great deal of digital space, or they can be compressed to very small sizes that can degrade the AV content. There are innumerable intermediate levels in between these two extremes. The ideal size/quality intersection could vary for a collection or even each individual piece of content, and the decisions made regarding how the content is preserved will have concrete consequences in the future. While

3. Anthony Cocciolo, *Moving Image and Sound Collections for Archivists* (Chicago: Society of American Archivists, 2017), 41-50.

4. Ibid., 14.

5. Ibid., 21.

the weight of such decisions can rest heavily on an archivist, acknowledging that there is not a "one size fits all" approach for all content can also be liberating for modestly funded organizations. In this article, I provide a case example of how we at the BYU Library engaged with these specific considerations and determined our own approach.

To transition from the broad overview to the specifics of AV digitization, a great resource for guidance in the specific steps for digitization are the resources made available by the Canadian Conservation Institute. There are a number of technical bulletins that outline the digitization of audio tape and the digitization of VHS videotapes. These are excellent resources but can get very specific with 62 pages alone on digitizing a VHS tape (with principles that can thankfully be applied to any video format after the playback deck stage). So once the broader context is understood, these are great references to be consulted to support successful preservation initiatives. Other resources outline very similar practices, but CCI offers quite comprehensive and methodical resources that are conveniently collected online.[6]

There are technical specifics of AV preservation that serve to establish best practices and international standards. References I frequently consult include the guidelines for audio and video preservation outlined by the technical committee of the International Association of Sound and Audiovisual Archives (IASA). The Guidelines on the Production and Preservation of Digital Audio Objects (IASA-TC 04) recommends standards, practices, and strategies for audio preservation.[7] Its counterpart from a decade later, Guidelines for the Preservation of Video Recordings (IASA-TC 06), outlines recommendations in a similar fashion, albeit with the recognition that while audio preservation is quite standardized and has been performed for almost two decades, video preservation specifics must be outlined in more principle-based recommendations as specific digital video preservation practices continue to emerge and mature.[8] But these can get very specific and technical, providing deep dives into even the scientific explanations of how electronic AV signals are captured digitally.

6. I recommend the following CCI resources: Electronic Media (https://www.canada.ca/en/conservation-institute/services/care-objects/electronic-media.html), Canadian Conservation Institute (CCI) Technical Bulletins (https://www.canada.ca/en/conservation-institute/services/conservation-preservation-publications/technical-bulletins.html), Digital Preservation Format Literature Review (https://www.canada.ca/en/heritage-information-network/services/digital-preservation/format-literature-review.html), and Digital Preservation File Format Recommendations (https://www.canada.ca/en/heritage-information-network/services/digital-preservation/recommendations-file-format.html).

7. IASA Technical Committee, Guidelines on the Production and Preservation of Digital Audio Objects, ed. by Kevin Bradley, 2009 (second edition), (= Standards, Recommended Practices and Strategies, IASA-TC 04), https://www.iasa-web.org/tc04/audio-preservation.

8. IASA Technical Committee, Guidelines for the Preservation of Video Recordings, 2019, (= Standards, Recommended Practices and Strategies, IASA-TC 06), https://www.iasa-web.org/tc06/guidelines-preservation-video-recordings.

My final resource recommendation regarding approaches and strategies for preserving AV content is Mike Casey's *Media Preservation and Digitization Principles*, published in 2022.[9] Casey is an experienced media archivist, and this publication outlines the guiding principles of AV content preservation for Indiana University's Media Digitization and Preservation Initiative. Casey illustrates how these philosophical directives should underpin all decision making. He outlines the inherent principles and concepts that govern and support specific actions and practices in preservation. He provides a hierarchy of the inherent principles that inform preservation principles, which ultimately culminate in applied media digitization practices. He teases out important demarcations that can often get blurred when considering digitization and the digital preservation of AV content.

While the principles and policies outlined by Casey have been discussed for decades and are found in various writings in the field of AV preservation, Casey has compiled, identified, and skillfully articulated these principles for each decision and approach. In my last two decades as a media archivist, I have had to work through these very same cognitive puzzles and apply them to the specific missions and realities of the institutions where I was employed. I only wish Casey's resource had existed for me years ago as it astutely distills the principles to essential points of articulation.

Casey's first principles are similar to the assumptions this article is based on, namely that AV content has inherent value, that preserving the content is worthwhile, and that the focus is on preserving the content rather than permanently storing the physical AV items in their current forms.[10] Casey's preservation program principles, which grow naturally out of these first principles, uphold that media preservation requires a commitment to the long term, that timely actions need to be taken in a prioritized manner that values unique content, and that accuracy and faithful reproduction are essential.[11] These preservation program principles are intuitive and logical, and Casey shows how each digitization action is built upon these preceding principles.

Casey's "Media Preservation and Digitization Principles" is a great reference to vet decisions against to ensure that local adaptations do not lead too far from the ideal and the intended purpose of preservation. I recommend Casey's publication as a resource to be consulted with regularity. Since most organizations will not be able to fulfill everything to the imagined ideal, careful consideration must be given to which standards are essential and which are optimal. Returning to the root reasons behind preservation and digitization helps us ground ourselves as we develop our own processes.

9. Mike Casey, *Media Preservation and Digitization Principles*, 2022, https://hdl.handle.net/2022/27446.

10. Ibid., 10.

11. Casey, *Media Preservation and Digitization Principles*, 11-22.

This section may read more like a "recommended reading" section than a "literature review". While our AV preservation and digitization decisions were based upon my experience from the last 20 years of archiving AV, these recommended resources support learning so that AV archiving doesn't require 20 years of experience. Casey and Cocciolo's writings are fantastic resources that provide background understanding for addressing the issues that arise in *supervising* AV preservation efforts, albeit from two very different approaches. One key role of an AV archivist is navigating the balancing act to weigh the application of ideal principles, the institution's goals, and what is reasonable and feasible. Such specifics are understandably out of the scope of a principle-based discussion like Casey's publication or of an introductory guide like Cocciolo's book. At the other end of the spectrum are the referenced IASA technical guides. While these technical guides provide fantastic reference material, they offer no hints for specific decisions that institutions must make, or even a "how-to" to begin digitization. The CCI guides are great for the purpose of step-by-step how-to technical guides that will foster confidence and enable action. All of these resources focus specifically on limited aspects of AV archiving. An understanding of the variety of far-reaching considerations necessary for successful AV archiving is best developed through consulting multiple resources.

One challenge of AV archiving stems from the fact that there are so many variables that must be considered for each institution, department, collection, and situation. Indeed, when an institution seeks to implement an AV preservation program, the process will require significant planning, adaptation, and discussion. Navigating the complexity inherent in the preservation of AV content can easily be overwhelming for an archivist, leading to hesitation and possible loss. My hope is that the documentation of our experiences and of our decisions in applying principles and policies will be a helpful illustration to others who are contemplating setting up AV preservation programs, providing an example intermediate layer to connect these levels of resources.

Review of Previous Case Study

Beginning in 2019, I have employed student workers to systematically review over 85,000 containers of manuscript materials in order to identify and locate AV items or carriers interleaved into manuscript collections. These students have been trained to identify our five most common formats (standard audiocassettes, VHS videocassettes, quarter-inch open reel audiotapes, optical discs, and gramophone audio discs) and to report any items in any other format that appeared to be AV to another student with specialized training. This tiered approach to training and delegation supported a high -efficiency survey that maximized the strengths of multiple student workers with limited AV experience and utilized more specialized workers with greater experience or interest in AV materials. As a result of this process, we identified about 6,600 containers that house AV materials, with a total of about 132,000 individual physical AV carriers.

I had previously developed a preservation priority scale to evaluate both content priorities and the physical risks of deterioration and format obsolescence. This preservation rating was a combination of a numerical risk assessment value that I assigned as audiovisual materials curator, and a priority value assigned by the responsible content curator of each collection. This aggregate priority level score guides the prioritization order in the AV preservation queue.

While the assessment of AV was still in process, I began fleshing out the in-house reformatting workflow procedures and the building of AV digitization systems. So far, we have successfully preserved over 400 preservation projects and completed over a dozen outsourcing projects. I also continue to add specific format capabilities to our internal AV digitization suites based upon the data returned from the survey.

As is to be expected, we have found some omissions and misidentifications in our survey. I have needed to address kinks in the coordination processes. We have experienced logjams that needed attention or required the development of some workarounds. But these issues are not a cause for discouragement or frustration. Rather, such experiences naturally occur in any new endeavor, and our solid base of rooting procedural policies in guiding principles has led us to consider this period a great success. I look forward to further refinement, adaptation, and improvement in all levels of our engagement with AV content digitization and preservation.

Providing Access to AV Content

As time continues, providing access to content becomes both more feasible and more fraught with necessary considerations. Internet uploading, streaming, and downloading speeds continue to improve, and technology continues to offer greater sophistication. Simultaneously, we become steadily more aware of sensitive information and content that is showcased or obliquely creeps into AV content created throughout the twentieth century. While participation in an oral history project may imply that the interviewee understood that the recording would be available for researchers, without documented disclosure, there is risk involved. In one instance, an oral history interviewee relayed an experience with a cousin. Without the consent of all individuals included in the relayed experience, such as the cousin, we run the risk of passing along unconsented information within the oral history's content. Although copyright restrictions continue to march into public domain through the 1920s, the bulk of our holdings may still have some type of consideration that would restrict fully open web streaming.

With our focus on the impending loss of access to AV content due to fragility or obsolescence, preservation has been set as our first priority, and we have so far offered access to AV content primarily through on-site servers. Our access derivative files are small enough that moving them to a viewing/listening station in our reading room for patrons has not been terribly prohibitive or taxing on our end. Aware that this situation stymies interest and limits access for patrons who cannot physically visit our facilities, we strive to facilitate remote access requests and approve streaming or download for appropriate materials on a case-by-case basis. These cases have been manageable, but likely precisely because our collections are not as promoted nor promotable as they should be.

The task still stands before us to identify materials that can be shared broadly and then take the steps to proactively share them. We need to address the technical questions of platforms and services available to support this active access method. With such a system in place, we hope to identify and begin proactive efforts that might only require the solicitation of permission for content to be shared and promoted more broadly. However, the access derivative files we have created are ideal for sharing over web-based platforms and small enough to move quickly through streaming and download, which positions us well-prepared for when the next phase in access is initiated.

Tracking the Materials throughout the Steps of the Digitization Lifecycle

As documented in my previous article, it takes thoughtful effort to identify and assess AV holdings. With that initial step in place, we are able to segment our holdings into manageable AV preservation projects, tracking the status of these projects as they move from our stacks to our digitization suites, and the final step that documents the completed preservation.

There is a plethora of project management software solutions available, and if you are comfortable with one of them already, it is likely best to integrate these steps into your established system. We have simply used spreadsheets to walk us through these processes. We have a tracker spreadsheet for each digitization station, which helps us monitor the progress status of active projects. But we recognize that spreadsheets require a certain level of manual involvement, may require updating multiple documents with the same information, and that many other software solutions offer tools for collaboration and automation.

Outlining some steps in greater detail is likely helpful. When AV materials are found in a physical container in the manuscript stacks in our review process, the information about those materials is entered into a spreadsheet that records call number/collection identifier, container number, shelf location, and AV format type and count. The call number/collection identifier is used by the responsible curator to assess the preservation priority of the collection primarily based on uniqueness of content, collection prominence, and frequency of access requests. Each AV format type has been evaluated with a risk level based upon its fragility and estimated obsolescence. Taken together, these two values are simply added together to determine the preservation priority value. The spreadsheet row from the assessment containing all this information is copied into the video or audio digitization queues or the outsource queue, depending on the AV format. These worksheets are regularly sorted according to the column containing the preservation priority value, which brings the items with the highest priority to the top of the worksheet.

Digitization technicians usually keep one to four projects in their active project queue so that they can be managing multiple projects through the stages of digitization. These stages include, in order: physical inspection, capture preparation, capture, descriptive metadata documentation, and preservation/access file transcoding. Some projects can require months, so a secure holding area in the digitization suites is required. Containers are checked out in our automated request and workflow management software system and brought to the lab. Containers typically house more than one AV item, and often the AV items vary in carrier format as well. One physical container may hold 10 audiocassettes, 2 VHS tapes, and 7 open reel audio tapes. Although these formats may have varying preservation characteristics (one format is high risk while another is low risk or one is video while another is audio), we have found it ideal to complete the digitization of the entire AV preservation project before returning it to the storage area. This approach requires a search in the queues to move all format types from the specific container to the active project queue of each technician. With each container and format type occupying its own spreadsheet row on the AV assessment, it would alternately be straightforward to truly digitize each in its own individualized preservation priority order. To streamline description, minimize impact on reference staff support, and for ease, we have chosen to attempt to process each container as a whole as much as possible once called. The exception is if the container has format types that require outsourcing and that would likely prohibitively complicate and lengthen project completion. Outsourcing is handled as a critical count of items of one format is reached, and these are delivered to a vendor for batch digitization based upon format type.

Once AV content has been preserved, the metadata has been recorded, and the files have successfully passed a quality control audit, the access files are moved to the digital access server and the preservation files are moved to a dark digital repository. Ideally a description/cataloging review is performed post-digitization because preliminary description had to rely solely on exterior carrier information to describe the content. This description workflow step is required in our processing protocol for newly acquired collections. Since we have only begun this effort for legacy collections, we have an instantaneous 60-year backlog. Once digitization is complete for a project, it is reported to a list where (re)description is requested, and these await description review as resources permit.

Preserved materials are clearly marked and reported on the AV assessment and in the electronic finding aids. We have also found it helpful during our AV assessment and digitization processes to affix a physical label to each container where AV materials reside. These labels have a checkbox to indicate when content has been completely or partially preserved. This checkbox alerts reference staff and patrons to the digitization status of content inside. While there is redundancy between the status of preservation recorded in the electronic description and this physical label, this indicator has proven itself useful and worth the allocation of only minute resources.

Our Legacy of Audio and Video Digitization Actions

To best understand our choices from this point, it is helpful to frame our inherited AV digitization legacy. Our good fortune was that the BYU Library had already invested in audio digitization. For years, we had a functional audio digitization suite to support access to our analog sound recordings with professional equipment. In our reading room, we had a listening/viewing station that supported a few formats: audio cassettes, VHS, DVD/CD player. On another floor in the library where the music collections were located, a single quarter-inch magnetic tape deck and a few gramophone turntables were available for patron use. But materials from special collections were not to be transported outside of the secure area, so access to AV materials was limited to formats available in the reading room or required an escort up to the music area. After some years, to eliminate materials requiring escorted removal from special collections, the audio digitization suite was created to support the digitization of audio recordings on analog formats to audio CD. The suite was used to create CD access copies that were then maintained in the collection physically next to the analog masters. But this was not a systematic preservation process, as the access copies were generated only upon patron request. The CD was a format-limited derivative of the original media and was not considered a type of permanent preservation since writable CDs hold information only for a limited amount of time. To facilitate the transfer of AV content from analog formats, the research patron was required to pay a digitization fee, unless an access CD already existed due to previous patron request.

Unfortunately, files were also not quality-reviewed before preservation, so some files have been found to have been preserved at incorrect speeds, backwards, or were unintelligible without explanation. As technology and best practices progressed over two decades, there were further steps of incremental improvement: audio content was reformatted to digital files and burned to more permanent M-discs as storage devices, and eventually these files were preserved into the Rosetta digital asset management system that the Library subsequently invested in. But preservation action was still only a disorganized result of requests; file naming conventions were inconsistent; and no record was kept of what had been digitized. While benefitting from these incremental improvements, we were still in need of comprehensive reassessment to adequately undertake systematic audio digitization and preservation.

Video was available only through the format players in the reading room (VHS and DVD) and, eventually, a corner desk of the audio transfer suite was set up to accommodate the transfer of content on U-Matic and Hi-8 video tape formats to DVD-Video. The approach was similar to the audio situation, with access-centered placement of DVD-Video discs placed next to original carriers.

Desired Outcomes, Ideal Preservation Actions, and Ensuing Procedures

Circling back to fundamental goals and evaluating whether a project or program is deviating from intended outcomes is a necessary iterative action to ensure success.

Here is a list of the broad goals of our AV preservation program, a list of characteristics that should describe preservation actions, and then some of the procedures built upon those preceding directives.

Desired Preservation Outcome

- Preserve all content currently recorded on machine-readable formats before obsolescence and deterioration prohibit digitization
- Describe AV content more accurately and completely in the catalog and discovery tools
- Provide access to AV content and enable its promotion

Ideal Preservation Actions

- The digitization process will do as little damage to the original carrier as possible.
- The digitized file will accurately reflect the content on the original carrier.
- The files will be able to persist without degradation into the future, allowing for both research and experiential use.

Some fundamental procedures in our digitization have grown out of these goals. Below are descriptions of our procedures along with their justification and the cost associated with following them.

Preservation accompanies access. Ideally, there would be one workflow for preservation projects and one for reference requests. But the reality is that preservation projects are ongoing and patron requests come in fits and starts. Running patron requests through a station that is actively and consistently used for performing preservation projects may slow down reference response time. Likewise, interrupting preservation projects to suddenly switch gears and interject a patron request can be a challenge. Keeping things organized and tracked through multiple workflows of preservation and access requests requires strict attention to detail. But, in the long run, transferring materials only once has become a guidepost to which we cling.

With playback equipment limited and the aging physical media materials in some state of deterioration, there is no time like the present to preserve. We have found examples where access DVD copies of transfers from U-matic video tapes in 2005 are superior in visual quality to the transfers we can make today. The DVD-Video format is limited in its resolution and image quality, but some of these tapes after repeated baking treatment have not yielded the consistent quality that they were able to produce over fifteen years ago. We can now only wish that we had preserved these at higher quality originally when the access request was received.

This approach of preserving materials when they are accessed has at times required asking patrons to plan their research ahead with greater preparation, and it requires that we keep our workflows flexible to accommodate sudden interjections without disorganization or significant loss of efficiency. However, we anticipate the positive aspects of this practice outweigh the challenges it presents.

Every physical carrier receives a unique identifier. Filenames describe physical source carrier as well as intellectual content. The content recorded on any given piece of physical media may consist of multiple content segments, but there is a one-to-one relationship between AV item identifier and physical media. The physical media is labeled with a unique identifier, and all files on that physical media will have that identifier in their file name. Incremental segment numbers can account for disparate content contained on a single carrier so that they can be separately described in metadata.

Some donors have stacked multiple recordings on a single carrier to save money and space. Conversely, some recordings are so long that they span multiple carriers, and to account for that we must title files "part 1" and so forth. Previous file naming conventions relied solely upon a content description ("event, date, performer," for example). But because content is often duplicated on various carriers, it has proven difficult to discern after the fact whether the digital file was sourced from the cassette copy, a library rerecording initiative, or from one of the CD protection copies from the donor. Metadata and accessibility are much clearer when we can attribute the holdings to the specific physical carrier. While labeling is tedious and time consuming, it is a practice that has saved us headaches and promises to leave a tended path for others to follow in the future. Providing metadata clues in filenames requires exacting attention to detail, but immediately communicates information about the nature of the file without required use of external databases.

The content should be captured at the best possible fidelity and faithfulness to the original recording. Discussion, deliberation, and decisions can be made after the content has been digitized. When digitizing/capturing the content from the physical carrier, we treat it with the highest standards. As much as we may be tempted to make assumptions from the carrier or about the content, until the file is reviewable by the authorized steward who can make those decisions, treating the content based on its *potential value* is paramount. Downstream actions can be worked into the workflow and recapturing wastes time, which is virtually our most precious commodity in this work.

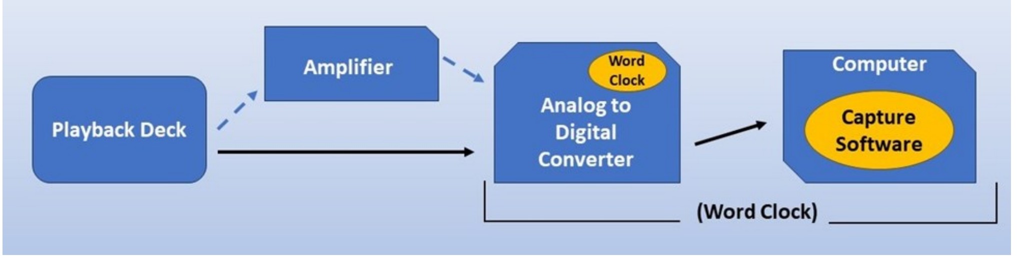
We must address the issue that someday the analog materials will likely no longer be kept. As we strive to responsibly care for AV content, we currently maintain the original carriers after content digitization, as the early twenty-first century has taught us to not place all our eggs in the digital basket. But with physical materials degrading and playback equipment disappearing, the same reasoning that pushes us to digitize as much and as soon as possible logically leads us to accept that someday these recordings will be unplayable and may be only taking up valuable physical shelf space. I make no predictions when that might finally occur, but we must face this inevitability. When it does finally come to this, having the content captured at the best possible fidelity to the original is essential.

Audio Digitization Station Set Up and Optimization

Digitization Structure: The Signal Path

The initial step in transitioning to a robust AV content preservation program was building an appropriate digitization station. I first focused on the best-functioning unit, which was the audio suite, to develop the workflow and finetune the equipment for preservation purposes. Building upon the existing infrastructure supported a quick start and allowed successive trials to move forward quite quickly.

The guiding blueprint of an audio digitization station is the signal flow. The signal flow is the flow of electronic signals from the analog playback device to an analog-to-digital converter and finally to the computer with a capture software application. You always need to be able to follow the directional chain from where the signal originates all the way through to its point of digitization. This knowledge is essential to the setup as well as to any subsequent troubleshooting.



A professional, calibrated playback deck is vital to the safe and accurate reproduction of magnetic-based media. This primary playback device step is the same initial module of equipment whether you are playing gramophone discs on a turntable, using magnetic tape in cassette or open reel formats, or even using magnetic wire recordings or phonograph cylinders: the playback deck is what will interact directly with the media carrier, and therefore the quality and calibration of this machine is vital. It can be quite expensive to purchase the right kind of playback deck, and it can also be difficult to find some formats. We were fortunate to have a legacy of audio digitization, and maybe some decent-quality decks could be found at your institution as well. Because any signal from this point can only be maintained or degraded rather than improved, it is worth investing in a quality playback deck.

Ideally, the connection from the playback deck to the digital converter should have balanced audio outputs. A balanced audio cable is one that has three separate pins, commonly called XLR cables. Each cable delivers audio information for a single channel from the playback device, and it is typical for a playback device to have two cables for left and right signals. This cable formulation allows for less interference and for greater-fidelity transfer of the audio signal, and these balanced outputs are often an indicator that a device is of the professional variety. These cables carry the signal from the playback device to the analog-to-digital converter. Within this section of the signal path, it might be necessary to introduce amplification of the signal if there is not significant signal strength or signal control for the digital converter. A gramophone turntable will always require some sort of amplification, and these devices often have a “pre-amp” that is sold with them. A simple in-line amplifier that will not unnecessarily color sound information is the solution if you need additional volume level control between the playback device and the analog-to-digital converter (sometimes called an interface). A signal peaking between -15 dB and -3 dB in the capture software is our standard for optimum signal strength.

There are a variety of analog-to-digital converters available, and quality is often correlated with price. A recommended specification is an analog to digital converter that can produce files at a 96kHz sample rate and 24-bit depth audio quality. This specification is the industry standard and best practice to sufficiently capture audio information. Some converters have an internal word clock, which is a device that keeps the converter in sync with the computer that is creating the file. Otherwise, an external word clock can be purchased and integrated into your system. Whether the word clock is internal or external is immaterial, as long as you have one and establish sync between capture software and digital converter.

The final link in the signal chain is some type of digital connection from the converter to the computer and computer software that accepts the digital signal and captures/creates audio files. This type of digital audio software is typically referred to as a DAW (Digital Audio Workstation). The software can range in price and tool types, but robust and trusted software is all that is required for strict preservation. As already noted, the standard is to capture all file types at a sample rate of 96kHz and 24-bit depth. Professional speakers are nice for monitoring, but headphones are a great alternative that is both reasonably priced and especially useful for those who do not have a dedicated room for this process.

It is good to be able to trace all connections from one component to the other. Keeping things simple and direct helps with troubleshooting: if you can see signs of audio signal received at various stages, or missing from one, then identifying where the problem lies can be less of a mystery. Getting computers to talk with analog-to-digital converters or getting the software to see the signal coming from the converter can be a headache at times, but through tech support, tutorial videos on YouTube, and trial and error, usually mysteries are quickly solved.

Digitization Decisions & Procedures

While we had the audio equipment in the lab to build upon for the actual digitization of content, it was essential to both reevaluate our technical resources and establish our standard workflow. I needed to outline the process of systematically selecting items for preservation, the establishment and documentation of digitization procedures, and the method of reporting completed preservation projects.

For the hardware, we began with good quality playback equipment. For the cabling, I eliminated any routers. While routers are very convenient and support the management of many cables, I chose direct connections between each component to ensure simplicity and eliminate steps where interference could be introduced into the signal. I was careful to run power cabling away from audio cabling whenever possible, and when it was not possible, I made sure that cabling crossed in a perpendicular direction rather than in parallel to reduce the possibility of electrical interference. I purchased additional playback equipment to support formats we could not already support, and the AV assessment supported these decisions by identifying how many we had of each media format, its fragility, and what equipment resources could help us reach our goals.

We had professional playback equipment that allowed us to make physical adjustments to optimize the signal output. The most common and simple adjustment for a magnetic recording is to adjust the azimuth of the playback head. Since analog is a physical representation of sound waves fixed onto a pliable medium, it is best to adjust your machine to resemble as closely as possible the machine that made the initial recording. Azimuth adjusts the angle at which the tape runs across the playback head. There is usually a spring-loaded screw attached to the playback head, which adjusts the angle of the playback head when turned, allowing users to optimize the playback deck for the content. You will want to hear as much brightness in the signal as possible, which often translates to listening for tape hiss to be as loud and clear as possible. When listening critically during this adjustment, you will notice how the signal can sound muffled when misaligned. This simple adjustment can go a long way to getting the best signal possible from the carrier.

I needed to add a number of professional amplifiers into the signal chain as our capability to adequately control signal levels was limited. Often our signals arrived at our capture software at around -30 dB at best, and some of our audio decks did not have adjustable output controls. As stated before, a signal peaking between -15 dB and -3 dB in the capture software is our standard for optimum signal strength. To leave enough room for louder portions, I typically aim for -8 peak loudness when beginning a transfer.

We purchased robust analog-to-digital converters that are utilized in professional recording studios. The same technology that is used to sufficiently convert analog sound produced by microphones into a digital signal will adequately transmit reproduced sound from an analog physical carrier produced sixty years ago. We purchased a converter that could handle multiple inputs so that we could transfer from multiple playback decks simultaneously. This converter was then connected to a robust computer that had adequate processing power, writing speed, and memory storage for our digital audio files.

As mentioned, there is a myriad of audio capture software that can handle multiple streams of audio capture simultaneously. Since our university has a licensed subscription with a software company, we use their digital audio workstation (DAW) for our capture software. We capture all our audio at a sample rate of 96kHz and 24-bit depth. To begin a capturing session, the first step is to ensure that the computer sees the analog-to-digital converter and that the word-clock is synchronized. Then we open the capture software application and make sure its settings are also set to receive signal from the analog-to-digital converter and they are properly synchronized. Next, we use templates to save setup time, saving each session to a unique folder where all the necessary files will reside. Following the sequential flow of data from playback deck to capture software is worth the time and reserves mental and emotional bandwidth as troubleshooting can otherwise become a puzzle to unravel with so many points of possible miscommunication. When a question or problem arises during a final quality-control audit on the file, it is helpful to be able to track back to the exact digitization session. Within our digitization metadata, we are careful to create a separate session for each recoding period and identify which session each capture originated from in the project metadata, so that it can be researched or recaptured if necessary.

It is important to have the digital file resemble the original recording. Magnetic tape, particularly in open-reel formats, can have a variety of speeds and different audio track configurations. Common speeds for open-reel tapes are 3 ¾, 7 ½, and 15 inches per second, with speeds of 1 [illegible] and 30 inches per second being less common. Typically, a professional playback deck can play back at two different speeds, which means it is not usually possible to capture all material held by an archive at correct speeds with a single deck. Playback decks have audio track reproducers that are usually full-track, half-track, or quarter-track. Since playback equipment usually has only a single audio track reproducer, optimized audio track reproduction will also likely require a number of playback decks. With five possible speeds and three possible audio track configurations, there are fifteen different possible configurations to accommodate. Therefore, forethought and careful planning are needed in equipment purchasing decisions to determine what would work best for each institution based on the content and carrier formats found in that institution's collections.

The most common *archival* recording speeds are 3 ¾ and 7 ½ inches per second, so it is highly recommended to have a deck that will play back at these speeds. If the speeds of the tapes you are seeking to digitize are ones your playback machine cannot reproduce, you can either seek to purchase equipment that can reproduce those speeds or to perform speed correction after capture using digital audio software. While the digital speed correction approach is not ideal, it is possible and can yield a decent transfer of the content. Similarly, a one-to-one relationship of audio track recorded on the tape to digital audio track is ideal, but smaller audio track reproducers at least allow for track separation (half-track is smaller than full-track, and quarter-track is smallest). An audio track reproducer too *large* for the recorded tracks on the tape will result in a mixed signal that is impossible to separate out and cannot be used to successfully capture the content on the carrier. An audio track reproducer that is too *small* for the recorded tracks on the tape will result in a loss of audio fidelity but will still have an acceptable representation of the content as recorded. For a budget-limited institution, the most common essential setup I would recommend is to have a quarter-track reproducer deck that can play at speeds of 3 ¾ and 7 ½ and a half-track reproducer deck that plays at the same speeds. If limited to a single deck, a quarter-track reproducer deck would allow the separation of each track you may encounter. While using only a quarter-track reproducer is certainly not ideal, having less-than-ideal AV content in the twenty-second century is better than having none at all.

Digital Audio Preservation Files—Keep in What Form?

Decisions regarding preservation standards will undoubtedly require input from multiple stakeholders. Available best practice standards outline adequate preservation formats for both audio and video files. However, these standards have been set within certain paradigms that are based upon certain assumptions and might not best serve the realities of all institutions and archival content.

To this point, the guiding principle I have clung to has been to capture the full *potential* of the audio signal in a digital file. The goal has been to ensure against any limitations or degradations to the quality of the signal from the analog playback machine to the point of capture by the audio software. Indeed, one of our stated digitization procedure goals has been: *The content should be captured at the best possible fidelity and faithfulness to the original recording*. All of this is absolutely correct and vital because assumptions should never dictate digitization. Until content is digitized, there is no knowledge of what the carrier may actually hold, and decisions at the digitization level can be irreversible once captured. Manipulation of a file is relatively easy downstream from the capture, but we don't want to embed limitations in the initial digitization phase.

Our custodial relationship to the captured content can fundamentally change once the content is captured. Once the content is digitized at its potential and is reviewable, serious evaluation can occur. Now that review of the content is possible, I pivot to evaluate the content and accordingly, optimize the file we will preserve. It requires separately focusing on the two steps of digitization and archiving in the larger AV preservation process.

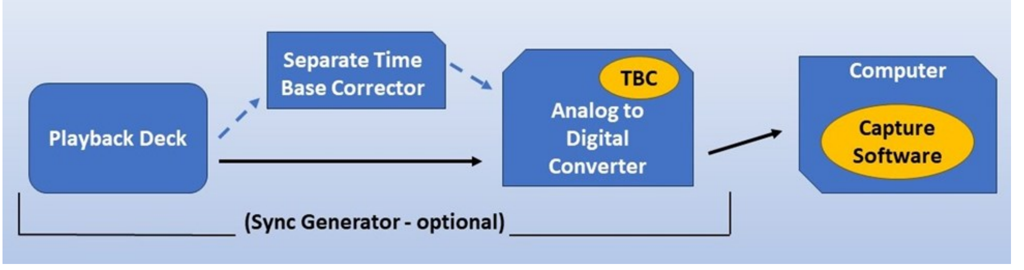
The standard audio preservation format is uncompressed pulse code modulation (PCM) audio information at 96 kHz and a sample rate of 24 bits in a .wav wrapper. This standard yields files of approximately 1 GB for an hour of mono signal recording or 2 GB for an hour of stereo. This standard allows for the preservation of the full bandwidth of sound recorded in a professional studio setting. It is a wonderful ideal to strive for, and the data size is not very prohibitive for even a small archive. However, substantial data storage size savings can accumulate if appropriate audio is preserved at only 48 kHz and 24 bits. With oral histories that are limited in frequency range to human speech and are often recorded in less-than-optimal settings, the difference is imperceptible. Additionally, oral histories are most likely to be reused in a research and reference setting, where evidentiary value is prioritized over aural experience. An audio file with 48 kHz with 24-bit is actually within the recommendations set by IASA-TC 04 for the preservation of audio files, even music. This size is not too reduced to cause significant loss of data due to lossy compression schemes, like mp3s, which can yield great space savings but can noticeably and irreversibly alter sound quality.

With our holdings of audio carriers approaching 100 thousand items and approximately half of those being voice-only, it represents a substantial cumulative difference. I decided to preserve audio at 48 kHz/24-bit audio for any recording containing speech alone and at 96 kHz/24-bit for any recording containing music. I feel these quality levels are adequate, and this approach helps us manage our limited digital storage allocations. To extrapolate out the example, at 96 kHz five hundred hours of stereo audio can be stored per terabyte of digital storage, but at 48 kHz one thousand hours of stereo audio can be stored per terabyte. This logic could lead some institutions to go further and utilize mp3 technology to save even more space. Each institution must draw the line that will establish the relationship between resource limitations and quality. While I have the luxury to preserve content with greater fidelity, if such space allocation is truly prohibitive for an institution, it is still better to have small files than to have no files at all in the 22nd century.

Video Digitization Station Setup and Optimization

Digitization Structure: The Signal Path

After the audio lab was set up and running, I turned my attention to the video lab. Again, we had some playback decks that had been salvaged from surplus when the university was divesting analog video equipment. With the advent of digital video, these decks were being removed from units all over campus, and thankfully someone had the foresight to keep some decks for a variety of formats. Unfortunately, this article is coming at a time when it might be too late for many institutions to salvage decks from similar purges. While we inherited a handful of decks and a few video monitors of various quality levels and conditions, I had to start from scratch with our analog-to-digital converters and video capture computer stations. We have added additional format playback capabilities, the key being getting the proper equipment to digitize and capture video signals in place so that we could immediately begin with what we had and to then add prioritized format components gradually.



Mirroring the signal path organization of the audio lab, the electronic video signal will originate with the playback deck. Once again, optimizing the machine to produce the best signals possible is of key importance because nothing downstream can improve upon a degraded original signal. For best results, using professional broadcast quality playback decks will provide for the most consistent results. However, we did find that some consumer formats, particularly VHS, often offer flexibility for multiple recording speeds. Professional decks were designed for the broadcast environment, optimized to record and playback at the best quality speed (fastest), so multiple speeds are typically not optional. But many archival collections were produced by consumer models that will record at slower speeds. While recording at slower speeds degraded the signal quality, more hours fit on a single cassette this way. To properly play these lower-speed recordings, we needed to have a number of consumer decks also on hand. Consumer decks break more easily, but they are relatively inexpensive, so having a stockpile of such decks has proven advantageous.

The next step in the signal flow would be to ensure that you have the correct connector type in your cables. Professional equipment usually has BNC connectors to transfer synchronization signals as well as video information. It may also have the same XLR connectors that are found on professional audio equipment for the transfer of audio information. BNC connectors have a locking mechanism that keeps the cables connected even when some stress is applied, which is helpful when one is working on cable connection projects. Over the years, cable improvements have been made to better carry the video signal, and using the best available connection is important for achieving the best results. The most basic video connection is a composite connection. S-video was an improved connection from the late 1980s that improved the image quality by separating out various components of the video signal for optimized transfer, but unfortunately S-Video does not accommodate a BNC connector. Component connections separate out colors into three distinct cables for an even more improved signal transfer. Component connections are the common term for YPbPr or CAV connections, so you will see those terms as well. Such connections break the video signal into three distinct signals, which further reduces possible signal interference. This is the developmental evolution where analog connections ended and digital connections took over.

Digital video connections come in quite a variety, most commonly FireWire or SDI (serial digital interface), but a guiding principle is that if your deck can output a digital video signal, it is best to try to utilize it directly. Since our end goal is to have a digital signal arrive at the capture computer, skipping all signal conversion is optimal. While the deck may be able to convert the digital signal to an analog signal and then have this converted back to digital for the computer capture, this process may introduce problems. However, if your system is set up for analog video capture, and if it is cost prohibitive or proves difficult to add direct digital connections, analog signals will suffice for transferring the signal for evidentiary content. While that approach is not optimized for experiential content, again preserving something is better than preserving nothing.

As in the audio transfer process, keeping connections as simple and direct as possible in the video transfer process is helpful. Routers can be convenient but may degrade the signal and can make troubleshooting more difficult. The next step will be bringing the signal into an analog-to-digital converter. Such converters are increasingly challenging to find. In 2011–2018, the converters could likely be found quite easily because many broadcast facilities were divesting themselves of analog resources, but now they have become scarce again. Standalone units are no longer being produced and can be a challenge to track down. These units often have a built-in processing amplifier ("proc amp" is the common jargon) that can act functionally similarly to the separate line amplifier that you might need in an audio signal chain. This processing amplifier will enable the adjustment of brightness, darkness, hue, and chroma to optimize the video signal. Similar to the word clock that helps synchronize the computer with the audio signal, a time base corrector (TBC) is needed to synchronize and stabilize the signal for video capture. A TBC can be internal to the analog-to-digital video converter or can also be an external unit. If the above tools prove insufficient, a secondary synchronization tool in the form of an external sync generator may help. This sync generator will be connected to playback decks and the analog-to-digital converter in order to keep them all synchronized like an orchestra conductor, resulting in further stabilized image signals. Before purchasing an external sync generator, check the back of your playback equipment for external synchronization inputs, since such a generator cannot be used without such inputs.

From the analog-to-digital converter, the signal can then be passed to the capture computer. This connection requires one final piece of hardware: either an internal-mounted capture card or an external capture device. You might also need some adapters along the way (Thunderbolt, USB-C, etc.). Video capture software is usually offered to accompany a capture card or external capture device. This step can get quite technical, and there are many options available at various costs, but a good rule of thumb is that if the price seems too good to be true, it likely is. Small units that can do it all or cheap-looking devices will probably pass along only satisfactory signals, not optimized ones.

For monitoring the video signal, a legacy CRT monitor and/or a waveform/vectorscope can provide helpful clues about the video signal. However, usually your capture computer should have a display of the digitized video signal, and by and large what you see is what you get. The most common adjustments will be in brightness and darkness to verify that there is no information lost in the brightest or darkest sections, and also maintaining the range of those sections. The "proc amp" built into the converter should allow you to adjust black levels and brightness. Hue and chroma adjustments can also be made to correct color balancing, but hue and chroma are adjusted conservatively and less frequently.

With a streamlined signal transmitted to the computer capture station, the final step is to encode the signal into a specific video file codec, possibly an audio file codec, and place these into a file wrapper that will have information to reproduce them correctly upon playback in the digital realm. Your capture software may only support the encoding of signals into a limited number of certain codecs and file wrappers. Decisions regarding codec encoding also have an effect on file manipulation as editing applications commonly interact only with limited file types. Codecs have inherent characteristics and limitations; thus the end preservation goal and the initial capture encoding must be considered in conjunction with one another.

Referring to file formats by their file wrapper (mp4, .mov, etc.) is a common oversimplification. These file wrappers only have a limited list of codecs and parameters that they will support, but there is enough variation that referring to them only by the wrapper type does not clearly communicate what is in inside. An .mp4 file wrapper is quite prescriptive of what types of video codecs it supports, but the .mov file wrapper is much more open to variation, including any video and audio codecs that could be found in an .mp4 file wrapper. This means that if you were to take the information from an .mp4 file and re-wrap it into an .mov, it would still work just fine and the information in the file would not change at all (no improvement or degradation).

A discussion of AV preservation, particularly video, requires a basic understanding of codecs and the various characteristics they offer. An oversimplified yet helpful analogy for an introduction to codec considerations can help illustrate the differences between open-source and proprietary codec options. When you encode a file into a certain codec, it is like locking the information into a chest that requires a key to unlock. The key is a particular software application. You will need to keep careful stewardship of that key, as it is the way to unlock the content. Concern arises because this key is a digital software tool that can be slippery or even change its own properties with updates, so while the chest may securely hold the information and not change, the key must be monitored and repeatedly tested on the chest lock to catch any variations that might inhibit the ability to unlock the content. Open-source tools and codec formats should in theory always allow you to unlock that chest in the future. Proprietary software tools may not always allow you to use those keys because the software company owns them. Yet it must also be taken into account that open-source tools are often developed to successfully manipulate popular and robust proprietary codecs without requiring the specific software that creators will offer.

For example, FFV1 is an open-source video codec and FFMPEG is an AV processing application not owned by a software designer. Encoding video stream information into FFV1 should allow the future manipulation via FFMPEG without restriction. In contrast, Apple ProRes is a proprietary format designed by Apple. Apple may decide to no longer support video information in this codec in future software applications. If you want to use an Apple editing application to manipulate a ProRes file in the future but the new Apple software no longer accepts this codec, you will be unable to open and manipulate the file. Yet in practicality, ProRes is such a widely adopted and robust compression codec that FFMPEG has developed tools to unpack these file codecs and transcode them to FFV1 or another video codec that the future editing software would likely accept.

It can be overwhelming to balance and keep abreast of these numerous analog and digital considerations, especially for modestly funded/supported institutions and for lone arrangers. The next section illustrates our decisions to provide a model or a foil to help others navigate such choices from a sufficiently informed position or at least to help facilitate the formulation of specific discussions and research actions.

Digitization Decisions & Procedures

Our first priority in the signal chain is to obtain appropriate playback equipment—professional equipment as much as possible and equipment specialized for certain needs and purposes. We maintain the playback gear with regular cleaning after each digitization and scheduled monthly powering up to keep the playback gear viable when not in regular use. Correct analog format playback has always involved the mechanical physical movement of a physical carrier coming in contact with a point of reproduction (stylus or magnetic head). Physical adjustments by the playback engineer are always necessary for optimized signal reproduction, and we carefully train our staff to make these adjustments to the video tracking to optimize video signal orientation.

The cabling was not difficult to come by as we had a lot on hand, and cabling is also available for purchase. Adapters allow use of cables with BNC connections to connect to RCA connections when necessary. For decks that do not have balanced audio outputs (XLR), we purchased interface adapters to help us move from unbalanced RCA output connections. We also purchased and integrated external sync generators for professional equipment that allowed this added signal stabilization support.

We were able to procure analog-to-digital converters with internal TBCs. We purchased vectorscopes to help us utilize the processing amp capabilities of the converter to ensure that video signals are neither too bright nor too dark and to occasionally adjust chroma and hue to account for variation in the original recording. Our output from the analog-to-digital converter is an SDI cable with BNC connection that carries both the audio and video signals together to our computer capture hardware that supports an SDI input.

Despite the care we have invested in setting up our video digitization suite, we still run into consistent trouble. The audio lab configuration is quite stable in comparison, but we experience occasional problems, such as computers not recognizing signals and capture software not responding as anticipated, which are usually remedied by unplugging/re-plugging and/or restarting equipment. Despite our best efforts, these problems persist and I share this fact to temper expectations.

The most essential objective of appropriate AV digitization is to introduce no artifacts or interference into the digitized signal from playback apparatus to captured signal on the computer. This is our goal in the audio and video suites, and I feel that we achieve this goal best through the use of broadcast-standard equipment, direct cable connections, broadcast-standard analog-to-digital converters and trusted capture software. Although we do not discard original media carriers after digitization, we strive to create digital surrogates of the content that accurately and adequately represent recorded content so that re-digitization would be unnecessary. Our intention is that the digital files we have saved will accurately represent the original content in case the original becomes unavailable for playback, whether through deterioration, obsolescence, loss, or other causes.

Digital Video Preservation Files—Keep in What Form?

Preservation file standards for video are less standardized and mature than preservation file standards for audio. Decisions regarding your preservation file standards must be carefully considered, balancing resources against commitment to the original content characteristics. Adopting specifications that can reproduce the potential range of color and definition with high fidelity to the original will invariably require more digital storage space. Although similar in principle to decisions in audio preservation standards outlined above, video presents some very different scales and therefore the stakes are higher and need to be addressed very carefully.

In parallel to the previous argument regarding preparing audio files for preservation, video content warrants even closer and more specific evaluation. Due to much more variation in file types, formats, codecs, and standards, compounded with higher stakes due to file sizes, parsing through video preservation options can get quite complicated and technical. I attempt here to support the novice with plain enough description and discussion, yet necessarily delve into discussions that require technical description, hopefully tending a path to greater comprehension and not confusion. Again, up to this point in video digitization, the guiding principle I have clung to has been to capture the full *potential* of the video signal in a digital file. The goal has been to eliminate any limitations or degradations to the quality of the signal from the analog playback machine to the point of capture on the computer. While our digitization goal has been established as *the content should be captured at the best possible fidelity and faithfulness to the original recording*, I now exchange my role as analog digitization custodian for digital video archivist. Now that captured content can be evaluated, preservation files can be appropriately optimized for the intersection of specific content and limited resources.

Recommended standards for video preservation outline characteristics that will preserve image clarity (resolution), color information/fidelity, and not introduce digital artifacts. The ideal standard for video preservation outlined in IASA-TC 06 is to maintain files in perpetuity that have lossless compression, that have minimum 10-bit color depth, and that have image resolution based upon the inherent resolution of the original format. The equivalent of the 96kHz/24-bit audio preservation master for video is uncompressed video codec with 10-bit color and standard definition resolution is 720x486. For such a file, approximate size is 97 GB per hour of digitized content. Some archivists are only accustomed to working with comparatively small image files and have expressed hardship managing files approaching even 1 GB.[12] It is not hard to imagine how files of this size must appear. That is almost 1 TB of data for 10 hours of video content. We must also remember that this is not necessarily the most beautiful imagery in high-definition you have seen, but an average VHS recording with all of its inherent format limitations. High-definition content would require over twice that data size. Following this digital preservation standard for video is unreasonable and prohibitive to all but a handful of institutions in the world.

Thankfully there have arisen some new technologies that mitigate the immense storage required to preserve digital video files without sacrificing data. Motion JPEG 2000 (MJP2) is a lossless video codec that can compress video data requirements to roughly one-third of the uncompressed video file without sacrificing quality. This kind of compression is considered lossless because it uses algorithms to compress data to a smaller size, but without actually discarding any image information. Another video codec that is gaining archival adoption for lossless video compression is FFV1, which similarly requires roughly 33 GB for an hour of standard definition video at 10-bit color depth. These solutions have been widely adopted and are welcome advances to any video archival program.

Accurate color reproduction is another concern when preserving video content. The recommended color specification of 10-bit color depth can reproduce color variations from 1,024 discrete color variations and gradations. A lower valued 8-bit color video file can reproduce color from a reduced 256 different gradations. Reducing the color bit depth from 10- to 8-bit color results in a file roughly half the size when used in conjunction with a lossless codec, so this is a commonly used in many archives for formats or content that have their own limits for color reproduction. For example, 1 hour of content with MJP2 or FFV1 at 8-bit color requires only about 17 GB of storage, but some color subtlety may be sacrificed. In comparison, 256 compared to 1,024 is a great difference and might sound like reducing an image to a pale representation, but we must consider that 8-bit color is far and away the most common video files available: DVDs and Blu-ray discs are both limited to 8-bit, and certainly any file found on the internet is assuredly 8-bit. Color-depth is one of the first decisions to be made regarding preservation files for video content. Color fidelity must be weighed against a substantial reduction in data

12. Alice Pearman, "Teacher's Tales Go Online: Digitizing Oral Histories on Cassettes," *The American Archivist* 82, no. 1 (2019): 129.

storage size, half the space, especially when considering maintaining files in perpetuity.

Acting in the role of digital video archivist, and with the ability to review files after capture, preservation files can be appropriately optimized for specific content and resource options. To illustrate, our collections include many recorded classroom lectures that last a full hour or longer. In these recordings the image consists of a professor wearing a white button-down shirt and a blue blazer and standing before a chalkboard or white wall. The content was recorded with a standard definition prosumer camera model onto a VHS tape. A number of content characteristics illustrated in this example invite consideration:

- The importance of color representation for the content recorded is an important consideration. If the content is a simple lecture, then it is likely not as essential that the exact hue of the shirt be reproduced. Therefore, 8-bit color depth will surely suffice in this scenario.

- The recording media carrier (non-broadcast camera and VHS format) used to record these classroom lectures in our collections inherently cannot meet the potential capability of standard definition video recording technology. These particular video files therefore contain limited color and picture sharpness from their inception—further reasons to question whether preserving uncompressed at 10-bit color is appropriate for this specific content.

- Other quality considerations include: the lighting of the initial recording situation, the recording speed (consumer model videotape can be recorded at incredibly slow rates, sacrificing image quality but allowing up to six or even eight hours of video to be recorded on a single VHS tape), the intentional and/or creative use of color, whether the value of the content is artistic/experiential or evidentiary, and so forth.

All of these considerations are likely sufficient justifications for rejecting the advised standard in the case of our classroom lecture recordings. If these recordings are preserved in FFV1 at 8-bit color depth, a terabyte of storage could hold approximately 58 hours of video rather than only 30 hours. Ideally, we would have the luxury of preserving all video files at their potential capacity, but for many situations this standard is outright prohibitive or would present significant roadblocks to video preservation.

With audio, it was easier to support the infrastructure of preserving content at broadcast standard (2 GB for an hour of stereo), but video requires more deliberation because it takes up so much more space. The standard as written is to capture the *potential capacity* of an ideal video signal, but the content might not justify this. An analogy is loading a semi-trailer with 50-gallon barrels to move various liquids in anticipation that some barrels *may* contain 50 gallons of liquid, even though the majority of the barrels being moved usually contain only 20 or 30 gallons. Tailoring the container size to more closely fit the actual content would make better use of the space. Preserving the potential capacity is optimal for a broadcast environment—this preservation approach assumes that all of the information is essential and that the content will likely utilize near-capacity of the recording format. However, what is appropriate for a commercial content producer will likely not be necessary for a local community center capturing oral histories. This type of distinction is what Cocciolo was pointing to when adding "keeping in what form" as a necessary appraisal question in AV preservation.[13]

For many situations, even 17 GB per hour of standard-definition content is prohibitive or limits the amount of video holdings that could be preserved responsibly. There are tools that can further reduce space, though they must be considered carefully. Again, further file size reduction will be based upon image resolution, to transcode to further-compressed video codecs, and/or to use color subsampling. Each of these methods have potential size savings that must be evaluated and weighed against their potential loss in fidelity. Reducing the information in a video file is an irreversible process, so the quality and characteristics of all future derivatives would be limited by these decisions.

The first option, namely, image resolution reduction, is not recommended. Standard definition imagery (720x486 resolution) is already blurry to our modern eyes, and further resolution reduction only degrades the image further. With high-definition video, I have found that this approach still degrades the image quality significantly and in undesirable ways, making the image appear either blocky or fuzzy. It is difficult to provide specifics here, but I have found that reducing image resolution for file size reduction is the most noticeably negative option for maintaining fidelity to the original recording. Simply put, better technology has been developed for using other options to reduce file size and minimize the degradation of the image quality.

Although navigating the unsteady waters of lossy compression can be treacherous, I have found this to be a better tool to exchange size for image quality. Justified by the considerations mentioned above, the smaller file sizes of compressed video can be considerable, and therefore enticing and even liberating, for some situations. Preservation files still need to be compressed with a scheme that limits the irreversible loss of visual information as much as possible. Commonly, when files are found in an .mp4 container, they are using the ubiquitous h.264 compression codec. Constant Rate Factor (CRF) is a setting for compression with h.264 that determines how aggressive information is sacrificed for reduced file size. This factor in h.264 compression can be set to a value between 0 and 51, where lower values result in better quality at the expense of higher file sizes. For preservation, CRF values lower than 20 are advised. New codecs such as h.265 offer even more space-saving wizardry, yet the h.265 codec is still new enough that I currently find it difficult to gauge how robust and how widely-adopted the codec will be for preservation purposes.

13. Cocciolo, *Moving Image and Sound Collections for Archivists*, 21.

With video files, chroma subsampling is a data management approach that trades color information for digital space. A signal with chroma 4:4:4 has no additional color compression and transports incredible luminance and color data in their entirety. In a four-by-two array of pixels, 4:2:2 has half the chroma information of 4:4:4, and 4:2:0 has a quarter of the color information available. This explanation may sound considerably technical, but simply understanding that there are three levels available and that each level reduces by half the data required, is sufficient to help support decision making. Only the newest high-definition file formats from the last decade or professional motion picture elements on celluloid can hope to fully utilize 4:4:4 color quality, which rules out this option for a good percentage of archival content immediately. Standard definition video contains only 4:2:2 color levels, so maintaining this specification level will not shift colors during conversion. Although 4:2:0 will degrade and shift the colors noticeably, such loss in color fidelity may be deemed acceptable in certain circumstances.

These options in the preceding paragraphs certainly present more radical decisions than the concession to reduce voice-only audio recordings to a 48 kHz sample rate described in the audio section above. These options are not recommended in the established recommended practices for commercial and archival circles, but in all probability those standards may keep many organizations with limited resources from considering AV preservation altogether. In turn, I hope to provide some tools in this article to support the difficult decisions that must be made in some cases to avoid the total loss of priceless historical content. In total real numbers, without reducing resolution (720x486), an hour of standard definition video with an h.264 codec, compressed with a CRF of 17 and maintaining 4:2:2 chroma subsampling will approximately only require 2 GB per hour of data storage. Returning to our 1 TB of digital storage example, FFV1 lossless compression at 10-bit color depth is able to hold 30 hours of video content, FFV1 lossless compression at 8-bit color depth yields 58 hours of video content, and the conservative h.264 specification listed above allows for a capacity of 500 hours. For large collections of cultural heritage recordings, this may present an option that finally offers a sustainable scale.

In our reevaluation of recommended practices against the reality of thousands of video recordings, I do suggest a break from convention, but I try to do so with as much consideration and information as possible. Concretely and transparently, this is our video preservation specification approach:

- Capture analog video tape format types with broadcast-level information capacity as 10-bit uncompressed V210 video files (Beta formats, Type C open reel video). Audio will be captured as PCM at 48 kHz and 16-bit depth.

- Capture analog video tape format types with limited information capacity as 8-bit uncompressed V210 video files (VHS, U-matic, Hi-8). Audio will be captured as PCM at 48 kHz and 16-bit depth.

- After review and evaluation, a preservation level is assigned for each recording based upon the following considerations: artistic quality, rebroadcast potential, image dynamicity, quality of image, whether the recording is a duplicate or a master recording, quality of recording, primary anticipated use of the content, and primary value of the content (evidentiary, experiential, or both). The preservation level is not determined in a codified table-based methodology but rather through the weighing of each of these factors. This preservation evaluation is first entertained only when a significant portion of a project has been sufficiently digitized and reviewed, so that it can be supported within the context of the collection content. The evaluation for preservation level is either “broadcast/full preservation” or “reference preservation.”

- Broadcast/full preservation video content will be re-encoded into the FFV1 codec, contained in an .mkv file wrapper. The audio will be copied without any transcoding as PCM at 48 kHz and 16-bit depth.

- Reference preservation will result in transcoding the video stream into an h.264 codec at CRF 16 and 4:2:2 chroma subsampling and audio compressed to AAC at 256 kbps, all within an .mkv file wrapper.

- Access files are generated uniformly regardless of preservation level as h.264 video files at CRF 21 and 4:2:0 chroma subsampling and audio compressed to AAC at 192 kbps, all within an .mp4 file wrapper.

I understand and have carefully considered the potential risks of this approach and have measured it against our mission, our goals, and our resources.

One reason I have been bold in our adoption of a lossy compression format for video preservation is our optimism for the future. Information loss occurs at the point of initial encoding or transcoding video information, not during copying, moving, storage, etc. This initial suggested transcoding from uncompressed video to reference preservation results in very little visible degradation. Archival concern for significant loss is centered in anticipated future codec migrations. I understand that the files we create today will someday become obsolete and that another transcoding to a future lossy codec could discard even more information. Extrapolating this out over the next century presents a view of decreased information with each step until the image becomes disastrously unrecognizable. Hence the current fear of lossy compression for AV preservationists. While this fear is logical, the logic also stands that codecs will only become more advanced in the future (more fidelity requiring less space). Ideally subsequent migration will be required only at regularly increasing intervals as the technology settles and matures. If a step is ever determined to discard too much information, a retreat to FFV1 can be utilized to at least maintain what information is currently in the file. The high efficiency video codec (HEVC) h.265 is already evidence that compression algorithms will likely continue to progress. I also feel confident in the hope that digital storage costs will continue to decrease. But we are at the fulcrum where the future looks increasingly optimistic for digital preservation, and yet we should have already begun our AV preservation activities yesterday to avoid the oncoming wave of obsolescence. We need to begin transferring today using the best tools we have available even if restrained by today's realities.

Again, these are the specifications I have decided upon, and these are under constant reevaluation. I hope that by laying out the various options of compression, chroma subsampling, and resolution, others can feel empowered to establish specifications that meet their evaluation. I suggest running you own visual and audio tests to determine your own thresholds of risk and confidence. For example: for over a year, we used CRF 17 as our reference preservation compression setting, but the added assurance of moving up a value to CRF 16 has only slightly increased required space and added a feeling of assurance (even if only placebic). However, this step was only taken after we received an upgrade to our computers and the increased transcoding time was more manageable.

Some Nuts and Bolts of Stratified Video Preservation

To select specific chroma subsampling, specific CRF-based compression, and other specific parameters, the correct tool is needed. Many editing software applications do not offer these options in specificity. A wrapper and a codec can usually be selected, and at times an unspecific selection of quality (low, medium, high). For video transcoding, it is essential to have the ability to specifically select the parameters of the files created for preservation and access. The tool I recommend for specific preservation actions is FFMPEG because it allows for this specificity and is also open-source, meaning it is both free of cost and is freely made available.

When the transcoding of video files is adopted as part of the video preservation workflow, file processing time must be accounted for since it is significant. Unfortunately, the complex compression of video files requires its own investment outside of digital storage. Transcoding requires the computer application to search through the video file and compress information according to its specified algorithm, utilizing the computer's central processing unit. It is highly advised to perform digitization and file re-encoding separately, never at the same time, as one may interfere with the other and result in file corruption, video dropouts, or data loss. While FFV1 is considered a lossless compression, meaning it does not discard information, it still must search through and compress information where possible without sacrificing any visual information. The lossy compression h.264 codec, while presenting greater size reduction, determines both how to compress the visual information and which data can be discarded, requiring even greater processing power.

One of the limitations of analog signal capture is that it must be performed in real-time, which means that an hour of content requires an hour of time. We purchased computers with accelerated processing power so that the transcoding of the video from the uncompressed native capture format requires less time than with a standard processor, yet transcoding is usually slower than real time, which means that an hour of content will require longer than an hour of transcoding time. Our workflow is divided between planned capture periods and planned transcoding time blocks. Capture requires operator interaction to initialize the transfer and monitor the capture, while the computer can work on transcoding largely unattended. For efficiency, we have the computers work on the transcoding in between these scheduled capture sessions and overnight. At times, we use remote access to the computers to initialize transcoding without having to physically return to the lab, allowing the computer to perform its work outside of staff working hours.

Using FFMPEG to transcode our video files, files receiving "broadcast/full preservation" are transcoded to FFV1, typically at two times the speed, requiring 30 minutes of transcoding time for one hour of video content. The access h.264 file can be transcoded near real time, and the "reference preservation file" will transcode at about ¾ speed, requiring 90 minutes for a one-hour file. The lower CRF encoding value requires even more processing power to transcode at the superior image compression. While capturing and transcoding at the same time is not advised, we have found efficiency transcoding a few files at a time, but in quite limited amounts so that the computer processor does not get overloaded. We typically initiate the transcoding of a file to its access and preservation files at the same time. I have found our workstations can effectively perform transcoding on two capture files at once (simultaneously creating four files total). Attempting to transcode more files than this has dramatically overtaxed the processor and resulted in significant slowing in the transcoding efficiency. Of course, quality control verification is always performed on the resulting files to verify that no errors were introduced.

FFMPEG Resources

Using FFMPEG is very specific and can be quite technical. This is likely a step that separates a novice AV archivist from an intermediate practitioner. It requires very specific command line syntax to be followed, but there are some wonderful resources, and it is well worth the effort when committing to preserving your video content. ffmprovisr is supported by the Association of Moving Image Archivists and is a great introductory resource with links to download FFMPEG and command examples on its website.[14] There are also descriptions of many of the flags we are using in our command recipes. There are lots of arguments and flags that can be entered into the command line to specify how FFMPEG works with the video and audio streams in a file. It can be exciting to explore, or conversely confusing. Have some patience and build off what you find in these friendly resources. I offer in Appendix A the specific FFMPEG command recipes I use for our transcoding.

14. "ffmprovisr," AMIA, accessed August 2023, https://amiaopensource.github.io/ffmprovisr.

Conclusion

Our efforts have led to successes via challenges. It can be very satisfying as puzzles are solved, patrons are pleased, and progress is made. But I also feel the gravity of the decisions I am making. There is risk involved when embarking boldly in any specific direction. While these actions may be seen by some as outside recommended best practices, I am no longer as constrained with digital storage limits now that I allow some video content to be preserved at “reference preservation” level. I feel that I can better perform my function as an archivist of AV content as I can expend substantial digital storage space on those items we have appraised to warrant such space investment and expend comparatively little on other content. We have some very high-quality AV content that is absolutely unique and we are able to dedicate sufficient resources where it is warranted.

I feel assured that our specifications fulfill our objectives of fidelity to the original in a manner that is responsible, specific, and calculated. I feel confident that I have approached these complex questions of resource allocation with sufficient information and come to legitimate conclusions. I am fascinated to hear what others are doing and hope this article prompts even more thoughtful and specific discussion. My assumption is that others are coming to similar conclusions but possibly unsure of sharing their approaches that fall outside of the recommended standards. I know that many will question and even disagree with my decisions, and I hope that increased dialogue regarding standards and best practices will continue with greater frankness as we all struggle with calculated risks and our responsibility as stewards of history.

Appendix A. FFMPEG Resources

These are the FFMPEG command recipes I use for our transcoding:

Full or Broadcast Preservation

```
ffmpeg -i input_file -c:v ffv1 -level 3 -coder 1 -context 1 -g 1 -
slicecrc 1 -slices 16 -c:a copy output_file
```

Reference Preservation

```
ffmpeg -i input_file -c:v libx264 -pix_fmt yuv422p -preset veryslow
-crf 16 -vf yadif -c:a aac -b:a 256k output_file
```

Access Copy

```
ffmpeg -i input_file -c:v h264_videotoolbox -b:v 1400k -vf yadif -
c:a aac -b:a 160k -movflags +faststart output_file
```

These are calibrated for standard-definition file transcoding. There may need to be adjustments made for high-definition transcoding. As of yet, for our institution, if incoming content is high-definition, it is delivered as a digital file, and we are handling this relatively small amount of content on an individual basis.