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IASA Journal Editorial Board

In order to ensure diverse and clearly-articulated viewpoints in each issue of the journal, the IASA Journal solicits input and guidance from an Editorial Board consisting of the current IASA Editor and President as well as an invited group of IASA member representatives from each continental region throughout the world.

The IASA Journal Editorial Board provides general review and guidance on direction of the IASA Journal, meets once yearly during the IASA annual conference, assesses previous year's journal issues and makes general suggestions for future activities.

Board positions are entirely voluntary and receive no remuneration or financial support from IASA.

Current IASA Journal editorial board members

For the past two years, the IASA Journal has been in a state of flux, including the implementation of double-blind peer review, the commencement of an editorial board to provide input into the development of the Journal, a move from static PDF delivery on the IASA website to a dedicated searchable e-Journal website, and a shift from closed content (i.e., members only) to open access (i.e., free to the world). As editor, I have largely been responsible for driving these changes, although I will note that others in the association called for these changes, and that the general trend worldwide is to provide open access to information. With support from IASA's membership and the Executive Board, we have opened the door and paved the way for the IASA Journal to be sustained, and even to strive, in the 21st Century.

Another significant change is looming for this Journal. Now that the Journal has full electronic distribution, I made the proposition to the Executive Board, based on an historical analysis of printing and shipping costs, that IASA cease offering a paper copy of the journal. Instead, I proposed that we focus our efforts on increasing electronic distribution, diverting the twice-yearly printing and shipping expenses towards other areas of IASA activity, for example membership development, or training and education, both areas that could use additional resources. The Executive Board agreed with my request, and this issue — Issue 50 — will be the last printed issue of the IASA Journal.

This issue is an exciting one, offering five engaging articles, two profiles, and a book review. We have three articles that focus heavily on workflows in a digital environment. In *To Normalise or To Manage the Multitude? Determining Workflows and Output Specifications for the Transfer of a Heterogeneous Collection of DV-based Video Cassettes*, Brecht Declercq, Peter Bubestinger, and Gaël Fernandez-Lorenzo present a detailed case-study on the digitization of DV-based video tapes at VIAA in Belgium. The paper is valuable to the international audiovisual archives community because of the thorough details provided by the authors as they illustrate the choices they had to make to achieve a quality outcome. Also relevant to digitization efforts, in this issue Michael Casey from Indiana University in the USA provides guidance on quality control in his paper, *Quality Control for Media Digitization Projects*. Casey has had the opportunity over the past few years to lead his organization on a massive and continuous digitization journey called the Media and Digitization Preservation Initiative. Because mistakes happen, and perfection is a fleeting ideal, Casey has implemented a thorough quality control and risk management strategy to ensure continuation of an around the clock digitization factory while simultaneously reducing as many issues as possible in such a high-throughput environment.

Our colleagues from New York in the USA, Annie Schweikert and Dave Rice, have written a thorough analysis and case-study of using software microservices in the archive to increase productivity, to reduce technical dependencies on commercial software, and to fine-tune the control archivists have over digital file and data handling. In *Microservices in Audiovisual Archives: An Exploration of Constructing Microservices for Processing Archival Audiovisual Information*, Schweikert and Rice detail their ongoing work to develop function-specific software modules to handle their day-to-day digital audiovisual archives needs. The article offers examples of code and general design principles that may be of use to archives around the world.

Focusing on archival content and less on digitization and digital preservation, the remaining two articles in this issue highlight efforts to extend and diversify the scope of archival collections, providing visibility and a voice to the depth and richness of the human experience. Diana Chester provides an article that recounts her efforts to record and to disseminate the Islamic call to prayer. Chester analyses how sound maps can increase accessibility and

ultimately increase collection of archival materials from broader audiences. Dr. Colter Harper and Judith Opoku-Boateng offer an article that highlights the ongoing effort to build a sustainable audiovisual archive that documents African music and culture at the University of Ghana. *Renewing Cultural Resources and Sustaining J.H. Kwabena Nketia's Vision for an African Music Archive in Ghana*, is an important case study on the challenges of accessibility, preservation, and sustainability for audiovisual archives.

In the IASA Journal's Profile section, authors have a space to offer opinions, creative writing, and other information that may be important to the community but that does not require full double-blind peer-review. In this issue, Paul T. Jackson offers a short vignette on the disappearance of parts for audiovisual equipment in *Where Are the Parts?*, and Michael Casey makes a second appearance with his ongoing epic media preservation fairy tale, *Degralescence, Prince Codec, and the Kingdom of Media*. (I will say nothing more of this fairy tale as an attempt not to spoil the ending for anyone.) Rounding out this issue of the Journal, Trent Purdy revives IASA's interest in book reviews with his well-crafted review of *Moving Image and Sound Collections for Archivists (Cocciolo, SAA, 2017)*. Does he recommend it or not? You'll have to read Purdy's review to find out.

You might also note, in this issue of the Journal, the appearance of a DOI (Digital Object Identifiers) for each article. The IASA Journal now has a registered DOI prefix and all publications listed in our online portal (and all moving forward) are assigned DOIs automatically by our Journal software and registered automatically with our DOI provider (CrossRef). The IASA Journal will mint DOIs for all individual articles as well as for each Journal issue. Once activated in CrossRef, then other journals will enforce their authors to use our DOIs when our articles are cited, creating broad referrals and enlarging IASA's presence in the literature worldwide. The IASA Journal will also require the use of DOIs when available in our article citation lists moving forward to uphold our part of the open-access and DOI bargain.

I look forward to hearing your thoughts on the contents of this Issue, as well as on the future of the IASA Journal.

Bertram Lyons, CA
IASA Editor

A Letter from IASA's President
Toby Seay, Drexel University, USA

Welcome to the 50th IASA Journal. 2019 is a special year for IASA as we will hold our 50th Anniversary Conference in Hilversum, Netherlands on 30 September – 3 October 2019. At the International Association of Music Libraries (IAML) annual conference of 1969 in Amsterdam, "IASA was established to function as a forum for international cooperation between archives preserving recorded sound and audiovisual documents" (https://www.iasa-web.org/sites/default/files/40years/iasa/intro.html). Sound archivists within IAML sought to represent all sound recordings more broadly (not just music) and to place them within an archival context (not just libraries). This desire led to the formation of IASA and 50 years of leadership in audiovisual archives. We look forward to celebrating the last 50 years and hope you can join us in the Netherlands. This year's programme is sure to be one of the most engaging to date.

Since the 49th IASA Journal, much of IASA's work has been toward the planning of the conference. However, there are a number of exciting events and initiatives in the works that I would like to discuss.

Each year we celebrate UNESCO's World Day for Audio Visual Heritage (WDAH). This year's celebration will be on Sunday, 27 October 2019. "The World Day provides an occasion to raise general awareness of the need to take urgent measures and to acknowledge the importance of audiovisual documents. In this way, the World Day also serves as an opportunity for UNESCO's Member States to evaluate their performance with respect to implementing the 2015 Recommendation Concerning the Preservation of, and Access to, Documentary Heritage, Including in Digital Form (https://en.unesco.org/commemorations/worldaudiovisualday)."

Each year, the Coordinating Council of Audiovisual Archives Associations (CCAAA), of which IASA is a member, assigns a theme to WDAH with this year's being, *Engage the Past Through Sounds and Images*. We ask that you celebrate this event by posting your work, events, and achievements in audiovisual heritage to the CCAAA site https://www.ccaaa.org/ and all social media in an effort to raise awareness of audiovisual materials and their impact on telling the world's stories.

IASA is also excited about the forthcoming Magnetic Tape Alert Project. Spearheaded by Dr. Dietrich Schüller, UNESCO's Information for All Program's Working Group for Information Preservation in cooperation with IASA intends to alert stakeholders of the imminent threat of losing access to their audiovisual documents held on obsolete magnetic audio and video tape formats. A survey of existing audiovisual documents on magnetic tape that are not yet digitally preserved will be conducted. The information obtained through the questionnaire on collections at risk will serve as a basis for the planning of adequate solutions for the safeguarding of these irreplaceable original documents (music, endangered languages, folklore, rituals, dance, oral history, etc.) in the long-term. You can access more information at the following website: http://www.mtap.iasa-web.org/. Stay tuned for future announcements.

This year's conference will be the two-year mark in the current IASA Executive Board's three-year term, making 2020 an election year. Please watch for the upcoming call for nominations. As outlined in my New Year's message, IASA's success depends on everyone's voice and participation. IASA is the association for all who create, use, manage, and

preserve sound and audiovisual documents and participation shall always be inclusive and respectful. Therefore, I encourage you to consider how you can serve the IASA community by standing for nomination to the Executive Board. Your leadership is needed to shape the future of the audiovisual archival field.

See you in the Netherlands!

Toby Seay
IASA President
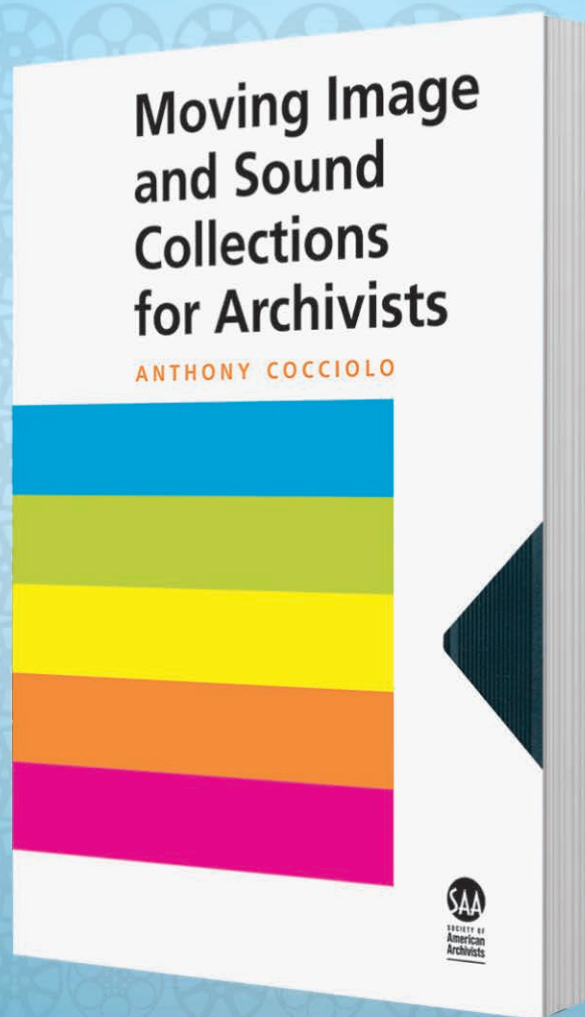
Where Are the Parts?

Paul T. Jackson, Trescott Research, USA

Back in 1965 I was doing research and found that six regional recorded sound archives didn't know the others existed, so my question to the curator of the media at the Ford Museum in Dearborn, Michigan, was "how do we get these people together to share what they have and know?" The curator, Frank Davis, phoned me and said, "First we have to have a meeting." The meeting took place; we had Kurtz Myers of the Detroit Public Library join us, and decided to organize a national meeting which was held in June of 1965, leading to another in 1966 at Syracuse University, the founding meeting of the Association for Recorded Sound Collections.

At that meeting our main concern was developing methods for letting people what the various collectors and collections had, thus my article in American Record Guide, "Record, Record, Whose Got the Record." I've since written and updated the article "Collectors and Collections" in the Encyclopedia of Recorded Sound, 1993, 2004.

From early technology we were able to see the publications of several large catalogs of collections, and eventually digitization of various library's collections catalogs, and most recently access to them. But this doesn't always get us too some of the oldest recordings, non-commercial field recordings, or even oral history recordings.

One of the newer basic issues for preserving some of this material is finding the mechanical playback equipment. And we know, or should know, there is no particular permanence in any sound preservation method, so in the course of developing methods for preservation, and enhancing the sound, many computer programs, and equipment have been brought forth to help. In fact to hear of all the things used by ARSC members is a bit mind-boggling given that I've not kept up with the area of sound as I had in my youth…although I have used one or two transfer programs for moving from analog to MP3 on the computer. But what about the mechanical needs of playback.

There has been some newer items like optical turntables, and the Memnon/Sony group who use a cylinder machine they developed. http://blogs.iu.edu/mdpi/page/3/ along with other very sophisticated cleaning machines and metadata capture in a building to isolate sound, vibrations, and electrical variations.

Not everyone or every organization has the money to mount such programs. Even the Library of Congress preservation people continue to haunt thrift stores for working equipment.

So, given that many who are searching for a given recording may be able to now find it via catalogs, blogs, listseves, Facebook groups, Twitter groups, and connections via LinkedIn, we are now faced with finding the mechanical means to reproduce the sounds, whether cylinders, Berliners, tape, cassette, wire, Dictaphone, et al.

I know I've found an excellent turntable at a thrift store for a mere $20; a Technics DL B200 but it doesn't have the 78rpm speed setting, although one can manipulate the speeds of the other two, 45rpm and 33.3rpm. My Motown collection is long gone (sold to dealers.) So 45rpm isn't required. I do have some very old various labels of 78s and 33s, and wonder if I should take the time to preserve these with my CD burner. There are now several turntables out which will do this, making the analog material into MP3 tracks without the middle software needed on a computer.

I've also located several 8mm film cameras which work, along with the rest of the set to splice and edit.

We are more recently, coming to have national or international brokers/exchanges to find and make available the exchange of these things other than eBay or some other selling format on the Internet. But here are some places I've found.

ARSC has this publication, a directory listing of companies and individuals doing or having equipment for preservation: https://www.arsc-audio.org/audiopreservation.html
This PDF directory is searchable with some PDF software like the free Nitro.

The Library of Congress has this excellent site: (not sure of equipment listings) https://www.loc.gov/preservation/about/faqs/audio.html and here https://www.loc.gov/programs/national-recording-preservation-board/resources/audio-preservation-bibliography/

Our **U.S. National Archives** has this excellent site: https://www.archives.gov/preservation/formats/audio-video-resources along with a directory of suppliers of equipment and software: (dead Link) This links to the **Association of Moving Images Archivists** which is here and updated Quarterly (new link) https://amianet.org/wp-content/uploads/Supplier-Directory-2019.01.pdf

The National Recording Preservation Foundation also has a resources site: http://recordingpreservation.org/links-resources/ this site includes links of many collections, associations, and then further down is a listing of resources with links… some dead.

Although the **Council on Libraries and Information Resources** has a spelled out program for developing a national preservation infrastructure including a directory for sound recording and media, and mentions some of those heavily involved in preservation of sound and media: https://www.clir.org/pubs/reports/pub156/section1/ the directory at Cornel University is not available to the public. It requires a login. There is also a good report from Wikipedia about this 'national' plan here: https://en.wikipedia.org/wiki/National_Recording_Preservation_Plan

Still, for those individuals who would like to preserve their collections, find, that finding the equipment to do this easily, and maybe expertly, is one of the main reasons for not doing anything. Our national and regional collections of rare sound (audio), media, film, broadcast programs, all have often arrived via collectors who loved what they collected, and it would seem, not just to show them where they can find things they enjoy and love, but how they too can preserve them with the mechanical resources necessary. Lots of work is yet to be done in this area. The directory I envision would include more like this. https://vinylcarolina.com/directory/listing/vintage-audio-exchange and this https://vinylcarolina.com/links-resources/

Degralescence, Prince Codec, and the Kingdom of Media

A Media Preservation Fairy Tale by Mike Casey, Media Digitization and Preservation Initiative, Indiana University, USA

Once upon a time, a king and queen ruled the kingdom of Media. Media was a peaceful land that was home to all things audio and video. Its subjects lived happy analog lives where preservation, access, and the means of production all revolved around their physical forms. But the king and queen had felt the winds of change blowing across their lands. They had heard tell of an unspeakable evil lurking about their borders. And they knew that the old ways could hold fast no longer.

Reports of the first attacks on the border towns of Media were sketchy and difficult to understand. A few residents of the kingdom, known as analogons, noticed that if a certain type of shadow fell upon them, their bodies began to crumble away. They could not interact with the material world around them. Their hands passed ghostlike through objects and they lost the ability to speak. A growing number of analogons, both young and old, in the border towns and villages of Media were lost in this way.

It was clear that a force more powerful than ever seen before was moving swiftly into the kingdom. It was the evil twin-headed monster, Degralescence, a hideous instantiation of degradation and obsolescence. The king and queen now quickly realized that this could mean the destruction of their kingdom and the loss of most of their subjects. They knew that it was beyond their power to repel Degralescence, so they called to the neighboring kingdom for help. Within days, Prince Codec rode to the rescue.

When Degralescence heard this news, he laughed and spat upon the ground. "I eat codecs for lunch," he cried! Which was true. He was not particularly concerned about this turn of events and went back to plotting Media's demise.

The next day, Prince Codec met with the King and Queen to discuss the recent attacks on the borders of Media, which were increasing daily. After hours of talking, and with no good ideas in sight, Prince Codec asked them, "who is the wisest person that you know?"

 "That would be the wise woman of Preserverance," said the Queen. "She lives outside the kingdom in an enchanted forest that has endured for thousands of years. The seasons do not affect it. I don't know why I didn't think of her. Some of our finest scholars have consulted her and her persistent records over the years."

"How do I find this wise woman of Preserverance?" asked Prince Codec.

"Ride in the direction of the setting sun in the fall of the year. Ride until you think you can go no further, until you despair of ever reaching your destination. Then keep going. Just before you give up, you will find yourself in the forest called Preserverance."

Fortunately for all concerned, it was the fall of the year and Prince Codec set out the very next evening at sunset.

Days turned into weeks turned into months and still Prince Codec rode on. He was a particularly determined and optimistic person who was not inclined to give up easily, and so it seemed that he never got close to his destination.

In due course, the land began to change. Leaves fell off the trees, branches and logs lay rotting on the ground, grass decayed, flowers withered, and the sky turned a permanent shade of ominous gray. The air was heavy with the smell of things crumbling. Food became scarce and there were no signs of other creatures. Dark was the Prince's mood and darker still were his thoughts. After weeks of traveling through this degrading landscape, Prince Codec awoke from another night of restless half-sleep and thought that he could go no further. He muttered under his breath "I give..…"

And at that very moment, he found himself on the edge of a splendid green forest.

Prince Codec entered the forest carefully. The sun shone brightly and birds darted from tree to tree. There was a well-worn path to follow. In about a mile he came to a small limestone house that appeared old but immaculately preserved. The Prince dismounted and entered the house. He saw a long table at which was seated a woman who seemed both old and young and neither old nor young. The walls of the room were lined with floor to ceiling bookshelves in which old and new books occupied every available space. On the table were several books that appeared to be in the middle of repairs. Scattered about the table were various brushes, an X-acto knife, a scalpel, and a few types of glue and tape. On the far end of the table was an audiocassette with its shell open, a roll of splicing tape, a splicing block, and a stack of ten other audiocassettes. From the doorway, Prince Codec could see into an adjoining room that was stuffed full of books, photographs, and audio and video recordings. A small sign on the door read "The Backlog."

"I am looking for the wise woman of Preserverance," said Prince Codec.

"Yes, that is what they call me," said the woman. "How can I help you?"

Prince Codec explained about the kingdom of Media and the attacks by Degralescence.

"This has been foreseen for many years, but the kingdom has not prepared for it," said the wise woman. "The power to stop Degralescence lies with the Sword of Migration. You must seek it. It is your only hope."

"Where can I find this sword?" asked Prince Codec.

"Finding is easy," said the wise woman, "but capturing it and making it do your bidding are quite difficult. Many have tried, but none have succeeded. Its power is not yet available to us. Ride to the Forsaken Glen. You will find a small lake in the middle of the glen. The sword is hidden in the lake where it is guarded by the three Queens of Obsolescence. You must successfully complete a task given to you by each of the queens to gain the sword."

"That doesn't sound so hard," said Prince Codec.

"I would wish you luck, but I can't tell that you have any more foresight, persistence, or courage than any of the others who have tried," said the wise woman.

"One more question," said Prince Codec. "Do I have to go back through that miserable grey land where nothing is left alive?"

The wise woman laughed and said, "That's my nemesis, Old Man Degradation. It takes a lot of time and energy to keep him out of my forest. He does like to have his fun with adventurers who travel through his domain. No, it's only possible to travel in one direction through his dominion. You will return along the same path but you will see no sign of him."

Prince Codec thanked the wise woman of Preserverance and rode off.

Three days later, Prince Codec entered the Forsaken Glen and soon came to the lake in the middle. As he walked to the edge of the lake, he noticed three whirlpools moving towards him. When they reached the shore, they rose up out of the water revealing three women with constantly changing faces that were beautiful and terrible in turn, and bittersweet with echoes and shadows. One moment the faces were filled with longing for the past. The next, they were lit by the dreams of the future.

"Who are you? And what do you seek?" they cried as one.

"I am Prince Codec and I seek the Sword of Migration."

"That shall never be," said the first Queen of Obsolescence. "No one has yet been found who can wield the Sword. Obsolescence rules in this world!"

"Then I shall take the sword!" cried Prince Codec, although in the next moment he realized he could not move his legs.

"You have no power here," said the second Queen. "There is only one way to capture the sword. You must complete a task set before you by each Queen of Obsolescence. If you successfully complete all three tasks, the sword will be yours. If you fail, you shall forfeit your life."

The first Queen stepped forward. "I am the Queen of Playback Obsolescence. Your first task takes the form of a riddle. Listen carefully."

> *He dances with me, we are bound together,*
> *We seek the same end—to banish 'forever.'*
> *He works with the product while I pursue the means;*
> *Media, after all, must be played by machines.*
> *Chemistry and biology are the tools of his trade*
> *Culture and profit drive the victories of my reign*
> *He is the master of decay, I am the master of supersession;*
> *We are both masters of decline, in the service of regression.*
>
> *Who is he?*

Prince Codec thought long and hard about this riddle. He asked the Queen to repeat it several times. Something seemed strikingly familiar, as if it were part of his recent experience. He understood how culture, profit, things superseded, and the means of accessing media were part of the Queen of Playback Obsolescence's trade, but who was her partner? Decay, decline, chemistry and biology, the products that carry media….and then he had it.

"Is it Old Man Degradation?" asked the Prince.

It was the right answer and the Queen flew into a rage that might have lasted a good long while had it not been interrupted by one of her sisters.

"My sister and her silly riddles—they never work," cried the second Queen. "I am the Queen of Format Obsolescence and I have a real task for you. Your clue is this: s-h-n. Bring me an example of what this represents and tell me what is locked away inside."

Prince Codec thanked the Queen, assured her that he would return with what she asked for, and rode away.

Being the prince of codecs, and having specific knowledge of such things, he immediately guessed that the letters shn might be a file format extension. However, try as he might, he was not able to think of a file format that fit. Prince Codec recognized his weakness here—he was a young man and did not have direct experience with older file formats. He needed someone whose knowledge base stretched back at least a few decades, and so he decided to call upon an old family friend.

On the southern border of Media, there is a small town called Normal. On the edge of town lived a man who was known to all as "The Keeper," although his real name was Thomas Render. His passion was creating and maintaining lists and documentation of all the formats that could be found in Media. This included physical analog and digital carrier formats as well as digital file formats. The Keeper was highly regarded by the citizens of the town but not by the castle, which had on numerous occasions declined to hire him even though they had no one else engaged in this line of work. So The Keeper relentlessly pursued his mission over the course of many years, providing free information to anyone who inquired, although there were no inquiries from the castle. The Codec family had known Thomas Render for years, and the Prince had often visited his house as a young lad.

Prince Codec followed a side road to the edge of Normal until he came to the house of The Keeper. He was greeted at the door by an elderly man with a shock of white hair and piercing brown eyes.

"Prince Codec, my young friend. What brings you here?"

The Prince described the quest for the Sword of Migration and the task set upon him by the Queen of Format Obsolescence.

"The only clue I have is the three letters, shn. I am wondering if it could be a file extension?"

"I think you might be right," said Thomas. "I seem to recall an audio format that used .shn, but let's check the registry of digital audio file formats."

Thomas retrieved an oversized book and placed it on the table in front of them. The two pored over the registry, looking through page after page documenting every audio codec and file format that Thomas had encountered in Media. A little more than halfway through the book they found it: .shn, the file extension for the Shorten audio file format.

"That's a good name for a short-lived codec!" said the Prince.

It had not occurred to him that not only analog objects could experience obsolescence, but digital file formats too. Now he had to find an example of audio encoded in this format to bring to the Queen of Format Obsolescence.

This turned out to be surprisingly easy. The Keeper was also a dedicated collector of the formats he documented and he quickly came up with an .shn file. He dragged and dropped the file into a media player and nothing happened. They tried three other players with no luck. Unfortunately, the format was not supported by any of the media players he had on hand so they were not able to play the file.

Prince Codec's heart sank. If The Keeper was not able to play the file, he was not sure who could, and his quest for the Sword of Migration would end rather earlier than he might have hoped.

In the meantime, Thomas had returned to the registry, where he was examining the Shorten entry. "It appears that I have an appendix entry," he said as he turned to the back of the book. "Ah, here it is: Shorten is a lossless codec that is no longer developed and is hardly used but is supported by libavcodec."

The Prince breathed a sigh of relief. libavcodec is an open source library of codecs for encoding and decoding audio and video data. He knew it well. This would allow him to transcode from the Shorten format to a .wav file that could be played by a media player.

Prince Codec thanked Thomas many times and bid him farewell. The Keeper, however, had one last request.

"If you are going to use this information to save Media, then I would appreciate a kind word on my behalf to the King and Queen."

Prince Codec gave his word that if he were to prove successful, he would do just that and more. Off he rode.

When the Prince arrived back at the Forsaken Glen, all three of the Queens of Obsolescence were waiting for him in the lake. He approached the second Queen.

"shn is a file extension for the Shorten audio file format," he said. "Here is a Shorten file, and now we will listen to the contents of the file, which I have converted to the .wav format so that it will play on this media player." He then began to play the song "Losing You" as sung by Alison Krause.

The Queen was incredulous. "How did you convert it to a .wav file?"

"I used libavcodec," said the Prince.

"libavcodec—the bane of my existence! It always gets in the way of progressive obsolescence."

The Queen was furious but ultimately realized that she had been beaten at her own game.

The third Queen of Obsolescence then stepped forward.

"I am the Queen of Repair Obsolescence. Here is the third and final task. If you are successful then the sword is yours. But, I warn you that this is the most difficult task. In the kingdom of Media, there exists a format called Betamax. Find me a person who can repair a Betamax machine, if you dare."

The Queen handed the Prince a broken-down Betamax machine to be repaired.

"This is tough," thought Prince Codec. "I have heard of only one person who can supposedly repair a Betamax machine, and he does not give out his name. I have no idea where to find him."

Prince Codec bade the three Queens farewell and set out on his final task. He made his way to the kingdom of Media where he paid a visit to the director of operations at the largest media archive in the kingdom. After listening to the Prince's request, the director said "I'm sorry, but I have never found anyone who can repair machines in this format. I have heard of one person who is rumored to be the last Betamax repair person alive. He goes by the name Mr. Betamax and nobody knows his real name. The best I can offer is to tell you to check the Betamax neighborhood to see if one of its residents can provide a clue. All the Betamaxes live down on Lost Street next to VHS Park."

Prince Codec thanked him and hurried off to find the Betamax neighborhood. He knew he was in the right place when he saw the distinctive Beta logo on the mailboxes of each house.

The Prince began knocking on doors and talking with the residents one by one. The result was always the same: no one had been repaired even though many needed it. At last he came to a house on the edge of the neighborhood. The resident had a dim memory of being repaired when he was a young boy. "That's the story I was told when I was growing up. I needed a new upper drum assembly and I was sent to an expert in another kingdom who was able to get me running again. You are welcome to check for a repair sticker."

Prince Codec began to disassemble the machine in search of any evidence of repair. After an hour of looking he found it—a small sticker that said "repaired by Mr. Betamax" followed by an address. The Prince thanked the resident and hurried off.

He did not have to ride far to get to the address on the sticker. Mr. Betamax still lived there, and he listened intently as Prince Codec told him the story of Degralescence, the kingdom of Media, the wise woman of Preserverance and the three Queens of Obsolescence. He supported the fight against Degralescence and agreed to repair the machine that the Prince carried. It took him two days to repair, and he was successful only after sending the Prince back to the Betamax neighborhood to scrounge spare parts. Mr. Betamax packed the repaired machine in a custom box and handed it to Prince Codec, who thanked him many times.

When the Prince arrived back at the Forsaken Glen, all three of the Queens of Obsolescence were again waiting for him in the lake. Prince Codec approached the third Queen and presented her with the custom box saying "in this box is something you have never seen. It fulfills my task from you." The Queen opened it and inside found the Betamax machine that she had given him, only now it was repaired, completely functional, and like-new. The Queen of Repair Obsolescence's fury knew no bounds. And although they raged, the three Queens of Obsolescence had no choice but to present the Sword of Migration to Prince Codec and to retreat back to the lake, diminished.

Prince Codec picked up the sword. It was light as a feather. He noticed faint markings down the middle of the blade that popped out when it was held at a certain angle in relation to the sun. The Prince followed the markings. "These are metadata mappings," he mused to himself. He was certain now that the sword was authentic, and he was beginning to understand its power. A dark cloud passed over the sun, shaking him out of his reverie. He was filled with an overwhelming sense that too much precious time had passed. Sheathing the sword, he jumped onto his horse and began riding for Media.

When the Prince reached Media, he saw the damage done to the villages on the border and learned that Degralescence was marching to the middle of the kingdom, threatening the castle. He saw streams of analogons running from the towns trying to escape the effects of Degralescence. There was fear in their eyes. Many of the recordings were crumbling and none of them could speak. Playback machines limped or crawled for want of spare parts. His greatest fear was being realized—the content on thousands of recordings locked up in analog formats was being lost.

Prince Codec reached the edge of the field leading up to the castle and there he saw Degralescence, who was preparing to lay siege. He was immense, larger than any animal that the Prince had ever seen. He had two heads, each on a long, serpent-like neck. His body was like that of an elephant with a large tail that looked more like a weapon than a tail. It seemed to the Prince that the beast grew slightly, but noticeably, larger as he watched him over the course of an hour. When Degralescence caught sight of Prince Codec at the edge of the field, he roared, rising up on his hind legs and pivoting his two heads, showing off his power. But, Prince Codec was not particularly concerned, for he now wielded the Sword of Migration and upon that he would rely. As Prince Codec and Degralescence readied themselves for battle, the sands of time continued to slip away for the survival of Media and all of its inhabitants.

At first light the next morning, the battle was joined. It was fierce and hard-fought. The Sword of Migration was effective but could never quite bring down the beast. Degralescence was a powerful fighter but could not get through the Sword to reach Prince Codec.

After many hours of fighting, both Degralescence and Prince Codec fell exhausted to the ground. A truce was called. Degralescence looked at the Prince, who was leaning against a tree with the Sword of Migration by his side.

"You are a tough opponent," said Degralescence, rubbing his back with his tail while cradling both of his heads in his hands. "Where did you get that sword?"

"From the three Queens of Obsolescence," replied Prince Codec.

"So you have met my mother, the Queen of Playback Obsolescence?"

"Yes, she asked me a riddle about her partner who I had met on the way to see the wise woman of Preserverance."

"So, then, you have also met my father, Old Man Degradation?"

It was like someone had lit a hundred candles simultaneously during the darkest of nights. Everything came into focus and made perfect sense. Of course. Degralescence was the offspring of the Queen of Playback Obsolescence and Old Man Degradation. He carried the worst traits of both of them. More importantly, he could never be killed, since obsolescence and degradation are invincible forces that are inherent in the very nature of the world itself. "Then what good is this sword?" the Prince thought to himself as he picked it up and raised it over his head.

Prince Codec despaired of finding a way to stop Degralescence from destroying the kingdom of Media. He knew he could not leave, as the kingdom would shortly be overrun. He also knew that he could not win.

Finally, in his hopelessness, he fell into a deep but unsettled sleep.

And when Prince Codec awoke, he realized that the purpose of the Sword was not—had never been—to put an end to Degralescence once and for all, as he'd assumed. Despite its shape, the Sword of Migration had been forged not for attacking, but for protecting; it was less a sword, in fact, than a shield. It would serve to keep Degralescence in check, but the beast would always try to assert the forces of decay and extinction and must be constantly monitored and fought.

He now turned the Sword towards the analogons who had been watching the battle from what they judged to be a safe distance, and to Degralescence he said:

"You want to harm these good citizens of Media? Go on, then; just try it."

Degralescence, too, was just waking from a fitful slumber, and Prince Codec's words caught him in an unusually foul temper. With a roar, he rose to cast his shadow upon the cowering crowds as before.

But with a flash of the Sword of Migration, Prince Codec swept the crowds up in a bright globe of glowing light just moments before Degralescence could reach them. True, the shells of their old bodies crumbled away just as they had in the previous attacks—nothing could be done about that. But within the glowing orb all their true forms could still be seen, undiminished and unchanged; and Prince Codec deposited them swiftly and safely into a surrounding hillside. No longer humble analogons, they were now transformed into things of spirit that could inhabit any object at will.

Then Prince Codec returned his attention to Degralescence. "Is that the best you can do?" he taunted.

Fast as lightning, Degralescence turned to launch a fresh attack on the crowds in the hillside; but Prince Codec was faster still as he swung the Sword a second time and migrated them all to safety once more, this time into the clouds in the sky.

Again and again Degralescence attacked, and again and again Prince Codec frustrated his onslaught, laughing merrily and whirling the Sword of Migration about him to keep the citizens of Media perpetually out of the monster's reach.

And there the two of them remain locked in battle.

Except, of course, for when Prince Codec takes a moment's break to decompress.

And that is the way it has happened for many years, right up to this very day.

The End

SUSTAINABLE AUDIOVISUAL COLLECTIONS THROUGH COLLABORATION

PROCEEDINGS OF THE 2016
JOINT TECHNICAL SYMPOSIUM

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Sound Mapping as a Tool for Sharing Sonic Cultures: Citizen Archivists and the Question of Accessibility of Materials Versus Archival Standards

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Abstract

The Islamic call to prayer, the adhan, azaan, or athan, is recited five times daily as a way of signifying prayer times to Muslims. Over the past 8 years I have been involved in a research project of collecting field recordings of the call to prayer from mosques around the world and using a web-based sound map to geo-locate, share these recordings, and reach contributors outside of my own network. In this paper, I will offer a perspective of how the sound map as tool can participate in a discourse on the accessibility of archival materials to broader audiences, as well as the collection of archival materials from broader audiences. The paper will also consider that there may be an inverse relationship between accessibility of materials and archival standards and will look at how this impacts the breadth of accessibility versus the temporality of accessibility. What are the benefits and pitfalls of sharing compressed formats of archival recording through sound maps and widely accessible streaming services, that allow for broader dissemination, searchability, and access, and does this impact our understanding of the role of the archive? What can a sound map offer in connecting users, materials, and communities and how can we leverage such a form of digital media toward archival ends? And finally, in a time when there are communities and people who are disappearing across the globe due to conflicts, how can tools like the sound map help us to archive and document these places.

Paper

As a sound studies scholar and an audio engineer I am very interested in using recorded sound as a way of exploring culture and community. This is from the perspective of the aurality of place and environment, as it is heard through recordings in a given context as well as of the subject matter of the source sounds that are the focus of the recording. This is to say that when we record a sound, we are in actuality recording many sounds. Sometimes we record sounds we don't intend or want to hear like cars passing by on a main road, and other times we record sympathetic sounds of the environment, culture, and community of the place where we are recording. Depending on the methodological techniques we employ in our recording practice, these sympathetic sounds may or may not be decipherable or even considered valuable by some. However, these sounds and the way we understand them can play an important role in the broader value of these recordings. The types of sympathetic sounds we find ourselves recording, and the contexts in which we have access and choose to record have an impact on the types of 'hidden' sonic material that make their way into recordings, what and who gets represented in these recordings, and ultimately which histories and cultures we are preserving. The people who make these recordings play a large role in what gets captured and preserved.

In this paper, I will focus on a world sound map project of the Islamic call to prayer. I will consider how the sound map, as a tool of collection and possibly archiving, can participate in a discourse on the accessibility of archival materials to broader audiences, as well as the collection of archival materials from broader audiences. The paper will also consider and problematize the inverse relationship between accessibility and archival standards of recorded audio material and will look at how this impacts the breadth of accessibility versus the temporality of accessibility, and ultimately how these issues of access impact the types of recordings that are included in a sound map, and that are 'archived.'

In her keynote speech at IASA's 49th annual conference in Accra, Ghana, Esi Sutherland-Addy talked about the need for Citizen Archivists, people in communities who become the documenters of their own culture. And this call for citizen archivists raises some very important questions around how our definitions of archival audio-visual materials, and our requirements for what constitutes such material, invites or excludes contributions from citizen archivists. I am interested in how people, without technical or archival skills, but equipped with basic tools like mobile phones, can play a role in sharing aspects of their culture and community heritage. In this paper I will talk about my own process grappling with these questions as I moved through several stages of thought and implementation around what archival means and to what extent the recordings of the call to prayer documented on the sound map, need to be "archival." I will also look at the benefits of 'citizen archivist' contributions and whether or not these contributions necessitate a reduction of standards in the types of materials that can be collected.

> "[T]he question of the archive is not, we repeat, a question of the past. It is not the question of a concept dealing with the past that might *already* be at our disposal or not at our disposal, *an archivable concept of the archive*. It is a question of the future, the question of the future itself, the question of a response, of a promise and of a responsibility for tomorrow. The archive: if we want to know what that will have meant, we will only know in times to come."
> —*Jacques Derrida (1995, p. 36)*

To begin, let us look at the passage above, taken from Jacques Derrida's *Archive Fever: A Freudian Impression* (1995), in which he considers the question of the archive. Derrida argues that the question of the archive is a question of the future, rather than one of the present, and also a question about the meaning of the archive, which he argues can only be ascertained in the future, when people look back on that which has been archived with an eye that can see what the archive came to mean. I interpret Derrida's (1995) statement to mean that what we choose to archive, the very question of what the archive includes, also has an impact on how we see today and tomorrow. This is to say that the objects and stories we deem important to represent us in the future, shape how we identify our community and ourselves today. How will we see 100 years ago in 300 years? Derrida is arguing that the very decision of what the archive is, what it contains, what it aims to do, and how it is woven into the fabric of society, carries the responsibility for what tomorrow understands of today. If we apply this interpretation to how citizen archivists can contribute sounds of their own communities, differently than an outsider of a community can, then we must balance or weigh the importance of materials collection by citizen archivists to the means used for this collection. This is of course not to say that citizen archivists cannot document their communities with equipment that support archival quality standards, but more that these standards and the equipment necessary to achieve them can be an obstacle to who can capture what and what gets captured.

When I began the sound mapping project of the Islamic call to prayer, I traveled to different mosques with a Sound Devices recorder and a stereo capsule microphone. I recorded everything at archival standards, producing huge WAV files which I compressed down so that they could ultimately be streamed online, and therefore more easily accessible to people in places with lower bandwidth, and so that I could leverage common web-based audio streaming tools. The large uncompressed WAV files get stored on local hard drives and redundantly in secure cloud storage environments and wait to be revisited, or more properly archived at some later point in time when the impetus and resources

to do so become available. The purpose of the sound map is to share the nuance of the recorded azaans with as many people as will listen, making them easily available so that people from anywhere can access them. On a practical level, this means that the website needs to load quickly and easily, and the user interface needs to be streamlined for phones and computers alike.

The sound map project has been in development for eight years. A few years in it became clear that in order to accomplish the intended scope of the project, which was to have field recordings from mosques all over the world, a goal that I am still working toward, no one person would have the time or resources to properly accomplish this task in as far reaching a way as I would want the map to reflect. I began to ask friends who were sound people or technology folks, if they would help me to record the Azaan where they lived, when they travelled, and or if they knew others with access to high quality audio recording equipment who could make recordings. The result was a few recordings here or there over a year, many of which did not successfully capture the entire azaan, which is the main requirement for recordings posted to the map. The challenge was that those who had audio recording equipment available and the skills to use it, were not often in the physical locations to make recordings.

Due to the low number of contributions, the call for contributors grew to include friends and family of sound folks who were able to make recordings in their local communities but who lacked the technical tools and expertise to do. This second batch of folks who sent in recordings were often doing so from the mosque in their local community where they went for prayers. These were arguably a disparate group of citizen archivists, recording the azaan in their own communities. I began receiving recordings in .mp3 and mpeg4 format which were made primarily on cell phones. The recordings were generally well recorded and very clean, capturing the entire azaan and also an intimate snapshot, often of the interior prayer space of the mosque. One of my former colleagues from when I lived in Abu Dhabi, asked his brother in Khartoum if he would make a recording at mosque for the sound map. A few weeks later he sent me a recording of the azaan his brother made inside the stone and concrete central courtyard of the mosque.[1] I could hear in this azaan, the acoustic resonance of the architecture, and the dull hum of people walking in for prayer. The recording struck me as it was in such stark contrast to my recordings, which had been largely taken outside of mosques boasting sounds of the local environs including the wind blowing the trees or a noisy intersection, at times these environs were sonically foregrounded in my recordings, reflecting the distance I had from the communities where I was recording.

The contributions made by these 'citizen archivists' like my colleague's brother, were low quality, mostly made on mobile phones and sometimes passed along as video files taken on cameras, compressed into low quality formats. As a result these recordings were in stark contrast to the archival standard recordings I had made on my Sound Devices recorder. However, because I was compressing all of the recordings in order to upload them to Soundcloud, the audio streaming server I used to fuel the sound map, the difference in quality was less apparent and arguably less important, than the fact that these recordings of the azaan were now represented on the sound map.

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1   Recording of Azaan made by Waeil Idris on November 2014 at Masjid Al Adarsa in Khartoum, Sudan.
     https://soundcloud.com/diana-chester-1/masjid-al-adarsa-khartoum-sudan

I made the decision to prioritize access to the call to prayer from the broadest possible communities - the initial aim of the project - over the fidelity of the recordings. There were a few reasons that drove this decision the first being that I was actually getting contributions that I could put on the map from places that otherwise had no representation. An additional reason was that when I sat back and listened to the recording's the 'citizen archivists' had made, I found myself listening with a differently critical ear to their recordings than to my own. I was hearing the environment, the ambient sounds, and the sense of place that had been recorded. This process of including recordings others had made opened my ears to new ways of listening to and hearing the sonic materials included in the sound map.

John Cage added a new dimension to the exploration of composition by using sound in composition as a means of defining sonic culture. John Cage's compositional style offered a new approach to making music in the second half of the twentieth century, which considered the relationship between sound and music, and that utilized the found environment as a space for "renewed listening within a musical framework" (LaBelle, 2015, p. 3) I want to now look at the example of John Cage's Composition *4'33"* to explore the value of having citizen archivists or contributors to projects like the sound map. Cage's *4'33"* is a three-movement composition for piano, which instructs the pianist to close the piano lid and time each movement while sitting at the piano in silence. Cage's composition is a prime example of the role that the acoustics of space and noise of place can play in constructing a composition. *4'33"* becomes a composition made up primarily of the sonic qualities contributed by the audience in the space at the moment of the performance. Because the sounds brought into each performance of *4'33"* reflect the unique nature of the cultures of each, not only did performances sound different in each performance hall, but the audiences of each performance created a micro community within a particular cultural context, and the performance became a conduit through which to hear the sonic attributes of that community, inclusive of sonic qualities like language, affect, ambiance, and demographic makeup of the audience.

Like *4'33"* the recordings of the azaan are also always different, from place to place and day-to-day. Even a recording of the Maghrib, sunset azaan, from the same mosque on two different days will be sonically diverse from one another. I began the sound map of the call to prayer to capture the sonic nuance of the call to prayer, and to create a sonic representation of the diversity of Islam geographically, but also culturally, linguistically, and with regard to the cultural contexts in which Islam exists, as revealed through sound. What I have found simply put is that while those qualities still emerge in the recordings I have made and posted to the map, the aim of the project has been greatly furthered by having 'citizen archivists' make contributions from within their own communities. The decision to expand the breadth and scope of geographies that could be included on the map was also a decision to deprioritize the quality, longevity, and sonic fidelity of the recordings. Herein lies an inverse relationship between accessibility of materials and archival standards of those materials. While these are not mutually exclusive things necessarily, my findings with the sound mapping project were that in order to have access to more recordings, and to make the recordings and the map most broadly accessible, I needed to include and share compressed formats of the recordings, as they are simply easier to access, can be streamed, and most importantly are accessible more quickly than larger file types, which are typically at least ten times the size. I found there to be a direct relationship between the breadth of accessibility, how much information can be made accessible to how many people, and the temporality of that accessibility, or how quickly people had access to materials, and how relevant those materials were by the time they had access.

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Due to the success of these initial contributions, I decided to expand the call for submissions through social media and networking. This entailed posting calls on Facebook, reaching out to individuals in a targeted fashion, and putting a call for contributions on the sound map website. I created a brief description for potential collaborators with specifications about recording, which detailed that the recordings should be audio only, they must be complete and not cut off any part of the azaan, and finally to include a photograph from where the recording was made. I explicitly omitted requirements around format, recording devices, or quality. The decision to not focus on quality control for the submitted recordings, was a decision to get more people involved, and to better meet the bigger goal of the sound map which is broad visibility of the azaan around the globe.

While it would be ideal to have a repository of archival quality recordings of each azaan, I feel it is nicer to have the breadth of recordings that are currently on the map. I also hope to continue to flesh out the map to be inclusive of as many Muslim communities around the world as possible. Thus far I have found that most contributors are not often sound engineers or audiophiles, they are members of the Muslim communities where they are making these recording. They are brothers, sisters, parents, and friends of people I have met, or friends of theirs. The contributors are largely people who are interested in sharing the sounds of their community with others, but who do not have fancy equipment or training to do so at archival standards.

I will leave off by saying that this experience has left me ruminating on the following questions. Is it better to have the contributions and not have them be archival, or not have the contributions at all? And what are the benefits and pitfalls of sharing compressed formats of archival recording through sound maps and widely accessible streaming services, that allow for broader dissemination, searchability, and access—and does this impact our understanding of the role of the archive? Sound mapping as a tool offers a means of viewing, searching, and accessing materials contextualized within a frame that positions a thing in direct geographic relation to another thing. The web-based nature of the map makes it more easily shareable and accessible. Because the recordings are compressed they are easier to stream and to share, and not placing specific quality requirements on contributions allows for a greater number of contributors to help grow the body of work. This arguably creates a scenario that jeopardizes the sustainability of the material and its longevity and raising into question whether a collection of sounds such as the sound map discussed here constitutes an archival collection.

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To Normalise or To Manage the Multitude? Determining Workflows and Output Specifications for the Transfer of a Heterogeneous Collection of DV-based Video Cassettes

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Abstract

This article discusses the preparation of workflows and output specifications for a transfer project of a collection of DV-based video cassettes (DV, DVCAM, DVCPRO), by VIAA, the Flemish Institute for Archiving. Two hard to predict characteristics of the collection determined the implementation of this project: the quality of the signal (the extent to which signal loss had occurred on the cassettes) and the precise technical characteristics of the recordings. Given these unknown factors, three major decisions had to be made for these cassettes, all of which together determined the work of an external transfer service provider: 1) the necessary steps in the workflow, 2) the output used of the player(s) and 3) the desired output format(s). In making these decisions, the confrontation between two good practices from the audiovisual archive world was crucial: on the one hand, keeping the technical characteristics of the source signal unchanged and, on the other hand, limiting the number of file formats of master files in the archive, in order to increase file format manageability. This article first outlines the project and its mission. Further on it discusses and arguments the technical choices made, culminating in a workflow proposal for the transfer of the cassettes, that brings together the advantages of two different approaches.

1.   Project context and mission

The Flemish Institute for Archiving (VIAA) digitizes, stores and provides access to audiovisual material, photos, documents, etc., for so-called content partners from the cultural, heritage and media sectors in Flanders. Its mission can be summarized as to preserve and archive the digital heritage of Flanders in a sustainable manner and to make it accessible to everyone. VIAA does not own a collection, but acts as a service provider to a growing group of currently 151 Flemish media and cultural organisations (content partners). These partners include broadcasters (national public and commercial as well as regional), cultural heritage institutions, governmental bodies, city archives and performing arts organisations.

The partners take part in VIAA's transfer projects, depending on the carrier formats they have in their collections. VIAA plans, coordinates and finances the transfer projects for them, by inventorying the collections, drafting the specifications for the transfer process, selecting a specialised transfer service provider and coordinating the project logistics of carriers and files. After the transfer, the original carriers are returned and stored again by the content partners. The files are ingested on the VIAA servers and made accessible via the VIAA Media Asset Management system (MAM). Finally, they're made available to VIAA's target groups, whilst respecting IPR and other rights.

As a part of its mission to digitise the Flemish audiovisual heritage, VIAA prepared a state-of-the-art transfer-to-file project of DV-format based video cassettes in 2018-2019. The estimated volume of carriers is around 20.500, coming from all kinds of content partners, in total around 65 (cf. fig. 1).

CARRIER TYPE	DV (cassette)	¼" DVCAM (cassette)	¼" D7 DVCPRO 25 (cassette)	¼" D7 DVCPRO 50 (cassette)	¼" D7 DVCPRO HD (cassette)	TOTAL
CULTURAL HERITAGE	406	736	220	0	0	1362
BROADCASTERS	4321	9623	132	0	0	14076
CITY ARCHIVES	405	93	29	0	0	527
PERFORMING ARTS	4004	373	3	1	0	4381
GOVERNMENT BODIES	205	31	0	0	0	236
TOTAL	9341	10856	384	1	0	20582

Fig. 1: distribution of the estimated numbers of DV-cassettes per type and per sector.

One of the most important specifications for VIAA to determine was about a suited output format (container, codec and file format specifications), taking into account the properties of the digital signal on the cassettes, requirements of digital sustainability of the file formats, codecs and specifications, requirements of data efficiency in the transfer-to-file process and last but not least the requirement to deliver also a *showable* result, i.e. images that were ready to use on VIAA's access platforms.

2. Technical properties influencing the transfer workflow

Before considering file formats, codecs and specifications (and their subsequent workflows steps) for the transfer of DV-based video cassettes, two partially interfering unpredictable factors were identified:

- **Unpredictable signal quality:** the number of broken bits and their consequences for the quality of the sound and image is unpredictable and certain dropout compensation mechanisms are only applied if the cassette is played back via the SDI output. In certain cases it might be interesting to keep a file transferred via SDI, next to the file as transferred via the IEEE 1394 output[1].
- **Unpredictable diversity of the significant technical properties of a stream or full cassette:** how homogenous (or heterogenous) are the technical specifications according to which the content has been recorded and which variations occur within the total collection and possibly even within one cassette or stream?

When both of these unpredictable factors were cleared up, two partially interfering choices are to be made in the workflow:

- **To normalise or to keep-as-is?** Whether the intra- and inter-cassette variations should be normalised (signal alteration but limiting the number of different file specifications in the archive) or kept as they are (no signal alteration but increasing the different file specifications in the archive dramatically).

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1   Commonly known as FireWire or Sony i.link.

- **To use the IEEE 1394 output (data transfer) or the SDI output (signal transfer)?** Which one of the player's output should be used: both outputs have advantages and disadvantages.

2.1 Signal quality

In order to mediate the unpredictability of both factors they were analysed further. The first one, a low signal quality on DV-based video cassettes, can have several causes. The most common causes of a bad signal quality or problems occurring during their read-out are stickiness or dirt on the tapes themselves, tape demagnetisation causing bit errors, reading head clogging and reading head misalignment. All of these can at least partially be eliminated, except for the second one. For this one the effects can only be limited.

2.1.1. Dirty tape, sticky tape and head clogging

Dirt on the tape, or even parts of the magnetic layer itself (sticky tape), might chip off and clog the player's reading head. The rate of 'head clog' problems depend on things like tape brand, its previous storage conditions, etc. A clogged head might issue different symptoms, not all of them clearly identifiable as 'head needs cleaning'. In any way, all the occurring symptoms are identical to 'tape data not readable' in one way or another:

- Undefined tape gaps, which are in fact blank signal levels: real tape gaps appear between recordings, but if the same behaviour occurs during a recording, it might be a clogged head.
- Visual drop-outs.

If errors like these suddenly occur on tapes previously known as 'clean', or if the rate of these errors increases over time, it is advised to check the player's head. Physically cleaning the DV tapes (using a tape cleaning machine) has not shown sufficient improvements, but might cause additional damage to already worn out tapes. Some machines even have a bad tape-feeding mechanism that breaks the cartridge (e.g. double-hatch).

It was also observed in previous DV ingest operations, that DV cleaning machines that claimed to be able to report about the tape's condition, merely printed out 'reports' with rather arbitrary error counts. Tests were performed in real world practice situations, analysing several tapes multiple times, showing completely stochastic numbers. So, practice seems to indicate that the physical tape cleaning step before ingest could be questioned whether it's really an improvement. This does not however, apply to tapes that obviously require cleaning before putting them into a player.

2.1.2. Reading head misalignment errors

As any tape-based material, DV-based cassette formats are also subject to reading head misalignment errors. It is therefore necessary to apply a correct alignment of the heads onto the tape path to do a proper transfer. If the original recording device had a misaligned reading head angle, players with an actually correct reading head angle will show an increased number of reading errors. In such a case, the player's reading head angle must be 'misaligned' accordingly for these tapes (and adjusted back to its proper angle afterwards, of course).

2.1.3. Bit errors due to tape demagnetisation

If all causes above are excluded, it is still possible that at least some of the tapes will suffer from unrecoverable data errors due to tape demagnetisation. Although this might depend on the tape brand and type and its storage conditions, even well stored cartridges may suffer from data errors. These errors in the DV-bitstream may cause different erratic behaviour when interpreting the data stream. Typical effects are drop-outs in the image and audio cracks. When transcoding these erroneous bitstreams captured via the IEEE 1394 output however, other things may happen, like losing audio/video synchronicity after these error positions, as well as causing an application that transcodes the DV file later on in the process to prematurely exit or even crash. Of course, this depends on how the transcoding tool is implemented.

DV has error detection features built-in, which can be used as a prerequisite for triggering notification or error concealment. If and how error concealment is applied, is up to the hardware / software interpreting the DV-stream though. When attempting to capture and preserve the original DV-stream (via the IEEE 1394 data output), it might be good to define a certain threshold of (sequential) errors in order to abort soon enough and switch to an alternative capture method because depending on what kind of data error, it might take an unrateable amount of time trying to improve the situation.

Transfer via SDI is the only way in which a specific dropout compensation mechanism is applied. This dropout compensation mechanism is to be considered as a (automatic and immediately applied) form of restoration. From a restoration-theory perspective, it deserves recommendation to preserve the signal as unaltered as possible. However, the application of the automatic dropout compensation is probably the best image restoration method that is currently available. To create a reusable image, it would be a shame not to use it.

Notwithstanding the value of the dropout compensation when transferring via the SDI output, working via the IEEE 1394 output still has a few important advantages, also for cassettes of which the signal contains many errors:

- in theory, better algorithms for dropout compensation could be applied to the unaltered signal.
- working via the IEEE 1394 data output is the only way to recuperate certain data in the data stream such as the time code signal, the number of dropouts, etc. To do this, a tool like AVP's DV Analyzer can be used.

The risk for a crash of the capturing application exists, but it is related to the extent that the application interprets the binary data coming from the tape. If it writes the received bites to a file as they are, error manifestations may only happen when a later process (e.g. of transcoding) tries to interpret the data. In practice many tapes can be transferred without a crash of the application and only when trying to transcode or play a position where the DV-bitstream was malformed, problems occur. This even counts for intra-cassette format changes. If the capture application just dumps the stream as it is, it keeps the intra-cassette format changes. Only when interpreting the data problems on how to deal with these changes might come up. It might be possible though to automatically split the file upon detected format changes in the data.

2.2 Signal diversity

In this project, many significant technical properties of the signal on the cassettes are unknown, but they are expected to be rather variable. The following variations can occur:

- **Inter-cassette variations:** within the whole collection of cassettes to be transferred, there may be differences in significant technical properties between the cassettes.
- **Intra-cassette variations:** within one cassette to be transferred, there may be differences in significant technical properties. Here, three scenarios can apply:
  - □ **mid-tape variations:** on one tape, several streams are recorded, one or more of them with different significant technical properties.
  - □ **mid-stream variations:** within one stream, one or more significant technical properties change during a continuous recording.

The scheme below explains the different kinds of variations, each of them has consequences for the transfer workflow (cfr. 5.1):
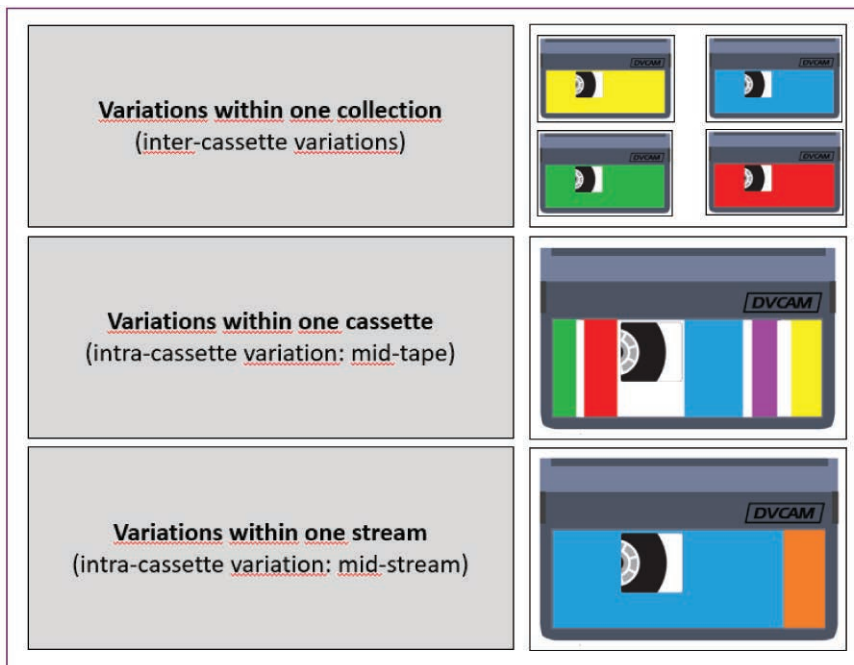
Fig. 2: types of variations within one collection, within one cassette and within one stream.

We identified the most important properties for the images as:

- **Pixel resolution and frame rate**, both important properties of the television standard: for SD these are 720 x 576px at 25 fps (for PAL) and 720 x 480px at ca. 29,97 fps for NTSC.
- **Chroma subsampling:** 4:2:0 (standard for DV and DVCAM in PAL), 4:1:1 (standard for DVCPRO and for DV and DVCAM in NTSC) and 4:2:2 (standard for DVCPRO50).

- ■ **Scan type:** interlaced or progressive.
- ■ **Display aspect ratio:** 4:3 or 16:9.

Image					
Format	Pixel resolution	Frame rate	Chroma sub-sampling	Scan type	Display Aspect Ratio
PAL	720 x 576px	25 fps	4:2:0 (PAL only)	Interlaced	4:3
NTSC	720 x 480px	ca. 29.97 fps	4:1:1 4:2:2	Progressive	16:9

Fig. 3: most important image properties in the collection to be transferred. The combination expected to occur most is indicated in purple.

For the sound, the following most important properties were identified:

- ■ **Frequency, bitrate, number of channels:** 32 kHz and 12 bit for 4 channels, or 48 kHz and 16 bit for 2 channels.

Sound		
Sample rate	Bit depth	Channels
32 kHz	12 bit	4
48 kHz	16 bit	2

Fig. 4: most important sound properties in the collection to be transferred. The combination expected to occur most is indicated in purple.

3. Normalisations to be considered

The combination of the most important variable properties in sound and image – further on called significant technical properties – lead us to a total of **40 theoretically possible combinations** of settings for one audiovisual stream. The combinations expected to be most common in this project are indicated in green in the two tables above, but all the others may possibly occur. This is the point where preservation theory seems to contradict itself: on the one hand we'd like to preserve unaltered signals as much as possible, on the other hand we'd like to keep the number of master file formats in a digital format not larger than necessary. In order to be able to judge whether the heterogeneity in technical characteristics may be limited, we must consider whether a possible normalisation to one common characteristic would entail changes in the image and sound, and whether these changes, if any, are acceptable.

3.1   General NTSC to PAL conversion

A general conversion from NTSC to PAL would affect:

- The pixel resolution: from 720 x 480 px (NTSC) to 720 x 576 px (PAL)
- The frame rate: from 30000/1001 fps (NTSC) to 25 (PAL)
- The chroma subsampling from 4:1:1 (NTSC) to 4:2:0 (PAL)[2]

3.1.1. Normalising display aspect ratio (DAR)

The display aspect ratio (DAR) of images stored on DV-based cassettes will – in this project – most likely be 4:3 (both in PAL and in NTSC), with exceptionally also 16:9 (both in PAL and in NTSC). The storage aspect ratios (SAR), also referred to as horizontal x vertical resolution, is 720 x 576 for PAL and 720 x 480 for NTSC. For DV in PAL the pixel aspect ratio (PAR) is 5:4 and in NTSC the pixel aspect ratio is 6:4.

Since the Storage Aspect Ratio (SAR) is identical to the pixel dimensions (width x height) and therefore always defined in a video file, the Pixel Aspect Ratio (PAR) can be calculated if the DAR is known. The formula is as follows: 'PAR = DAR/SAR'. Therefore, it is only mandatory to store the DAR metadata within the resulting video file. Since the default for DV is to have a 5:4 (PAL) or 6:4 (NTSC) SAR, normalising (i.c. resizing) the pixel resolution is not necessary - even for anamorphic material - as it can be assumed that proper resizing, according to the DAR, is a default use-case and therefore well supported.

3.2   Normalising chroma subsampling

For DV and DVCAM in PAL the chroma subsampling is normally 4:2:0. For DV and DVCAM in NTSC, and for DVCPRO 25 the chroma subsampling is normally 4:1:1. For DVCPRO 50 the chroma subsampling is 4:2:2. Via normalisation this diversity could be reduced to one of those mentioned. It should be acknowledged that subsampling normalisation is an irreversible interference in the signal, and 4:2:2 might be the preferred option in this case, because it is the highest quality of the three.

3.3   Normalising audio resolution to 48kHz and 16bits

DV also allows to record 32 kHz / 12 bits audio, offering 2 additional channels, but this is a rather uncommon audio resolution. If the choice is made to normalise 32 kHz / 12 bits (one common audio resolution for a mixed collection), 48 kHz / 16 bits may be a good option, since that is the more common resolution for the audio in DV files, it is well supported across different domains (professional and consumer) and tools (hardware and software) and it also happens to match the SDI resolution. Obviously any change made (e.g. resample audio) should be documented properly.

4.   Workflow recommendations

After identifying the most important variable video and audio properties and how they could be normalised, we have considered whether these normalisations were opportune, considering explicitly the possible alterations of the video and audio signal they would cause. The conclusions of these considerations are listed below. As a more general recom-

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2   This only applies to DV and DVCAM, as DVCPRO is always 4:1:1 and DVCPRO50 is always 4:2:2.

mendation, considering the complexity of possible issues and to some extent unpredictable results of the transfer, we concluded that testing the capture- and transcoding pipeline thoroughly on every scenario of signal quality and of signal diversity is crucial.

4.1   Solving signal quality issues

Considering the factors above, as soon as the dropout rate of a certain cassette ends up above a certain threshold, it deserves recommendation not to choose between the two transfer methods (via SDI or IEEE 1394), but **to keep both essence files**. The version created with the IEEE 1394 output is the archival master file, while the one created via the SDI output can be considered as a normalised, restored copy. This so-called 'parallel capture' method can be chosen to save time (cfr. 4.3).

Taking into consideration only aspects of signal quality, a possible transfer workflow could then look as follows:
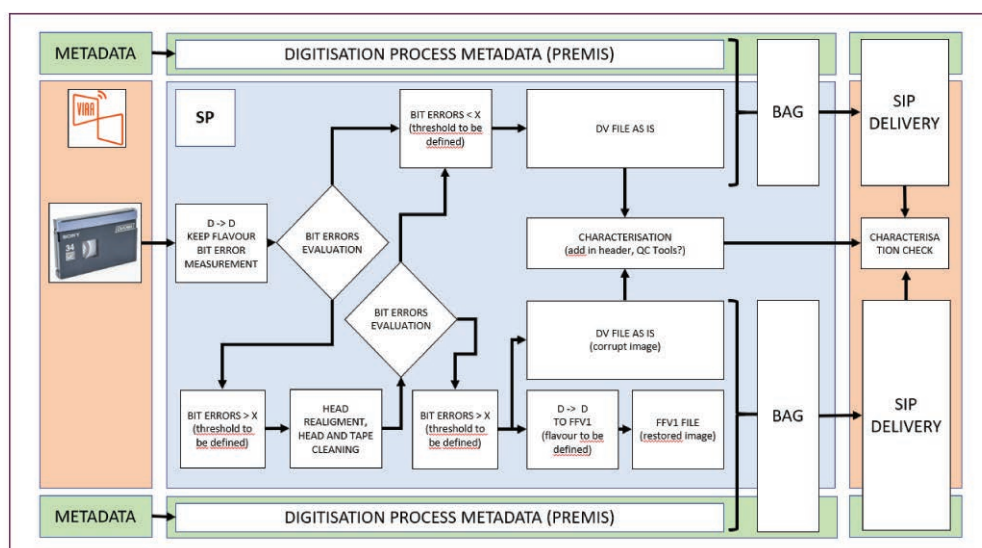
Fig. 5: possible workflow for DV-based cassette transfer, taking into account factors of signal quality only.

This workflow has the obvious advantage that for cassettes with low error rates, not more essence than strictly needed (the capture via the IEEE 1394 output) has to be preserved. For the cassettes with higher error rates, an unaltered file stays available, the data that comes with the essence via the IEEE 1394 output can be preserved and there's an 'as good as possible' file from the SDI output available for reuse as a fallback option.

The exact threshold of the bit error rate can in this project be agreed upon in collaboration with the service provider, based on a testing phase.

4.2 Solving signal diversity issues

As argued above, considering the diversity of significant technical properties of the au-
diovisual stream, the following variations may occur: inter-cassette variation and intra-
cassette variation, with this last one subdivided into mid-tape variations and mid-stream
variations. A special form of mid-tape variations are the undefined gaps on a tape. For each
of these diversity issues, the paragraphs below discuss possible workflow consequences.

4.2.1. Inter-cassette variations

In order to be able to decide which tapes shall be captured natively (DV stream as-is over
the IEEE 1394 output) or rather over SDI, it is good practice to separate tape collections
according to their provenance or source. In this project it would most likely have to be
done by the service provider.

For certain material sources, it can be assumed that they are more likely to be homog-
enous – meaning, they stick to a certain set of technical properties of their recordings
– whereas other sources might be very heterogeneous. For homogenous ('clean') collec-
tions, it is more likely that their native DV-streams can be recorded and kept as preser-
vation master, whereas for heterogeneous ('unclean') collections it might be significantly
faster to ingest them over SDI.

When capturing a collection that is assumed to be 'clean', the ingest operator may still
encounter situations that are out of the norm, such as:

- A significantly high data error rate
- Recordings that have tech-properties that don't conform to the defined 'norm' for
  its DV type.
- Other problems

In such cases, it might be good for the operator to be allowed to ingest these tapes over
SDI, in order not to spend too much time trying to fix or deal with these situations.

4.2.2. Intra-cassette variations

4.2.2.1. Mid-tape variations

Recordings with different properties on the same tape could possibly cause issues during
capture, depending on how the capture application deals with this case. Not all capture
applications deal properly with mid-tape (and mid-stream) changes during capture. If they
'lock' onto the technical properties of the first recorded stream, unclear things may hap-
pen when individual recordings have different properties (codec, audio, etc).

Additionally, if these recordings are stored in a single video file, their behaviour might be
different and possibly erratic upon playback, transcoding or usage. Again, depending on
which tools (hardware and software) are being used to work with these files. This behav-
iour will stay with the file as long as it exists. The following options should be considered:

1. To split the tape into each recording, allowing to maintain its properties. This would
   also create 'stable' files with a single set of technical properties across the whole
   file.

2. To normalise all recordings to a common set of tech-properties afterwards. This is non-trivial, as the actual behaviour of the transcoding application must be checked beforehand, as it is often not well supported to deal with these kinds of mid-file property changes.

3. Record the tape over SDI, which can be considered as a different way of normalising.

4.2.2.2. Mid-stream variations

This possible issue is similar to mid-tape variations (multiple recordings with different tech-properties on same tape), but not identical. Capture applications often lock on to the tech-properties initially present on the tape when the DV recording is started and store only those in the header of the video container. For example, it is possible that the audio resolution was changed on-the-fly during the original recording. How mid-stream changes are dealt with greatly depends on the capture application, as well as the container format used for capture, because it is usually assumed that the technical properties do not change within one video file.

4.2.2.3. Mid-tape undefined gaps

Between individual recordings, the tape contains 'no' information. Depending on the capture application, as well as player- and transcoding applications, these undefined tape gaps may cause e.g. audio/video synchronicity issues when dealing with the material. This applies when the DV-stream was captured directly 'as-is' and is then used or transcoded.

4.2.3. Properties to normalise or not to normalise

As mentioned above (cfr. 2.2 Signal diversity), the following properties could potentially be normalised. For all of these, we discuss whether this normalisation is opportune from a heritage and / or workflow perspective.

It should be remembered that any modification to the video material on DV requires complete re-encoding of the original stream. There is no such thing as 'lossless DV-to-DV conversion'. Only if the target codec is lossless or uncompressed, an additional generation loss can be avoided.

4.2.3.1. General normalisation of NTSC based streams to PAL

As described above (cfr. 2.2.1), a general normalisation of NTSC to PAL would include:

- **pixel resolution compensation:** since NTSC has the same width but a smaller height, the missing 96 lines could be padded, adding 49 black lines at the top and at the bottom: 'letterboxing'. This would allow keeping the original resolution without interpolation. This is an acceptable alteration of the signal.
- **frame rate conversion:** about 5 frames will have to dropped every second to fit the ~29.97 fps of NTSC into 25 fps PAL. This is an irreversible alteration of the content.
- **normalising chroma subsampling:** all 4:2:0 or 4:2:2? See paragraph 4.2.3.3 for details.

From a heritage perspective, if possible, keeping NTSC sources as-is is preferred for preservation. Especially because the impact of any conversion step is non-trivial, irreversible, and it can be assumed that most (if not all) applications dealing with audiovisual files will be able to handle NTSC properly.

It can further be assumed that the most likely use-case where this might be a problem is, if someone who is not experienced enough with digital video is trying to use an NTSC source material, mixed with PAL material in a PAL production. But in such a case, it is also very likely that they will manage to use the NTSC clip, but maybe their conversion/import step was not 'as good as it could have been'.

4.2.3.2. Normalisation of the display aspect ratio

As explained under 3.2.2, normalising the display aspect ratio (DAR), is not necessary and therefore not recommended.

4.2.3.3. Normalisation of the chroma subsampling

Changing the chroma subsampling will require interpolation of colour values. It can be assumed that the visible impact will not be too severe, but should be avoided unless absolutely necessary. When capturing uncompressed DV over SDI, the subsampling will always be normalised to 4:2:2, regardless of the source material. In this case the colour information of any DV source (except DVCPRO50) will be interpolated. This conversion is done by the player. This means that normalising the chroma subsampling is an irreversible signal alteration with possible visible effects and is therefore not recommended.

4.2.3.4. Normalisation of the audio resolution to 48 kHz, 16 bit

As mentioned, 48 kHz and 16 bits is most common for DV cassettes, but 32 kHz and 12 bits is also possible. The normalisation of these into 48 kHz and 16bit has the following advantages:

- One audio sample rate across all collections: all audio behaves the same.
- A common audio resolution vs a non-common one
- Less issues expected when working with the material

However, this normalisation also has a few disadvantages:

- This normalisation means an irreversible sample rate conversion. Since 48 is not a multiple of 32, sample interpolation needs to be done (whereas resampling from e.g. 96 to 48kHz is done, every 2nd sample is simply dropped). The quality and effect of this step depends on the tool (hardware/software) being used, as well as the audio source itself.
- Dithering 12 to 16 bits, as an optional part of the normalisation: not only the number of samples, but also the samples itself must be modified in an irreversible way: the 12-bit values would need to be stretched to their 16-bit representation as they're not just zero-padded with 4 bits. The quality and effect of this step depends on the tool (hardware/software) being used - as well as the audio source itself.

If done properly, the artefacts introduced by this conversion step should be minimal to unnoticeable. Since the audio is originally interleaved into the DV video signal, when capturing the original DV stream, it is possible to keep the original audio stream, while simul-

taneously writing the resampled (48 kHz / 16 bits) PCM channels to a separate audio track inside the recorded video container.

Most (if not all) applications will prefer the container's audio track over the interleaved audio inside the DV stream, therefore using the video files will behave like any other regular file. Yet, if for whatever reason, the original, unresampled audio is to be accessed, the video track can be unwrapped from the container and written to a native ".dv" file. When accessing this file, it will be a valid video file with its own audio track(s). This can easily be done using e.g. FFmpeg.

Normalising the audio resolution is an irreversible signal alteration, but unnoticeable if done properly. It can be applied if necessary in order to reduce the technical diversity in the archive, but as mentioned earlier, it is optional.

4.3 Signal capture scenarios: IEEE 1394, SDI or both?

Looking at things from another perspective, one might ask: when is the IEEE 1394 output preferred and when the SDI output? In principle, it is always and for all tapes recommended to use the IEEE 1394 output of the player to capture the stream and transfer it to file completely, including its DV-specific properties and original time code information.

As a possible fallback option where the original DV-stream has too many errors or where too many different recordings with changing properties (mid-stream-, mid-tape-changes) are expected (or present), capturing the uncompressed audiovisual stream over SDI is an option. The main advantages are:

- Different tech-properties are 'normalised' on the fly during playback.
- Realtime error concealment, creating 'as good as possible' files for re-use.
- No further issues with problematic bitstreams, as all bitstream-quirks will automatically be manifested as uncompressed-SDI essence during playback.

The main disadvantages are:

- If this is the only copy: loss of DV-specific information and the original timecode information.
- The realtime error concealment applied when transferring via the SDI is also a disadvantage from a heritage-theory perspective (see above), as an error concealment is automatically applied whereas when the data stream is captured directly as-is via the IEEE 1394 output, it is possible to display the images with unconcealed dropouts.
- Image and audio quality may also depend on player.

To remediate the first disadvantage, the following measures could be taken:

- To preserve the timecode via the SDI output: this depends on the player, as well as the capture application and target format being used. If a lossless or uncompressed codec is used for capturing the SDI signal, the process is equivalent to the following individual steps:

- ☐ Capture the original DV-Stream
- ☐ Transcode it to lossless/uncompressed, while normalising its technical properties to:
  - a common resolution
  - a common framerate
  - apply error handling / concealment
  - determine gaps on the tape as an audio and video 'placeholder' (e.g. still image and mute audio)
  - convert chroma subsampling to 4:2:2
- ■ To preserve the DV-specific information, the above mentioned 'DV Analyzer' could be used. To do this in only one tape-transfer step, a 'parallel-capture' setup would be required.[3]

The parallel-capture system and workflows might be a bit more complex to set up, but this approach may save a great amount of time, as well as reducing the physical wear on the tapes. It provides the capture operator with two capture versions of one tape: the original DV-Stream (as-is) and the digitally decoded, normalised and error-corrected, etc. audio and video signal (over SDI).

The difference to just capturing the SDI signal is, that due to the availability of the DV stream capture, all technical metadata can be extracted and its information can be stored as preservation metadata, or applied to make certain decisions like re-capture or drop the SDI version because the DV stream is 'fine'.

In order to avoid hardware performance bottlenecks (which might lead to interstitial errors during the capture), it might be good (or necessary) to have two separate computers - each capturing only one signal: 1 DV, 1 SDI.

4.4 Documenting aspect ratio and field order information

Whatever the method chosen, the following technical metadata shall be properly stored in the resulting video files - this means in a machine-readable, standard-conform and supported way (e.g. in the container) so that not only the information is preserved, but also that a player can automatically read and interpret them so that the image is displayed correctly.

As these three tech-properties are very basic and common, it can be expected that any modern video-container, and application, will support handling them by default (cfr. 3.2.2. Normalising Display Aspect Ratio).

- ■ Scan type (interlaced or progressive)
- ■ Field order (if interlaced)
- ■ Display- and Storage Aspect Ratio (DAR/SAR) information

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3   Some DV-players output the IEEE 1394 stream and the decoded, uncompressed SDI simultaneously. This can be used to capture both signals in one recording step, while requiring to play each tape only once (as compared to capture DV first and then SDI as fallback). This great idea is from Marion Jaks, video archivist at the Austrian Mediathek.

5. Conclusion

5.1 Recommendations in normalisation and output use

This conclusion summarizes the recommendations considering normalisation of the most important technical properties of the signal on the DV cassettes and advises on the choice for the IEEE 1394 output, the SDI output or both.

The recommendation is influenced **firstly by the assignment of signal quality** and **secondly by the signal diversity,** the reason being that a possible remediation on signal quality (by measures like reading head realignment, head and tape cleaning) can effectively improve the results of the signal diversity evaluation.

For tapes of which the signal remains below a certain threshold of bit errors, the IEEE 1394 output of the player should be used. For tapes of which the signal exceeds a certain threshold of bit errors, the SDI output should be used as a fallback, additional to the capture via the IEEE 1394 output. The height of this threshold should be determined in collaboration with the service provider during a testing phase.

Regarding differences in the technical properties of the signal, as occurring between cassettes (inter-cassette variation), within one tape (intra-cassette, mid-tape) or even within one stream (intra-cassette, mid-stream), the recommendation is to normalise only the audio resolution (frequency and bit depth). Normalising the audio resolution is irreversible, but it's the only normalisation that does not constitute a significant alteration of the signal and at the same time tempers the effects of file format heterogeneity. Normalisations such as on the television signal (from NTSC to PAL) and the chroma subsampling are also irreversible, but they also hold the risk of significant alterations on the signal. Normalising the display aspect ratio has no significant advantage in tempering the negative effects of file format heterogeneity. Considering the levelled definitions of 'significant properties' given by Grace and Montague (2008), all the considered technical properties would have significance level 10 (essential and unchanged), whereas the audio resolution (frequency and sample rate) could be considered level 07 to level 09 (essential – some variation allowed).

This leaves us with the following possible output formats:

Image			Sound	
Pixel resolution, frames, chroma subsampling	**Scan type**	**Display Aspect Ratio**	**Original samplerate, bitdepth, channels**	**Normalised frequency, bitdepth, channels**
720 x 576 px 25 fps 4:2:0	Interlaced	16:9	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
		4:3	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
	Progressive	16:9	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
		4:3	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
720 x 576 px 25 fps 4:1:1	Interlaced	16:9	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
		4:3	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
	Progressive	16:9	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
		4:3	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
720 x 576 px 25 fps 4:2:2	Interlaced	16:9	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
		4:3	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
	Progressive	16:9	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
		4:3	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	

Image			Sound	
720 x 480 px 29,98 fps 4:1:1	Interlaced	16:9	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
		4:3	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
	Progressive	16:9	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
		4:3	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
720 x 480 px 29,98 fps 4:2:2	Interlaced	16:9	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
		4:3	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
	Progressive	16:9	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	
		4:3	32 kHz, 12bit, 4 channels	48 kHz, 16bit, 4 channels
			48 kHz, 16bit, 2 channels	

Fig. 6: table with all possible output formats and their normalised sound specification.

5.2 General workflow proposal

Based on the signal quality evaluation and on the signal diversity evaluation we have developed the following proposal for a transfer workflow, in which the diversity of technical properties of the files is limited.

For tapes of which the signal remains below a certain threshold of bit errors, the IEEE 1394 output of the player should be used. For tapes of which the signal exceeds a certain threshold of bit errors, first head realignment and reading head and even possibly tape cleaning should be tried. If these measures result in an improvement of the signal, again only the IEEE 1394 output should be used. However, if these measures do not result in an improvement of the signal, the SDI output should be used as a fallback, additional to the capture via the IEEE 1394 output. The height of this threshold should be determined in collaboration with the service provider during a testing phase.

For both kinds of tapes (below and above the bit error threshold), the transfer workflow via the IEEE 1394 output is determined by the **signal diversity evaluation**. This step may result in finding cassettes of three kinds:

- **Tapes with no mid-tape, nor mid-stream changes:** should be transferred according to the specifications of the stream(s). The only allowed normalisation is in the sound domain: if recorded in 32 kHz, 12 bit, the frequency should be normalised to 48 kHz and the bit depth to 16 bit. This cassette will result in as many essence files (DV) as there are recordings on the cassette. For cassettes with a high number of bit errors this number of files is doubled to 2 essence files (one file via the IEEE 1394 output[4] and one file via the SDI output[5]) per stream on the cassette. However, all files under the same codec should have the same specifications.
- **Tapes with mid-tape changes:** should be transferred according to the specifications of the streams. The only allowed normalisation is in the sound domain: if recorded in 32 kHz, 12 bit, the frequency should be normalised to 48 kHz and the bit depth to 16 bit. This cassette will result in as many essence files (DV) as there are recordings on the cassette. For cassettes with a high number of bit errors this number of files is doubled to in 2 essence files (one file via the IEEE 1394 output and one file via the SDI output) per stream on the cassette. At least two files of the same codec will have different specifications.
- **Tapes with mid-stream changes:** should be transferred according to the specifications of largest part of the stream. The only allowed normalisation is in the sound domain: if recorded in 32 kHz, 12 bit, the frequency should be normalised to 48 kHz and the bit depth to 16 bit. keep it in one file. The service provider should check whether the player normalises automatically. If not, normalisation has to happen through an additional transfer via the SDI output. This cassette will result in as many essence files (DV) as there are recordings on the cassette. For cassettes with a high number of bit errors, or if the player doesn't apply a correct automatic normalisation, this number of files is doubled to 2 essence files (one file via the IEEE 1394 output and one file via the SDI output) per stream on the cassette. How many different specifications will exist under one codec, depends on the presence of mid-tape changes on that same cassette.

One can conclude that each essence *stream* should be digitised according to its specifications at the time of recording. The only allowed normalisations are:

- in the sound domain: if recorded in 32 kHz, 12 bit, the frequency should be normalised to 48 kHz and the bit depth to 16 bit.
- in case of mid-stream changes, in order to keep the stream in his entirety, the transfer should follow the specifications of largest part of the stream. Streams with mid-stream changes should always be transferred to short play mode.
- If a stream is part of a cassette with a large number of errors, also a normalised FFV1 version should be made via the SDI output.

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4   VIAA has chosen here to go for an unwrapped .dv file.
5   VIAA has chosen here to go for an FFV1 file with LPCM sound, wrapped in an MKV container.

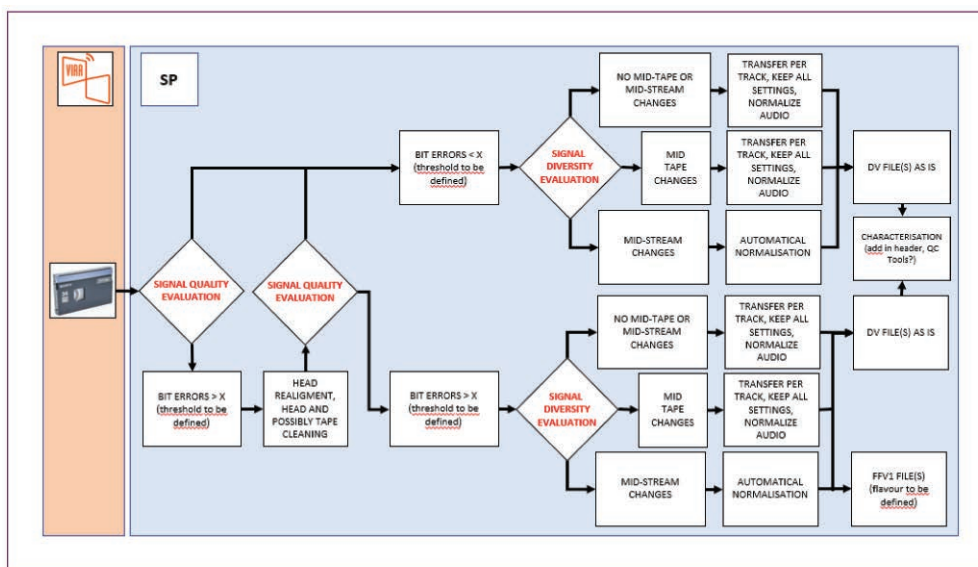This results in the following possible workflow scheme:

Fig. 7: proposed workflow scheme for the transfer of DV-based video cassettes.

Whether this workflow scheme will work in practice has to be considered further. Especially determining a bit error rate threshold value might prove to be hard, as this not only has to take into account an average bit error rate, but also the occurrence of peak values and possibly even at which point in the stream these peak values occur. Also the behaviour of the playback machines used will be crucial: discarding, blanking or interpolation of bit errors might cause audio/video synchronicity issues. Because of this, the file resulting from the transfer via the SDI output may be retained more often than anticipated together with the file resulting from the transfer via the IEEE 1394 output, to serve as a displayable and reusable video file.

5.3 Overall conclusion

In this article we have considered the preparation of workflows and output specifications for a transfer project of a collection of DV-based video cassettes (DV, DVCAM, DVCPRO), by VIAA, the Flemish Institute for Archiving. The quality of the signal (the extent to which signal loss had occurred on the cassettes) and the precise technical characteristics of the recordings in this collection are unknown and hard to predict and this has appeared to be a circumstance with far-reaching consequences when taking the most important decisions in the design of a transfer workflow.

We have therefore studied how the quality of the signal could be respected as much as possible, whether and how the diversity in technical properties of the signal could be accommodated without violating essential preservation principles and – subsequently – which outputs of the player should be used to achieve these goals. In making these decisions, the confrontation between two good practices from the audiovisual archive world was crucial: on the one hand, keeping the technical characteristics of the source signal unchanged and, on the other hand, limiting the number of file formats of master files in the archive, in order to increase file format manageability.

The study of the technical properties has shown that their normalisation always implies an unacceptable change of the signal. All these properties can therefore be labelled as significant properties. The only technical feature for which a normalisation is allowed as an option to reduce the technical diversity of the files resulting from the transfer project, is the normalisation of the audio resolution (frequency and bitrate).

This argument - together with the fact that the data stream may contain useful data that can only be read via the IEEE 1394 output - leads to the recommendation to certainly use this IEEE 1394 output for the transfer. However, in order to simultaneously include the benefits of the automatic error concealment that is only possible with a transfer via the SDI output, such a transfer via the SDI can also be considered. The file that results from the transfer via the IEEE 1394 output must be considered as the master file, whereas the file that results from the transfer via the SDI must be considered as a normalized, restored copy.

This article therefore recognizes the benefits of both approaches and refuses to choose only one of the two methods. By assigning the status of archive master to the files from the transfer via the IEEE 1394 output, we give clear priority to that method, but at the same time we do not neglect the importance of the files from the SDI output.

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7.   Annex 1: norm per DV based cassette subtype

This part lists which technical properties are to be considered *normal* or *most common* in this collection, depending on which DV-type (DV, DVCPro, etc). HDV is not expected in this collection.

DV Norm	Image						Sound		
	Pixel reso-lution	Bits per com-ponent	Sub-sampling	Scan type	Display Aspect Ratio		Samplerate	Bit depth	Channels
DV	PAL SD (720 x 576 px)	8 bpc	4:2:0	Interlaced (BFF)	4:3 16:9		32 kHz 48 kHz	12 bit 16 bit	4 2
DVCAM			4:2:0				48 kHz	16 bit	=2*
DVCPRO			4:1:1						=2*
DVCPRO50			4:2:2						=4*

* For DVCAM, DVCPRO and DVCPRO50 the number of channels is fixed.

8. Annex 2: format encoding policies for FFV1/PCM in MKV

This annex suggests a list of specifications for the FFV1/PCM in MKV files, resulting from the transfer via the SDI output.

General	Audio	Matroska	FFV1
Constant Framerate (CFR)	Codec: Uncompressed, Linear PCM (LPCM)	Version >= 4	Version: FFV1.3
Colorspace: YUV	Resolution: 48 kHz / 16 bits	SegmentUID: present	GOP size: 1
Scan type: must be defined. Interlaced or Progressive	Channels: 2 or 4	SeekHead: present	SliceCRC: enabled
Field order: must be defined. Top- or Bottom-Field-First			Slices: 24(for SD), 64 (for HD)
DAR: must be defined. Valid options: 4:3 or 16:9			Coder: Range Coder
Valid subsampling options: 4:2:0 (PAL) 4:1:1 (DVCPRO or NTSC) 4:2:2 (DVCPRO50)			Context: small

Quality Control for Media Digitization Projects

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Abstract

This article defines types of quality control and explores risk management strategies that are broadly applicable to any organization engaged in media digitization for long-term preservation. It uses the quality control system for audio and video digitization that was developed by Indiana University's Media Digitization and Preservation Initiative to provide examples and illustrations of these ideas.

1.   Introduction

Everyone makes mistakes. It is endemic to the human condition that perfection can never truly be achieved or, at the very least, sustained. Rest assured that any operation created or guided by human beings will make mistakes.

Media digitization operations are no exception. Even the best vendors and in-house digitization studios make errors that they consider embarrassing. These errors should be rare, and media digitization projects must develop robust quality control and quality assurance systems that provide a reasonable chance of finding or preventing them.

The terms 'quality control' (QC) and 'quality assurance' (QA) are often used interchangeably even though they mean different things. The American Society for Quality defines QC as a *reactive* procedure used to check products for adherence to a defined specification. Key products of media digitization include digital media and metadata files, and QC involves examining them to validate that they meet the digitizing institution's guidelines. Quality assurance, on the other hand, is a *proactive* process that consists of taking steps in advance to ensure that the product *will* meet the specification (ASQ, 2018). For example, in a media digitization operation the QA program may develop guidelines relating to personnel, training, type of equipment used, or other areas that affect the quality of the product.

For the digitizing institution, the quality control function is nearly as important as the act of digitization in the quest for long-term preservation. The institution must perform its due diligence on files submitted for preservation, assessing them for adherence to its specification. It does this best through a QC program that validates the products destined for storage, providing proof that the appropriate pieces are in place for enduring preservation.

Quality assurance is critical for vendors who cannot rely solely on a reactive QC process to identify problems. By the time a problem is identified by QC, it already exists and is impacting the vendor's ability both to perform accurate work and to manage the project's bottom line. Instead, vendors must put in place safeguards that prevent problems from developing. When problems do occur, the vendor may use them to make improvements to the digitization system, as part of a process of continual improvement.

2.   Indiana University Context

The present article defines types of quality control and explores risk management strategies that are broadly applicable to any organization engaged in media digitization for long-term preservation. It uses the quality control system for audio and video digitization that

was developed by Indiana University's (IU) Media Digitization and Preservation Initiative (MDPI) to provide examples and illustrations of these ideas.

MDPI is charged with digitally preserving all significant audio and video recordings on all IU campuses in time for the University's Bicentennial in 2020. As of this writing, the project has digitized more than 305,000 recordings in just over three years. The bulk of the digitization is handled by Sony Memnon, the University's private partner, who uses parallel transfer workflows for most, but not all, of this work. Parallel transfer workflows are characterized by the use of one operator to digitize multiple recordings at the same time. For fragile formats and problem items that cannot go through a parallel transfer workflow, IU established a smaller digitization operation—IU Media Digitization Studios (IUMDS)—that utilizes mostly, but not completely, 1:1 workflows where one engineer digitizes one recording at a time.

At peak, Memnon delivers 12 TB of data *per day* from the digitization of more than 600 recordings, yielding over 4,000 digital files. The IU operation generates additional files. All of these are subject to quality control. MDPI resources allow for one full-time QC specialist. Two other staff devote a portion of their week—typically 10-40%—to QC work, and two student hourly workers also contribute to checking files.

3. Types of Quality Control

At the highest level, we recognize two basic QC types: automated (machine-based) and manual (human-intensive). Automated QC is carried out by software tools, while human-intensive QC is a manual process that relies on the human senses of sight and sound as well as on our capacity for logic and reasoning. These may seem like very different strategies, but in truth, the two types of QC make use of each other. For example, human cognition is necessary to interpret the software output of machine-based QC while machines must render the digital files that are analyzed using sight and sound.

3.1 Automated QC

Automated machine-based QC routines may use commercial, open source, and/or homegrown applications. For MDPI, IU developed its own scripts that analyze 100% of the media files produced by the project. This is part of the MDPI post-processing system, and it includes checks in the following areas, among others:

- presence/absence of digital provenance metadata
- presence/absence of specified embedded metadata
- directory and file names
- presence of expected file types (preservation master, production master, etc.) for the format digitized
- format and wrapper
- file extension
- audio stream count
- sample rate, bit depth, codec name, frame rate, pixel format
- duration across streams and across file types

3.2 Human-intensive QC

Human-intensive QC, on the other hand, features an MDPI staff member listening to and/or viewing digital files to judge the accuracy of characteristics that are typically not assessed well by machines. For example, open reel audio tapes recorded in the field occasionally exhibit problems such as reversed audio or changes in speed. Currently, software cannot accurately discover these issues. Nor can software identify cases where the audio or video content and corresponding metadata are mixed up and obviously (and mistakenly) refer to different recordings. One example is where the content does not appear to match the title provided. Also challenging are cases where a metadata value is logical and/or possible, but not correct. In these instances, human senses and cognition are necessary to evaluate for accuracy.

Human-intensive QC may be conducted using the source recording that was digitized, comparing it directly to the resulting digital files. It may also be performed without the source recording, in which case judgments are based on general expectations about the format and its technical characteristics as well as experience in identifying typical problems. We use the term 'Direct QC' to refer to the methodology that uses the source, comparing it directly to the digital files produced. This direct comparison is the only way to assess workflow steps that rely upon the judgment and accuracy of the operator. The azimuth adjustment step in an open reel audio tape or audiocassette workflow, for example, is one area in which the operator makes a judgment call as to which setting is the most accurate. The only way to check this choice is to play the digitized recording, comparing it to the corresponding part of the digital file created during digitization to assess its accuracy. Luma adjustments for video digitization—setting black and white levels—also represent judgment calls by the operator when there are no reference color bars and are best evaluated with Direct QC.

While effective, Direct QC requires more resources than a quality control methodology that does not use the source recording. Appropriate playback equipment, knowledge of safe playback procedures, a critical monitoring environment,[1] and additional staff time are essential for successful Direct QC. Employing a methodology that does not use the source recording enables QC staff to examine a larger number of recordings. An ideal QC workflow may make use of both, targeting Direct QC to digitization steps that cannot be adequately evaluated in any other way.

3.2.1. Selection for QC

Project resources allow us to undertake human-intensive QC for approximately 10% of the recordings digitized by the MDPI project. We take a random sample of recordings identified by our tracking/management database for QC staff to tackle. However, to maximize our resources we also employ the following selection strategies:

3.2.1.1. Value-based QC

Directing more QC resources to formats, collections or recordings that are considered of higher value and fewer to those deemed less valuable.

As an illustration, the MDPI project digitized a limited number of commercial LPs and 45s.

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1   Although an audio studio designed as a critical listening room is ideal, Direct QC using headphones is workable.

IU curators told us that, while these were valuable enough to digitize, they were significantly less valuable than other formats. In their estimation, directing fewer QC resources to these formats in order to make available additional resources for in-depth checking of more valuable formats was worth the risk.

3.2.1.2. Risk-based QC

Analyzing digitization workflows and digitized formats to identify where risk is greater and directing more resources to those areas.

For example, we define the time period in which something new is started or something has changed as carrying greater risk. Therefore, when the digitizing operation begins a new format, hires a new person, or begins using a new machine, the QC team will allocate additional resources for a specific period of time to mitigate the risk.

Some formats may be more problematic and require extra QC effort. For instance, U-matic videotapes are actively degrading, resulting in a greater risk that problems such as head clogs from oxide buildup during playback will develop. Solving this problem may necessitate re-digitization.

4.   Quality Control as Risk Management

The types of human-intensive QC described above all make use of an evaluation of risk in one form or another. In fact, the entire QC function of a media digitization operation may be conceptualized as an exercise in risk management. Quality control procedures must provide a reasonable level of confidence that the products of digitization meet expectations. However, we already know that human beings make mistakes, and therefore there is a risk that the human-run digitization operation will make mistakes. A useful definition of risk for our purposes is the chance or probability of a loss.

4.1   Risk in Media Digitization

The primary high-level risk for a media digitization operation is that it will produce digital files that do not meet an organization's specification for preservation, and that these 'bad' files will be stored into the future as trusted preservation surrogates. More specifically, there is a risk that the digitization process itself will introduce errors into the files (**loss of accuracy**). There is also a risk that the work will not be done optimally—that we will have 'left something on the table' that results in, generally speaking, audio that could have sounded better or video that could have looked better (**loss of fidelity and accuracy**). Further, there is a risk that errors will be introduced into the metadata that accompanies a recording (**loss of context and interpretability**). Finally, there is a risk that the operation will not digitally preserve an item at all because of a mistake in keeping track of recordings or files (**loss of preservation**).

Let's consider examples of actual problems in each of these categories in turn. First, a loss of accuracy may result from equipment problems such as a malfunctioning time base corrector that produces flashing video frames during digitization of a U-matic tape. This can be corrected by using a different TBC to produce a more accurate digital file. A loss of fidelity may be the consequence of skipping the azimuth adjustment on an open reel audio tape since this may well yield less high frequency content in the digital file than is on the tape. Making the adjustment provides greater (and, hopefully, maximum) fidelity. A classic example of a loss of context and interpretability begins with a digitization operator

neglecting to note that a crack on a cylinder recording resulted in a periodic thump during playback. A researcher hears this sound, misinterprets it, and concludes that the recording includes a drum. Finally, a prep worker notices a potentially serious defect on a recording, sets it aside for later examination, does not enter it into the database, and forgets to note that it was pulled. The recording is effectively lost and is not digitized or preserved.

The impact of these losses on future uses of the target content may be subtle or profound. They can result in researchers using representations of content that are inaccurate or of lower quality than is possible, reaching false conclusions based on misleading or absent metadata, or not discovering content at all because it was not preserved.

These risks can be managed by the QC system in tandem with a robust quality assurance program. Risk management may be defined as "the identification, assessment, and prioritization of risks followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events" (Hubbard, 2009, p. 4). Classic risk management thinking identifies four basic areas in which an operation may respond to or treat risks:

1. Transfer the risk
2. Avoid the risk
3. Reduce or mitigate the risk
4. Accept the risk

4.1.1. Transferring Risk

Transferring the risk involves moving responsibility to another entity to minimize or remove the risk to the organization originally carrying it. A typical example is the use of insurance. The insurance company assumes specifically defined financial risks from a policyholder who pays a premium for this service. However, risk transfer may also be employed through a contract that contains an indemnity clause in which one party agrees to be financially responsible for specified liabilities that may be incurred by another party. Within the audio/video part of the MDPI project, some risk is transferred to the digitization vendor through provisions of its contract with IU. The contract stipulates that the vendor is responsible for fixing all problems and re-digitizing as necessary at no cost to MDPI as long as problems are reported within a fixed time period after digitization (40 days for audio and 30 days for video). This provision protects IU from mistakes made by the vendor as long as they are detected promptly.

4.1.2. Avoiding Risk

There are two ways in which an operation can avoid risk altogether: by choosing not to take whatever action exposes it to risk or by employing a resource that removes the risk. Avoiding actions that result in greater risk is often not an option for media digitization operations. For instance, the use of parallel transfer workflows is typically considered to carry greater risk than 1:1 workflows, although this is a complex question that is open to debate. It may not be a reasonable option for institutions with cost and time limitations to use only 1:1 workflows, which result in greater costs and time, to digitize their collections. Specific workflow steps may present similar issues. For example, performing an azimuth adjustment as part of an audio tape digitization workflow adds significant risk—if not done well, the audio will be missing high frequencies. However, this step is essential to obtaining maximum fidelity and accuracy in the digital file and is considered mandatory.

There are, however, some areas in which risk can be avoided. For example, MDPI removes risk by designing QC checks into its post-processing system. All files are handled by post-processing and therefore all are subject to this series of checks. A list of some of the QC checks performed by the post-processing system may be found above in the section on types of quality control. In this way, we remove practically all risk for the variables checked by the system. To illustrate, all audio files are checked for bit depth. Files that are not 24 bit are failed and the original recordings sent back to the vendor for re-digitization. Since computers are quite capable of accurately checking this variable, and every file is checked, there is little risk of not meeting this specification.

4.1.3. Reducing Risk

When risk cannot be avoided altogether, the probability of loss can still be lessened by applying controls or taking particular actions. Even something as fundamental as the timing of QC work can reduce risk. Quality control is most effectively performed soon after digitization. That is because staff currently in place are familiar with the digitization project and possess the skill set and motivation to discover problems. While it may seem reasonable to think that files safely stored can be checked at any time, there is no guarantee that staff in years to come will have the context and ability to perform QC optimally. There is also no guarantee that the vendor will still be in business or willing to help troubleshoot serious issues. Moreover, given the pace of obsolescence for some formats, finding appropriate playback machines may prove difficult in the future.

MDPI has implemented a number of policies, procedures, and programs to reduce the risk that out-of-spec digital files will be placed into preservation storage. First, all fragile formats such as wax cylinders, lacquer discs, wire recordings, and ½" EIAJ videotapes are automatically routed to the 1:1 workflows used by IUMDS rather than the parallel transfer workflows used by the vendor. Successful playback of these formats typically requires the constant attention that is possible when one engineer digitizes one recording at a time. There is the added bonus that recordings in these formats tend to represent some of the highest value content for IU. This policy is more akin to a quality assurance step than a quality control check.

MDPI also implemented a human-intensive QC program to reduce risk. An MDPI staff member listens to or views files from a randomly selected sample of 10% of digitized recordings in order to judge their suitability for preservation storage. Staff use format-based checklists containing specific checkpoints to guide them in this work. This part of the QC operation includes the use of value-based QC, risk-based QC, and Direct QC as described above.

Human-intensive QC takes another form with a regular project team meeting to review the output of cylinder digitization, which is particularly complex. Two audio preservation engineers alternately work on cylinders, producing signal-processed production master files along with unaltered preservation master files. Every two weeks, the cylinder team gathers for a listening session that focuses on work from the previous two weeks. Discussions at the meeting foster consistency between the two engineers as well as confirm the overall quality of the work, reducing risk in this area.

Finally, MDPI has implemented a program to retrospectively select and perform focused QC on files created from some of IU's highest-value recordings and collections to provide further assurance that they meet our specification. Our aim is to confirm that the most significant content owned by IU, as selected by curators from the media-holding units themselves, was digitized accurately.

4.1.4. Accepting Risk

We may choose to accept a risk that we consider tolerable, working with it in the interest of achieving a greater gain. For example, the IU Music Library holds some 38,000 open reel tape recordings of student and faculty recitals and concerts dating from the 1950s. While curatorial staff tell us that there are recordings of a number of prominent classical and jazz musicians interspersed within this collection, the majority of items are judged to be of moderate value. That is, they are valuable enough to justify digitization and long-term preservation but are not considered highly valuable. In addition, some of the most valuable tapes were digitized as part of an earlier project. Digitizing this collection using parallel transfer workflows may entail a greater risk than using 1:1 workflows, but IU is willing to accept this risk rather than incurring the much higher cost of using 1:1 workflows. Our calculations indicate that it would take 27.86 years to digitize this collection using a single 1:1 workflow versus 7.43 years for one parallel transfer workflow that digitizes four recordings simultaneously.

The boundaries between these risk response procedures can be a little blurry. For example, transferring risk can also be thought of as a form of avoiding risk for the party that gave the risk to another entity. Also, reducing risk can imply accepting what is left of the risk after it is reduced (Hubbard, 2009).

4.1.5. Identifying and Assessing Risk

The questions listed below may help organizations identify and assess risk when building a QC workflow. This is by no means a standard or comprehensive look at identifying/assessing risk. Rather, it presents illustrative questions that MDPI found helpful in developing its QC workflow.

1. How much automated QC can be put into place?

Automated QC can easily provide checks on 100% of files delivered. It is also used to perform checks on points that software can handle more quickly and with greater accuracy than human beings. Using it on a daily basis is not costly. Therefore, as much automated QC should be developed as resources and expertise allow.

2. How much human-intensive QC is needed?

The answer might depend on the kind of material digitized. For example, a collection of open reel tapes recorded for radio broadcast may require less human-intensive QC than a collection recorded in the field. Radio collections are typically recorded by professionals using pro machines and tape stock in a professional setting. They are recorded in a standard, consistent way in terms of technical characteristics. Conversely, field recordings may be recorded anywhere by academicians who have little or no recording experience. Field collections are often heterogeneous and may contain anomalies such as changes in speed or reversed audio that may or may not be intentional. Field collections may require more human-intensive QC to validate that these problems were either not present or were found and resolved during digitization.

3. Where are the judgment calls in the QC workflow?

Workflow steps that require digitization operators to make choices, judgment calls, or interpretive decisions need human-intensive QC to evaluate their accuracy. For example, chroma adjustments for digitization of a videotape rely, in the absence of reference color

bars, upon the operator's interpretation of proper saturation and hue levels that are the most natural looking and accurate.

4. What can go wrong in a workflow? What do we think cannot go wrong?

It is useful to list all of the steps in a workflow in which something can go wrong. This list may be expanded and refined based on experience as the project proceeds. It is also helpful to list workflow steps in which we believe there is little or no chance of error. If such steps exist, they may require fewer QC resources.

5. Are QC resources limited? How can they be allocated most effectively?

It may help to determine the relative value of content to support effective allocation of resources.

6. What risks are acceptable? Which ones are unacceptable?

Answers to these questions are specific to an individual institution's goals, available resources (including funding and expertise), and designated uses of the digitized content.

5.   Conclusion

It is critical to acknowledge and confront the risks inherent in digitization work for the sake of future staff who must manage preserved content and for future researchers who must rely on the content for their inquiry. Although it is not possible to remove or reduce all risk associated with media digitization, it is feasible to manage risk through the QC system to give a high level of confidence that the products of digitization meet a designated specification. Using procedures for transferring, avoiding, reducing, and accepting risk enables staff to find problems, prevent problems, reduce the likelihood that problems will occur, and understand areas in which a small number of problems are acceptable. Understanding the types of QC available, and how to implement them, helps stretch and focus scarce resources. All of this engenders trust in the output of the digitization process.

Thanks to Patrick Feaster for his assistance with this article.

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Microservices in Audiovisual Archives: An Exploration of Constructing Microservices for Processing Archival Audiovisual Information

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Abstract

Properly managing audiovisual archival material requires identifying, using, and possibly creating the right tools and workflows to facilitate archival objectives. In creating these workflows, two models are possible. One model is the monolithic architecture, which includes complex all-in-one systems (for instance, a comprehensive digital asset management system). Another model is the microservice architecture, which combines independent tools into a loosely coupled system based upon common underlying standards and understandings. In a microservice architecture, an individual tool may be added, replaced, or upgraded independently of the other tools.

This document describes and examines strategies for designing lightweight microservice environments for the processing of digital, file-based, audiovisual data within an archive. It guides the reader through the design of a simple example microservice architecture by establishing foundational archival frameworks for microservice design, describing examples of packages and microservices tailored to audiovisual archives, and finally demonstrating an end-to-end workflow.

This document does not intend to be a standard for the design of audiovisual microservices, but seeks to contribute a use case to the work and dialogue of many audiovisual archives exploring and implementing microservice structures; see in particularly the compiled, collaborative documentation at https://github.com/amiaopensource/open-workflows. This document presumes an overview understanding of the Reference Model for an Open Archival Information System[1] (OAIS). Since the document intends to focus on archival routines for audiovisual content, an introduction to FFmpeg[2] can also be helpful.

Microservices and Monoliths

Properly managing audiovisual archival material requires identifying, using, and possibly creating the right tools and workflows to facilitate archival objectives. Such tools may include various independent utilities that change based on the material; for analog video media, this might include cleaning supplies, a video tape player, a time base corrector, or a video card for digitization. Archives of analog media are generally rich with discrete tools independently selected for their own focused objectives. These items may more or less be selected independently and combined into a loosely coupled system, based upon common underlying standards and understandings. An individual tool may be added, replaced, or upgraded independently of the other tools.

Alternatively, a tool could be in the form of a complex all-in-one system, for instance a comprehensive digital asset management system or an archival vendor that cares for multiple aspects of a project. Archives of digital media, for which tasks can be more easily automated, present the opportunity to integrate tools into a single centralized system.

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1   https://public.ccsds.org/pubs/650x0m2.pdf
2   https://www.ffmpeg.org

This system can manage multiple tasks through a single application and provide a comprehensive, foundational environment for archival workflows. For example, a complex digital asset management system may be able to facilitate cataloging, digitization, transcoding, and access as a single, self-contained product, thereby clustering the objectives of several tools into a singular, comprehensive system.

These descriptions illustrate the difference between **microservice architectures** and **monolithic architectures** as applied to an audiovisual archive. Both styles have distinct opportunities and challenges. A monolithic system, such as a complex digital asset management application, may suggest reliability and efficiency, as control of each task is integrated under a single company's umbrella. However, if the monolith contains some strong functions and some weak functions, it may be difficult to adapt the architecture to an archive's preferred workflow, or remix the monolith with other, preferred tools. The addition of a plugin architecture or API may allow the application to integrate new objectives and roles, but in such an application individual tools do not operate independently of the product.

In a microservice architecture, on the other hand, many tools that accomplish discrete, bounded tasks—each task a "microservice"—are combined into archival workflows like links in a chain. The customizability of such a workflow structure requires independent knowledge of each tool and its functions, the field's standards and best practices for each task, and the ground-up construction of an archive's workflows. Microservices may therefore necessitate a much more comprehensive understanding of all tools and objects involved, and present greater risks to the archive if misunderstandings are integrated into the design. Nonetheless, a microservice-based archival environment supported by the archive's staff and/or related communities may be easier to independently evolve over time, and may be easier to steer or customize to the unique needs of its collections or its organization.

Both systems work to accomplish the objectives of an audiovisual archive: to preserve, manage, and make accessible its archival materials. The customizability of a microservice architecture should not imply that monolithic architectures are inherently less suited to archival administration. Some of the reasons to favor popular monolithic architectures include situations when an archive wants to use a tool that is known to be compatible and comprehensive, or when the workflow defined by a monolithic architecture matches the goals of the workflow defined locally by the archive. However, there are situations where a microservice approach is favorable. Such situations may include:

- when the design of workflows is required to be agile and responsive to serve its target communities, whose evolving needs may demand continuous development, flexible scaling, and a shortening of the time between software development and release;
- when the staff of the archive has or is willing to acquire comprehensive technical knowledge of its objects, processes, and tools, and/or desires to work with a provider that empowers the archive to implement highly customized workflows based on this technical knowledge;
- when different archival communities and institutions wish to pool resources in a collaborative, open source approach to preservation workflows;
- optionally, when the responsibility for the function, maintenance, and design of archival functions is appropriate to rest on the archive's personnel rather than an outsourced company;
- when the opportunity for a monolith is not worth the cost of a long-term investment, such as when the work is managed in a temporary state or the evolution of technology is paced such that the archive must be prepared to examine and replace its tools and components on an ongoing basis.

The administrator of the archive who works on a web of microservices, as opposed to within the boundaries of a monolith, encounters unusual opportunities for creativity as well as constraints. In his book *Code 2.0*, Lawrence Lessig offers a comparison between the coded reality of Second Life and real-world legal systems. He describes how, in the real world, it typically constitutes illegal nuisance and/or trespassing to fly an airplane at a low height over someone's private property, but airplanes are free to fly at a high height over the same property. He describes how in Second Life any character may fly at a height of more than 15 meters over someone else's virtual land, but may only move in the space from 0-15 meters over someone else's land if enabled to do so by the landowner's settings. Lessig describes:

> But notice the important difference. In real space, the law means you can be penalized for violating the "high/low" rule. In Second Life, you simply can't violate the 15-meter rule. The rule is part of the code. The code controls how you are in Second Life. There isn't a choice about obeying the rule or not, any more than there's a choice about obeying gravity.

> So code is law here. That code/law enforces its control directly. But obviously, this code (like law) changes. The key is to recognize that this change in the code is (unlike the laws of nature) crafted to reflect choices and values of the coders.[3]

The monolith may present a similar experience as Second Life, where the options and opportunities may be bounded by what is in code that is uncontrolled by the archive; for instance, the options allowed in a particular decision may be fixed within a drop-down menu of an interface, or a yes/no dialogue box, and limit opportunity.

This document will describe and examine strategies for designing lightweight microservice environments for the processing of digital, file-based, audiovisual data within an archive. It presumes an overview understanding of the Reference Model for an Open Archival Information System (OAIS). The document also makes references to programming archival routines in command languages, but seeks to provide examples in pseudo-code rather than favoring any particular computer language. Since the document intends to focus on archival routines for audiovisual content, a basic introduction to FFmpeg may be helpful.

Though this document does not address cross-archives collaboration in detail, it is important to note that microservice-based archival designs are often more successful when employing collaboration amongst archival communities and open source approaches. Many examples of open, archival microservice documentation may be found at https://github.com/amiaopensource/open-workflows. This document does not intend to purport to be a standard for the design of audiovisual microservices, but seeks to contribute to and build upon this successful dialogue and implementation across audiovisual archives.

1. Building Microservices with the Open Archival Information System Reference Model

The Open Archival Information System (OAIS) reference model defines mandates, objectives, and methods for archives, and provides a clear set of guidance to the design of both monolithic or microservices systems. The OAIS documentation also provides a set of vocabulary for describing basic components and functions within an archive, as

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3   Lessig, Lawrence. 2011. http://codev2.cc/download+remix/

well as a structure that divides workflow between submission, dissemination, and archival management. The workflows that bridge these states are referred to as Ingest, in which a submission is moved into a state of archival management, and Access, in which content is moved from archival management to dissemination. The content in its form before ingest workflows, within archival management, and after access workflows is called the Submission Information Package (SIP), Archival Information Package (AIP), and Dissemination Information Package (DIP), respectively.
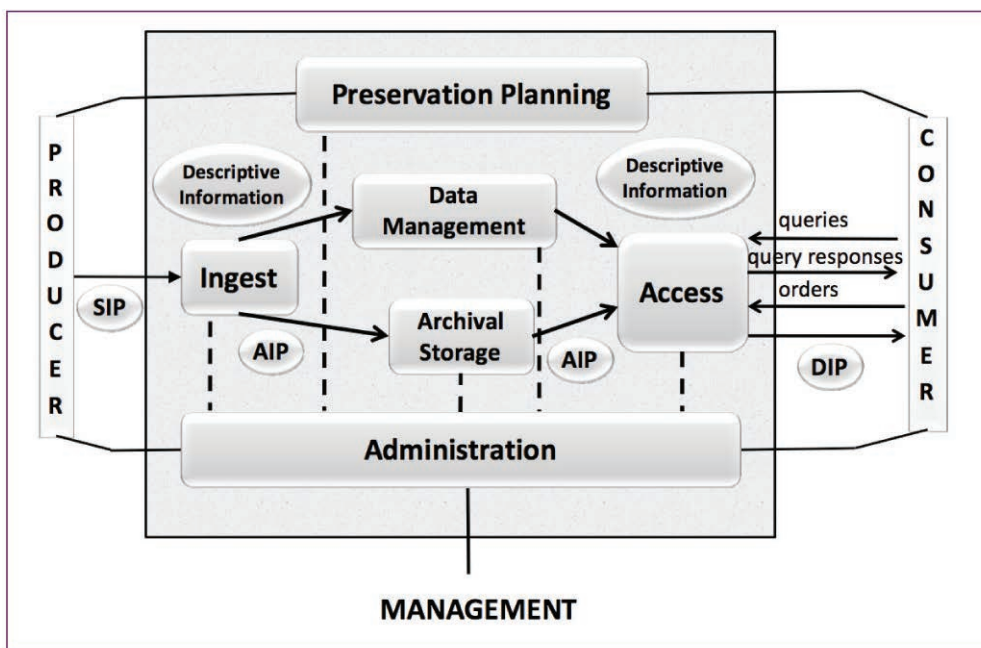
"Figure 4-1: OAIS Functional Entities." From Consultative Committee for Space Data Systems, Reference Model for an Open Archival Information System (OAIS), Recommended Practice, CCSDS 650.0-M-2 (Magenta Book). Issue 2, June 2012.

An archive will likely conceive and define several forms of SIPs and DIPs for different purposes. If an archive is too open or undefined in regards to the expectations of the SIP, the Ingest process and subsequent archival management of the content may be harder to automate as it becomes less clear what can be expected. Some archives may be able to constrict submission into a single form, but often the diversity of incoming content and its creators necessitates a short list of SIP definitions to accommodate different workflows. Likewise, an archive may need to support multiple types of access, such as supporting access to audiovisual content in the form of a web stream for the public or as a higher quality file for production work.

1.1 SIP Definitions

Content Information[4] arriving at or created within an archive for preservation may be considered a Submission Information Package (SIP). In its analog equivalent, a SIP could be something simple and self-contained such as a videotape with a handwritten label, or it may be more complex, such as a collection of media objects accompanied by submission documentation. A digital SIP, by comparison, could arrive as a set of video files with embedded metadata or as a chaotic collection spread across many hard drives. An archive receives SIPs from submitters, who may be creators (such as producers in a broadcast archive) or donors (common in cultural heritage organizations).

Requiring too little information or context to accompany a qualifying SIP could cause risks or confusion in the ongoing management of the Content Information. On the other hand, mandating too much information may bottleneck the Ingest process or burden submitters. It is recommended that the structure, form, and minimal requirements of a SIP are defined in collaboration between the archive and the submitters. There may be worthwhile reasons to make controlled customizations to SIP definitions for different Ingest workflows. Employing the concept of locally defined SIPs during the acquisition of content helps arrange content more precisely, so that the boundaries between one SIP and another is clarified, so that more automation is feasible, and so that there may be a greater awareness of the state or quality of the SIP.

In audiovisual archives the SIP is generally composed of audiovisual media (Content Information) and supporting metadata (Preservation Description Information). For analog formats, the media and metadata may be physically attached—for example, labels on a videocassette—but metadata could exist as separate documents or even emails that provide information about the media. With some digital audiovisual collections, that metadata may be wholly embedded within the file (such as EXIF or IPTC data for images, or ID3 tags for audio), but it is more likely that archives will receive media with supplemental metadata as separate forms or files when obtaining a SIP.

OAIS requires archives to establish a SIP Definition to clarify the requirements and recommendations for SIPs. For instance, an archive may require that certain paperwork or a web-form must be completed for each SIP with pertinent data such as the identifiers, title, description, and access rights. Archives may also mandate that the media contained in a SIP adhere to a predefined list of formats that the archive is prepared to manage. The SIP Definition should also distinguish the media (Content Information) from the supporting metadata (Preservation Description Information) in a manner that is unambiguous and clear. Furthermore, the SIP Definition should establish the boundaries between one SIP and another clearly, for example defining whether a directory containing a single collection of multiple media files constitutes one SIP or a set of multiple SIPs.

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4   'Content Information' is defined by the OAIS as "A set of information that is the original target of preservation or that includes part or all of that information."

A selection of recommendations for SIP Definitions that are useful in building Ingest work-flows includes:

- Define what forms of media (whether analog or digital) are accepted
- Define what metadata types are required and recommended
- Define what form the metadata should be provided in, such as paperwork, xml, csv, informal text)
- Define the structure for digital media delivery (e.g., whether files should be grouped into directories to represent a form of organization or semantics)[5]

1.2   SIP + *?* = AIP

Why can't the SIP simply become the AIP?

The OAIS reference model states that the SIP alone is not well-prepared enough to be considered for long-term storage, and is thus not suitable to automatically be considered as an AIP (Archival Information Package). The SIP is missing pertinent Preservation Description Information, which consists of four categories of metadata (provenance, context, reference, and fixity) and includes information such as checksums, identifiers, or preservation action documentation. Many of these values must be generated during the Ingest process. The Content Information of a SIP may also require some review or quality control work to ensure that the data is as it should be, is not malformed, and is identified correctly. The AIP should add what is needed for readiness for long-term storage and a status of permanence. AIPs generally will require information for reference, provenance, fixity checking, and access rights, even if this information was not part of the SIP.

For audiovisual materials, the AIP may also add specifics such as technical metadata reports (such as those produced by FFmpeg or MediaInfo), frame checksums (such as produced by `ffmpeg -i INPUT -f framemd5 -an OUTPUT.framemd5`), and possibly derivatives. Whereas non-audiovisual file formats may support quick generation of DIPs (such as derivatives); audiovisual content is often very large and more time-consuming to process, thus there is more of an incentive to generate DIPs in the process of generating the AIP.

1.3   DIP Definitions

Content Information being passed to the user is usually normalized and compressed from the Content Information as submitted (i.e., the original content packaged within the SIP and AIP). It is often packaged and delivered with the same metadata from the AIP.

The DIP is relatively simple; it can consist of as little as a derivative and a metadata file. Considered within the frame of microservices, it is also simple to generate, as it requires only a consistent access-level file and a pre-existing metadata file. However, it is worth attention at the time of Ingest actions, as it is simple to generate derivatives from Content Information files to have on hand for quick access if this task is performed within the chain of Ingest microservices.

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5   An example of Archivematica's definition of a SIP Structure may be found at https://wiki.archivematica.org/ SIP_Structure. Archivematica will be discussed in greater detail below.

1.4 An OAIS-like Example: YouTube

To provide an example of the SIP to AIP transformation, let us consider YouTube. The submission interface of YouTube offers a very controlled method for providing a SIP. Here the SIP includes exactly one audiovisual file plus a controlled set of metadata including:

- Title
- Description
- Tags
- Privacy Status
- Category
- License

While the YouTube SIP may simply be a single media file (Content Information) and a webform entry (similar to Preservation Description Information), YouTube generates and gathers a substantial amount of additional information in order to prepare for long-term storage, management, and access for the content. These additions may include:

- Automated captions
- User reviews
- Content flagging
- Several derivatives of various sizes and media formats
- Embed codes and short urls
- Assessment of audio watermarks
- View count and statistics on use
- Technical metadata

YouTube's methods to convert their SIPs into "AIPs" add a significant amount of information to the package in order to increase the functionality, accessibility, and reuse of the material. However, the original Content Information is often transcoded to YouTube's standards, and the closest to Preservation Description Information that YouTube's package comes is the Access Rights and Context implied by the video's availability on YouTube. Ultimately, this added information does not conform to the OAIS AIP specifications, and YouTube's packaging procedure comes closer to producing a DIP.

1.5   An OAIS-like Example: Internet Archive

The Internet Archive (archive.org) manages a more flexible SIP definition than YouTube. Here the submission process offers many more metadata options, including comprehensive opportunities to provide customized metadata. Additionally, the archive can access multiple files within a single SIP. The Internet Archive provides some transparency to its techniques for processing a SIP into an AIP.

For example, let us consider this Internet Archive item as an AIP: https://archive.org/details/umatic_controlled_damage

- All contents (including both Content Information and Package Description Information) may be found at https://archive.org/download/umatic_controlled_damage
- The archive adds a manifest that documents checksums and file attributes for all files: https://archive.org/download/umatic_controlled_damage/umatic_controlled_damage_files.xml
- This document also lists whether a file was considered part of the original submission (source="original") or if it was created by an Internet Archive microservice (source="derivative"). The package also maintains an XML file that concentrates all descriptive information for the package, found at: https://archive.org/download/umatic_controlled_damage/umatic_controlled_damage_meta.xml
- The processing history of that AIP since the Ingest started can be found at https://archive.org/history/umatic_controlled_damage. From this location, an archivist may review the logs of each microservice applied to the package and perform a comprehensive audit of all processing actions.

1.6   An OAIS Example: Archivematica
Finally, Archivematica is an example of a digital preservation system explicitly based on the OAIS reference model. Archivematica offers a package of free and open-source tools for digital preservation, including ingest, storage, and access to digital archival content.[6] Archivematica's SIP is highly structured, to the point where inclusion of certain files (such as metadata files) trigger specific workflows (in this case, processing by the Archivematica system).[7] Documentation is clear and publicly available on the Archivematica Wiki.

The process of turning this SIP into an AIP is similarly highly structured and includes reorganizing SIP content, generating metadata, and performing audits of the SIP and AIP. The final version of the AIP is packaged in accordance with the Library of Congress Bagit specification; the "data" directory includes the original content, logs from the Archivematica Ingest process, thumbnails for access, and a file with metadata. A full sample AIP structure can be found at https://wiki.archivematica.org/AIP_structure.

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6   "What is Archivematica?," *Archivematica documentation*, Artefactual Systems Inc., 2019. https://www.archivematica.org/en/docs/archivematica-1.9/getting-started/overview/intro/#intro

7   "SIP Structure," *Archivematica development wiki*, Archivematica contributors, 30 Mar. 2017. https://wiki.archivematica.org/SIP_Structure

2. Expressing Package Definitions and Considering Storage

Because monolithic digital archiving systems manage most or all aspects of archival packaging and storage, archivists are not always required or able to define the structure and storage location of the AIP. These attributes may be defined behind-the-scenes or be described in system documentation.

Without a monolith, it becomes more pertinent for the archive to define and describe its Information Packages clearly in order to build microservices upon the expectations and standardization that the package definitions can bring. In addition, the ability to standardize Information Packages from the ground up also allows the archivist to craft standardized microservices that hook neatly into the structure of the Information Package. Shaping an Information Package according to the needs of the archive then empowers the archivist to create workflows that similarly address the needs of the archive. By the end of such a process, the archive can be powered by chains of microservices linked together, building on each other and on the Information Packages they define.

2.1 Guide to Pseudo-Code

The OAIS reference model is a framework with a wide range of possible implementations, not a prescriptive template. However, in order to describe relationships between packages and microservices in a practical way, this paper will provide the reader with concrete examples of packages and microservices. Examples throughout the paper are drawn from and based on the set of microservices in use in the archives of City University Television (CUNY TV), the television station of the City University of New York.

For the sake of expressing package definitions through this document, the following pseudo-code system is proposed:

- By default names represent the path of a **file** of an Information Package.
  - □ Names ending in a '/' represent a **directory**.
- Components of names wrapped in '{}' (curly brackets) and preceded by a '$' represent variables that would be conditional to each Information Package.
- Components of names followed by an '*' (asterisk) indicates that the file is separately stored from the rest of the Content Information.
- Names wrapping in '[]' (square brackets) represent data that is not stored as a file, such as a database record. The use of square brackets also indicates that the data is separately stored from the rest of the Content Information.
- Names may be followed by the following flags that are wrapped in '()' (parentheses) and are comma-delimited.
  - □ 1: indicates that exactly one occurrence of the data is required
  - □ ?: indicates that zero or one occurrence of the data is required
  - □ +: indicates that more than one is allowed

For instance, a SIP definition for a single file and an associated web-form record could be expressed as:[8]

Submission Information Package Expression (Example 1)
```
${CONTENT} (1)
[web-form-record] (1)
```

If the received content is then received and arranged to create an Archival Information Package which stored in a directory structure that arranges the data, the result may appear as follows:

Archival Information Package Expression (Example 2)
```
${PACKAGE-UUID}/content/${CONTENT} (1)
${PACKAGE-UUID}/metadata/web-form-record.txt (1)
```

A more complex Archival Information Package for video files may appear as follows:

Archival Information Package Expression (Example 3)
```
${PACKAGE-UUID}/content/${CONTENT} (+)
${PACKAGE-UUID}/metadata/web-form-record.txt (1)
${PACKAGE-UUID}/metadata/logs/ingest.txt (1)
${PACKAGE-UUID}/metadata/technical-metadata.txt (1)
${PACKAGE-UUID}/metadata/checksums.md5 (1)
${PACKAGE-UUID}/metadata/mets.xml (1)
[database record of descriptive metadata] (1)
```

Alternatively, in cases when the archive intends to store technical metadata and records of preservation events in a database as opposed to a package, the same data could be defined as:

Archival Information Package Expression (Example 4)
```
${CONTENT _ UUID} (+)
[web-form-record] (1)
[database event record of ingest process] (1)
[database object record of technical-metadata] (1)
[database object record of checksums] (1)
[database record of METS data] (1)
[database record of descriptive metadata] (1)
```

The Dissemination Information Package made at the same time as these AIPs might hold derivatives, their logs, and descriptive metadata to guide the user.

Dissemination Information Package Expression (Example 5)
```
${PACKAGE-UUID}/derivatives/web/${CONTENT}.mp4 (+)
${PACKAGE-UUID}/derivatives/edit/${CONTENT}.mov (+)
${PACKAGE-UUID}/metadata/logs/make-web-derivative.txt (+)
${PACKAGE-UUID}/metadata/logs/make-edit-derivative.txt (+)
[database record of descriptive metadata] (1)
```

---

8   The names used here are provided as examples and not necessarily recommendations.

2.2 Separating Content Information and Preservation Description Information

The AIP is a theoretical concept with many different implementations, none of which are required to be wrapped up in a literal package; the examples above present methods of separating Content Information from Preservation Description Information. Examples 3 and 4 describe identical content, just packaged differently. (A migration from example 3 to example 4 would comprise a lossless repackaging.) In Example 3, the package is relatively self-contained, consisting of a directory structure with original content files and supporting technical and administrative metadata (part of the Preservation Description Information, which includes records of preservation actions taken). The descriptive metadata alone is stored in a separate database, constituting Descriptive Information. Example 4 expands on the separation of the AIP by moving the original content into preservation storage, pre-created derivatives into a different storage system, and all metadata (descriptive, administrative, and technical) into database records.

Separating content from metadata in storage can be a necessity for audiovisual collections, due to relatively larger data storage and cost requirements. For instance, an archive may determine that larger original content should be stored on lower cost LTO tapes, while the derivatives remain in online storage because of its greater priority for access. This scenario optimizes storage, but increases the need and potential risks involved in ensuring that all links between the components of the AIP are well-maintained and understood. For instance, the discovery of a descriptive metadata record for a package in a database should inform as to the location and identity of the package that it describes. Similarly, the package in storage should indicate and reference the related set of descriptive information.

In both examples 3 and 4, the descriptive metadata is stored in a separate database, which allows the description to evolve over time as the archive learns more about the content, changes description standards, or corrects information (in contrast to the content of the Archival Information Package, which is considered a permanent set of data that is not to be changed). With this separation, the AIP could be moved into offline storage, such as LTO tape, as there is minimal or no reason for the archive to change the package.

2.3 Defining Expected Files

In the process of defining package definitions, an archive should also set standards for the files they expect and create for preservation and access. If the archive specifies that all video files for preservation should be wrapped in Matroska and encoded using FFV1 and FLAC, the archive can verify that the files stored for long-term preservation or access conform to these standards by writing a file format policy. For example, a file intended for broadcast can be compared to a standard broadcast file definition, or policy,[9] with tools such as MediaConch.[10] A file successfully validated against a policy is then shown to be compliant with local standards.

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9   See a sample broadcast policy at https://github.com/mediamicroservices/mm/blob/master/makebroadcast_policies.xml

10 See a description of how MediaConch policy implementation works at https://mediaarea.net/MediaConch/Documentation/HowToUse

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3. Microservices for Ingest

3.1 Roadmap for Ingest

Having clear documentation on how Information Packages can be stored or arranged is essential for microservice development and the development of storage strategy. To deploy each microservice, one will need to understand:

- If the input is indeed a Package,
- If the Package is malformed or valid,
- If the Package qualifies for the microservice called,
- If the microservices has already been applied to the Package or not,
- Where to find any information needed to initialize the microservice (context or user-selected options), and
- Where to store resulting data and where to log resulting information.

Audiovisual archives can perform Ingest actions on their content either manually, or using tools and libraries developed to address audiovisual media. Some of these tools include `mediainfo` and `exiftool`, which report values for embedded metadata; `mediaconch`, which can report whether audiovisual files conform to predefined technical specifications, among other functions; and `ffmpeg`, a suite of libraries and programs that can perform a wide range of tasks on audiovisual files (including `ffprobe`, the metadata reporting component of FFmpeg). Tools that monitor fixity do not have to be specific to audiovisual media; for example, `hashdeep` is a command line utility that can recursively generate checksum reports from directories in order to produce a comprehensive manifest. The utility `bagit` could also be considered to fulfill this role.

Following are a series of example microservices for Ingest.

3.2 Validating a Submission Information Package

Submission Information Package structures should be defined by the archive, and validated according to that definition. For an example, see `Submission Information Package Expression (Example 1)` in this paper.

ValidateSubmissionPackage
As part of archival management, a validation process for packages must be created in order to support any ongoing testing, auditing, or review of the status and health of the packages created. Validating Submission Information Packages is the first step in ensuring a successful preservation workflow, giving the archivist the ability to identify malformed or incomplete submissions early.

Microservice Steps:

1. Receive Content Information (for example, a video file) and Preservation Description Information (for example, a web form entry) through a submission form, command line interaction, or other mechanism.
2. Verify that checksums are created and/or documented for all files that need them.
   a. If checksums are not created, generate checksums using `MakeChecksums` (detailed in next section).
3. If the SIP structure is validated according to local definitions, conditionally pass the SIP straight into technical metadata generation (in next section).

3.3 Generating Preservation Description Information

These microservices generate or report metadata that are expected in the Preservation Description Information section of the AIP.

MakeChecksums
This microservice generates checksums. It is most obviously applicable to Content Information, which must be monitored for fixity throughout its preservation life, but it may be applied to other directories or files. Because of this flexibility, it may be called again within other microservices and not just as a single step in the workflow.

Microservice Steps:
1. Accept an Information Package as an input (such as a SIP validated by `ValidateSubmissionPackage`).
2. Determine if the output of this microservice is already created or not in need of update, and if so stop proceeding.
3. Iterate through all Content Information files within the `./content` subdirectory (and optionally through the `./derivatives` subdirectory) and generate checksums to document all such files.

Example: Creating a sha256 checksum manifest with hashdeep using relative links
```
hashdeep -c sha256 -rl ${CONTENTS _ DIRECTORY}
```

MakeDFXML
In addition to support the writing of simple checksum manifests that list the file name and associated checksum, hashdeep can also produce DFXML files (Digital Forensics XML). The advantage of a DFXML report over a checksum manifest is that the DFXML includes file attributes, file sizes, file dates, and information about the environment in addition to the filenames and checksums. Such contextual information can be very helpful to assessing or resolving checksum mismatches at a later point.

Microservice Steps:
1. Accept an Information Package as an input (such as a SIP validated by `ValidateSubmissionPackage`).
2. Determine if the output of this microservice is already created or not in need of update, and if so stop proceeding.
3. Iterate through all Content Information files within the `./content` subdirectory (and optionally through the `./derivatives` subdirectory) and generate DFXMLs to document all such files.

Example: Creating a DFXML with md5 with hashdeep using relative links
```
hashdeep -c md5 -drl ${CONTENTS _ DIRECTORY}
```

MakeTechnicalMetadata
This microservice extracts values for technical metadata embedded within the Content Information files. It can exist as a single microservice that generates a standardized series of metadata reports—for example, multiple logs (generated by multiple tools) for all Content Information files. It can also exist as a set of smaller microservices that generate logs from only tool, which can then be selected or combined as needed based on the Content Information's file type or purpose.

Microservice Steps:

1. Accept an Information Package as an input (such as a SIP validated by `ValidateSubmissionPackage`).
2. Determine if the output of this microservice is already created or not in need of update; if so, stop proceeding.
3. Iterate through all Content Information files within the `./content` subdirectory (and optionally through the `./derivatives` subdirectory). Generate a technical metadata report to document all such files, using one or more reporting tools such as `ffmpeg`, `ffprobe`, `mediaconch`, `mediainfo`, and `exiftool`.

The technical metadata reported in this microservice may be used to make decisions within other microservices. For instance, the FFmpeg command used in `MakeWebDerivative` may be different depending on metadata such as the audio channel layout. Because FFmpeg can act as both a reporting and a processing tool, it may be more consistent to instead use `ffprobe` in the generation of technical metadata. (FFprobe and FFmpeg are derived from the same source library.) If `mediainfo` and `ffmpeg` differ on an assessment of a file, using FFprobe would avoid incorporating any processing logic into an FFmpeg command.

Example: Creating an XML with FFprobe
```
ffprobe ${INPUT_FILE} -show_format -show_streams -show_data
-show_error -show_versions -show_chapters -noprivate -of xml=q=1:x=1
> ${TECHMD_FFPROBE}
```

Example: Creating an XML with MediaInfo and MediaTrace data with MediaConch
```
mediaconch -mi -mt -fx ${INPUT_FILE} | xml fo > ${TECHMD_MEDIACONCH}
```

Example: Creating an XML to document the files and directories within a section of a package with `tree`
```
tree -DaNXs --du --timefmt "%Y-%m-%dT%H:%M:%SZ" ${PACKAGE_SECTION} >
${TREE_XML}
```

3.4 Creating and Validating an Archival Information Package

In Section II, we looked at example Information Package structures, with a SIP represented in Example 1 and an AIP represented in Example 3. In these examples, as in all successful implementations of SIPs and AIPs, all data from the SIP (Example 1) is stored within the AIP (Example 3) in a way that provides context to the role of each file. However, the AIP contains many new pieces of information that were not part of the SIP, but are added to support long-term storage and maintenance of the SIP's content. The added data infers that several workflows or programs (microservices) were applied to the content. There are many routes that may be developed or established to get from the defined SIP of Example 1 to the defined AIP of Example 3; the below microservices illustrate one route to creating and validating the AIP.

PackageContent
This microservice accepts Content Information and Preservation Description Information and organizes them into a subdirectory structure, in order to clarify the role of each piece of data within the package.

Microservice Steps:

1. Gather or request any additional data required by the archive for the initial genera-tion of an AIP; for example, logs created in the process of running microservices.
2. Verify that the file as submitted adheres to archival preservation standards, for example checking that the audio codec, video codec, and important technical meta-data values match the preservation file profile defined by the archive.
3. Create a unique Package Identifier based on (for example) the filename or media identifier from the Preservation Description Information submission. Create a di-rectory based on that identifier.
4. Create sub-directories `./content` and `./metadata` and file the Content Information and Package Descriptive Information within those directories.

ValidateArchivalPackage

Archival Information Packages will require more extensive validation than those of Submission Information Packages, considering the amount of Preservation Description Information generated. During the growth of a digital archiving program, the tests and checks within a validation procedure may be extended and expanded to cover more and more specific checks. The list below presents some tests that such a microservice may consider.

Microservice Steps:

1. Verify that checksums are documented for all files that need them, as defined by the archive's local policy for Archival Information Packages.
2. Verify that checksums are accurate to all files by regenerating the same checksums with the same algorithm and comparing it to the ones stored; this may be accom-plished by calling the `MakeChecksums` microservice and comparing its output with the previous `MakeChecksums` output.
3. Check to make sure that all anticipated microservices have properly run. This check can be accomplished by using a Bash file test operator[11] to check that all anticipated output file and directories are present, or by using exit codes to evaluate the suc-cess or failure of operations.

ValidateDisseminationPackage

It is efficient to generate derivative files for Dissemination Information Packages at the same time as Archival Information Packages; these derivatives should also be checked for conformance to local specifications.

1. Verify that the files generated by the microservices adhere to locally-set derivative specifications. For instance, check if the output of `MakeWebDerivative` uses the H.264 video codec and AAC audio codec as defined by local plicy.
2. Verify that checksums are accurate to all files by regenerating the same checksums with the same algorithm and comparing it to the ones stored; this may be accom-plished by calling the `MakeChecksums` microservice and comparing its output with the previous `MakeChecksums` output.

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11   See, in particular, the -f, -s, and -d tests as described here: https://www.tldp.org/LDP/abs/html/fto.html

3.5 Creating Derivatives

Other microservices generate derivatives from Content Information files to have on hand for quick access. In this case, derivatives are included within a DIP rather than an AIP, as local conventions on access files can change over time and complicate the validation of the AIP itself.

MakeWebDerivative

This microservice uses Content Information from the package to create a derivative using FFmpeg for packaging in the DIP. A derivative created during the creation of the AIP can then be stored for quicker access to the content, rather than requiring that a derivative be created at the time of a request for access. In this microservice example, a derivative will be created to deliver content on the Web.

Microservice Steps:

1. Accept an Information Package as an input (such as the output of `PackageContent`).
2. Identify what data to use as a source in the creation of a derivative. In this case, the source can be identified as the file within the `./content` subdirectory.
3. Identify if the anticipated output already exists. If so, stop proceeding.
4. Create a unique Package Identifier based on (for example) the filename or media identifier from the Preservation Description Information submission. Create a directory based on that identifier, with something to signify the package's status as a DIP.
5. Create a new subdirectory (if none already exists) in the package to store the anticipated derivative. In this example, the service directory is called `DIP/derivative/web/`.
6. Create a new subdirectory (if none already exists) in the package to store the the log associated with making the anticipated derivative, in this case `DIP/metadata/logs/`.
7. Use FFmpeg with the source file from the AIP's `./content` subdirectory to create a web-optimized derivative in the `DIP/derivative/web/` directory.
8. Generate checksums for derivatives using `MakeChecksums`.
9. Log the FFmpeg process and other aspects of the microservice's event into a log file within `DIP/derivative/web`.

Strategies for generating derivatives should negotiate the processing opportunities of the archive, access systems to be deployed, and the potential needs of the communities potentially served with this content. Currently, web-ready derivative profiles include H.264 video with AAC audio in an MP4 container (as implemented in the example), or VP9 video with Opus audio in a WebM container.

Example: Creating a Web-ready derivative

```
ffmpeg -i ${CONTENT _ INPUT} -c:v libx264 -movflags faststart -pix _ fmt
yuv420p -crf 18 -c:a aac -ac 2 {WEB _ DERIVATIVE}.mp4
```

MakeEditDerivative

`MakeWebDerivative` is very similar to `MakeEditDerivative`, except that the process generates a derivative prepared for a different type of access, such as file transfer or editing. Whereas `MakeWebDerivative` aims to generate a derivative well-prepared for use in web streaming and access, this microservice run through the same steps but could use au-

diovisual encodings and container formats prepared for likely editors or production staff.

Microservice Steps:

1. Accept an Information Package as an input (such as the output of `PackageContent`).
2. Identify what data to use as a source in the creation of a derivative. In this case, the source can be identified as the file within the `./content` subdirectory.
3. Identify if the anticipated output already exists. If so, stop proceeding.
4. Create a unique Package Identifier based on (for example) the filename or media identifier from the Preservation Description Information submission. Create a directory based on that identifier, with something to signify the package's status as a DIP.
5. Create a new subdirectory (if none already exists) in the package to store the anticipated derivative. In this example, the service directory is called `DIP/derivative/edit/`.
6. Create a new subdirectory (if none already exists) in the package to store the the log associated with making the anticipated derivative, in this case `DIP/metadata/logs/`.
7. Use FFmpeg with the source file from the AIP's `./content` subdirectory to create a web-optimized derivative in the `DIP/derivative/edit/` directory.
8. Generate checksums for derivatives using `MakeChecksums`.
9. Log the FFmpeg process and other aspects of the microservice's event into a log file within `DIP/derivative/edit`.

Operations for generating files for editing use should consider the needs and systems of those likely to request such derivatives. Additionally, the archive should consider whether creating a derivative for editing use is necessary, as the Content Information files may be appropriate to edit as-is.

Example: Creating an edit-ready derivative
```
ffmpeg –i ${CONTENT_INPUT} -c:v prores_ks –profile:v 3 –flags +ildct+ilme
-c:a pcm_s16le {EDIT_DERIVATIVE}.mov
```

3.6 Event Logging

The OAIS reference system requires that preservation events, or the actions and outcomes of microservices, be logged and included as a component of the AIP's Preservation Description Information. Such logs provide details regarding preservation events and can be particularly helpful when the processing of AIPs requires auditing. For example, if a microservice under a particular version and/or scenario is later discovered to be flawed, having records of what versions of what microservices were run on what packages with what options can help the archive better react to bugs as they are discovered and corrected.

The Preservation Metadata: Implementation Strategies (PREMIS) metadata standard defines a structure for event logging and documents the following concepts:

PREMIS Event Element	Context in microservice logging
`eventIdentifier`	A unique identifier to refer to the event.
`eventType`	A general classification of the sort of event. See, for example, the vocabulary at http://id.loc.gov/vocabulary/preservation/eventType.html
`eventDateTime`	The point of time or range of time in which the event occurs.
`eventDetailInformation`	Information about the event, such as the name of the microservice.
`eventOutcomeInformation`	Details about the result of the microservice, including whether the event completed successfully and any logged data from the process.
`linkingAgentIdentifier`	Linking agents are agents that had an effect on the resulting AIP, and can include the name of the operator, the name and version of the involves software, and/or the name and version of the microservice.
`linkingObjectIdentifier`	Identification of the objects processed and/or created by the microservice.

Such data could be pushed by each microservice to a component of the AIP, such as a database record or log file within a package. The goal of such logging is to ensure that the contents of the AIP are independently understandable. To this end, it is important to document what parts of the AIP were part of the SIP, what parts were generated from the SIP, and by what processes the information was generated.

The principles of preservation event logging neatly dovetail with microservices that generate technical metadata or validate packages. For example, a fixity check is not just evidence of a microservice having completed successfully, but its execution and success or failure also may be stored as an event and eventOutcome within the PREMIS dictionary.[12] For such events,

Many microservices for audiovisual content use FFmpeg for actions such as derivative-creation, validation, and frame checksums. FFmpeg supports a `-report` option or an `FFREPORT` environment variable[13] which is used to log the console output of FFmpeg into a log file. Other command-line utilities can be logged by piping the standard error or standard output to a file. If events are logged to text files, then the design of the AIP should document practices for naming log files, for example ${microservice-name}_${microservice-version}_${datetime}.txt.

---

12 See page 258 of the current PREMIS Data Dictionary for more detail, https://www.loc.gov/standards/premis/v3/premis-3-0-final.pdf
13 See -report in http://ffmpeg.org/ffmpeg-all.html

4. Building an Ingest Script

4.1 Microservice Commonality

The microservice examples listed above demonstrate that once a packaging definition is established by an archive, the archive's microservices can share substantial commonalities. For instance, `MakeWebDerivative` and `MakeEditDerivative` are nearly identical in that they both check if the microservice is eligible to proceed, log their procedures, and file their output. Both `MakeTechnicalMetadata` and `MakeChecksums` operate similarly, except for the type of tool used (and the resulting report stored as part of the AIP). And `ValidateArchivalPackage` and `ValidateDisseminationPackage` both take the step of verifying that the files generated by the microservices adhere to locally-set file specifications—only the profiles themselves are different.

Commonalities can be exploited in development by creating common functions or code snippets that can be shared across a set of microservices. These common functions can be turned into a local microservice library. For example, in the microservice library in use at CUNY TV, common functions are defined in a script resource called `mmfunctions.` Functions are called from this central resource by each microservice as needed.[14] Defining commonalities across microservices in a single place not only saves lines of code, but means that updates to a common function only need to happen in one place. For example, if multiple microservices report information from a certain field in a database, the database pull can be defined in a single central function that is called by each microservice. If the archive eventually changes the location of this database or the name of the field, this information can be edited in that central function, allowing each microservice to be updated with a single edit.

Successful commonalities structures also depend upon shared parameters and common libraries. A set of microservices built up with consideration of local standards will naturally refer to similar settings and structures. Attention should be paid to selecting tools that are compatible with each other. For example, using MediaInfo to report metadata in `MakeTechnicalMetadata` means other tools that rely on the MediaInfo library—for example, MediaConch—will be easy to integrate and can potentially provide many more points of connection.

4.2 Linking Microservices Together

In some cases, one or more microservices may be combined into one, larger microservice, in order to create a combination of tasks that always take place together. This choice takes advantage of the wide range of tools that can perform Ingest tasks, including some that can accomplish the tasks of multiple microservices. For example, the `baginplace` function of BagIt combines the goals and results of the PackageContent and MakeChecksums microservices, as defined above, but at the same time. Combining microservices in this matter can be useful if it becomes clear that the two microservices always take place together. In other cases, retaining separation at a granular level between microservices integrates them better into workflows.

Example End-to-End Microservice Architecture
An example chain of microservices using the templates put forth in this paper might look like the following:

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14   https://github.com/mediamicroservices/mm/blob/master/mmfunctions

1. Submission (creation and validation of SIP):
    a. Initial submission of Content Information and Preservation Description Information
    b. *ValidateSubmissionPackage*
        i. Call *MakeChecksums* as part of validation procedure.
        ii. Conditional continuation if package passes this microservice.
2. Ingest (creation and validation of AIP):
    a. *MakeDFXML*
    b. *MakeTechnicalMetadata*
    c. *PackageContent*
    d. *ValidateArchivalPackage*
        i. Call *MakeChecksums* as part of validation procedure.
        ii. Conditional continuation if package passes this microservice.
3. Access (creation and validation of DIP):
    a. *MakeWebDerivative*
        i. Call *MakeChecksums* as part of derivative creation procedure.
    b. *MakeEditDerivative*
        i. Call *MakeChecksums* as part of derivative creation procedure.
    c. *ValidateDisseminationPackage*
        i. Call *MakeChecksums* as part of validation procedure.
        ii. Conditional confirmation if package passes this microservice.

Packages Generated by Example End-to-End Microservice Architecture

At the end of this chain of microservices, the following packages will have been created. The italicized content indicates files or information generated by microservices. Content without italics represents information that must be supplied by the creator or archivist.

Submission Information Package
- Content Information
    - `${CONTENT} (1)`
- Preservation Description Information
    - *`[checksum file] (1)`*
    - `[web-form-record] (1)`

Archival Information Package
- Content Information
    - Content Data Object
        - `${CONTENT} (1)`
    - Representation Information
        - `[extracted technical metadata] (+)`
- Preservation Description Information
    - Provenance Information
        - *`[log files from microservice events] (+)`*
    - Context Information
        - `[database record of relationships with other database materials] (+)`
    - Reference Information
        - `[web-form-record] (1)`
        - `[database record of descriptive metadata] (1)`
        - `[database record of access metadata] (1)`

       ▫ Fixity Information
          ▫ *[checksum file] (1)*
          ▫ *[DFXML file] (1)*

Dissemination Information Package
    ■ Content Information
       ▫ */derivatives/web/${CONTENT}.mp4 (+)*
       ▫ */derivatives/edit/${CONTENT}.mov (+)*
    ■ Preservation Description Information
       ▫ `[database record of descriptive metadata] (1)`
       ▫ *[log files from microservice events] (+)*

4.3 Collaboration with Other Archives

These examples of microservice commonality and interconnectedness demonstrate how complex a microservice-based archival design can become. An archive might rightfully find that maintaining and updating code is too large a task to assign alongside archivists' day-to-day work. Microservice-based architecture is often more successful when employing collaboration amongst archival communities and open source approaches, wherein multiple stakeholders can contribute to a common goal and share responsibility for maintenance, as well as the advantages of additions and updates. Many examples of open, archival microservice documentation may be found at https://github.com/amiaopensource/open-workflows.

5. Advanced Considerations for Audiovisual Files and Derivatives

The example FFmpeg commands presented in `MakeWebDerivative` and `MakeEditDerivative` consist of a one-line command to convert a video file into a derivative. However, in some environments a more complex approach may be required. For instance, in broadcast environments, a single presentation may be digitized from two videotapes to two files; an original video file may include color bars and black frames that aren't needed for inclusion within some types of access files; or a video file might include multiple audio tracks that may need to be down-mixed or selectively picked for inclusion with an access file. These complications can either be employed as concatenation or trimming microservices, or—if the archive determines they should be applied consistently in tandem across the archive's materials—may still represent a single cohesive microservice.

When dealing with multiple timelines, it is important to make the relationship explicit between the original file and its edited timeline. Concatenation and trimming are a preservation event[15] and its occurrence should be noted in a log generated by the microservice, or inserted into a structured metadata standard such as METS. If employing these methods on the original object, it is also important to generate a new checksum for later package validation and fixity checks.

5.1 Temporal Selection

Often videotapes are digitized in a manner that includes video content that is supported by colorbars, informational slates, black frames, countdown, static noise, or other visual information that surrounds a program. With videotapes, generally such supporting infor-

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15 For example, they may be logged as a "modification" according to the PREMIS vocabulary, with more information stored as a PREMIS Event Detail.

mation is recorded into a tape to contextualize a presentation but is not intended to be a part of the presentation itself. For instance, the digitization of a videotape may result in a 34 minute preservation file that may contain the following segments:

- 00:00 - 01:00: Color bars
- 01:00 - 01:30: Informational slate
- 01:30 - 01:40: Countdown
- 01:40 - 31:40: A presentation
- 31:40 - 32:40: Black frames
- 32:40 - 34:00: Static noise recorded until the digital recording was stopped.

For some forms of access it may be appropriate to create derivatives that represent the full timeline of the digitization; however, in other cases, that is not how the presentation is intended to be shown. FFmpeg has several options that can be used to support temporal selection so that an output derivative represents only a range of time of the input.

To fit temporal selection into the microservice scenario presented above, the `PackageContents` could request or identify the starting and the ending time of the intended presentation within the timeline of the preservation file. With the 34 minute video file depicted above, we may want an access derivative to represent the time range from 01:40 - 31:40 to mimic the intended presentation that the videotape would have been used to create. If `PackageContents` can store intended start and end times within the package, then subsequently `MakeWebDerivative` could be written to check for the presence of starting and ending times and, if so, then apply them while constructing an FFmpeg command.

Example: `MakeWebDerivative` with trimming at head and tail

```
ffmpeg -ss ${STARTING _ TIME} -i ${CONTENT _ INPUT} -c:v libx264 -mov-
flags faststart -pix _ fmt yuv420p -crf 18 -c:a aac -ac 2 -to ${ENDING _
TIME} {WEB _ DERIVATIVE}.mp4
```

5.2 Multi-file Input

The examples above presume that the Content Information of each package is a single video file. However, more complex video representations may need to be supported. For example, a camera may produce a continuous recording through the creation of multiple concurrent files, or a single presentation may be digitized from two videotapes to two files. It may be desirable to concatenate multiple preservation-level files into a single, master preservation file, or a single derivative.

To support such cases, the `PackageContents` microservice may be extended to support the ingest of multiple files into a single package. FFmpeg documents several methods to support concatenating multiple files into a single output.[16] If the technical characteristics of the package's content files are similar (same frame size, codecs, etc.) then FFmpeg's concat demuxer is recommended.[17] To use this tool, a text file should be generated listing the input files in order, with optional start and end times for each file. If this text file, named 'package_input.txt', lists:

```
file 'INPUT _ FILE _ 1'
```

---

16 See "Concatenate" documentation in the FFmpeg wiki, at https://trac.ffmpeg.org/wiki/Concatenate
17 See "Concat Demuxer" in the FFmpeg documentation, at http://ffmpeg.org/ffmpeg-formats.html#concat-1

```
file 'INPUT _ FILE _ 2'
file 'INPUT _ FILE _ 3'
```

Then an FFmpeg command can be extended to join together multiple files by referencing that text file as the input, as in the examples below.

Example: Concatenating preservation files
In this example, the preservation files to be concatenated are already in the proper preservation file format, and need only be joined.

```
ffmpeg -f concat -i package _ input.txt ${CONTENT _ CONCATENATED _ ID}
```

Example: Concatenating files in the production of a Web derivative
In this example, the preservation files are already in the proper preservation file format, and need only be joined.

```
ffmpeg -f concat -i package _ input.txt -c:v libx264 -movflags faststart
-pix _ fmt yuv420p -crf 18 -c:a aac -ac 2 {WEB _ DERIVATIVE}.mp4
```

6.   Conclusions

By defining a consistent and OAIS-inspired packaging structure within an archive, a microservice environment can be developed and expanded as the archive integrates services and functions. Packaging techniques should make a clear distinction between the object or objects that are the focus of preservation and any derivative files or metadata that support access and knowledge about those objects. Any microservice processing with the AIP as an input must be able to understand the AIP structure sufficiently to determine what specific files within it should be used in the microservice's work.

Many archives have been developing and sharing microservices amongst each other, as can be seen in places such as https://github.com/amiaopensource/open-workflows. Currently implementations of AIP structure do not have a standardized manner of expressing that structure, as in similar to a way in which an XML Schema can document an XML expression and be used to assess its validity. On the other hand, the development of more methods to transform AIPs from one archive's AIP implementation to another, or the development of microservices that are more easily shared amongst archives, are likely outcomes as archives integrate more collaboration and sharing in their own microservice implementations.

While monolithic systems for management of digital archives are still considered to be crucial requirements within many corners of the field, archives generally do not aspire for such systems to maintain the same level of permanence that is expected for the media and metadata of archival collection. Over time, as monoliths become obsolete or are replaced with another monolith, the migration of the media and metadata from one monolith to another often becomes a complex, expensive, and/or risky pain point in the timeline of archival management. The use of microservice architectures within audiovisual archives puts the media and metadata itself rather than the system at the center of archival management. Individual microservice components may be improved or replaced on an individual basis in a manner that facilitate a more natural evolution of an archive's gradual expanse in services, functions, and adherence to standards.

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18   https://creativecommons.org/licenses/by-sa/4.0/

Renewing Cultural Resources and Sustaining J.H. Kwabena Nketia's Vision for an African Music Archive in Ghana

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Abstract

This article examines the processes through which the J.H. Kwabena Nketia Archives has struggled to build a sustainable model for audio-visual archiving within an African university and looks to how its contents may serve future students and scholars in an effort to locate African cultural materials and knowledge production in Africa. The archive, operated within the University of Ghana's Institute of African Studies, was named in honor of Professor Nketia in 2015 and is the realization of over six decades of gathering audio and visual data, acquiring new collections, conducting research, and preservation efforts. The core collection of quarter-inch reels were recorded by Nketia in the early decades of his extensive career shaping Ghana's cultural policy, building teaching and research institutions, and studying music, culture, and language in Africa. As a part of the University of Ghana, the Nketia Archives provide a valuable resource for local students and scholars and creates a site in which broader conversations about the country's cultural legacies are brought into the socio-political discourse. The archive is also a resource for housing and making available new acquisitions including over 300 recently digitized recordings of Ghanaian popular music from professor John Collins' Bokoor African Popular Music Archives Foundation (BAPMAF). With ongoing challenges in accessibility, the Nketia Archives provides a valuable case study for how an African audio-visual archive is created and sustained.

> We in the school of music and drama are deeply committed to African culture, and more especially to the performing arts of Africa. We believe that African traditional arts should be recorded, they should be preserved, they should be studied. But we believe also that they should not merely be studied, recorded, preserved, but practiced as living art. We believe also that the art must develop and that the study of African traditions should inspire creative experiments in the African idiom.
>
> *J. H. Kwabena Nketia*
> *1963 Institute of African Studies Convocation speech*

Introduction

In 1952, four years into the establishment of the University College of the Gold Coast (now University of Ghana), the idea of unifying the nation through collecting and archiving Ghanaian musical resources was conceived by young Joseph Hanson Kwabena Nketia, then a research fellow in African Studies. With the financial support and guidance of the head of the Sociology Department, Kofi Abrefa Busia, Nketia collected hundreds of recordings in the following decade. These recordings now comprise the core of the J.H. Kwabena Nketia Archives, which is operated by the University of Ghana's Institute of African Studies (IAS). The Archives, named in his honour in 2015, is the second largest audio-visual collection of traditional music in Ghana after the Ghana Broadcasting Corporation (GBC) Archives and has grown from the efforts of over six decades of gathering audio and visual data, acquiring new materials, conducting research, and undertaking preservation efforts. The core holdings of the archive are approximately 480 quarter-inch reel-to-reel tapes of field record-

ings collected throughout Ghana by or under the direction of Nketia from 1952 to the late 1970s. These recordings span a key moment for Ghana as an emerging nation and for the University of Ghana at Legon as a site for the study of African music, dance, and theater.

Nketia's work as a scholar included both building this collection of recordings that reflected a national cultural identity as well as shaping university institutions where Ghanaian performing arts could be studied and practiced. The 1963 quote above reflects Nketia's dedication to documenting and preserving African performing arts as part of the decolonization of higher education in Africa and Ghana's efforts in nation building. His dedication remained unwavering throughout his extensive career and would take form in his teaching, lectures, publications, and musical compositions as well as his establishment of the International Centre for African Music and Dance (ICAMD) in 1992. In his 2016 book *Reinstating Traditional Music in Contemporary Contexts* (written at the age of 94), Nketia reflected that this preservation work, while in service of scholarly study, was also "a political priority for promoting national integration and the consciousness of the African identity undermined by colonialism" (Nketia 2016, 56). With Nketia's passing in 2019, IAS continues to search for ways to realize his vision for the study of Ghana's performing arts while sustaining a site for knowledge production of African culture. His namesake archive continues the work in recording, preserving, promoting, and disseminating knowledge of traditional music, and this article aims to be part of this effort through building an awareness of its manifold activities.

What began as Nketia's fieldwork as a research fellow, grew to include the recordings collected by other Ghanaian scholars including Ephraim Amu as well as European and American scholars who came to conduct research on West African music and culture. These efforts were foundations of an Africanist musicology, which engaged African music as part of a "network of interweaving cultures" that include "not only musical traditions that must be safeguarded for posterity, but also those that need to be actively studied, documented, developed and promoted and contemporary context of application in the light of Africa's ideas and vision of its modernity" (Nketia 2016, 105). The Nketia Archives is presented here as a case study of the important yet extensive process of building and sustaining an audio-visual archive in Africa. The challenges as well as the long-term commitment of this work is apparent in the fact that it was not until 2014 that the recordings created in the 1950s and 1960s became accessible to researchers in a digital format. What follows is a survey of this path from an African musicologist-oriented collection of music in Ghana to acquisitions of newer collections and current efforts to preserve recordings. We look specifically at early fieldwork efforts of the 1950s and 1960s; subsequent acquisitions of the 1970s; the establishment of ICAMD; the professionalization of the archive; digitization efforts; and the recent acquisition of the Bokoor Studio collection.

Early Fieldwork and Acquisitions (1952-1978)

Nketia approached fieldwork as an opportunity to expand his own musical sensibilities and connections to a broader African culture that extended beyond his own upbringing as an Akan. As a curious observer, Nketia was fascinated by the musical distinctions between various linguistic groups yet always listened for commonalities and themes that might be realized later in his own creative work (Nketia 1994, 10). Fieldwork was a process of discovery for Nketia: of Ghana's physical and musical landscapes; his own emerging sensibilities as a composer; and the primary research questions that would drive his scholarship. His recordings, experiences, and notes contributed to foundational studies of African music including *Funeral Dirges of the Akan People* (1955), *African Music in Ghana* (1963), *Folk Songs of Ghana* (1963), and *The Music of Africa* (1974).

A survey of the hundreds of reel-to-reel tapes that have been digitized from Nketia and his colleagues' early fieldwork efforts shows a wide sample of music from throughout Ghana's five regions. Mary Seavoy, a student of Nketia's during his time at UCLA, visited Ghana likely in the late 1970s and helped catalogue and further organize the quarter-inch reels into a system called AWG (Africa-West-Ghana). Categories within this system included Akan (234), Ewe (71), Dangbe (36), Ga (30), Dagomba (26), Gonje (19), Sisalla (16), Frafra (11), and popular music (29). Samples from these categories include: Akan drumming styles such as *Adowa, Atumpan, Akcm, Fcntcmfrcm, Sikyi,* and *Kete*; festivals such as *Akwanmc* in the Central Region and *Sokpoe* Festival in the Volta Region; puberty rite music; funeral dirges; women's *Adenkum* vocal groups; Christian choral groups; brass bands; guitar bands; Dagomba *gonje* and *lunsa* drumming; and *gyil* (xylophone) music of the Upper West Region. These early fieldwork recordings range in styles from live performances (in festival and funeral settings), to analytical recordings (in which individual parts were demonstrated), to interviews conducted in Twi and English. In addition to some descriptive information on the reel boxes, the recordings are accompanied by typed field logs, which frequently included the researcher's name, musician names, locations, years, song titles, and recording descriptions.

Notable among this early fieldwork are ten reels, recorded by Ephraim Amu, which include recordings of *seperewa* (Akan harp-lute) musicians Kwadwo Nsia, Kwaku Asuo, and Kwadwo Okoto of the Ashanti region.[1] These recordings exemplify the fieldwork methods, preservation efforts, research potential, and ongoing creative application of a fading musical tradition. The *seperewa* or *sankuo*[2] practice had been in decline in Akan culture by the mid-20th century, possibly due to the guitar's growing popularity as the string instrument of choice. The *seperewa*'s history reaches before the formation of the Ashanti confederacy in 1670 with European descriptions of it first appearing around that time. In one short interview, conducted in Twi with musician Kwadwo Nsia (Tape AWG-A-93) by Amu, Nsia discusses the instrument's origins, construction, tuning, and use in performance. In the following excerpt, Nsia explains the instrument's name[3]:

Ephraim Amu: Wo sanku yi, wɔfrɛ no dɛn?	Ephraim Amu: This string instrument, what do you call it?
Kwadwo Nsia: Wɔfrɛ no seperewa.	Kwadwo Nsia: It is called *seperewa*.
EA: Seperewa. Adɛn nti na wɔfrɛ no seperewa?	EA: *Seperewa*. Why do you call it *seperewa*?

1   Nketia writes in his article "The Scholarly Study of African Music: A Historical Review" (*Garland Encyclopedia of World Music: Africa*) that Amu, while teaching at the University of Science and Technology in Kumasi, conducted several years of fieldwork throughout Ghana with the support of a Rockefeller Foundation grant. These tapes were deposited in both the University in Kumasi and Legon and likely include those currently held in the Nketia Archives.
2   According to Christaller's *Dictionary of Fante and Asante Language* (1881), sankuo refers to a local "stringed musical instrument" as well as European string or polyphonic instruments such as the guitar, fiddle, violin, harp, harpsichord, piano, and organ.
3   Twi transcription and English translation by Patrick Osafo Adu.

KN: Seperewa no, ɛne sɛ nsamanfo no a ɛkɔkyerɛɛ ɔbɔfo no, ɛnna obisaa wɔn nanso na ɛyɛ daeso nti wanhu wɔn anim. Ɔdae na wɔsoo no dae kyerɛɛ no sɛ, sɛ worepɛ a, wobehu. Woahu? Ɛnna obisaa wɔn sɛ, ɔkwan bɛn na mɛfa so ahu? Ɛnna wɔka kyerɛɛ no sɛ, gyae, yɛbɛkyerɛ wo. Ɛno akyi no, ansa na wɔreyi akyerɛ no sɛnea wosi pam akaka yi ne ɛho nneɛma nyinaa, na wose "prɛ."	KN: The *seperewa*, [they say] it was ancestral ghosts who taught the hunter. It was in a dream that he met them so he didn't see their faces. He slept and saw them in a dream and they told him, "If you want to know, you will know." Then he asked them, "What path do I take to learn?" Then they told him, "Wait, we will teach you." It was later that they taught him how to make this box and all the things you see here, and the told him "pluck."
Ɛnna wɔse, "Sɛ yɛprɛ." Ɛne "sepra". Woka sɛ "sɛ yɛprɛ a" ɛnyɛ yiye. Efisɛ ɛyɛ sanku enti yɛse "seperewa". Gye sɛ, woprɛ, wode wo nsa na ɛprɛ na atumi aka asɛm.	KN: Then they said, "when you pluck." That became "sepra". When you say "sj yjprj *a*" it doesn't sound good. Because it is a string instrument, we say "seperewa." Unless you pluck, you use your hand to pluck [the strings] before it can speak/communicate [sound].
EA: Wobɔɔ nsamamfo bi din na sanku yi ɛyɛɛ dɛn bae? Asɛm bɛn na ɛwɔ ho.	EA: You mentioned some ghosts. What was their role with this instrument? Tell us more about it.
KN: Nea ɛmaa sanku no bae ne sɛ ɔbommɔfo bi kɔɔ wuram. Ɔkɔyɛɛ ha, ɛnna ɔyerae. Onhu kwan mma fie. Ɔkɔtenaa dua bi adukuro mu…	KN: How it came about is that a hunter went to the forest to hunt but got lost and couldn't find the road to his house so he decided to rest under a large tree…

This interaction and the accompanying performances, while a valuable record of a fading performing arts tradition, also offers an intimate look into the fieldwork process as conducted by Amu. Conducting the interview in Twi allows for a conversational approach free of interruptions from translation since Amu is able to guide the conversation based on the information he is receiving. Amu's position as a cultural insider (Ghanaian and Twi speaker) and his status as an influential educator, scholar, and composer allow him to shift his role from curious student to experienced researcher to artist as he draws out folklore, asks technical questions about instrument construction, and discusses tuning techniques. The above conversation that emerged from Amu's question about the instrument's name reveals the importance of the origin story for Nsia. We learn that the instrument is associated with hunter culture, which invokes the importance of the similarly constructed *donso ngoni* for hunters in Burkina Faso. That the instrument originated from ancestral knowledge gained through communication with the spirit world grounds the practice in the Akan historical imaginary. When Amu pushes further to learn about the role of ancestral spirits, Nsia recounts a story in which a hunter becomes lost in the forest. While resting, the hunter hears the sound of an instrument which he follows but cannot locate. In his search, he reaches a road that leads him home though he remains eager to find the instrument that he had heard. It is only when he is visited in his dreams by ancestors that he is able to construct and play the instrument.

Nketia returned to these recordings in the early 1990s and published his article "Generative Processes in Seperewa Music" (1994) and wrote unpublished text transcriptions currently held in the Archives. As Nketia wrote, the *seperewa*, likely related to the Mandinka *kora*, became an important symbol in the early Ashanti nation. The first Ashanti king, Osei Tutu

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(1701-17) valued the instrument so highly that his successor King Opoku Ware (1720-50) had one built and covered in gold leaf to be included with the Golden Stool—the primary symbol of Ashanti identity and collectivity (Nketia 1994, 119). In an exemplary demonstration of how the archive should be the foundation for a living art, rather than a passive repository, Nketia hired *seperewa* master Osei Kwame Korankye in 1995 to contribute to ICAMD's research, teaching, and outreach activities while developing this fading tradition. Korankye continues to teach the instrument in the University of Ghana's Department of Music and also at Winneba College and performs extensively both in Ghana and abroad. As part of his evolving practice, Korankye has returned to Amu's field recordings in the development of his own approach to *seperewa* performance, which draws on his roots in Akan music and linguistic arts, experiences with Pan-African ensembles such Hewali Sounds and the Ghana Dance Ensemble, and collaborations with international artists.

From 1965 to 1979, Nketia directed IAS with continued dedication to fieldwork and preservation of Ghanaian performing arts. Nketia also pursued extended periods teaching abroad in ethnomusicology programs of UCLA (1969-1983) and the University of Pittsburgh (1983-1991). In 1975, IAS began implementing a five-year development plan that included establishing technical service units in photography, film, sound, and visual arts. The Photographic Unit documented cultural events such as festivals and other important traditional ceremonies. The Film Unit made ethnographic films and documentaries for teaching and archival purposes. The Visual Arts Unit collected Ghanaian and West African arts and crafts as the basis for establishing an IAS museum. The Sound Unit, tasked to amass materials that covered ethnomusicology and related fields, came to house the field research materials collected by Nketia and others. The recorded assets were managed by ethnomusicologist S. D. Asiamah and sound engineer Henaku Pobi. In the late 1970s, donations from sister institutions as well as research expeditions by other ethnomusicologists, fellows, staff and visiting researchers of IAS increased the archive's holdings. This included Mary Seavoy's research materials from Ife, Nigeria and Northern Ghana; Indiana University in Bloomington professor Ruth Stone's research materials labeled Ghana-Owen Collection in the 1970s; and the British anthropologist Jack Goody's field research materials on Northern Ghana. In 1996, according to a report submitted by Dr. Asiamah to Professor Agovi, the then director of IAS, the IAS Sound Archive housed approximately one thousand records of 78, 45 and 33 1/3 rpm shellacs and 1,500 reel-to-reel tapes.[4]

International Centre for African Music and Dance (ICAMD) (1992-2008)

After retiring from the University of Pittsburgh, Nketia returned in 1992 to the University of Ghana to establish the International Centre for African Music and Dance (ICAMD). With support from the Ford Foundation, the Rockefeller Foundation, and Swedish International Development Agency (SIDA), Nketia created a research library from his personal collection, developed a program for gathering new documentation of Ghanaian performing arts, and hired resident artists to teach and perform. In a 1998 newsletter, he described ICAMD's aims:

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4   Under Asiama, the collection was catalogued using an index system which was an alphabetic re-working of the Systematische Catalogus, devised by Bernard Broere of the Ethnomusicologisch, Archief, Institute Voor Muziekwetenschap, Universiteit Van Amsterdam. There were also card indexes which analysed the collection in terms of individual items, musical types, performers, instruments and societies (Asiamah 1996: 3).

> The challenges of the milieu to which I was returning after my sojourn in the US required that I do something different. …I could inspire others to do field research instead of doing everything myself the way I used to do, encourage scholars and artists to make use of the archival materials I had already set up in the Institute of African Studies which could be enlarged through various modes of acquisition, develop a specialized "library" with my own collection of books and other materials as a base for a small institutional reference library, and share my knowledge, experience and reflections with others who might carry them forward, as we collectively confront the practical realities of music and dance in our changing African environment (ICAMD Newsletter 1998: 1).

In the late 1990s, ICAMD served as a platform for encouraging scholars from the Music Department and the School of Performing Arts to conduct research trips and supplement Nketia's early recordings.[5] Additionally, the Centre organized a lecture series and conferences on issues such as music therapy, music education, music composition, and established various institutional linkages through invitation to research fellows from Ivory Coast, Nigeria, Zambia, Tanzania, Congo, and Zimbabwe, who were given the opportunity to research in the Archives and work under Professor Nketia's personal supervision.[6] Resident artist positions were created for promising young musicians including the aforementioned *seperewa* master Osei Korankye as well as *atɛntɛnbɛn* virtuoso Dela Botri and his group Hewale Sounds, which became the ICAMD's performing group in residence. According to Nketia,

> This idea of reaching out to others in the disciplines of music seemed to me appropriate for the situation in Africa where composers may be ethnomusicologists, music educators, cultural officers, members of arts organizations etc., multiple roles I had previously assumed myself. It has led me to redefine the subject areas of my field to include development studies in ethnomusicology with particular reference to African music and dance (ICAMD Newsletter, 1998: 2).

Within ten years, the ICAMD audiovisual archives, managed by archivist Maxwell Agyei Addo, was the most vibrant audiovisual archives on the University of Ghana campus, serving local and international students and faculty. This encouraged scholars affiliated with ICAMD to donate their research materials to the archive in order to support Nketia's vision and efforts. Donations included:

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5   Some of these scholars included Professor Mawere Opoku, Dr. Willie Anku, Mr. Kosi Adom, Mr. T. E. Andoh, Mrs. Bertha Adom, Dr. Nissio Fiagbedzi, Dr. Asante Darkwa, and Miss Patience Kwakwa.
6   Some of these research fellows included Pascal Zabana Kongo, Josephine Mokwunyei, Robson Rudsvidzo, Prince Lamba, Herbert Makoye, Bridget Chinouriri, and Adepo Yapo.

Year	Source	Contents
c. 1994	Paul Neely	Ghana Institute of Languages Literature and Bible Translations (GILLBT) recordings of church music in traditional singing styles
1994	Catherine Melhorn	Collection of songs from Ghana - 1994
1994	Claudia Melrose	Collection on dances and standard books on dance and related fields
1995	Patience Kwakwa	Video recordings on dances in Ghana and other parts of Africa
c. 1996	Mary Seavoy	Audio and visual recordings, slides, and photographs from Northern Ghana
1997	Mitchel Strumpf and Gustav Oware Twerefoo	Audio and visual recordings of traditional music and dance from Malawi and the Venda of South Africa
1997	Sharon Katz and Marilyn Cohen	Concerts in South Africa
1997	Herbert F. Makoye	Field recordings from Sukumaland, Tanzania
1998	Ceasar Ndlovu	Materials from Zululand, South Africa
c. 1998	Leo Sarkissian	Leo Sarkissian's Voice of America's Time in Africa recordings
1998	Josephine Mokwunyei	1998 recording from Ekpe, Nigeria
1999	Jesse Shipley	Recording of Panafest 1999
1999	Kwasi Ampene	Field research materials on Ashanti culture (Nnownkor□) from 1999
1996-2000	Mawere Opoku	Video recordings of traditional dances, palace ceremonies, funerals, and dance groups
c. 2000	Trevor Wiggins	Audio and visual recordings from Nandom, Sisaala, Lambussie and parts of Burkina Faso
c. 2000	Catherine Cole	Donation of Melville Herskovits's 1931 film study of West Africa
1999-2010	Dominik Phyfferoen	Audio and visual recordings from the DEKKMMA Project; fieldwork in the Northern Region of Ghana from 1999 to 2010
c. 2000	Jacqueline Djedje	Audio and visual recordings from Northern Ghana
c. 2000	Tervuren Museum and colleagues in Zimbabwe	The UNESCO collection of selected field recordings from Africa

Despite the success in growing the invaluable collection of Ghanaian cultural heritage, the IAS Sound Archive lacked the resources to provide for the physical and administrative care of the recordings. Playback machines were in disrepair, the rooms in which the materials were kept were in bad shape, and worst of all, the materials were difficult to access. In 2003, African music scholar Kofi Agawu reflected on the seeming impossibility of "productive scholarship" on African music stemming from African libraries and archives:

> …the archivist may not be seen for days, where the playback equipment, although visibly displayed, does not work, and where a request for a copy of this or that recording may be greeted by the suspicion that the scholar is going to make money with it. (How strange that the archivist and his staff have not sought to make money with these recordings all these years.) Then follows the invention of any number of excuses why a copy would be hard to make. (Dangling your wallet can work wonders on such occasions.) The archives are, in a sense, a microcosm of the difficulties that enshroud institutions in postcolonial Africa, difficulties that have led to a profound undervaluing of treasures that lie under our very noses (Agawu 2003, 35).

Recounting his frustrated attempts to access Nketia's recordings through the then "Archives of Recorded Sound at the Institute of African Studies," Agawu puts forth the possibility that "a precondition for significant and authentic contribution to scholarship may well be that the individual scholar leave Africa, if only temporarily. The archive of African music must therefore necessarily exist outside the continent's geographical and perhaps psychical boundaries. It must exist overwhelmingly in the hands of others, not Africans" (Agawu 2003, 35).

Taking into consideration such negative feedback, Nketia consulted IAS director Takyiwaa Manuh to merge the audiovisual collections at ICAMD and that of the old Sound Unit's archive of the IAS, so that the combined archive could be properly managed under new staff. In 2004, the audiovisual collection of ICAMD was moved and added to the IAS collection managed by ICAMD until 2008 when Nketia, who had until then been running ICAMD, handed the merged unit over to IAS and named it the IAS/ICAMD Audiovisual Archive. With this new institutional structure in place, there remained a need for managers and technicians to find ways to preserve and make these materials available. These developments were implemented largely through partnerships with New York University in the following decade.

Professionalizing the Archive

In May 2011, the Audiovisual Preservation Exchange (APEX), a research branch of New York University's Moving Image Archiving and Preservation (MIAP) programme, organized its annual training workshop for audiovisual heritage practitioners in Accra, Ghana. This workshop took place at the Ghana Broadcasting Corporation (GBC) and provided an important networking opportunity for the IAS/ICAMD Audiovisual Archive's Principal Research Assistant Judith Opoku-Boateng.[7] The theme of the workshop was "Imagining

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7   Opoku-Boateng won the Jim Lindner Prize for Cultural Heritage Preservation, which provided support to purchase a laptop and cataloguing software.

Access to Audiovisual Heritage" and covered collection assessment, proposal writing, caring for collections, and metadata standards.[8] A month later, the US State Department, through its embassy in Accra, nominated Opoku-Boateng for the International Visitor Leadership Programme (IVLP) on the theme of cultural heritage preservation. This programme, coupled with the APEX training, significantly enhanced the management practices at the Archive by demonstrating international standards of archival care and linking its staff to a network of professionals.

In February 2012, two of the NYU APEX team members, Mona Jimenez and Kara Van Malssen, returned to Ghana to inspect and assess the IAS/ICAMD Audiovisual Archive's assets and storage environments and produced a 65-page document titled *University of Ghana: Audiovisual Collection Assessment and Digitization Plan*. The report supported the University's vision of preservation and access of significant audiovisual materials and was submitted to IAS with copies distributed to collection managers, information technology specialists, and the decision-making bodies at the University. To further support the IAS-NYU collaborative effort, a two-month summer internship was developed for MIAP graduate student Kelly Haydon, a database specialist, as per the recommendations outlined in the collection assessment report. Haydon helped to customize the database to fit the archive's needs, worked with staff to create metadata standards, provided training, and assisted the archivist with promoting the database within the larger context of the University of Ghana (Opoku-Boateng 2014: 2).

In the meanwhile, Akosua Adomako Ampofo, the director of IAS, oversaw the creation of a full-time archivist position within IAS and appointed Opoku-Boateng in January 2013. Additionally, two former National Service Personnel at the Archive, George Gyasi Gyesaw and Nathaniel Worlanyo Kpogo, who had undergone training by the NYU/AVPS team, received long-term appointments. These appointments marked the first significant step in the professionalization of the archive as an important body within the institute. In recognition of the profound need for continued training and constant maintenance and improvement of collections standards, Opoku-Boateng was selected by the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) in 2013 to attend the International Training Programme: SOIMA 2013: Sustaining Sound and Image Collections. This programme equipped Opoku-Boateng with the requisite knowledge as the archive was embarking on an analogue to digital journey through the NYU/IAS collaborative project that year.

In 2013, Ampofo called for a proper restructuring of the Archives and in June 2014, the facility was expanded from two to seven rooms in order to properly house a storage for audiovisual records, IAS Paper Heritage Materials, and Arabic Manuscripts; an audio digitization laboratory; a listening station, cataloguing room, and reception; a classroom for group viewing or listening; an oral history cinematic studio and transcription room; and an office space for the archivist and staff. The renewed investment in the archives at IAS culminated in February 2015 when the institute named its new archive complex the J.H. Kwabena Nketia Archives. These efforts demonstrate the increasing awareness and embracing of the archive as a national resource and a common cultural treasure to be maintained in line with Nketia's vision of it as a place for the living arts of Africa.

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8   APEX team members and included Mona Jimenez, Kara Van Malssen, Jennifer Blaylock, Ishumael Zinyengere.

Donations which have been so far added to the collection in this facility include:

Year	Source	Contents
2014	Prof. Mary Esther Dakubu Kropp and Dr. Samuel Ntewusu	2012-2013 Materials from ELDP funded research project: "Vanishing Voices in Ghana's Middle Belt"
2014	Karl Haas	Field research materials from Northern Ghana
2015	Professor Esi Sutherland Addy	Afua Sutherland's audio recordings of concert parties
2015	Godwin Adjei	Field research materials on Ghanaian culture
2016	Royal Hartigan	Research materials and analytical books on Ghanaian drumming
2017	Kwabena Nketia	Published and unpublished personal papers
2017	Kwasi Ampene	Recordings of the burial and funeral rites of Nana Afia Serwaa Kobi Ampem II (late Asantehemaa)
2017	Obadele Kambon	Ritual performances in Ghana, Ghanaian festivals, storytelling, musical performances, etc.
2017	Bertha Setor Adom	Commercial recordings produced by Faisal Helwani
2017	Tobias Klein	Documentary on "Life in Ghana After Independence" produced in Germany
2018	Alice Daniel	Oral history interviews on political history of Ghana with some Ghanaian journalists
2018	Michael Vercelli	Field recordings from Northern Ghana
2018	Egberto Bermudez	Recordings from Colombia
2018	Janet Topp Fargion	Digitized recordings of Robert Sutherland Rattray Wax Cylinder Recordings on Akan traditions, recorded in the 1920s and deposited in the British Library
2019	Austin Emielu	Personal collection of highlife and gospel music

As an independently staffed and managed institution, the Archives has facilitated further collaborations with outside institutions. In summer 2017, the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) organized an international training workshop titled *SOIMA 2017: Sustaining Sound and Image Heritage*. Hosted by IAS, the Nketia Archives was presented as the case study for nineteen participants from twelve countries. In October 2018, IAS and the Nketia Archives hosted the 49th annual conference of the International Association of Sound and Audiovisual Archives (IASA). Over 150 attendees from more than 30 countries worldwide participated in this

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important meeting of educators, scholars, and technicians in West Africa.[9] Such active participation in international professional gatherings has increased the awareness of the Archives as a key institution. Networking with peers from around the world, the Nketia Archives is becoming an encouraging case study to other under-resourced archives, and through collaborations and partnerships, it can remain open to future possibilities, especially in terms of increasing access to researchers from around the world.

Contemporary Challenges of Accessibility and Digital Infrastructure

The primary goal of any audiovisual archive is to both preserve and facilitate the access to its holdings, which has become synonymous with digitization in the last three decades. The first efforts to digitally transfer the quarter-inch reel recordings held by IAS were initiated during the 1987 meeting of the International Association for the Study of Popular Music (IASPM) held in Accra. It was during this conference that visiting scholars including the German musicologist Wolfgang Bender (University of Mainz) were taken on a tour of the University of Ghana and the fieldwork collection in IAS. Driven by the deteriorating conditions of the audiovisual materials, Bender coordinated efforts to digitize the reels with professor Simeon Asiama of IAS, and, after securing support from the cultural department of the German Foreign Office, began the process in 1993. Working with Asiama, John Collins (technical assistant), Henaku Pobi, and Victoria Honu, Bender oversaw the transfer of approximately 480 reels onto two sets of Digital Audio Tapes (DATs).

This project lasted eight months during which time the reels were transferred onto two sets of DAT. The first set of tapes stayed with IAS and the second set of "safety copies" was transferred to the newly established African Music Archive (AMA) housed in the Johannes Gutenberg University in Mainz, Germany (Bender 1994, 156). In a recent email correspondence with the authors, current AMA director Dr. Hauke Dorsch confirmed that these DATs left the collection with Bender upon his retirement as director in 2008 but have been returned in July, 2019. To date, these recordings have not been digitized by the AMA though Bender did released a commercial CD titled *Music in Ghana* (1997), made up of selections from the Nketia collection.

As for the first set of DATs held at the Nketia Archives, they proved impractical for the rapidly changing needs of the twenty-first century archive. Though the DATs were technically in a digital format, they still required real time transfer to be stored on a hard drive or online. With a growing partnership with NYU's APEX team, the Nketia Archives began devising a digitization plan that ultimately involved a direct transfer from the original reels. In July 2014, the Nketia Archives, with its newly appointed staff and management at helm, welcomed back APEX to execute the long overdue audio digitization project, with the following goals: "build capacity for archival quality digitization at the IAS Audio-Visual Archive; create broad access and ensure digital preservation of the newly created digital assets; promote Ghana's rich sound heritage by facilitating new uses of these materials for teaching, learning, scholarship, production and application" (APEX).

The first phase of the project was the setting up of an audio digitization laboratory and designing the workflow for the files to be safely stored in the University's servers. The project provided hands-on training in audio preservation and digitization for the now long-

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9   Countries represented at the conference include: Ghana, United Arab Emirates, Latvia, South Africa, Australia, Taiwan, China, Belgium, Sweden, Portugal, Ireland, Portugal, Thailand, India, Czech Republic, United Kingdom, United States of America, Malawi, New Zealand, Italy, Norway, Switzerland, Australia, Israel, France, and Japan.

term staff of the Archives. Additionally, it combined old and new technology – techniques needed to dry out and clean mold on the tapes so that they may be played – and the latest methodologies for capture of the content and metadata that allows for discovery, use, and sustainability. Since August 2014, the Archives has physically preserved and digitized over five hundred hours of traditional music, oral histories, and indigenous cultures recorded on quarter-inch reels. The recorded assets are accessible at a listening station at the Archives, and preservation masters have been stored on University of Ghana's Computing System's Storage Environment. Access to this directory is limited to the UGCS adminis-trators and the logins of key staff, while patron access remains restricted at this stage.[10]

The project has created a model for other sound and image heritage preservation institu-tions in the country and across the globe as a successful example of a partnership that has left a long-term, positive impact on an under-resourced archive in need of professional training and start-up support required in large-scale digitization efforts. The challenges to preserving and researching African music in African institutions are immense and magnified in a digital environment. Agawu's 2003 indictment of the Archive's management at that time serves as a benchmark measuring recent progress and development and also offers a glimpse of how valuable materials, though located in Africa, require an extensive network of like-minded specialists to be accessed.

With scholars in African universities lacking resources to access European and American archives, majority of the current scholarship on African music in major journals is pro-duced abroad. Problems compound to create a unique challenge for preserving and access-ing historical audio-visual documents in Africa. The lack of local funding towards training, storage, climate control, equipment purchases and maintenance, and digitization create an environment where valuable materials face deterioration. Challenges to building digital platforms and providing physical space for reviewing materials also limit access and poten-tial utility of collections. Beyond these technical problems, there remain prickly questions of copyright around the use and representation of living folklore.

The picture of audiovisual archives in Africa reveals a great need for varied technical and management skills as well as a context in which cultural documents are accessible for re-searchers. Archivist Nathan Mnjama notes that many audiovisual collections in Botswana are overseen by librarians who have the training to catalog and process materials but lack the knowledge and equipment to repair damaged materials and digitize older recording mediums (Mnjama 2010). In another case, audiovisual archivist Ishumael Zunyengere paints a bleak picture of the challenges faced by Zimbabwe's national archives in 2008 in the larger scope of the country's state of welfare:

> The humanitarian, social and political crisis is of immense pro-portions. Most significantly in the past months lives have been lost through disease, starvation and acute economic decay. Our main hospitals of Parirenyatwa and Harare Main Hospital have now been effectively closed down in some wings be-cause of the lack of medicines and staff. With these problems government reverts all its attention to the humanitarian crisis

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10 The IAS stores a local copy of the digital files on the RAID 5 array, that is in the audio lab. The UGCS creates and maintains an offline backup copy of the data. The IAS Archive network is connected to the fibre backbone, via dual gigabyte connectivity to allow appropriate throughput of data which is sometimes transferred in bulk. Digitized data per year is estimated at 1.5 Terabyte, or 125 Gigabyte per month.

and the National Archives is left with less funds to just keep it running. The audiovisual heritage is therefore left to the Archivist to find ways of conserving the materials using the resources available (Zinyengere 2008, 38).

While Ghana has not suffered comparable economic collapse and social hardships experienced in Zimbabwe, archival efforts have met with many of the common challenges in building a sustainable audio-visual archive in an under-funded context. While the partnership with NYU has lent an enormous platform for furthering the work of the Nketia Archives, one-off or even intermittent collaborative projects must be supplemented with a long-term engagement with local scholars and students who embrace their role as advocates and active contributors and users of the Archives.

The Bokoor Studios Acquisition (2019)

The Nketia Archives is an open archive, continuing its acquisition activities in its ongoing efforts to build a fuller picture of Ghana's musical heritage. Of the recent acquisitions, the following case demonstrates the work being done by the Archives to ensure sustained growth and utility for researchers and students. The archives' most recent acquisition includes materials from professor John Collins' Bokoor African Popular Music Archives Foundation (BAPMAF), which is comprised of photographs and commercial recordings collected and produced by Collins throughout the 1970s and 1980s. In addition to his work as a researcher, Collins operated a recording studio from his home in Taifa on the outskirts of Accra from mid-1981 to around 1994. During this period Collins acted as producer and engineer for approximately 250 recording sessions of popular, traditional, and gospel music from Ghana. These sessions were recorded on a Tascam four-track Portastudio, which offered the least expensive and most portable means to multitrack recording in the 1980s. The Portastudio revolutionized entry-level recording by using the inexpensive cassette tape as a medium though running the tape at double speed to increase sound quality. The machine had four microphone inputs which could be assigned to four separate tracks. These four tracks were mixed to a stereo recording, which could be duplicated for local markets. Collins' innovative use of the Portastudio enabled him to produce professional recordings including up to nine instrumentalists and vocalists. From the approximately 500 cassettes that Collins used during these sessions, about 290 have survived and contain approximately 90 hours of four-track recordings.

In the spring of 2019, these tapes were digitized by ethnomusicologist Colter Harper in a collaborative project with John Collins and the Nketia archives with the goal of making them available for research. A small percentage of these recordings have already appeared as international LP releases with subsequent streaming released. These including *The Guitar and the Gun* (Africagram Records, 1983), *The Guitar and the Gun II* (Africagram Records, 1985), *N'Tutu* by the Genesis Gospel Singers (Africagram Records, 1984), *Electric Highlife: Sessions from the Bokoor Studios* (Naxos World, 2002), and *Kukurantumi* by Amertey Hedzoleh (Chop Time Music, 2014). Other recordings were released near the time of recording on the Ghanaian LP and cassette market but have become difficult to locate due to the disappearance of cassette shops. The value of this rare collection is apparent in the intimate look it offers into the musical life of Ghana under the military government of Jerry Rawlings (1982-1993), a period when live music was greatly curtailed under the military curfew enforced from 1982 for about three years. The collection also documents Collins' practice as a music producer, which remains an ill-addressed side of his career as a contributor to the popular music in West Africa.

The addition of this collection of materials significantly updates the Nketia Archives holdings by filling in a big gap in the chronology of musical history of Ghana. In Nketia's footsteps as an active researcher, Collins' recordings provide yet another model of scholarly research that can inspire future work among the users of the Archives. Currently, Harper and Collins are working to contact artists from the recordings and collect oral history relating to the experiences of musicians in Rawlings era Ghana. These stories will provide a detailed look at the creative lives of popular musicians during a pivotal decade in which new technologies dramatically changed how music was produced, performed, and consumed.

Conclusion

There is a growing support for Africa's right to determine and preserve its cultural heritage as exemplified in the 2018 report *The Restitution of African Cultural Heritage: Toward a New Relational Ethics* by Felwine Sarr and Bénédicte Savoy, which calls for a sweeping new relational ethics of engaging with African material culture and restitution of objects to their places of origin. The recent endorsement by French President Emmanuel Macron for the return of 26 art objects to Benin reflects a growing momentum in repatriation efforts of looted objects in colonial Africa. While the moral question of returning looted items seems indisputable, the question remains of where these objects will live, how they will be cared for, and accessed by the public. The case of the J.H. Kwabena Nketia Archives presented here, though not comparable in terms of care conditions and provenance of objects, pose relevant questions: rather than lamenting the lack or substandard infrastructures for care of material heritage, how do we promote a culture of collective care, increase professional standards, and promote resource sharing from a place of respect and recognition of cultural ownership?

The challenges faced by audio-visual archives in Africa should not relegate collections of African materials to American and European universities, out of the reach of many scholars and students from their countries of origin. Archivists recognize that the location of these materials is as important as their preservation for they contain "vital elements of our collective memory, determining our achievements over the years, documenting our past, present and determining our future" (Zinyengere 2008, 37). The work of the scholars at the University of Ghana who have long contributed to the field of music— Amu, Nketia, Collins, etc…. —are best contextualized in the Archives in which their work of knowledge building has cumulative and collaborative effect. This overview of the Nketia Archives' historical formation as well as current challenges and activities is part of the larger effort stemming from the ground up by the very scholars and archivists at the University of Ghana. Advocacy, continued reflection and evaluation, and awareness-raising are as integral to archival work as conducting fieldwork and building facilities for digitization. Stemming from the Greek *archeîon*, meaning public office, the archive has a commitment to its public—in this case to the Ghanaians and West Africans whose cultural heritage and musical histories are housed here, as in Nketia's vision, to be studied, recorded, preserved, and practiced as living art. As we have hoped to show here, the process of building and maintaining an audio-visual archive in Ghana is closely linked to the larger struggles of nation forming in post-Colonial Africa.

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Review of *Moving Image and Sound Collections for Archivists*

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Anthony Cocciolo's *Moving Image and Sound Collections for Archivists* is written as a manual for every archivists who encounters audiovisual assets amongst their repository's holdings. Cocciolo created this work with the traditional archivist in mind who does not work regularly with audiovisual materials and gets anxious by handling these unfamiliar and oftentimes confounding information carriers. Within the book's intro, Cocciolo opines that "Professional archivists are not trained to work with audiovisual materials, and given the abundance of moving image and sound materials created in the middle of the 20th century, and the ease with these materials are made concurrently, all archivists should possess some familiarity with audiovisual formats and know when to ask for help with complex issues." This statement in essence forms the thesis of the work resulting in a manual that is useful to both the traditional paper-based as well as the veteran audiovisual archivist.

With *Moving Image and Sound Collections for Archivists*, Cocciolo has filled the gap in professional archival literature, typically written for audiovisual archivists working in well-funded institutions. This work is unique as Cocciolo's target audience is the lone arranger ensconced in a small, resource-constrained institution. The archivist who panics at the sight of a 1/4 inch audiotape, reel of 16mm motion picture film, or other unfamiliar audiovisual asset, and needs to know exactly what that bizarre thing sprawled out on their desk is and how they can responsibly steward it.

Anthony Cocciolo is the Dean of the School of Information at Pratt Institute and throughout the text he draws upon his professional archival experience and background in computer science to convey professional best practices, positing the ideal solution to some of the biggest quandaries posed by working with audiovisual carriers. Depositing digitized preservation files from an analog audio carrier into a trusted digital repository as recommended in Chapter 4 "Digital Preservation of Digitized and Born-Digital Content", is just one example providing readers with a sound map towards responsible stewardship. However, the author is very pragmatic in his approach and offers numerous low cost, and more often, no-cost DIY options to archivists at cash strapped repositories – providing a line of code to download a website for archiving from Chapter 11 "Complex Media" is a particular favorite. Cocciolo draws upon case studies from his time teaching a class at Pratt to illustrate examples of theories, supplementing these will examples given from well-respected professionals from the archives field. This approach results in a text that is firmly rooted in real world solutions to abstract quandaries useful at every stage in an archives professional's career.

The book is logically divided into two parts. The first part comprises six chapters, providing general archival practices that draw on traditional paper-based archival theory concepts. Essentially these chapters follow the same structure, beginning with a brief overview of the concept, followed by how the varying theories apply to the stewardship of audiovisual carriers, and ending with case studies that exemplify how theories are applied by professionals. In the first chapter "Appraisal and Reappraisal," Cocciolo writes that "A notable issue with appraisal, as it is discussed in the archives literature, is that most of it does not apply particularly well to audiovisual records." (pg.11) Due to this gap, the author calls upon the professional to expand its conceptualization to accommodate for the unusual demands

that audiovisual records present from storage of analog carrier, to description, to storage of reformatted digital copies. This statement resounds particularly strongly with anyone who has managed a large scale digitization project of a format like ¼ inch audiotape and the investment posed both in terms of personnel time and storage costs. The suggestions made by Cocciolo aids archivists in making better informed decisions about what materials to accession and reformat.

The second part of the book–comprises five chapters and provides guidance for media formats--audio, motion picture film, analog video, digital video, and complex media specifically. Parallel to the first part, these chapters are logically structured starting with a brief history of the format, followed by a description of its technical dimensions and storage considerations, and ending with an overview of commonly encountered and less popular formats. Each chapter provides detailed specifics for preservation formatting including encoding specs and file wrappers.

Cocciolo's writes in an approachable, almost conversational style and covers dense concepts and oftentimes complex technical aspects in a clear and concise manner providing a comprehensive roadmap for professionals. Professional organizations, websites, and consortia are cited throughout as a reference for more complex issues that fall outside the scope of the work. A preference for open source tools dominates, furthering the development of a supportive and mutually beneficial audiovisual centered archival community. An abundance of color figures, illustrations, graphs, endnotes, and glossary of terms also act as a handy reference point and effectively enhance the work.

Cocciolo opines in the book's epilogue that we live in challenging times for archives: facing increasing quantities of moving image and sound records in desperate need of stewardship in institutions that are woefully underfunded. This predicament jeopardizes the profession's mission of preservation of and access to our collective audiovisual heritage. While *Moving Image and Sound Collections for Archivists* does not fully address the myriad of nuanced and complex issues that face archivists stewarding audiovisual materials, it does inspire paper-based archivists to take action towards effective stewardship, while serving as an essential on-hand reference for the seasoned audiovisual archivist as well. Highly recommended.

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