

Swinging in the Archives: In-House File Transfer of DATs

Lynda Schmitz Fuhrig; Smithsonian Institution Archives; Washington, D.C., USA

Abstract

Not long ago Digital Audio Tapes (DATs) were a popular medium for professional digital recording. The Smithsonian Institution Archives holds almost 2,000 DATs in its accessions but until recently lacked equipment to retrieve the rich collections of music, interviews, and programs from across the Institution.

Very few archives have conducted in-house transfers of DATs. The Smithsonian Institution Archives launched a successful pilot in 2010 to transfer the audio from the DATs to its secure servers and LTO tapes. These DATs contain priceless material from Smithsonian Jazz Masterworks Orchestra concerts to Native American radio programs to events at the Freer-Sackler Galleries of Art. This project is making these recordings accessible for the long term, as DAT machines are hard to acquire.

The audio is being saved in the WAV/BWF preservation formats. Best practice procedures include checksums, quality assurance reviews, and regular backups. This paper discusses how the pilot operated and the challenges SIA encountered.

Introduction

The Smithsonian Institution Archives (SIA) is responsible for preserving the institutional memory of a unique cultural, historical, and scientific complex of 19 museums and galleries, nine research centers, and the National Zoo. SIA's collections contain everything from handwritten correspondence to 19th-century images to 21st-century social media accounts and websites.

These collections include nearly 2,000 Digital Audio Tapes (DATs). The National Museum of the American Indian, the Freer-Sackler Art Galleries, the Hirshhorn and Sculpture Garden, and Smithsonian Productions have all transferred these tapes to the Archives, contributing to Smithsonian's permanent record.

In addition to DATs (see figure 1), SIA has audio on wax cylinders, aluminum discs, LPs, reel-to-reel tapes, cassettes, microcassettes, CDs, and DVDs. Digitization of other audio recordings has been conducted internally and externally over the years.

This paper documents what SIA started doing with its collection of DATs.

DATs background

Developed by Sony, Digital Audio Tapes were introduced in 1987 and were touted as having the same quality as CDs with recording ability [1].

"Digital audio tape (DAT) promises to be the music medium of the future. It renders sound quality on a par with digital compact discs, but in a smaller package. Moreover, DAT provides the opportunity of digital recording to hi-fi enthusiasts – a feature which the playback-only CD lacks. ... Indeed, DAT can sound splendid – but it doesn't make bit-for-bit clones of CDs any more, than today's conventional analog cassette decks do," *Popular Mechanics* wrote in 1987 [2].

Legal issues arose over copyright, resulting in a drive for anti-copying mechanisms and a "DAT tax" before DAT recorders

could be sold in the United States in 1990. Sony announced in November 2005 that it was ending production of DAT machines, making this an obsolete technology [3].



Figure 1. Digital Audio Tape or DAT recorded in 1990 for the Folk Masters radio program. SIA Accession 06-106, Smithsonian Press/Smithsonian Productions, Productions, 1991-1997.

DATs never really caught on with the general consumer market due to other emerging technologies and price, meaning fewer machines were sold, and resulting in fewer technicians who can repair DAT recorders. The DAT format also was used for data storage as Digital Data Storage (DDS) tapes [4]. Blank DATs and used DAT machines continue to be available for sale online.

DATs are about half the size of an analog cassette. The tape is contained inside the plastic housing with a slider that retracts, just like a VCR tape. DAT recorders rely on a rotary head, again using videotape technologies. Tapes are between 15 and 180 minutes in length and are recorded on one side. DATs are uncompressed, and the recordings have no tape hiss. Sampling frequencies are 32, 44.1, or 48 kHz at 16-bit linear quantization, while 96 kHz sampling frequency was available in some machines [5, 6].

Compared to open reel or analog cassette equipment, DAT recorders are complex and known for mechanical misalignment problems. "DAT machines used in professional settings were typically worked hard, and the heads are likely to be worn from extensive use. As fewer and fewer machines become usable over time, archives must determine whether they have enough head life on their machines to transfer their holdings," according to The Field Audio Collection Evaluation Tool (FACET) report from the Archives of Traditional Music at Indiana University [7].

DATs also are susceptible to fungus on the tape due to storage at high temperatures/humidity. Other issues include dirt, oxide loss, and "clumps of coating material become trapped in the head gap or debris adheres to the head leading to drop-outs or worse." [8]

The Association for Recorded Sound Collections Technical Committee's recommendations on archival sound recordings from

2009 state that DATs are inappropriate for archival storage due to “dropouts and mechanical problems” and because the machines were discontinued [9].

These issues stress that thousands of hours of Smithsonian recordings are at risk.

SIA pilot

SIA has been receiving DATs for nearly 10 years but lacked equipment to listen to or transfer the audio. Smithsonian Folkways [10] had a DAT player available for loan. SIA decided to pilot a DAT-to-computer transfer project with a 2010 full-time summer intern.

Research focused on DATs and DAT machines, other audio preservation projects, and software options, while also testing/validating workflow and procedures for transfer. Most preservation literature refers to analog-to-digital rather than digital-to-digital preservation audio projects. Research found very few organizations doing their own in-house DAT transfers, which included the National Security Archive and Democracy Now [11]. External audio preservation experts and Smithsonian sound production staff also were consulted.

Equipment includes a Mac Pro 4.1/OS 10.6.3, Audacity 1.2.5 software, a Panasonic Professional Digital Audio Tape Recorder SV-3800, and AKG K240 Monitor stereo headphones. The Mac and DAT recorder are connected through the AES/EBU IEC Type II optical output from the DAT machine to the Mac’s S/PDIF optical input. The digital-to-digital transfers are conducted in SIA’s Audiovisual Preservation Lab, where videotape digitization is also done.

The audio files are exported as WAV or Waveform Audio File Format using Audacity. This is SIA’s audio preservation format because it is uncompressed, works in Windows, Mac, and Linux environments, and has been widely used in cultural heritage institutions such as the Library of Congress, Libraries and Archives Canada, and the Florida Digital Archive [12]. SIA’s best practices include using formats that possess accessibility and longevity functions such as WAV for audio, TIF for images, and PDF for text.

BWF or Broadcast Wave Format is the European adaptation of Microsoft’s WAV and contains embedded metadata in extension chunks, which makes it more desirable as a preservation option. The International Association of Sound and Audiovisual Archives and Audio Engineering Society recommend BWF for archival use [13]. AIFF or Audio Interchange File Format is another uncompressed option but is not as widely used as WAV/BWF [14]. More details about BWF are provided later in this paper.

Other audio recordings on analog tape at SIA have been digitized as WAVs, and audio tracks from CDs are ripped as WAVs.

Each DAT creates one WAV file ranging in size from 28 MB to 1.2 GB.

Audacity has been used successfully with past projects at SIA. It also is free and open-source. More robust proprietary software has been considered and may be acquired in the future when funds are available.

Smithsonian Productions recorded many special events, concerts, and Smithsonian Jazz Masterworks Orchestra performances. The original recordings were used to create radio productions such as *Folk Masters*, *Jazz Smithsonian*, and *Musica*

de las Americas. In many cases, SIA has the original recordings, the final radio programs, and all of the elements created in between. Smithsonian Productions closed in 2002, and its analog and digital files were accessioned by SIA.

The full-scale transfer started with *SIA Accession 04-062, Smithsonian Productions, Productions, 1991-2001* [15], which contains DATs and other audio carriers such as Hi8 tapes used for sound recordings. These DATs document production of the *Jazz Smithsonian* radio program hosted by the late Lena Horne. The program ran from 1994-2001 and featured music from Smithsonian Jazz Masterworks Orchestra concerts recorded by Smithsonian Productions. This accession contains original master recordings, safety copies, and production masters, which means some duplication across recordings.

The first box contains 46 tapes, which amounted to 31.44 GB of storage.

Even though Audacity is easy to use and does not require sound engineering skills, getting the correct sample and export format settings within it took some additional research and trial and error before successful files were created. Early transfers either caused Audacity to crash or distortion was present on the WAV file. Audacity also had a tendency to crash when other applications were open on the Mac.

Even though the accepted preservation standard for audio is 24-bit, 96 kHz [16], this is unattainable with the DATs because they were recorded at 16-bit, 44.1 or 48 kHz, and accurate copies cannot be created at higher sample rates. Sampling at a higher rate could even cause noise within the WAV file [17]. Original rates should be maintained for digital transfers.

These DATs typically run 60 to 90-plus minutes, and transfers are done in real time. Only two to three DATs can be transferred and checked for a first round of quality assurance in a workday with SIA’s current procedures.

Audacity settings include:

- Stereo
- Default Sample Rate – 44.1 kHz or 48 kHz
- Default Sample Format – 32-bit float (optimal for input even though export is 16-bit)
- Real-time Dither – None
- High-quality Dither – None
- Uncompressed Export Format – WAV (Microsoft) Signed 16-bit PCM (linear pulse code modulation)

The pilot resulted in the transfer of 87 DATs of more than 89 hours of audio, which included additional *Jazz Smithsonian* material and recordings for Smithsonian Folkways’ CDs of Native American music. These WAVs totaled 57 GB. Only four tapes had to be re-transferred due to distortion/noise on the WAV files that was not present in the original recordings.

Audio quality was usually good as well in terms of little static or distortion on the DATs. Nevertheless, in some cases, spoken word was low sometimes due to the speakers who were not near the microphone. Edited program masters and air copies did not have this problem.

SIA’s best practices strive to handle the original file/object once to create an optimal digital preservation file with the highest standards as possible. From there, derivative use copies can be created that are smaller in size due to compression, such as MP3

files for the web. Due to DAT's obsolescence issue and the risk of tapes themselves deteriorating, SIA's goal is to transfer the tape only once if possible. As noted in some instances with distortion, a tape has to be transferred again after quality control is done on the WAV.

The transfer starts with the archivist listening with professional headphones to the DAT while recording the audio in Audacity. The headphones eliminate external noise and provide better sound quality than the Mac's internal speakers. The archivist documents any distortions or other issues on the original. Once the tape has finished playing in the DAT recorder, the recording in Audacity is stopped and the file is exported as a WAV. The WAVs are not altered to eliminate problems heard on the DAT. The WAV file is played back by the processing archivist on the Mac in iTunes as the first quality check. The pilot started out with the entire WAV file being played back but was later modified to sample a few minutes at the beginning, middle, end, and any areas of known distortion by the processing archivist. Each audio file is run against FITS (File Information Tool Set) [18] to validate its format and to generate an MD5 checksum. The XML output from FITS is kept with the accession. Another archivist then performs a second listen of the full file on a PC.

Metadata is stored in an Excel spreadsheet. Fields include date of transfer, archivist, file name, start and end times of audio, any issues during transfer or playback, tape manufacturer, and checksum. As stated previously there was some duplication among tapes and this was noted, but no transfers have been deleted as of yet. Files are saved on the Mac, a backed-up preservation server, and LTO tapes. In the future the WAV files could be saved in the Smithsonian's enterprise Digital Asset Management System once audio is being accepted.

Initial research on BWF done during the pilot turned to the work of the Federal Agencies Digitization Guidelines Initiative (FADGI). FADGI's Audio-Visual Working Group created an open-source free software tool called BWF MetaEdit. BWF MetaEdit can check or add WAV metadata, allowing the BEXT chunk to be populated to create valid BWF files. [19, 20]. A chunk is a self-contained set of data with a header and accompanying data. FADGI recommends the BEXT or Broadcast Audio Extension chunk to include the following elements: Originator, OriginatorReference, Description, OriginationDate, Version, and Reserved. Metadata can be imported or exported with the tool or entered directly [21]. See Figure 2. Software that does not support BWF cannot retrieve the BEXT metadata, but the audio can still be played. A BWF file retains the .wav extension.

Initial testing of the tool was conducted late in the pilot with good results, except for some crashes. Since then, additional testing has been done, and a set of WAVs has been saved in the BWF format. The BWF MetaEdit tool soon will be fully implemented at SIA.

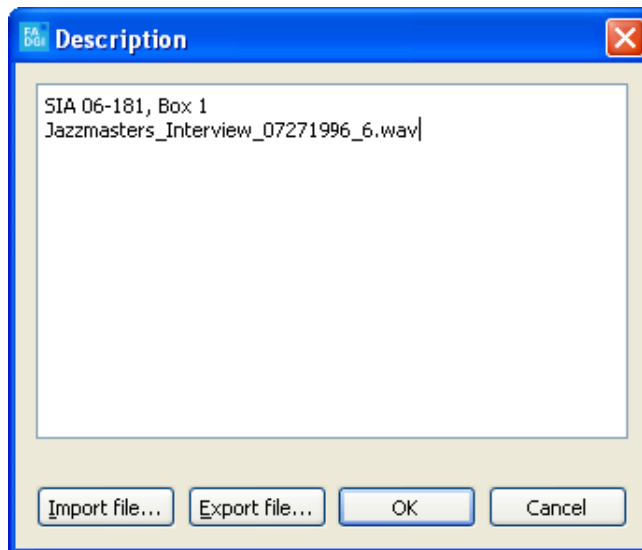


Figure 2. The description element for the BEXT chunk in FADGI's BWF MetaEdit tool.

The audio files are saved within a directory structure that follows the accession number, box number, and file name, which is taken from the name on the DAT label or insert.

```
04-062 folder
  Box_7 folder
    JS95PM0252.wav file
    JS95PM0253.wav file
    JS95OM0254.wav file
```

The physical condition of the DATs transferred to date has been very good, with no signs of mold or other tape problems. Part of this is due to proper storage conditions employed by SIA. It is also possible that the original holders of DATs are less likely to tuck them into a drawer like the ubiquitous 3.5" diskette.

Once the pilot ended SIA decided to continue DAT transfers. This work is being done by interns and volunteers. Distortion started during playback/transfer though with a set of DATs, after more than 100 hours of transfers. Since the DAT recorder had extensive use in the summer this was not too surprising. Luckily, a vendor in the area was able to service the machine while Smithsonian Folkways had another DAT player for loan.

Out of 161 DATs as of March 2011, only five would not play back on the equipment and could not be transferred. The Panasonic DAT recorder indicated these tapes were 32kHz. After trying on other equipment, sound experts at Smithsonian Folkways thought the recording possibly was not done properly and/or was created on portable equipment. The FACET report noted that mechanical misalignment can result in a tape replaying on the recording machine but not on other DAT machines [22].

Challenges

As an archive, SIA is at the mercy of what formats and media the depositing unit used. Some digital records (text, images, audio, video, etc.) come to SIA fifteen to twenty years after they were

created. Equipment and software, as seen with the DATs, might be obsolete.

Many of the recordings came from an office that no longer exists at the Smithsonian, making it difficult to contact people who may have created the DATs. It is not known what equipment was used or even the settings in some cases.

Sound engineers are not on staff at SIA but expertise is available elsewhere within the Institution. Nevertheless, SIA is not editing/enhancing the WAV files and only creating preservation masters. The professional quality of these original recordings is helpful.

The transfer and quality assurance is very time consuming and no full-time staff is available to regularly continue the work. The average running time of DATs was longer than initially expected during the pilot. SIA plans to continue transferring these tapes as long as machines are available and operational.

There is the need to convert the WAV files to BWF files. Proprietary software, which is more complicated to learn, would do this automatically but has not yet been acquired.

There are possible rights issues with some of the radio recordings.

A New Life

Thanks to social media the Smithsonian has been able to expose some of these recordings to a broader audience through various blogs.

The summer intern was able to write about her experience and challenges on SIA's blog *The Bigger Picture* while providing sound clips to one of her new favorite pieces by Dizzy Gillespie [23].

Another DAT contained the groundbreaking ceremony of the Hirshhorn Museum and Sculpture Garden in 1969. In this case, a DAT in 1998 was used by the Hirshhorn to digitize audio from an LP (SIA does not have record player either). The actual timing of the transfer of this DAT to a WAV file was perfect in that it was during the groundbreaking anniversary. *The Bigger Picture* was able to highlight this digital record featuring President Lyndon Johnson [24].

SIA has also worked with the Smithsonian Jazz Month Initiatives at the National Museum of American History on researching and providing audio of Lena Horne and the late Billy Taylor for its own blog postings [25].

The future

SIA has transferred 161 DATs, creating 95 GB of WAV files. Dissemination/access files are available as MP3 or FLAC.

The acquisition of DATs has not stopped, as SIA continues to receive these tapes in 2011. Best practices are to transfer them as soon as possible since machinery can become defunct at any time.

Despite the time the transfers take, the pilot and continuing work has been rewarding. Working in Audacity takes minimal training and volunteers and interns can start transfers quickly. The project also has demonstrated the success of various Smithsonian offices working together.

While at the current rate the 1,800-plus remaining DATs will not be transferred anytime soon, the digital-to-digital transfers will continue as long as feasibly possible since organizations are at the mercy of a dwindling supply of machines. In some cases these are

the only copies of recordings that document the history of the Smithsonian's various projects and events.

Acknowledgements

The author wishes to thank Susan Eldridge, Riccardo Ferrante, Pete Reiniger, Sarah Stauderman, and Jennifer Wright for their assistance with SIA's DAT preservation endeavors.

References

- [1] "Sony Corporate History," (retrieved 17 February 2011), <http://www.sony.net/SonyInfo/CorporateInfo/History/SonyHistory/2-10.html>
- [2] Stephen A. Booth and Frank Vizard, "Digital audio cassettes: small tape, big sound," *Popular Mechanics* (July 1987) pg. 106. (retrieved 28 February 2011), http://books.google.com/books?id=QuQDAAAAMBAJ&printsec=frontcover&rvview=1&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false
- [3] "DAT stirs piracy fears, loses out to plastic discs," *EDN* 51.1 (2006) pg. 94. General OneFile. Web. (retrieved 7 March 2011) .
- [4] Mike Casey, FACET: The Field Audio Collection Evaluation Tool. Format Characteristics and Preservation Problems Version 1.0 (2007) pg. 49-51.
- [5] "All About DAT," *World Book Science Year*. (Aug. 2009) eLibrary, Web. (retrieved 7 March 2011).
- [6] Ken C. Pohlmann, *Principles of Digital Audio* (New York : McGraw-Hill, 2000) pg. 195-197.
- [7] Mike Casey, FACET: The Field Audio Collection Evaluation Tool. Format Characteristics and Preservation Problems Version 1.0 (2007) pg. 49.
- [8] *Ibid.* pg. 53-54.
- [9] "ARSC Technical Committee Preservation of Archival Sound Recordings Version 1, April 2009," (retrieved 15 February 2011), http://www.arsc-audio.org/pdf/ARSTC_preservation.pdf
- [10] Smithsonian Folkways is Smithsonian's nonprofit record label, which is part of the Smithsonian Center for Folklife and Cultural Heritage, <http://www.folkways.si.edu/>
- [11] Susan Eldridge, *Digital Audio Tapes: Their Preservation and Conversion* (unpublished 2010) pg. 11-12.
- [12] "Sustainability of Digital Formats," (retrieved 28 February 2011), <http://www.digitalpreservation.gov/formats/fdd/fdd000001.shtml>
- [13] Susan Eldridge, "Digital Audio Tapes: Their Preservation and Conversion" (unpublished 2010) pg. 9.
- [14] Rob Bamberger and Sam Brylawski, *The State of Recorded Sound Preservation in the United States: A National Legacy at Risk in the Digital Age* (Council on Library and Information Resources and the Library of Congress, 2010) pg. 70.
- [15] "Finding Aids to Official Records of the Smithsonian Institution, Accession 04-062, Smithsonian Productions, Productions, 1991-2001," <http://siarchives.si.edu/findingaids/FA04-062.htm>
- [16] "ARSC Technical Committee Preservation of Archival Sound Recordings Version 1, April 2009," (retrieved 15 February 2011), http://www.arsc-audio.org/pdf/ARSTC_preservation.pdf
- [17] Susan Eldridge, *Digital Audio Tapes: Their Preservation and Conversion* (unpublished 2010) pg. 7.
- [18] File Information Tool Set (FITS), developed by the Harvard University Library Office for Information Systems, "identifies, validates, and extracts technical metadata" for file formats. The tools it uses are Jhove, Droid, File Utility, Exiftool, National Library of New Zealand Metadata Extractor, and FFIdent. The results are written to an XML file. <http://code.google.com/p/fits/>
- [19] "Guidelines: Embedding Metadata in Broadcast WAVE Files - BWF MetaEdit Help:BEXT Audio Metadata Information," (retrieved 1

- March 2011), <http://www.digitizationguidelines.gov/audio-visual/documents/btext.html>
- [20] Mike Casey and Bruce Gordon, *Sound Directions, Best Practices for Audio Preservation* (2007) pg. 34.
- [21] “Embedding Metadata in Digital Audio Files: Guideline for Federal Agency Use of Broadcast WAVE Files,” (retrieved 1 March 2011) http://www.digitizationguidelines.gov/audio-visual/documents/Embed_Guideline_090915r.pdf
- [22] Mike Casey, FACET: The Field Audio Collection Evaluation Tool. Format Characteristics and Preservation Problems Version 1.0 (2007) pg. 49.
- [23] “Swingin’ and Swayin’ in the Archives,” <http://blog.photography.si.edu/2010/08/12/swingin-and-swayin-in-the-archives/>
- [24] “An Audio Anniversary: Groundbreaking at the Hirshhorn,” <http://blog.photography.si.edu/2011/01/12/groundbreaking-at-the-hirshhorn/>
- [25] “In tribute to Lena Horne (June 30, 1917–May 9, 2010),” <http://blog.americanhistory.si.edu/osaycanyousee/2010/05/in-tribute-to-lena-horne.html>

Author Biography

Lynda Schmitz Fuhrig is an electronic records archivist at the Smithsonian Institution Archives. Her research focuses on long-term curation and preservation issues of born-digital materials, including email collections, websites and social media sites, audio, and images. She holds a MA in history from the University of Illinois at Springfield. She is a member of the Society of American Archivists and Mid-Atlantic Regional Archives Conference.