Contents

Summary Table

Summary table of videotape formats. Includes the number of recordings digitized in each format, the number of hours digitized, and the digitizer.

Format	Number	Hours	Digitizer(s)
1” Type C	4,084	2,524.69	Memnon/IUMDS
½” Open Reel (EIAJ and CV)	519	285.62	IUMDS
2” Quad	157	106.37	Quad Tape Transfer
8mm	1,077	1458.51	IUMDS
Betacam	19,367	13,897.08	Memnon/IUMDS
Betamax	1,231	1,968.48	IUMDS
DV	2,868	2,816.87	Memnon/IUMDS
DVD-R	4,840	5,044.06	Memnon
U-matic	15,850	9,882.87	Memnon/IUMDS
VHS	47,402	78,444.42	Memnon/IUMDS
Total	97,395	116,428.97	

I. Introduction

This document provides a summary of the digitization of ten video formats by the MDPI project from June 2015-June 2021. Both an external vendor—Sony Memnon—and an internal operation—IU Media Digitization Studios (IUMDS)—supplied digitization services. An overview of the workflows used by Memnon and IUMDS, along with descriptions of key decisions, challenges, and items that were left undone, are provided for each format. These items provide a technical summary only. The details of digitization, including such things as complete signal chains, staffing (IUMDS), and condition notes for individual recordings, may be found elsewhere.

II. Issues that impact multiple formats

A. Closed captions

We extracted the bytestream from the digitized video (by interpreting the line 21 flickers) and then sent them into ccextractor (https://www.ccextractor.org/) to generate webvtt. files. Right now, Avalon doesn't support webvtt display, but most standalone players do.

Brian Wheeler from IU Libraries wrote a tool to extract the data. It's at https://github.com/IUMDPI/Extract-CC-Bytestream

The tool is a perl script that does the following things:

- runs ffmpeg on the video and to create a set of files, one per frame
    - the frames are in PGM (Portable Gray Map) format
    - the frames are cropped to only the line 21 data (plus a couple surrounding lines)
- each frame image is processed and a raw byte dump of the data is created
    - two bytes per frame
    - a frame is valid if it ...
        - has the right file format
        - has seven cycles of clock run-in
        - has a start bit
        - and has two 7-bit-with-parity characters
    - invalid frames dump two null values.
- creates a tarball of the frame images
- uses ccextractor to convert the raw bytes into webvtt

MDPI chose webvtt instead of alternatives such as .scc or .mcc because it seemed like WebVTT was pushing to have full functionality for CC features at some point in the future. In any case,

once the raw bytestream is extracted, creating new captioning formats does not require reprocessing the original video.

Although it is our impression that MKV can wrap pretty much anything, we are keeping the captioning data separate so that the player can access it as needed.

B. Timecode

There is very little actionable timecode in IU collections. An exception might be recordings from the public television station, WTIU. Original timecode is most useful if it is from a multi-camera shoot where, if it is not captured, sync is lost. This would mostly show up on TV work tapes which were, in any case, typically not saved. Program masters were saved but they have timecode set only for master control.

For the most part, we did not see strong use cases for capturing what timecode existed in the IU collections and had doubts about its value for research. It is possible that field recordings may have timecode synced to time of day which could be useful metadata.

We agreed that there was little need to capture timecode coming from Betacam SP, VHS, U-matic, and 1" tapes digitized by Memnon. That said, we also realized that we did not have specific expertise available to help analyze issues relating to the use and value of timecode within a preservation project. Requests to engage a consultant were denied.

C. Source for access files

Access files for use in Media Collections Online (Avalon) were always generated from mezzanine files, not preservation masters. Audio and video preservation master files were defined as comprehensive, complete, and accurate a representation of source recordings as possible. The preservation master is the raw material from the digitization event, and it therefore may contain stops and starts from the engineer attempting to improve playback, overlapping content from recordings that change speed, etc. The mezzanine (and, for audio, production master) files are processed to present the content as it was intended to be played.

III. 1” Type-C

A. Statistics

Number of tapes digitized by Memnon: 4,056
Number of tapes digitized by IUMDS: 28

Total tapes digitized: 4,084

Number of hours digitized by Memnon: 2,510.47
Number of hours digitized by IUMDS: 14.22

Total hours digitized: 2,524.69

Average duration per recording: 37.1 minutes
Average duration per recording—Memnon: 37.14 minutes
Average duration per recording—IUMDS: 30.47 minutes

B. Workflows

1. Memnon

Memnon used a parallel transfer workflow for this format to digitize as many as two tapes at the same time using one digitization operator. The operator was frequently also responsible for an additional grouping of decks of a different format such as VHS, U-matic, or Betacam. Memnon digitized all carriers from beginning to end of tape regardless of program content duration. Two streams of audio were created for each digitized carrier, even if program content did not exist on all tracks. Playback machines were Sony BVH-2000 and BVH-2500 with external BVT-2000 time base correctors.

2. IUMDS

IUMDS digitized one-inch tapes that failed the Memnon workflow. The IUMDS workflow was 1:1, that is, one video engineer digitized one tape at a time. Digitization took place in the IUMDS video studio designed for critical viewing and listening. All tapes were inspected before digitization noting tape type, content duration, audio configuration, and any notable defects or anomalies. Any remediation steps such as baking, cleaning, or rehousing were carried out as needed by the MDPI Video Preservation Engineer and MDPI AV Specialist. Two streams of audio were created for each digitized carrier, even if content was not present on all tracks of the

source tape. Playback machines were Sony BVH-2000 with internal or external BVT-2000 time base correctors.

C. Key Decisions

1. Problem tapes

Tapes with characteristics defined as problematic by MDPI and/or Memnon (see the list below); or tapes that could not be diagnosed, remediated quickly, or digitized by Memnon within their role as a provider of high-throughput parallel transfer workflows; were sent to IUMDS for digitization.

Tapes containing one or more of the following characteristics were failed by Memnon and re-routed to IUMDS:

- Tapes that were broken or damaged prior to or during attempted playback
- Squealing tapes due to sticky shed syndrome or defective cassette mechanisms
- Perceived major signal anomalies such as severe mis-tracking or compromised RF signals
- Perceived generally poor physical condition such as stretched, creased or with defects in tape wrap
- Presence of fungus
- Non-NTSC standard tapes such as PAL
- Non-Type-C format one-inch tapes, such as Type-A and Type-B
- Three-hour tapes, requiring a special model deck such as a Sony BVH-2180
- Anything that seemed unusual or odd that could not be immediately diagnosed and remedied

2. Video levels

Memnon:

At Memnon, if color bars were present on a tape the TBC chroma level was set to 100% and the set-up (black) level to zero. Video gain and hue were left in TBC preset.

Program playback was observed and if black levels were crushed, an adjustment was made to correct. If hard clipping (110 units) of video gain was observed, the level was lowered out of clipping range.

If no color bar reference was present on a tape, the TBC was operated with all settings in the preset mode. Program playback was observed and if black levels were crushed, an adjustment was made to correct. If hard clipping (110 units) of video gain was observed, the level was lowered out of clipping range.

IUMDS:

At IUMDS, video levels for each tape were set up with a time base corrector and waveform monitor for faithful reproduction of recorded content. If color bars were present on a tape, the set-up (black) level was set to zero, the video gain to 100, the chroma level and hue were set to align to the graticule of the vectorscope, with the red vector being the priority. Program playback was observed and if black levels were crushed, video gain was hard clipping, or chroma saturation was creating excessive video noise, adjustments were made to correct.

If no color bar reference was present on a tape, the TBC was operated with all settings in the preset mode as a starting point. The objective was to best preserve a good range of the luma and chroma signal. Program playback was observed and if black levels were crushed, video gain was hard-clipping or chroma saturation was creating excessive video noise, adjustments were made to correct.

D. Challenges

1. Tapes with sticky shed syndrome--Memnon used an RTI 6120 tape cleaner to clean tapes exhibiting exudation prior to digitization
2. Tapes with recordings made on machines that were out of alignment
3. Damaged tapes that required a splice
4. Tapes with three channels of audio, DVS (Descriptive Video Service)

E. Left Undone

1. Non-NTSC tapes; PAL (26 tapes), Type-B PAL (8)

IV. ½” Open Reel

A. Statistics

Number of tapes digitized by IUMDS: 519
Number of hours digitized by IUMDS: 285.62
Average duration per recording—IUMDS: 0.55 hours (33.01 minutes)

B. Workflows

1. IUMDS

IUMDS digitized both EIAJ (color and monochrome) and CV tapes. The IUMDS workflow was 1:1, that is, one video engineer digitized one tape at a time. Digitization took place in the IUMDS video studio designed for critical viewing and listening. All tapes were inspected before digitization noting format type and any notable defects or anomalies. All tapes were baked and cleaned prior to digitization by the MDPI Video Preservation Engineer and MDPI AV Specialist. One stream of audio was created for each digitized carrier. Playback machines were Sony AV-8650 and Sony CV-2200. External time base correctors used were the DPS-235 and Snell and Wilcox TBS24.

C. Key Decisions

1. Video levels

At IUMDS, video levels for each tape were set up with a time base corrector and waveform monitor for faithful reproduction of recorded content. If color bars were present on a tape, the set-up (black) level was set to zero, the video gain to 100, the chroma level and hue were set to align to the graticule of the vectorscope, with the red vector being the priority. Program playback was observed and if black levels were crushed, video gain was hard clipping, or chroma saturation was creating excessive video noise, adjustments were made to correct.

If no color bar reference was present on a tape, the TBC was operated with all settings in the preset mode as a starting point. The objective was to best preserve a good range of the luma and chroma signal. Program playback was observed and if black levels were crushed, video gain was hard-clipping or chroma saturation was creating excessive video noise, adjustments were made to correct.

D. Challenges

1. Squealing tapes or tapes that would not run at the proper speed due to sticky shed syndrome
2. Unstable tapes that require frequent tracking and skew adjustments due to signal anomalies
3. Tapes that were slit, improperly spliced or otherwise stretched, creased or with defects in tape wrap
4. Keeping playback decks repaired; both EIAJ and CV decks required a video head replacement as well as other frequent maintenance service.

E. Left Undone

None.

V. 2” Quad

A. Statistics

Number of tapes digitized by an outside vendor (Quad Tape Transfer): 157
Number of hours digitized: 106.37
Average duration per recording: 0.68 hours (40.65 minutes)

B. Workflows

1. Quad Tape Transfer

All tapes were given a carrier visual inspection by the MDPI Video Preservation Engineer before shipping to Quad Tape Transfer in Gray, Tennessee. Items noted: tape, reel or case damage or deterioration, reel type, size and stock brand, label information. Quad Tape Transfer removed all foam-lined flanges and removed any leeching adhesive from the tape wrap before baking all back-coated tapes for two weeks at 124 degrees. Each tape was cleaned prior to digitization. The Quad Tape Transfer workflow was 1:1, that is, one video engineer digitized one tape at a time. Each carrier was digitized to an uncompressed 10-bit v210 AVI file with a single stereo pair stream. The program audio channel was sent to the left and the cue channel was sent to the right. Playback machines were Ampex VR-1200C. *(Potentially other decks may be used if needed: Ampex AVR-2, Ampex AVR-1, Ampex AVR-3, Ampex VR-2000, RCA TR-600A. Time base correctors used: VTR respective onboard units or external DPS-220.)*

C. Key Decisions

1. File Roles

The 10-bit uncompressed file from the vendor is designated the preservation master. This file is transcoded by IU to FFv1 in a Matroska wrapper, which functions as a preservation master-intermediate.

The mezzanine file is the same as for other IU video formats: IMX50 / SMPTE D10, Audio – 24-bit/48 kHz PCM.

D. Challenges

1. Problem tapes

- Tapes with bent reels

- Tapes with glue leeching from Scotch foam-lined flanges
- Tape with unstable video signals and significant video dropouts

VI. 8mm

A. Statistics

Number of tapes digitized: 1,077
Number of hours digitized: 1,458.51
Average duration per recording: 1.35 hours (81.25 minutes)

B. Workflows

1. IUMDS

The IUMDS workflow was 1:1 or 2:1, that is, one video engineer digitized one or two tapes at a time. Digitization took place in the IUMDS video studio designed for critical viewing and listening. All tapes were inspected before digitization noting tape type (Video8, Hi-8, Digital-8) speed (SP/LP), speed changes (if any), content duration, audio configuration (presence of PCM channels or not) and any notable defects or anomalies. Any remediation steps such as baking or rehousing were carried out as needed by the MDPI Video Preservation Engineer and MDPI AV Specialist. A single stream with a stereo pair was created for carriers with normal AFM audio tracks. A few tapes contained both normal AFM and PCM tracks; each of the four tracks were recorded to a separate audio stream. Playback machines were Sony EVO-9850, Sony EVO-9500A, Sony GV-D200. External time base correctors used were the DPS-235 and Snell and Wilcox TBS24.

C. Key Decisions

1. Video levels

Memnon:

At Memnon, if color bars were present on a tape the TBC chroma level was set to 100% and the set-up (black) level to zero. Video gain and hue were left in TBC preset.

Program playback was observed and if black levels were crushed, an adjustment was made to correct. If hard clipping (110 units) of video gain was observed, the level was lowered out of clipping range.

If no color bar reference was present on a tape, the TBC was operated with all settings in the preset mode. Program playback was observed and if black levels were crushed, an adjustment was made to correct. If hard clipping (110 units) of video gain was observed, the level was lowered out of clipping range.

IUMDS:

At IUMDS, video levels for each tape were set up with a time base corrector and waveform monitor for faithful reproduction of recorded content. If color bars were

present on a tape, the set-up (black) level was set to zero, the video gain to 100, the chroma level and hue were set to align to the graticule of the vectorscope, with the red vector being the priority. Program playback was observed and if black levels were crushed, video gain was hard-clipping, or chroma saturation was creating excessive video noise, adjustments were made to correct.

If no color bar reference was present on a tape, the TBC was operated with all settings in the preset mode as a starting point. The objective was to best preserve a good range of the luma and chroma signal. Program playback was observed and if black levels were crushed, video gain was hard-clipping or chroma saturation was creating excessive video noise, adjustments were made to correct.

D. Challenges

- Tapes that were broken or damaged prior to or during attempted playback
- Tapes with broken shells, doors, or internal parts requiring some adjustment or complete rehousing
- Squealing tapes due to sticky shed syndrome or defective cassette mechanisms
- Tapes with unstable video signals due faulty tape formulations (Sony)
- Perceived generally poor physical condition such as stretched, creased or with defects in tape wrap
- Tapes with recordings made on machines that were out of alignment
- Sticky shed problems with some metal particle tapes requiring a low-heat in-shell baking

E. Left Undone

1. Non-NTSC tapes; PAL (3)
2. Exabyte Data8 data tape (3)
3. DA-88 digital multi-track (6)

VII. Betacam

A. Statistics

Number of tapes digitized by Memnon: 18,916
Number of tapes digitized by IUMDS: 451

Total tapes digitized: 19,367

Number of hours digitized by Memnon: 13,588.03
Number of hours digitized by IUMDS: 309.05

Total hours digitized: 13,897.08

Average duration per recording—Memnon: 0.72 hours (43.1 minutes)
Average duration per recording—IUMDS: 0.69 hours (41.12 minutes)

B. Workflows

1. Memnon

Memnon used a parallel transfer workflow to digitize twelve tapes at the same time using one digitization operator. The operator was frequently also responsible for an additional grouping of decks of a different format such as VHS, U-matic, or one inch. Memnon digitized all carriers from beginning to end of tape regardless of program content duration. Four streams of audio were created for each digitized carrier, even if program content did not exist on all four tracks. Playback machines were Sony DVW-A500 (for Betacam oxide, Betacam SP, Digital Betacam), Sony DVW-M2000, Sony HDW- M2000 (for Betacam oxide, Betacam SP, Digital Betacam, Betacam SX, IMX).

2. IUMDS

IUMDS digitized Betacam tapes that failed the Memnon workflow. The IUMDS workflow was 1:1, that is, one video engineer digitized one tape at a time. Digitization took place in the IUMDS video studio designed for critical viewing and listening. All tapes were inspected before digitization noting tape type, content duration, audio configuration (presence of 1-4 channels) and any notable defects or anomalies. Any remediation steps such as baking, cleaning, or rehousing were carried out as needed by the MDPI Video Preservation Engineer and MDPI AV Specialist. Four streams of audio were created for each digitized carrier, even if content on all

four tracks was not present on the source tape. Playback machines were Sony DVW-M2000 and a BTS (Sony) PBC-2800.

C. Key Decisions

1. Problem tapes

Tapes with characteristics defined as problematic by MDPI and/or Memnon (see the list below); or tapes that could not be diagnosed, remediated quickly, or digitized by Memnon within their role as a provider of parallel transfer workflows; were sent to IUMDS for digitization.

Tapes containing one or more of the following characteristics were failed by Memnon and re-routed to IUMDS:

- Tapes that were broken or damaged prior to or during attempted playback
- Tapes with broken shells, doors, or internal parts
- Squealing tapes due to sticky shed syndrome or defective cassette mechanisms
- Perceived major signal anomalies such as severe mis-tracking or compromised RF signals
- Perceived generally poor physical condition such as stretched, creased or with defects in tape wrap
- Presence of fungus
- Non-NTSC standard tapes such as PAL
- Anything that seemed unusual or odd that could not be immediately diagnosed and remedied

2. Video setup

Memnon:

At Memnon, if color bars were present on a tape the TBC chroma level was set to 100% and the set-up (black) level to zero. Video gain and hue were left in TBC preset.

Program playback was observed and if black levels were crushed, an adjustment was made to correct. If hard clipping (110 units) of video gain was observed, the level was lowered out of clipping range.

If no color bar reference was present on a tape, the TBC was operated with all settings in the preset mode. Program playback was observed and if black levels were crushed, an adjustment was made to correct. If hard clipping (110 units) of video gain was observed, the level was lowered out of clipping range.

IUMDS:

At IUMDS, video levels for each tape were set up with a time base corrector and waveform monitor for faithful reproduction of recorded content. If color bars were present on a tape, the set-up (black) level was set to zero, the video gain to 100, the chroma level and hue were set to align to the graticule of the vectorscope, with the red vector being the priority. Program playback was observed and if black levels were crushed, video gain was hard-clipping, or chroma saturation was creating excessive video noise, adjustments were made to correct.

If no color bar reference was present on a tape, the TBC was operated with all settings in the preset mode as a starting point. The objective was to best preserve a good range of the luma and chroma signal. Program playback was observed and if black levels were crushed, video gain was hard-clipping or chroma saturation was creating excessive video noise, adjustments were made to correct.

D. Challenges

1. Tapes with sticky shed syndrome
2. Tapes with recordings made on machines that were out of alignment
3. Digital tapes with channel condition/high concealment errors

E. Left Undone

1. Non-NTSC tapes--PAL (53 tapes)

VIII. Betamax

A. Statistics

Number of tapes digitized: 1,231

Number of hours digitized: 1,968.48

Average duration per recording: 1.6 hours (95.95 minutes)

B. Workflows

1. IUMDS

The IUMDS workflow was 1:1 or 2:1, that is, one video engineer digitized one or two tapes at a time. Digitization took place in the IUMDS video studio designed for critical viewing and listening. All tapes were inspected before digitization noting tape speed (Beta I, II, III), speed changes (if any), content duration, audio configuration (presence of Hi-Fi channels or not) and any notable defects or anomalies. Any remediation steps such as baking, cleaning, or rehousing were carried out as needed by the MDPI Video Preservation Engineer and MDPI AV Specialist. Four streams of audio were created for carriers with normal and Hi-Fi audio tracks. A single stream with a stereo pair was created for carriers with normal audio only. Playback machines were Sony SLO-1800, Sony SL-HF750, Sony SLO-420. External time base correctors used were the DPS-235 and Snell and Wilcox TBS24.

C. Key Decisions

1. Problem tapes that were routed to IUMDS

- Tapes that were broken or damaged prior to or during attempted playback
- Tapes with broken shells, doors, or internal parts
- Squealing tapes due to sticky shed syndrome or defective cassette mechanisms
- Perceived major signal anomalies such as severe mis-tracking or compromised RF signals
- Perceived generally poor physical condition such as stretched, creased or with defects in tape wrap
- Presence of fungus
- Non-NTSC standard tapes such as PAL

2. Video levels

Memnon:

At Memnon, if color bars were present on a tape the TBC chroma level was set to 100% and the set-up (black) level to zero. Video gain and hue were left in TBC preset.

Program playback was observed and if black levels were crushed, an adjustment was made to correct. If hard clipping (110 units) of video gain was observed, the level was lowered out of clipping range.

If no color bar reference was present on a tape, the TBC was operated with all settings in the preset mode. Program playback was observed and if black levels were crushed, an adjustment was made to correct. If hard clipping (110 units) of video gain was observed, the level was lowered out of clipping range.

IUMDS:

At IUMDS, video levels for each tape were set up with a time base corrector and waveform monitor for faithful reproduction of the recorded content. If color bars were present on a tape, the set-up (black) level was set to zero, the video gain to 100, the chroma level and hue were set to align to the graticule of the vectorscope, with the red vector being the priority. Program playback was observed and if black levels were crushed, video gain was hard clipping, or chroma saturation was creating excessive video noise, adjustments were made to correct.

If no color bar reference was present on a tape, the TBC was operated with all settings in the preset mode as a starting point. The objective was to best preserve a good range of the luma and chroma signal. Program playback was observed and if black levels were crushed, video gain was hard clipping or chroma saturation was creating excessive video noise, adjustments were made to correct.

D. Challenges

- Tapes with recordings made on machines that were out of alignment
- Tapes with extreme shedding that caused frequent head-clogs even after baking and cleaning
- Mechanical problems with cassettes; distorted shells, spools that scraped against cassette walls, faulty clutches and springs, all requiring some adjustment or complete rehousing
- Tapes that had been exposed to an electromagnetic field that damaged the RF signal, picture and audio information to the point that a normal playback was not possible

- Extremely long tapes such as cassettes recorded at the Beta III speed which exceeded 5 hours of record time on one tape

E. Left Undone

1. Non-NTSC tapes; PAL (4)
2. Tapes with fungus (3)
3. Sony F1 PCM (86) Indiana Fiddlers Gathering

IX. DV

A. Statistics

Number of tapes digitized by Memnon: 2,824
Number of tapes digitized by IUMDS: 44

Total number of tapes digitized: 2,868

Number of hours digitized by Memnon: 2,775
Number of hours digitized by IUMDS: 41.87

Total number of hours digitized: 2,816.87

Average duration per recording, Memnon—0.98 hours (58.96 minutes)
Average duration per recording, IUMDS—0.95 hours (57.1 minutes)

B. Workflows

Memnon used a parallel transfer workflow to digitize 4-5 tapes at the same time using one digitization operator. By the end of this format, they digitized eight tapes at once. The Memnon DV operator may also be responsible for an additional grouping of decks of a different format such as Betacam, U-matic, VHS or one inch that are actively digiting. From the deck's SDI output, Memnon digitized all carriers from beginning to end of tape regardless of program content duration. This file was defined as a preservation master-intermediate file and was encoded as an FFv1 file with a Matroska wrapper. Four streams of audio were created for each digitized carrier even if all tracks did not contain active content. Simultaneously, a separate unwrapped native DV file was created from the playback deck's Firewire (IEEE 1394) output. This file was defined as a preservation master. Playback machines for the mini-DV, DVcam, DVC-Pro versions of the format: Sony DSR-1800, Sony DSR-1800A, Sony DSR-2000, Panasonic AJ-SD93, Panasonic AJ-SD955, Panasonic AJ-HD1200A**,** and Panasonic AJ-D455.

C. Key Decisions

1. Streams, formats, and file roles

The DV format is notorious for the difficulties it presents in playback. DV tape is thin and prone to drop-outs, errors, and data loss. Degraded sections may play back with wildly diverging

results from deck to deck or even playback to playback. In addition, the technical characteristics of the recorded images can be heterogeneous, with changes in recording speed and audio settings within one collection, within one cassette, and even within one data stream. These issues can make it difficult to capture all of the content that was recorded and to present a viewable version for end users. Importantly, there is metadata on the DV tape that may be significant to end users and is worth capturing.

DV decks typically output a stream via SDI that utilizes robust error correction to smooth over playback issues and create a version is viewable despite errors on the tape. SDI, however, does not carry metadata from the DV tape. Because SDI uses error correction, it may not provide an accurate representation of the data on the tape. Choosing to preserve the SDI output only may not support preservation principles.

Considering these issues, MDPI decided to capture both the DV stream and the SDI output at the same time. The unwrapped DV stream was defined as the preservation master while the SDI output version was designated the preservation master-intermediate. Memnon did the technical work to enable simultaneous capture of both outputs.

2. Production masters

DV has a data rate of 25 Mbps. We are choosing to use MPEG-2 at 25 Mbps for the mezzanine file for this format. It does not make sense to use MPEG-2 at 50 Mbps (as we do for mezzanine files for other formats) since we would just be padding the file with empty data to reach 50 Mbps. Our non-DV mezzanine files (at 50 Mbps) conform to the IMX/D10 standard and are therefore generated using constant bit rate encoding as required by the standard. 25 Mbps files cannot be part of the IMX/D10 standard as this bit rate is not defined for this standard. This opens up the possibility of generating variable bit rate files. This is preferable as VBR provides a higher-quality picture in some circumstances than CBR.

3. Problem tapes

Tapes with characteristics defined as problematic by MDPI and/or Memnon (see the list below); or tapes that could not be diagnosed, remediated quickly, or digitized by Memnon within their role as a provider of parallel transfer workflows, were sent to IUMDS for digitization.

- Tapes recorded at a mix of different speeds on the same carrier, SP and LP
- Tapes that are broken or damaged prior to or during attempted playback
- Tapes with broken shells, doors, or internal parts
- Perceived generally poor physical condition such as stretched, creased or with defects in tape wrap

- Tapes with fungus
- Anything that seems unusual or odd that cannot be immediately diagnosed and remedied

At the end of MDPI, IUMDS transferred 44 MiniDV tapes that had failed the Memnon process for a number of reasons, including: mixed speed recordings, mixed aspect recordings, mixed sample rates, a few channel condition errors, one needed to be spliced and rehoused, etc. Some utilized the SDI output only, others had to be played on a DV camcorder using the S-video out.

IUMDS was able to capture an SDI stream only for these tapes. There is no data captured via FireWire.

D. Left Undone

1. Non-NTSC tapes: PAL, SECAM
2. High-Definition format tapes (HDV)
3. Tapes that were failed by Memnon

X. DVD-R

A. Statistics

Number of discs transferred by Memnon: 4,840
Number of hours transferred by Memnon: 5,044.06
Average duration per recording—1.04 hours (62.4 minutes)

B. Workflows

Memnon transferred all of the DVD-R's that were selected for the project.

C. Key Decisions

1. File types

An ISO disc image was captured for the preservation master file.

The mezzanine file is MPEG2 wrapped in MP4. Variable bit rate. Audio is AAC-LC, 320 kb/s, 48 kHz sample rate.

Up to two streams of audio were automatically accepted by the post system. More than two resulted in the item being failed, in which case someone will have to examine it to see what is there.

2. Data discs

Data discs were not transferred.

D. Challenges

The following were challenging to transfer:

- Items recorded with OneStepDVD utility (5 discs)
- Carriers with 0 audio streams (e.g., slideshow loop) (18)
- More than one audio stream when only 1 is expected (e.g., two identical streams different audio formats such as AC3 & MPEG, (14)
- There is an audio stream present, just no audio content on the media. (3)

- Heavily scratched or damaged discs resulting in video freeze, cyclical dropped frames, jump cuts
- Still frame program content
- A/V synchronization

E. Left Undone

There was never any intention to transfer commercial DVDs.

XI. U-matic

A. Statistics

Number of tapes digitized by Memnon: 15,014
Number of tapes digitized by IUMDS: 836
Total tapes digitized: 15,850

Number of hours digitized by Memnon: 9,331.53
Number of hours digitized by IUMDS: 551.34
Total hours digitized: 9,882.87

Average duration per recording—Memnon: 0.62 hours (37.29 minutes)
Average duration per recording—IUMDS: 0.66 hours (39.57 minutes)

B. Workflows

1. Memnon

Memnon used a parallel transfer workflow to digitize as many as twelve tapes at the same time using one digitization operator. The operator may have also been assigned to an additional grouping of decks of a different format such as Betacam, U-matic, or one inch. Frequently a second operator was present and deck/format responsibilities were divided between them depending on the formats in the work queue at any given time.

Memnon digitized all carriers from beginning to end of tape regardless of program content duration. Two streams of audio were created for each digitized carrier even if no audio content was recorded on both tracks. Playback machines were Sony VO-9800, Sony VO-9850. External time base correctors used were Leitch DPS-575 and FOR-A FA-410.

2. IUMDS

IUMDS digitized U-matic tapes that failed the Memnon workflow. The IUMDS workflow was 1:1 or 2:1, that is, one video engineer digitized one or two tapes at a time. Digitization took place in the IUMDS video studio designed for critical viewing and listening. All tapes were inspected before digitization noting format type (low band, high band, SP), content duration, audio configuration and any notable defects or anomalies. Any remediation steps such as baking, cleaning, or rehousing were carried out as needed by the MDPI Video Preservation Engineer and MDPI AV Specialist. Two streams of audio were created for each digitized carrier even if

there was not audio content on both tracks. Playback machine was the Sony BVU-900 with an internal time base corrector. Sometimes an external time base corrector--either a DPS-235 or a Snell and Wilcox TBS24--was used.

C. Key Decisions

1. Problem tapes

Tapes with characteristics defined as problematic by MDPI and/or Memnon (see the list below); or tapes that could not be diagnosed, remediated quickly, or digitized by Memnon within their role as a provider of parallel transfer workflows; were sent to IUMDS for digitization.

Tapes containing one or more of the following characteristics were failed by Memnon and re-routed to IUMDS:

- Tapes with excessive oxide shedding
- Tapes that were broken or damaged prior to or during attempted playback
- Tapes with broken shells, doors, or internal parts
- Squealing tapes due to sticky shed syndrome or defective cassette mechanisms
- Low band tapes
- Perceived major signal anomalies such as severe mis-tracking or compromised RF signals
- Perceived generally poor physical condition such as stretched or creased or with other defects in the tape wrap
- Presence of fungus
- Non-NTSC standard tapes such as PAL
- Anything that seemed unusual or odd that could not be immediately diagnosed and remedied

2. Video setup

Memnon:

At Memnon, if color bars were present on a tape the TBC chroma level was set to 100% and the set-up (black) level to zero. Video gain and hue were left in TBC preset.

Program playback was observed and if black levels were crushed, an adjustment was made to correct. If hard clipping (110 units) of video gain was observed, the level was lowered out of clipping range.

If no color bar reference was present on a tape, the TBC was operated with all settings in the preset mode. Program playback was observed and if black levels were crushed, an adjustment

was made to correct. If hard clipping (110 units) of video gain was observed, the level was lowered out of clipping range.

IUMDS:

At IUMDS, video levels for each tape were set up with a time base corrector and waveform monitor for faithful reproduction of recorded content. If color bars were present on a tape, the set-up (black) level was set to zero, the video gain to 100, the chroma level and hue were set to align to the graticule of the vectorscope, with the red vector being the priority. Program playback was observed and if black levels were crushed, video gain was hard clipping, or chroma saturation was creating excessive video noise, adjustments were made to correct.

If no color bar reference was present on a tape, the TBC was operated with all settings in the preset mode as a starting point. The objective was to best preserve a good range of the luma and chroma signal. Program playback was observed and if black levels were crushed, video gain was hard clipping or chroma saturation was creating excessive video noise, adjustments were made to correct.

D. Challenges

1. Problem tapes

- Tapes with extreme shedding that caused frequent head clogs even after baking and cleaning (especially Agfa and some Sony tapes). IUMDS was unable to play these tapes.
- Other lesser-known brand cassettes with failing oxide problems (Karex, Crolyn-Dupont)
- Tapes with sticky shed syndrome (especially Ampex brand)
- Mechanical problems with cassettes requiring some adjustment or complete rehousing
- Tapes with defective control track

E. Left Undone

1. Non-NTSC tapes --PAL (64)
2. Problem tapes listed under Challenges, above.
3. Tapes with fungus (5)
4. Low band tapes (approximately 10)

XII. VHS

A. Statistics

Number of tapes digitized by Memnon: 44,677
Number of tapes digitized by IUMDS: 2,725

Total tapes digitized: 47,402

Number of hours digitized by Memnon: 74,598.41
Number of hours digitized by IUMDS: 3,846.01

Total hours digitized: 78,444.42

Average duration per recording—Memnon: 1.67 hours (100.18 minutes)
Average duration per recording—IUMDS: 1.41 hours (84.68 minutes)

B. Workflows

1. Memnon

Memnon used a parallel transfer workflow to digitize as many as twelve tapes at the same time using two digitization operators. There were two setups in the same room, with one operator responsible for up to eight professional standard play S-VHS tape machines and the other responsible for consumer grade multi-speed capable machines. Each of the two operators was usually also responsible for an additional grouping of decks of a different format such as Betacam, U-matic, or 1". Memnon digitized all carriers from beginning to end of tape regardless of program content duration. Four streams of audio were created for each digitized carrier, normal and Hi-Fi audio tracks, even if no Hi-Fi tracks were present on the source tape. Playback machines were Panasonic AG-DS850, Panasonic AG-DS545, Panasonic AG-DS555, Panasonic AG-DS840, Panasonic AG-1980, Sony SVO-5600, Sony SVO-5800, Sony SLV-679HF, Sanyo RFWDV224F, Sanyo FWDV225F, Philips DVP3355V, Philips FWZV475F, Philips FWZV225F, JVC HR-XVC33U. External time base correctors used were Leitch DPS-575 and FOR-A FA-410.

2. IUMDS

IUMDS digitized VHS tapes that failed the Memnon workflow. The IUMDS workflow was 1:1 or 2:1, that is, one video engineer digitized one or two tapes at a time. Digitization took place in the IUMDS video studio designed for critical viewing and listening. All tapes were inspected before digitization noting tape speed, speed changes (if any), content duration, audio

configuration (presence of Hi-Fi channels or not) and any notable defects or anomalies. Any remediation steps such as baking, cleaning, or rehousing were carried out as needed by the MDPI Video Preservation Engineer and MDPI AV Specialist. Four streams of audio were created for each digitized carrier, normal and Hi-Fi audio tracks, even if no Hi-Fi tracks were present on the source tape. Playback machines were Sony SVO-9600, Panasonic AG-7350, Panasonic AG-W3 and Panasonic PV-V4621. External time base correctors used were the DPS-235 and Snell and Wilcox TBS24.

C. Key Decisions

1. Problem tapes

Tapes with characteristics defined as problematic by MDPI and/or Memnon (see the list below); or tapes that could not be diagnosed, remediated quickly, or digitized by Memnon within their role as a provider of parallel transfer workflows; were sent to IUMDS for digitization.

Tapes containing one or more of the following characteristics were failed by Memnon and re-routed to IUMDS:

- Tapes recorded at non-standard speed; Long Play (LP), Extended Play/Super Long Play (EP/SLP) or a mix of different speeds (Memnon later added consumer grade multi-speed capable decks to accommodate non-standard speed tapes)
- Tapes that were broken or damaged prior to or during attempted playback
- Tapes with broken shells, doors, or internal parts
- Squealing tapes due to sticky shed syndrome or defective cassette mechanisms
- Perceived major signal anomalies such as severe mis-tracking or compromised RF signals
- Perceived generally poor physical condition such as stretched, creased or with defects in tape wrap
- Presence of fungus
- Non-NTSC standard tapes such as PAL or SECAM
- Anything that seemed unusual or odd that could not be immediately diagnosed and remedied

2. Video levels

Memnon:

At Memnon, if color bars were present on a tape the TBC chroma level was set to 100% and the set-up (black) level to zero. Video gain and hue were left in TBC preset.

Program playback was observed and if black levels were crushed, an adjustment was made to correct. If hard clipping (110 units) of video gain was observed, the level was lowered out of clipping range.

If no color bar reference was present on a tape, the TBC was operated with all settings in the preset mode. Program playback was observed and if black levels were crushed, an adjustment was made to correct. If hard clipping (110 units) of video gain was observed, the level was lowered out of clipping range.

IUMDS:

At IUMDS, video levels for each tape were set up with a time base corrector and waveform monitor for faithful reproduction of recorded content. If color bars were present on a tape, the set-up (black) level was set to zero, the video gain to 100, the chroma level and hue were set to align to the graticule of the vectorscope, with the red vector being the priority. Program playback was observed and if black levels were crushed, video gain was hard clipping, or chroma saturation was creating excessive video noise, adjustments were made to correct.

If no color bar reference was present on a tape, the TBC was operated with all settings in the preset mode as a starting point. The objective was to best preserve a good range of the luma and chroma signal. Program playback was observed and if black levels were crushed, video gain was hard-clipping or chroma saturation was creating excessive video noise, adjustments were made to correct.

D. Challenges

- Tapes with extreme shedding that caused frequent head-clogs even after baking and cleaning
- Troublesome tapes that caused stress and errors to decks due to sticky shed syndrome, especially Ampex brand
- Mechanical problems with cassettes—distorted shells, spools that scraped against cassette walls, faulty clutches and springs, all requiring some adjustment or complete rehousing
- Tapes with defective control track; recordings made on machines running at intermittent speeds that could not be resolved on any playback deck
- Tapes that had been exposed to an electromagnetic field that damaged the RF signal, picture and audio information to the point that a normal playback was not possible
- Extremely long tapes such as T-120 or T-160 cassettes recorded at the EP/SLP speed which exceeded 6-8 hours of record time

E. Left Undone

1. Non-NTSC tapes; PAL (433), SECAM (16)
2. Failed tapes with extreme shedding; chunks of oxide falling off leaving only clear PET substrate
3. Tapes with fungus (59)
4. ADAT *(Indiana Fiddlers Gathering for example, exact number TBD)*