



**Federal Agencies  
Digitization Guidelines Initiative**

**Digitizing Motion Picture Film  
Exploration of the Issues and  
Sample SOW**

April 18, 2016

The FADGI Audio-Visual Working Group  
<http://www.digitizationguidelines.gov/audio-visual/>

# Digitizing Motion Picture Film

## Exploration of the Issues and Sample SOW

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### 1. What is this document?

This is an exploration of motion picture film scanning from a subgroup of the Federal Agencies Digitization Guidelines Initiative (FADGI). The subgroup is led by Christina Kovac and Heidi Holmstrom of the National Archives and Records Administration (NARA), with active participation from the Library of Congress including the Packard Campus for Audio-Visual Conservation, the American Folklife Center and the Office of Strategic Initiatives. Many other agencies have also participated, including the Smithsonian Institution and the National Air and Space Administration. The effort is intended to be an initial advisory for agencies that face increased requests for high quality file formats from moving image content, but are unaware, or overwhelmed by, the plethora of file format choices available and the nuances of the technical specifications that ought to be considered.

### 2. Film digitization in archives: an emergent discipline

Archivists in memory institutions generally see the digitization of motion picture film as an emergent discipline and a still-evolving set of practices. This emergent state results from three main factors. The first pertains to the materials to be digitized. The array of types of motion picture materials is broad and varied, represented by gauges ranging from 8mm to 16mm to 35mm and above; with types of footage ranging from camera original to pre-print or duplication materials to release prints, containing imagery in color and black-and-white, negative and positive; with many different aspect ratios (to say nothing of anamorphic, 3D imagery, and other variations), and with soundtracks of various formats and configurations. The range is too broad and diverse to permit of easy generalization.

The second factor pertains to an output format or formats. It is worth saying that digitization itself is the subject of vigorous debate among film-preservation specialists, with many practitioners insisting that photochemical, film-to-film reproduction is the only acceptable method for preservation reformatting. (Many others disagree.) This FADGI description is interim and limited: the digitized copies we describe are intended to serve as surrogates, e.g., digital footage for a new television program or a production master suitable for use in the creation of a DVD or for streaming. The original film materials ought to be protected and retained.

The third factor pertains to the state of technology and relevant standards. The digital cinema specifications (DCP or Digital Cinema Package) are relatively mature, although it is worth noting that the format in current use is called *InterOP* (short for *interoperable*), employed during the period when the full set of SMPTE digital cinema standards are being finalized and implemented. In any case, *digital cinema* refers to a distribution copy, not specifications for the film scanning that is the subject of this FADGI investigation. For film scanning and the related activity often referred to as *digital mastering*, the Motion Picture Academy's Science and Technology Council and SMPTE standards groups are applying sophisticated image science to the development of new practices and standards that will provide improved support for film scanning in the future. When complete, the Academy project will be especially important for color materials.

There are other, additional technological factors in play. One of the proposed output formats in this document is SMPTE's Standard for File Format for Digital Moving-Picture Exchange (DPX) format (SMPTE ST 268:2003, and Amd. 1:2012). This standard goes back to technologies developed in the 1990s, and many experts highlight its shortcomings today. It is typically used with a tonal range of 8 and 10 bit sample depth--some specialists wish for increased bit-depth and one 16-bit type is offered in the 2012 amendment--and with integer-based data representations--some specialists wish for floating point numbers--and the minor annoyance that DPX does not in and of itself support sound. There are some ad hoc vendor-support solutions in play to manage the synchronization of the digital waveform audio, and some archives use the DPX format as a means to reproduce optical tracks as images; see sidebar below.

When speaking about DPX, most specialists use the singular form of the word *file*, but in fact the format creates a separate file for each frame of film, resulting in a large set of files with sequentially numbered file names. One non-FADGI commenter who read an early version of this document called out one technical difficulty when DPX files are stored on LTO or other data tapes. "Although this segmented structure allows for more granular fixity," the commenter wrote, "when DPX file sets are stored on LTO or other data tapes, the file-transfer movements require tens of thousands of jumps between network handshakes, checks for unique filenames, updates to file system tables, setting attributes, file i/o, and so on."

DPX does, however, include a range of embedded metadata options. These can be valuable: one federal agency reports that it has made good use of the "frame position" data element as a redundant carrier of the frame sequence data carried by the filename.

Meanwhile, we now see the wide adoption of digital cinema, with its 4K and even 8K levels of resolution, and scanned-from-film imagery at this level of resolution is now being offered by stock footage houses. For example, in 2016, the Sherman Grinberg Film Library announced that they had scanned many old newsreels for today's market at 4K.<sup>1</sup> These high levels of resolutions are echoed in the emergence of Ultra High Definition Television (UHDTV), with its similar-but-not-identical 4K and 8K levels. Whatever the details, the thrust is that higher-than-HD standards have come or are coming to theatrical, broadcast, and non-broadcast dissemination. The adoption of digital cinema and UHDTV will push producers toward higher levels of resolution and drive demand for film scanning at those levels.

Thus the larger point of factor three is this: film scanning inhabits a realm where new, disruptive developments abound.

Therefore, for all of the reasons outlined above, the FADGI subgroup for film scanning has undertaken a limited task, identifying and describing a handful of film-digitization use cases that it hopes will be useful in the current moment.

### 3. Inputs and outputs

The crux of the film-scanning process has to do with the conversion of analog imagery into digital imagery, the concomitant management of sound, and the assembly of a digital package that either can be *played* (in the customary sense of "playing a movie") or that can be used to produce a derivative or subsidiary element that can be played.

In this document, we call the motion picture source material the *input* and the digital file copy the *output*. As indicated in section 2 above, the range of possible inputs is very broad. And, although not as broad, there are also a number of options for outputs. For this exploration, therefore, we have focused on a handful of inputs that represent some key types of archival material. We confess that we have selected "the easy ones" to start with. For this section of this document, the archetypal inputs are:

- 35mm or 16mm positive, color or black and white, ranging from reversal camera originals to duplication materials to prints
- 4:3 aspect ratio
- Monaural soundtracks as synched optical or mag stripe, or soundtracks on double system; in all cases, "synchronization depends upon sprockets."

On the output side, we sketch examples from two classes:

- *video*, meaning an HD digital video file
- *DPX image+audio*, meaning a bundle of high-resolution digital files that represent all of a given film's imagery and sound.

Note that the example for a Statement of Work (section 6 of this document) is more limited: the input is a 35mm film and the output is video.

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<sup>1</sup> Communication from Lance Watsky posted on AMIA-L, March 22, 2016.

A video output will satisfy most of today's customers, tends to carry a lower cost than the DPX image+audio output, and results in a smaller, easier-to-manage file. The image quality, however, generally captures less of the underlying information in the original and means that most archives will find themselves rescanning the material in the future. As an example, a pillar-boxed HD scan of a 4:3 (1.33:1) image will occupy about 1440 x 1080 pixels ("1.6 megapixels") inside the 1920 x 1080 frame.

Our conversations with memory institution archives suggest that most of the outside patrons who seek digital copies of film holdings are video-program makers who are producing in the 16:9 HD format. Very often, they seek clips--footage--to edit into their longer productions. Some want to maintain the 4:3 aspect ratio that is common for older film holdings and they require transfers with pillar-boxing. Others, however, seek cropped images at 16:9. Similarly, a patron may plan to integrate archival footage originally exposed at, say, 18 frames per second into a new program that runs at "today's" frame rates of, say, 24 or 30 frames per second. The general practice at NARA and in some other memory institutions is to provide a patron with an authentic copy of the original, e.g., 4:3 aspect ratio (pillar-boxed if video) at 18 fps. It is up to the patron to post-process the delivered materials if alternate aspect ratios or frame rates are required for their new production.

The DPX image+audio output is generally executed in a manner that captures more of the underlying information in the original than the video approach. As an example, a 2K scan of a 4:3 (1.33:1) image will occupy about 2048 x 1536 pixels ("3.1 megapixels"). Such imagery tends to carry a higher cost, results in a greater extent of data to manage, and requires the creation of additional (generally lower resolution) copies for practical purposes like viewing or for the provision of, say, the HD video version that today's video-production-customer demands. At the same time, DPX's higher resolution will make it easier for patrons who desire cropped 16:9 imagery, or a different frame rate, to post-process the footage provided to them with reduced loss of quality as compared to the video-output footage. As suggested earlier, the fact that practices for film scanning in archives are not yet fully mature means that the source item in the DPX image+audio instance may eventually have to be rescanned. Nevertheless, the DPX image+audio output is future-proofed to a greater degree than the video output.

#### **Sidebar: Notes on using DPX**

Two federal agencies that produce DPX files employ a two-step workflow. They produce an initial DPX file via film scanning and then use this file as the basis for the production of a second file that plays an important role in providing service copies to end users (including the agencies themselves). This concept is similar to that embodied in a pair of terms in the FADGI glossary: [archival master file](#) and [production master file](#).

At NARA, the output of the initial capture is called a *Raw DPX*. The specifications vary a bit depending on the nature of a given job but, at its maximum, the Raw DPX image area goes

beyond the picture proper ("overscanning"), and covers an area that includes the inner portion of the sprocket holes, the frame lines, and the optical sound track.<sup>2</sup> The Raw DPX is a stalking horse for a future in which such copies might serve as NARA's preservation masters: they provide an accurate and authentic copy of the physical source item in NARA's collection. Raw DPX files are retained by NARA and these are the files described in the tables that follow.

The optical soundtrack data--presented visually in the overscan--can be recovered and transformed to sound. (If the archive also holds, say, a magnetic version of the track on separate media, that will provide higher fidelity and would be preferred as source for soundtrack audio.) One tool for converting an optical track to audio is called AEO-Light, an open-source application developed by the Moving Image Research Collections (MIRC) and the Interdisciplinary Mathematics Department at the University of South Carolina, with support from the National Endowment for the Humanities: <http://sourceforge.net/projects/aeolight/?source=3Ddirectory>.<sup>3</sup>

In many cases, NARA uses the image data in the Raw DPX to produce a *Restored DPX*, intended not as an accurate copy of the physical source, which may be scratched or faded or have suffered other damage. The goal is to restore the look of the item in its original state, as best can be determined from the evidence at hand, and NARA's staff applies a variety of digital tools to remove or mitigate dust, dirt, and scratches, correct color, and, in some cases, apply algorithms to make the imagery look more "filmic." NARA staff emphasize that the Restored DPX is considered to be a complementary copy rather than a replacement of the original.

The Library's Packard Campus has begun to use a workflow that treats DPX image files as a pathway to an MXF file where picture (formatted as losslessly compressed JPEG 2000) and sound (linear PCM format) can be wrapped in a standardized way, and where the picture compression significantly reduces file size. In its current mode, this workflow does not include clean-up or restoration of the data; the MXF picture data is an exact duplicate of the DPX source. Since the picture in the MXF is identical to the DPX file, current planning calls for the DPX (and sound files, if any) to be deleted. However, staff members at the Packard Campus are exploring tools for efficient clean-up and restoration, and if this practice comes into play in the future, the imagery-as-scanned will be retained. In any case, the original film elements are always retained.

Packard Campus staff have considered overscanning but they report two image-quality concerns that have kept them from doing this. First, especially for 4:3 aspect ratio imagery, there is a reduction in pixels applied to the picture proper, i.e., lower spatial resolution. Second, there is a reduction in quality due to flare characteristics from scans that show perforations. An operator

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<sup>2</sup> At this writing, NARA's practice of overscanning is being re-evaluated for reasons similar to those outlined in the final paragraph of this sidebar.

<sup>3</sup> Greg Wilsbacher, curator of the Newsfilm Collections in the MIRC at the University of South Carolina, supports the practice of overscanning, and his organization screens footage with the optical soundtrack visible along the edge of the picture. Wilsbacher writes that "overscanning preserves important metadata in graphic form, integrated into the digital object: soundtracks, negative edge number, edge codes, frame lines, print through, mechanical damage, etc. Preserving this is part of the broader mission of preserving cultural objects. We provide digital access to the scanned film with some amount of overscan to remind audiences that they are not looking at a *video* but a digital surrogate of a physical object." (Email to the authors, April 9, 2016)

would have to reduce the overall dynamic range of the scan because of the level of white that shines through the perforation holes.<sup>4</sup>

#### 4. Three examples: source film inputs, recommended actions and outputs

##### *Example 1: Positive film, optical sound*

- Input
  - 16mm or 35mm positive, black-and-white or color
  - 1.375:1 aspect ratio ("4:3" with sound aperture)
  - 24 fps (25 fps if non-US)
  - Monaural optical soundtracks, composite or on separate reel
  - Includes countdown leader, frame #2 sync with tone on track
  
- Video output

<b>TRANSFER SETTINGS</b>	
Extent, per reel	Capture full-reel, recording from head to tail of each reel.
Aspect ratio	Maintain 1.375:1 sound aperture, pillarbox to fill out 16:9 video frame
Timing, grading	One-light transfer, best setting determined prior to transfer
Image "tonal" settings	Rec. 709; scanning parameters must be kept within 5% of the ceiling or the floor of rec. 709 to avoid clipping white levels or crushing the blacks.
Frame rate	Maintain 24 fps (25 fps for some non-US content)
<b>PICTURE ENCODING</b>	
Bitstream	Uncompressed 10 bit (V210), progressive , 4:2:2 chroma subsampling
<b>SOUND ENCODING</b>	
Sampling/bit depth	Linear PCM 48/24
Sound field	Dual mono

<sup>4</sup> Wilsbacher states that this issue varies depending upon the physical characteristics of the source elements and the capabilities of the film scanner. New scanner software at MIRC (designed by Tommy Aschenbach of Video and Film Solutions and Colorlab) utilizes GPU processing power to grade sections of the sound track differently from the rest of the frame. In its current configuration these changes are not recorded in the final scanned image. Although experimental, this work proves the concept of applying multiple grades to the same scan. Encouraging vendors to develop this capability is an important step forward for overscanning. Currently MIRC grades for the image and then adjusts the grading for the sound track after the fact. "The next version of AEO-Light," Wilsbacher says, "will include a feature that allows users to grade the selected track region to optimize audio quality."

<b>FILE WRAPPER</b>	
Type: <i>NARA preference</i>	AVI, interleaved picture and sound
Type: <i>Alternate</i>	QuickTime, interleaved picture and sound
Type: <i>LC preference</i>	MXF OP1a, interleaved picture and sound
Timecode	SMPTE "12M" non-drop, start clock as 01:00:00.00 at countdown leader #2 (sync with tone)

- DPX image+audio output

<b>TRANSFER SETTINGS</b>	
Extent, per reel	Capture full-reel, recording from head to tail of each reel.
Aspect ratio (raster)  <i>NARA preference for composite optical track</i>	Capture the entire picture area.  <i>In some cases use overscanning to additionally capture the optical soundtrack and frame-lines ("to the inner edge of perforations"), to ensure that the entirety of the optical track has been captured</i>
Timing, grading	One-light transfer, best setting determined prior to transfer
<b>PICTURE ENCODING</b>	
Image "tonal" settings	DPX 10-bit log or <i>print density</i> transform is common. It captures as much detail in the blacks as 16-bit linear and makes smaller files. It is important to note that the black & white code values (one channel) are not 0 – 1023, but 64 – 940. This leaves code values below black and above white and preserves the entire dynamic range of the film.  <i>Note: At NARA, when image data for an optical track is captured along with picture, tonal values are set for best fit to picture, although this may do an imperfect job of rendering the optical track's tonal range.</i>
Bitstream for 16mm (may also be used for some 35mm prints or multi-generational fine grain or dupe negatives)	Bit Depth: 10 Bit; Resolution: 2K (2048x1556); Color model: RGB Log  <i>Many capture and post-processing systems are limited to color imagery and this forces the use of RGB even for black-and-white source materials. This output specification is framed "as if" that were the case.</i>
Bitstream for 35mm (may also be used for camera-original)	Bit Depth: 10 Bit; Resolution: 4K (4096x3112); Color model: RGB Log



16mm)	<i>Many capture and post-processing systems are limited to color imagery and this forces the use of RGB even for black-and-white source materials. This output specification is framed "as if" that were the case.</i>
<b>WAVEFORM SOUND ENCODING (all agencies)</b>	
Sampling/bit depth	Linear PCM 96/24
Sound field	Dual mono
<b>IMAGE OF OPTICAL SOUNDTRACK, SEPARATE REEL (NARA preference)</b>	
Bitstream for "non-composite" optical soundtracks (NARA)	Bit Depth: 10 Bit; Resolution: 2K (2048x1556); Color model: RGB Log
<b>FILE WRAPPER</b>	
Picture	DPX frames, bundled in logical file system directories
Waveform sound	Broadcast WAVE
Sound as image (NARA)	DPX frames, bundled in logical file system directories
Sync management	DPX first frame ("00000001") at countdown leader #2 (sync with tone) WAVE file timestamp at tone sync to countdown leader #2
Byte order	Big endian

**Example 2: Positive film, double-system or composite mag sound**

- Input
  - 16mm or 35mm positive, black-and-white or color
  - 1.375:1 aspect ratio ("4:3" with sound aperture) or 1.33:1 aspect ratio ("4:3" with silent aperture)
  - 24 fps (25 fps if non-US)
  - Mag sound composite or on separate reel
  - Matched leader on both reels, with head sync punch holes (and tone?) in each head leader
  
- Video output

<b>TRANSFER SETTINGS</b>	
Extent, per reel	Capture full-reel, recording from head to tail of each reel.
Aspect ratio	Maintain aperture, depending on source (1.375:1 or 1.33:1), pillarbox to fill out 16:9 video frame
Timing, grading	One-light transfer, best setting determined prior to

	transfer
Image "tonal" settings	Rec. 709; scanning parameters must be kept within 5% of the ceiling or the floor of rec. 709 to avoid clipping the white levels or crushing the blacks.
Frame rate	Maintain 24 fps (25 fps for some non-US content)
<b>PICTURE ENCODING</b>	
Bitstream	Uncompressed 10 bit (V210), progressive, 4:2:2 chroma subsampling
<b>SOUND ENCODING</b>	
Sampling/bit depth	Linear PCM 48/24
Sound field	Dual mono
<b>FILE WRAPPER</b>	
Type: NARA preference	AVI, interleaved picture and sound
Type: Alternate	QuickTime, interleaved picture and sound
Type: LC preference	MXF OP1a, interleaved picture and sound
Timecode	SMPTE "12M" non-drop, start clock as 01:00:00.00 at sync-punch on head leader

- DPX image+ audio output

<b>TRANSFER SETTINGS</b>	
Extent, per reel	Capture full-reel, recording from head to tail of each reel.
Aspect ratio (raster)	Capture the entire picture area
Timing, grading	One-light transfer, best setting determined prior to transfer
<b>PICTURE ENCODING</b>	
Image "tonal" settings	DPX 10-bit log or <i>print density</i> transform is common. It captures as much detail in the blacks as 16-bit linear and makes smaller files. It is important to note that the black & white code values (one channel) are not 0 – 1023, but 64 – 940. This leaves code values below black and above white and preserves the entire dynamic range of the film.
Bitstream for 16mm (may also be used for some 35mm prints or multi-generational fine grain or dupe negatives)	Bit Depth: 10 Bit; Resolution: 2K (2048x1556); Color model: RGB Log <i>Many capture and post-processing systems are limited to color imagery and this forces the use of RGB even for black-and-white source materials. This output specification is framed "as if" that were the case.</i>
Bitstream for B&W 35mm (may also be used for camera-	Bit Depth: 10 Bit; Resolution: 4K (4096x3112); Color model: RGB Log

original 16mm)	<i>Many capture and post-processing systems are limited to color imagery and this forces the use of RGB even for black-and-white source materials. This output specification is framed "as if" that were the case.</i>
<b>WAVEFORM SOUND ENCODING</b>	
Sampling/bit depth	Linear PCM 96/24
Sound field	Dual mono
<b>FILE WRAPPER</b>	
Picture	DPX frames, bundled in logical file system directories
Sound	Broadcast WAVE
Sync management	DPX first frame ("00000001") at sync punch on head leader WAVE file timestamp at sync punch on head leader
Byte order	Big endian

**Example 3: Positive film, silent**

- Input
  - 16mm or 35mm positive, black and white
  - 1.33:1 aspect ratio ("4:3" with silent aperture)
  - Frame rate varies
  - Includes countdown leader or head leader with hole punch where timecode ought to start
- Video output

<b>TRANSFER SETTINGS</b>	
Extent, per reel	Capture full-reel, recording from head to tail of each reel.
Aspect ratio	Maintain 1.33:1 silent aperture, pillarbox to fill out 16:9 video frame
Timing, grading	One-light transfer, best setting determined prior to transfer
Image "tonal" settings	Rec. 709; scanning parameters must be kept within 5% of the ceiling or the floor of rec. 709 to avoid clipping the white levels or crushing the blacks.
Frame rate	Maintain frame rate
<b>PICTURE ENCODING</b>	
Bitstream	Uncompressed 10 bit (V210), progressive [or

	progressive segmented?], 4:2:2 chroma subsampling
<b>SOUND ENCODING</b>	
Sampling/bit depth	n/a
Sound field	n/a
<b>FILE WRAPPER</b>	
Type: NARA preference	AVI
Type: Alternate	QuickTime
Type: LC preference	MXF OP1a
Timecode	SMPTE "12M" non-drop, start clock as 01:00:00.00 at countdown leader #2 or at hole punch in head leader

- DPX image+audio output

<b>TRANSFER SETTINGS</b>	
Extent, per reel	Capture full-reel, recording from head to tail of each reel.
Aspect ratio (raster)	Capture the entire picture area
Timing, grading	One-light transfer, best setting determined prior to transfer
<b>PICTURE ENCODING</b>	
Image "tonal" settings	DPX 10-bit log or <i>print density</i> transform is common. It captures as much detail in the blacks as 16-bit linear and makes smaller files. It is important to note that the black & white code values (one channel) are not 0 – 1023, but 64 – 940. This leaves code values below black and above white and preserves the entire dynamic range of the film.
Bitstream for 16mm (may also be used for some 35mm prints or multi-generational fine grain or dupe negatives)	Bit Depth: 10 Bit; Resolution: 2K (2048x1556); Color model: RGB Log <i>Many capture and post-processing systems are limited to color imagery and this forces the use of RGB even for black-and-white source materials. This output specification is framed "as if" that were the case.</i>
Bitstream for B&W 35mm (may also be used for camera-original 16mm)	Bit Depth: 10 Bit; Resolution: 4K (4096x3112); Color model: RGB Log <i>Many capture and post-processing systems are limited to color imagery and this forces the use of RGB even for black-and-white source materials. This output specification is framed "as if" that were the case.</i>

<b>SOUND ENCODING (digital)</b>	
Sampling/bit depth	n/a
Sound field	n/a
<b>FILE WRAPPER</b>	
Picture	DPX frames, bundled in logical file system directories
Sound	n/a
Sync management	n/a
Byte order	Big endian

## 5. Outsourced film scanning: general notes about statements of work.

This and the following section--an example of a Statement of Work--are intended to assist institutions interested in scanning motion picture film through external vendors. As noted in section 2, the thrust of this FADGI exploration is for output files that serve users today and tomorrow, but which are not recommended as archival master copies that serve the highest-level preservation requirements. Guidance on motion picture film scanning for preservation will be developed in the future.

We hope that the model Statement of Work can be used by federal agencies and other institutions to develop project parameters, outline technical requirements, and ensure high quality transfers for access purposes. The model Statement of Work offers guidance pertaining to the process of outsourcing the scanning of motion picture film that will result in the creation of a high quality video-file output. Many of the "housekeeping" notes about the preparation of materials and the possible division of labor between agency and contractor would be equally applicable if the output were of the type called DPX image+audio in the preceding section.

The writers of this document note that DPX footage is not ordinarily "played" for viewing. Typically a film or video derivative copy will be prepared for screening. If the source item is a sound film, the picture and sound must be also synchronized and "composite" in a post-process for proper viewing. Some archives will be equipped to carry out the required post-process steps themselves. In contrast, other archives may not be so equipped, and they may ask the contractor to prepare a screening copy or copies at the same time that the DPX and audio materials are produced. Since the formatting of screening copies will vary according to an archive's mission and circumstances, this document does not include any such specifications.

A non-FADGI specialist who reviewed this document called attention to a useful feature in the outsourced DPX film scanning projects that he has overseen, having to do with the exigencies of quality assurance as the work proceeds. "There has usually been a process," he reported, "of vendors periodically sending hard drives containing proxy viewing files to clients for approval, akin to an answer print screening in the realm of film production."

In addition, this document does not address the technical infrastructure requirements needed to store and maintain files generated through a vendor request. Depending upon the file types requested a large volume of data will be created and a SAN system and/or a networked processing environment with a tape back-up is recommended for storage, processing,

transcoding, and migration of the files. An additional recommendation is the acquisition of software that is able to run fixity values against the generated files to verify that the files were not modified or corrupted during storage or migration. Free software programs include FileVerifier++, Marxio File Checksum Verifier and AV Preserve's Fixity. For more information, see the 2014 NDSA publication *Checking Your Digital Content: What is Fixity and When Should I be Checking It?*

([http://www.digitalpreservation.gov/ndsa/working\\_groups/documents/NDSA-Fixity-Guidance-Report-final100214.pdf](http://www.digitalpreservation.gov/ndsa/working_groups/documents/NDSA-Fixity-Guidance-Report-final100214.pdf)).

### **What are the elements in the description portion of a typical Statement of Work?**

- 1 – Background – This should include a brief overview of the institution's overall mission and why this particular group of materials has been selected for digitization.
- 2 – Objectives – State the goals of the project including deliverables, defined responsibilities, and expectations for the vendor and institution.
- 3 – Definitions – Provide definitions for appropriate terms and definitions used within the Statement of Work
- 4 – Description of Source Material – Describe the characteristics (format, gauge, condition, etc.) of the film to be scanned.
- 5 – Description of Services/ Requirements – Describe the place of performance, the institution and the vendor's roles and responsibilities in regards to material handling, shipping and transport, digitization workflows, required metadata, and deliverables.
- 6 – Specifications for File Deliverables – describe requirements for file deliverables in detail including file naming conventions.
- 7 – Administrative – Describe responsibilities for tracking, customer service, points of contact, etc.
- 8 – Payment – Outlines terms of payment, invoice submittal, etc.
- 9 – Timeliness – Describe the turnaround time required by the project

### **What metadata ought to be provided to a contractor, what metadata ought to be requested in the Statement of Work?**

Decisions regarding descriptive, technical, and provenance/rights metadata should be clearly outlined. The institution is responsible for supplying the information to the vendor. A commonly used standard should be agreed upon (such as MODS, PREMIS, or PBCore).

- Descriptive Metadata includes information such as: Title, Creator, Unique Item Identifier, Rights information, Collection, date of creation, language, etc.
- Provenance Metadata includes information such as: Format, Gauge, Length, Emulsion/stock type, duration, information from cans
- Technical Metadata includes information such as: File Name, Format, Codec, Bit Rate, Color Space, Frame Rate, Version, File Size, Duration, and Encryption. Institutions should also capture information about the scanner and software used to create the file. When using the DPX format, consider the use of its embedded metadata, which includes elements that can track such facts as frame position (in a sequence) and motion-picture-film KeyCode or timecode (when present).

## Vendor Requirements

Within the Statement of Work what the agency requires of the vendor should be clearly outlined. This includes how the vendor will inventory and track your project within their facility, what standards you require for handling, cleanliness, and storage, security, what types of equipment the film will run on, and how often the equipment is serviced.

## Workflow, Scanning, and Other Specifications

- How the original should be scanned – original aspect ratio (pillar boxing when deliverable is 16:9), no clipping/ crushing, 24 fps, progressive, not interlaced, etc.
- File naming convention – File names should be consistent across the project and follow standard file naming conventions. Spaces and special characters (i.e. !, @, #, \$, %, ^, &, \*, etc.) should not be used. When using the DPX format, be aware that DPX sequences require a five or six-digit numbering convention.
- Directory specification – The directory structure should follow defined and easily followed parameters. The writers recommend that BagIt, an Internet Engineering Task Force specification (<https://tools.ietf.org/html/draft-kunze-bagit-11>), be employed to package the file, metadata, and fixity checks in a straightforward structure.
- Addition of Slates – Information on slates could include the unique identifier, title, date file was created, name of agency, etc. If using slates the agency should decide on length and design of slate.
- Mitigating artifacts – The agency should determine what artifacts may, or may not, be acceptable. Depending upon the age, generation, or quality of the original noise, gate weave, breathing, or other artifacts may be introduced. Video artifacts introduced during capture are not acceptable; see the very helpful AV Artifact Atlas (AVAA), developed by the Stanford Media Preservation Lab, New York University Digital Library Technology Services, and the Bay Area Video Coalition ([http://avaa.bavc.org/artifactatlas/index.php/A/V\\_Artifact\\_Atlas](http://avaa.bavc.org/artifactatlas/index.php/A/V_Artifact_Atlas)).
- A & B rolls – The agency will need to determine how to instruct vendors in dealing with A & B Rolls – a discussion about editing the two rolls together, length of fades/ dissolves, etc. should result in the vendor delivering an archivally acceptable product.
- Audio requirements – The agency will need to address separate picture and track, wild sound, synching, and editing from ¼” tracks within the Statement of Work.
- Quality Assurance and Control – The vendor should be able to provide documentation stating that all equipment used for the project is regularly maintained and serviced by in-house engineers or through service and maintenance contracts. Quality control should be performed by both the vendor and the agency. The vendor should check all files to make sure that the files match the original (frame rate, aspect ratio, etc.), play back correctly, no new digital artifacts were introduced, audio is in sync, metadata is correct, etc. The agency should check the file naming conventions, metadata, that the format specifications have been met, that all files play back, etc.
- Failures – Errors on the part of the vendor or the agency should be addressed within a specific time frame. Different types of failures should be clearly outlined and may include erroneous data or incomplete data provided by the agency or quality control failures as outlined above.

## 6. Statement of work example.

### STATEMENT OF WORK (NARA Example) VIDEO FILE DERIVATIVES FROM MOTION PICTURE FILM

#### 1.0 BACKGROUND

1.1 The mission of the National Archives and Records Administration (NARA) includes making historical records available for use by the public and by other federal agencies. This document in particular shall address motion picture film. As a preservation policy for its original motion picture holdings NARA does not use them as duplicating masters for repeated reproduction purposes but rather creates from them a copy to serve thereafter as a duplicating master. In the past, reproduction copies consisted of film copies in a variety of formats.

#### 2.0 OBJECTIVES OF STATEMENT OF WORK

- 2.1 The overall objective of this contract is to obtain digital files of desired file formats that satisfy NARA's concerns about the safety and handling of its film collection while also satisfying NARA's concerns and those of its customers for the timeliness of delivery and the quality of copies.
- 2.2 Under the provisions of this Statement of Work (SOW) we are requesting uncompressed HD AVI files. This newly made file will then be used by NARA to serve to requestors as a source master for which additional derivatives may be created. The intent in creating these file formats is to reduce handling of the original film elements and to increase access to the content.
- 2.3 NARA shall provide the original films to be scanned and the vendor shall be required to undertake all duties described in the SOW without the use of subcontractors.
- 2.4 The volume of work for this particular project consists of XXX reels of 35mm film, or approximately XXX,000 feet, of material.

#### 3.0 DEFINITIONS

**Customers:** Requestors who wish to obtain digital reproductions of NARA holdings

**Original:** For purposes of this contract, the "original" is the copy NARA will furnish to the Vendor. It may technically classified as a camera original negative or reversal, a dupe negative or internegative, a fine grain master positive or an interpositive, or a projection print. There may be corresponding separate sound elements, magnetic or optical, or the film may be a composite. In short, these "originals" are the best available copy held by NARA.

**One Light Transfer:** A transfer made at what the Vendor's colorist or film timer deems to represent the best overall exposure to create an acceptable copy without scene by scene timing or color correction.

**Vendor:** The Vendor who will make reproduction masters from the original archival films furnished by NARA. NARA will not ship any original materials outside of the DC Metro area, nor permit overnight shipping. The Vendor must be located within a 50-mile radius of NARA. The Vendor must be able to pick up the materials or send a courier to pick up and deliver on the same day.



## **DESCRIPTION OF MOTION PICTURE RECORDS OR MATERIALS**

- 3.1 The films to be provided to the Vendor's laboratory under this contract were produced or acquired by agencies of the United States Government and are permanently valuable historical materials. Others were donated by individuals or organizations as valuable historical materials.
- 3.2 Some items may be in the public domain; however, some may be copyrighted or subject to other restrictions. In any case, the Vendor shall only make copies of each furnished item as specified in this contract; no other copying is authorized under this contract without the written authorization of the Contracting Officer's Representative (COR).
- 3.3 All original films contain a high intrinsic value and are of continuing historical interest. Some of the original films are fragile owing to age and deterioration.
- 3.4 NARA inspects 100 percent of original films provided to the Vendor before they are made available to the Vendor and again when they are returned. This inspection is to determine whether the Vendor's handling practices or equipment is damaging the government's archival originals. As part of this inspection process NARA will ensure the following:
  - 3.4.1 That all film arriving at the vendor is equipped with leader
  - 3.4.2 That all reels are clearly labeled and identified
  - 3.4.3 That separate tracks/ picture have been synchronized at clearly stated sync marks
- 3.5 The film originals to be sent to the Vendor's facility will consist of the following types:
  - 3.5.1 Cellulose nitrate, acetate or polyester-based film
  - 3.5.2 35mm gauge film
  - 3.5.3 Black and white or color film
  - 3.5.4 Positive image film
  - 3.5.5 Sound or silent film
  - 3.5.6 Composite sound or double system sound film
  - 3.5.7 Optical sound tracks in bilateral, dual bilateral or variable area or density format
  - 3.5.8 35mm stripe or full coat sound film
- 3.6 The films sent for copying will generally be in good condition. NARA will not, knowingly, send film in poor condition, characterized by excessive shrinkage (more than 1.3 percent for 35mm) brittleness, failing splices or other mechanical, chemical, or biological deterioration. NARA shall make every good faith effort to provide quality film for transfers.

## **4.0 DESCRIPTION OF SERVICES/REQUIREMENTS**

- 4.1 NARA reserves the right to inspect the Vendor's facilities prior to the award of the contract and during the term of the contract. This inspection may include its

- receiving, storage, film preparation, production suite, and shipping areas as well as any other areas film may pass through.
- 4.2 All work shall be performed at the Vendor's work site. No subcontractor shall be permitted to directly handle any of NARA's original holdings. The originals will be packaged in individual numbered film cans and shall not be changed by the vendor or its courier. Blank leader may be added to original leader for threading purposes. Original leader or markings may not be removed or altered otherwise.
- 4.3 NARA will package the original films for shipment and will require the Vendor or their courier to pick them up. Each shipment will be accompanied by an inventory list. An e-mail with an identical inventory list will also be sent to the Vendor. The inventory list identifies each film by its unique NARA identifier.
- 4.4 It is required that the Vendor perform an inspection to confirm preservation copies provided are in a condition to be transferred without damage prior to placing any original film on its equipment to ensure safe transfer. At this point, for archival films specifically, shrinkage shall be measured by the Vendor as readings may vary from gauge to gauge. Films inspected by the Vendor and deemed by the Vendor to be in poor physical condition shall be promptly returned to NARA for preservation work.
- 4.5 Films in poor condition due to marginal picture or sound quality (e.g., poor focus, unstable framing, inaudible or distorted sound) shall not be copied without initial consultation and approval from the COR.
- 4.6 **Handling** – Archival film must be handled in a clean work environment with dust-free and clutter-free worktables.
- 4.6.1 Smoking, beverages, and food must be prohibited in the receiving and shipping areas, the media storage area, technical equipment facility, and the work area where the film transfers occur.
  - 4.6.2 Archival film must always be handled with undyed (white) nylon or cotton lint-free gloves. The film must be handled by the edge or by the head and tail leaders. The film must be threaded on the datacine/scanner by the leader and not by the picture or sound portion of the reel.
  - 4.6.3 In film rewinding, the Vendor must use only manual rewinds and avoid sudden starts and stops, aiming for a smooth and even wind that will not cinch the film. After transfer, the film should be left tails out, emulsion in, on a core and returned in its original container. The free end of the film should be taped down to the film pack with archival white paper tape.
  - 4.6.4 Tissue paper, clear plastic bags or written documents may not be placed in the cans. In some cases there may be older documents in the can: timing tapes, inspection cards, etc. Those should remain in the can. NARA preservation practice calls for acetate base motion picture film to be unbagged so that it can "outgas." This allows the products of its slow chemical deterioration, "vinegar syndrome," to escape and lower the concentration of acetic acid in the can

- 4.6.5 The original films should not be left uncovered or threaded on equipment for lengthy periods of time such as during staff refreshment and meal breaks and certainly not overnight or over weekends.
  - 4.6.6 The use of cleaning fluids must be approved in advance by the COR. If used, all cleaning fluids must be allowed to thoroughly evaporate before the film is wound for storage so as to leave no residue on the film.
  - 4.6.7 All equipment that comes in contact with the film must be in good working order and cleaned regularly as recommend by the original equipment manufacturer.
  - 4.6.8 If a film needs to be spliced at any location of the film other than the leader, the Vendor shall contact the COR. Should repair splicing of original acetate be approved by the COR, no frames or partial frames containing image or sound may be removed during the repair. The Vendor shall use only fresh cement and wipe off excess cement before it dries. If the damage occurs over frames containing image or sound the Vendor shall use Mylar film splicing tape from a reputable manufacturer. Repair of polyester base film must be done using tape or ultrasonic splice. Each splice shall be tested before the film is loaded on the equipment to ensure its smooth passage through the transfer machine. If a splice fails or damage has occurred to the film during the content transfer the Vendor shall contact the COR.
  - 4.6.9 If the Vendor finds film in poor condition due to high shrinkage (greater than 1.3 percent for 35mm), brittleness, breakage, or other conditions that may result in further damage to the film if it is copied, it shall be returned to NARA uncopied with a report and any pertinent notes. NARA will then assess the condition and take corrective action.
  - 4.6.10 The Vendor is encouraged to provide any comments about the technical condition of original film to the COR. Such notes may be provided to the COR by placing them in an envelope taped to the outside of the film can and/or communicated to the COR by e-mail.
  - 4.6.11 If, during the handling of or transfer of preservation copies of films, the film is damaged (e.g. film breaking, splice failure, etc.) the Vendor shall immediately stop work, remove the film from the machine, and notify the COR of the nature and extent of the damage and wait for further instructions. The Vendor shall not attempt repair the film or continue the transfer of the film.
- 4.7 For this project NARA requires an unsupervised, "one light" scan with moderate color correction in the case of faded images or minor equalization adjustment of sound as needed. The Vendor may employ a wet gate process as needed to minimize base scratches visible in the digital image.
- 4.8 The vendor must:
- 4.8.1 Transfer sound, if provided with the original.
  - 4.8.2 Maintain sound or silent aperture, as appropriate to match the original.
  - 4.8.3 Capture full-reel, recording from head to tail of each reel.

- 4.8.4 Scanning parameters must be kept within 5% of the ceiling or the floor of Rec. 709 to avoid clipping the white levels or crushing the blacks.
- 4.8.5 All film originals in their original containers and file based deliverables shall be returned to NARA upon completion of the work.

## 5.0 SPECIFICATION FOR DELIVERABLES

### 5.1 File Format –Audio Video Interleaved (AVI)

- 5.1.1 Uncompressed AVI
- 5.1.2 Target Total Bitrate: ~800 Mbps
- 5.1.3 Timecode: Source LTC/VITC
- 5.1.4 Frame size: 1920 x 1080
- 5.1.5 Bit Depth: 10
- 5.1.6 Video frame rate: 24 fps , progressive or progressive segmented frame
- 5.1.7 File shall maintain original aspect ratio (use pillar boxing if necessary for 16:9 files) and frame rate
- 5.1.8 Chroma format: 4:2:2
- 5.1.9 Progressive Scan
- 5.1.10 Audio channels: 2 (stereo L R)
- 5.1.11 Audio codec: PCM
- 5.1.12 Audio sample rate: 48 KHz
- 5.1.13 Audio sample size: 24 bit

5.2 Slates – The Vendor shall prepare an electronic slate and insert it at the head of each item identifying the recording by its NARA identifier. The length of time the slate shall be visible is five seconds.

5.3 **Metadata** – TBD (This requirement will vary according to an organization's prevailing practices. See also the preliminary note on metadata on page 14.)

5.4 **File Naming** – File names should be item number specific in the following format: 342-usaf-12345.avi.

5.5 **Directory Structure** – The first level Hierarchy should be the Record Group Number (342), the second level Hierarchy should be the Series (USAF) and the third level Hierarchy should be the item number (12345). The file name shall contain all three components of the structure as referenced in 6.4.

5.6 The Vendor shall provide documentation of quality assurance either by providing the name of the in-house engineer or by providing up to date documentation of service plans and/ or maintenance agreements on the equipment being used for the project.

5.7 The Vendor shall be responsible for its own quality control of the files, subject to ultimate review by the COR. The Vendor shall check all files to ensure that

- 5.7.1 The file matches the original (frame rate, aspect ratio, audio in sync)
- 5.7.2 The file plays back correctly

- 5.7.3 No digital artifacts have been introduced
- 5.7.4 Metadata is correct

## 6.0 ADMINISTRATIVE

- 6.1 Upon receipt of shipment, the Vendor shall verify the inventory and send a return e-mail to abcd@nara.gov confirming receipt within 12 hours of obtaining the films. Any deviation(s) from the received inventory shall be reported, on the inventory list in order to alert both the Vendor and NARA immediately. The receipt shall then constitute a written record of shipment acceptance by the Vendor.
  
- 6.2 Customer Service Representative: The Vendor shall establish a tracking system to control orders and, on the basis of this system, designate a customer service representative to be available to answer status inquiries from customers and NARA staff.
  
- 6.3 **Security and Storage** – Given the historical and permanent record character of these films, the Vendor shall take all necessary steps to safeguard these materials in accordance with the provisions listed below.
  - 6.3.1 The archival film must be safeguarded against theft, vandalism, unauthorized use, damage, and alterations of any kind.
  - 6.3.2 Storage, transportation, and use temperatures shall not exceed 75 degrees Fahrenheit and shall not exceed 50 percent relative humidity.
  - 6.3.3 The Vendor's facility must have a fire detection system and be wired to an emergency signal company that will bring the fire department to the facility expeditiously.
  - 6.3.4 If the facility handles cellulose nitrate motion picture film, that film must be handled and stored in accordance with National Fire Protection Association (NFPA) Standard 40, Standard for the Storage and Handling of Cellulose Nitrate Film, and/or in accordance with the requirements of the local fire protection authority.
  - 6.3.5 The Vendor's facility must have good ventilation, be free from gaseous fumes such as those emitted from chemical stores or freshly painted rooms.
  - 6.3.6 NARA's original film may not be sent to any other facility except NARA without the written authorization of the COR.
  
- 6.4 NARA shall provide a Removable Hard Drive for the files
  
- 6.5 **Pick-up and Delivery** – The Vendor shall pick up the film within 72 hours after being notified via email by NARA that it is available for pick up. It shall be delivered to the Vendor's facility on the same day it is picked up without overnight storage at a location other than NARA or the Vendor's facility.
  - 6.5.1 The Vendor shall carefully perform a complete inspection and inventory upon receipt of all materials picked up from NARA for adequacy with respect to quality as well as quantity. The Vendor shall contact the COR immediately if there are any items listed on the inventory, but not included

with the materials received. Damaged materials shall be reported to \_\_\_\_\_ and the COR.

- 6.5.2 Upon completion of the required work to make the reproduction file all materials will be shipped from the laboratory expeditiously. For shipments of originals and file deliverable media coming to NARA, the Vendor will return the originals to their original individual film can, package them securely, label removable hard drives and deliver them to NARA.
- 6.5.3 Original films must travel separately from the file deliverable media made from them. They must not travel together in the same vehicle or on the same day in order to preclude the loss of all copies of the item in case of an accident or disaster on the road. The originals must be returned to NARA within 15 business days after being notified that the items are available for pickup.
- 6.5.4 While en route the ambient temperature in the portion of the vehicle where the film and file deliverable media is carried must be maintained at 65 to 75 degrees Fahrenheit. The Vendor may choose to meet this requirement by providing storage containers that will maintain this range for 24 hours.
- 6.5.5 Only a secure, closed vehicle will be permitted to carry archival film and file deliverable media. Trunks of private cars are not acceptable. The vehicle must not be used to transport chemicals or other dangerous materials while transporting NARA film. Smoking, eating and drinking are not allowed in the travel compartment with shipments of originals and file deliverable media.
- 6.5.6 Archival film and file deliverable media must not be transported with non-NARA materials.
- 6.5.7 Each shipment shall be accompanied by a Vendor-created shipping inventory that lists each item by its number and the order number that it is a part of. Upon receipt of a shipment, NARA shall verify the inventory, and send an e-mail that lists the items received. Receipt of the e-mail shall then constitute a written record of the acceptance of the shipment by the COR. Therefore, any deviation(s) shall be known by both the Vendor and by the COR immediately.
- 6.5.8 The COR may return unsatisfactory file deliverable media to the Vendor not later than 30 calendar days after initial receipt of copies for re-transferring at the Vendor's expense. Neither NARA nor the Vendor shall bear any responsibility for unsatisfactory copies that are the result of defects inherent in the originals (e.g., copied cellulose nitrate deterioration).

**6.6 Packaging and Labeling** – The original films and file deliverable media shall be packaged separately for shipment to NARA.

- 6.6.1 Film originals: All films will be returned to NARA in the original containers.
- 6.6.2 File deliverable media: The Vendor shall number each drive with the corresponding NARA unique title or identifier range, the date the files

were transferred to the drive ("Files created: mm/dd/yyyy"). The Vendor's name, logo or other identifier shall not appear on the drive.

## **7.0 PAYMENT**

7.1 Terms of payment are to be 30 days after completion of work. Payments are to be submitted to the Bureau of Public Debt as per terms of the awarded contract.

## **8.0 TIMELINESS**

8.1 The Vendor shall complete batches within 10 business days. Rush service shall be completed within 5 business days or less. The vendor must return originals and file deliverable media to NARA within 15 business days of being notified of the items being available for pickup and completion of work.

8.1.1 The count of 15 days starts at the beginning of the first full business day the requested item is available for pick up. Thus, if the Vendor is notified at noon on a Monday, the count will start Tuesday. The count shall end on the day the original and the file deliverable media are received at NARA.

8.2 The Vendor shall pick up and complete large orders in increments of not more than 25 reels. The timeliness standard shall apply to each increment.