

Digitizing History (and preserving history in the making)

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Government Video
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Carl Fleischhauer
Library of Congress

My name is Carl Fleischhauer, from the Library of Congress. I made up a one-pager with my contact information and a URL where you can get a copy of this slide show, including the text.

. . . about what to put into
a DAM system more than
about the DAM itself

. . . about formatting the
video

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My topic is what to **put into** a DAM system more than about the DAM itself. I will discuss some aspects of formatting video with preservation in mind. But it is terrific to talk to an audience with as much experience and knowledge as this one -- I am sure at the end, you will pass along things that improve my understanding.

National Digital Information Infrastructure and Preservation Program (NDIIPP) www.digitalpreservation.gov

The screenshot shows the website for the National Digital Information Infrastructure and Preservation Program (NDIIPP) at the Library of Congress. The page features a navigation bar with links for 'ASK A LIBRARIAN', 'DIGITAL COLLECTIONS', and 'LIBRARY CATALOGS'. Below the navigation bar, there is a search box and a 'GO' button. The main content area is divided into several sections: a 'DIGITAL PRESERVATION' header, a 'National Digital Information Infrastructure and Preservation Program (NDIIPP)' title with a graphic of people holding hands, and a 'News & Events' section. The 'News & Events' section includes a 'North Carolina States Project Holds Kick-Off Meeting' and a 'NDIIPP Launches Newsletter'.

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Most of the activities I will describe are associated with the National Digital Information Infrastructure and Preservation Program (NDIIPP) at the Library of Congress.

NDIIPP History and Goals

- Created by federal legislation (PL 106-554) in December 2000
- Identify and preserve at-risk digital content
- Develop a national digital collection and preservation strategy
- Support development of improved tools, models, and methods for digital preservation
- Work with industry, concerned federal agencies, libraries, research institutions and not-for-profit entities

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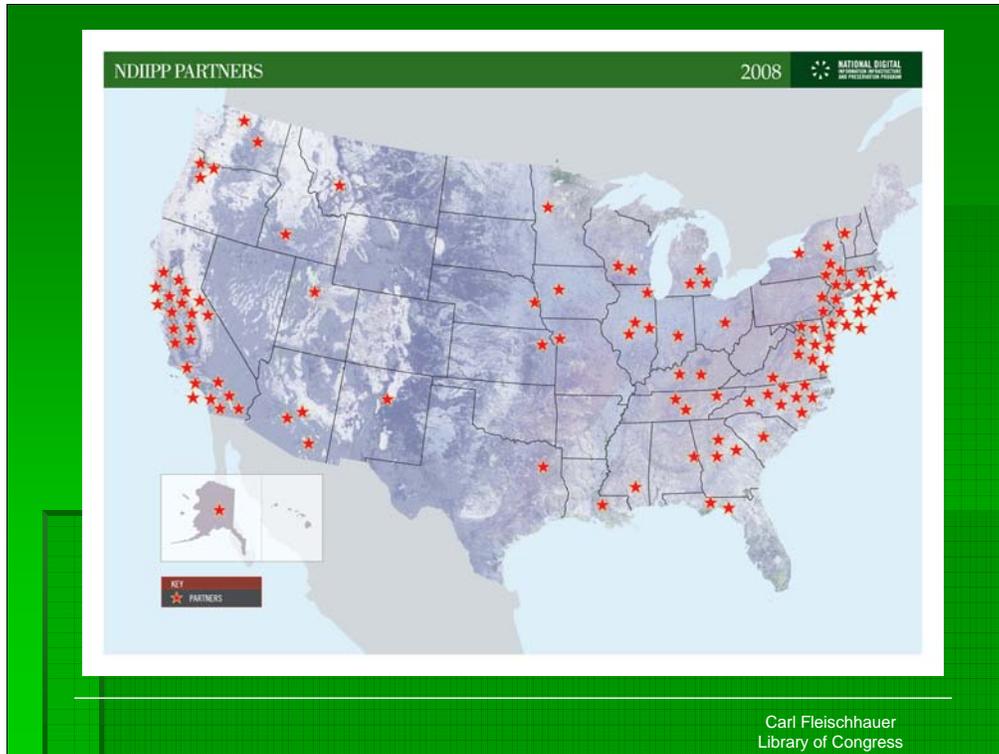
NDIIPP was created by federal legislation in December 2000, and structured to run for 10 years -- we wrap up next year -- at which point we will evolve into a similar-but-different continuing activity.

NDIIPP is a Portfolio of Activities

- Four areas of focus
 - Network of preservation partners
 - Architectural framework for preservation
 - Digital preservation research
 - Intellectual Property
- Two phases of investment
 - Phase I commenced 2004
 - Phase II commenced 2006
- Transitioning 2009-2010

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NDIIPP has been exploring the issues and policies associated with the preservation of content in digital form. This includes looking at the changing role of the national library in a digital environment and copyright issues, since we are the home of the Copyright Office.



One premise from the start has been that the preservation of the national collection cannot be done by a single institution. The Library of Congress has shared in this effort for many years--right here in town, there are also national libraries for medicine and agriculture--but we see an even greater need for partners to help in the digital realm.

Preserving At-Risk Content

- Eight Original Content Partners, exploring different content domains:
 - **Public television (digital initiative)**
 - WNET, WGBH, PBS, NYU
 - Southern U.S. Cultural Heritage Archives
 - Government and political web sites
 - Social science data
 - Geospatial data
 - Dot-com era business records
- Variety of Format Types and Technical Issues

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So we started on trial basis with eight in 2004, with more added later. The archiving of **digital video** is being investigated in the preserving public television project--led by WNET, joined by WGBH, PBS, and NYU.

Preserving Creative America (PCA)

- Preserve at-risk digital cultural heritage collections:
 - Moving images
 - Multimedia art (computer art)
 - Photography & digital pictorial art
 - Recorded sound
 - Video & computer games
- Preservation standards & best practices
- Demonstration projects with new tools & services
- Moving image project with the Academy of Motion Picture Arts and Sciences (Science and Technology Council)

Other projects connect to the private sector. Moving image content is represented in a project from the Science and Technology Council of the Academy of Motion Picture Arts and Sciences.

Technical Architecture Projects

- DAM-related elements here, ask for contacts if you want to follow up
- Archive Ingest and Handling Test
 - Four universities conducted ingest, export, format migration and exchange on a common archive
- Tools and protocols
 - Los Alamos National Lab Research Library developing tools and standards to package, disseminate and store e-journal content
- Repository and storage
 - San Diego Supercomputer Center building and testing utility and trust in a third-party repository
 - National Digital Newspaper Program building distributed content production and validation network and a central repository to preserve digital newspaper content over time
 - eDeposit through Copyright acquiring and preserving eJournal content from multiple sources in different formats

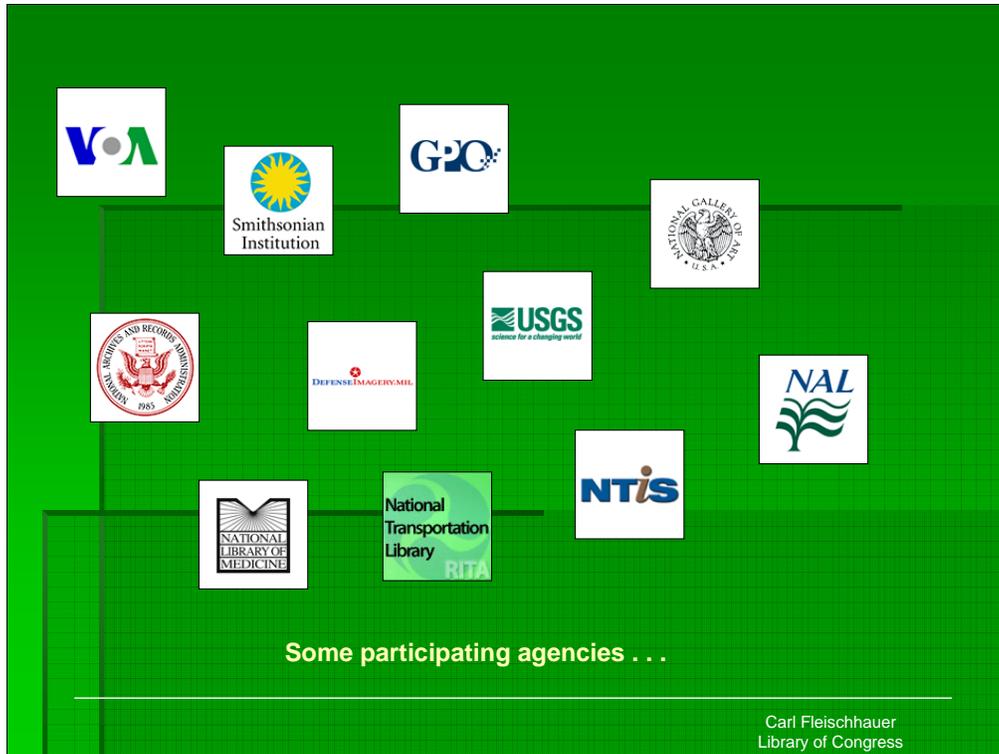
There have also been some partner projects that touch directly on digital asset management. I don't work with these directly; catch me later for contact information if there is interest in following up.

Section 108 Study Group

- Study group sponsored by NDIIPP in cooperation with the U.S. Copyright Office
- Composed of 19 copyright experts – half from libraries and archives; half from content industries (Software, Publishing, Multi-media)
- Report Issued this April 2008
- Refers to Section 108 of the U.S. Copyright law
 - Permits libraries and archives to make certain uses of copyrighted materials in order to serve the public and ensure the availability of works over time
- **Mission:**
 - Re-examine copyright exceptions applicable to libraries and archives in light of digital technologies
 - Make findings and recommendations on revising the law
 - Ensure appropriate balance among copyright interests and needs of libraries and archives in manner that best serves the national interest

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Working together, NDIIPP and the Copyright Office organized an examination of section 108 of the copyright law, which governs what libraries and archives can do in the name of preservation. There is a report to congress, copies online.



Very recently, NDIPP convened a pair of working groups--with representatives from a number of federal agencies, to draft guidelines for digitization. One important player is the National Archives but several others participate.

FEDERAL AGENCIES
DIGITIZATION GUIDELINES INITIATIVE

SEARCH

Home < Still Image Working Group

→ HOME

→ NEWS & EVENTS

→ STILL IMAGE WORKING GROUP

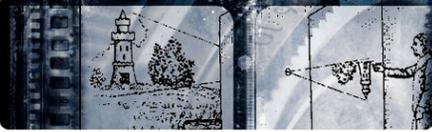
- Participating Organizations
- Advisory Board
- Sub-Groups
- Documents and Guidelines
- Resources and Industry Standards
- Provide Comments

→ AUDIO-VISUAL WORKING GROUP

RELATED RESOURCES

- Glossary of Terms
- Sustainable Formats

RSS E-Mail



STILL IMAGE WORKING GROUP

This group is involved in a cooperative effort to develop common digitization guidelines for still image materials (such as textual content, maps, photographic prints and negatives). The expectation is that this work will enhance the exchange of research results and developments, encourage collaborative digitization practices and projects among [federal agencies](#) and institutions and provide the public with a product of uniform quality. It will also serve to set uniform quality and establish a common set of benchmarks for digitization service providers and manufacturers.

The work will focus on guidelines intended for works categorized as historical, cultural and/or archival. In addition to digital imaging and encoding, guidelines will be developed for the metadata that is embedded in digital image files, with a view to increasing the extent to which the files can be "self-describing."

Primary considerations in the development of specific guidelines will be:

- Defined objectives for the digital object being produced
- Defined categories and characteristics of content to digitally represented
- Common image performance measures and methods of validating those measures to defined requirements

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Our main emphasis is *digitization*--also known as digital reformatting--the conversion of analog originals into digital form. The still image group is looking at things like books, photos, and maps.

<http://www.digitizationguidelines.gov/audio-visual/>

The screenshot shows the website for the Audio-Visual Working Group. At the top, it says "FEDERAL AGENCIES DIGITIZATION GUIDELINES INITIATIVE" with a search bar. Below that is a breadcrumb trail: "Home > Audio-Visual Working Group". The main content area is divided into several sections:

- HOME**
- NEWS & EVENTS**
- STILL IMAGE WORKING GROUP**
- AUDIO-VISUAL WORKING GROUP**
 - Participating Organizations
 - Sub-Groups
 - Documents and Guidelines
 - Resources and Industry Standards
 - Provide Comments
- RELATED RESOURCES**
 - Glossary of Terms
 - Sustainable Formats
- RSS and E-Mail icons

The right side of the page features a large image of a film reel and a video player. Below the image is a section titled "AUDIO-VISUAL WORKING GROUP" with the following text:

The goal for this working group is to identify, establish, and disseminate information about standards and practices for the digital reformatting of audio-visual materials by federal agencies. The effort will cover sound and video recordings and will consider the inclusion of motion picture film as the project proceeds. The main focus of the work is on older materials, with the formatting born-digital content to be considered where strong synergy exists. Topic areas include formatting, metadata, and related practices and methodology.

Below this text is a link to the [Working Group Charter](#).

There is also a download button for Adobe Acrobat Reader to view PDF documents.

The bottom section is titled "PLANNED DOCUMENTS" and lists:

- Recorded Sound Digitization Overview and Guidelines. See [Proposed Table of Contents](#) (PDF 74KB)
- Video Recordings: Discussion of Digital Target Format Options
- Motion Picture Film: Discussion of Current Practices

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I coordinate the group looking at audio and video. Both working groups seek common guidelines in the name of increased standardization--a good thing if you don't overdo it--and the development of comparable approaches agency to agency, which will be especially helpful in the relationships with vendors who provide equipment and services.

Library of Congress Packard Campus, Culpeper

The screenshot shows a website layout for the Library of Congress Packard Campus. At the top left, there is a navigation menu with links: "A/V Conservation Home", "Experience the Collections", "The Packard Campus", "Preserving the Collections", "Film/Recording Boards & Registries", "Events & Screenings", and "Contact Us". Below this is a "Related Resources" section with links to "American Memory films", "American Memory recordings", "MTC: Moving Image Collections", and "Sound Online Inventory and Catalog".

The main content area features a header image of the Packard Campus building with the text "AUDIO-VISUAL CONSERVATION at The LIBRARY of CONGRESS". Below the header is a video player showing a close-up of a film reel with the text "Audio-Visual Conservation Clips click to watch" and a "View Credits" button. To the right of the video player is a section titled "Upcoming Events" with a sub-section for "Film Programs" listing "Theater, (Culpeper, VA) current schedule" and "Mary Pickford Theater, (Washington, DC) current schedule". Below this is a "More Information on Events" link and a "Registries" section with two sub-sections: "2007 Film Registry" and "2007 Recording Registry".

The "2007 Film Registry" section includes the text: "Have a favorite movie? Recommend it for the 2007 National Film Registry. To be eligible, a film must be American produced, at least 10 years old and of 'cultural, historical, or aesthetic significance.'"

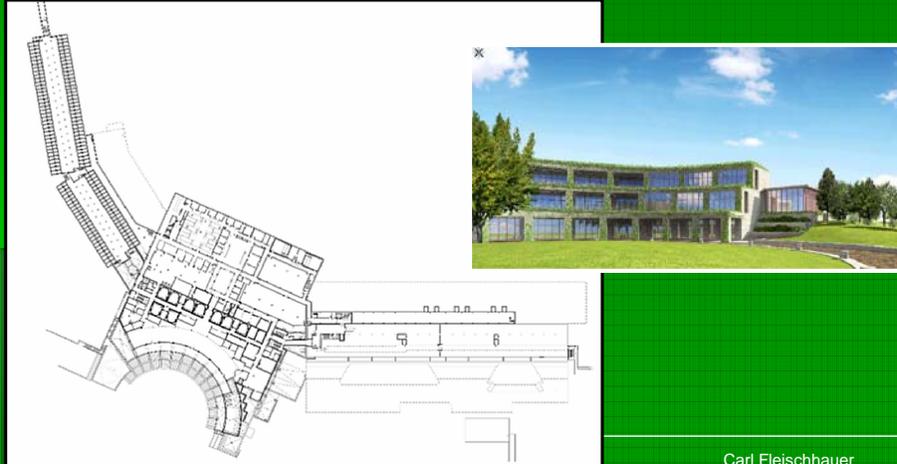
The "2007 Recording Registry" section includes the text: "Nominate a sound recording for the 2007 National Recording Registry. To be eligible, it must be American produced, at least 10 years old and of 'cultural, historical, or aesthetic significance.'"

At the bottom of the main content area is a section titled "The Packard Campus" with the following text: "Located at the foothills of the Blue Ridge Mountains in Culpeper, Virginia, the Library's newly completed Packard Campus of the National Audio-Visual Conservation Center provides underground storage for this entire collection on 90 miles of shelving, together with extensive modern facilities for the acquisition, cataloging and preservation of all audio-visual formats. The Packard Campus was created through a unique

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At the Library of Congress, our NDIPP activities -- the two "outside" projects I mentioned and the Federal Agencies working groups -- co-exist with the ongoing work of the Motion Picture, Broadcasting, and Recorded Sound Division.

Library of Congress Packard Campus, Culpeper



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This division is the custodian of the Library's collections of audio, video, and film. They are now located in the new National Audio Visual Conservation Center, Culpeper, VA

LC moving image activities

- NDIIPP
 - Public Television partner project
 - Academy of Motion Picture Arts and Sciences, Sci/Tech Council partner project
 - Federal Agencies Audio-Visual Digitization Guidelines Project
 - Motion Picture, Broadcasting, and Recorded Sound Div
 - National Audio Visual Conservation Center, Culpeper, VA
-
- All are about archiving, preserve content for the long term
 - Many elements, but all share interest in **formatting** (in the broadest sense)
 - Greatest amount of planning for video, that is the subject matter for this talk

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For them and us, the core concern is archiving--preserving content for the long term. And within this--although there are many elements--formatting (in the broadest sense) is central. Since video has received more attention than film, **that** is what I will emphasize in this talk.

Video Format Problem Space #1

- Reformatting from old videotapes



From 1961: Ampex VR-1000-B
2-inch quadruplex VTR

Image from Wikipedia

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The big job right now for us and for our sister agencies has to do copying old videotapes into digital file form. We want to break away from the old, traditional practice of copying to a fresh set of videotapes -- everyone sees that we need to switch to file-based approaches.

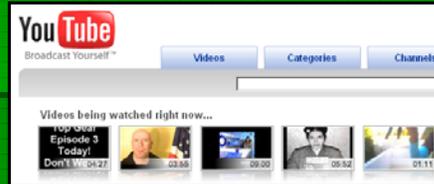
Video Format Problem Space #2

- Born Digital

- Professional zone: broadcasters



- Prosumer zone: YouTube, and its kin



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But that ain't all -- we-all also confront new content, arriving in digital-file form. For born-digital, there seem to be two broad classes. First: professional born digital: production by broadcasters and other pros. Second: the often-inspired, prosumer work so significant today on Web sites like YouTube.

Allies in the Industry

- Producers, creators seek interoperability via standards
 - May be from “true” or industry standards bodies, MPEG-2, MPEG-4, MXF, AAF
 - May be relatively open and public, albeit proprietary, AVI, QuickTime



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Format standardization is not only important to preservation in archives. It is also important where video content is exchanged, for example during the production or distribution of broadcasts. For professionals, *interoperability* is an important keyword. Many feel caught **between** their desire for open standards **and** the desire of system vendors to be proprietary. Trade organizations like the Advanced Media Workflow Association represent content creators in the back-and-forth with companies like AVID over the implementation of standards.

Formatting Elements

- Encodings
- Wrappers
- Metadata

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[Three elements.] We tend to describe formatting in terms of three elements: encoding, wrappers, and metadata.

Formatting Elements

Encoding

- Bitstream structures appropriate for our purposes
- Examples: MPEG-2 compression, JPEG 2000 frame-image representations
- Academy “film” project has high interest in color space and color transform management

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By encoding, I mean the bitstream structures that are appropriate for our purposes. To define by example: MPEG-2 compression, JPEG 2000 frame-image representations.

By the way, to reduce the length and complexity of this talk, I limit myself to picture information, and will not discuss sound.

Formatting Elements

Wrapper

- File formats that encapsulate one or more constituent bitstreams and include metadata
- Archetypal examples:
 - Broadcast WAVE, TIFF
- Complex examples:
 - QuickTime, MXF

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By wrappers, I mean file formats that encapsulate one or more constituent bitstreams and include metadata that describes what's inside. Archetypal non-video examples include Broadcast WAVE and TIFF. More complex (video) examples include QuickTime or MXF may contain multiple objects, e.g., one or more video and audio streams.

Formatting Elements

Metadata

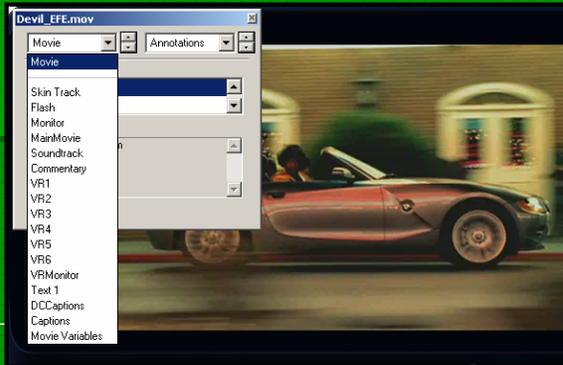
- This talk: technically oriented chunks of administrative metadata.
- Metadata overlaps with wrapper encoding issues.
- To what degree is metadata embedded in the wrapper or even the bitstream?
- To what degree is such embedded metadata standardized?

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Regarding metadata, my talk will emphasize technically oriented chunks of administrative metadata. Our questions include these: To what degree is metadata embedded in the wrapper or even the bitstream? To what degree is such embedded metadata standardized?

Profiles, Levels, and Application Specifications

- Many new specifications are complex, multipart
 - Examples: MPEG-4, JPEG 2000, MXF



*BMW movie
QuickTime file
with two
soundtracks
and a virtual
reality feature*

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[Profiles and more.] Ending my last slide with “degree” questions sets me up to describe a factor that underlies the three elements: profiles, levels, and/or application specifications. Many published standards that pertain to video are complex and full of options, some of which will never be used.

Profiles, Levels, and Application Specifications

- Which allowable elements will actually be used?
- Will *this* device play *this* file?
- Profiles and levels an important part of MPEG family from an early day

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These multiple choices inhibit interoperability. Will *this* device play *this* file?
Long ago, video professionals profiled MPEG encodings.

MPEG-2 Profiles and Levels

Profile @ Level	Resolution (px)	Framerate max. (Hz)	Sampling	Bitrate (Mbit/s)	Example Application
SP@LL	176 × 144	15	4:2:0	0.096	Wireless handsets
SP@ML	352 × 288	15	4:2:0	0.384	PDAs
	320 × 240	24			
MP@LL	352 × 288	30	4:2:0	4	Set-top boxes (STB)
MP@ML	720 × 480	30	4:2:0	15 (DVD: 9.8)	DVD, SD-DVB
	720 × 576	25			
MP@H-14	1440 × 1080	30	4:2:0	60 (HDV: 25)	HDV
	1280 × 720	30			
MP@HL	1920 × 1080	30	4:2:0	80	ATSC 1080i, 720p60, HD-DVB (HDTV)
	1280 × 720	60			
422P@LL			4:2:2		
422P@ML	720 × 480	30	4:2:2	50	Sony IMX using I-frame only, Broadcast "contribution" video (I&P only)
	720 × 576	25			
422P@H-14	1440 × 1080	30	4:2:2	80	Potential future MPEG-2-based HD products from Sony and Panasonic
	1280 × 720	60			
422P@HL	1920 × 1080	30	4:2:2	300	MPEG-2-based HD products from Panasonic
	1280 × 720	60			

From Wikipedia

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For MPEG-2, the ISO/IEC specifications themselves spell out profiles that define the structure of the encoded stream. They characterize the complexity of the encoding, indicating how difficult this signal will be to decode. Levels influence quality: all other things being equal, the higher the data rate, the higher the quality. Put them together and you can associate profiles and levels with applications.

Target encodings

- Most reformatting today entails playing back an existing videotape and transforming the existing signal into a *target* encoding format.
- We can foresee the need to reformat *some* born digital files, again *target* formats need to be identified

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Now: about encodings:

First, there are *target* encodings. Many organizations are reformatting from existing videotapes, mostly analog, and occasionally digital, like DV. In time, we may begin reformatting some of the digital files that we receive. Most reformatting requires playing back the videotape or the file, and re-recording the output signal into a *target encoding format*.

“Keeper” encodings

- Other born digital encodings will be sustainable (keepable) for several years as they stand.
- WGBH expert says “don’t waste effort transcoding now.”
- But these encodings are not sufficiently appealing to serve as target formats if you are going to reformat.
- Examples later in talk.

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Second, there are “keeper” encodings. Some born digital content employs encodings that are sustainable for a period of years, even though they are not sufficiently appealing to serve as target formats. For short, we call them *keeper encoding formats*. My colleague Dave MacCarn at WGBH uses the elegant phrase “retaining acquisition bandwidth,” and he argues some encodings are good for several years—don’t waste effort transcoding now.

Component video

From Wikipedia, the free encyclopedia

This article is about analog component video: for the processing of color components in digital video, see [digital video](#), [Chroma subsampling](#) and [YCbCr](#)

Component video is a video signal that has been split into two or more components. In popular use, it refers to a type of [analog video](#) information that is transmitted or stored as three separate signals. Component video can be contrasted with *composite* video (such as [NTSC](#) or [PAL](#)) in which all the video information is combined into a single line level signal. Component video cables do not carry audio.

Contents [[hide](#)]

- 1 Analog component video
 - 1.1 RGB analog component video
 - 1.2 YPbPr analog component video
 - 1.2.1 Connectors used
 - 1.3 S-Video analog component video



Three cables, each with [RCA plugs](#) at both ends, are often used to carry analog component video

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[Target formats.] The discussion of target *encoding* formats generally begins with an unstated assumption: the signal arriving for reformatting is a component video signal. *Component video* is a bitstream in which luminance or brightness information is separate from color information.

Composite video

From Wikipedia, the free encyclopedia

Composite video, also called **CVBS** (Composite Video Blanking and Sync), is the format of an [analog television](#) (picture only) signal before it is combined with a sound signal and [modulated](#) onto an [RF carrier](#).

Composite video is often designated by the **CVBS** acronym, meaning any of "[Color](#), [Video](#), [Blank](#) and [Sync](#)", "Composite Video Baseband Signal", "Composite Video Burst Signal", or "Composite Video with Burst and Sync".

It is usually in a standard format such as [NTSC](#), [PAL](#), or [SECAM](#). It is a composite of three source signals called Y, U and V (together referred to as [YUV](#)) with sync pulses. Y represents the brightness or *luminance* of the picture and includes synchronizing pulses, so that by itself it could be displayed as a monochrome picture. U and V between them carry the color information. They are first mixed with two orthogonal phases of a color carrier signal to form a signal called the *chrominance*. Y and UV are then combined. Since Y is a [baseband](#) signal and UV has been mixed with a carrier, this addition is equivalent to [frequency-division multiplexing](#).

Composite video



The [RCA connector](#) is the most common connector for composite video.

In contrast, *composite* video is represented by analog signals on older videotapes and the signals transmitted by broadcasters, until the great changeover next February. A composite signal blends the luminance and chrominance information.

ADC-8032B - *Leitch Compatible*
 ADC-8032B-S - *Leitch Compatible*
Analog Composite to SDI Decoder

Superior quality analog-to-digital converter specially designed to handle tough microwave and satellite feeds as well as all general decoding requirements.

[What about the ADC-8032A and ADC-8032A-S products?](#)

ANALOG IN: Y, C, M, S, K
 INPUT FILTERS & GAIN
 12 BIT ADC
 BALANCED ADAPTIVE DECODER
 LINE EQUALIZATION
 EDI DETECTION & SDI CONVERSION
 SDI OUTPUTS
 EXTERNAL FRAME REFERENCE IN
 COLOR-BLACK REFERENCE IN
 COLOR-BLANK REFERENCE IN
 MASTER REFERENCE
 FRAME SYNCHRONIZER (S-VERSION)
 TRACKING DELAY PULSE
 TRACKING OUT

- Advanced adaptive 3-D comb filter for near perfect composite decoding
- Oversampled 12-bit A-to-D conversion
- Designed to handle difficult, unstable signals such as off-air and VCR feeds
- On-board full frame synchronizer (ADC-8032B-S version)

This means that the first step for signal processing in analog-to-digital reformatting entails the transformation of composite into component video. Of course, the composite-to-component transform has been part of video reformatting for years--it happens when you record to a SONY BetaCam videocassette.

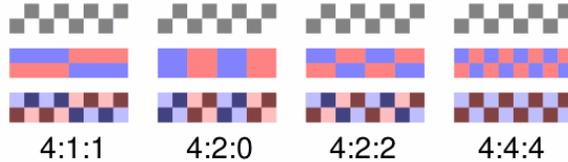
Sampling systems and ratios

[edit]

The subsampling scheme is commonly expressed as a three part ratio (e.g. 4:2:2), although sometimes expressed as four parts (e.g. 4:2:2:4). The parts are (in their respective order):

- **Luma** horizontal sampling reference (originally, as a multiple of 3.579 MHz in the NTSC television system)
- **Cr** horizontal factor (relative to first digit)
- **Cb** horizontal factor (relative to first digit), except when zero. Zero indicates that **Cb** horizontal factor is equal to second digit, and, in addition, both **Cr** and **Cb** are subsampled 2:1 vertically. Zero is chosen for the bandwidth calculation formula (see below) to remain correct.
- **Alpha** horizontal factor (relative to first digit). May be omitted if alpha component is not present.

To calculate required bandwidth factor relative to 4:4:4 (or 4:4:4:4), one needs to sum all the factors and divide the result by 12 (or 16, if alpha is present).



The mapping examples given are only theoretical and for illustration. Also note that the diagram does not indicate any chroma filtering, which should be applied to avoid aliasing.

From Wikipedia

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The sampling of component video can vary. A 4:4:4 specification means that there are equal amounts of brightness and color information. Most professional video systems work in a 4:2:2 mode, with half as much color information, and your consumer camcorder is very likely to be 4:2:0, with even less color information. Video data may also be at 8 or 10 bits per sample; the higher the better.

Target encoding categories

- Uncompressed
- Lossless compressed
- Lossy compressed

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Generally speaking, existing preservation-oriented projects treat a 4:2:2 or 4:2:0 video signal, downstream from the composite-component transform, and their encoding falls into three broad categories: uncompressed, lossless compressed, and lossy compressed.

Uncompressed video

- Stanford, Rutgers, NARA (early planning)
- 4:2:2, 10-bit SDI stream
- About 100 GB per content-hour
 - Another source reported 70 GB for 8-bit video

Recommended Standards for NJDH and RU-CORE Video Digitization

For preservation masters:
File format: *Uncompressed, Full Frame Video (AVI file format)*

Frame rate for analog Standard Definition (SD) video, NTSC: *29.97 frames per second, 640 x 480 resolution (assuming square pixels), 4:2:2 quantization, 30MiB/s data rate.*
We recognize this sampling scheme as the minimum acceptable rate to ensure a good preservation master of analog SD video archives, and will be the most common sampling rate for objects that come to us as SD analog video. This standard is based on our experiences with digitizing S/VHS video objects.

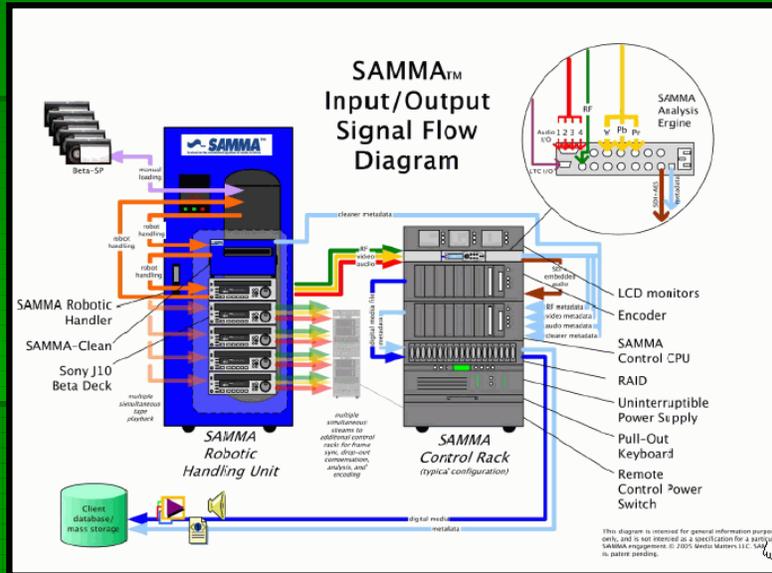
RUCORE Media Standards Working Group: I. Beard, I. Bogus, E. Conder, N. Gonzalez, B. Nahory, R. Sandier
RUCORE and NJDH Standards Analysis for Moving Image Objects
Draft Revision 3 -- Last Modified 6 April 2007

Rutgers spec: http://rucore.libraries.rutgers.edu/collab/ref/dos_avwg_video_obj_standard.pdf

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Projects at Stanford and Rutgers Universities save the incoming 4:2:2 signal without further compression. And a planning group at the National Archives has made a similar recommendation for their next phase of work. You could see this as the equivalent of saving uncompressed still image information in a TIFF file. My understanding is that-- for standard definition-- this approach yields files on the order of 70-100 GB per hour of program time, depending on whether the incoming signal is 8 or 10 bits deep. High def would make bigger files, natch.

Lossless compressed



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A second approach is to compress the picture using a lossless algorithm, the equivalent of saving your still image with LZW compression in a TIFF file. The leading proponent for this is Jim Lindner, whose company (recently sold to Front Porch Systems, they have a booth in this trade show) developed an integrated system called SAMMA. LC is beginning to implement SAMMA in the new facility in Culpeper, Virginia, as is the National Archives in College Park.

Lossless compressed

- Each frame is a JPEG 2000 image
- Lossless (reversible) transform
- If 8-bit, 25-35 GB per content-hour
- If 10-bit, 35-50 GB per content-hour

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In this system, each video frame is compressed with the reversible (lossless) transform offered by the JPEG 2000 standard. Ian Gilmour, a member of the SAMMA team, reckons that 8-bit video will compress to something like 25-35 GB per hour; in one set of early tests, 10-bit came in at 35-50 GB per hour. For this type of compression, defined profiles would be very welcome but have not yet been developed.

Lossy compressed

- Lossy JPEG 2000
 - Used by digital cinema
 - Provided by some new cam-corders, e.g., Infinity
 - No reformatting examples



Supports DV25, Infinity JPEG 2000, and MPEG-2* compression schemes

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A third approach is to apply lossy compression to the picture information. You could do this using the irreversible transform in JPEG 2000, the approach used in the new digital cinema specification—movies for theaters. Although there is some uptake for lossy JPEG 2000 in born digital video in new cameras (like the Infinity), I have not encountered this encoding in archiving and have no estimates of possible file sizes.

Lossy compressed

- MPEG-2
 - ITU-T H.262
 - In the ATSC digital TV standard
- MPEG-4
 - ITU-T H.263 and H.264
 - May come to play a bigger role as high-resolution increases

GUIDE
TO THE USE OF THE
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5.1.2 Compatibility with MPEG-2

The video compression system does not include algorithmic elements that fall outside the specifications for MPEG-2 Main Profile. Thus video decoders which conform to the MPEG-2 MP@HL can be expected to decode bit streams produced in accordance with the Digital Television Standard. Note that it is not necessarily the case that all video decoders which are based on the Digital Television Standard will be able to properly decode all video bit streams which comply to MPEG-2 MP@HL.

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Today, the most frequently selected lossy compression encoding is MPEG-2 (aka H.262 in Europe). MPEG-2 has legs because it is part of the ATSC digital television standard, guaranteeing it a place in professional work for several more years. In time, one of the MPEG-4 schemes (H.263 or H.264 in Europe) may come into play. On paper, very high quality H.264 signals are possible but most applications today are lower quality, for mobile devices and home satellite delivery.

SONY IMX, MPEG-2 @ 50 mbps

Sony's IMX Format
by Alistair Jackson

This article first appeared in Digital
Media World magazine October 2002

From: <http://www.edithouse.com.au/information/imx.html>

However, Sony has cleverly taken advantage of the fact that while an MPEG stream can be made up of a series of I, P and B frames, it doesn't have to be. The standard simply says that a GOP must start with an I-Frame, which can then be followed by P or B Frames. The Betacam SX format creates MPEG-2 GOPs of only two frames - one I and one B. The higher quality IMX format has only one picture to a GOP - a single I-Frame.

By only using I-Frames, IMX does not have an issue with edits. In fact, we are back in the same ballpark as DV based formats. However, in this case we have an MPEG-2 compliant stream. The idea is that you can load this tape footage onto a disk, and you end up with an MPEG-2 file. It is not as small as an MPEG-2 file that takes advantage of P and B Frames, but it is compliant with the standard.

IMX is seen by Sony as a key element for its MXF (Material eXchange file Format) vision for converging broadcast quality video into an IT infrastructure. A crucial part of this concept is the eVTR board, which allows IMX machines to interface to an Ethernet network. This allows for VTR control and for transfer of Audio and Video over a LAN, WAN, or even the Internet. The board buffers several frames from the tape, and if necessary pauses the tape until the buffer requires refilling.

- MPEG-2, all I-frames, 50 mbps
- File size about 28 GB/hour

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A number of broadcast organizations have selected MPEG-2 for archiving. SONY is a major player in professional circles and the widespread use of SONY IMX recorders has led to the acceptance of MPEG-2 with a data rate of 50 megabits per second as a benchmark. This encoding consists of all I-frames, meaning that each frame is fully represented in the data, and it yields files on the order of 28 GB per hour. 50 megabit MPEG-2 is often called a "contribution format" because producers use it to contribute content to a television network.

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The Netherlands Institute for Sound and Vision
MPEG-2 @ 50 mbps and 30 mbps (news)

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There is some use of MPEG-2 for archiving in Europe. For example, I recently read an account of work at the Netherlands Institute for Sound and Vision. They have begun to digitize their extensive collection, with funding from the Dutch government, using MPEG-2 at 50 Mbps for much of their television material, and 30 mbps for news.

Encoding preferences

- For high value, uncompressed or lossless compressed is very attractive.
- For second-rank content, some make a good case for modest-but-lossy compressed.

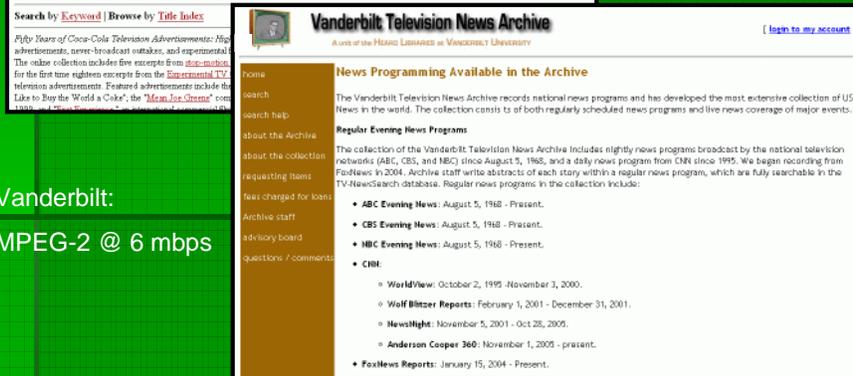
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How shall we vote on reformatting target encodings overall? For high value content, it is hard not to be drawn to uncompressed or lossless encodings, the latter adding complexity to the bitstream but reducing storage requirements significantly. For second-rank content, some will make a case for modest-but-lossy compression, to further reduce storage requirements or for other practical reasons.

Born digital encoding



Coca-Cola:
MPEG-2 @ high
streaming quality



Vanderbilt:
MPEG-2 @ 6 mbps

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[Born digital encodings.] On the born digital side, when transcoding is necessary, the same target options recur: uncompressed, lossless compressed, and lossy compressed. But what are examples of the *keeper encodings* I mentioned earlier? At the Library, we started receiving content from the Coca-Cola advertising collection and the Vanderbilt University television news collection during the 1990s. In both cases, Library staff conferred with the donors and the outcome was appropriately conservative for that time: MPEG-2 files at varying (but moderate) levels of resolution.

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SCOLA World TV Online and Week In Review

It is now **11 05** Central Time
[GO TO LIVE BROADCAST](#)

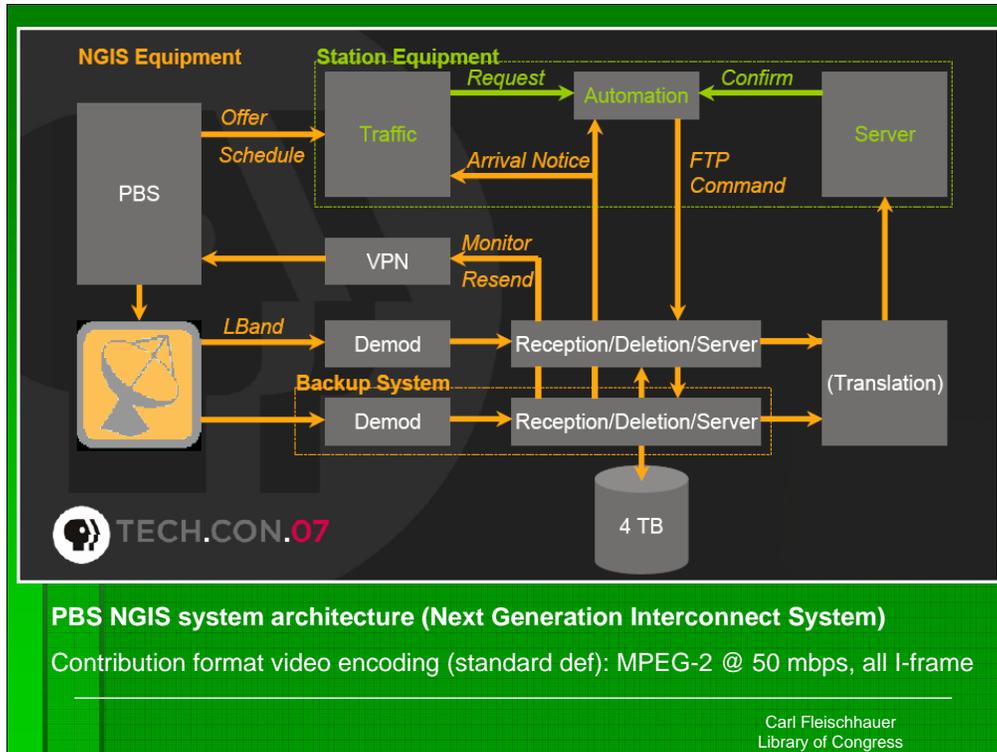
SCOLA Channel Five features programming from continental Africa. More than 20 African dialects are offered from nations across Africa.

Tuesday 10/23/2007	Wednesday 10/24/2007	Thursday 10/25/2007	Friday 10/26/2007	Saturday 10/27/2007	Sunday 10/28/2007	Monday 10/29/2007
(Tuesday through Sunday are downloadable Archives from the previous week)						
Central Time	Country	Program				Downloads
0010--0045	Zambia (Bemba)	Daily News: Local Language News and Main News from Lusaka				download
0045--0215	Tanzania (Swahili and Kiswahili)	Nightly News: Nightly News from Dar Es Salaam				download
0215--0245	Uganda (Luganda)	Nightly News: Nightly News in Luganda from Kampala				download
0245--0315	Nigeria (Igbo)	Evening News: from Abuja in Igbo				download
0315--0715	Ethiopia (Amharic and Oromifa)	News: Awude in Amharic or the Oromifa Dialect from Addis Ababa				download
0715--0815		SCOLA International Showcase: Varied Programming and Topics from a Different Country Every Day				download
0815--0845		Kids Around the World: Children's Variety Programs from Around the World				download
0845--1015	Ivory Coast (French)	Daily News: Le Journal in French from Yamoussoukro				download
1015--1415	Sudan (Modern Standard Arabic-MSA)	Daily News: Daily News from Khartoum				Watch Now!

SCOLA: MPEG-4, part 2 video compression @ 380 kbps
 Planned upgrade in 2008: MPEG-2 @ 5 mbps

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Meanwhile, in a project under the auspices of the National Digital Information Infrastructure and Preservation Program (NDIIPP), the Library is receiving large numbers of foreign news broadcasts with MPEG-4 "part 2" encoding, at Internet-streaming levels of quality. We believe that this encoding will also be sustainable for the next several years.



And what are we hearing from the NDIIPP public television project? Using PBS's new interconnect system, the producers of public TV content plan to contribute finished standard-definition programs as 50 mbps MPEG-2 files.

From a report by Dave MacCarn, WGBH

This footage can be any number of digital formats. Since source material can also come from the Archives, this may include analog material, but for the purpose of this discussion, comments will be restricted to digital formats only. At the time this paper was written the physical formats most commonly used are (*see definitions below*):

- DV
- DVCAM
- DVCPRO
- Digital Betacam
- D3
- D5

Newer formats for standard definition:

- XDCAM

For HDTV it's:

- DVCPRO HD
- HDCAM
- HDV
- XDCAM HD

<http://www.ptvdigitalarchive.org/wp-content/uploads/2007/09/report-on-file-formats-and-packages-fin.pdf>

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The NDIIPP public television project is also looking at acquisition formats, for the footage recorded during program production, some of which are in keeper encodings. This is Dave MacCarn's list of the professional-quality encodings WGBH encounters at the acquisition stage. In conversations with me, Dave has said that most will be sustainable for several years.

Overall, this strategy seems promising: identifying native encodings that are safe to keep as-is (for several years) and distinguishing them from encodings that cry out for transcoding upon arrival.

MPEG wrappers

- MPEG-2
 - No file wrapper established by standards body
 - De facto file format convention in wide use
 - .mpg extension (also for MPEG-1)
- *By the way: MPEG-4 has two standardized file formats, both based on BMFF (from QuickTime, same as JPEG 2000 FF); .mp4 extension for both*

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Now, about wrappers. Some activities are proceeding in a no-wrapper mode -- We store the Coca-Cola and Vanderbilt content as MPEG-2 files, for example. There is no "legal" standardized file format for MPEG-2, although the de facto format is widely supported.

MXF Wrapper

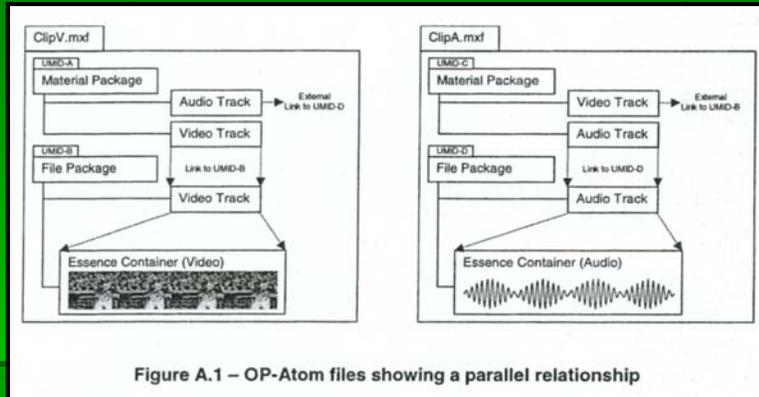


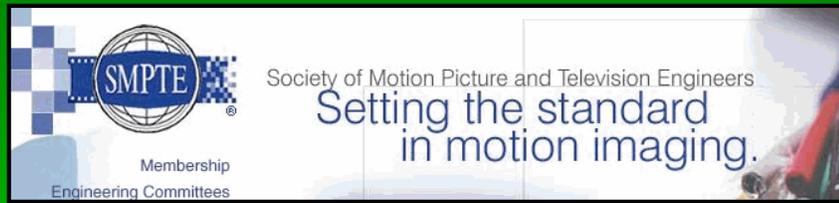
Diagram for the simple “OP-Atom” structure, from SMPTE spec 390M

BTW: AAF (Advanced Authoring Format) is a close cousin to MXF.

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In professional circles, the wrapper buzz these days concerns the Material Exchange Format (MXF), standardized by SMPTE. MXF is an object-based file format that bundles video, audio, timecode information, closed captions, and what amounts to an "edit decision list." Complexity of structure is categorized by what are called *operational patterns*.

A few examples of MXF specifications . . .



SMPTE 377M-2004	Television Material Exchange Format (MXF) File Format Specification (Standard) \$90.00 - Purchase this Document
SMPTE 378M-2004	Proposed Material Exchange Format (MXF) — Operational pattern 1A (Single Item, Single Package) \$26.00 - Purchase this Document
SMPTE 379M-2004	Material Exchange Format (MXF) — MXF Generic Container \$30.00 - Purchase this Document

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MXF is intended to support content interchange between creators and distributors, and to be implemented in cameras, recorders, and computer systems. It is used in the digital cinema specification. MXF is complicated and new: between 2004 and the present, SMPTE has published more than thirty specification documents.

http://www.sammasystems.com/

http://www.ptvdigitalarchive.org/

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MXF is gaining momentum. In our archiving circle, there are two important MXF adoptions: in Jim Lindner's SAMMA system and by the NDIIPP public television team, each with its own encoding.

From the working draft for the first PBS MXF application specification

1.4 Operational Pattern Constraints

1.4.1 Baseline Operational Patterns

AS-PBS files shall comply with MXF Operational Pattern OP1a.

Note: one exception may be where it is required to provide indication of SCTE-35 Splice Points or decoder precharge for seamless splicing of video in constraint sets other than SD Distribution in this case OP2a shall be used.

1.4.2 Additional Constraints

1.4.2.1 Container

AS-PBS Files shall use the MXF Generic Container Structure. The Number of Elements in each GC is defined for each

1.5.1.5 Video

Video shall be MPEG-2 MP:ML 4:2:0 GOP 15, at bit rates of 8 up to 15 Mbps, in compliance with ISO 13818-2 Elementary Streams.

The video stream shall be carried in a SMPTE 381M-2005-compliant MXF GC Element.

1.5.1.6 Audio

Audio shall be 48kHz, 16 bit PCM, with 2 or 4 channels.

Each pair of channels shall be carried in a SMPTE 382M-2007-compliant MXF GC Element within a BWF Container (not AIFF container).

1.5.1.7 Closed Captioning

If present, CEA 608 line 21 (CC and XDS) data shall be carried in a SMPTE 334-1- and -2-2007-compliant ANC packet within a SMPTE 436M-2006-compliant VBI/ANC GC Element, using 8 bit encoding.

If present, CEA 708B DTV captioning data shall be carried in a SMPTE 334-1- and -2-2007-compliant ANC packet within a SMPTE 436M-2006-compliant VBI/ANC GC Element, using 8 bit encoding.

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The public television folks are attending to profiling: they have drafted one MXF *application specification* (“AS”) for their moderate-resolution *distribution* files, and PBS plans to draft an AS for the high-res *contribution* files.

Other wrappers

- Motion JPEG 2000
 - ISO/IEC 15444-3 (part 3)
 - Not aware of use by broadcasters or archivists

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Meanwhile, there seems to be little or no uptake for ISO's Motion JPEG 2000, a wrapper designed for use with JPEG 2000 frame encoding. The folks I talk to use MXF to wrap JPEG 2000 frames instead.

Other wrappers

Recommended Standards for NJDH and RU-CORE Video Digitization

For preservation masters:

File format: *Uncompressed, Full Frame Video (AVI file format)*

Frame rate for analog Standard Definition (SD) video, NTSC: *29.97 frames per second, 640 x 480 resolution (assuming square pixels). 4:2:2 quantization, 30MiB/s data rate.*

We recognize this sampling scheme as the minimum acceptable rate to ensure a good preservation master of analog SD video archives, and will be the most common sampling rate for objects that come to us as SD analog video. This standard is based on our experiences with digitizing S/VHS video objects.

RUcore Media Standards Working Group:
I. Beard, I. Bogus, E. Gorder, N. Gonzaga, B. Nahory, R. Sandler

RUcore and NJDH Standards Analysis for Moving Image Objects
Draft Revision 3 – Last Modified 6 April 2007

- Relatively open, documented proprietary standards
 - AVI, used at Rutgers (above)
 - QuickTime, used at WGBH

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Another meanwhile: broadcasters and archivists sometimes employ proprietary wrappers, several of which have relatively open, public or mostly public specifications. For the time being, Rutgers wraps their uncompressed files in AVI, an open spec from Microsoft and IBM, while WGBH uses the QuickTime wrapper while they wait for better tools to support MXF.

Video "Object" Metadata

- Compare to NISO image data, MIX XML schema
- Compare to AES (Audio Engineering Society) AES-X098B: Audio Object Schema (in final draft)
- Many definitions could come from SMPTE RP-210 registry of terms
- On the right track: PB Core Instantiation (box at right)

PB Core	
--INSTANTIATIONS--	
25.00	pbcoreInstantiation
25.01	dateCreated
25.02	dateIssued
25.03	formatPhysical
25.04	formatDigital
25.05	formatLocation
25.06	formatMediaType
25.07	formatGenerations
25.08	formatStandard
25.09	formatEncoding
25.10	formatFileSize
25.11	formatTimeStart
25.12	formatDuration
25.13	formatDataRate
25.14	formatBitDepth
25.15	formatSamplingRate
25.16	formatFrameSize
25.17	formatAspectRatio
25.18	formatFrameRate
25.19	formatColors
25.20	formatTracks
25.21	formatChannelConfiguration
25.22	language
25.23	alternativeModes
25.24	pbcoreDateAvailable
25.24.1	dateAvailableStart
25.24.2	dateAvailableEnd
25.25	pbcoreFormatID
25.25.1	formatIdentifier
25.25.2	formatIdentifierSource
25.26	pbcoreAnnotation
25.26.1	annotation

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[Metadata.] Let me close with a snapshot of three metadata subcategories. The first concerns the technical characteristics of the video *object* at hand, comparable to the NISO data set for *still images*, aka MIX, and to the *audio object* metadata specification from the Audio Engineering Society (AES). The closest video equivalent that I have seen is public broadcasting's new PB Core specification, which includes a section called *instantiation*.

Video "Preservation" Metadata

- NASA Open Archival Information System (OAIS) reference model
- Now ISO 14721: 2003
- Archived objects should include *representation information* and *preservation description information*
- Information necessary to maintain the viability, renderability, and understandability of digital resources over the long-term.



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In the digital library community, there is another category: "preservation" metadata, the information you need to maintain the viability, renderability, and understandability of digital resources over the long-term. For those familiar with NASA's Open Archival Information System reference model -- OAIS -- they call it *representation information* and *preservation description information*.

Video formatting scorecard

- **Encoding:** not bad, two or three good options to work with, need more experience
- **Wrappers:** strong pull toward MXF, frustration over state of adoption and availability of tools
- **Metadata:** up in the air, likely to be ad hoc solutions for the time being

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Here's a one slide wrap-up -- a scorecard for archive- and preservation-oriented video formatting.

-- Encoding: not bad, two or three good options to work with, need more experience

-- Wrappers: strong pull toward MXF, frustration over state of adoption and availability of tools

-- Metadata: up in the air, likely to be ad hoc solutions for the time being



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Thank you very much.