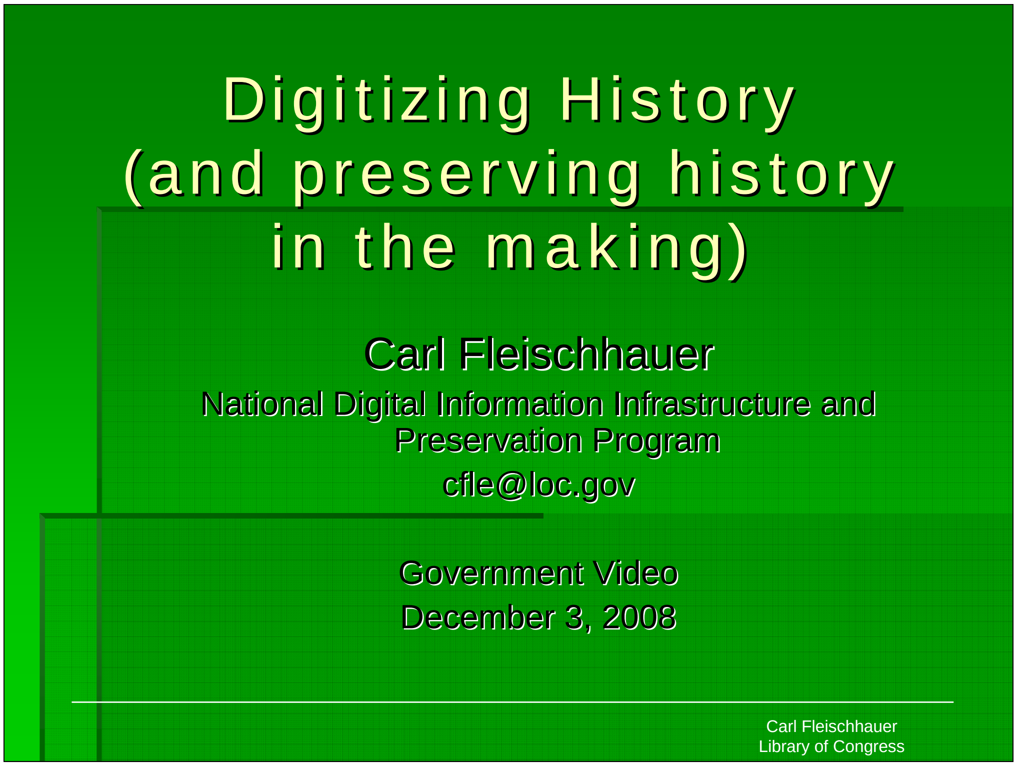
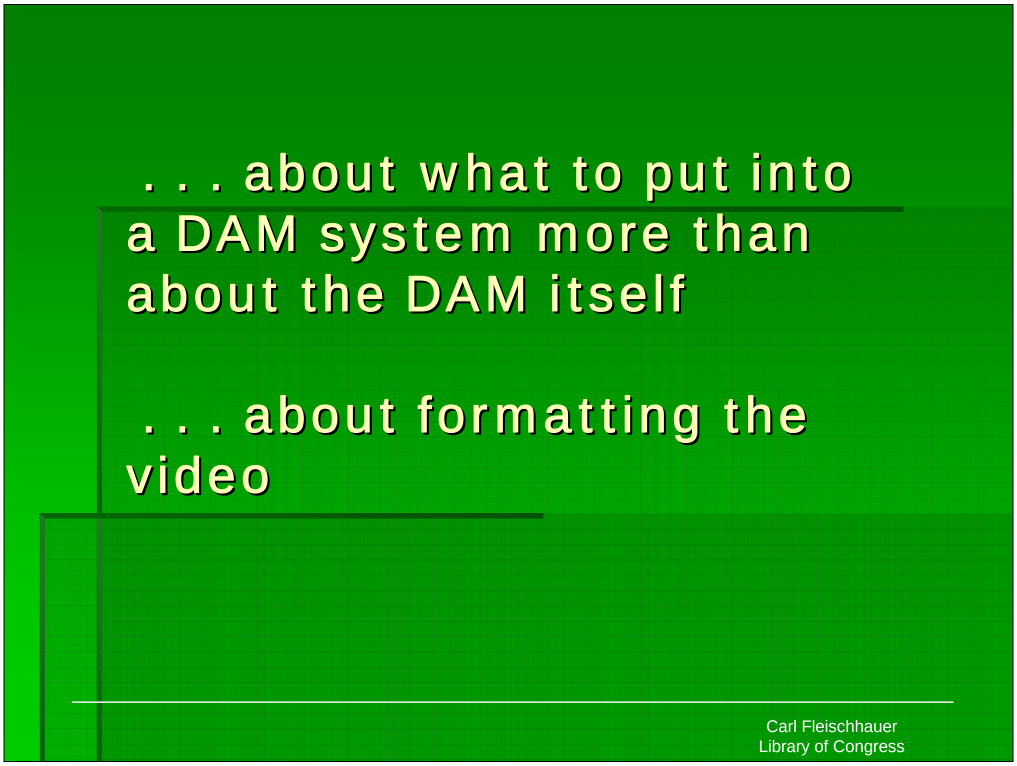
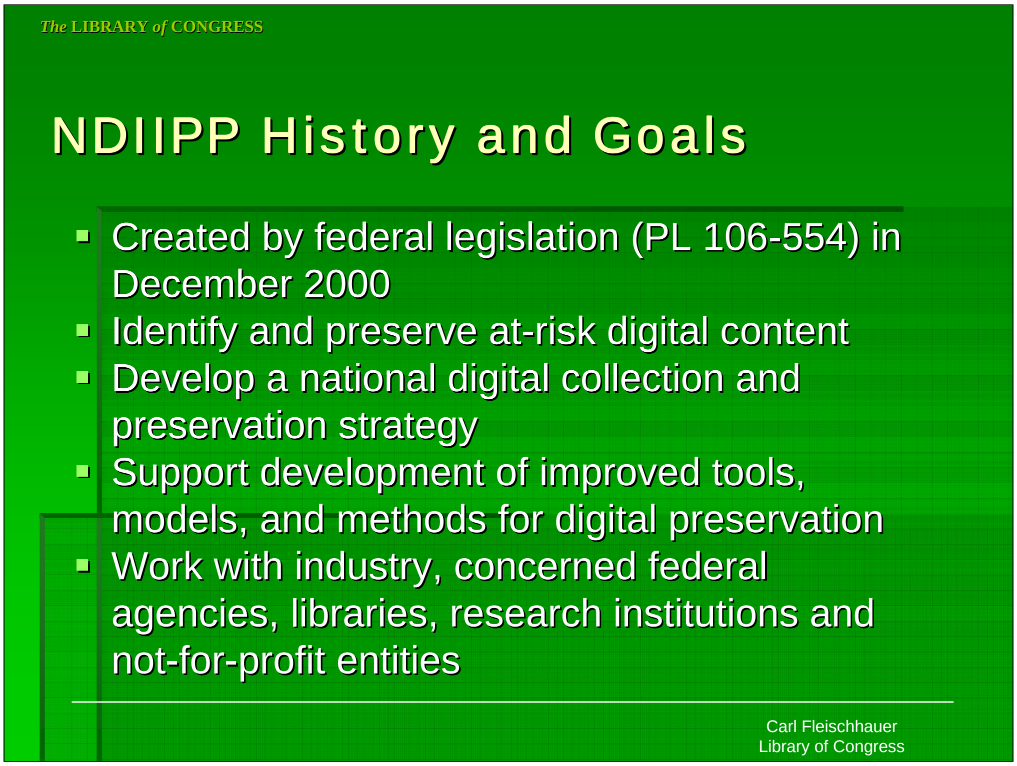


My name is Carl Fleischhauer, from the Library of Congress. I made up a one-pager with my contact information and a URL where you can get a copy of this slide show, including the text.

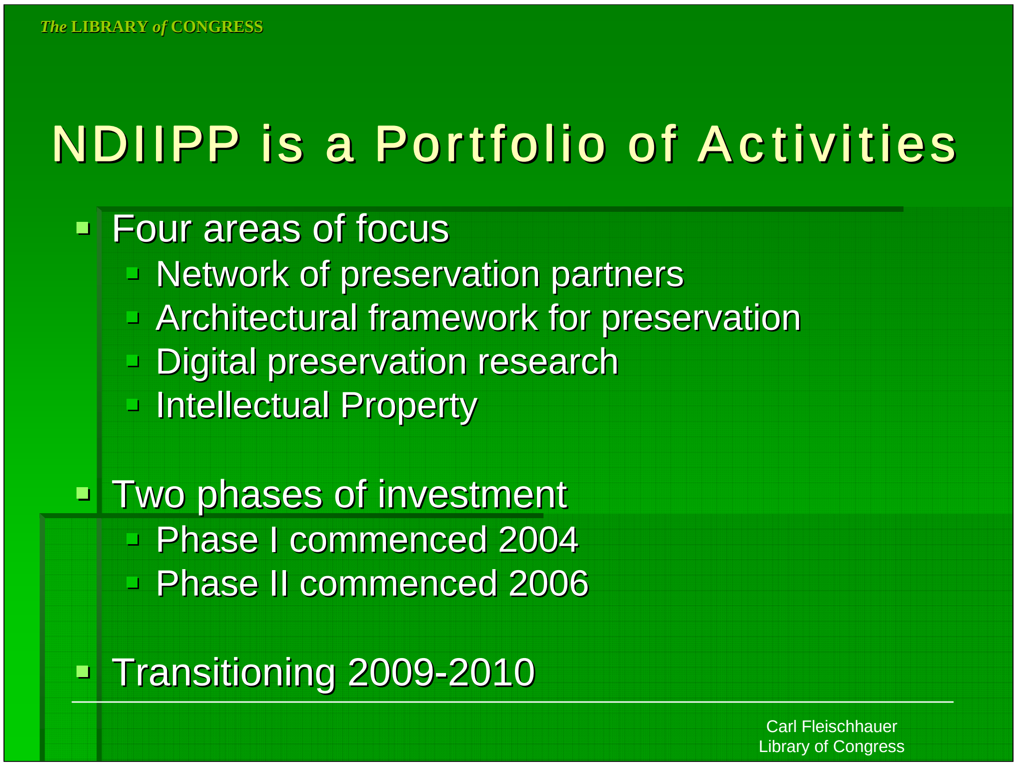


My topic is what to **put into** a DAM system more than about the DAM itself. I will discuss some aspects of formatting video with preservation in mind. But it is terrific to talk to an audience with as much experience and knowledge as this one -- I am sure at the end, you will pass along things that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

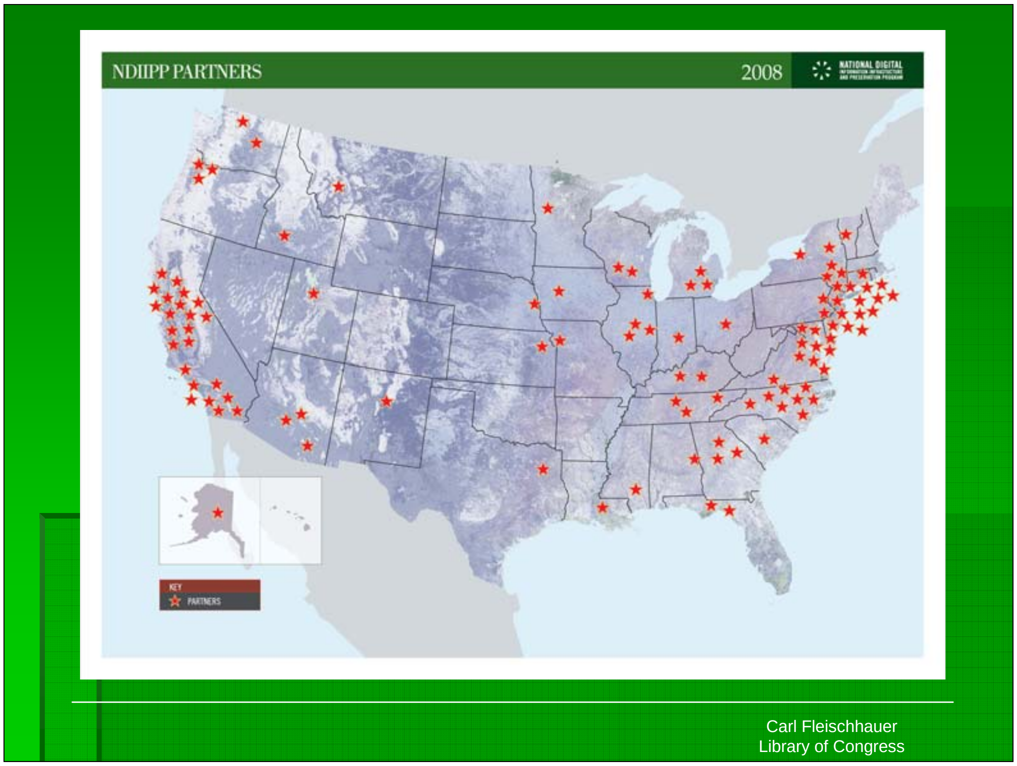
Most of the activities I will describe are associated with the National Digital Information Infrastructure and Preservation Program (NDIIPP) at the Library of Congress.



NDIIPP 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 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.

The LIBRARY *of* CONGRESS

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

Carl Fleischhauer
Library of Congress

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.

The LIBRARY *of* CONGRESS

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)

Carl Fleischhauer
Library of Congress

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

Carl Fleischhauer
Library of Congress

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.

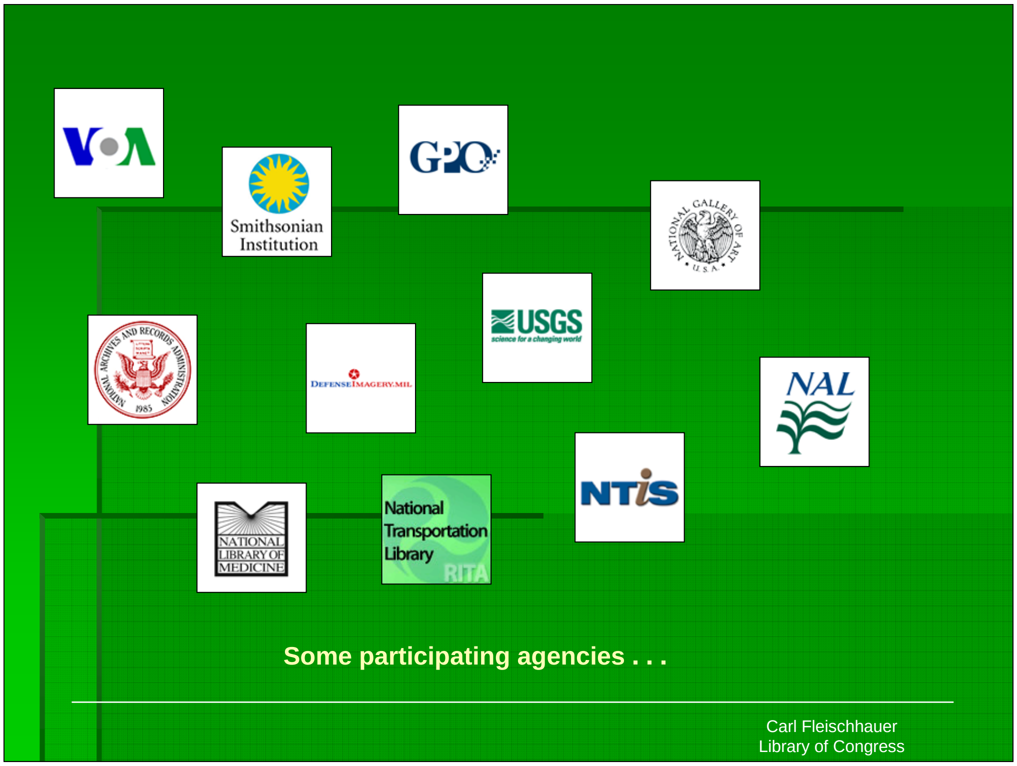
The LIBRARY *of* CONGRESS

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

Carl Fleischhauer
Library of Congress

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.

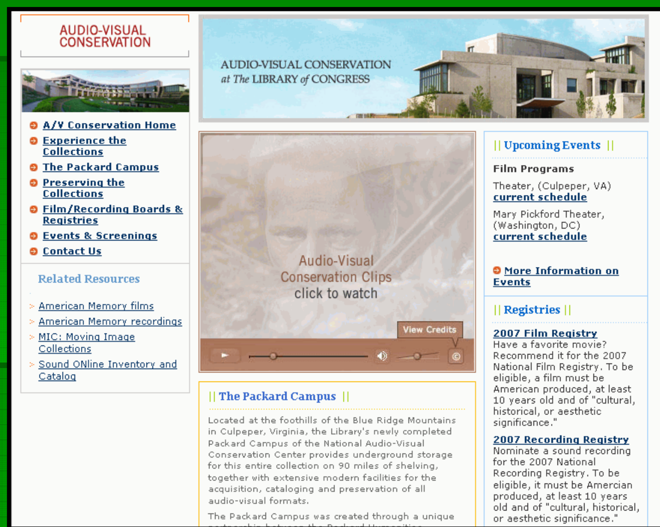


Very recently, NDIIPP convened a pair of working groups--with representatives from a number of federal agencies, to draft guidelines for digitization. One important player is the National Archives but several others participate.

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.

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



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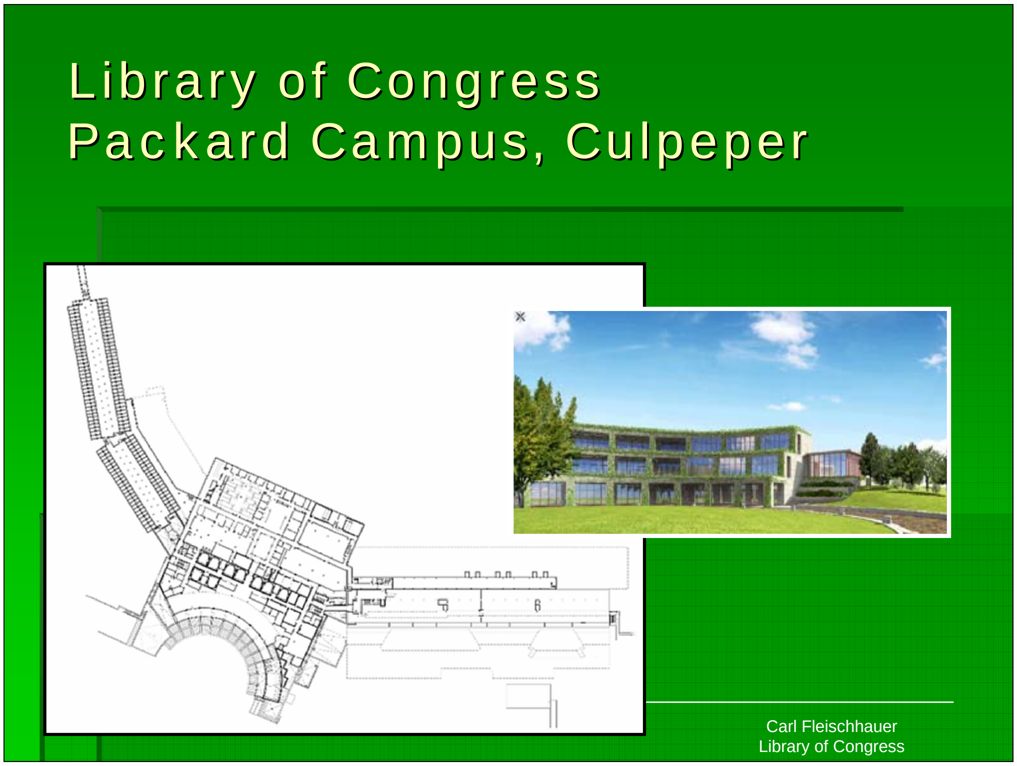
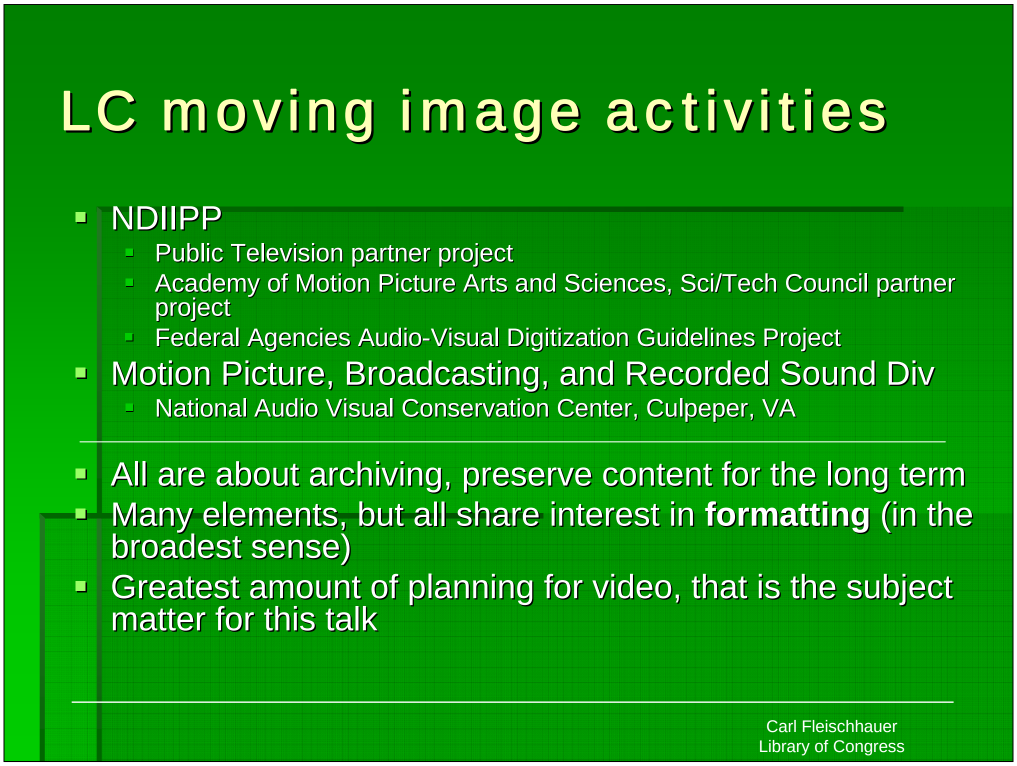
At the Library of Congress, our NDIIPP activities -- the two "outside" projects I mentioned and the Federal Agencies working groups -- co-exist with the ongoing work of the Motion Picture, Broadcasting, and Recorded Sound Division.



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



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

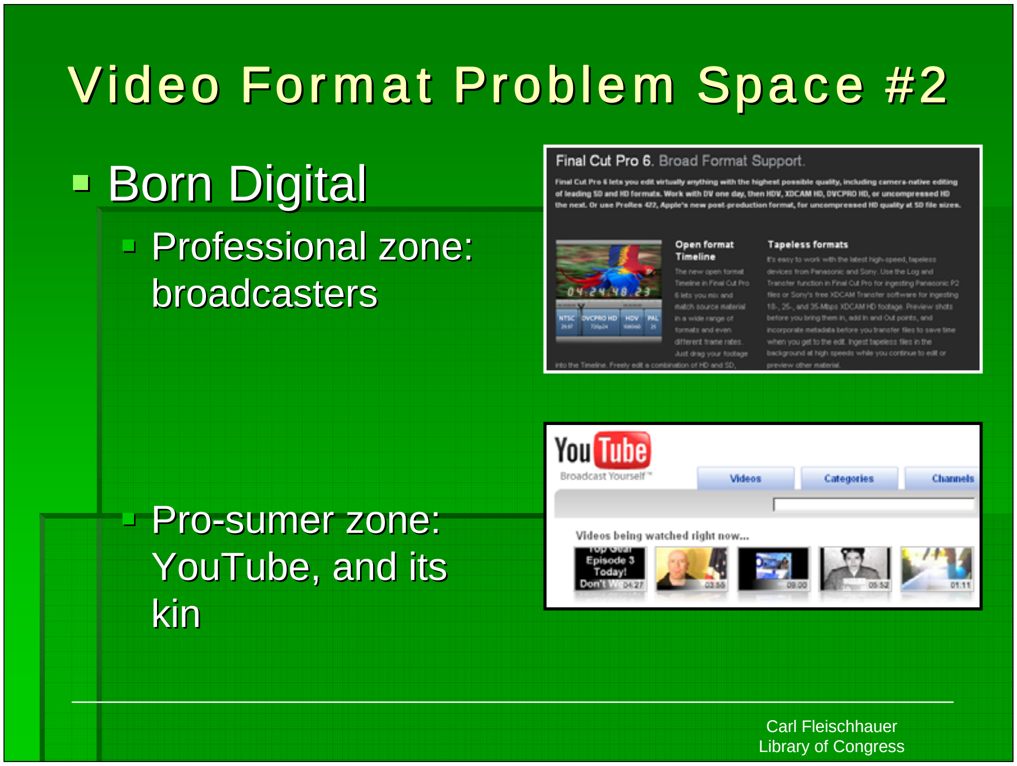
- Reformatting from old videotapes

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

Image from Wikipedia

Carl Fleischhauer
Library of Congress

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.



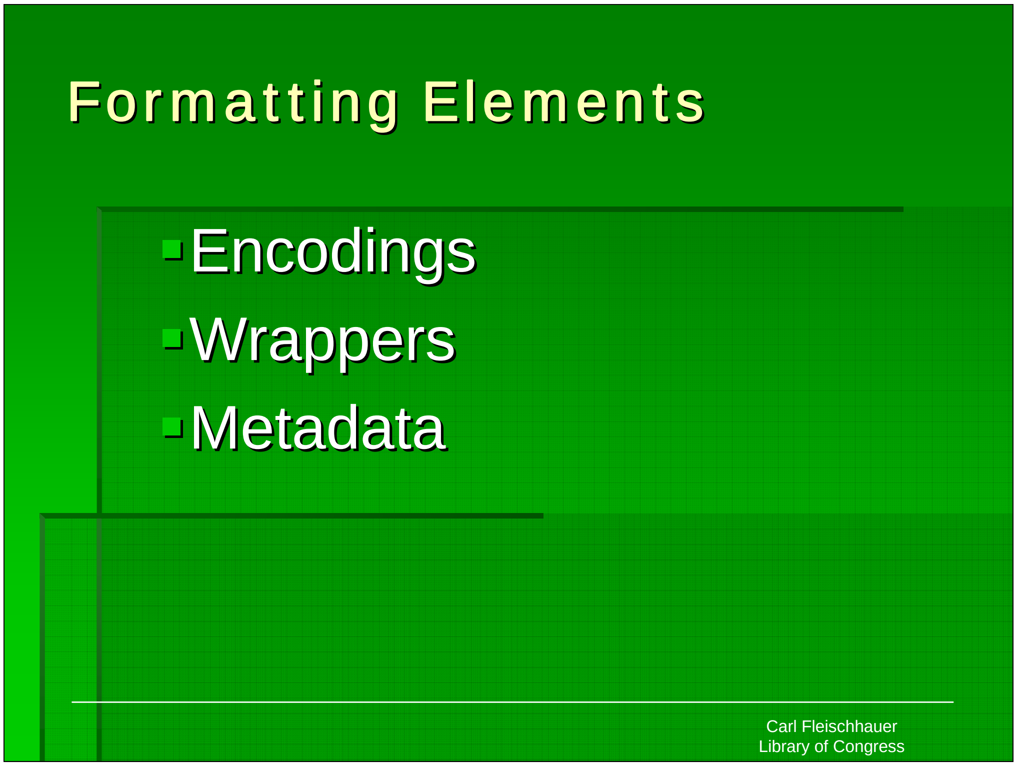
But that ain't all -- we-all also confront new content, arriving in digital-file form. For born-digital, there seem to be two broad classes. First: professional born digital: production by broadcasters and other pros. Second: the often-inspired, prosumer work so significant today on Web sites like YouTube.

Allies in the Industry

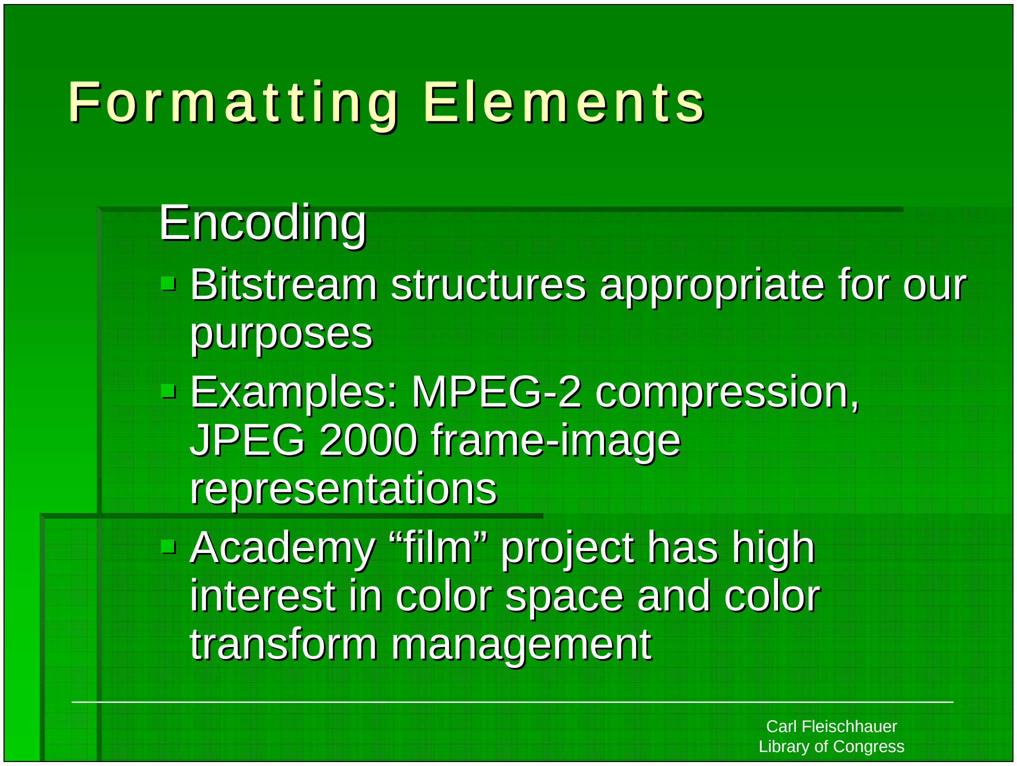
- Producers, creators seek interoperability via standards
  - May be from “true” or industry standards bodies, MPEG-2, MPEG-4, MXF, AAF
  - May be relatively open and public, albeit proprietary, AVI, QuickTime

Carl Fleischhauer
Library of Congress

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.

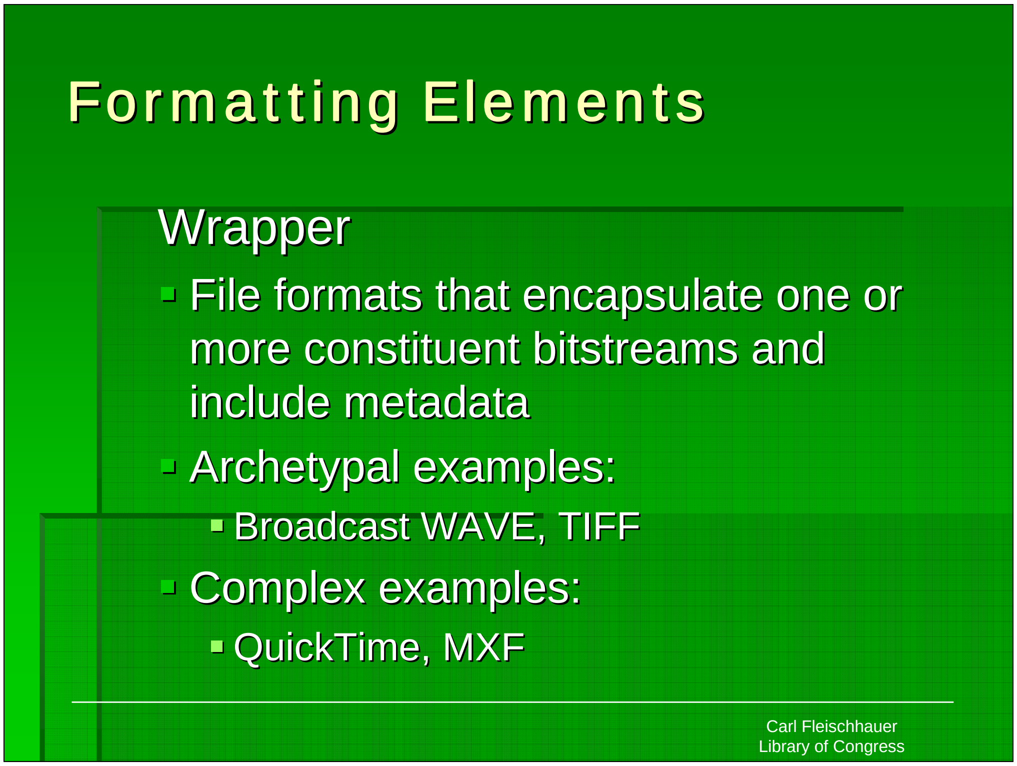


[Three elements.] We tend to describe formatting in terms of three elements: encoding, wrappers, and metadata.



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.



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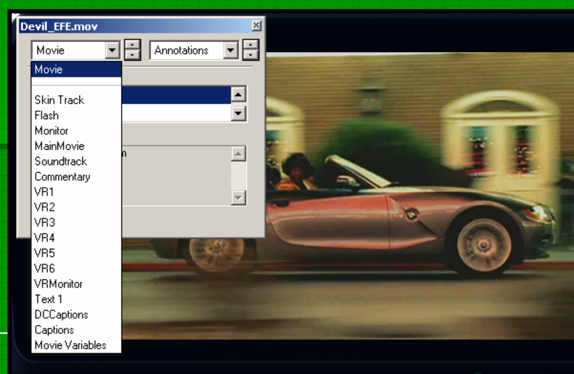
Regarding metadata, my talk will emphasize technically oriented chunks of administrative metadata. Our questions include these: To what degree is metadata embedded in the wrapper or even the bitstream? To what degree is such embedded metadata standardized?

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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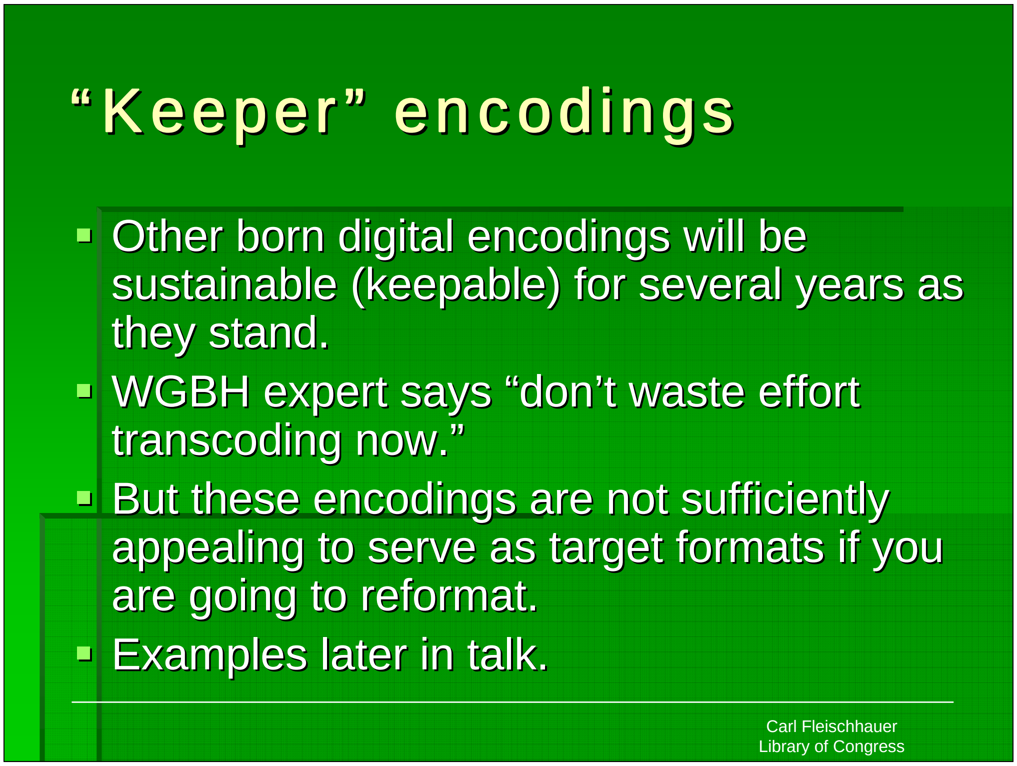
Library of Congress

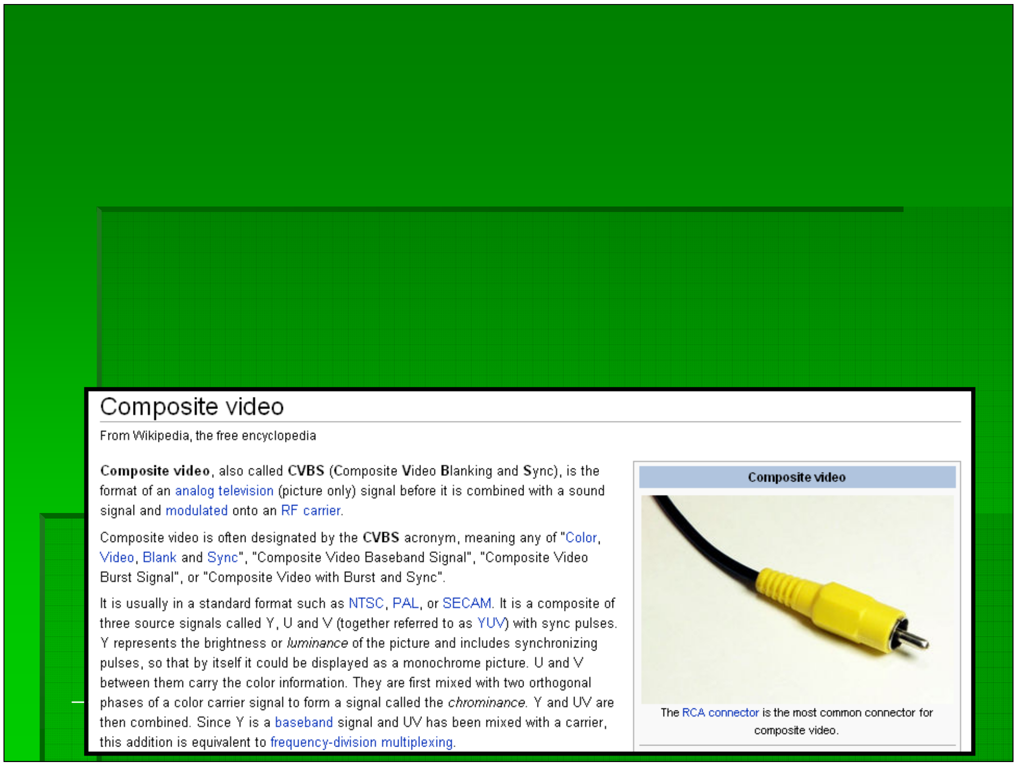
Now: about encodings:

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.*

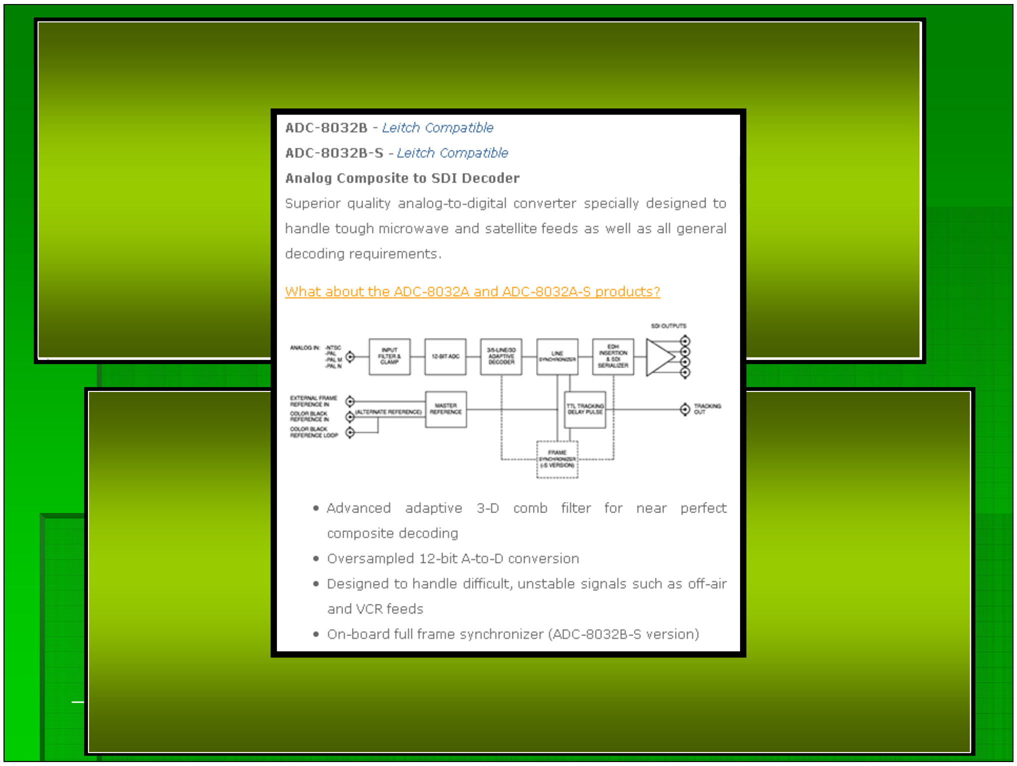


Second, there are "keeper" encodings. Some born digital content employs encodings that are sustainable for a period of years, even though they are not sufficiently appealing to serve as target formats. For short, we call them *keeper encoding formats*. My colleague Dave MacCarn at WGBH uses the elegant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

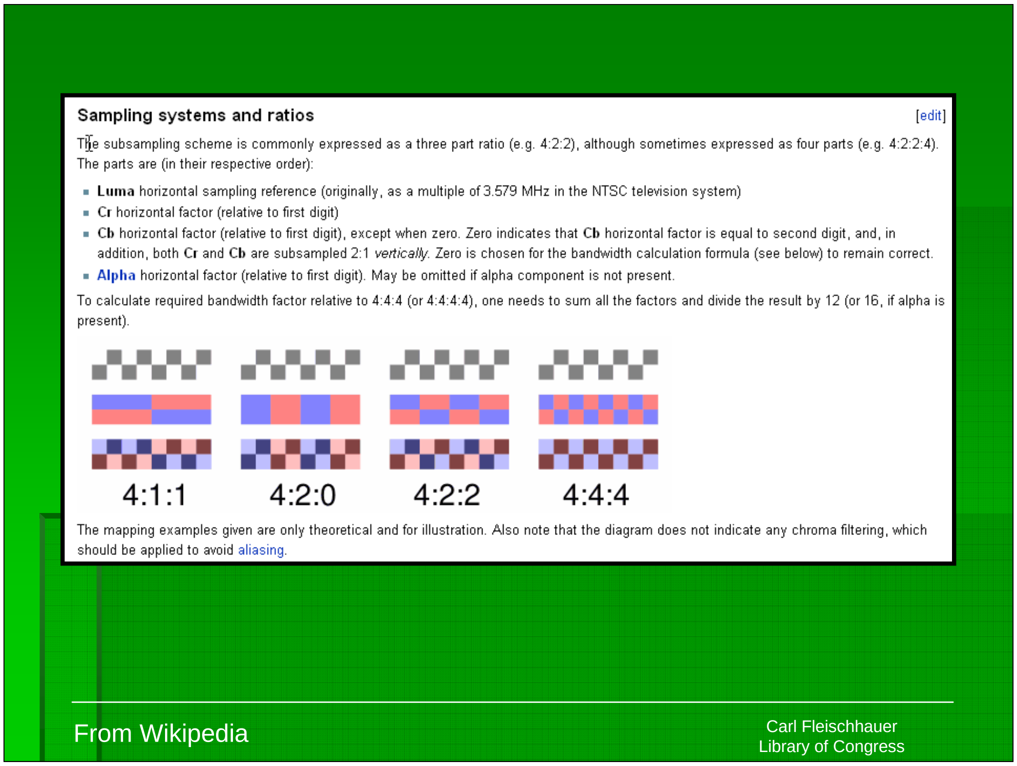
[Target formats.] The discussion of target *encoding* formats generally begins with an unstated assumption: the signal arriving for reformatting is a component video signal. *Component video* is a bitstream in which luminance or brightness information is separate from color information.



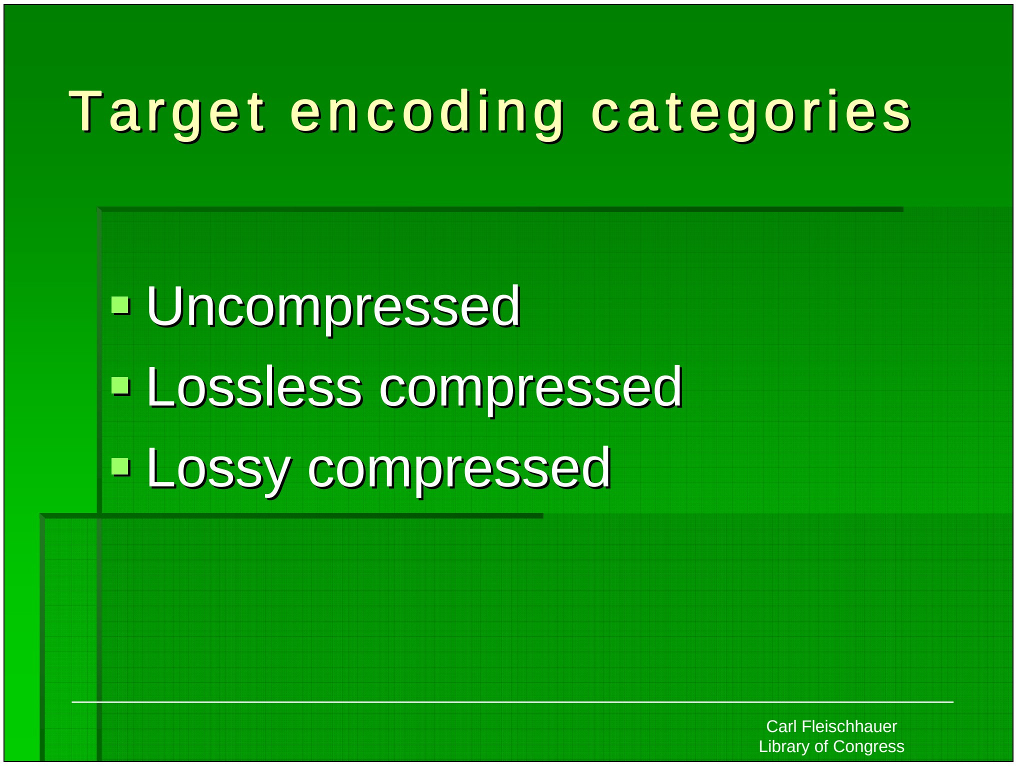
In contrast, *composite* video is represented by analog signals on older videotapes and the signals transmitted by broadcasters, until the great changeover next February. A composite signal blends the luminance and chrominance information.



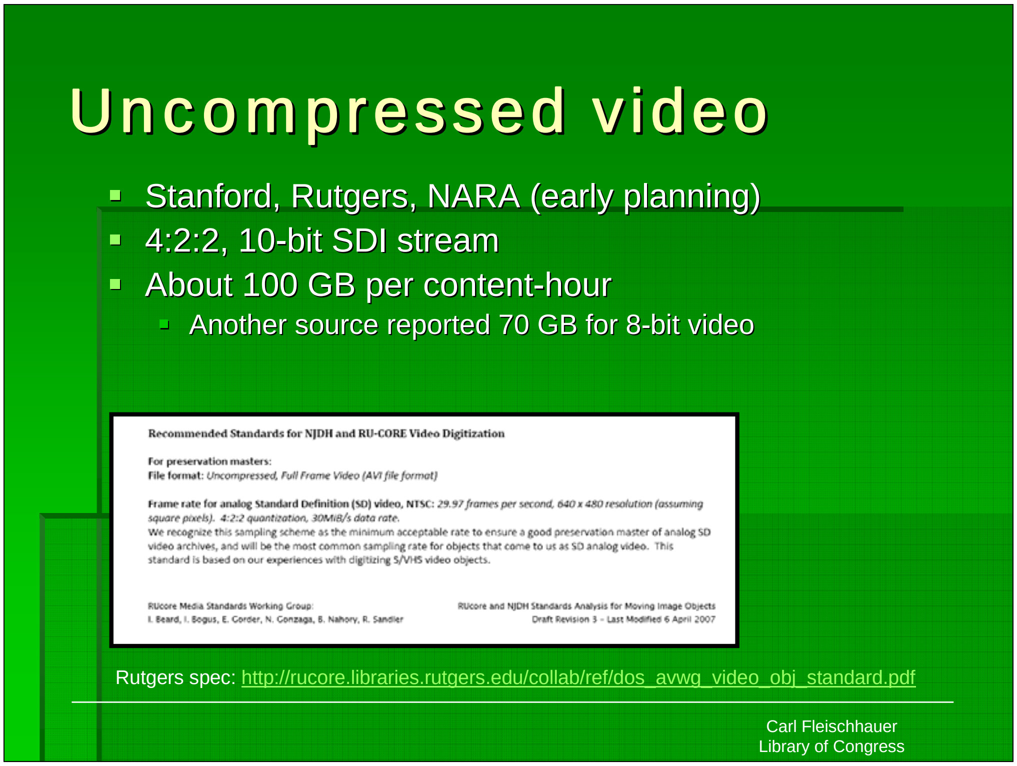
This means that the first step for signal processing in analog-to-digital reformatting entails the transformation of composite into component video. Of course, the composite-to-component transform has been part of video reformatting for years--it happens when you record to a SONY BetaCam videocassette.



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.

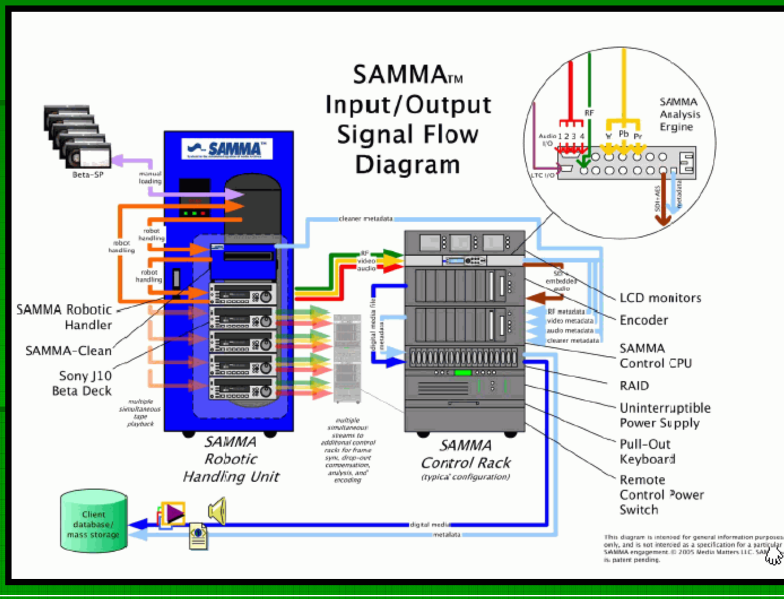


Generally speaking, existing preservation-oriented projects treat a 4:2:2 or 4:2:0 video signal, downstream from the composite-component transform, and their encoding falls into three broad categories: uncompressed, lossless compressed, and lossy compressed.



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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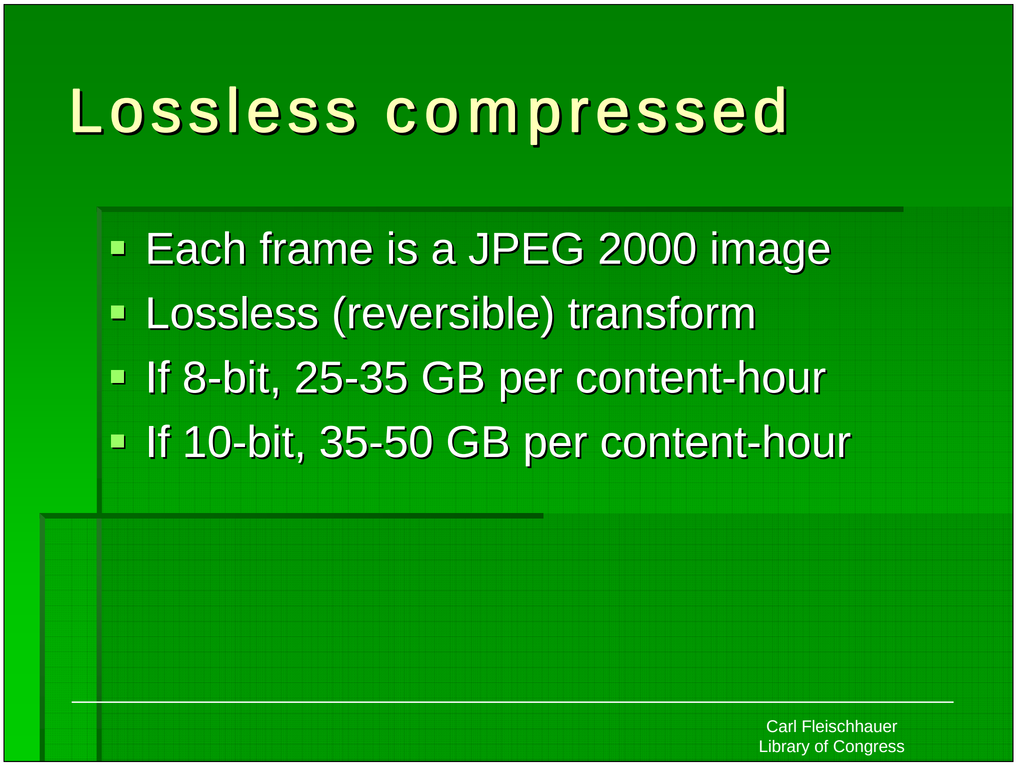
A second approach is to compress the picture using a lossless algorithm, the equivalent of saving your still image with LZW compression in a TIFF file. The leading proponent for this is Jim Lindner, whose company (recently sold to Front Porch Systems, they have a booth in this trade show) developed an 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.



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

THOMSON

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

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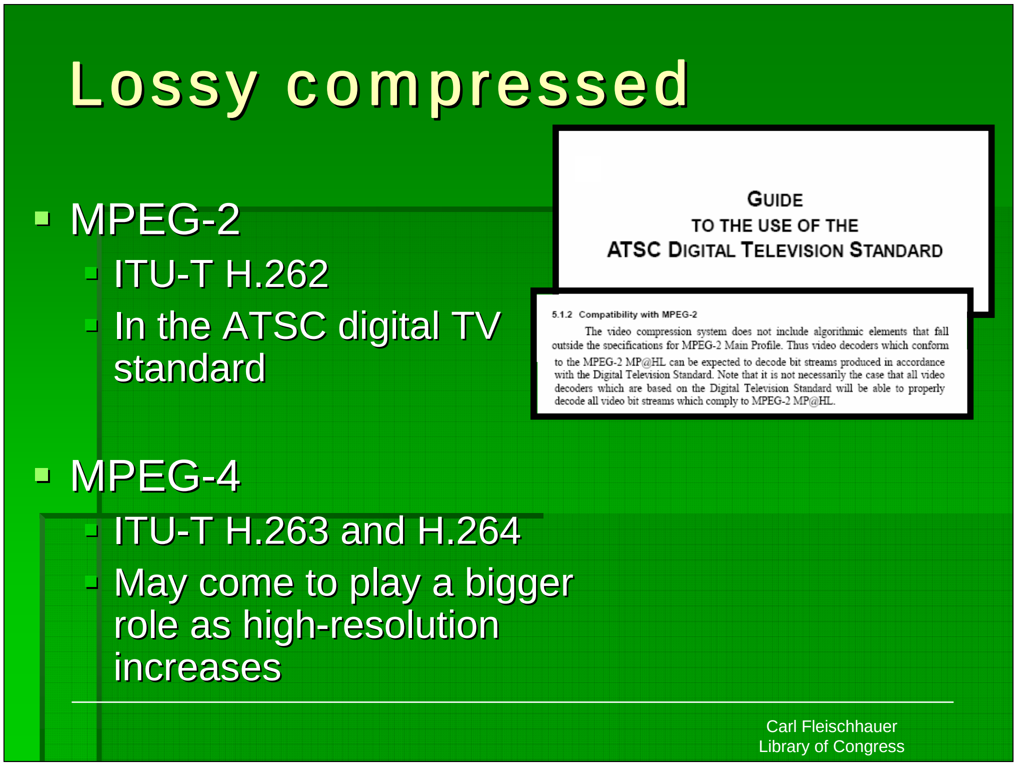
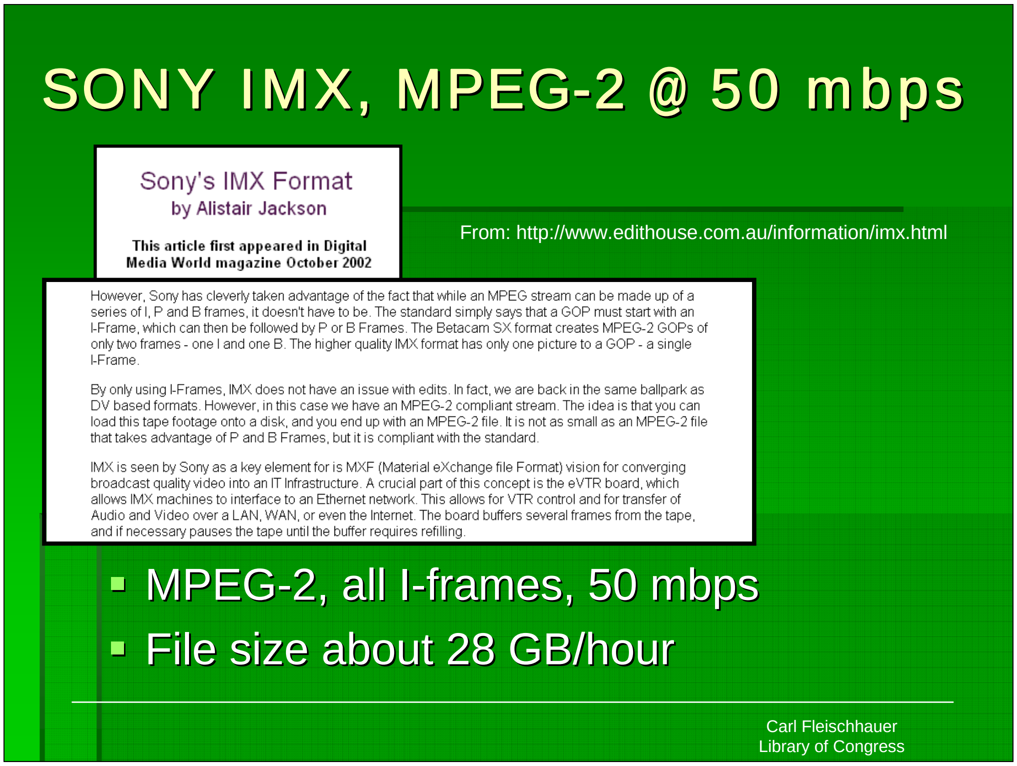
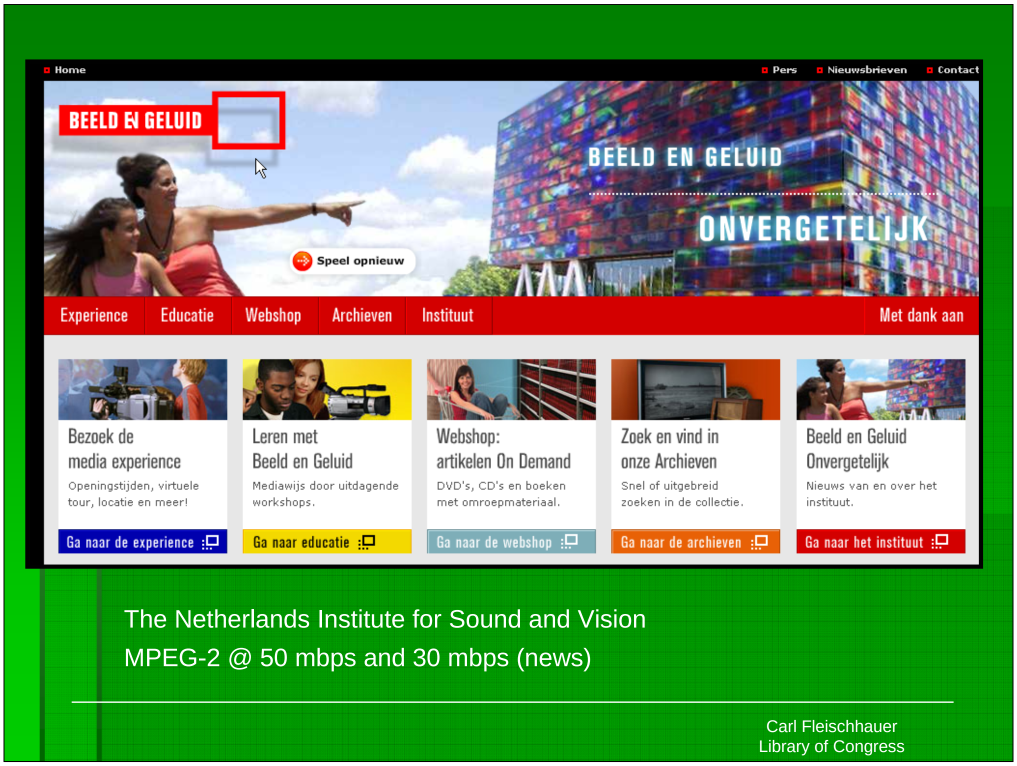
A third approach is to apply lossy compression to the picture information. You could do this using the irreversible transform in JPEG 2000, the approach used in the new digital cinema specification—movies for theaters. Although there is some uptake for lossy JPEG 2000 in born digital video in new cameras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



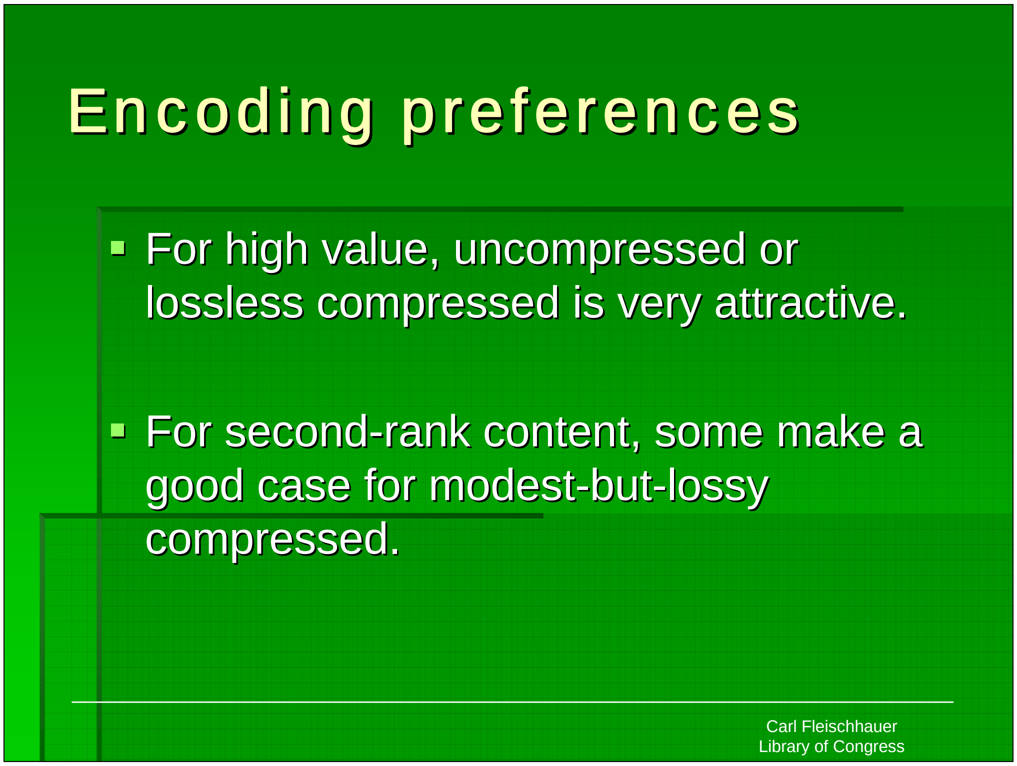
Today, the most frequently selected lossy compression encoding is MPEG-2 (aka H.262 in Europe). MPEG-2 has legs because it is part of the ATSC digital television standard, guaranteeing it a place in professional work for several more years. In time, one of the MPEG-4 schemes (H.263 or H.264 in Europe) 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.



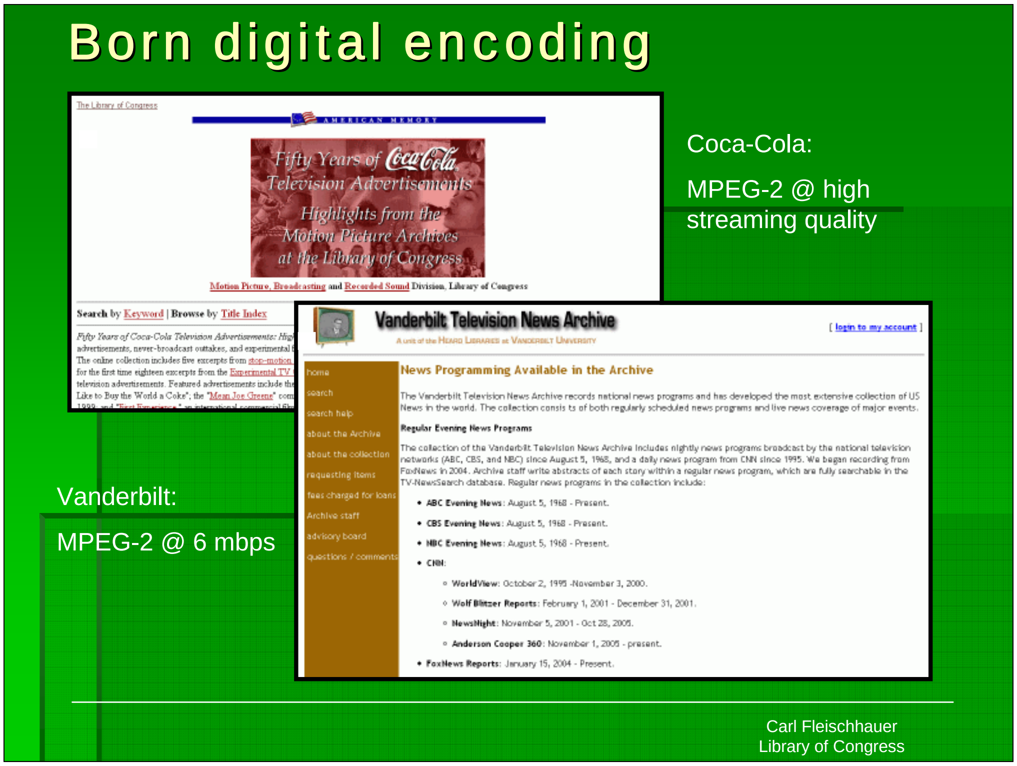
A number of broadcast organizations have selected MPEG-2 for archiving. SONY is a major player in professional circles and the widespread use of SONY IMX recorders has led to the acceptance of MPEG-2 with a data rate of 50 megabits per second as a benchmark. This encoding consists of all I-frames, meaning 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.



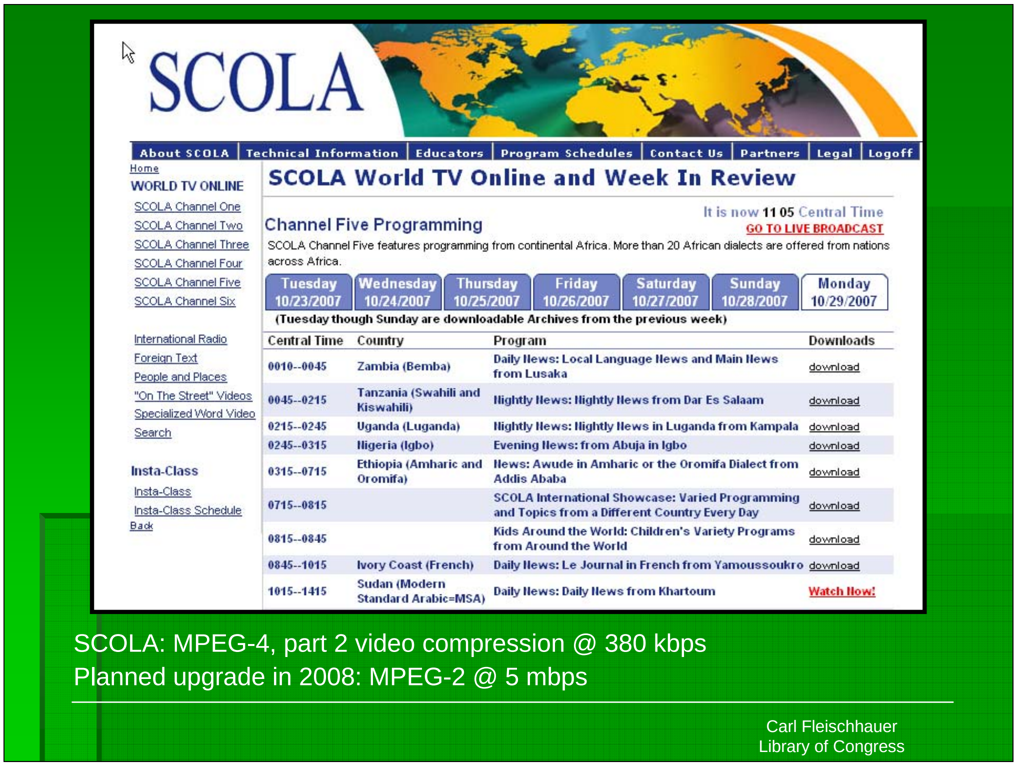
There is some use of MPEG-2 for archiving in Europe. For example, I recently read an account of work at the Netherlands Institute for Sound and Vision. They have begun to digitize their extensive collection, with funding from the Dutch government, using MPEG-2 at 50 Mbps for much of their television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



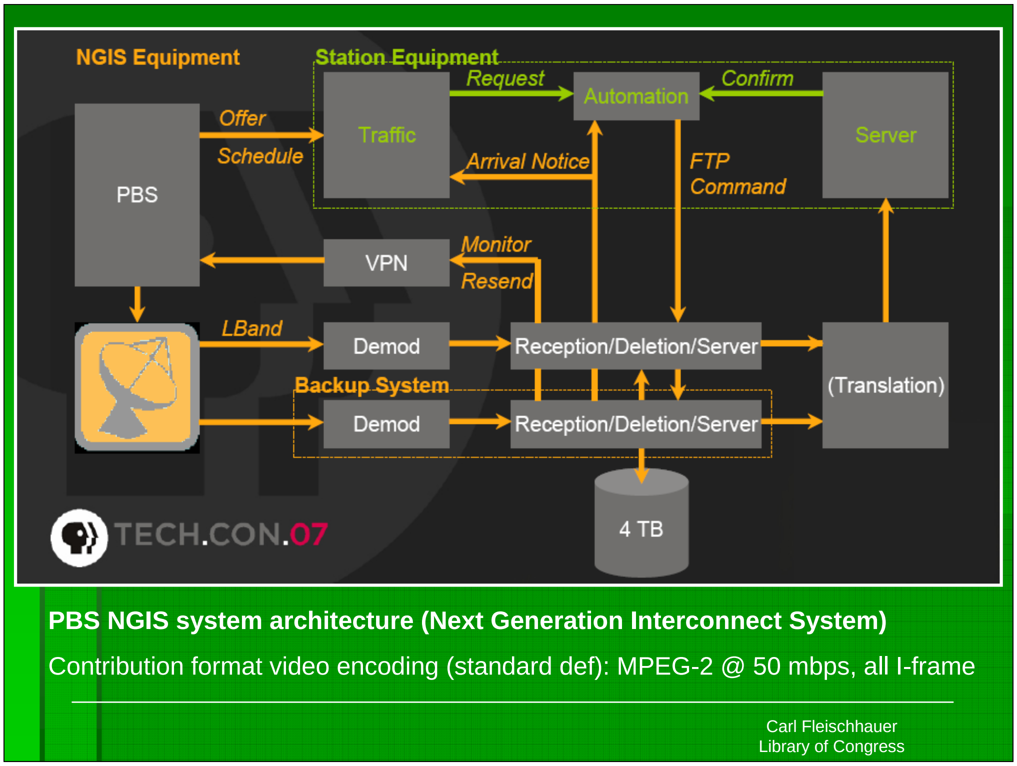
How shall we vote on reformatting target encodings overall? For high value content, it is hard not to be drawn to uncompressed or lossless encodings, the latter adding complexity to the bitstream but reducing storage requirements significantly. For second-rank content, some will make a case for modest-but-lossy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



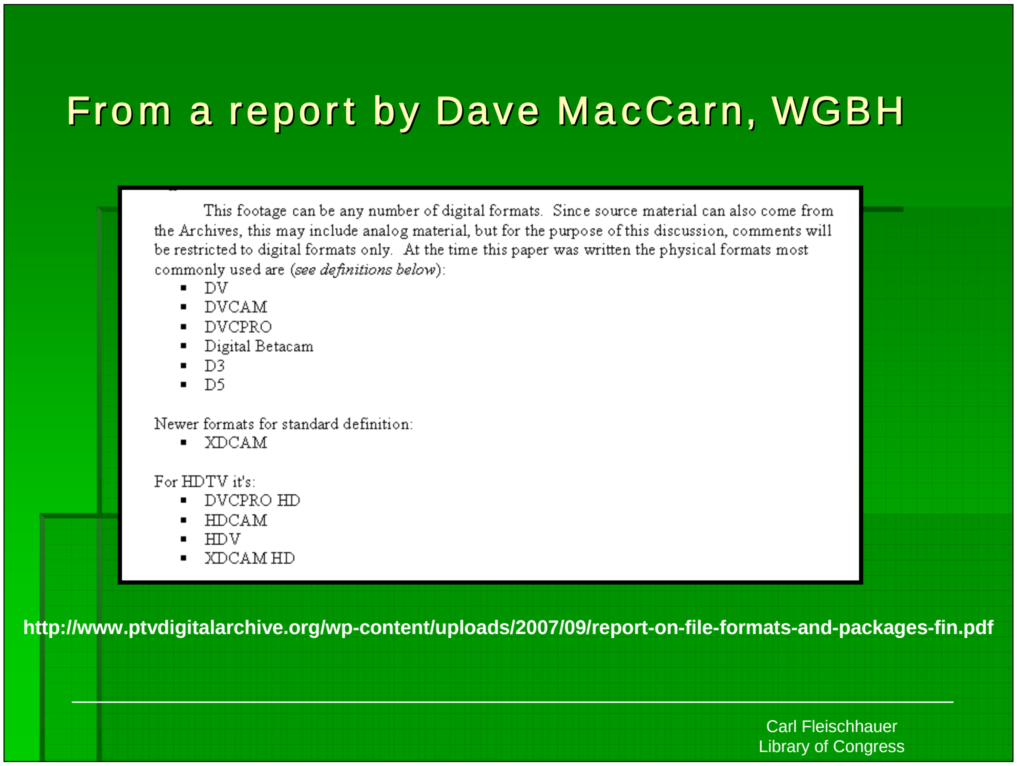
[Born digital encodings.] On the born digital side, when transcoding is necessary, the same target options recur: uncompressed, lossless compressed, and lossy compressed. But what are examples of the *keeper encodings* I mentioned earlier? At the Library, we started receiving content from the Coca-Cola 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.



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.

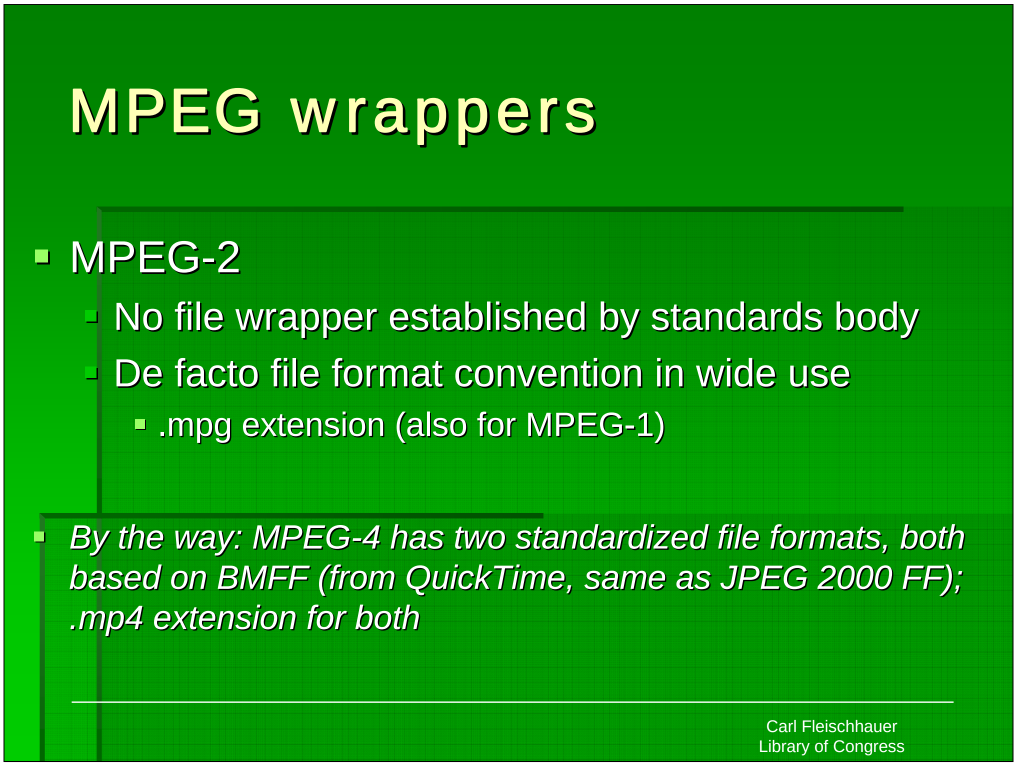


And what are we hearing from the NDIIPP public television project? Using PBS's new interconnect system, the producers of public TV content plan to contribute finished standard-definition programs as 50 mbps MPEG-2 files.



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.



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

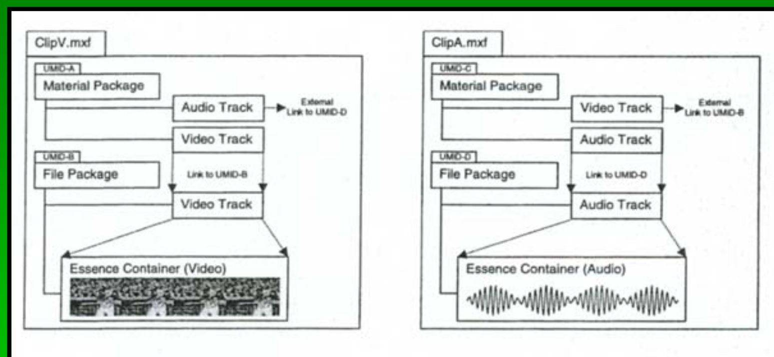


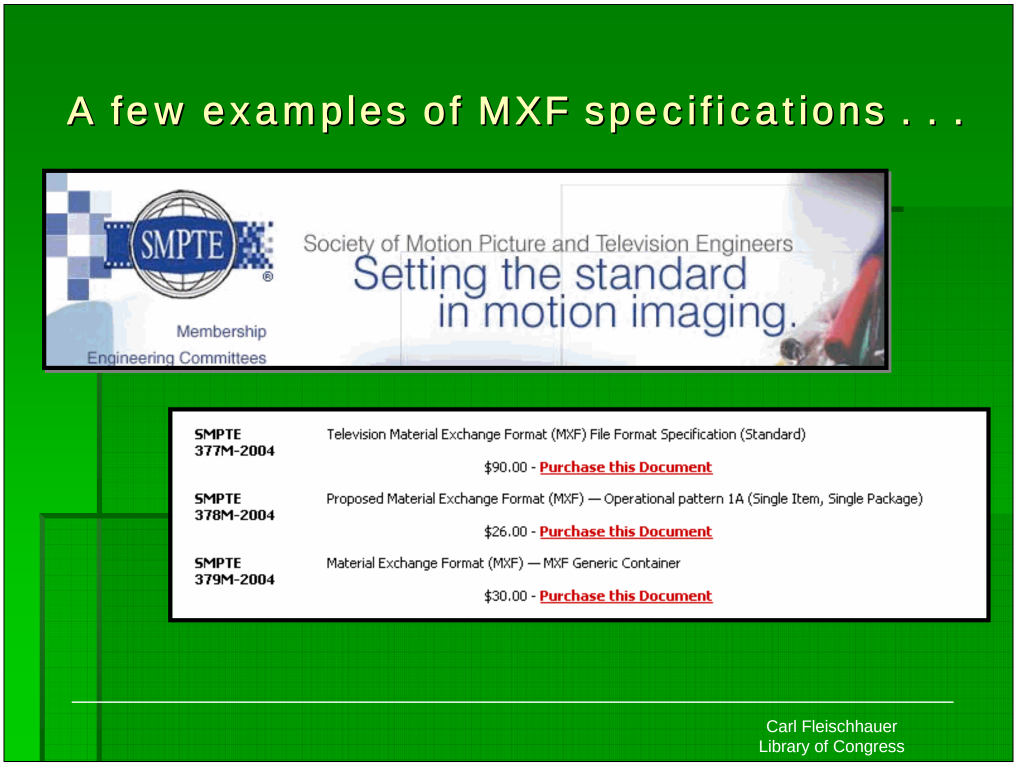
Figure A.1 – OP-Atom files showing a parallel relationship

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

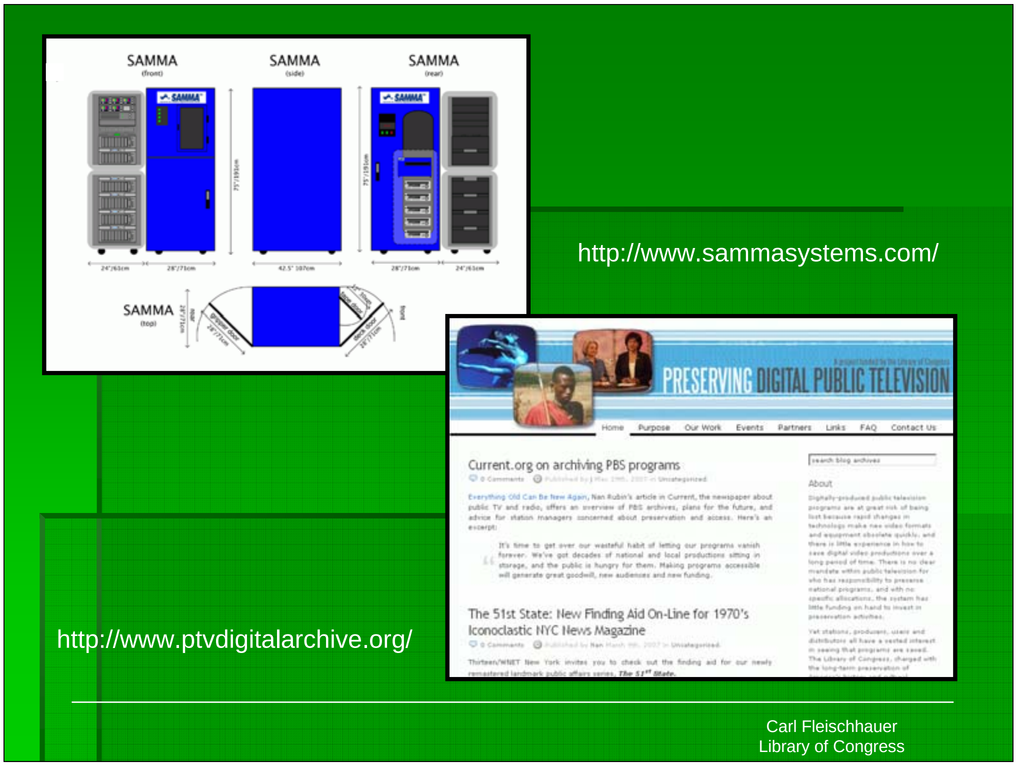
BTW: AAF (Advanced Authoring Format) is a close cousin to MXF.

Carl Fleischhauer
Library of Congress

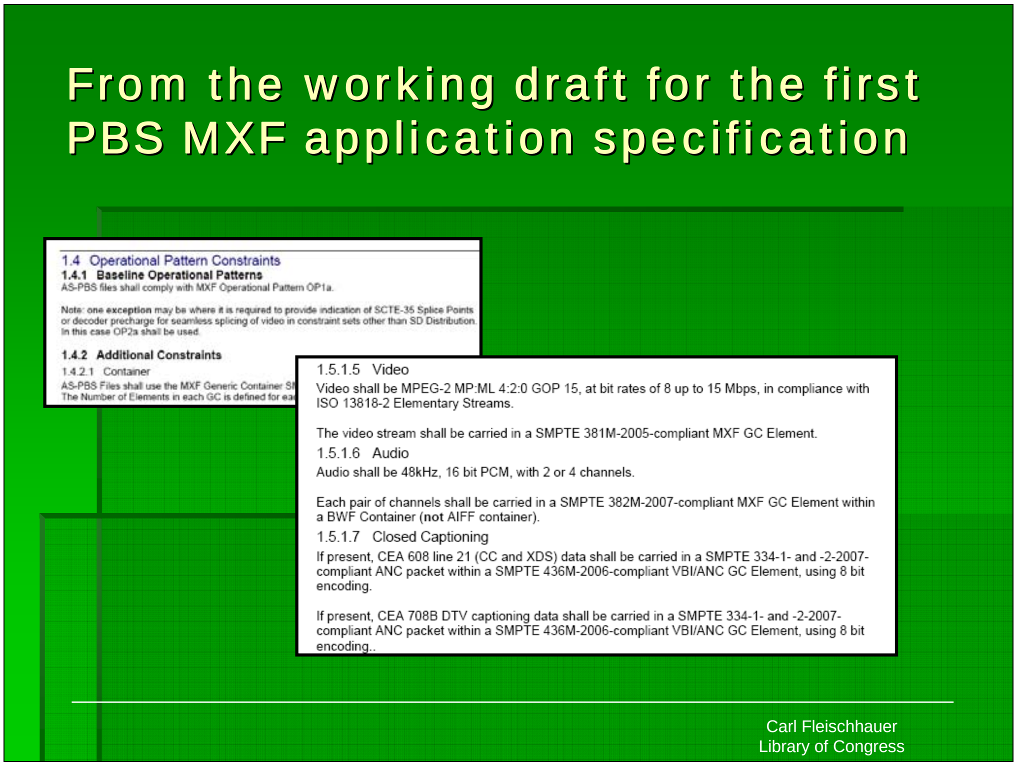
In professional circles, the wrapper buzz these days concerns the Material Exchange Format (MXF), standardized by SMPTE. MXF is an object-based file format that bundles video, audio, timecode information, closed captions, and what amounts to an "edit decision list." Complexity of structure is categorized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



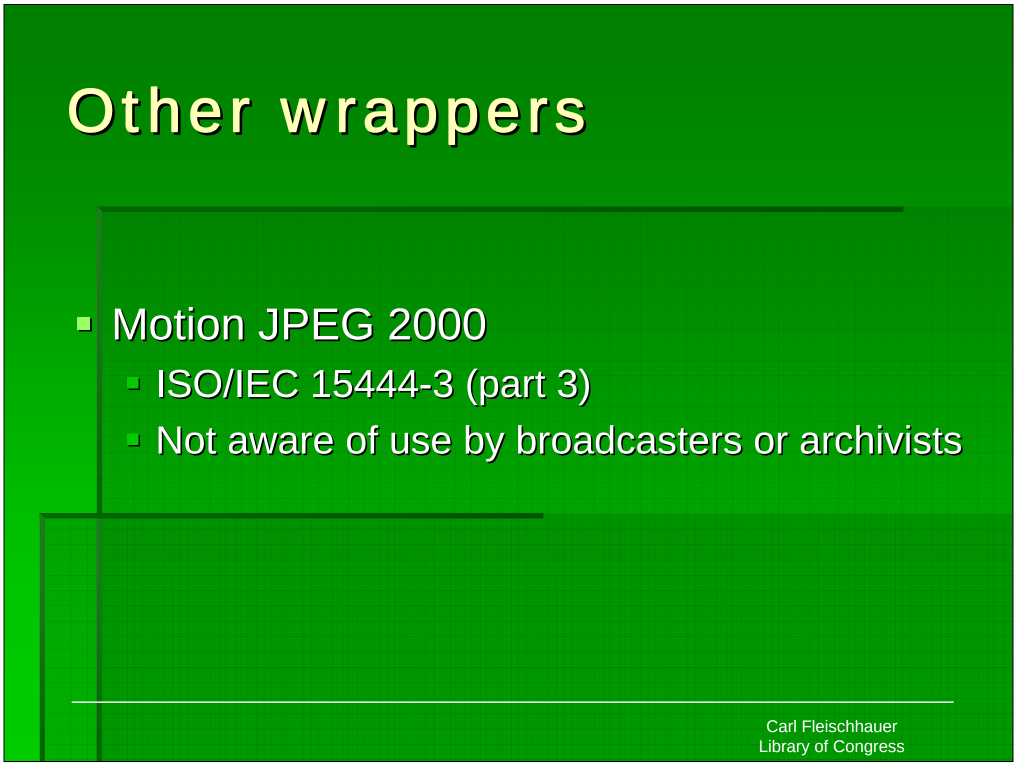
MXF is intended to support content interchange between creators and distributors, and to be implemented in cameras, recorders, and computer systems. It is used in the digital cinema specification. MXF is complicated and new: between 2004 and the present, SMPTE has published more than thirty specification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



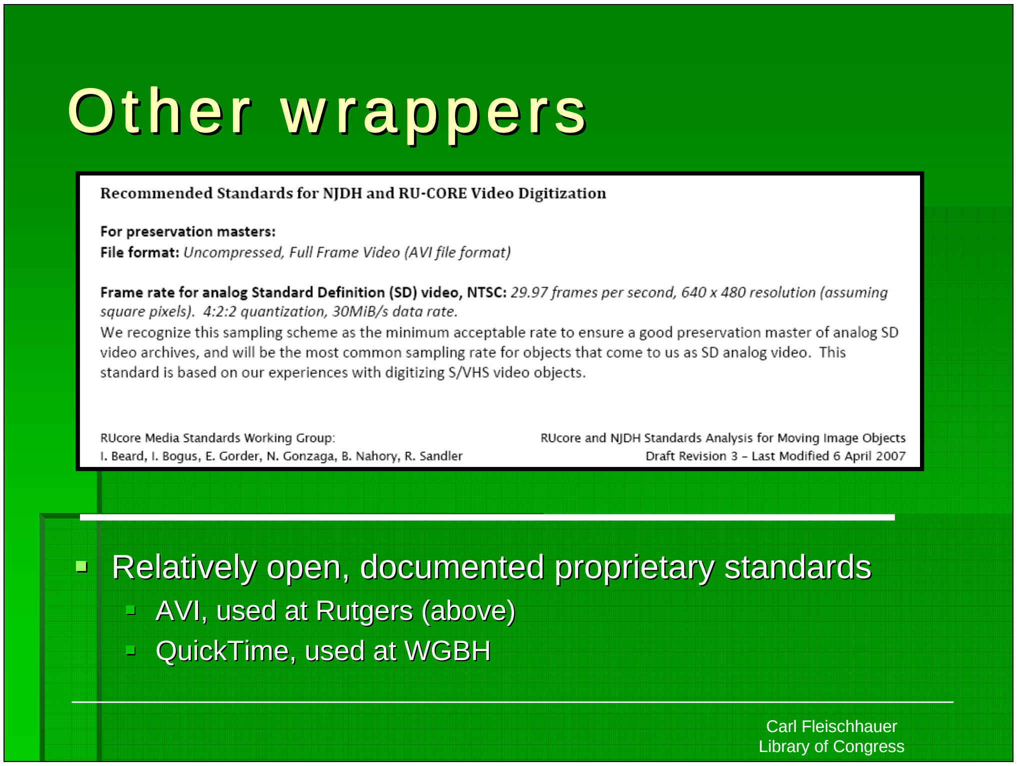
MXF is gaining momentum. In our archiving circle, there are two important MXF adoptions: in Jim Lindner's SAMMA system and by the NDIIPP public television team, each with its own encoding.



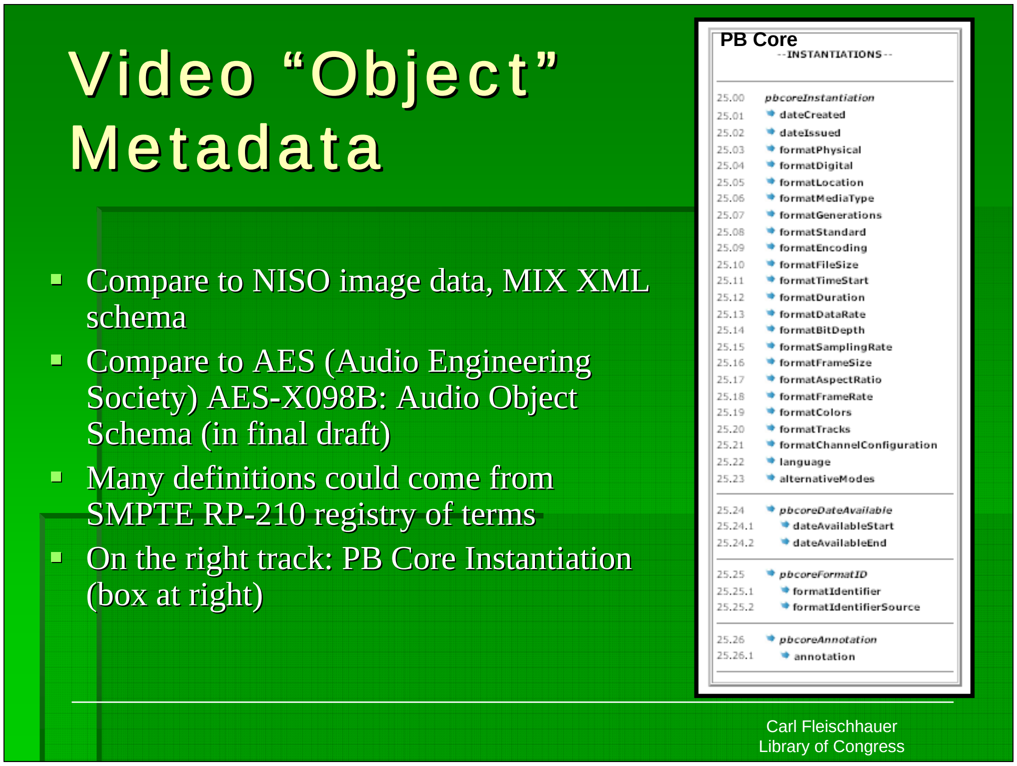
The public television folks are attending to profiling: they have drafted one MXF *application specification* (“AS”) for their moderate-resolution *distribution* files, and PBS plans to draft an AS for the high-res *contribution* files.



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.



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.



[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*.

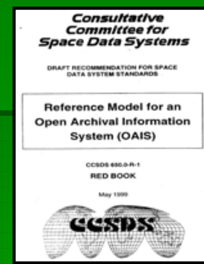
Video “Process” Metadata

- What you did to get what you got
- Compare to AES (Audio Engineering Society) AES-X098C: Process History Schema (in draft)
- Not aware of exact video example
- SAMMA logging metadata similar-but-different
  - Box contains 1 percent of one example


```xml
<Log>
  <Contents>Starting migration at 09:43:43 Thu Sep 27 2007\x0D\x0ARewinding source tape...\x0D\x0ASource tape stopped\x0D\x0AMotion JPEG2000 cued for record OK\x0D\x0AMPEG2 cued for record OK\x0D\x0AEnabled metadata\x0D\x0AStarted metadata analysis\x0D\x0APlaying source tape...\x0D\x0AMotion JPEG2000 recording...\x0D\x0AMPEG2 recording...\x0D\x0AINPUT threshold triggered normal End of Program\x0D\x0AStopping migration\x0D\x0AStopped metadata analysis\x0D\x0ADisabled metadata\x0D\x0AStopped source tape\x0D\x0AMotion JPEG2000 Stopped\x0D\x0AMPEG2 Stopped\x0D\x0ASource tape stopped\x0D\x0AEjecting source tape...\x0D\x0ASource VTR cassette empty\x0D\x0AMotion JPEG2000 Transfering file...\x0D\x0AMPEG2 Transfering file...\x0D\x0AMPEG2 Post processing completed successfully\x0D\x0AMotion JPEG2000 Post processing completed successfully\x0D\x0AMigration completed SUCCESSFULLY at 10:28:07 Thu Sep 27 2007\x0D\x0A</Contents>
  <ElapsedTime>00:33:57</ElapsedTime>
  <SampleCount>57961</SampleCount>
  </Log>
<Data IX="Index" TC="Frame Count" IN="Input Present" TT="Timecode" TB="Timecode User Groups" CB="Color Present" RF="RF Level" RW="RF Level Warning" RA="RF Level Alarm" HW="RF Head Difference Warning" DL="DOC Length" DN="DOC Number" DW="DOC Warning" DA="DOC Alarm" MH="Missing H-Pulse Count" NR="Noise Level" MD="Motion Detect" LA="Luma Average" LP="Luma Peak" UP="Pb Max" UM="Pb Min" UA="Pb Average" VP="Pr
```


For audio, AES has been working on “process” metadata, to document what you did to get what you got. There’s nothing quite like this in the video arena, although the SAMMA system collects extensive logging data during the reformatting process, and encodes this as XML.

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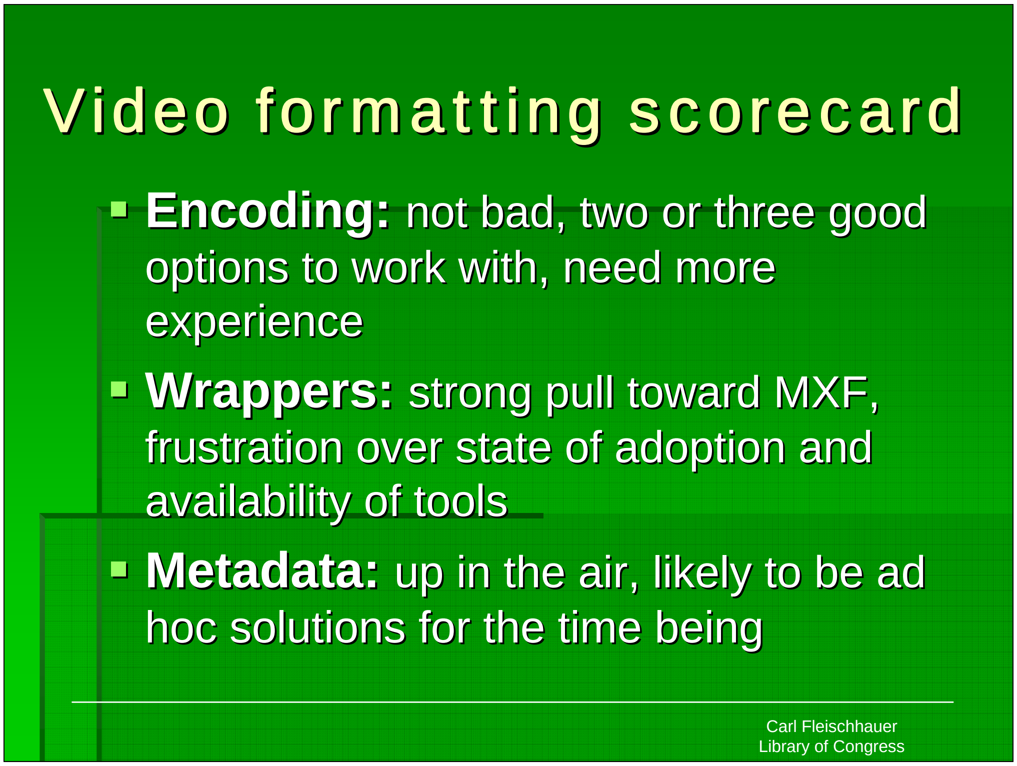
In the digital library community, there is another category: "preservation" metadata, the information you need to maintain the viability, renderability, and understandability of digital resources over the long-term. For those familiar with NASA's Open Archival Information System reference model -- OAIS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



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.