MXF Application Specification for Archiving and Preservation

The U.S. Federal Agencies Digitization Initiative

AMIA/IASA 2010

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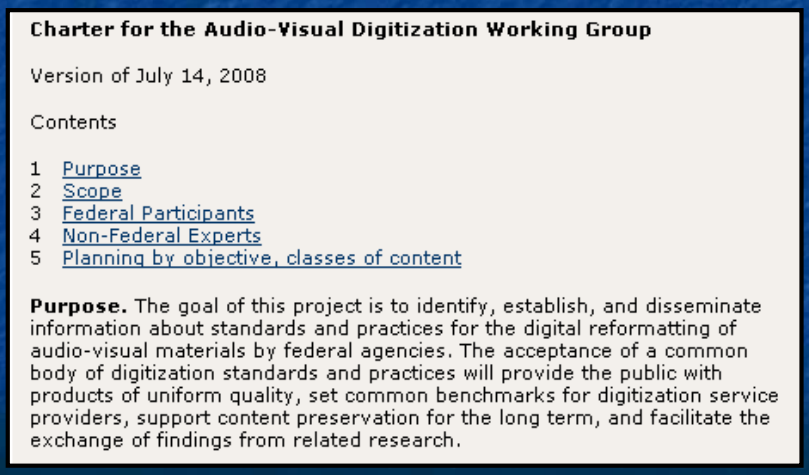
The Federal Agencies Digitization Guidelines Initiative was launched in 2007 under the auspices of the National Digital Information Infrastructure and Preservation Program (NDIIPP) at the Library.

It is a collaborative effort with participation from a number of federal agencies, including the U.S. National Archives, the National Gallery of Art, the Voice of America, the National Library of Medicine, the Smithsonian Institution, and several others.

. . . common body of digitization standards and practices will provide the public with products of uniform quality, set common benchmarks for digitization service providers, support content preservation for the long term . . . .



Charter for the Audio-Visual Digitization Working Group

Version of July 14, 2008

Contents

1 Purpose
2 Scope
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4 Non-Federal Experts
5 Planning by objective, classes of content

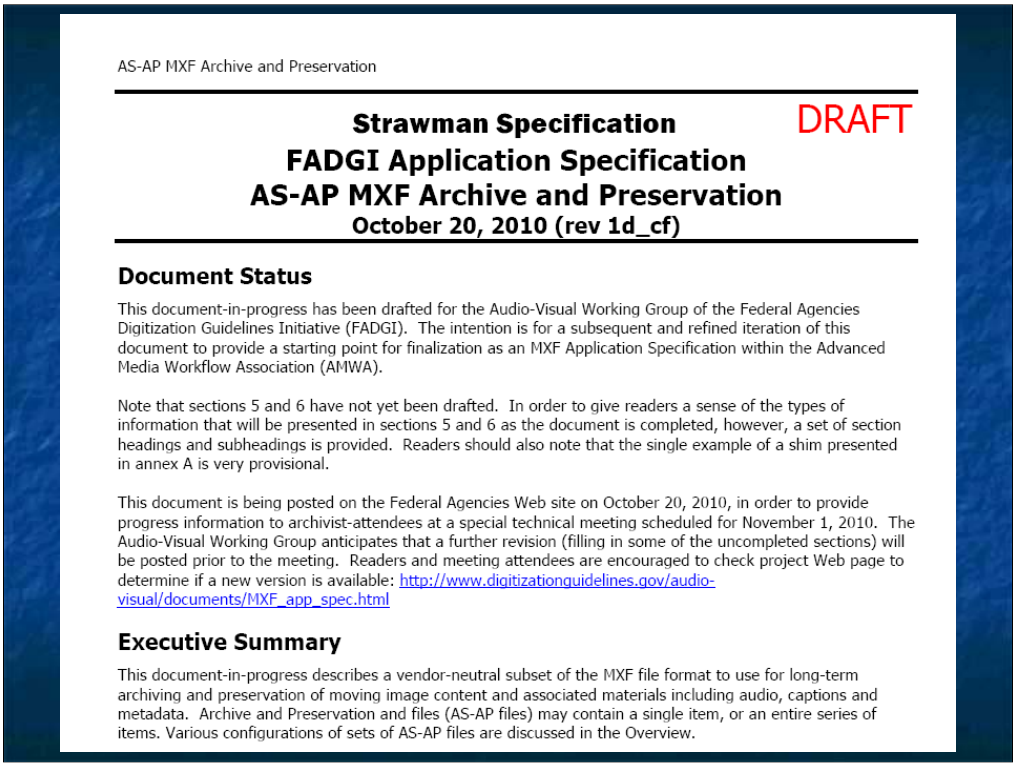
Purpose. The goal of this project is to identify, establish, and disseminate information about standards and practices for the digital reformatting of audio-visual materials by federal agencies. The acceptance of a common body of digitization standards and practices will provide the public with products of uniform quality, set common benchmarks for digitization service providers, support content preservation for the long term, and facilitate the exchange of findings from related research.

http://www.digitizationguidelines.gov/audio-visual/charter.html

We want to develop guidelines that are comparable from agency to agency, for the sake of uniformity and to make it easier for the vendors who provide equipment and services.

Our main emphasis is digitization--the conversion of analog originals into digital form. There are two working groups: one for still images -- they look at things like scanning books, photos, and maps.

And one for audio-visual materials, focused on sound and video recordings and motion picture film. This group (and to a lesser degree the still image group) also has an interest in the preservation of born digital content.



AS-AP MXF Archive and Preservation

Strawman Specification DRAFT

FADGI Application Specification

AS-AP MXF Archive and Preservation

October 20, 2010 (rev 1d_cf)

Document Status

This document-in-progress has been drafted for the Audio-Visual Working Group of the Federal Agencies Digitization Guidelines Initiative (FADGI). The intention is for a subsequent and refined iteration of this document to provide a starting point for finalization as an MXF Application Specification within the Advanced Media Workflow Association (AMWA).

Note that sections 5 and 6 have not yet been drafted. In order to give readers a sense of the types of information that will be presented in sections 5 and 6 as the document is completed, however, a set of section headings and subheadings is provided. Readers should also note that the single example of a shim presented in annex A is very provisional.

This document is being posted on the Federal Agencies Web site on October 20, 2010, in order to provide progress information to archivist-attendees at a special technical meeting scheduled for November 1, 2010. The Audio-Visual Working Group anticipates that a further revision (filling in some of the uncompleted sections) will be posted prior to the meeting. Readers and meeting attendees are encouraged to check project Web page to determine if a new version is available: http://www.digitizationguidelines.gov/audio-visual/documents/MXF_app_spec.html

Executive Summary

This document-in-progress describes a vendor-neutral subset of the MXF file format to use for long-term archiving and preservation of moving image content and associated materials including audio, captions and metadata. Archive and Preservation and files (AS-AP files) may contain a single item, or an entire series of items. Various configurations of sets of AS-AP files are discussed in the Overview.

The AV Working Group is pushing along a proposal for an archiving and preservation format based in the Material eXchange Format (MXF)--a standard from Society of Motion Picture and Television Engineers (SMPTE).

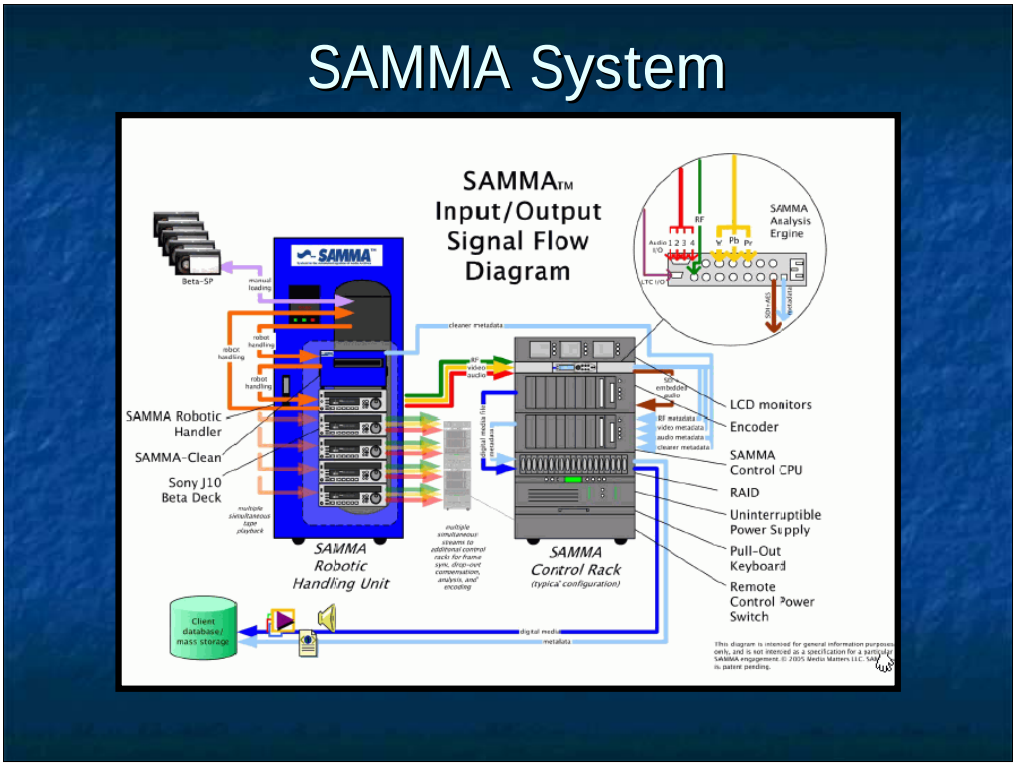
What started us down this path? It was the pressing need to reformat videotapes. Our agencies have extensive holdings of the obsolescent magnetic recordings and want to transfer them to a file-based format, while working playback devices can still be found.

Library of Congress
Packard Campus,
Culpeper, Virginia

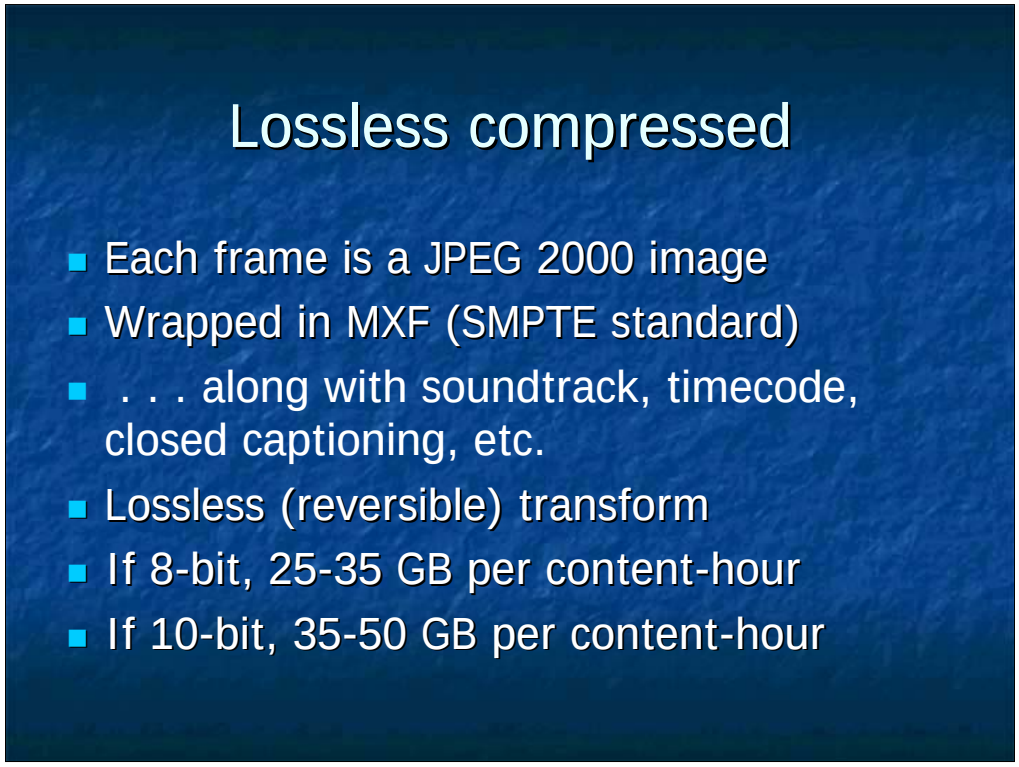
National Archives,
College Park,
Maryland

Smithsonian
Institution Archives,
Washington DC

In fact, three members of our Federal Agencies Working Group are doing some digital reformatting of video.



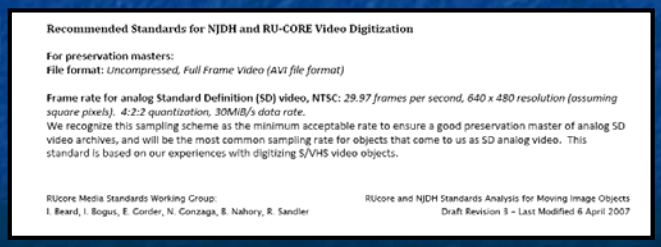
They have purchased SAMMA devices, a product of the Front Porch Digital company. The Library of Congress has done the most work thus far, while the National Archives and the Smithsonian Institution are starting to carry out projects of their own.



The Library is using SAMMA's best-known implementation in a workflow that produces a stream of video-frame images, each encoded in lossless JPEG 2000. This picture data, together with soundtrack, timecode, closed captioning, and so on, is wrapped in MXF. Files in this format serve as archival masters for preservation in the moving image collections at the Packard Campus for Audio-Visual Conservation, Culpeper, Virginia. File sizes for standard definition video run from 25 to 50 gigabytes per hour, depending on variables like bit depth.

Also of interest: uncompressed video

- U.S. activities: Stanford Univ., Rutgers Univ.
- 4:2:2 or 4:4:4, 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)*

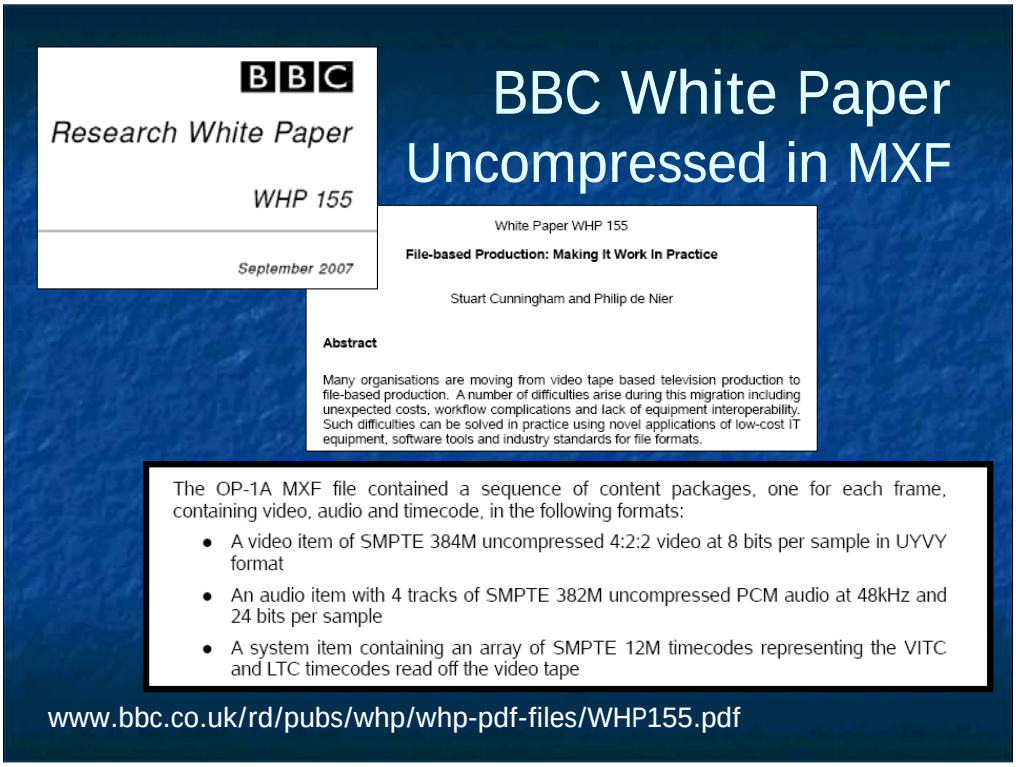
Frame rate for analog Standard Definition (SD) video, NTSC: *29.97 frames per second, 640 x 480 resolution (assuming square pixels). 4:2:2 quantization, 30MiB/s data rate.*
We recognize this sampling scheme as the minimum acceptable rate to ensure a good preservation master of analog SD video archives, 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. Corder, N. Gonzaga, B. Nahory, R. Sandler

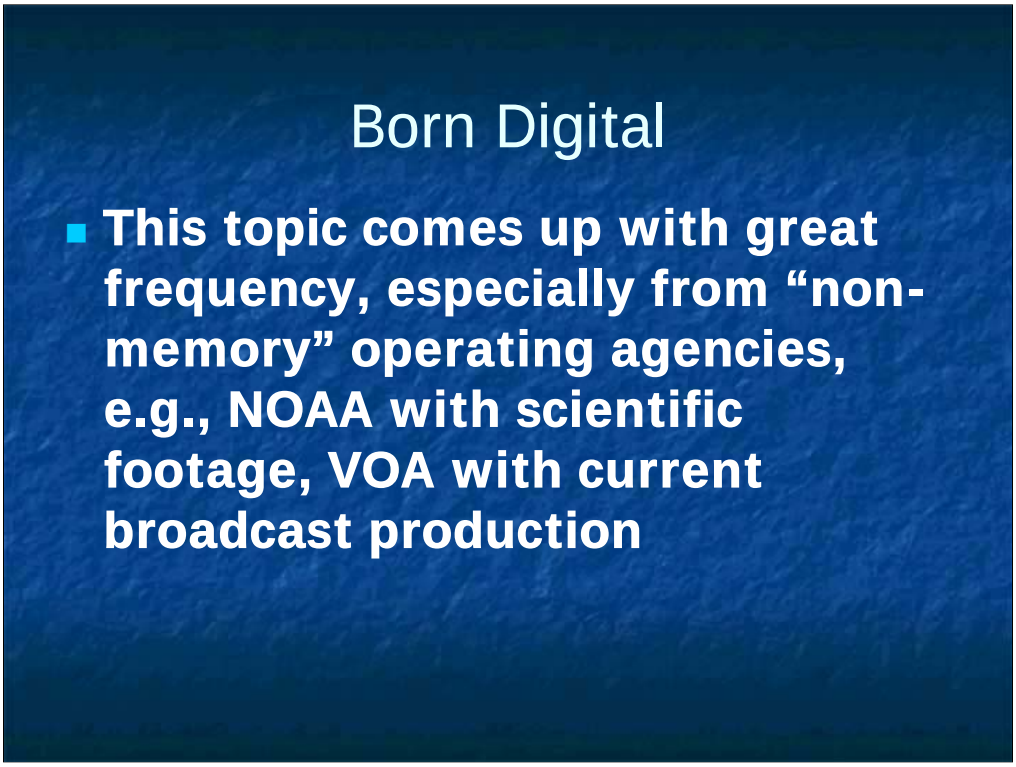
RUcore and NJDH Standards Analysis for Moving Image Objects
Draft Revision 3 – Last Modified 6 April 2007

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

At the same time, others in the Working Group--notably the National Archives--are interested in essences that consist of uncompressed video streams. In this, they echo the specifications in use at Stanford and Rutgers universities, as well as the BBC. File sizes for standard definition video run from 75 to 100 gigabytes per hour.



The BBC approach is of special interest because it also employs the MXF container format.



In addition to our current central concern with reformatting old tapes, we also hear a lot about born digital video content, especially from “non-memory” operating agencies, e.g., NOAA with scientific footage and VOA with current broadcast production. Some of these files are in native encodings--for example MPEG-2, or file-form DV--that are probably sustainable for a few years without transcoding. So as we began to shape the MXF application specification, we wanted to allow for the wrapping of at least some "safe" born digital encodings.

As an aside, let me emphasize that the Working Group knows that we are at an early stage in this process; we have comparatively little experience. We believe that there is value in drafting a thorough specification--a gesture in the direction of standardization. But we will wait until we have more experience under our belts before making a real recommendation.

About MXF and Application Specifications

MXF Package

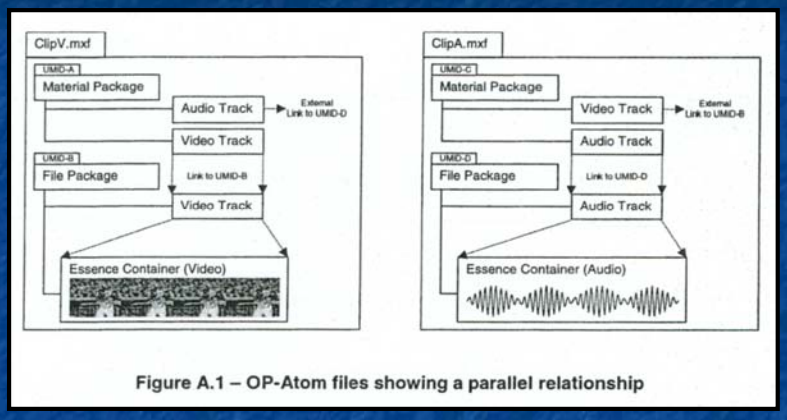
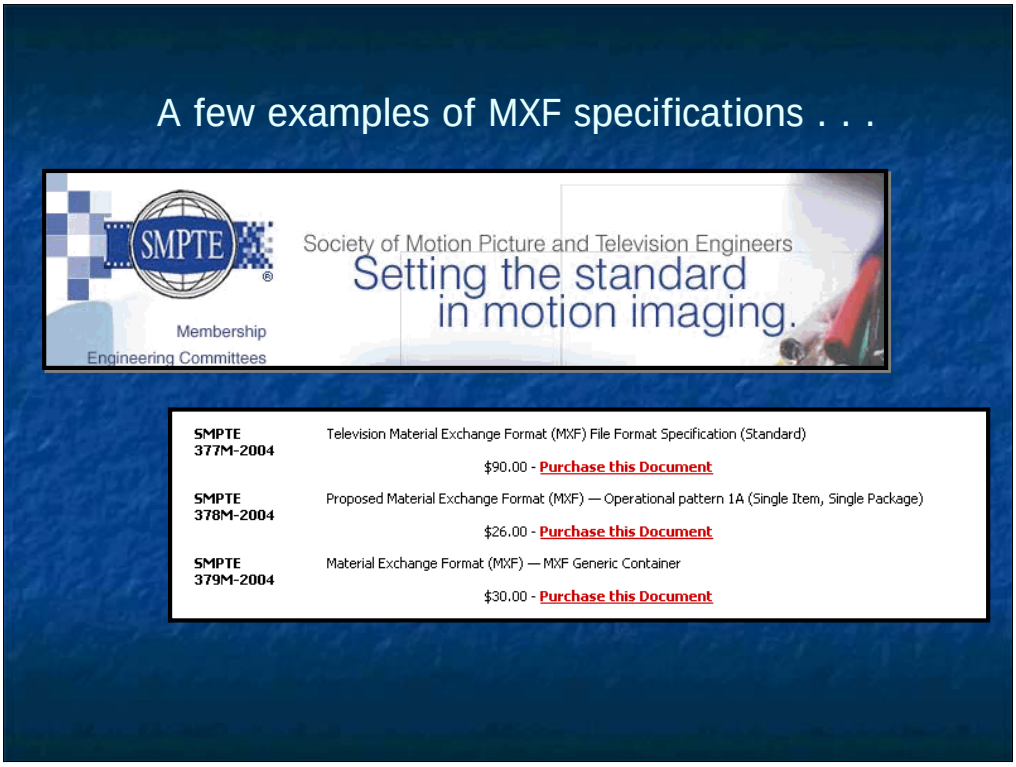


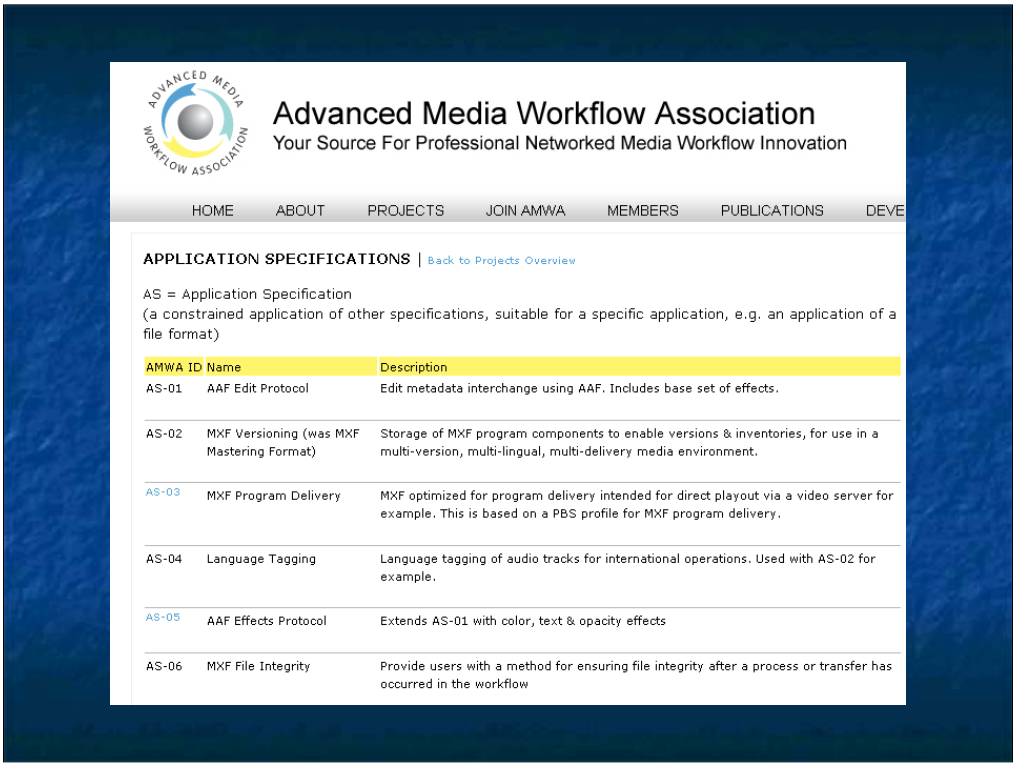
Figure A.1 – OP-Atom files showing a parallel relationship

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

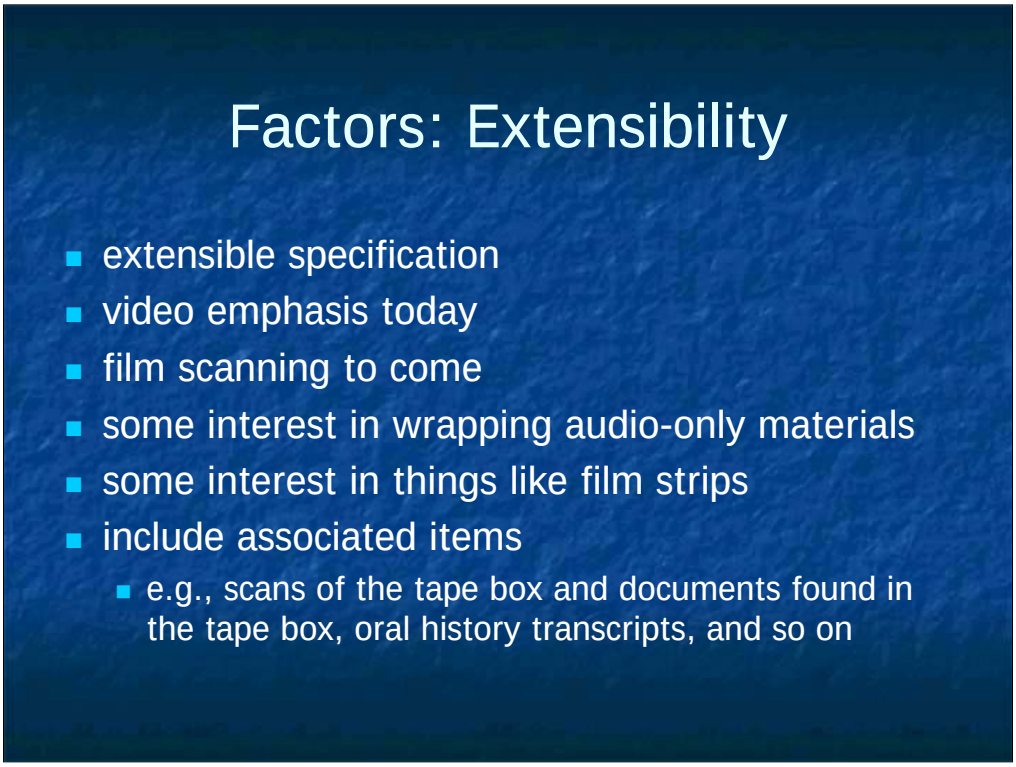
MXF can usefully be thought of as a wrapper or a container, one that can hold a variety of "essences," as AV specialists call the bitstreams for moving image content ("video") and audio. MXF is seeing increasing adoption in broadcast and motion picture industries. It is central to the digital cinema specification developed in Hollywood for theatrical distribution. SMPTE is the most important standards organization for professional broadcasters and movie-makers and they are the big customers for whom tools are built.



MXF is a broad-spectrum standard that features many options for packaging, embedded metadata, and essence encoding. The successful implementation of an MXF approach will be enhanced if we users define a set of constraints. Well-defined constraints will support the development of tools to validate files and encourage multiple vendors to provide conforming equipment, and this increase in the level of standardization applied will in turn increase interoperability, content exchange, and long-term, preservation-oriented data management.



For users of the MXF standard, formal constraint statements are called Application Specifications. These can be compared to JPEG 2000 profiles or to the profiles and levels that characterize MPEG video content. The incubation of MXF Application Specifications is the special province of the Advanced Media Workflow Association, an organization that provides a meeting ground for professional moving-image users and vendors. We will work with AMWA as this proceeds.



With archiving and preservation in mind, we are seeking a specification or family of specifications that are

Extensible in scope

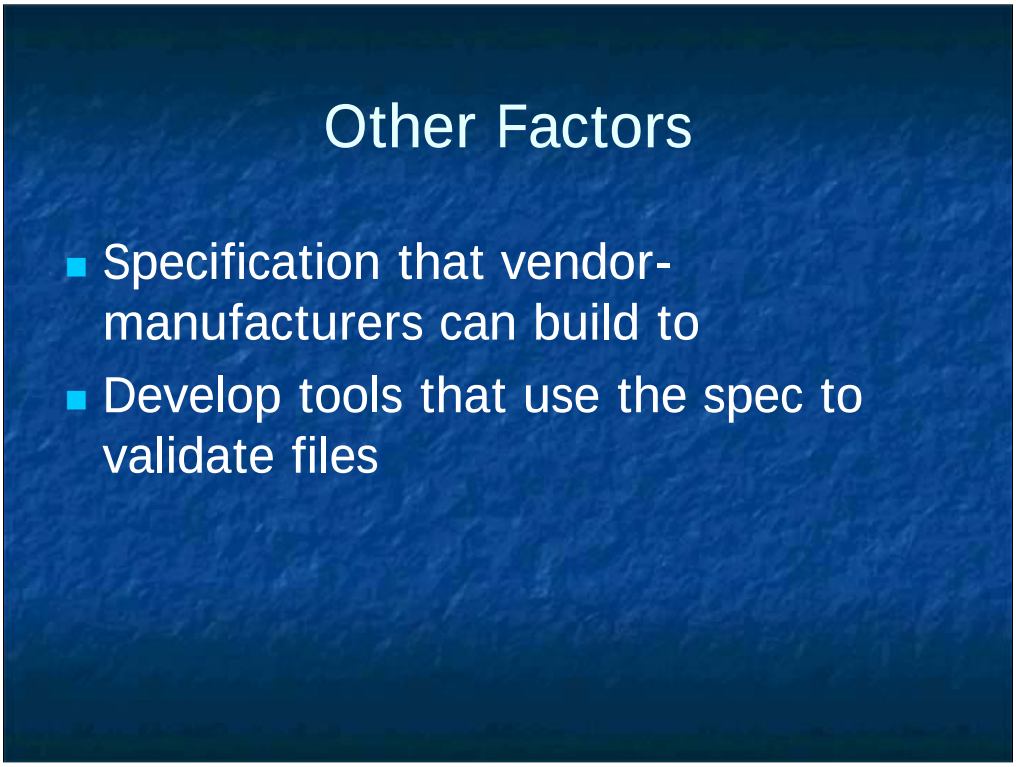
> video emphasis today

> film scanning to come

> some interest in wrapping audio-only materials

> some interest in things like film strips

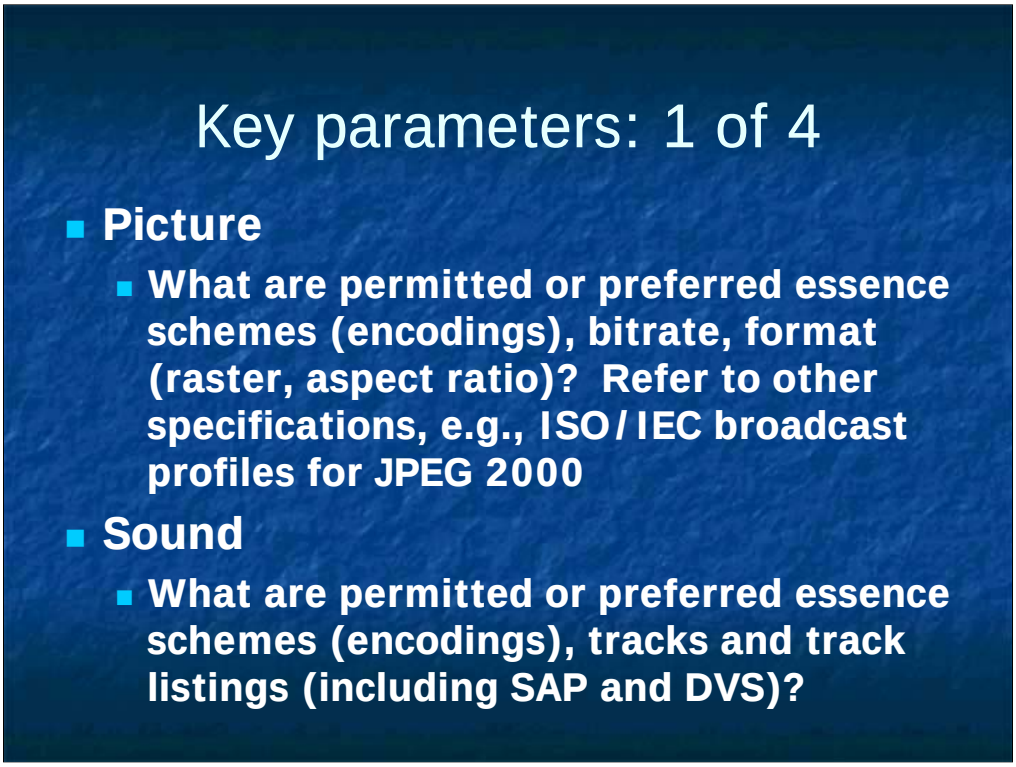
> general interest in including associated items: scans of the tape box and documents found in the tape box, oral history transcripts, and so on



[and]

Something vendor-manufacturers can build to (we want more than one company in the game)

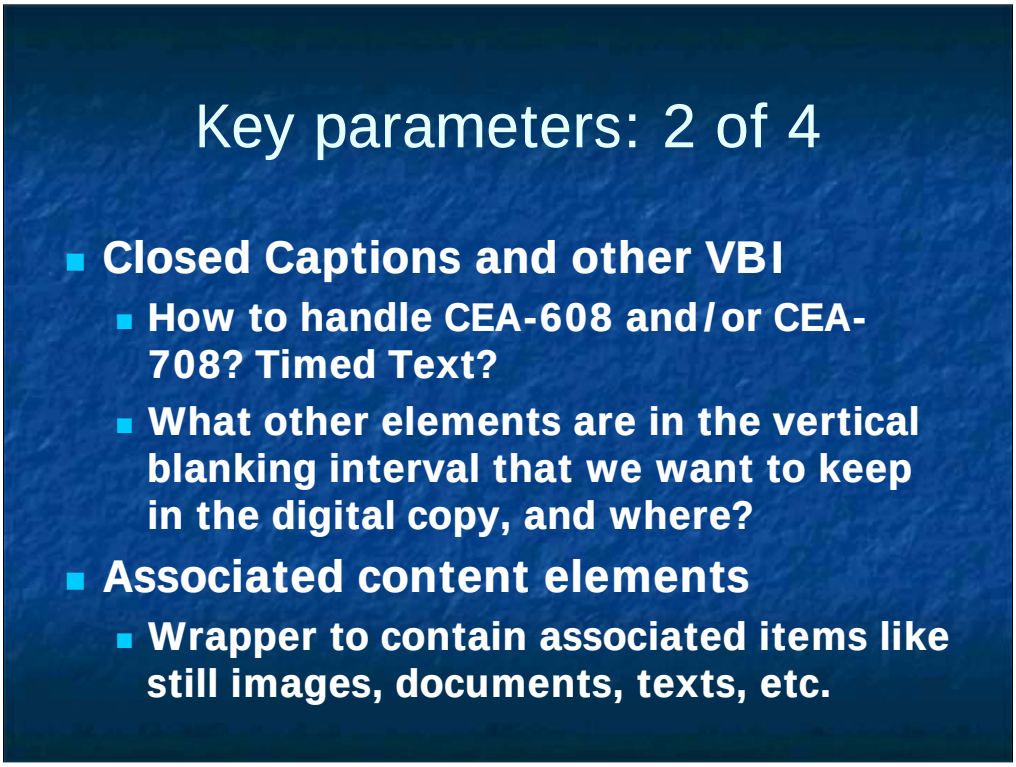
Validation tools can use the spec to validate



What might you find in an Application Specification? I'm not going to read or explain the individual items on the slides, but they are a few of the typical parameters for an MXF AS.

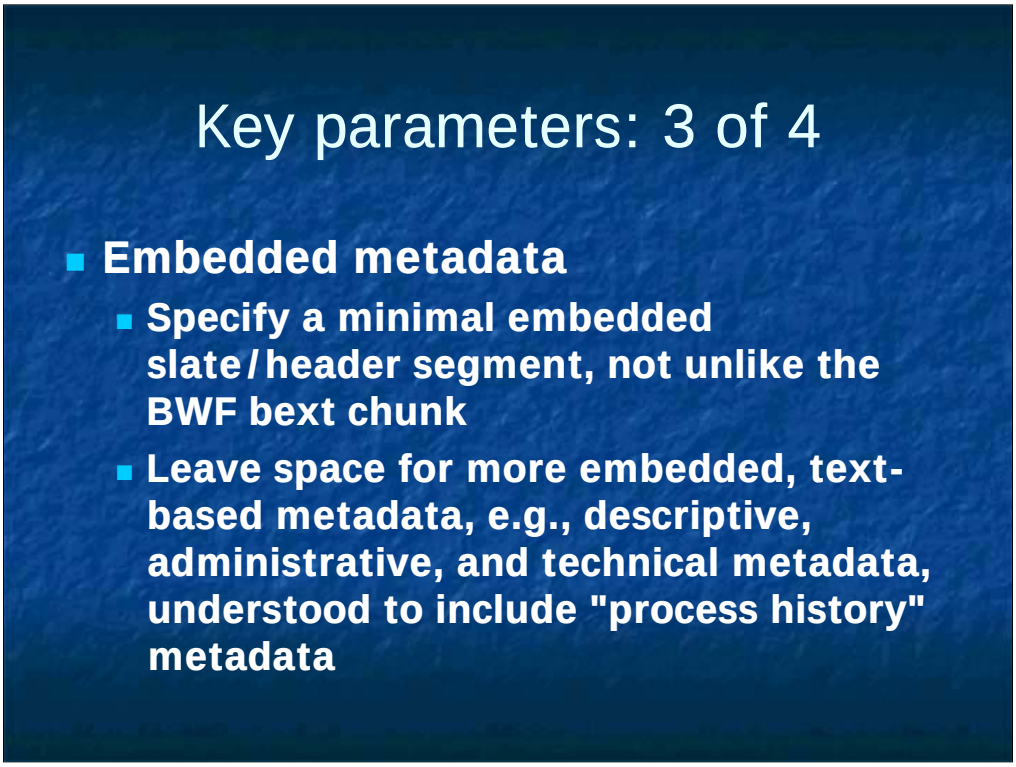
Picture -- the permitted essence schemes (encodings) and other elements

Sound -- again, permitted or preferred essence schemes and other elements

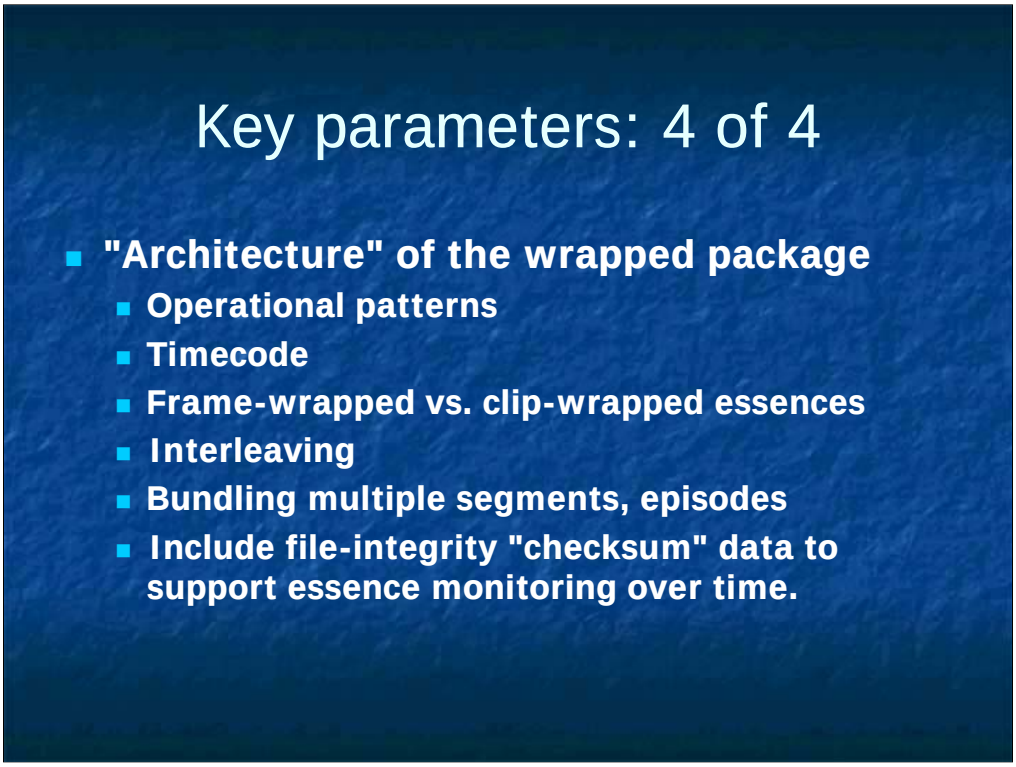


Closed Captions and other VBI -- about the elements are in the vertical blanking interval of the source signal that we want to keep in the digital copy, and where?

Associated content elements -- we want the wrapper to embrace associated items like still images, documents, texts, etc.

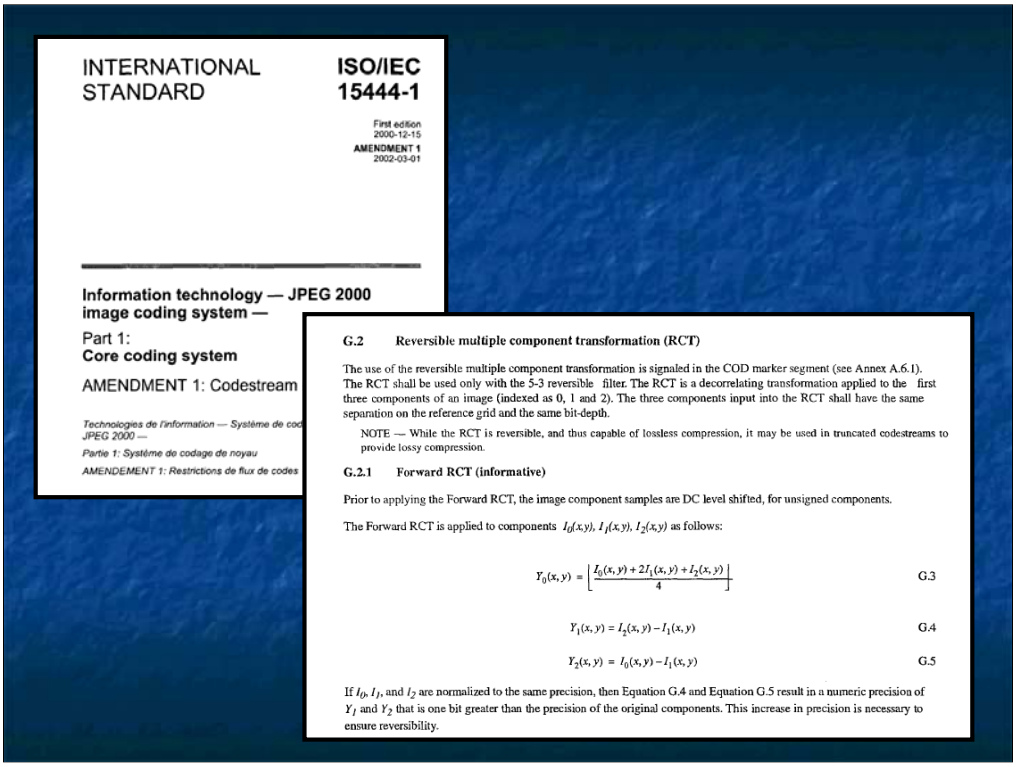


Embedded metadata -- we are thinking of a minimal embedded slate/header segment, not unlike the BWF bext chunk, and leaving space for more embedded, text-based metadata, e.g., descriptive, administrative, and technical metadata

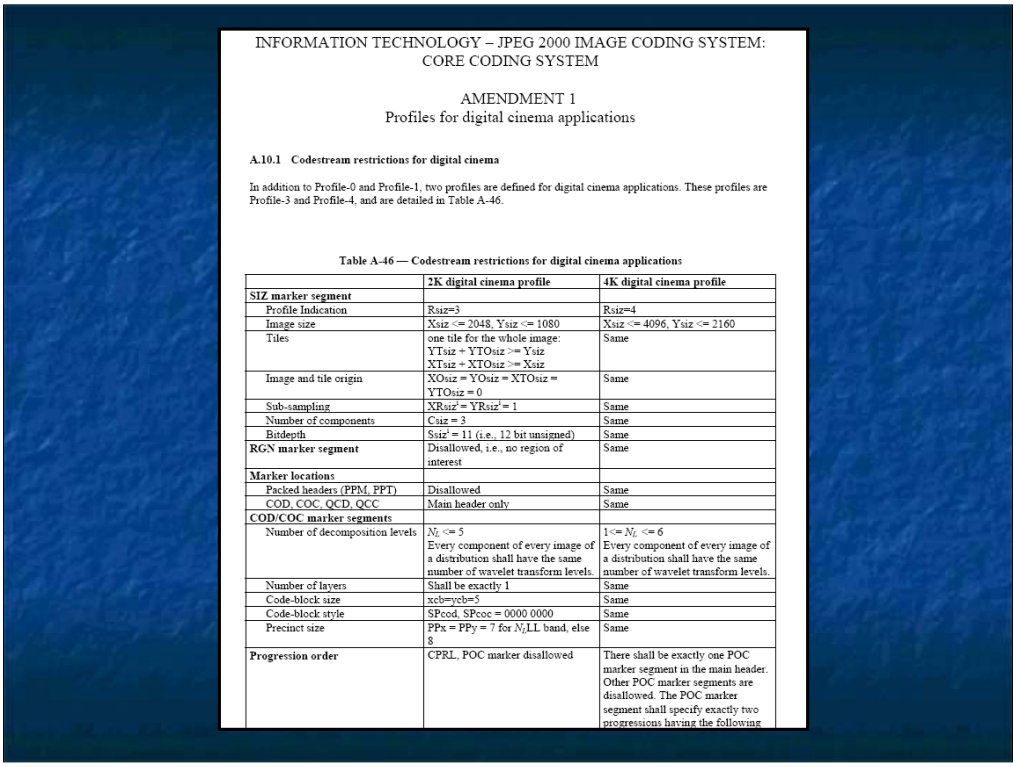


"Architecture" of the wrapped package -- MXF operational patterns, Timecode, Frame-wrapped vs. clip-wrapped essences, Bundling multiple segments, and file-integrity "checksum" data to support essence monitoring over time.

About JPEG 2000



Like MXF, JPEG 2000 is broad-spectrum standard with many options. Developed by the International Standards Organization (ISO) and the International Electrotechnical Commission (IEC), the JPEG 2000 compression approach is based on what is called the *wavelet* transform. When using JPEG 2000, one notable option is whether this transform is applied in an irreversible manner--resulting in lossy compression--or in a reversible manner--producing lossless compression. For our preservation-oriented application, the most desirable JPEG 2000 profiles are those that feature the reversible transform.



INFORMATION TECHNOLOGY – JPEG 2000 IMAGE CODING SYSTEM:
CORE CODING SYSTEM

AMENDMENT 1
Profiles for digital cinema applications

A.10.1 Codestream restrictions for digital cinema

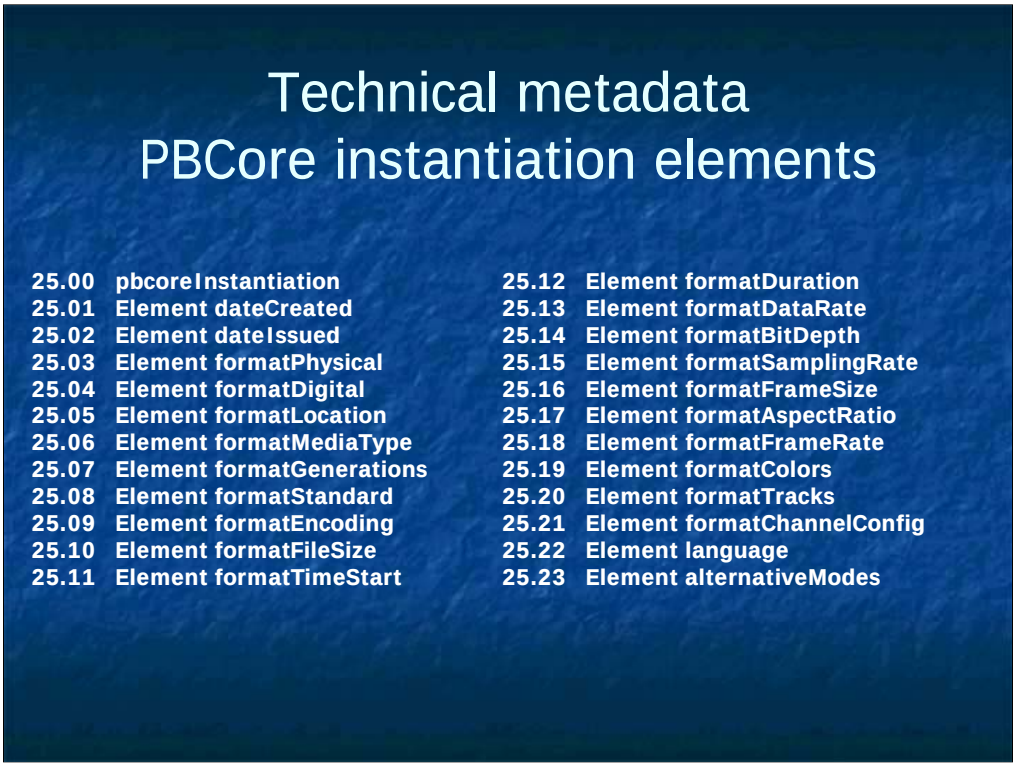
In addition to Profile-0 and Profile-1, two profiles are defined for digital cinema applications. These profiles are Profile-3 and Profile-4, and are detailed in Table A-46.

Table A-46 — Codestream restrictions for digital cinema applications

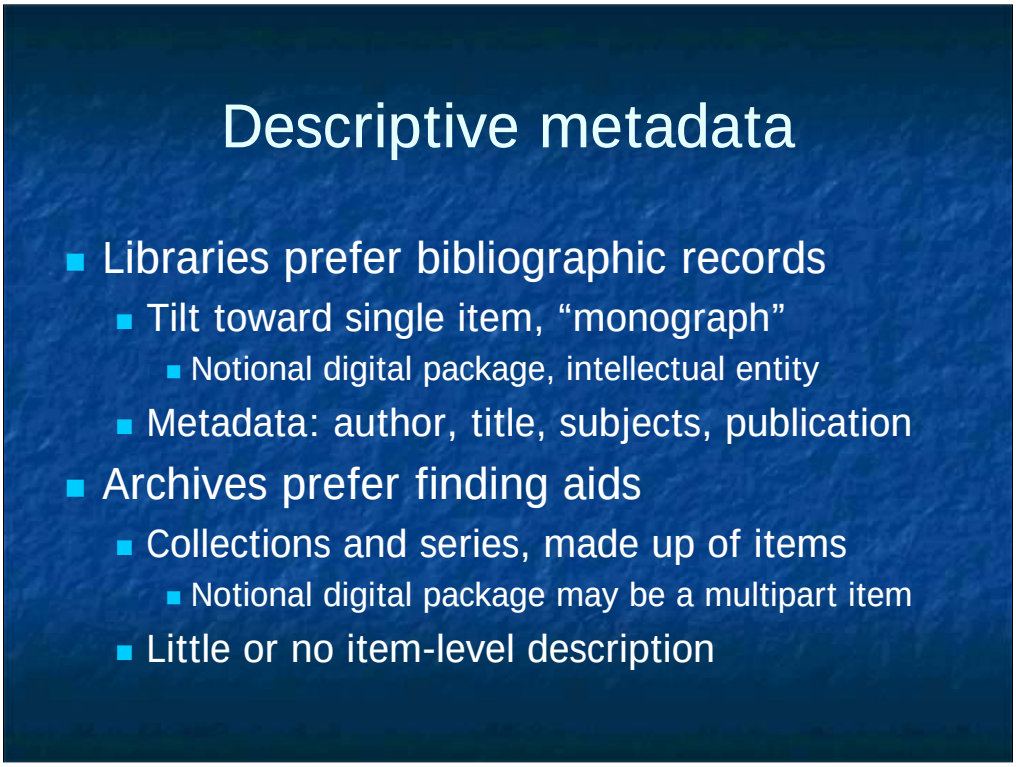
	2K digital cinema profile	4K digital cinema profile
SIZ marker segment		
Profile Indication	Rsiz=3	Rsiz=4
Image size	Xsiz <= 2048, Ysiz <= 1080	Xsiz <= 4096, Ysiz <= 2160
Tiles	one tile for the whole image: YTsiz + YTOsiz >= Ysiz XTsiz + XTOsiz >= Xsiz	Same
Image and tile origin	XOsiz = YOsiz = XTOsiz = YTOsiz = 0	Same
Sub-sampling	$XRsiz^i = YRsiz^i = 1$	Same
Number of components	Csiz = 3	Same
Bitdepth	$Ssiz^i = 11$ (i.e., 12 bit unsigned)	Same
RGN marker segment	Disallowed, i.e., no region of interest	Same
Marker locations		
Packed headers (PPM, PPT)	Disallowed	Same
COD, COC, QCD, QCC	Main header only	Same
COD/COC marker segments		
Number of decomposition levels	N_L <= 5 Every component of every image of a distribution shall have the same number of wavelet transform levels.	1<= N_L <= 6 Every component of every image of a distribution shall have the same number of wavelet transform levels.
Number of layers	Shall be exactly 1	Same
Code-block size	xcb=ycb=5	Same
Code-block style	SPcod, SPcoc = 0000 0000	Same
Precinct size	PPx = PPy = 7 for N_LLL band, else 8	Same
Progression order	CPRL, POC marker disallowed	There shall be exactly one POC marker segment in the main header. Other POC marker segments are disallowed. The POC marker segment shall specify exactly two progressions having the following

As luck would have it, some in the broadcast community--especially in Europe--have been working up what they call *broadcast profiles* for JPEG 2000. The most recent set has not yet been published -- that is why I am showing a page from the digital cinema profiles -- but we understand that it will include two profiles that feature the reversible wavelet transform, i.e., lossless compression. When available, we will reference these profiles in our MXF specification.

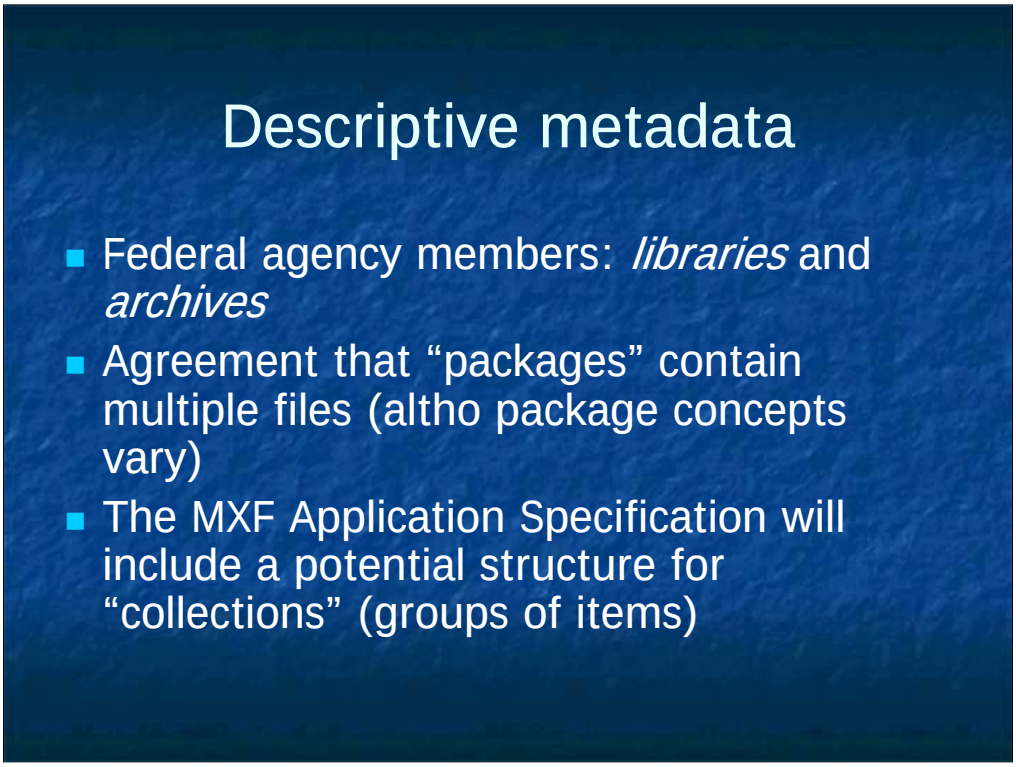
About Metadata



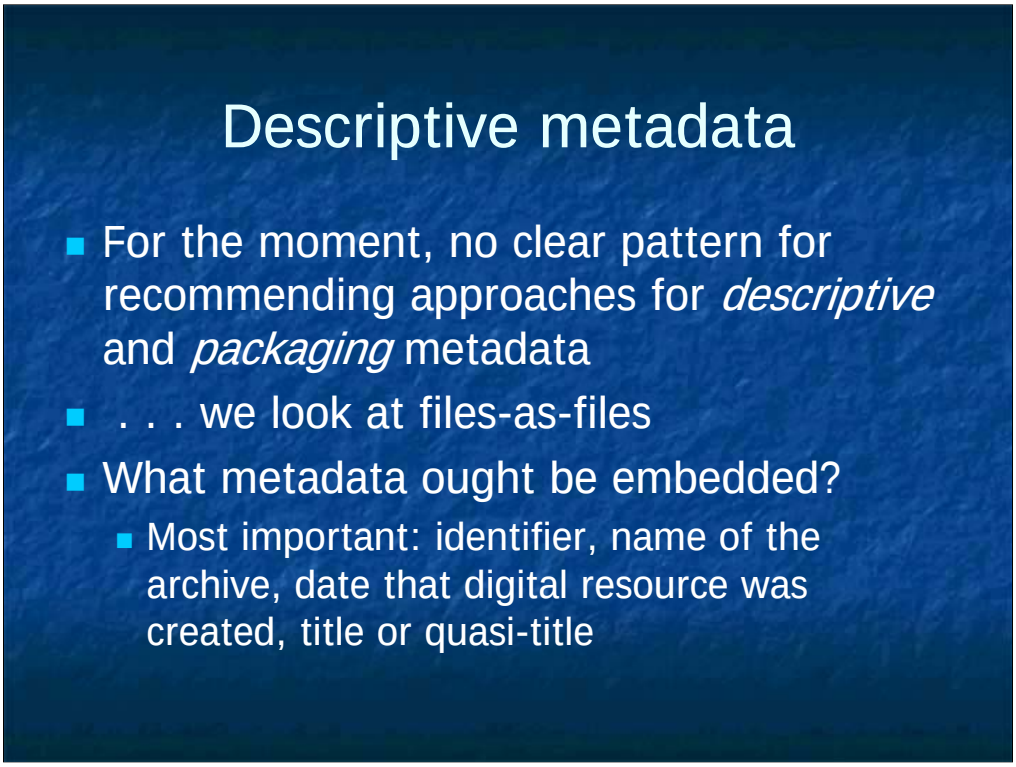
My colleagues Kate Murray and James Snyder chair a sub-working-group devoted to technical metadata. Their work is still under development, but this list of elements from the PBCore specification from public broadcasting gives you the flavor of what is at stake.



Descriptive metadata is another matter. I don't have to tell this audience that approaches to the provision of descriptive metadata vary in striking ways between libraries (“bibliographic data”) and archives (“finding aids”). In simplified terms, the librarian’s bibliographic record uses tagged elements to provide such information as author, title, publication place and date, and subject terms, generally selected from a thesaurus. Meanwhile (simplifying again), the archivist’s finding aid helps researchers see the coherence of a given collection, the archival *fond*, and presenting blocks of related documents in what are often call *series*. Only a handful of finding aids describe content at the level of an individual document and it is rare for them to provide author’s names, titles, and formal subject terms.

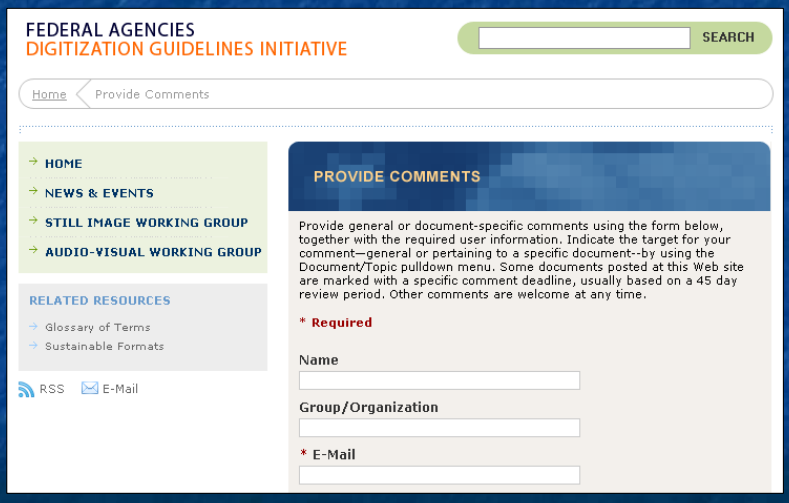


The Federal Agencies Working Group includes representatives from both archive and library organizations, and their practices for resource description vary in significant ways. In addition, their approaches to content packaging—the "binding" of multiple related files—also vary. Nevertheless, as the archiving and preservation MXF application specification takes shape, we will include a way to wrap *collections*, i.e., sets of items.



But it is the case that we will not make strong recommendations regarding descriptive metadata. We will probably recommend--as we did for audio embedding--that everyone include an identifier, the name of the archive that takes responsibility for the content, and a working title or something like it. But our emphasis on metadata tilts toward the technical and our emphasis on digital objects tilts toward files (rather than packages), since files are produced by all reformatting activities.

Send us your thoughts



http://www.digitizationguidelines.gov/contact/index.php

Thanks for your attention -- let us know your thoughts.