

Federal Digitization Moving to Common Guidelines

The U.S. Federal Agencies Digitization Initiative

<http://www.digitizationguidelines.gov/>

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The Library of Congress

National Digital Information Infrastructure and Preservation Program (NDIIPP)

www.digitalpreservation.gov



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 of Congress.



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

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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.

FEDERAL AGENCIES
DIGITIZATION GUIDELINES INITIATIVE

SEARCH

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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

Our main emphasis is *digitization*--the conversion of analog originals into digital form. There are two working groups. Michael Stelmach at the Library leads the still image working group; they look at things like scanning books, photos, and maps.



I lead the Audio-Visual Working Group, focused on sound and video recordings and motion picture film.

STILL IMAGE WORKING GROUP
Content Categories and Digitization Objectives

Description of 8 categories and 23 subcategories of printed matter, manuscripts, and pictorial materials. The Working Group's recommended specifications for the digital reformatting of these items (under development) will be defined and evaluated in terms of objectives. Why are the copies being made? What uses will these copies support? Do considerations vary from one category to another? The objectives are presented here as [use cases](#).

CURRENT DRAFT

> [HTML](#) | Content Categories and Digitization Objective

DOCUMENT BACKGROUND

The Working Group believes that its guidelines should articulate articulated objectives describing the expected uses of the items. This presentation was drafted by the [Categories and Objectives Subcommittee](#). Each of the 23 content subcategories is reformatting objectives, i.e., the objectives of the organization of the digitizing and, equally important, the objectives will consult or use the images in their work.

CONTENT CATEGORIES

- 1 (T) — Textual and illustrated printed matter (books, journals, manuscripts, some maps). Visual-arts elements of limited significance and generally consisting of printed halftones, line art, explanatory tables and drawings, and the like.
- 2 (PR) — Visual/pictorial items (photographs, prints, some drawings and paintings, some maps). Generally greater visual-art significance than category 1. Two-dimensional, many with continuous tone images (and occasional halftones). Viewed by reflected light.
- 3 (PT) — Photographic negatives and transparencies. Significant visual-arts elements. Viewed by transmitted light.
- 4 (AR) — Special-purpose images (aerial, medical, and scientific images, architectural and engineering line drawings and blueprints). Viewed by reflected light.
- 5 (AT) — Special-purpose images (aerial and medical images). Viewed by transmitted light.
- 6 (3D) — Objects, artifacts, and three-dimensional works of visual art encountered in archives, galleries, and museums (medals and badges, physical evidence from legal archives, some works of art). See also category 7.
- 7 — Specialized imaging of works of art and other objects and artifacts. For future development. To include such examples as two- and three-dimensional works, art in a frame, items with and without gilding, three-dimensional objects in history and science museums, etc.
- 8 — Special-purpose imaging for analysis and research (multispectral, X-ray, other technologies). For future development.

Both groups will define their recommended specifications in terms of objectives. For still images, the objectives (and thus the specifications) will vary by category of content. There are 8 major categories for still images.

Taxonomy of Digital Imaging Performance – Part I
 (Information on evaluation criteria, definitions, related descriptive terms,
 and possible causes of failure can be found in Part II)

Foundation Metrics	Signal							Signal-to-Noise Ratio	Noise ¹										
	Image Science/Engineering Metrics				OECE (Opto-Electronic Conversion Function)				SFR (Spatial Frequency Response)			Radiometric Distortion NPS (Noise Power Spectrum)				Geometric Distortion			
Derivative Metrics	Sensitivity							Dynamic Range	Total Noise										
	Tone, Exposure								Temporal			Fixed pattern				Chroma Noise			
	White Balance/Neutrality								Random (stochastic)			Banding/Streaking (deterministic)				Defects (stochastic)			
Color Encoding Accuracy							Sampling Rate			Non-uniformity (deterministic)			Color Uniformity (deterministic)				Color SFR Uniformity (deterministic)		
Resolution							Sharpening			Regional (deterministic)			Color Misregistration (deterministic)				Aliasing (deterministic)		
Acutance							Flare			Spatial SFR Uniformity (deterministic)			Pincushion/Barrel (deterministic)						
Depth of Focus																			

From this document:
http://www.digitizationguidelines.gov/stillimages/documents/Digital_Imaging_Framework.pdf

What elements will be part of the still image specifications? They will move away from a reliance on "output" measures like pixel density and bit depth. Instead, they want to be attentive to more appropriate ways to specify tonality, spatial resolution, color, uniformity, and noise.

Bijlage 2. Schematisch overzicht toleranties en criteria Preservation Imaging
Metamorfoze.

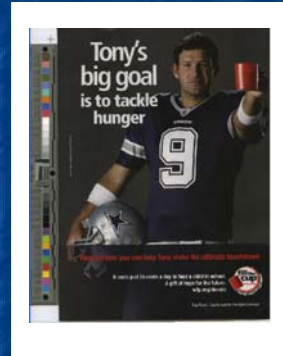
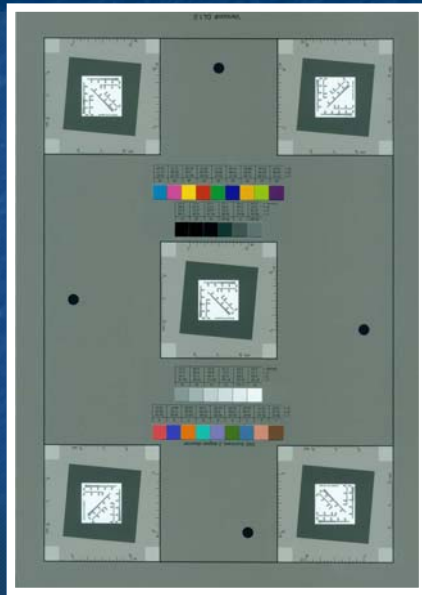
	Artwork,	Unique librarian and archival material.	Not Unique librarian and archival material. uniek bibliotheek en archief materiaal	For access only*
Color space	eciRGBv2	eciRGBv2	eciRGBv2	Not specified
Bitdepth	16/8 Bit	8 bit	8 bit	Not specified
Tonalcapture				255
1. pixel value vak A (reflectiewaarde = 0,89)	249 - 238	249 - 238	249 - 238	
2. Highlight gamma	0,8 - 1,08	0,8 - 1,08	0,8 - 1,08	Not specified
3. pixelvalue vak 1 (reflectiewaarde = 0,70)	228 - 218	228 - 218	228 - 218	255
4. D-max	1,95/2,15	1,50	1,50	Not specified
noise	STD < 4	STD < 4	STD < 4	Not specified
Su/r	> 1	> 1	> 1	Not specified
Uniform illumination	7	7	7	Not specified
• < A-2				
• < A-1	11	11	11	Not specified
• ≥ A-1	13	13	13	Not specified
Colorcast	+3 en -3	+3 en -3	+3 en -3	Not specified
Color accuracy (formule cIE 1976)	Gemiddelde ΔE < 4 Maximale ΔE < 12	Gemiddelde ΔE < 6 Maximale ΔE < 15	Niet gespecificeerd	Not specified
hmm	Minimaal 5 hmmm	Minimaal 5	Minimaal 5	Not specified

Working document from the National Library of the Netherlands.

Three columns, three categories. Specifications in the various rows.

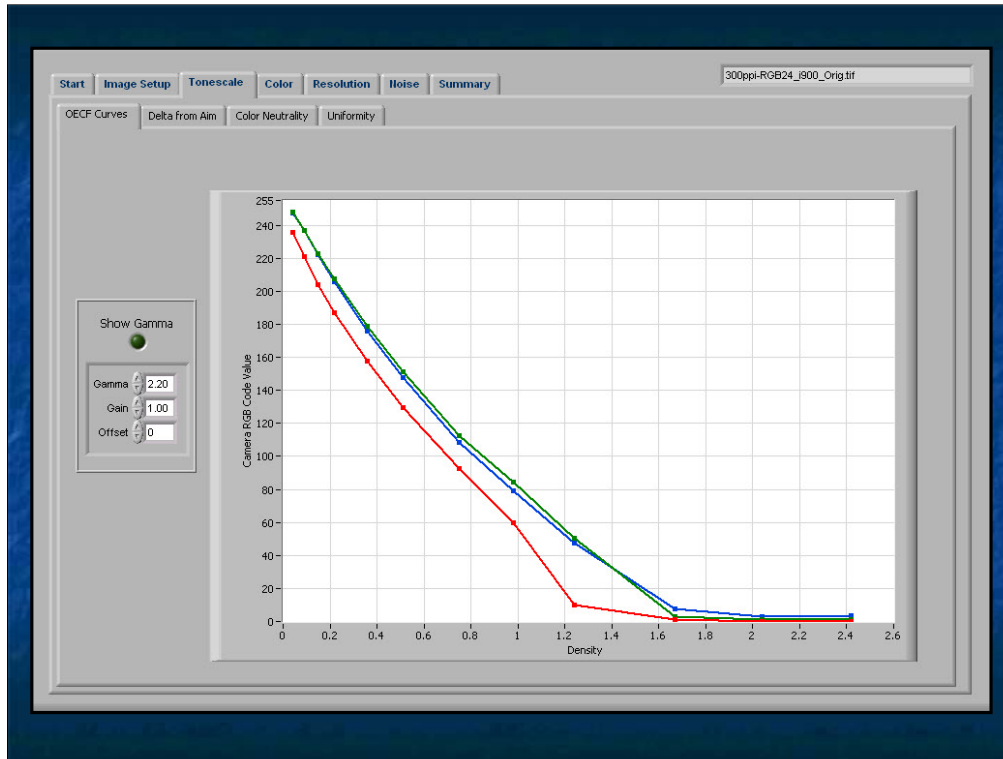
The Federal Agencies still image specifications are not yet ready, but we see that others are thinking in the same way. Here is a page from the Metamorfoze project at the national library of the Netherlands: the columns are categories, the rows are the specifications, which vary by category.

Device and Object Targets



Object target as positioned for use

Meanwhile, how will you know if your equipment and the work it produces conform to the recommendations? The still images group is developing tools, including a pair of targets--both about ten inches long--and supporting software.



The images of the targets are analyzed by a custom application built on top of LabVIEW, from National Instruments. It reports if your scanning device passes or fails and provides more detail if you wish.

Beyond performance measurement

- Other “gaps” in prior guidelines to be investigated
 - Image Sharpening
 - Quality Management
 - Image Specification Metric Aims and Limits
 - Foldouts and Inserts in Bound Materials
 - Color Encoding Accuracy
 - Color Space Encoding
 - Selection Criteria for Master Image File Format

Imaging performance is not the only game for the Still Images Working Group. They have also published a recommendation for metadata to be embedded in image file headers, and there is a list of “gaps” in existing guidelines, to be filled during the next year or two.

Audio-visual effort: recorded sound

- Compile guidelines for recorded sound

[A.1 Goals at a high level](#) Updated 2 months ago by Carl Fleischauer

[A.2 Categories that are relevant to setting specifications](#) Updated 12 months ago by Martin Piquero

[A.3 Objectives for reformatting physical originals \(or for treating born digital\)](#) Updated 12 months ago by Martin Piquero

[B.1 Introduction: master and derivative files](#) Updated 12 months ago by Carl Fleischauer

[B.2 Introduction: encoding](#) Updated 2 years ago by Carl Fleischauer

[B.3 Introduction: file formats and wrappers](#) Updated about 2 hours ago by Martin Piquero

[B.4 Introduction: metadata and content marking](#) Updated 22 hours ago by Carl Fleischauer

[B.5 Introduction: file formats, multichannel, and multicomment sound](#) Updated 22 hours ago by Carl Fleischauer

[in-house or outsourced](#) Updated 22 hours ago by Carl Fleischauer

B.2 Introduction: encoding

The discussion in this section falls under the following headings:

- ENCODING MASTER FILES
- ENCODING DERIVATIVE FILES (AKA SERVICE, ACCESS, OR REFERENCE FILES)
- ENCODING IN BORN-DIGITAL FILES
- PERFORMANCE MEASURES FOR DIGITIZATION EQUIPMENT

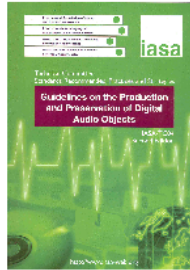
These guidelines use the term *encoding* to name the digital representation of the waveform of a sound, uncompressed or compressed. In an uncompressed encoding, the stream of bits (or samples) directly represent the waveform. This orderly series of samples might be compared to the way row after row of pixels in an uncompressed bitmap represents a picture. In a compressed encoding, the stream of bits do not offer such a direct representation; they must be decoded in

Work in progress

Meanwhile, in the Audio-Visual Working Group, we have started to compile a guideline--as comprehensive as we can manage-- pertaining to sound recordings.

The Federal Agencies guidelines will owe a huge debt to these (and other) great predecessors. We will offer summaries and pointers to the larger volumes.

**IASA Technical Committee
Standards, Recommended Practices and Strategies
IASA-TC04
Second Edition**



Already an accepted authority in the sound archiving field, the second edition is a thoroughly revised and updated publication with substantial new information and chapters

The second edition contains:

- guidance on the production and preservation of digital audio objects with examples and exercises which
- an entirely new chapter on the production and preservation of digital audio objects
- an extensive chapter on the production and preservation of digital audio objects
- guidance on the production and preservation of digital audio objects
- advice on the production and preservation of digital audio objects

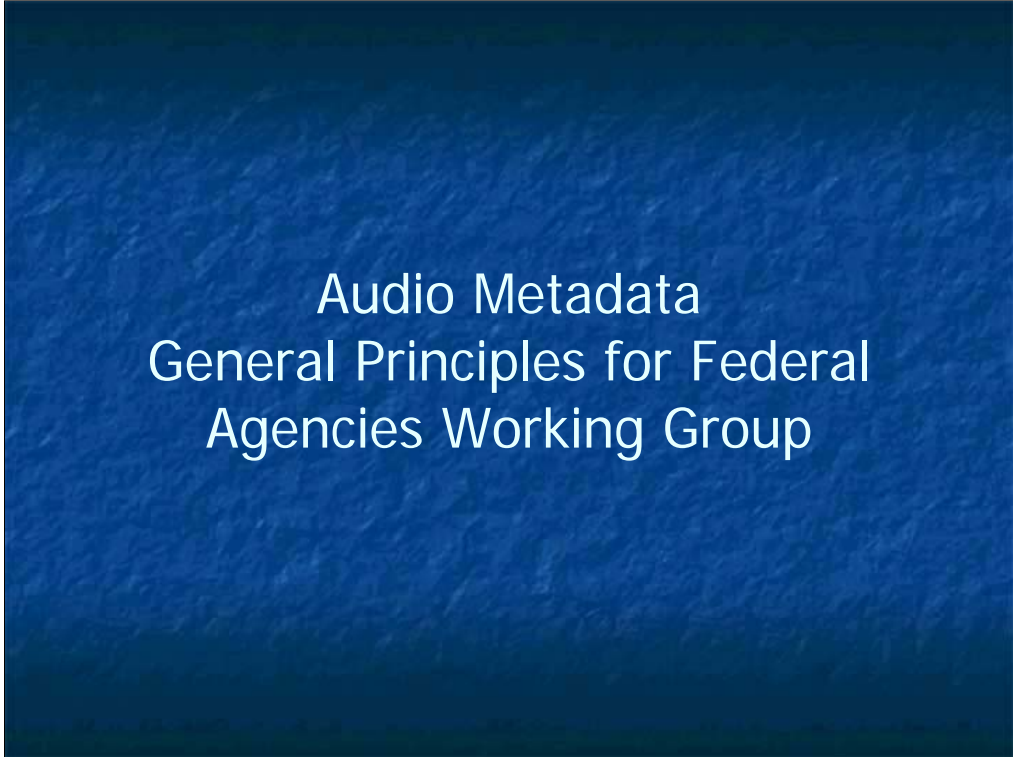


It will build on the great work produced by IASA, the Sound Directions project from Indiana and Harvard Universities, the Engineer's Roundtable organized by the National Recording Preservation Board, and other documents.

Audio-visual effort: recorded sound

- Compared to TC-04: two areas where we wish to elaborate or specify in greater detail
 - Metadata, including identifiers
 - Emphasis on embedding at least some metadata
 - Performance testing of digital systems
 - Multitrack and multisegment content

As we drafted our document, we saw a few areas where we want to elaborate or add detail to what is offered in TC-04. These include metadata and digital system performance testing, which I will discuss in this talk. We also see a need for more guidance on multitrack and multisegment recordings but we have nothing to offer at this time.



Audio Metadata General Principles for Federal Agencies Working Group

In TC-04, Chris Clark's chapter on metadata covers a broad swath, reminding us all how big this topic is.

Audio metadata

- Working Group metadata emphasis:
 - *technical* more than *descriptive*
 - Many other activities address descriptive metadata
 - For us, descriptive metadata (and some other categories of metadata) spans multiple forms of digital content: textual materials, geospatial, moving image, data sets, etc. Thus this is not *special* to AV content.
 - For planning, as a practical matter, we assume that descriptive metadata lives in an archival finding aid or a library catalog; digital entities ought to link to these with an identifier.

As a practical matter, our Working Group decided to take on a smaller piece of the whole. We think our expertise can be applied to technical metadata -- we will leave descriptive (mostly) to others. In any case, in institutions like ours, descriptive metadata practices tend to sweep across *all* types of digital content, and there are a lot of other players in that game.

Audio metadata

- Our definition of *technical metadata* includes:
 - Data about this *digital entity*
 - -- compare to AES X098B
 - Data about the *source entity*
 - -- also covered by AES X098B
 - Data about the *process* to produce it
 - -- compare to AES X098C

Our definitions for technical metadata are in accord with the new specifications from the Audio Engineering Society. The metadata categories pertain to the *digital entity* you have produced, the *source entity* you started with, and the *process* used to digitize.

Audio metadata

Special focus on embedding

- Preservation support
 - Don't rely only on file and pathnames
 - File and path names are attributes of the filesystem/ storage system, they are not really "in" the file, names may change
 - Embedded data offers protection against mishap with a self-describing file
 - At least some metadata will be available from the file itself

Like the Still Images Working Group, we have also begun to specify what ought to be embedded in digital entities. This is partly to support preservation. Identifiers in file and path names may be helpful . . . but they change or are subject to change by (for example) a digital asset management system. We think there is added safety in having identifying metadata *in* the file itself.

Audio metadata

Special focus on embedding

- User support
 - Embedded data can answer “What is this?” and similar questions
- Industry trend
 - If audio production and distribution follows the path of professional still photography, embedding will be heavily promoted and adopted

Embedded metadata can also help endusers who may have downloaded a file and, if professional still photography is any kind of indicator, we will see more and more embedding in the sound and video industries.

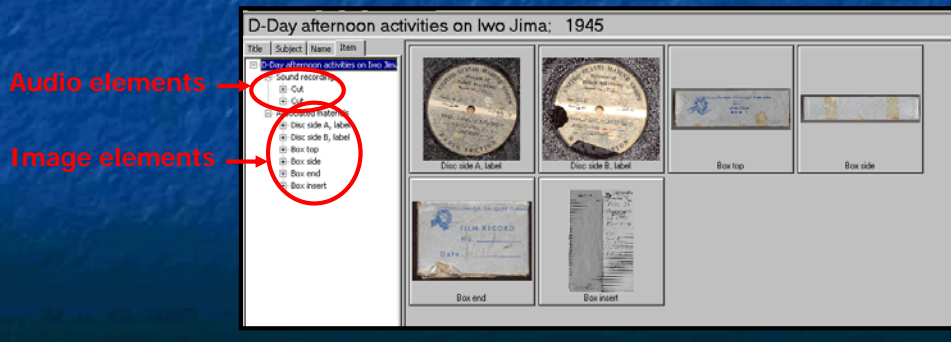


Audio Metadata Issues We Consider

As we proceeded, we considered some issues.

Metadata planning issues: packages and files

- *packages* as compared to *files*
 - An package is an entity (often) represented by multiple files
 - A side, B side, images of labels



We see digital *entities* as taking (at least) two forms: *packages* and *files*. Our simple definition of package is "a digital entity made up of multiple files."

Audio metadata issues: packages and files

- Descriptive metadata refers to content that takes the form of a digital package
 - U.S. National Archives (finding aids)
 - A tape recording in a presidential papers collection
 - The package is an *item* in the *finding aid*, identified in terms of the archive's record group-series-and-item
 - Library of Congress (bibliographic records)
 - Published, commercial disc recording
 - The package is a *manifestation* (using FRBR lingo), i.e., a content entity in a *library catalog*
 - *Lay people might just call it a "work."*

More often than not, descriptive metadata refers to an entity that--once it is in digital form--takes the form of a *package*. Archivists who use a finding aid often call this content entity an *item*. Librarians who use bibliographic records in a catalog (and who use FRBR terminology) may call it a *manifestation*. The rest of us just call the package entity a "work."

Audio metadata issues: package identifiers

- Existing identifiers tend to be at the *package* level
 - Industry: ISBN, IFPI's GRid, etc.
 - National Archives, finding aids
 - The package is a finding-aid "item," identified in terms of the archive's "record group, series, and item"
 - Example: 306-MUSA-9658B
 - Library of Congress, bibliographic records
 - The package is a "manifestation" (using FRBR lingo), i.e., a work in a library catalog, identified by a handle
 - Example: <http://hdl.loc.gov/loc.mbrsmi/westhpp.2033>

Many pre-existing identifiers are associated with content at the same level as the descriptive metadata—if the content is digital: *packages*. Examples from industry are the ISBN or the IFPI's GRid (*Global Release Identifier*). And from memory institutions we have the U.S. National Archives' representation of *Record Group, Series, and Item*; and from the Library of Congress, a *handle*.

Audio metadata issues: multiple identifiers

- For us, more often than not, each *package* is associated with multiple identifiers
 - Legacy identifiers that often predate digitization
 - RYI_6039, shelf number for the original audiotape
 - 58979818, original filename for digital file
 - 306-MUSA-9658B, finding aid: record group-series-item
 - Harmonia Mundi France HM 957, label for a phonodisc
 - New identifiers for the digital entities
 - <http://hdl.loc.gov/loc.mbrsmi/westhpp.2033>, URL (handle)
 - 1201566-2-1, number from MAVIS collection-mgt database

In addition, we found that our organizations usually have multiple identifiers in play, ranging from the shelf number for the tape to the filename this one had "last time."

Audio metadata issues: identifiers

- What actions should identifiers support?
 - Legacy identifiers
 - Archive's physical collection management, various inventory functions, double-check or crosswalk data (be sure you have the correct entity)

. . . . as a little side-topic: let's remind ourselves what identifiers help people do. Legacy identifiers like the shelf number give archivists another way to cross-check the inventory.

Audio metadata issues: identifiers

- What actions should identifiers support?
 - Digital-entity identifiers
 - Support "get more metadata," e.g., from a database
 - If a file is a part of multi-file package: "Who is my parent?" "Who are my siblings?"
 - If for an package: "What files are my children?"
 - Preceding pair imply the shape of an package's "package" even in the absence of a formal structure like METS or MXF
 - May be manual, nice if automated

For digital-entity identifiers, the most important job is "go and get more metadata," for example, from a database. With content in a package, identifiers might help a "parent" find the "children files" or might let one of the "children" be connected to the "parent package."



Audio Metadata Actions We Are Taking

So what is our Working Group actually doing?

Audio metadata action *start with files*

- We wish we could recommend metadata practices at the package level . . .
- But today's agency-level ("local") implementations (or lack thereof) for packages make this difficult
- No real adoption-in-place of packaging schemes like METS or MXF at this time
- Thus our current focus is on *file-level metadata*
 - . . . it's a place to start

We found that package-level practices were in their infancy; they were too local to build upon at this time. None of our organizations have really implemented packaging schemes like METS or MXF. So we decided to start with metadata at the file level.

Audio metadata action *what to embed in files?*

- Critical elements, vary by agency
 - What 1: the identifiers (plural)
 - What 2: the title or working title
 - Who: the responsible archival organization
 - When: date the digital file was created
 - Some kind of statement about restrictions
 - Often boilerplate: "may be restrictions, please contact the archive"

When we talked about what our agencies want to embed, there was some variation. Here's the set of core elements we ended up with--some will be optional:

What is this file? Answered (above all) by the identifiers and, for some, by a title or working title.

Who is responsible? The name of the archiving organization.

When was the digital entity created?

And some kind of a statement about restrictions on access or use. For a lot of our materials, this will be boilerplate: "May be restricted, check with the archive."

Draft document for public comment

AUDIO-VISUAL WORKING GROUP

Broadcast WAVE Metadata

The most current version of the Broadcast WAVE Metadata document is available for download below. Public review and comment for the draft version will close on September 15, 2009. All comments will be reviewed by the Audio-Visual Working Group before finalizing this document. The Working Group is always interested in receiving additional comments and any document may be revised when warranted; please submit comments using the link provided below.

CURRENT DOCUMENT

> [Broadcast WAVE Metadata - Draft for public comment](#) (Version 1.0; July 20, 2009)

The Metadata submitted by the Working Group is a minimal set of recommended metadata for cultural heritage digital audio files. A new recommended interim guideline. A new recommended

interim guideline encompassing a richer metadata set in a more flexible format, with wider file format support, will be developed by the Working Group in the future. Note that the guideline is accompanied by two explanatory documents:

- > [Introductory discussion](#) for the proposed audio metadata embedding guideline
- > [Consultant's report on embedding options](#) in digital audio files

PROVIDE COMMENTS ON THE CURRENT VERSION

Use the [online form](#) to submit your comments.

http://www.digitizationguidelines.gov/audio-visual/documents/wave_metadata.html

We have a draft document for public comment.

Draft document for public comment

Embedding Metadata in Digital Audio Files **Proposed Guideline for Federal Agency Use of Broadcast WAVE Files**

By the Federal Agencies Audio-Visual Working Group
<http://www.digitizationguidelines.gov/audio-visual/>

TABLE OF CONTENTS

I.	THE BEXT CHUNK
I.A.	Strongly recommended elements (page 2) Originator, OriginatorReference, Description (for additional identifiers), OriginationDate, Version
I.B.	Recommended elements (page 5) TimeReference
I.C.	Optional elements (page 5) OriginationTime, CodingHistory
II.	THE INFO CHUNK
II.A.	Recommended tags (page 7) IARL (archival location)
II.B.	Optional tags (page 7) INAM (name, title), ICMT (comment for identifiers), ICRD (creation date), ICOP (copyright and other restrictions)

It recommends the placement of certain types of information in elements in both the Broadcast WAVE bext chunk and also the RIFF INFO chunk.

Draft document for public comment

DESCRIPTION: This element is recommended as a container for identifiers for the work at hand and/or as pointers to additional, non-embedded (externally maintained) metadata. Members of the Working Group have repeatedly encountered the need to provide multiple identifiers for a given item. The resulting extent of data cannot be accommodated in the OriginatorReference element. For these reasons, the Working Group's recommendations for the Description element deviate from the EBU specification.

Our greatest departure from the EBU specification is for the Description element. We needed a place to put multiple identifiers, and we decided to use the Description element to meet that need.

Constraints of BWF bext *not ideal for our metadata*

- Good things about bext
 - Widely adopted in professional circles
 - Supported by some digitizing systems
- Shortcomings of bext
 - Only one identifier, limited to 32 characters
 - No place for restriction statement
 - Not visible in some software
 - No XML, more difficult to validate

As the preceding suggests, we found that the bext chunk fell short of our requirements. Other shortfalls include the lack of a place for a restriction statement, and the fact that bext metadata is not visible in all application software.

RIFF INFO chunk

helps fill some gaps

- Good things about INFO chunk
 - Place for restriction statement
 - Less severe character limits
 - Visible in many enduser software applications
 - So we repeat some data from bext
- Shortcomings of INFO chunk
 - Not as well documented, less rigorous
 - Little professional use in archiving
 - No XML, more difficult to validate

This is why we allow for optional use of the RIFF INFO chunk that is part of all WAVE files. INFO offers a few additional places to park metadata, and this metadata is visible in common end-user software. But neither bext nor INFO are expressed as XML and cannot be validated.

Embedded Metadata

what does the future hold?

- Current proposed guideline - compromise for today
- Future? Something tailored to the needs of archiving and preservation?

Thus we see our guideline as a compromise for now. We fervently wish for something tailored to the needs of preservation archiving.

Embedded Metadata

what does the future hold?

- Appealing file level possibilities:
 - aXML from EBU/BWF
 - XMP from Adobe
- Appealing package level possibilities:
 - MXF from SMPTE
 - METS from the world of digital libraries
- May be others

There are some other metadata options to consider, some for embedding, some not.

Embedded Metadata

what does the future hold?

- Is there any hope of adoption, uptake by manufacturers?
- Should this future exploration be at the package rather than the file level?

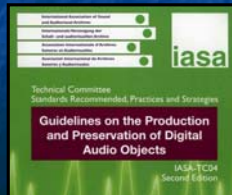
But we worry about adoption. The implementation of any of those options depends upon support from manufacturers, notably those who make digital audio workstations or playback software.

Audio Digitization Performance Testing

Next . . . we have started to look at digitization system performance testing.

Performance testing of audio digitization systems

- System performance testing
 - Considering IASA TC04 pass-fail specifications
 - Digital systems (A-to-D convertor, DAW, and other elements in path)



2.4.1.1 Total Harmonic Distortion + Noise (THD+N)
With signal 997 Hz at -1 dB FS, the A/D converter THD+N will be less than -105 dB unweighted, -107 dB A-weighted, 20 Hz to 20 kHz bandwidth limited.
With signal 997 Hz at -20 dB FS, the A/D converter THD+N will be less than -95 dB unweighted, -97 dB A-weighted, 20 Hz to 20 kHz bandwidth limited.
2.4.1.2 Dynamic Range (Signal to Noise)
The A/D converter will have a dynamic range of not less than 115 dB unweighted, 117 dB A-weighted. (Measured as THD+N relative to 0 dB FS, bandwidth limited 20 Hz to 20 kHz, stimulus signal 997 Hz at -60 dB FS).
2.4.1.3 Frequency Response
For an A/D sampling frequency of 48 kHz, the measured frequency response will be better than ± 0.1 dB for the range 20 Hz to 20 kHz.
For an A/D sampling frequency of 96 kHz, the measured frequency response will be better than ± 0.1 dB for the range 20 Hz to 20 kHz, and ± 0.3 dB for the range 20 kHz to 40 kHz.
For an A/D sampling frequency of 192 kHz, the frequency response will be better than ± 0.1 dB for the range 20 Hz to 20 kHz, and ± 0.3 dB from 20 kHz to 50 kHz (reference audio signal = 997 Hz, amplitude -20 dB FS).
2.4.1.4 Intermodulation Distortion IMD (SMPTE/DIN/AES17)
The A/D converter IMD will not exceed -90 dB. (AES17/SMPTE/DIN twin-tone test sequences, combined tones equivalent to a single sine wave at full scale amplitude).
2.4.1.5 Amplitude Linearity
The A/D converter will exhibit amplitude gain linearity of ± 0.5 dB within the range -120 dB FS to 0 dB FS. (997 Hz sinusoidal stimuli).
2.4.1.6 Spurious Aharmonic Signals
Better than -130 dB FS with stimulus signal 997 Hz at -1 dB FS.
2.4.1.7 Internal Sample Clock Accuracy
For an A/D converter synchronised to its internal sample clock, frequency accuracy of the clock measured at the digital stream output will be better than ± 25 ppm.
2.4.1.8 Jitter
Interface jitter measured at A/D output < 5 ns.
2.4.1.9 External Synchronisation
Where the A/D converter sample clock will be synchronised to an external reference signal, the A/D converter must react transparently to incoming sample rate variations $\pm 0.2\%$ of the nominal sample rate. The external synchronisation circuit must reject incoming jitter so that the synchronised sample rate clock is free from artefacts and disturbances.

TC-04 provides our starting point with its list of pass-fail numbers for analog-to-digital convertors. It states the minimum levels required for total harmonic distortion plus noise, intermodulation distortion, jitter, and so on.

Performance testing of audio digitization systems

- Desire: imitate still image working group approach: affordable target, easy-to-use software
- For lay persons, not engineers
- Requires affordable tone generation at IASA pass-fail levels
- Requires easy software to read and report THD+N, IMD, jitter, etc.
- Alas, this is challenging . . . to be continued

Here we wanted to imitate the Still Image Working Group with their target and software. We wanted something affordable, for non-engineers to use, so the staff at an archive could perform testing. But a solution has not come easily in view . . . we will continue to pursue this topic.

Video Activities

Meanwhile . . . with video content . . .

Audio-visual effort: video

- Exploration of “target formats”
- We watch and wait while agencies to gain experience . . .

. . . our general approach is to wait for our members to gain some experience. It would be premature to make recommendations. But we do want to explore target formats.

Emerging encoding preferences

- For high value, uncompressed or lossless compressed is very attractive.
- For second-rank content, some make a case for modest-but-lossy compressed. Used by some broadcasters and some broadcast archives.

Our preferences--like those for still images and audio--are for essences that are uncompressed or compressed in a lossless manner.

Library of Congress
Packard Campus,
Culpeper, Virginia



National Archives,
College Park,
Maryland

Smithsonian
Institution Archives,
Washington DC



Three federal agencies are engaged in some initial work: the Library of Congress, National Archives, and Smithsonian Institution.

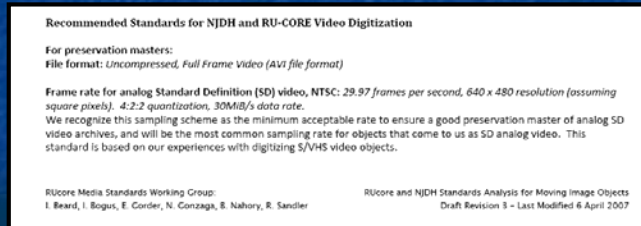
Lossless compressed

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

SAMMA produces a stream of video-frame images, each of which is encoded in the lossless JPEG 2000 format, wrapped in MXF. Early indications are that the file size ranges 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



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

Members of our group are also interested in uncompressed video files. Some work is being done at two American universities, with file sizes reported in the range of 70 to 100 gigabytes per hour.



Research White Paper

WHP 155

September 2007

BBC White Paper Uncompressed in MXF

White Paper WHP 155

File-based Production: Making it Work In Practice

Stuart Cunningham and Philip de Nier

Abstract

Many organisations are moving from video tape based television production to file-based production. A number of difficulties arise during this migration including unexpected costs, workflow complications and lack of equipment interoperability. Such difficulties can be solved in practice using novel applications of low-cost IT equipment, software tools and industry standards for file formats.

The OP-1A MXF file contained a sequence of content packages, one for each frame, containing video, audio and timecode, in the following formats:

- A video item of SMPTE 384M uncompressed 4:2:2 video at 8 bits per sample in UYVY format
- An audio item with 4 tracks of SMPTE 382M uncompressed PCM audio at 48kHz and 24 bits per sample
- A system item containing an array of SMPTE 12M timecodes representing the VITC and LTC timecodes read off the video tape

www.bbc.co.uk/rd/pubs/whp/whp-pdf-files/WHP155.pdf

The most thorough discussion of this approach that I have seen comes from the BBC.

Archetype for lossy compressed SONY IMX, MPEG-2 @ 50 mbps

Sony's IMX Format
by Alistair Jackson

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

This article first appeared in *Digital Media World* magazine October 2002

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

Meanwhile, we hear about high-resolution-but-lossy compression, often in broadcast archives. This usually employs an MPEG-2, all-I-frame approach, at 50 megabits per second, a format that owes a great debt to SONY's IMX systems. File sizes here are said to run about 28 gigabytes per hour.

Regarding video target formats: What will we do while we watch and wait?

- Federal Agencies Working Group planned action:
 - Improved documentation—profile and application specification (AS)
 - MXF/lossless JPEG 2000 format
 - MXF/uncompressed video

MEETING NOTES

Meeting Notes | February 19, 2009
Audio-Visual Digitization Working Group
(PDF, 44KB)

Discussion of film scanning and DPX format; discussion with consultant of planning for three future activities: (i) documentation of specifications for MXF wrapping JPEG 2000 and uncompressed video, (ii) audio-file metadata embedding project, and (iii) testing and discussion of audio production writing to disk.

This pertains to the exploration of target formats for the reformatting of videotapes. Although no agency has had enough experience to say with confidence, "this format is the one," three federal agencies (LC, NARA, and the Smithsonian) have purchased high efficiency equipment for their current video reformatting efforts. The default output of these devices is an MXF file that wraps (a) picture information compressed with lossless JPEG 2000 and (b) sound information as uncompressed LPCM. But these formats--MXF, JPEG 2000, and LPCM--each allow for some variation in how they are structured. The documentation provided by the manufacturer is helpful on this formatting but it does not provide comprehensive information. Among other things, this lack of complete information inhibits validation.

As we watch these developments, we have been starting an effort to document the MXF/JPEG 2000 approach (and perhaps a similar uncompressed approach). We believe that a JPEG 2000 profile and an MXF applications specification would support making tools to validate of the files that SAMMA produces, and might encourage other vendors to build similar video conversion devices.

Film (exploration in its infancy)

[Finally] Motion picture film scanning is in its infancy for our members.

What about film?

- Most activity is service to outside customers, usually television documentary makers
- Addressed by making a video copy, often still standard definition, understood to be an imperfect solution

In federal agencies today, most digital reformatting of film is done in response to requests from the makers of video documentaries seeking historical footage. This need is addressed by making video copies but no one sees that as a perfect solution.



Most active high-resolution film scanning program: NASA Johnson Space Center

www.nasa.gov

We heard from the National Aeronautics and Space Administration (NASA) Johnson Space Center in Houston. As far as we can tell, JSC is doing more high-resolution film scanning than any other federal agency.

What about film?

- Some experimental work, still to DPX format, hope to move to MXF/JPEG 2000

Everyone who scans film seems to use DPX as the target format, and our Working Group discussion of the matter highlighted some problems. We'd love to move in the direction of MXF and perhaps JPEG 2000 as we proceed.

Send us your thoughts

FEDERAL AGENCIES
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→ AUDIO-VISUAL WORKING GROUP

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*** Required**

Name

Group/Organization

*** E-Mail**

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

Altogether, there is a lot to do. We would love to hear from you. Thank you for your interest.