Federal Agencies Digitization Guidelines Initiative

Digital File Formats for Videotape Reformatting

Part 2. Detailed Matrix for Wrappers (multi-page)

This document presents the information on multiple, easily printable pages.

Part 1 provides the same information in a unified table to facilitate comparisons.

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The FADGI Audio-Visual Working Group

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

ATTRIBUTES: Sustainability Factors: Disclosure

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: Does complete technical documentation exist for this format? Is the format a standard (e.g., ISO)? How stable is the standard? Are source code for associated rendering software, validation tools, and software development kits widely available for this format?

AVI	**Good** Well-documented format with open standards available at no cost. The OpenDML specification written in 1996 is one of the primary sources of information about AVI. The RIFF specification, released by Microsoft and IBM, is also a key document. Additionally, Microsoft provides thorough information about the format, including detailed information about file structures and labels, via its Developer Network website. Some applications may add proprietary chunks which are not covered in the above documentation. There are also SDKs available for developers using DirectShow, Microsoft's multimedia framework. Those SDKs are also available on a website dedicated to developers building applications for the desktop environment.
MOV	**Good** Well-documented format with open standards available at no cost. There is a Classic Version of the QuickTime File Format specification (2001) and a current version of the QuickTime specification (2012). It seems like Apple is maintaining and updating this current version. Apple maintains portals and forums for developers. They also provide SDKs and other resources for working with the QuickTime multimedia framework (sometimes available only with a fee or subscription).
Matroska	**Acceptable** Format and documentation continue to evolve and increase in level of detail. The specification for Matroska is considered to be a draft, but its proponents consider it stable enough that developers could use it as a reference in order to refine libmatroska. The Matroska open-source community seems to be actively maintaining and updating the specification; they are currently developing version 4. Source code for ffmpeg (which provides good support for the Matroska format) is available for free. The Matroska website also provides supporting diagrams and text that further document the format.
MXF	**Acceptable** Well-documented format with standards available for a fee. Several

	SMPTE standards exist to describe MXF. The main file format standard is SMPTE 377-1:2011 Material Exchange Format (MXF) - File Format Specification. The remaining standards specify how to handle metadata, ancillary data and various essence encodings. The Advanced Media Workflow Association (AMWA) is the industry group that has taken responsibility for creating and publishing 'application specifications' which describe more narrow implementations of the standard that are suited to specific purposes. This has helped to increase interoperability among various applications that claim to support the standard.
MPEG-2	**Poor** Ad hoc format that lacks documentation. The .mpg format is an ad hoc wrapper that is not specified in or documented by any standards.

ATTRIBUTES: Sustainability Factors: Adoption

- Scoring conventions: Wide, Moderate, Low
- Questions to Consider: Is this format likely to become obsolete short, medium, or long-term? How widely adopted is the format in the vendor community? Are there user communities/developer communities that are actively discussing the format and its further development?

AVI	**Moderate** Relatively old and well-established format. Most applications currently support the AVI, but this may change in the short to medium-term as other more modern formats take its place. Digitization Services at NARA, Rutgers and Austrian Mediathek use AVI for preservation purposes.
MOV	**Wide** Well-established format that is used in both the production and cultural heritage communities. Most applications currently support the format, increasingly even those that run on the Windows platform can capture and/or transcode to MOV. Stanford University and New York University use MOV for preservation purposes.
Matroska	**Moderate** Relatively new format that is beginning to be adopted in the cultural heritage and open source communities. A growing number of software tools can work with the format- ffmpeg and Handbrake, for example. Most tools that support Matroska come out of the open source (as opposed to commercial) community. Most tools that work with Matroska seem to run on Windows or Linux platforms. The City of Vancouver Archives uses Matroska (MKV) for preservation purposes.
MXF	**Moderate** Widely adopted in the broadcast and film industries. The cultural heritage community has begun to adopt the standard, but it is not yet widespread. It is unlikely that MXF will become obsolete, even in the medium to long-term. Both SMPTE and AMWA continue to maintain and develop the standard. The Library of Congress and Library and Archives Canada use MXF for preservation purposes.
MPEG-2	**Moderate**

	Used by some cultural heritage institutions to store preservation masters. It is widely used throughout the production and cultural heritage communities as an intermediate or mezzanine-level format.

ATTRIBUTES: Sustainability Factors: Transparency

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: Transparency refers to the degree to which the digital object is open to direct analysis with basic tools.

AVI	**Good** Fairly transparent format that can be easily viewed using a hex editor.
MOV	**Good** Fairly transparent format. The QuickTime player has a 'Movie Inspector' feature that provides basic information about the technical properties of the file.
Matroska	**Good** Somewhat transparent format. It can be analyzed using the free tool ffprobe.
MXF	**Moderate** MediaInfo provides a decent amount of information, but this is somewhat dependent on the essence. For example, IMX MXF displays more information than JPEG-2000 encodings in MXF. In some cases, specialized tools are required to work with MXF files even for playback or metadata viewing.
MPEG-2	**Poor** Basic tools can open .mpg file, but most of the metadata they extract and provide to the user is stored in the essence, not the wrapper.

ATTRIBUTES: Sustainability Factors: Self-Documentation

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: Does the format offer ample documentation (e.g., metadata) that makes the digital object a completely self-describing entity? Does the metadata fully describe the file/file format?

AVI	**Acceptable** Include basic technical metadata that make the digital object fairly self-describing. Some modern video features are notably absent; see below for additional info. Optional descriptive and administrative elements can be included as well.
MOV	**Good** Include a significant amount of technical metadata. Optional descriptive metadata is also well-supported.
Matroska	Good Include a significant amount of technical metadata. Optional descriptive metadata is also well-supported.
MXF	**Good** Include a significant amount of technical metadata. MXF files also provide rich support for optional descriptive and administrative metadata.
MPEG-2	**Poor** Most metadata stored in the essence, not the wrapper.

ATTRIBUTES: Sustainability: Native Embedded Metadata Capabilities

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: What embedded metadata standards are available for this format? How mature are the schemas for each? What is the extent of use of the embedded metadata and who is using it?

AVI	**Acceptable** Requires that basic technical metadata be stored in various header fields. This includes characteristics like video standard, frame rate, bit rate, bit depth and others. More modern characteristics such as scan type and pixel aspect ratio are not included as required technical metadata. Throughout other chunks (or tags) in the file, additional descriptive metadata can be included. For example, the INAM chunk can give the title and the IART chunk can be used to name the creator (or artist) responsible for an item. Adding additional metadata requires specialized tools. Other specialized tools can be used to embed parseable or XML-based metadata into different parts of these files. This data is likely to appear in free text fields such as IMIT (more information) or ICMT (comments). XMP data may appear in the _PMX (XMP) chunks. Junk chunks can also be used to embed text-based metadata; applications may be able to display, but not parse, this information.
MOV	**Good** Many of the key technical metadata fields are required as part of the file structure. MOV files store technical metadata in various types of atoms, sometimes referred to as movie resources. These atoms contain information about timescale, color values, and the types of video and audio compression used. MOV files can include a significant amount of descriptive metadata as 'user data.' Title of the content and name of composer are basic examples of these metadata fields. Basic playback and editing tools can embed some of this additional metadata. XMP data can be included as an "XMP_" atom.
Matroska	**Good** Technical metadata is typically stored in the 'Track' section for the different pieces of the file. For example, basic characteristics of the video data like sample rate and bit depth are stored in the Track section. Descriptive metadata is included via the 'Tags' in the file.; these are analogous to ID3 tags in an MP3 file and would include information such as actor and director names.

	Because Matroska is content agnostic xml-based metadata or other types of content could be included as well.
MXF	**Good** Robust support for technical, descriptive and administrative metadata. Many technical metadata fields are required as part of the MXF header structure. DMS (Descriptive Metadata Schemes) developed by AMWA (Advanced Media Workflow Association) members can also be used to include technical, descriptive and administrative metadata. Additionaly, the EBU (European Boradcasting Union) has also written a recommendation for an XML schema to be used specifically with MXF (Recommendation R121-2007).
MPEG-2	**Acceptable** Technical metadata is held at the essence level, not the file level. Also, standardized methods of carrying descriptive data (program title and episode number, for example) are only specified at the essence level and not at the file level. It is possible to store to XMP as a standardized sidecar to an .mpg file.

ATTRIBUTES: Sustainability: Impact of Patents

- Scoring conventions: Possible Impact, No impact
- Questions to Consider: Are there patents related to this format that could have a direct impact on the long-term sustainability of files produced in this format?

AVI	**No Impact** Unknown, probably none.
MOV	**Possible Impact** Software and technology licensed by Apple.
Matroska	**No Impact** Open standards project. Matroska can be used without paying a license or patent fee. However, the Matroska name and logo cannot be used freely under certain circumstances.
MXF	**No Impact** Format developed by standards organizations, does not have license or patent fees associated with it.
MPEG-2	**Possible Impact** Patent rights cover tools used to create .mpg files, not the files themselves. While you may have to pay a license fee in order to purchase and use an MPEG-2 compliant product your files will not be subject to any licensing restrictions.

ATTRIBUTES: Sustainability Factors: Technical Protection Mechanisms

- Scoring conventions: Possible Impact, No Impact
- Questions to Consider: Are there technical protection measures inherent to this format that would prohibit the creation of ample derivatives/other formats?

AVI	**Possible Impact** There is conflicting information about encryption and AVI files. Some sources indicate that it's not possible to encrypt and others seem to imply that tools do exist to use "Advanced Encryption Standard (AES)" to password protect AVI files.
MOV	**Possible Impact** Files may be structured to require end-users to enter a media key before the file can be played. Newsgroup traffic about iTunes includes a statement from a commentator that reports, "iTunes uses a DRM system that prevents files to be played on more than 3 platforms and only the iTunes player can cope with that DRM system."
Matroska	**Possible Impact** Encryption is supported and the Matroska Website states that "It is easily possible to use the encryption framework in Matroska as a type of DRM." Any type of encryption can be used within a Matroska file and you can even layer two types so that two keys would be required for decryption.
MXF	**Possible Impact** Encryption is well-supported in the MXF format. The Digital Cinema implementation of MXF requires technical protection mechanisms.
MPEG-2	**No Impact** Encryption is handled at the essence, not the wrapper, level.

ATTRIBUTES: Cost Factors: Implementation Cost

- Scoring conventions: High, Medium, Low
- Questions to Consider: How expensive is it to capture, edit, store and move these files?

AVI	**Low** Well-supported and fairly simple, the costs for implementing this format are typically low.
MOV	**Medium** Well-supported by free and commercial software. More costly options will likely provide a richer set of features and functions. Therefore it may require additional costs to implement this format.
Matroska	**Low** Comes out of the open-source community and tools that support it are generally free. The costs for implementing this format are typically low.
MXF	**Medium** Well-supported by commercial tools, but somewhat complicated. This format may require additional costs to implement.
MPEG-2	**Low** Well-supported by both open source and commercial tools. The costs for implementing this format are typically low.

ATTRIBUTES: Cost Factors: Cost of Software

- Scoring conventions: Low (Free, minimum), Medium ($500+), High ($1,000+) Even though you can capture video with software alone, robust hardware makes capturing video faster and better.
- Questions to Consider: How much does capture and editing software cost? Are free tools available?

AVI	**Low** VirtualDub is a well-known example of free software that can be used to capture and edit AVI files. Many commercial products can also capture to AVI, these range in cost and platform compatibility.
MOV	**Low to Medium** Low cost commercial tools are available to capture and edit MOV files, but more costly options will provide a richer set of features and functions.
Matroska	**Low** You can transcode to Matroska (sometimes losslessly and with just a re-wrapping process) with free tools. According to the Matroska FAQ, it may be possible to encode directly to Matroska using VirtualdubMod: "From VirtualdubMod you can also directly encode into .mkv files from any source that it can open, and using every available VfW and ACM codecs, even in 2 pass mode."
MXF	**Low to Medium** The BBC's Ingex System is available for free and can capture to MXF, specifically the archive component (Ingex Archive) captures to MXF OP-1a files. It is designed to be used for tape-to-file reformatting. Commercial products are available at a wide range of costs to capture to MXF as well. These range from basic or average video capture setups to hardware/software combinations that are quite expensive.
MPEG-2	**Low to Medium** Various commercial products capture to .mpg. Some freeware applications are available to transcode to .mpg.

ATTRIBUTES: Cost Factors: Cost of Hardware

- Scoring conventions: Low ($1000), Medium ($1000+), High ($10000+). Even though you can capture video with cheap hardware, more robust hardware makes capturing/editing faster and better.
- Questions to Consider: How much does capture and editing hardware cost? Are low-cost tools sufficient?

AVI	**Low to Medium** Possible to capture to these formats with fairly cheap, generic hardware. However if you buy dedicated hardware, i.e. an encoding card, the performance and throughput of your digitization system will be significantly better.
MOV	**Medium** Files are usually created on Apple computers which tend to be more expensive than PCs; therefore you could argue that MOV files are more expensive to create.
Matroska	**Low to Medium** Possible to capture to these formats with fairly cheap, generic hardware.
MXF	**Low to Medium** Possible to capture to these formats with fairly cheap, generic hardware. However if you buy dedicated hardware, i.e. an encoding card, the performance and throughput of your digitization system will be significantly better.
MPEG-2	**Low** Possible to capture to these formats with fairly cheap, generic hardware.

ATTRIBUTES: Cost Factors: Storage Cost

- Scoring conventions: High= More than 1 GB per minute, Medium= 1 GB per minute, Low= Less than 1 GB per minute
- For additional frame of reference:
    - 1 hour of uncompressed 10-bit = 94 GB
    - 1 hour of uncompressed 8-bit =72 GB
    - 1 hour of J2K = 52.83 GB
    - 1 hour of MPEG-2 @ 50Mbps = 23 GB
- Questions to Consider: Are files created in this format usually large, medium, or small in size?

AVI	**N/A** Depends on the encoding you select (both uncompressed and losslessly compressed encodings are supported in this wrapper).
MOV	**N/A** Depends on the encoding you select (both uncompressed and losslessly compressed encodings are supported in this wrapper).
Matroska	**N/A** Depends on the encoding you select (both uncompressed and losslessly compressed encodings are supported in this wrapper).
MXF	**N/A** Depends on the encoding you select (both uncompressed and losslessly compressed encodings are supported in this wrapper).
MPEG-2	**Low** Cannot store uncompressed video in this wrapper therefore the file size and storage cost will always be lower.

ATTRIBUTES: Cost Factors: Network Cost

- Scoring conventions: High= More than real-time, Medium= Real-time, Low= Less than real-time. These costs may be more sensitive to scale of throughput than to size of the files. We are assuming an average network infrastructure, probably GigE with close to 1Gbps throughput.
- Questions to Consider: Does the transfer of files in this format effect performance of internal networks to the point where it would cost more to implement this format? We are assuming an average network infrastructure, probably GigE with close to 1Gbps throughput.

AVI	**N/A** Depends on the encoding you select (both uncompressed and losslessly compressed encodings are supported in this wrapper).
MOV	**N/A** Depends on the encoding you select (both uncompressed and losslessly compressed encodings are supported in this wrapper).
Matroska	**N/A** Depends on the encoding you select (both uncompressed and losslessly compressed encodings are supported in this wrapper).
MXF	**N/A** Depends on the encoding you select (both uncompressed and losslessly compressed encodings are supported in this wrapper).
MPEG-2	**Low** Cannot store uncompressed video in this wrapper therefore the file size and network cost will always be lower.

ATTRIBUTES: System Implementation Factors: Level of difficulty/complexity to implement

- Scoring conventions: High, Medium, Low
- Questions to Consider: Given all of the system implementation factors, how hard is it to implement this format? What is the level of effort associated with the implementation of this format? Are there special requirements for this format that would change the nominal workflow for digitization/information life cycle?

AVI	**Low** Relatively simple RIFF-based chunk format. It's fairly easy to understand the file structure, create files and edit files.
MOV	**Medium** File structure is more complex than AVI, for example, so there's a steeper learning curve.
Matroska	**Medium** Still an emerging format so the tools and knowledge base are still developing.
MXF	**High** Tools and workflows can be complicated to implement.
MPEG-2	**Low** Well-supported and not overly complicated.

ATTRIBUTES: System Implementation Factors: Technical Complexity

- Scoring conventions: High, Medium, Low
- Questions to Consider: Are the tools command-line meant for engineers or GUI-centered applications accessible to the average user?

AVI	**Low** Tools such as AVI MetaEdit are available as both GUIs and command line. Also, the relatively simple structure of format makes it easily accessible to a wide range of users.
MOV	**Medium** Tools are available, but the variety is somewhat limited.
Matroska	**Medium** Tools and other resources exist, but are still in development. Current tools (like FAME) are geared for those with strong developer skills and not necessarily for the general public. They probably run from a command-line instead of a GUI and may require less common platforms such as Linux.
MXF	**High** Current tools are geared for those with strong developer skills and not necessarily for the general public. Tools may run from a command-line instead of a GUI and may require less common platforms such as Linux.
MPEG-2	**Low** Tools are available as both GUIs and command line.

ATTRIBUTES: System Implementation Factors: Availability of Tools for: Rendering/playback and Editing

- Scoring conventions: Wide availability, Moderate availability, Limited availability
- Questions to Consider: Are there tools available for this format? What is the mix of open source and commercial tools?

AVI	**Wide Availability** Many tools are available for rendering and playback including open source players like VLC. Free editing software also exists.
MOV	**Wide Availability** Tools for rendering and playback include open source players like VLC.
Matroska	**Wide Availability (with a caveat)** Matroska files need CCCP (Combined Community Codec Pack) to playback through DirectShow media players such as Windows Media Player on Windows-machines. Other non-DirectShow players like VLC and MPV can play MKV files without the need for a parser. Mac and Linux operating systems similarly don't need a DirectShow parser since it's a Windows-only concern.
MXF	**Moderate Availability** Tools are mostly commercial, but open source options are growing.
MPEG-2	**Wide Availability** Tools for rendering and playback include open source players like VLC.

ATTRIBUTES: System Implementation Factors: Availability of Tools for: Metadata extraction and Metadata embedding

- Scoring conventions: Wide availability, Moderate availability, Limited availability
- Questions to Consider: Are there tools available for this format? What is the mix of open source and commercial tools? What level of effort is necessary in order to extract or embed metadata?

AVI	**Wide Availability** Open source tools are available for metadata extraction and embedding; MediaInfo, AVI MetaEdit and abcAVI are good examples.
MOV	**Wide Availability** Open source tools are available for metadata extraction and embedding; MediaInfo and Metadata Hootenanny are good examples. Low-cost editing and playback tools can also do this work.
Matroska	**Wide Availability** Open source tools for metadata extraction include MediaInfo and mkvalidator.
MXF	**Moderate Availability** Tools are available, but tend to be commercial and are not necessarily interoperable. One open source option for MXF AS-11 (Program Contribution) files using the DPP (Digital Production Parternship) DMS is also available.
MPEG-2	**Wide Availability** Open source tools like MediaInfo and VideoInspector can perform metadata extraction. Embedding tools are most likely commercial.

ATTRIBUTES: System Implementation Factors: Availability of Tools for: Transcoding

- Scoring conventions: Wide availability, Moderate availability, Limited availability
- Questions to Consider: Are there tools available for this format? What is the mix of open source and commercial tools? What level of effort is necessary in order to transcode [understood here to mean transwrap]?

AVI	**Wide Availability** It is relatively easy to transcode from this wrapper since both commercial and open source software can work with it.
MOV	**Wide Availability** Relatively easy to transcode from this wrapper since both commercial and open source software can work with it.
Matroska	**Moderate Availability** Relatively easy to transcode from this wrapper since open source software can work with it, especially FAME and ffmpeg. Commercial software isn't yet strongly invested, but may be with growing adoption.
MXF	**Moderate Availability** Sometimes have the ability to transcode from this wrapper. The complexity of the options including Operational Patterns (OP), Application Secifications (AS), Shims and essence encoding can make this more difficult.
MPEG-2	**Wide Availability** Relatively easy to transcode from this wrapper, both commercial and open source tools can work with it.

ATTRIBUTES: System Implementation Factors: Availability of Tools to: Measure Compliance with Institutional Specifications

- Scoring conventions: Wide availability, Moderate availability, Limited availability
- Questions to Consider: How easy is it to ensure that you are producing a file that conforms to your institutional specifications?

AVI	**Wide Availability** Open source tools like MediaInfo and AVI MetaEdit can extract technical metadata which can be compared against institutional specs. Commercial tools can also do this work.
MOV	**Wide Availability** Open source tools like MediaInfo and Metadata Hootenanny can extract technical metadata which can be compared against institutional specs. Commercial tools can also do this work.
Matroska	**Wide Availability** Open source tools like MediaInfo can extract technical metadata which can be compared against institutional specs. Commercial tools can also do this work.
MXF	**Moderate Availability** Commercial tools (some of which are highly specialized) can extract technical metadata which can be compared against institutional specs. Open source options are growing. The complexity of the options including Operational Patterns (OP), Application Secifications (AS), Shims and essence encoding can make this more difficult.
MPEG-2	**Wide Availability** Open source tools like MediaInfo can extract technical metadata which can be compared against institutional specs. Commercial tools can also do this work.

ATTRIBUTES: System Implementation Factors: Tools to Evaluate and Monitor Content Quality

- Scoring conventions: Wide availability, Moderate availability, Limited availability
- Questions to Consider: How easy is it to ensure that you are producing a file that conforms to broadcast specifications or other quality measures?

AVI	**Wide Availability** Commercial tools can perform these tasks. Open source tools like MediaInfo could also be used for QC-purposes. Additionally, the open source tool MDQC can perform quality control on metadata and Bay Area Video Coalition (BAVC) has released open source software (QC Tools) to perform quality control on actual video content.
MOV	**Wide Availability** Commercial tools can perform these tasks. Open source tools like MediaInfo could also be used for QC-purposes. Additionally, the open source tool MDQC can perform quality control on metadata and Bay Area Video Coalition (BAVC) has released open source software (QC Tools) to perform quality control on actual video content.
Matroska	**Moderate Availability** Some commercial tools can perform these tasks. Open source tools like MediaInfo could also be used for QC-purposes. Additionally, the open source tool MDQC can perform quality control on metadata and Bay Area Video Coalition (BAVC) has released open source software (QC Tools) to perform quality control on actual video content.
MXF	**Wide Availability** Commercial tools can perform these tasks. Open source tools like MediaInfo could also be used for QC-purposes. Additionally, the open source tool MDQC can perform quality control on metadata and Bay Area Video Coalition (BAVC) has released open source software (QC Tools) to perform quality control on actual video content.
MPEG-2	**Wide Availability** Commercial tools can perform these tasks. Open source tools like MediaInfo could also be used for QC-purposes.

	Additionally, the open source tool MDQC can perform quality control on metadata and Bay Area Video Coalition (BAVC) has released open source software (QC Tools) to perform quality control on actual video content.

ATTRIBUTES: System Implementation Factors Ease and Accuracy of Format Identification

(Defined by JHOVE as the format to which a digital object conforms)

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: Can the format be identified using DROID/PRONOM or other tools?

AVI	**Good** Format identification can be done by free tools like MediaInfo and DROID (PUID fmt/5) as well as by commercial tools (as part of other QC tests).
MOV	**Acceptable** Format identification can be done by free tools like MediaInfo and DROID (PUID x-fmt/384) as well as by commercial tools (as part of other QC tests). The structural variability of this format may make it slightly more difficult to pin down with certainty.
Matroska	**Poor** Not in DROID or UDFR.
MXF	**Acceptable** Poor for open source tools, but better for commercial tools. PUID is fmt/200 but it's a shell record only. UDFR entry, but also just a shell.
MPEG-2	**Acceptable** Professional analysis tools are robust and readily available from the broadcasting community; free software can also validate the technical integrity of .mpg files. The PUID is x-fmt/385 and x-fmt/386 but it's a shell record only. An UDFR entry also exists, but is just a shell.

ATTRIBUTES: System Implementation Factors: Ease and Accuracy of Format Validation

(Defined by JHOVE as the level of compliance of a digital object to the specification for its purported format. Validation includes well-formedness.)

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: Does the format specification include concepts and methods for conformance?

AVI	**Poor** There are no tools that can perform this task.
MOV	**Poor** There are no tools that can perform this task.
Matroska	**Poor** There are no tools that can perform this task.
MXF	**Poor** There are no tools that can perform this task.
MPEG-2	**Poor** There are no tools that can perform this task.

ATTRIBUTES: Settings and Capabilities: Clarity

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: Does the format support a variety of compression or encoding schemes? Are these schemes robust and thorough?

AVI	**Acceptable** Supports both 8- and 10-bit encodings as well as high chroma subsampling ratios; however it relies on the somewhat obscure Extensible Wave-Format to handle 8-channel audio.
MOV	**Good** Supports both 8- and 10-bit encodings, as well as high chroma subsampling ratios.
Matroska	**Good** Matroska was designed as a content agnostic wrapper format. These files are structured according to EBML principles and basically use a type of markup language to identify different pieces of data. Also, Martoska has support for many video-specific data types; timecode, captions and other video-specific metadata are well-defined in Matroska files.
MXF	**Good** The MXF wrapper was designed to be essence-agnostic and supports many types of essence formats; these include both 8- and 10-bit and a wide range of color spaces and chroma subsampling formats.
MPEG-2	**N/A** The support for different clarity features is handled at the essence level, not the ad hoc .mpg wrapper format.

ATTRIBUTES: Settings and Capabilities: Bit Depth

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: What bit depths does the format support (ie, 8-bit and/or 10-bit)?

AVI	**Good** Supports both 8 and 10-bit video and can even support bit depths of up to 16-bits. See Microsoft site regarding color space and fourcc codes for more information.
MOV	**Good** Supports both 8 and 10-bit video and can even support bit depths of up to 16-bits per pixel. See Apple Ice Floe site for further documentation.
Matroska	**Acceptable** Supports some VfW and native QuickTime codecs, but details are lacking. Uncompressed is also supported, but again details about which flavor of uncompressed are missing. Theora 16-bit video is also supported.
MXF	**Good** Supports both 8 and 10-bit video and has support for 12 and 16-bit video as well. See SMPTE ST 377 for more information.
MPEG-2	**N/A**

ATTRIBUTES: Settings and Capabilities: Chroma Subsampling

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: What chroma subsampling does the format support? Is this clearly declared in technical metadata?

AVI	**Good** Supports both 4:4:4 and 4:2:2 chroma subsampling. See Microsoft site regarding color space and fourcc codes for more information.
MOV	**Good** Supports both 4:4:4 and 4:2:2 chroma subsampling. See Apple Ice Floe site for further documentation.
Matroska	**Good** Matroska supports various VfW (Video for Windows) and native QuickTime codecs as well as MPEG-1, 2 and 4 Part 2 and Part 10. This means that a wide variety of chroma subsampling formats, including 4:4:4 and 4:2:2, should be supported.
MXF	**Good** Supports both 4:4:4 and 4:2:2 chroma subsampling, as well as other more advanced sampling formats that include alpha channels.
MPEG-2	**N/A**

ATTRIBUTES: Settings and Capabilities: Audio Channels

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: Can the format contain stereo audio, surround sound and other kinds of "aural space"? How many channels of audio are supported?

AVI	**Acceptable** Supports up to 8 channels of audio by relying on the Extensible Wave-Format. See Microsoft site regarding Extensible Wave-Format for more information.
MOV	**Good** Good support for different audio configurations. The QuickTime specification doesn't give an upper limit on the number of audio channels; it simply says that one or more channels are supported.
Matroska	**Good** No upper limit on the number of audio tracks is given in the Matroska documentation.
MXF	**Good** Supports typical configurations for audio including 2, 4 or 8-channels. It also supports much larger and more complicated channel configurations.
MPEG-2	**N/A**

ATTRIBUTES: Settings and Capabilities: Video Range

(Broadcast safe range or wide range/computer-graphics video)

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: Does the format clearly declare whether it contains broadcast safe range video or computer graphics video?

AVI	**Poor** Doesn't include a standardized means of specifying the video range used in the file.
MOV	**Acceptable** Uses a 'gama' field to specify the levels at which the image was captured.
Matroska	**Acceptable** Uses a 'GammaValue' element to provide information about video levels.
MXF	**Good** Specifies a reference value for white and black. This is stored as Properties in the Picture Descriptors section of the header metadata. See SMPTE ST 377 for more information.
MPEG-2	**N/A**

ATTRIBUTES: Additional Features

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: Does the format support storage of additional data, beyond simply the audio and video essences?

AVI	**Poor** Lacks support for clear declaration of scanning mode (interlaced or progressive), allows for only a start timecode value and does not have a standardized way to specify Display Aspect Ratio. Lastly, there is no native support for closed captions or subtitles.
MOV	**Good** Even though it is one of the older wrapper formats, MOV generally has good support for these more advanced features.
Matroska	**Acceptable** Relatively new format that has fairly good support for these more advanced features.
MXF	**Good** Modern file format that typically has very good support for additional features.
MPEG-2	**N/A** The support for different additional features is handled at the essence level, not the ad hoc .mpg wrapper format.

ATTRIBUTES: Timecode

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: Does the format have a specified location for timecode? Are breaks in timecode reflected? Can multiple timecodes can be stored?

AVI	**Poor** AVI supports only a start timecode value and only a single timecode track. It places this data in what is called the Tdat chunk/field. According to the OpenDML specification it is possible to store discontinuous timecode in an AVI file. However, no vendors have implemented this feature.
MOV	**Good** The tmcd atom stores the initial value only and then runs an edit list to deal with offsets and nonconsecutive values. MOV files can also store a synthetic timecode with a user-specified start value that counts up at a user-specified rate; it seems that this data goes into a timecode track. Timecode data is not always treated the same by various applications; this limits the ability for files with timecode data to interoperate between different capture and editing systems.
Matroska	**Good** Has the ability to track timecode in blocks, clusters, or other regions.
MXF	**Good** Can contain multiple timecodes in various tracks. Some timecode tracks, such as those stored in the header metadata, are synthetic meaning they only consist of a start value and a counting rate. Other types of timecode such as those that may be stored in Lower Level Source Packages or System or Data Items do contain a value for every individual frame of video.
MPEG-2	**N/A**

ATTRIBUTES: Closed-Captioning and Subtitles

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: Does the format have a specified location for closed captions?

AVI	**Poor** Does not have a good way to store closed captioning or subtitle information. Some organizations compensate for this by employing associated files (for example, .srt or .scc) to carry captions or subtitles.
MOV	**Acceptable** Supports closed captions and subtitles; they are stored in separate tracks labeled 'clcp' and 'sbtl' respectively. The QuickTime specification only mentions support for the CEA-608 format.
Matroska	**Acceptable** The specification doesn't discuss "closed captions," but does provide good support for subtitles as associated .mks files. Additionally, support for six different subtitle codecs are listed in the Matroska documentation: ASCII, UTF8, SSA, ASS, USF and VOBSUB.
MXF	**Acceptable** Can support closed captions although the production and vendor communities have not yet settled on a single standardized way to do so. The trend seems to be toward storing closed captions as Data Elements in the Generic Container. It is also technically possible to store captions in Generic Stream Partitions. Lastly, there is the possibility for storing captions in an external file.
MPEG-2	**N/A**

ATTRIBUTES: Scan Type and Field Order

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: Does the format support both interlaced and progressive encoding? Does it clearly declare whether it is interlaced or progressive, and if interlaced, is field order clearly specified?

AVI	**Poor** Does not clearly declare whether it is interlaced or progressive, nor does it have a means to specify field order if content is interlaced. According to the OpenDML AVI specification, there is support for declaring whether the file is interlaced or progressive. The Number of Fields per Frame field in the Video Properties Header allows the user to specify '1' for progressive or '2' for interlaced. However, this field is not always implemented by vendors.
MOV	**Good** In the Video Media Atom, MOV files use the 'fiel' field to specify scanning method. Interlaced or progressive can be specified, as well as field order if the data is interlaced.
Matroska	**Acceptable** The specification lists the element "FlagInterlaced" and instructs users to set this if the video is interlaced. It does not seem to have a field order element.
MXF	**Good** In the Picture Descriptors in header metadata, and possibly in accompanying DMS tracks, MXF declares whether the video essence is interlaced or progressive. It also specifies the number of lines of Resolution. Usually the FrameLayout Property and the VideoLineMap Property are used to provide these details.
MPEG-2	**N/A**

ATTRIBUTES: Display Aspect Ratio

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: Does the format clearly declare aspect ratio information, specifically display and pixel aspect ratio?

AVI	**Acceptable** Includes fields that specify width and height in terms of number of stored pixels, but does not have a standardized way to specify what the width and height should be upon display nor does it provide a field to specify the dimensions of each pixel (aka, pixel aspect ratio). Some files may also give the resolution and display aspect ratio as text data in the JUNK chunk, but uniform support for this data doesn't currently exist. Another possibility is the use of proprietary chunks or field such as the PARf field in the PRMa chunk that we have seen in some AVI files. According to the OpenDML AVI specification, there is support for declaring the display aspect ratio of the file. However, this field is not typically implemented by vendors.
MOV	**Good** Uses the following fields to specify pixel and display aspect ratios: 'pasp' meaning pixel aspect ratio (required if non-square) and 'clap' meaning clean aperture (always required).
Matroska	**Good** Uses an aperture value to specify the display characteristics of the image. Matroska also has elements called DisplayWidth, DisplayHeight and DisplayUnit to help provide specifics around how to display the image.
MXF	**Good** Uses DisplayWidth and DisplayHeight fields in the Picture Descriptor section of the header m metadata to provide this information. The AFD (Active Format Descriptor) field is also used for formats that do not fill the entire active video raster; typically these are formats that have undergone aspect ratio conversion and may need bars to be displayed properly.
MPEG-2	**N/A**

ATTRIBUTES: Multipart Essences

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: Does the format support multipart essences?

AVI	**Poor** Doesn't support multipart essences.
MOV	**Acceptable** According to the QuickTime specification multipart essences are supported with the Reference Movie structure. This allows a single QuickTime file to reference multiple movies and play the appropriate one depending on the application attempting to play back the file. The specification also discusses Target Atoms which support references to external movies and to embedded movies; this may provide support for multipart essences that are referencing different content (as opposed to different quality levels of the same content used by the Reference Movie structure).
Matroska	**Good** Easily supports multipart essences because of its flexible and modular underlying structure.
MXF	**Good** Has the ability to support the inclusion of multipart essences. For example multiple episodes of a particular program can be stored or referenced by a single MXF file. Certain Operational Patterns (OP) will be more suitable for this than others.
MPEG-2	**N/A**

ATTRIBUTES: Essences Other than Timed Data

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: Is it possible to include formats other than the usual audio, video and data types found in reformatted video files?

AVI	**Poor** Doesn't support essences other than timed data.
MOV	**Acceptable** Still images can be added to MOV files as metadata.
Matroska	**Good** Supports a variety of essence types and still image formats are easily included as Attachments. Still images should be either .JPG or .PNG files.
MXF	**Acceptable** Current drafts of the AS07 (Archiving and Preservation) Application Specification indicate that it will support essences other than timed data.
MPEG-2	**N/A**

ATTRIBUTES: Fixity Checks

- Scoring conventions: Good, Acceptable, Poor
- Questions to Consider: Does the format have a means to support fixity checks?

AVI	**Good** MD5 chunks can carry checksums.
MOV	**Poor** The QuickTime specification does not list a dedicated mechanism for storing an embedded checksum.
Matroska	**Acceptable** Supports CRC-32 checksums, they are included at the beginning of the file.
MXF	**Good** Can accommodate frame, chunk and file-level checksums.
MPEG-2	**N/A**