

# Codec Containers and Metadata

Demystifying codecs, wrappers and the alphabet soup of digital media files

History of Video Compression Standards

Year	Standard	Publisher	Popular Implementations
1984	H.120	ITU-T	
1990	H.261	ITU-T	Videoconferencing, Videotelephony
1993	MPEG-1 Part 2	ISO, IEC	Video-CD
1995	H.262/MPEG-2 Part 2	ISO, IEC, ITU-T	DVD Video, Blu-ray, Digital Video Broadcasting, SVCD
1996	H.263	ITU-T	Videoconferencing, Videotelephony, Video on Mobile Phones (3GP)
1999	MPEG-4 Part 2	ISO, IEC	Video on Internet (DivX, Xvid ...)
2003	H.264/MPEG-4 AVC	ISO, IEC, ITU-T	Blu-ray, Digital Video Broadcasting, iPod Video, HD DVD
2008	VC-2 (Dirac)	ISO, BBC	Video on Internet, HDTV broadcast, UHDTV

# Codec Containers and Metadata

Demystifying codecs, wrappers and  
the alphabet soup of digital media  
files

Prepared by James Brooks, Drastic Technologies



Presented by Phil Keeling, Oceana Digital



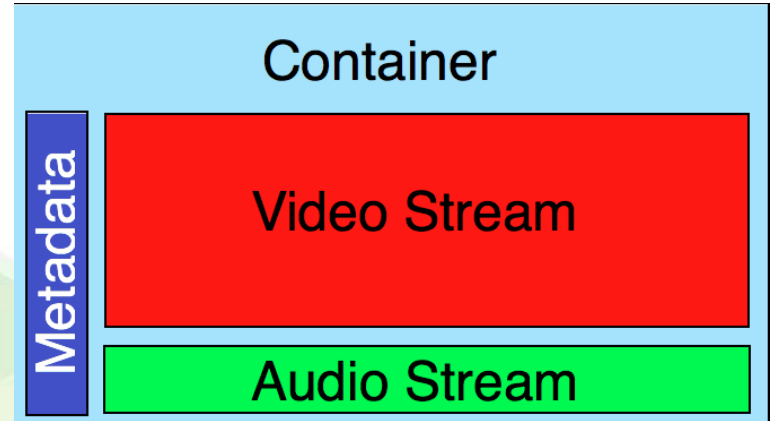
A media file is organized from outside to inside as:

- Metadata
  - Timecode, reel, info
- Container
  - MXF, MOV, AVI
- Media.
  - AVCi, DV100, JPEG2000, HD264, MPEG-2, Uncompressed



Metadata exists on all levels of a media file.

- External: XML/XMP/other
- Static: elements in the file
- Real Time: elements in the container or media



There are many container types:

- Customer/non-standard corporate files (ARI, GEN, ARC etc.)
- Standardized files (AVI, MOV, WAV etc.)

# There are also a wide variety of media types, including QuickTime, MPEG and RGB

None	<b>Matrox MXO2 Mini – Apple ProRes 422 (HQ) 1080p 23.98 48 kHz</b>	<b>Matrox MXO2 Mini – Apple ProRes 422 720p 25 48 kHz</b>
Digital Cinema Desktop Preview – Main	Matrox MXO2 Mini – Apple ProRes 422 (HQ) 1080p 25 48 kHz	Matrox MXO2 Mini – Apple ProRes 422 720p 29.97 48 kHz
Matrox MXO2 Mini – NTSC YUV 8-bit (720 x 486)	Matrox MXO2 Mini – Apple ProRes 422 (HQ) 1080p 29.97 48 kHz	Matrox MXO2 Mini – Apple ProRes 422 720p 50 48 kHz
Matrox MXO2 Mini – NTSC YUV 10-bit (720 x 486)	Matrox MXO2 Mini – Apple ProRes 422 (HQ) 720p 23.98 48 kHz	Matrox MXO2 Mini – Apple ProRes 422 720p 59.94 48 kHz
Matrox MXO2 Mini – PAL YUV 8-bit (720 x 576)	Matrox MXO2 Mini – Apple ProRes 422 (HQ) 720p 25 48 kHz	Matrox MXO2 Mini – Apple ProRes 422 NTSC 48 kHz
Matrox MXO2 Mini – PAL YUV 10-bit (720 x 576)	Matrox MXO2 Mini – Apple ProRes 422 (HQ) 720p 29.97 48 kHz	Matrox MXO2 Mini – Apple ProRes 422 NTSC Anamorphic 48 kHz
Matrox MXO2 Mini – DV PAL YUV 8-bit (720 x 576)	Matrox MXO2 Mini – Apple ProRes 422 (HQ) 720p 50 48 kHz	Matrox MXO2 Mini – Apple ProRes 422 PAL 48 kHz
Matrox MXO2 Mini – DV PAL YUV 10-bit (720 x 576)	Matrox MXO2 Mini – Apple ProRes 422 (HQ) 720p 59.94 48 kHz	Matrox MXO2 Mini – Apple ProRes 422 PAL Anamorphic 48 kHz
Matrox MXO2 Mini – 720p 50 YUV 8-bit (1280 x 720)	Matrox MXO2 Mini – Apple ProRes 422 (HQ) NTSC 48 kHz	Matrox MXO2 Mini – DV 480p 23.98 48 kHz
Matrox MXO2 Mini – 720p 50 YUV 10-bit (1280 x 720)	Matrox MXO2 Mini – Apple ProRes 422 (HQ) NTSC Anamorphic 48 kHz	Matrox MXO2 Mini – DV NTSC 48 kHz
Matrox MXO2 Mini – 720p 59.94 YUV 8-bit (1280 x 720)	Matrox MXO2 Mini – Apple ProRes 422 (HQ) PAL 48 kHz	Matrox MXO2 Mini – DV NTSC Anamorphic 48 kHz
<b>Matrox MXO2 Mini – 720p 59.94 YUV 10-bit (1280 x 720)</b>	Matrox MXO2 Mini – Apple ProRes 422 (HQ) PAL Anamorphic 48 kHz	Matrox MXO2 Mini – DV PAL 48 kHz
Matrox MXO2 Mini – 1080i 50 YUV 8-bit (1920 x 1080)	Matrox MXO2 Mini – Apple ProRes 422 (LT) 1080i 50 48 kHz	Matrox MXO2 Mini – DV PAL Anamorphic 48 kHz
Matrox MXO2 Mini – 1080i 50 YUV 10-bit (1920 x 1080)	Matrox MXO2 Mini – Apple ProRes 422 (LT) 1080i 59.94 48 kHz	Matrox MXO2 Mini – DVCPRO HD 1080i 50
Matrox MXO2 Mini – 1080i 59.94 YUV 8-bit (1920 x 1080)	Matrox MXO2 Mini – Apple ProRes 422 (LT) 1080p 23.98 48 kHz	Matrox MXO2 Mini – DVCPRO HD 1080i 59.94
Matrox MXO2 Mini – 1080i 59.94 YUV 10-bit (1920 x 1080)	Matrox MXO2 Mini – Apple ProRes 422 (LT) 1080p 25 48 kHz	Matrox MXO2 Mini – DVCPRO HD 1080p 23.98
Matrox MXO2 Mini – 1080PsF 23.98 YUV 8-bit (1920 x 1080)	Matrox MXO2 Mini – Apple ProRes 422 (LT) 1080p 29.97 48 kHz	Matrox MXO2 Mini – DVCPRO HD 1080p 29.97
Matrox MXO2 Mini – 1080PsF 23.98 YUV 10-bit (1920 x 1080)	Matrox MXO2 Mini – Apple ProRes 422 (LT) 720p 23.98 48 kHz	Matrox MXO2 Mini – DVCPRO HD 720p 23.98
Matrox MXO2 Mini – 1080PsF 25 YUV 8-bit (1920 x 1080)	Matrox MXO2 Mini – Apple ProRes 422 (LT) 720p 25 48 kHz	Matrox MXO2 Mini – DVCPRO HD 720p 25
Matrox MXO2 Mini – 1080PsF 25 YUV 10-bit (1920 x 1080)	Matrox MXO2 Mini – Apple ProRes 422 (LT) 720p 29.97 48 kHz	Matrox MXO2 Mini – DVCPRO HD 720p 29.97
Matrox MXO2 Mini – 1080PsF 29.97 YUV 8-bit (1920 x 1080)	Matrox MXO2 Mini – Apple ProRes 422 (LT) 720p 50 48 kHz	Matrox MXO2 Mini – DVCPRO HD 720p 50
Matrox MXO2 Mini – 1080PsF 29.97 YUV 10-bit (1920 x 1080)	Matrox MXO2 Mini – Apple ProRes 422 (LT) 720p 59.94 48 kHz	Matrox MXO2 Mini – DVCPRO HD 720p 59.94
Matrox MXO2 Mini – 486p 23.98 YUV 8-bit (720 x 486)	Matrox MXO2 Mini – Apple ProRes 422 (LT) NTSC 48 kHz	Matrox MXO2 Mini – DVCPRO NTSC 48 kHz
Matrox MXO2 Mini – 486p 23.98 YUV 10-bit (720 x 486)	Matrox MXO2 Mini – Apple ProRes 422 (LT) NTSC Anamorphic 48 kHz	Matrox MXO2 Mini – DVCPRO NTSC Anamorphic 48 kHz
Matrox MXO2 Mini – 576p 25 YUV 8-bit (720 x 576)	Matrox MXO2 Mini – Apple ProRes 422 (LT) PAL 48 kHz	Matrox MXO2 Mini – DVCPRO PAL 48 kHz
Matrox MXO2 Mini – 576p 25 YUV 10-bit (720 x 576)	Matrox MXO2 Mini – Apple ProRes 422 (LT) PAL Anamorphic 48 kHz	Matrox MXO2 Mini – DVCPRO PAL Anamorphic 48 kHz
Matrox MXO2 Mini – 486p 29.97 YUV 8-bit (720 x 486)	Matrox MXO2 Mini – Apple ProRes 422 (Proxy) 1080i 50 48 kHz	Matrox MXO2 Mini – DVCPRO 480p 23.98 48 kHz
Matrox MXO2 Mini – 486p 29.97 YUV 10-bit (720 x 486)	Matrox MXO2 Mini – Apple ProRes 422 (Proxy) 1080i 59.94 48 kHz	Matrox MXO2 Mini – DVCPRO50 NTSC 48 kHz
Matrox MXO2 Mini – 486p 29.97 YUV 8-bit (720 x 486)	Matrox MXO2 Mini – Apple ProRes 422 (Proxy) 1080p 23.98 48 kHz	Matrox MXO2 Mini – DVCPRO50 NTSC Anamorphic 48 kHz
Matrox MXO2 Mini – 486p 29.97 YUV 10-bit (720 x 486)	Matrox MXO2 Mini – Apple ProRes 422 (Proxy) 1080p 25 48 kHz	Matrox MXO2 Mini – DVCPRO50 PAL 48 kHz
Matrox MXO2 Mini – NTSC 16:9 YUV 8-bit (720 x 486)	Matrox MXO2 Mini – Apple ProRes 422 (Proxy) 1080p 29.97 48 kHz	Matrox MXO2 Mini – DVCPRO50 PAL Anamorphic 48 kHz
Matrox MXO2 Mini – NTSC 16:9 YUV 10-bit (720 x 486)	Matrox MXO2 Mini – Apple ProRes 422 (Proxy) 720p 23.98 48 kHz	Matrox MXO2 Mini – Uncompressed 1080i 50 10-bit 48 kHz
Matrox MXO2 Mini – PAL 16:9 YUV 8-bit (720 x 576)	Matrox MXO2 Mini – Apple ProRes 422 (Proxy) 720p 25 48 kHz	Matrox MXO2 Mini – Uncompressed 1080i 50 8-bit 48 kHz
Matrox MXO2 Mini – PAL 16:9 YUV 10-bit (720 x 576)	Matrox MXO2 Mini – Apple ProRes 422 (Proxy) 720p 29.97 48 kHz	Matrox MXO2 Mini – Uncompressed 1080i 59.94 10-bit 48 kHz
Matrox MXO2 Mini – DV PAL 16:9 YUV 8-bit (720 x 576)	Matrox MXO2 Mini – Apple ProRes 422 (Proxy) 720p 50 48 kHz	Matrox MXO2 Mini – Uncompressed 1080i 59.94 8-bit 48 kHz
Matrox MXO2 Mini – DV PAL 16:9 YUV 10-bit (720 x 576)	Matrox MXO2 Mini – Apple ProRes 422 (Proxy) 720p 59.94 48 kHz	Matrox MXO2 Mini – Uncompressed 1080p 23.98 10-bit 48 kHz
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Matrox MXO2 Mini – 486p 23.98 16:9 YUV 10-bit (720 x 486)	Matrox MXO2 Mini – Apple ProRes 422 (Proxy) NTSC Anamorphic 48 kHz	Matrox MXO2 Mini – Uncompressed 720p 23.98 10-bit 48 kHz
Matrox MXO2 Mini – 576p 25 16:9 YUV 8-bit (720 x 576)	Matrox MXO2 Mini – Apple ProRes 422 (Proxy) PAL 48 kHz	Matrox MXO2 Mini – Uncompressed 720p 23.98 8-bit 48 kHz
Matrox MXO2 Mini – 576p 25 16:9 YUV 10-bit (720 x 576)	Matrox MXO2 Mini – Apple ProRes 422 (Proxy) PAL Anamorphic 48 kHz	Matrox MXO2 Mini – Uncompressed 720p 50 10-bit 48 kHz
Matrox MXO2 Mini – 486p 29.97 16:9 YUV 8-bit (720 x 486)	Matrox MXO2 Mini – Apple ProRes 422 1080i 50 48 kHz	Matrox MXO2 Mini – Uncompressed 720p 50 8-bit 48 kHz
Matrox MXO2 Mini – 486p 29.97 16:9 YUV 10-bit (720 x 486)	Matrox MXO2 Mini – Apple ProRes 422 1080i 59.94 48 kHz	Matrox MXO2 Mini – Uncompressed 720p 59.94 10-bit 48 kHz
Matrox MXO2 Mini – 486p 29.97 16:9 YUV 8-bit (720 x 486)	Matrox MXO2 Mini – Apple ProRes 422 1080p 23.98 48 kHz	Matrox MXO2 Mini – Uncompressed 720p 59.94 8-bit 48 kHz
Matrox MXO2 Mini – 486p 29.97 16:9 YUV 10-bit (720 x 486)	Matrox MXO2 Mini – Apple ProRes 422 1080p 25 48 kHz	Matrox MXO2 Mini – Uncompressed NTSC 10-bit 48 kHz
Matrox MXO2 Mini – 720p 23.98 YUV 8-bit (1280 x 720)	Matrox MXO2 Mini – Apple ProRes 422 1080p 29.97 48 kHz	Matrox MXO2 Mini – Uncompressed NTSC 10-bit Anamorphic 48 kHz
	Matrox MXO2 Mini – Apple ProRes 422 720p 23.98 48 kHz	Matrox MXO2 Mini – Uncompressed NTSC 8-bit 48 kHz



The CODEC is the most important parameter of the workflow.

- Metadata is easily translated
- The container can easily be changed
- Changing the codec tends to introduce errors

## HD Acquisition Codecs

	Mbps	720p		1080i		1080p	Video Sample		Audio	
		960	1280	1280	1440	1920	Sample	10 Bit	#	Bits
<b>DCT</b>										
HDCam <sup>[1]</sup>	140				✓		3:1:1		4	20
DVCPProHD@24p	40		✓				4:2:2	✓	8	16
DVCPProHD-720p	100	✓					4:2:2		8	16
DVCPProHD-1080i	100			✓			4:2:2		8	16
Avid DNxHD	145		✓				4:2:2		4	16
Avid DNxHD	220		✓			✓	4:2:2	✓	4	16
Apple ProRes	145		✓			✓	4:2:2	✓	8	24
Apple ProRes HQ	220		✓			✓	4:2:2	✓	8	24
<b>Wavelet</b>										
Red	224-336		✓			✓	RGB or 4:2:2	12	4	24
<b>MPEG2 Long GOP</b>										
HDV	25		✓		✓		4:2:0		2	MP1
XDCamHD	18-35				✓		4:2:0		4	16
XDCam422	50		✓		✓		4:2:2		8	24
XDCamEX	25				✓		4:2:0		2	16
XDCamEX	35		✓		✓		4:2:0		2	16
GFCam	50		✓		✓		4:2:2		4	16
<b>MPEG2 I-frame</b>										
GFCam	100		✓		✓		4:2:2		4	16
<b>H.264</b>										
AVCHD	24		✓		✓		4:2:0		2	AC3
AVCHD@24	24				✓		4:2:0		2	AC3
Canon SDMKII	38					✓	4:2:0		2	16
<b>H.264 I-frame</b>										
AVCIntra	50	✓			✓		4:2:0	✓	2	16
AVCIntra	100		✓		✓		4:2:2	✓	2	16
<b>MPEG4 Studio Profile</b>										
HDCamSR <sup>[2]</sup>	440		✓		✓		4:2:2/4:4:4	✓	12	24
HDCamSR-HQ <sup>[2]</sup>	880		✓		✓	✓	4:2:2/4:4:4	✓	12	24

[1] Tape format for comparison

[2] Tape with DPX file out

# CODECS

- MPEG-1 One of originals still in use.
- MPEG-2 Most common Used on DVD, VOD
- Windows Media Compatibility
- MPEG-4 (H.263)
- H.264 (MPEG-4 part 10)
- JPEG2000
- **Codec Seminar by Chris Reynolds on YouTube**  
*see <http://www.youtube.com/watch?v=IRIMC2of15o>*

There are various codec families, most of which have a "lossy" portion. Translating this portion may introduce errors.

Check out some of the newer codecs

developed for higher resolution work

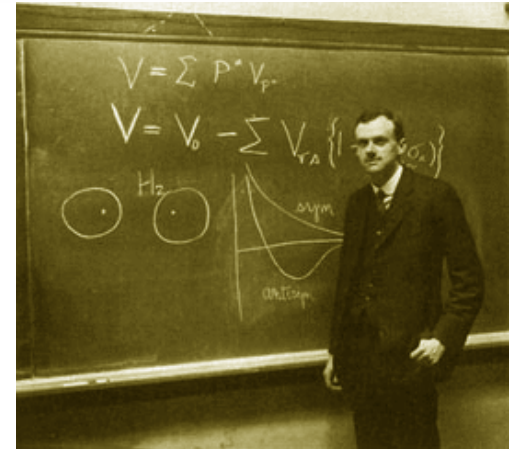
Cineform and Cineform3D

**CINEFORM**

CinemaDNG



Dirac



Many transcode engines do not write their own codecs but instead use the Main Concept codec set.



# Multimedia Container Formats

- The container file is used to identify and interleave different data types.
- Simpler container formats can contain different types of **audio formats**,
- Advanced container formats can support **multiple audio & video streams**, subtitles, chapter-information, and meta-data
- Along with the **synchronization** information needed to play back the various streams together.
- In most cases, the file header, most of the metadata and the synchro chunks are specified by the **container** format.
- For example, container formats exist for optimized, low-quality, internet video streaming which differs from high-quality DVD streaming requirements.
- Container format parts have various names: "**chunks**" as in RIFF and PNG, "**atoms**" in QuickTime/MP4, "**packets**" in MPEG-TS (from the communications term), and "**segments**" in JPEG.
- The main content of a chunk is called the "data" or "**payload**". Most container formats have chunks in sequence, each with a header, while TIFF stores offsets.

- The most popular multi-media containers are:
- 3GP** (used by many mobile phones; based on the ISO base media format)
- ASF** (container for Microsoft **WMA** and **WMV**, which today usually do not use a container)
- AVI**(the standard Microsoft Windows container, also based on RIFF)
- DVR-MS ("Microsoft Digital Video Recording", video container format based on ASF)
- FLASH VIDEO** (FLV, F4V) (container for video and audio from Adobe Systems)
- IFF** (first platform-independent container format)
- Matroska**(MKV) (not limited to any codec or system, as it can hold virtually anything.)
- MJ2** - Motion **JPEG 2000**file format, based on the ISO base media file format which is defined in MPEG-4 Part 12 and JPEG 2000 Part 12
- QuickTime File Format** (standard Quicktime video container from Apple Inc.)
- MPEG Program Stream**(standard container for MPEG-1 & MPEG-2 on reasonably reliable media such as disks; used also on **DVD-Video** discs)
- MPEG-2 Transport Stream**(a.k.a. MPEG-TS) (standard container for digital broadcasting and for transportation over unreliable media; used also on **Blue-Ray disc**)
- MP4** (standard audio and video container for the **MPEG-4** multimedia portfolio, based on the ISO base media file format defined in MPEG-4 Part 12and JPEG 2000 Part 12) which in turn was based on the QuickTime file format.
- Ogg** (standard container for Xiph.org audio format Vorbis and video format Theora)
- RM** (RealMedia; standard container for Real Video and Real Audio)
- There are many other container formats, **NUT, MXF,GXF, ratDVD,SVI, VOB, and DivX**



**WIKIPEDIA**  
The Free Encyclopedia

## **Comparison of container formats**

From Wikipedia, the free encyclopedia

[http://en.wikipedia.org/wiki/Comparison\\_of\\_container\\_formats](http://en.wikipedia.org/wiki/Comparison_of_container_formats)

In MXF, some metadata are defined via a registry, which may be prone to errors due to the number of elements, information lost during translation and a spec which may change at any time.



The MXF container was designed as a platform-agnostic stable standard for the future. The intent was to minimize the problems associated with non-professional formats.

The MXF spec however, left many implementation details undefined, and manufacturers each took a different path.

In addition, there are a number of different types of MXF.



Various manufacturers began to provide their own implementations of MXF, including Sony, Panasonic, Grass Valley, Omneon and more.



**Panasonic**



**SONY**



As a result there are many competing flavors of MXF provided by the various companies.



The media files contained within the MXF wrapper are more standardized and easier to handle. There are codecs that work well:

- DV (SD/25/50/HD/100)
- MPEG-2 (various)
- AVCi (50/100)
- JPEG2000 (some)

IMF (Interoperable Master Format) is being developed to re-standardize MXF to provide a standard implementation. This may come at the cost of a re-encoding step.



SMPTE has defined a number of operational patterns:

- SMPTE (390M,378M,391M and others)

Resolution			
Vertical	Horizontal	Scanning	Frame rate (Hz)
720	1280	Progressive	23.976
			24
			25
			29.97
			30
			50
			59.94
1080	1920	Interlace	25 (50 fields)
			29.97 (59.94 fields)
			30 (60 fields)
		Progressive	23.976
			24
			25
			29.97
			30

High Definition Section of ATSC A/53, Table 3

SMPTE has defined a number of generic containers:  
SMPTE (379M, 381M, 383M and others)

[Home](#) > [SMPTE Standards](#) >

[ST 0377-1-2011](#)



[store.smpte.org/product-p/st-0377-1-2011.htm](http://store.smpte.org/product-p/st-0377-1-2011.htm)

#### Description



Material Exchange Format (MXF) - File Format Specification (Revision of SMPTE 377-1-2009). This document defines the data structure of the Material Exchange Format (MXF) for the interchange of audio-visual material. It defines the data structure for network transport and may be used on storage media. This document does not define internal storage formats for MXF compliant devices. The document defines all the components of the MXF file specification including all those in the File Header, File Body and File Footer. It defines the application of Partitions in the file that provide valuable features such as the ability for an MXF file to serve many application requirements and recovery of partially received files. The document also defines key features of the file structure including the Partition Packs, the Structural Metadata, the Primer Pack, the Random Index Pack and Index Tables. The document does not define either the Essence Container or the Descriptive Metadata. Instead, it defines the requirements for these components to be added as a plug-in to an MXF file.

SMPTE has defined a number of metadata,  
dictionary and registry strategies:  
SMPTE (380M, 436M, RP210, RP224)



Conclusions: make sure to plan and test your workflow before it is needed.



Conclusions: Metadata and  
Container translation can be fast and  
lossless given the proper tools.





# Codec Containers and Metadata

Thank you  
Special Thanks to Richard Baker

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