

EMA Mezzanine File Creation Specification and Best Practices version 1.0.0

For encoding of contribution quality content delivered to EMA member companies.

Developed by the Digital Supply Chain Committee (Mezzanine File Work Group)
of the Entertainment Merchants Association.

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Introduction

- This is a spec that industry veterans from post production, delivery platforms, software vendors, and content creator's technical operations departments have come to agreement on.
- It is intended to create a common baseline format that all agreed upon parties can create and ingest.
- It is not intended to be academically the "best" spec for quality, but instead, for practicality and compatibility with sufficient quality.
- EMA vendor companies have agreed that they are able to receive these types of files. Parties involved may however, want to set up on a case by case basis special alternate formats and workflows with post production or content owners for various reasons.
- Many technologies were considered for inclusion in 1.0.0 but were decided to be insufficiently supported today. These will be considered for future versions of the specifications. These include:
 - Lossless audio codecs
 - 4:2:2 and 4:4:4 color
 - 10-bit or 12-bit precision
 - Specific stereo 3D modes
 - 4K/UHD
 - HEVC and other advanced codecs

Technical goals

- Lower bitrates than MPEG-2 or ProRes based deliverables for practical storage, transmission, and manipulation of these assets.
- Better source video quality than existing lowest common denominator MPEG-2 mezzanines.
- Broad decode compatibility with existing video workflow tools.
- Support for uncompressed or compressed audio.
- Reasonable encoding and decoding speed
- No or low cost to begin creation or acceptance of assets in this spec.
- "Creative" decisions are made by content owners or post production stakeholders rather than resellers.

Status

- Version 1.0.0

Content Preparation Considerations

Because one of the goals of this specification is to improve output quality while increasing consistency of results, it is important to limit the number of allowable standards for content formatting and have common expectations for preprocessing.

Video Preparation

It is always preferable to receive content in its native format, meaning the format in which it was initially produced and not necessarily the format in which it was distributed. For example, if a TV program was shot on film at 23.976p, but then was initially broadcast in 59.94p, it is required that this asset be delivered in its native 23.976p progressive frame rate. This can be achieved with properly applying an Inverse-Telecine. Content that contains 3:2 pulldown or has been telecined will not be accepted.

Content must end and begin with 1 second of black with silence. No head or tail content like slates, bars and tone, web-callouts, advertisements, etcetera are to be included with the mezzanine; the content should be only what the viewer would see and hear. The content must not contain commercial blacks. Content must not contain any advertisements, commercials, VITC (Vertical Interval TimeCode), horizontal or vertical blanking lines within the content.

Mixed mode content should be conformed to a single progressive mode. For example, a 23.976p SD TV show in 3:2 pulldown with a 29.97i intro should be converted to 23.976p. A special feature clip that is made up primarily of 29.97i behind-the-scenes content, with 24p clips occasionally, the file should become 59.94p.

Acceptable Formatting

#	VIDEO CODEC	FRAME RATE	SCAN TYPE	NOTES
1	AVC / H.264	23.976	Progressive	Preferred format for all HD and SD resolutions if content was natively produced in 23.976p.
2	AVC / H.264	59.94	Progressive	Only if sourced from true 59.94p content such as sports networks. No repeated/duplicate frames for telecine or up/cross-conversions from 29.97i.
3	AVC / H.264	29.97	Progressive	For content that is native 29.97 progressive. Or content that is true 29.97 interlaced and has been properly deinterlaced to 29.97 progressive. No intra-field motion (blended frames) and no unnecessary repeated/duplicate frames.
4	AVC / H.264	29.97	Interlaced	Only for content that was natively interlaced or converted to interlaced and no suitable recovery method is available to inverse telecine or deinterlace.
5	AVC / H.264	24	Progressive	For content that is native true 24.00 fps progressive.
6	AVC / H.264	25	Progressive	For content that is native 25 progressive, or content that was true 50 interlaced and properly deinterlaced to 25 progressive. No intra-field motion (blended frames) and no repeated/duplicate frames.

7	AVC / H.264	25	Interlaced	Only for content that was natively interlaced or converted to interlaced and no suitable recovery method is available for conversion to progressive.
8	MPEG-2	23.976	Progressive	A fallback option. ONLY allowed if vendor cannot provide suitable AVC encoding.
9	MPEG-2	59.94	Progressive	Same restrictions as #2 above. ONLY allowed if vendor cannot provide suitable AVC encoding.
10	MPEG-2	29.97	Progressive	Same restrictions as #3 above. ONLY allowed if vendor cannot provide suitable AVC encoding.
11	MPEG-2	29.97	Interlaced	Same restrictions as #4 above. ONLY allowed if vendor cannot provide suitable AVC encoding.
12	MPEG-2	24	Progressive	As for #5. ONLY allowed if vendor cannot provide suitable AVC encoding.
13	MPEG-2	25	Progressive	As for #6. ONLY allowed if vendor cannot provide suitable AVC encoding.
14	MPEG-2	25	interlaced	As for #7. ONLY allowed if vendor cannot provide suitable AVC encoding.

Video Encoding

H.264 File Format Specifications (Preferred)

This section covers the preferred formats #1-7 in the [Acceptable Formatting](#) section above. The MPEG-2 formats should only be used in fallback cases where H.264 file generation is not possible.

H.264 Video Encoding All Resolutions

Codec	H.264 / AVC / MPEG-4 Part 10
Bit-depth	8-bit standard video range. 0-255 range is not allowed.
Subsampling / color space	4:2:0 Y'CbCr/YUV. RGB is not allowed.
Frame rate:	Same as the source frame rate, after any preprocessing. Fixed frame rate only (aka constant frame rate), no variable frame rate.
Scan type:	Progressive. If interlaced material is delivered for Format #7, it must have the Interlace Mode correctly set (MBAFF is acceptable but not required) and the Field Order must be correctly assigned (Top Field First or Bottom Field First) matching the encoded content.
Resolution	Only standard resolutions will be accepted. Please see Appendix for " Standard Resolutions and Sample Aspect Ratios "
Sample Aspect Ratio (Pixel Aspect Ratio)	Defined within the respective HD and SD specifications as well as in the Appendix for " Standard Resolutions and Sample Aspect Ratios "
Rate Control	<p>Bitrate needs to be sufficient that a second generation encode from the mezzanine is visually identical to an encode generated with the same parameters from the original source. Acceptable rate control modes are, in order of preference based on quality at a given bitrate:</p> <ol style="list-style-type: none"> 1. Constant Rate Factor (CRF) 2. Constant Quantizer (QP) 3. 2-pass Variable Bitrate (VBR) 4. 1-pass Variable Bitrate <p>These options are encoder dependent. Resulting bitrate must stay within the constraints of the corresponding H.264 Profile/Level. See end of this document for example CRF usage. CRF value should be ≤ 6.</p>

Entropy Encoding	CAVLC
Scene Change Detection	Enabled (Variable GOP)
GOP Length	2 seconds max, with Scene Change Detection enabled.
GOP Style	Closed
B Frames	Maximum of 3 consecutive B Frames
Reference Frames	Maximum of 3 reference frames
Reference B Frames	If used, must adhere to "Strict" pyramid structure
Required Stream Flags	aspect_ratio_idc, field_flag, sequence_parameter_set, picture_parameter_set

H.264 High Definition Specific Requirements

H.264 Profile	High
H.264 Levels	4.1 for HD content (1080 and 720)
Bitrate Constraint	62,500 kbps maximum (variable bitrate)
Sample Aspect Ratio (Pixel Aspect Ratio)	HD must be 1:1 (aka square pixels) only. No anamorphic squeezing allowed.
Required Stream Flags	aspect_ratio_idc, field_flag, sequence_parameter_set, picture_parameter_set

H.264 Standard Definition Specific Requirements

H.264 Profile	High
H.264 Level	3.2
Resolution Constraint	NTSC: 720x480 (486 lines not supported) PAL: 720x576

Sample Aspect Ratio (Pixel Aspect Ratio)	32:27 (NTSC 16x9 - 720x480) 40:33 (NTSC 16x9 - 704x480) 8:9 (NTSC 4x3 - 720x480) 10:11 (NTSC 4x3 - 704x480) 64:45 (PAL 16x9 720x576) 16:11 (PAL 16x9 704x576) 16:15 (PAL 4x3 720x576) 12:11 (PAL 4x3 704x576)
Required stream flags	aspect_ratio_idc, field_flag, sequence_parameter_set, picture_parameter_set

MPEG-2 File Format Specifications (Fallback)

This section covers Fallback Formats #8-14 in [Acceptable Formatting](#) section above. These formats are only to be used if suitable results cannot be achieved by a vendor for delivering [Preferred Formats #1-7](#).

MPEG-2 Video Encoding All Resolutions

Container	MPEG-2 Transport Stream
Video Codec	MPEG-2
Frame Rate	Same as the source frame rate, after any preprocessing.
Scan Type	Progressive. If interlaced material is delivered for Formats #11 and #14, it must have the Picture Structure correctly set to Interlaced and the Field Order must be correctly assigned (Top Field First or Bottom Field First) matching the encoded content.
Resolution	Only standard resolutions will be accepted. Please see Appendix for " Standard Resolutions and Sample Aspect Ratios "
GOP Length	Maximum of 0.6 seconds Scene Change Detection allowed and recommended
B Frames	Maximum of 2 consecutive B Frames (a P-Frame distance of 3)

MPEG-2 High Definition Specific Requirements

MPEG-2 Profile	Main or High
MPEG-2 Level	High
Sample Aspect Ratio (Pixel Aspect Ratio)	1:1 (Square Pixels)
Color Space	4:2:2 required for interlaced content (4:2:0 accepted for progressive)

MPEG-2 Standard Definition Specific Requirements

MPEG-2 Profile	Main or High
MPEG-2 Level	Main

Sample Aspect Ratio (Pixel Aspect Ratio)	32:27 (NTSC 16x9 - 720x480) 40:33 (NTSC 16x9 - 704x480) 8:9 (NTSC 4x3 - 720x480) 10:11 (NTSC 4x3 - 704x480) 64:45 (PAL 16x9 720x576) 16:11 (PAL 16x9 704x576) 16:15 (PAL 4x3 720x576) 12:11 (PAL 4x3 704x576)
Subsampling	4:2:2 required for interlaced content (4:2:0 accepted for progressive)

Audio Encoding

Codec	PCM or MPEG-4 AAC-LC for .mov 2.0 Stereo PCM only for MPEG-2 5.1 Surround + 2.0 Stereo AES3 302m for MPEG-2 Blu-Ray mixed audio tracks will NOT be accepted.														
Sample Rate	48000 Hz														
Endianness	Little endian														
Bits per Sample	16 or 24-bit, following the source														
Channel Configuration	<p>Mono</p> <table border="1"> <tr> <td>1</td> <td>Mono</td> </tr> </table> <p>2.0 Stereo</p> <table border="1"> <tr> <td>1</td> <td>Left</td> </tr> <tr> <td>2</td> <td>Right</td> </tr> </table> <p>5.1 Surround</p> <table border="1"> <tr> <td>1</td> <td>Left Front</td> </tr> <tr> <td>2</td> <td>Right Front</td> </tr> <tr> <td>3</td> <td>Center</td> </tr> <tr> <td>4</td> <td>LFE</td> </tr> </table>	1	Mono	1	Left	2	Right	1	Left Front	2	Right Front	3	Center	4	LFE
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1	Left														
2	Right														
1	Left Front														
2	Right Front														
3	Center														
4	LFE														

	<table border="1" data-bbox="678 275 959 401"> <tr><td>5</td><td>Left Surround</td></tr> <tr><td>6</td><td>Right Surround</td></tr> </table> <p data-bbox="500 464 646 527">5.1 Surround + 2.0 Stereo</p> <table border="1" data-bbox="678 495 1094 989"> <tr><td>1</td><td>Left Front</td></tr> <tr><td>2</td><td>Right Front</td></tr> <tr><td>3</td><td>Center</td></tr> <tr><td>4</td><td>LFE</td></tr> <tr><td>5</td><td>Left Surround</td></tr> <tr><td>6</td><td>Right Surround</td></tr> <tr><td>7</td><td>Left Total (Downmix Left)</td></tr> <tr><td>8</td><td>Right Total (Downmix Right)</td></tr> </table> <p data-bbox="500 1052 646 1083">7.1 Surround</p> <table border="1" data-bbox="678 1083 1032 1577"> <tr><td>1</td><td>Left Front</td></tr> <tr><td>2</td><td>Right Front</td></tr> <tr><td>3</td><td>Center</td></tr> <tr><td>4</td><td>LFE</td></tr> <tr><td>5</td><td>Left Surround</td></tr> <tr><td>6</td><td>Right Surround</td></tr> <tr><td>7</td><td>Left Back Surround</td></tr> <tr><td>8</td><td>Right Back Surround</td></tr> </table>	5	Left Surround	6	Right Surround	1	Left Front	2	Right Front	3	Center	4	LFE	5	Left Surround	6	Right Surround	7	Left Total (Downmix Left)	8	Right Total (Downmix Right)	1	Left Front	2	Right Front	3	Center	4	LFE	5	Left Surround	6	Right Surround	7	Left Back Surround	8	Right Back Surround
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Minimum AAC Bitrates	Mono: 192 Stereo: 320 5.1: 640 Variable Bitrate modes recommended but not required																																				

Container

Container Type	<p>Must be a self-contained .mov file.</p> <p>See specification at: https://developer.apple.com/library/mac/#documentation/QuickTime/QTFF/QTFFChap3/qtff3.html#//apple_ref/doc/uid/TP40000939-CH205-SW1</p> <p>Video (seen in spec table 4-1): Only allowed video sample description atom type must be 'avc1'</p> <p>Required: 'pasp' 'fiel'</p> <p>Audio types allowed(seen in spec table 4-7): in24 lpcm twos sowt</p> <p>Other allowed atom types: tmcd stsd</p> <p>Not allowed: gama clap elst sprt twen load hint qd3d strm rtp vrsc imgp impr vrni</p>
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Container Extension	.mov														
Stream Order	<p>Video + Stereo audio</p> <table border="1"> <tr> <td>Stream 0</td> <td>AVC video</td> </tr> <tr> <td>Stream 1</td> <td>PCM or AAC stereo</td> </tr> </table> <p>Video + 5.1 audio + Stereo audio (audio on separate tracks)</p> <table border="1"> <tr> <td>Stream 0</td> <td>AVC video</td> </tr> <tr> <td>Stream 1</td> <td>PCM or AAC 5.1 surround</td> </tr> <tr> <td>Stream 2</td> <td>PCM or AAC audio stereo</td> </tr> </table> <p>Stereo audio only for alternate language tracks</p> <table border="1"> <tr> <td>Stream 0</td> <td>PCM or AAC audio stereo</td> </tr> </table> <p>5.1 audio only for alternate language tracks</p> <table border="1"> <tr> <td>Stream 0</td> <td>PCM or AAC audio 5.1 surround</td> </tr> </table>	Stream 0	AVC video	Stream 1	PCM or AAC stereo	Stream 0	AVC video	Stream 1	PCM or AAC 5.1 surround	Stream 2	PCM or AAC audio stereo	Stream 0	PCM or AAC audio stereo	Stream 0	PCM or AAC audio 5.1 surround
Stream 0	AVC video														
Stream 1	PCM or AAC stereo														
Stream 0	AVC video														
Stream 1	PCM or AAC 5.1 surround														
Stream 2	PCM or AAC audio stereo														
Stream 0	PCM or AAC audio stereo														
Stream 0	PCM or AAC audio 5.1 surround														
Language Labels	ISO 639-2														

Timed-text

Subtitles and other timed text events will be addressed in the “[CLOSED CAPTIONING OF IP-DELIVERED VIDEO PROGRAMMING BEST PRACTICES](#)” document. All assets must be conformed (synced).

Helpful Hints

- Do not assume that your encoder and multiplexing software is generating files with all of the required metadata properly populated. Double check this explicitly.
- Do not assume that the metadata in all containers will be the same. Files with progressive video streams require different container data than interlaced streams.
- Do not assume that the web player is unchanging with time. Internet capabilities constantly improve. Use the best available elements and do not pre-filter.

Sample Materials

The below samples and examples are only provided for illustration purposes only. The EMA Mezzanine roadmap includes the group working with enterprise software/equipment providers to supply certified configurations/presets to create EMA compliant files.

Free high quality source footage for testing: Tears of Steel, is available [here](#)

- high quality 1920 x 800 @ 24p source material
- lossless sources available for audio and video
- stereo and surround tracks available

ffmpeg Example

Sample file creation using ffmpeg built with x264. At least 49 GB of space should be available for these operations to complete successfully. The following example command lines were tested under Mac OS X 10.8.4 using ffmpeg version 1.1 git-716dbc7.

1. Take the webm version of tears of steel, and compress it using ffmpeg built with x264

(Note the following: Use of crf 6 to create constant quality output, the asset is true 24 fps so frame rate is set to 24 rather than 24000/1001 for 23.976, keyint value is dependent on the asset's frame rate and should be a maximum value of fps x 2, the pad filter has been added to normalize the resolution to 1920x1080 by padding since the source is 1920x800).

```
ffmpeg -i tears_of_steel_1080p.webm -an -pix_fmt yuv420p -c:v libx264 -crf 6
-preset medium -x264opts
nal-hrd=vbr:vbv-maxrate=62500:vbv-bufsize=78125:keyint=48:ref=3:b-pyramid=st
rict:no-cabac:force-cfr=1 -r 24 -tune film -sws_flags +accurate_rnd -vf
"setsar=1/1,scale=1920:-1,pad=1920:1080:(1920-iw)/2:(1080-ih)/2" -deblock
-1:-1 -profile:v high -psy 1 -psy-rd 1.00:0.00 -wpredp 0 -8x8dct 1
-partitions all -rc-lookahead 40 -me_method hex -me_range 16 -subq 6
-chromaoffset -2 -bf 3 -sc_threshold 40 -qcomp 0.60 -qmin 4 -qmax 51 -qdiff
4 -i_qfactor 0.71 -c:a pcm_s24le -f mov x264tears_video.mov
```

2. Encode audio (*.flac from download directory for Tears of Steel), properly tag channel mapping and mux it together with the h.264 video stream, to create a final EMA spec file, including metadata.

```
ffmpeg -i x264tears_video.mov -channel_layout "5.1(side)"
-i tearsofsteel-surround.flac -channel_layout downmix
-i tearsofsteel-stereo.flac -c:v:0 copy -c:a:0 pcm_s24le -c:a:1 pcm_s24le
-map 0:0 -map 1:0 -map 2:0 -metadata title="Tears of Steel" -metadata
```



```
artist="Blender Foundation" -metadata date="2012" -metadata copyright="(CC)
Blender Foundation | mango.blender.org" -metadata
license="http://creativecommons.org/licenses/by/3.0/" -metadata
description="EMA Mezzanine Encoding Spec Example File Beta 1"
-metadata:s:a:0 language=eng -metadata:s:a:0 description="DVD surround 5.1
mix" -metadata:s:a:1 language=eng -metadata:s:a:1 description="DVD stereo
mix" tears-of-steel-ema-example-file.mov
```

4. Move the atom to the front of the file using `qtfaststart`

```
~/qtfaststart/bin/qtfaststart tears-of-steel-ema-example-file.mov
qtfaststart-tears-of-steel-ema-example-file.mov
```

(Please note that the invocation of `qtfaststart` depends on how it was installed. With the `ffmpeg` package under Linux it is invoked with `qt-faststart`.)

libav + x264 Example

Sample file creation using `libav` and `x264`. At least 49 GB of space should be available for these operations to complete successfully. The following example command lines were tested under a Linux operating system.

1. Take the main video track out of the webm version of tears of steel, and turn it into an uncompressed file.

```
~/libav/avconv -i tears_of_steel_1080p.webm -f yuv4mpegpipe -pix_fmt yuv420p
-vf scale tears_of_steel_uncompressed_1920x800-master.y4m
```

2. Take the uncompressed file and compress it using `x264`

(Note the following: Use of `crf 6` to create constant quality output, the asset is true 24 fps so frame rate is set to 24 rather than 24000/1001 for 23.976, `keyint` value is dependent on the asset's frame rate and should be a maximum value of `fps x 2`, `tune` parameter is set to match the source content as film)

```
~/x264/x264 tears_of_steel_uncompressed_1920x800-master.y4m --r 24 --crf 6
--profile high --level 41 --ref 3 --b-pyramid strict --bframes 3 --keyint 48
--tune film --preset medium --no-cabac --vbv-maxrate 62500 --vbv-bufsize
78125 --trellis 1 -o x264tears.mp4
```

3. Encode audio (*.flac from download directory for Tears of Steel), and mux it together with the h.264 video stream, to create a final EMA spec file, including metadata.

```
avconv -i x264tears.mp4 -i tearsofsteel-surround.flac -i
tearsofsteel-stereo.flac -c:v:0 copy -c:a:0 pcm_s24le -c:a:1 pcm_s24le -map
0:0 -map 1:0 -map 2:0 -metadata title="Tears of Steel" -metadata
artist="Blender Foundation" -metadata date="2012" -metadata copyright="(CC)
Blender Foundation | mango.blender.org" -metadata
```

```
license="http://creativecommons.org/licenses/by/3.0/" -metadata
description="EMA Mezzanine Encoding Spec Example File Beta 1"
-metadata:s:a:0 language=eng -metadata:s:a:0 description="DVD surround 5.1
mix" -metadata:s:a:1 language=eng -metadata:s:a:1 description="DVD stereo
mix" tears-of-steel-ema-example-file.mov
```

4. Move the atom to the front of the file using `qtfaststart`

```
~/qtfaststart/bin/qtfaststart tears-of-steel-ema-example-file.mov
qtfaststart-tears-of-steel-ema-example-file.mov
```

(Please note that the invocation of `qtfaststart` depends on how it was installed. With the `ffmpeg` package under Linux it is invoked with `qt-faststart`.)

Appendix

Standard Resolutions and Sample Aspect Ratios

	Resolution	Display Aspect Ratio (DAR)	Sample Aspect Ratio (SAR) aka Pixel Aspect Ratio (PAR)
High Definition (HD)	1920x1080	16x9	1:1
	1440x1080	4x3	1:1
	1280x720	16x9	1:1
	960x720	4x3	1:1
Standard Definition (SD)	720x480	16x9	32:27
	704x480	16x9	40:33
	720x480	4x3	8:9
	704x480	4x3	10:11
	720x576	16x9	64:45
	704x576	16x9	16:11

	720x576	4x3	16:15
	704x576	4x3	12:11

XML Metadata initial proposal

Content that is originally mixed mode, but has been conformed to progressive, must be identified in the associated EMA file as a XML metadata file to provide details about the files that cannot be gleaned from the container itself.

Sample XML Metadata

```
<?xml version="1.0" encoding="UTF-8"?>
<Lab_Content>
  <ProcessedBy></ProcessedBy>
  <ProgressiveFromMixedModeSource></ProgressiveFromMixedModeSource>
  <ScanStructure>
    <Original></Original>
    <Target></Target>
  </ScanStructure>
  <FrameRate>
    <OriginalFrameRate></OriginalFrameRate>
    <Conversion>
      <Device></Device>
      <Method></Method>
    </Conversion>
  </FrameRate>
  <PitchShifting>
    <Used></Used>
    <Device></Device>
  </PitchShifting>
</Lab_Content>
```

Beyond frame rates and mattes, there are an enormous range of production and post-production artifacts that need to be considered. Future versions of this document will attempt to make more formal recommendations regarding handling challenging content. We have included early recommendations below.

