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| *Title:* | **Studio requirements for next-generation video codecs (and HExt: HEVC HDR Extensions)** | | |
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| *Source:* | Motion Picture Laboratories, Inc., Walt Disney Studios, 20th Century Fox, Sony Pictures Entertainment, Universal Pictures, Warner Bros. | | |

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# Abstract

A summary on current generation High Dynamic Range / Wide Color Gamut (HDR/WCG) developments in MPEG, VCEG, SMPTE standards body organizations, and applications in Blu-ray Disc Association and streaming (which utilize HEVC Main10 for coded HDR/WCG representation) are provided. These current combinations of consumer distribution codecs and video signal containers do not meet the full set of Hollywood studio requirements. The next-generation of video codecs, including potential HEVC extensions for HDR (HExt) should address this. Full chrominance spatial detail (4:4:4) is a key requirement, as is full gamut color, and sufficient code levels (such as provided by 12-bit ST 2084) and internal codec precision to represent video signals with minimal contouring (or banding). Additional precision may also be needed to permit processing and display adaptation downstream of the encoder. Other changes in color coding could be useful to improve the accurate reproduction of the reference rendering with a range of display technologies, environments and viewers. Meeting these requirements may involve developing more than one profile concurrently with the typical “Main” profile aimed at the median requirements of consumer distribution codecs.

# Background

MovieLabs is a joint venture of the six major Hollywood studios. At the Vienna meeting in July 2013, MovieLabs and its studio members approached MPEG and VCEG with a set of next generation video requirements that included features that went beyond the then current roadmap, including HDR and full color gamut. These are expressed in [1].

Since Vienna, many of these features have been standardized in SMPTE ST 2084, ST 2085 and ST 2086, which are also now supported in HEVC and AVC VUI and SEI messages.

Using these standards, single layer HEVC Main10 provides the most compact known representation for High Dynamic Range (HDR) / Wide Color Gamut (WCG) video in a number of studio applications launching this year including Ultra HD Blu-ray™ [2] and Over the Top (OTT) streaming services. Single layer HEVC Main10 also seems likely to be adopted in many, and perhaps in all, of the upcoming HDR broadcast systems.

Since the Strasbourg meeting in October 2014, MPEG and VCEG have been considering requirements for the next generation of video codec project (some times referred to as “Future Video” [[3]](http://mpeg.chiariglione.org/standards/exploration/future-video-coding)), estimated to launch in 2017, and completing a few years later. Separate from the primary bitrate reduction goal put forth by panelists in Strasbourg, and at meetings since then, the authors of this document state that a future codec generation should provide significant improvement in both features and quality over what can be conveyed in HDR/WCG signals represented in Main 10 and currently defined HEVC extensions such as Range Extensions (RExt) Main 12 or higher profiles.

Future codecs, or HDR-specific extensions of HEVC (HExt), should be capable of efficiently expressing the full spectrum of human vision to the end consumer (beyond BT.2020), with sufficient intensity range and quantization accuracy to provide the option of rendering video to a wide range of display devices, potentially at a point downstream of the encoder rather than having the ODT (Output Display Transform) stage of the workflow mostly fixed prior to encoding. Mechanisms to better convey to real observers the colors as captured and mastered should also be explored. Next generation consumer distribution decoders should also be capable of decoding video bitstreams in a non-subsampled chroma format, such as 4:4:4. Design and testing of the next generation or HExt coding tools should include the option that video samples be efficiently coded (and, for example, maintained in decoded picture buffers) in the primaries domain (e.g., RGB or XYZ), rather than rely on pre-transformation to a color difference signal (e.g., 4:4:4 YCbCr), or subsampled color difference format such as 4:2:0 (YCbCr). De-correlation steps could be performed in-loop, for example, by the Cross Component Prediction tool introduced in HEVC Range Extensions (RExt) tookit published in HEVC version 2. In order to mitigate posterization (banding) artifacts, sample bit-depths maintained in decoded picture buffers (DPB) and between other potential reconstruction decoding stages (e.g., motion compensated output to deblocking) may benefit from greater precision than codec input and output sample bit-depths --- a relationship known as “internal bit-depth increase” (IBDI) during the early HEVC v1 development phase between 2010 and 2013.

Considering the cost of upgrading systems over HEVC Main10, any future codec and associated system should provide significantly improved quality and expanded visible features at similar bitrates compared to the current and emerging HEVC Main 10 systems.

# Requirements

The desired studio requirements [1] that go beyond the features of current generation HDR/WCG products [2] for consumer distribution next generation video codec [3] bitstreams:

* The option of efficiently coding non-subsampled color component video: maintain 4:4:4 source coding from authoring, through encode, decode, and display connection. (decoder requirement)
* The ability to efficiently code full gamut color.
* Samples can be maintained through a codec chain in primary color spaces (e.g., RGB or XYZ), as indicated by VUI matrix\_coeffs = identity (value 0), with similar efficiency provided by a color difference space, such as YCbCr or other primary signal derivatives.
* Sufficient code levels, as for example provided by approximately perceptually uniform 12-bit or higher precision samples, to convey detail over wide latitude of intensities. Higher sample precision would be necessary when coded samples have approximately linear light steps, requiring 16 bit half-float or higher precision integer data types to cover the same range covered by lower bit depth, non-uniform intensity steps such as conveyed by12-bit gamma (ITU-R BT.1886) or PQ (SMPTE ST 2084) integer samples.
* If the full requirements of HDR/WCG above are not met within one profile, then there should be at least a second profile (aimed at a tier of more flexible execution devices) designed for publication at the same time of a lower electrical power consumer tier.

Any extension or new coding tools designed for HDR should be compared against HEVC Main 12 4:4:4 anchors with professional level pre-processing and post-processing steps.

# References

[1] MovieLabs Specification for Next Generation Video: [http://www.movielabs.com/ngvideo](http://www.movielabs.com/ngvideo\)

[2] Blu-ray Disc Association, Coding Constraints on HEVC video streams for BD-ROM Version 3.0, <http://www.blu-raydisc.com/en/Technical/TechnicalWhitePapers/General.aspx>

[3] MPEG FutureVideo webpage: <http://mpeg.chiariglione.org/standards/exploration/future-video-coding>