Configuring Versatile Video Coding: technical guidelines for broadcast and streaming applications

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Contents

VVC standardization status

VVC profiles in ed. 1 (2020)

- Standardized as Rec. ITU-T H.266 | ISO/IEC 23090-3
- Main 10 and Main 10 4:4:4 profiles
  - 8/10-bit video
  - SDR/HDR/WCG/HFR
  - Temporal sublayers support and core spatial scalability functionality
  - Additional support for 4:2:2 YCbCr and 4:4:4 RGB formats in Main 10 4:4:4
- Multilayer Main 10 and Multilayer Main 10 4:4:4.
- Main 10 Still Picture and Main 10 4:4:4 Still Picture

VVC related metadata (SEI messages)

- VVC specification
- Versatile SEI messages for coded video bitstreams (VSEI): Rec. ITU-T H.274 | ISO/IEC 23002-7.

VVC extensions in ed. 2 (2022)

- Bit depths up to 12 bits for YCbCr chroma formats.
- Intra-only profiles up to 16 bits for RGB formats.
- High bitrate coding: lossless and nearlossless coding

VVC support in systems & transport standards

- MPEG-2 Transport Stream: Rec. ITU-T H.222.0 | ISO/IEC 13818-1
- MPEG ISO BMFF (NALUFF): ISO/IEC 14496-15
- MPEG CMAF: ISO/IEC 23000-19
- MPEG HEIF: ISO/IEC 23008-12
- MPEG OMAF: ISO/IEC 23090-2
- RTP payload format: RFC 9328

VVC deployment status*

Software decoding

- HD playback on Android and iOS mobile plaftorms.
- UHD/4K playback on laptop/desktop grade processors.
- UHD/8K playback on AMD EPYC and Intel Xeon based servers.
- Web browser playback with WebAssembly with Edge, Firefox and Chrome browsers.

Encoding

- Offline commercial VVC encoders with >30% performance gains over HEVC integrated into cloud-based encoding, transcoding and mobile OTT services.
- Real-time commercial VVC encoders with 15-30% performance gains over HEVC using the same or comparable HW (1-1.5x).

Hardware decoding

- 8Kp120 VVC decoder IP core.
- 4Kp60 SoC decoder for STB.
- 4Kp120 and 8Kp120 SoC decoders for TVs.
- New TV ranges supporting VVC announced for 2023.

Open-source and commercial developer tools

- VVC encoder or decoder integration plugins available for FFMPEG, VLC, GPAC,..
- VVC conformance testing specification developed by JVET, VVC Verification and Validation bitstreams developed by DVB.
- Commercial test bitstreams and bitstream analyzers.

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JVET maintains up to date list of VVC deployment, document available from JVET repository: jvet-experts.org

** For references, please see the associated manuscript*

VVC adoption status*

ARIB ISBD

Investigating VVC Main 10 and Multilayer Main 10 profiles for its next generation digital video broadcasting system.

ATSC

Specifying VVC for inclusion in the ATSC 3.0 suite of standards.

CTA Wave

Added VVC profile to its Web Application Video Ecosystem Content Specification in 2021.

DASH-IF

Added VVC profile to its DASH-IF Interoperability Points in 2022.

DVB

Adopted VVC as Next Generation Video Codec into its codec toolbox in 2022.

SBTVD

Selected VVC as the sole video base layer codec in 2021. Specification drafting is ongoing.

SCTE

Adopted VVC into its standards, SCTE 281-1 and 281-2 in March 2023.

Compression performance requirements

DVB set out a number of performance related commercial requirements to be met by next generation video codecs.

- 8K video over legacy broadcast multiplexes.
- 5x 4K services in a 40Mbps multiplex (3x for HEVC).
- 27% and over 30% efficiency gains over HEVC for live and offline streaming.

In **SBTVD** evaluation, VVC technology was tested on variety of content test cases and gains >30% were reported for:

- Spatial resolutions from 720p to 4320p for HDR HLD and HDR PQ.
- 1080p SDR content with different frate rates.
- Sign language video in portrait mode (540x960 and 360x640)

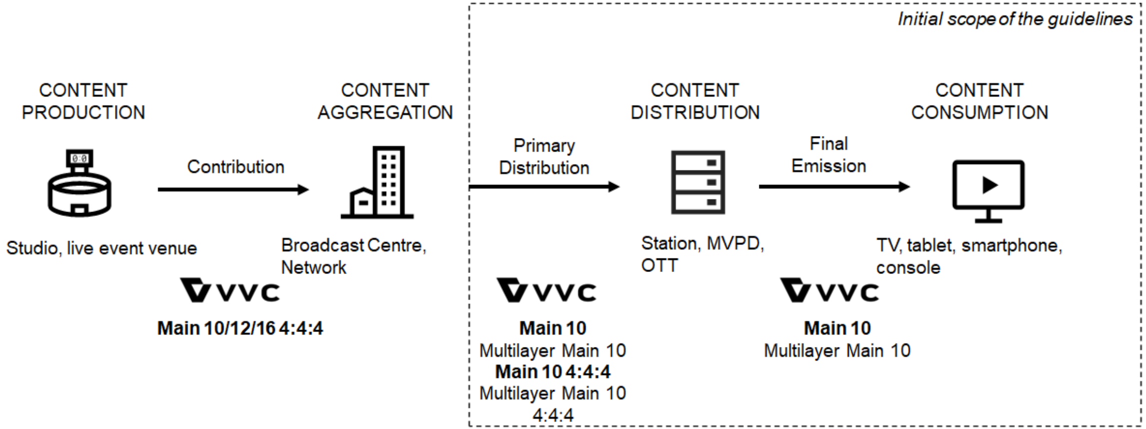
** Based on publicly available information*

MC-IF VVC technical guidelines

Media Coding Industry Forum is developing VVC technical guidelines for video broadcast and streaming.

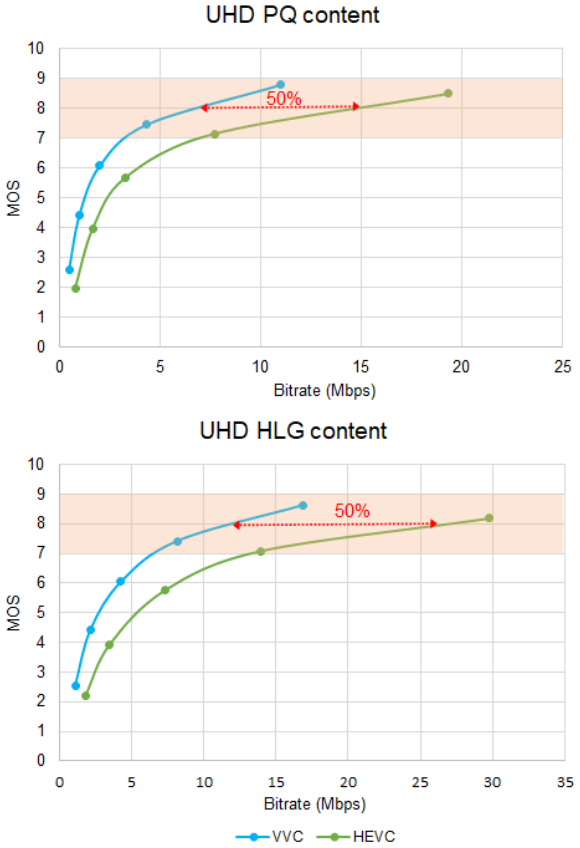
The guidelines aim to:

- cover best practices of VVC configuration for industry relevant VVC-based profiles,
- provide up to date information on VVC operating bitrate ranges,
- provide information on the usage of VVC with accompanying technologies such as VSEI standard,
- advocate interoperability and seek commonality of VVC usage.



Compression performance: HDR video

- HDR video services were enabled by HEVC Main 10 profile.
- In VVC, HDR support was included from the start by design with relevant tools present in the core technology.
- No separate VVC profile or coding tools for SDR or HDR video. Both, SDR and HDR as well as Wide Color Gamut are supported by VVC profiles.
- 3GPP SA4 5G codec feasibility study (TR 26.955) reported VVC achieved:
  - **coding gain of 37%** BD-rate (PSNR) for SDR UHD test content.
  - **coding gain of 39%** BD-rate (wPSNR) for HDR UHD test content.
- MPEG conducted several subjective VVC verification tests, including HDR HLD and HDR PQ content:
  - **50% bitrate reduction at broadcast quality operating range** was reported for SDR and HDR test content.



MOS quality over bitrate for UHD HLG and PQ content pooled over 5 test sequences in each category

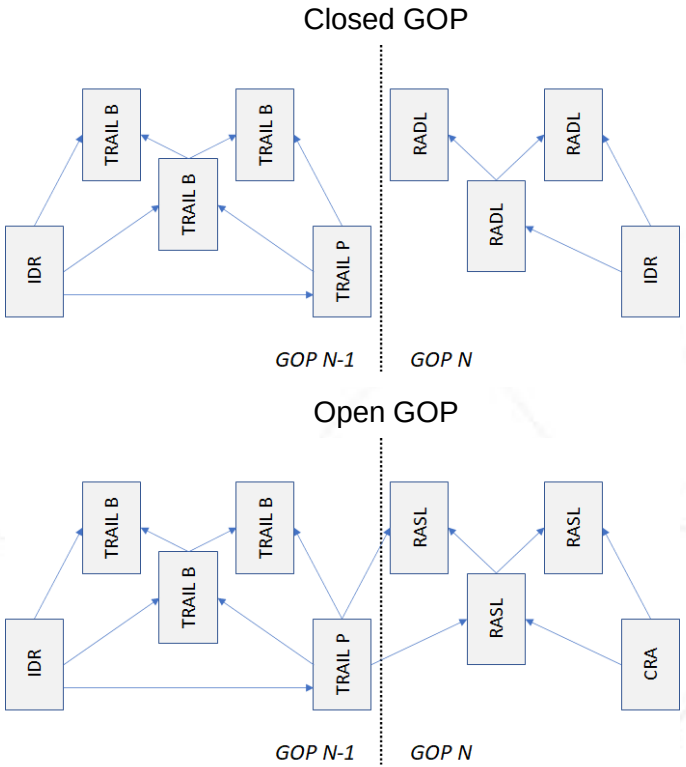
VVC functionality: reference picture resampling

Resolution switching in adaptive streaming

- Resolution switching is supported in adaptive streaming systems with the use of IDR frames at the start of each segment – closed GOP.
- IDR RAPs incur compression performance loss in comparison to open GOP
- Skupin, et.al.*, reported up to 9% BD-rate gains using constrained open GOP referencing with RPR.

Resolution change in linear video services

- Linear video services currently do not benefit from resolution change functionality.
- Interoperability tests** with deployed TV sets using IDR-based resolution change with HEVC Main 10 profile reported issues at switching points.



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*Skupin, R., et al., "Open GOP resolution switching in HTTP adaptive streaming with VVC," Proc. 35th Picture Coding Symp. (PCS)

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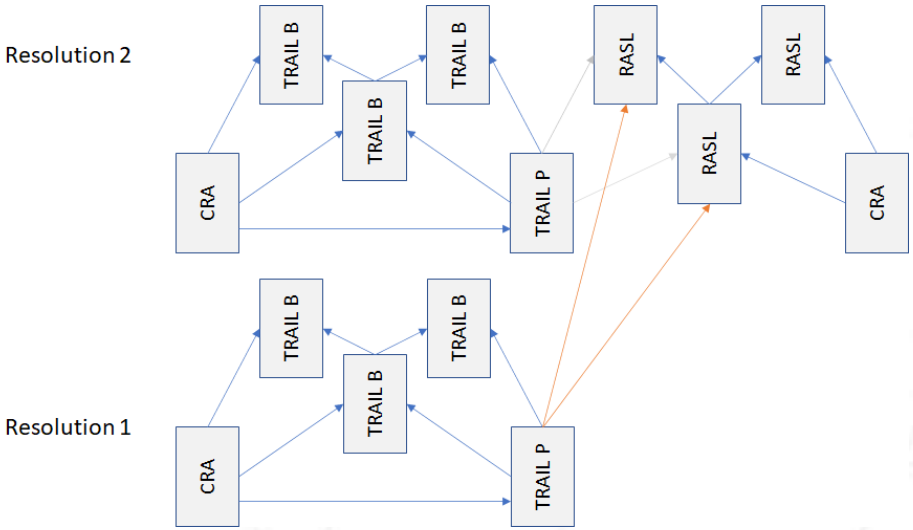

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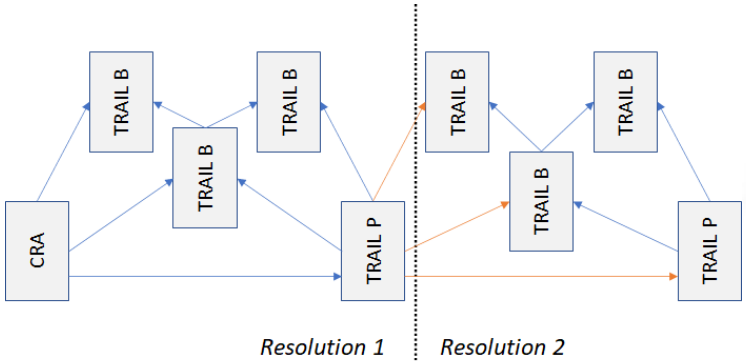
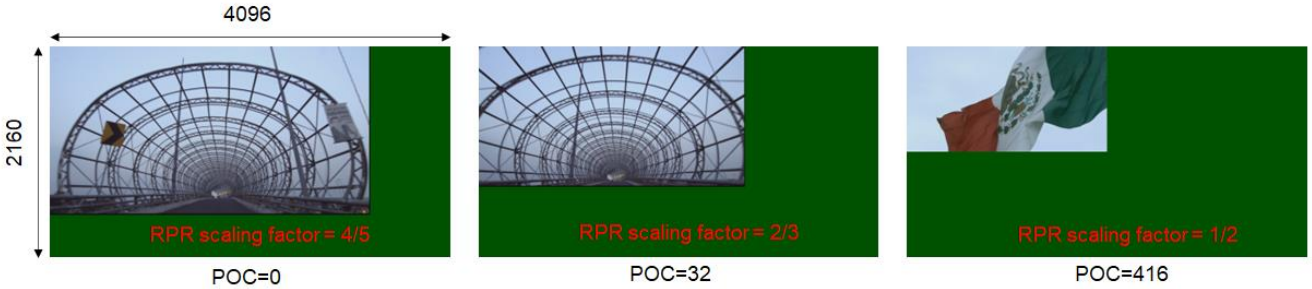
VVC functionality: reference picture resampling

Resolution change in a linear video service

- VVC can change resolution of coded video in order to optimize bitrate for difficult or easy content, or when „true” content resolution is lower than of the incoming format.
- This extends flexibility of existing encoder’s rate control mechanisms.
- In addition to VVC RPR constraints, encoder may need to excercise contraints regarding the use of resolutions and frequency of resolution changes.
- This functionality is supported for VVC profiles defined by DVB in TS 101 154.





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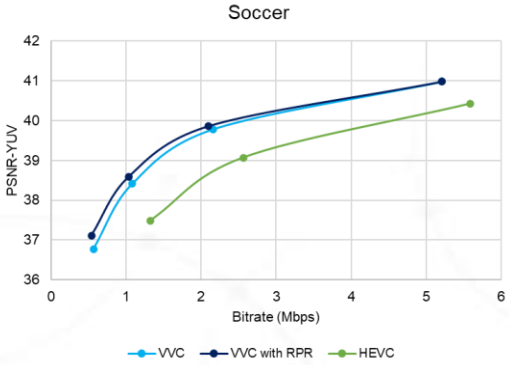
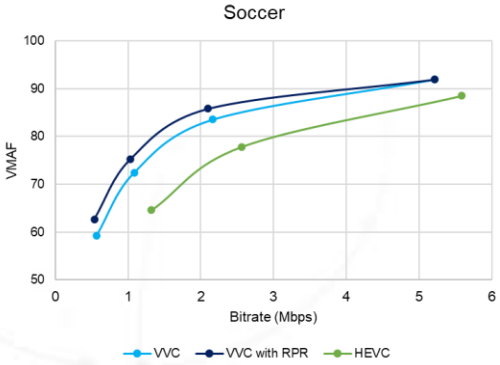
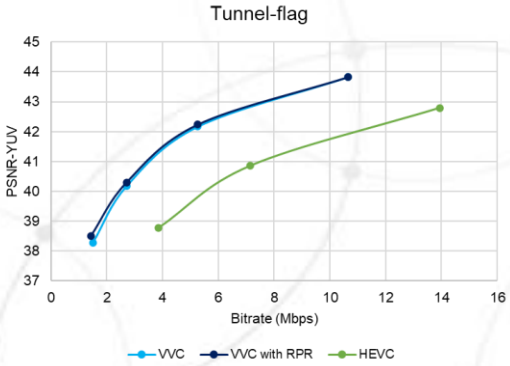
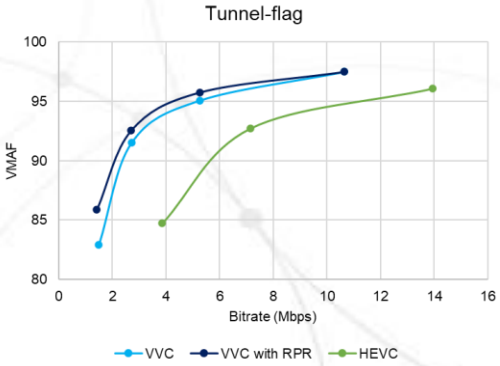




	BD-rate gains	
Soccer	PSNR-YUV [%]	VMAF [%]
VVC vs. HEVC	39.27%	40.23%
VVC with RPR vs. HEVC	43.02%	48.77%





	BD-rate gains	
Tunnel-flag	PSNR-YUV [%]	VMAF [%]
VVC vs. HEVC	52.64%	55.19%
VVC with RPR vs. HEVC	54.38%	61.55%

Metadata for VVC

Versatile Supplemental Enhancement Information

- VVC standard only defines processes required for conforming video decoders.
- Information about how video is intended to be post-processed, displayed, or otherwise used is specified mostly in the VSEI standard.
- VUI parameters provide information for the correct display of coded video: scanning format, transfer function, colour gamut, aspect ratio, etc.
- SEI messages provide additional information that can assist decoders, displays, and other video receivers perform as desired by the content producer.
- Several SEI messages such as MDVC, CLLI or ATC were developed for deployment of HDR video serivces.

Film grain synthesis

- Film grain synthesis (FGS) characteristics SEI message is increasingly important due to interest in film grain synthesis in high-value streaming services.
- FGS characteristics SEI message supported in AVC, HEVC and VVC
- A Technical Report on use of film grain technologies is currently in development in ITU-T and ISO/IEC.
- 2 main FGS use cases: preserving artistic intent and masking compression artefacts.

Neural-network post filter

- NNPF SEI messages enable use of neural networks for post-processing operations (e.g, super-resolution, frame rate upsampling)
- NNPFC SEI message signals NN weights.
- NNFPA SEI message signals a specific NN that is invoked.

MC-IF VVC technical guidelines - status

- First version of the VVC guidelines is under development and currently planned for a release at end of Q2 2023.
- If you're interested in contributing to VVC guidelines development join MC-IF at:

https://www.mc-if.org/become-a-member/

- Another way to contribute is planned through an open community review process.
- Tune in for updates at: https://www.mc-if.org/broadcast-streaming-guidelines/
- or reach out to us via interopwg-chair@lists.mc-if.org

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Thank you for your attention!